Sastrajyoti

Reference book for

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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 teacher, the ideal relationship between the teacher 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 teacher.

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. The Rigveda also realized that if one human being was superior to another it was not because the person had an extra hand or eye, but because education had sharpened his mind and intellect and rendered him more efficient.

The above objectives relate to the development of the individual. But transcending the individual is the society. Therefore, 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." Interestingly enough this echoes a similar idea met with in the Rigveda – *atma iva sevah*. 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*). Equally important is the advice to always strive for greatness (as a scholar) through continuous study and teaching (*bhutyaina-pramaditayam / svadhyapravacanbhyam na parmaditavyam*). In other words, the process of acquisition of knowledge is an open-ended endeavor, and the ideal teacher must always be engaged in it in order to remain at the vanguard of knowledge.

The Gurukula System and the Tol

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 close parallel to the system was the schools maintained by the Bishops in Europe during the sixth century A.D.

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. This type of institutions prospered, particularly in Bengal, Bihar and the United Provinces, and survived into the British period upon receiving some encouragement. 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.

Scientific, medical and technical education

Teaching of Astronomy, Mathematics and Physical Sciences

Narada's list of subjects presented to Sanatkumara contains a large number of scientific and technical subjects, e.g. arithmetic, jyotisa, military sciences, snake charming etc. Temple colleges, tols, and Buddhist universities uniformly encouraged secular studies including the sciences, medicine and technical subjects. Mathematics and astronomy occupied a pride of place in Vedic studies, the former being compared to the proverbial jewel on the hood of the snake and the latter being of such central importance that without acknowledgment one cannot perform the sacrifices. The construction of sacrificial altars of various sizes and shapes involved the knowledge of geometry of rational triangles, rectilinear figures, trapeziums and circles, transformation of figures from one type into another, irrational numbers and their operations, the determination of the ratio of the circumference of a circle to its diameter, and so on. As all these mensurational works used to be carried out with the help of a measuring cord, the *sulb*, the geometer was called the sulbavid and the science, the *sulbasastra.* The subject formed part of the more comprehensive *Srautasutras* concerned with rituals ad sacrifices. As mathematics and astronomy seprated out as secular subjects of study and became more and more specialized and sophisticated it came to be associated with individuals and families taking a special interest in, and developing aptitude for, the subject. The large number of commentaries on mathematical and astronomical works of a few masters, produced in ancient and medieval periods, bear testimony to their popularity.

Physical sciences as we know them today did not then have separate existence, but formed part of philosophical studies. These envisaged the six systems (*saddarsana)*, of which the *Nyaya-Vaisesika* and the *Samkhya* were noted for their many physical concepts, such as the concept of matter, its physical properties, its atomic character, explanation of physico- chemical changes on atomic and molecular theories, the concept of motion, sound , and light, of gravity and fluidity, and of force and energy. About many of these concepts, e.g. atomism, nature of motion, sound, to mention a few, there were sharp differences of opinion between the Brahmanic and the Buddhist schools, which undoubtedly enlivened the teaching and discussion of these subjects in the Buddhist universities as well as in Indian temple colleges, tols and agraharas. The method of mastering these sciences was by debate and discussion, an art perfected in *Nyaya-or-Tarka-Sastra*. These subjects received special encouragement for the sake of medical studies upon which some of the philosophical systems, particularly the *Samkhya*, and the *Nyaya – Vaisesika* had a deep impact.

Medical Education

While our information on the teaching of mathematics, astronomy and physical sciences the needs must be scrappy but it is fortunately not so with regard to medical education. This is because medical works took particular care to preserve for us what, in the opinion of ancient medical authorities, constituted the most effective teaching methods for the training of competent physicians. Both Caraka and Susruta stressed in various ways the characteristics of a good physician, the marks of a quack, the service the former can render to the society and the disaster the latter may bring about. Susruta defines a physician as one ‘who is well versed in the science of medicine and has attended to the demonstrations of surgery and medicine, and who himself practices the healing art, and is clean, courageous, light-handed, fully equipped with supplies of medicine, surgical instruments and appliances, and who is intelligent, well read, and is man of ready resources, and who commands a decent practice, and is further endowed with all moral virtues. Caraka makes a similar but longer statement about the qualifications of a good physician. Such a physician must be well acquainted with the anatomy and physiology of the entire body, manifestation and growth of the body and origin and evolution of the universe. He must understand the eight sections of the Ayurveda and apply his knowledge so acquired for the treatment of diseases. A bad physician or a quack, on the other hand, has qualities quite the opposite of those given above. Instead of curing diseases he may cause death and torture people like thorns. Quacks are traitors moving about in the guise of physicians because administrative vigilance is lacking. Susruta is equally furious with them when he equates them with ‘Killers of men out of stupidity.

Thus, the production of good physicians depends both on the qualities and qualifications of the teachers as wells the pupils , and therefore utmost care should be exercised in the selection of both the teachers and the taught. Let us first consider the selection of students. For learning medicine caste was no bar. Caraka opined that, in general, the science of life (Ayurveda) can be studied by all for the attainment of virtues, wealth and pleasure (*samanayato va dharmarthakama parigrahartham sarviah)* . Right to study medicine by any body regardless of caste has also been recognized by Susruta with the subtle distinction that a Sudra student at the time of initiation should omit to recite the mantras required on such occasions. More important than caste are the faculties of body and mind- thin lips, teeth and tongue, straight nose, large, honest and intelligent eyes, a contented frame of mind, good character, pleasant speech and good dealings with others, a good retentive memory, clear comprehension and insight into the subject of study. A student deficient in these qualities of faculty and character may not be regarded suitable for admission to a medical course. About the initial education of the entrant, Visweswara Sastri says that a preliminary knowledge of *sad-darshana* or at least of *Samkhya a*nd *Nyayam Vaisesika* was considered necessary. The normal age of entrance for medical studies appears to be sixteen. By this age he is sufficiently grown up, educated and mature to decide whether he intends to be a physician.

The medical instruction and practice usually took six years. Accordingly to the original classification of the subject, as taught to Bharadvaja in Vedic times, the course comprised the principles of health and ill health, the aetology, symptomatology and the treatment of diseases. Later on Ayurveda was divided into eight *angas or* branches for the convenience of teaching. Susruta mentions these eight branches as follows: *salyatantra* (surgery, general principles*) salakya-tantra* (Surgery of regions above the clavicles) *kaya-cikitsa*(treatment of disease), *bhuta-vidya* (demoniacal diseases), *kaumara-bhrtya*(children diseases),*agada-tantra* (toxicology), *rasayana-tantra* (Science of rejuvenation), and *vajikarana-tantra* (Science of aphrodisiacs). In many texts, the subject matter was arranged not in accordance with the above eight angas, but into broad areas, e.g. *sutrastana*, dealing with fundamental principles of ayurveda; *sarirstana*, discussing anatomy and physiology, including embryology; *nidanasthana* dealing with pathology, *cikitsasthana,* devoted to treatment of diseases, etc.

For a proper understanding of medical science, Caraka advised the holding of regular seminars and friendly discussions. Physicians should always hold professional discussions among themselves with a view to developing their powers of application, clarity of knowledge, the gift of the gab, resolving doubts and confirming what was understood before. To derive the fullest possible benefit out of such seminars, the discussions must be friendly and free from a hostile spirit.

The emphasis on practical training is clearly underlined by Susruta in his instructions on the development of surgical skills among the pupils. A pupil who is well read in the text-book and grounded in the principles of Ayurveda, but not initiated in surgical skills and practice of medicine is not competent to undertake either the medical or the surgical treatment of a disease. For the attainment of surgical skills the pupil must learn specific forms of incision by making cuts in the body of a fruit, - gourd (*alavu*), watermelon, cucumber etc. The art of making incisions should be demonstrated by performing neat openings in the body of a full water-bag, or in the bladder of a dead animal or in the side of a leather pouch filled with slime or water. Scrapping should be practiced on a piece of skin from which hairs were not removed. The vein of a dead animal or the stem of a lotus should be used for acquiring the skill of venesection (*vedhya*). Cauterization or application of alkaline preparations should be demonstrated on a piece of soft flesh. There are several other surgical operations of which practical learning methods have been described. A physician who thus becomes well versed in the principles of surgery as well as experienced in the practice of medicine is alone capable of curing distempers; just as a two wheeled cart is of service in a battle-field so is such a physician expected to achieve victory in his fight against disease.

After having mastered the science of medicine, both theoretically and by practical experience of surgery and medicine, the young physician should now seek the permission of the king of the country for commencing his medical and surgical practice. Susruta's clear statement in this regard shows that there was something like the licensing and registration of practitioners in order to distinguish between licensed qualified practitioners and unlicensed quacks. In the same section, Susruta even advises as to the dress and demeanour of the physician. The physician, he says, should wear white garments, put on a pair of shoes, carry a stick and an umbrella in his hands, and walk about with a mild and benignant look as a friend of all created things, ready to help all, and frank and friendly in his talk and demeanour.

Both Caraka and susruta laid emphasis on the need for nursing in the successful treatment of the patient. According to Caraka, there are four aspects of treatment or therapeutics, namely, the physician, the medicament, the attendant *(upasthata)* and the patient himself. The good attendant's qualifications should be the knowledge of nursing *upacarajnata*), dexterity (*daksyam*), affection (*anuraga*) and purity (*saucam*). Susruta holds the same opinion that the physician, the patient, the medicines and attendants are the four essential factors in medical treatment. If the physician be qualified, the patient self controlled, medicines genuine and the attendant's intelligently watchful, then even a serious case is readily cured. About the attendant he further says that a person who is cool-headed and pleasant in demeanors does not speak ill of others, attends readily and willingly to the needs of the patient, and strictly follows the instruction of the physician is alone, fit to attend the bed side of the a patient.

The *Mahavagga* prescribed that to be a good nurse, he should possess five qualities, that is (1) he should be capable of giving medicines (as directed by the physician), (2) he should know the diet which is good for the patient and accordingly serve him with such diet, (3) he should wait upon the sick out of love and not out o f greed (4) he should not revolt from removing the evacuation, saliva and vomited matter, and (5) he should be capable of teaching, inciting, arousing and gladdening the patient with religious discourses. The medical texts are silent on the question of training of nurses, but the qualification detailed clearly envisage some form of training.

We also find interesting statements about the duties and responsibilities of a physician in the service of the king. Such a physician must be responsible for the protection of the life of the king and also of the royal army particularly during war. There were always the dangers of secret poisoning when a king mobilized his armies to attack a neighboring ruler. In such cases the enemy usually had recourse to the common practice of poisoning road-side wells, articles of good cattle fodder, and shady resting places. The army physician marching with the king must examine and purify all these things in accordance with the method discussed in the chapter entitled *Kalpa-Sthanam*. Moreover, the physician should live in a camp near the royal pavilion, which is fully equipped with instruments and medicines, and be ready to treat anybody in the army wounded by arrows or other projectiles or suffering from the effects of imbibed poison. Buddhist sources also provide some information about nursing.

Teaching of Botany, Chemistry and Veterinary Sciences

Ayurveda or the science of life is based on all branches of science. This is as much true of modern medical science as it is of Ayurveda. Herbal remedies occupying a major part of the Ayurvedic materia medica, presuppose a deep knowledge of the plant sciences or botany. Ray and Gupta, from their analysis of the *Caraka Samhita*, have shown that plant substances accounted for 341 drugs as against 177 of animals origin and 64 based on metal and mineral substances. During his study at Taxila, Jivaka was asked by his teacher to make botanical survey of an area within a radius of a yojana from the city and find a plant devoid of medicinal properties. After a good deal of investigations he failed to discover a plant that was not medicinal. This and a cursory glance of any at Ayurvedic text of materia medica would immediately make obvious the importance of botanical studies. We are also aware of an extensive ancient botanical literature under the general title '*Vrksayurveda*' , to which frequent reference is made *in Kautilya's Arthasastra and Kamandaka's, Nitisastra*. The *Agnipurana* and the *Brhatsamhita* each as a chapter on *Vrksayurveda*, And we have full works on the subject ascribed to Kasyapa, Prasara and Sarasvata. So it is reasonable to expect that botanical studies were not only compulsory in the medical schools, but were quite popular and in course of time developed into a specialized subject of study

Inorganic remedies even at the time of Caraka and Susruta were not insignificant. Prepared out of metals, meal compounds and mineral substances, the chemical remedies as found in Caraka include bitumen, iron rust, black sulphide of antimony, gold dust, sulphur, alum and copper sulphate. Alkalis in different concentrations were prescribed in various types of treatment and their methods of preparation are also described in the texts. Susruta mentions several salts. With the discovery of the medicinal properties of mercury and the introduction of mercurial preparations in the materia medica, a new **iatrochemical** period was introduced, which proved fruitful for the development of alchemical studies. Between the ninth and the eighteenth century A.D., these studies resulted in the production of a sizable literature under the general name *rasasastra*, which is again a pointer to the existence of active teaching schools in chemistry within and outside the broader medical institutions.

An off-shoot of the science of human life was the science of animal life which formed the subject of a number of specialized treatises each devoted to a particular animal. In connection with the value of milk in human nutrition Susruta notices the characteristics of milk on a number of domesticated animals. A special treatise on bovine animals, which played and still play a crucial role in Indian economy first appeared under the title *Gavayurveda*, attributed to one *Gotama*, and used by *Bhojaraja* in his medical encyclopedia *Rajamartanda*. Horse and elephant, because of their military importance from very ancient times, formed the subject of a number of veterinary works, e.g. Salihotra Samhita on horse and commentaries on it by *Jayadattasuri* and *Nakula*, *Hastyayurveda* by *Palakapya* on elephant, which became very popular both within and outside India. Kautilya talks of veterinary doctors and surgeons at a number of places in his Arthasastra. “Elephant-doctors”, he says, “shall apply necessary medicines to elephants which, while making a journey, happen to suffer from disease, overwork, rut or old age.” Furthermore: “Veterinary surgeons shall apply requisite remedies against undue growth or diminution in the body of horses and also change the diet of horses according to changes in the seasons.” We are also aware of Asoka's great concern for the health and treatment of both men and animals for which he established hospitals throughout the length and breadth of his empire. Although the importance of veterinary science as a specialized subject of study can be safely assumed. We have little information as to whether such a study was confined to medical schools or left to special teachers or keepers of royal manageries.

Technical Education and the Apprentice System

With regard to the various schools at Taxila eighteen *silpas* or industrial and technical arts and crafts are often mentioned from scraps of information contained in the *Jatakas* the *Mahavagga*, *Milinda-Panha* and others sources, Aletkar suggested the following to constitute the traditional eighteen *silpas:* 1.vocal music, 2. instrumental music, 3. dancing, 4. painting, 5. mathematics, 6.accountancy, 7. engineering, 8. sculpture, 9. agriculture, 10. cattle breeding, 11.commerce, 12. medicine, 13. conveyancing and law, 14. administrative training, 15. archery and military art, 16 magic, 17. snake charming and 18. the art of finding hidden treasures. Persons engaged in these arts and crafts formed themselves into guilds for purposes of professional safeguards as also or orgnising the trining and education of the new entrants to the trade. The Muga-Pakkha jataka mentions eighteen guilds, but as no list is given it is not possible to ascertain whether they conformed to the list constructed by Altekar. On the basis of literary and inscriptional information, Das worked out a list of 27 guilds representing as following arts and crafts:- 1. cultivators , 2. traders, including caravan traders, 3. herdsmen, 4. money lenders, 5. workers in wood, 6. workers in metal including gold and silver, 7. leather workers, 8. workers in fabricating hydraulic engines (*Udayantrika)* 9. bamboo workers (*Vasakara)*, 10.braziers (*Kasakara*), 11. weavers, 12. potters, 13, oil millers, 14. painters, 15 corn dealers (*dhamnika*), 16. garland – makers and flower sellers, 17. Mariners 18.robbers and free booters, 19 forest police who guard the caravans, 20, workers in stone, 21. ivory workers, 22 jewelers, 23. Rush workers and basket makers, 24. dyers, 25 fisher folk, 26, butchers, and 27 barbers and shampooners. While the list includes many important industrial or technical arts and crafts it is baffling to understand, why items like money lenders corn dealers, butchers have been included and important crafts like architecture, engineering and medicine omitted. Finally we have Vatsyayana's list of sixty four traditional kalas (arts) which are expected to contribute to the cultural and technical development of a lady.

An apprentice system was developed and perfected as a part of the education in arts and crafts. This emphasizes that the teacher – student relationship in the sphere of learning. This is governed by certain contractual obligations binding on both sides: The master craftsman must teach the apprentice his trade secrets honestly, shall treat him as his son and must use him only in work relating to the trade. The apprentice, on his part, should complete the course and should not claim any earnings.

Technical Education

The excellence of manufactured articles of medieval India is well known. This excellence could not have been achieved and maintained for centuries without a dependable system of technical education.

Adapted from: Scientific and Technical Education in India. 1781-1900. (1991) S.M.Sen, Indian National Science Academy, New Delhi.

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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 Panduranga-swami, 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 reputation 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 ($\pi + \theta$) = 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 revolving 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 *Panchasi-dhanthika* 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. He was born and brought up in Magadha. He studied the works of Aryabhata and then moved to Ujjain-it is presumed. *Panchasidhanthika* (astronomy), *Bruhatjataka* (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 $\prod$ 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. *Sarah-geej,* 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 Mantars.

‘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 Mantars.

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 a 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.

VYNUBAPPU OBSERVATORY

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 Bapu returned to India in 1953, 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 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.

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> *"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.

CARAKA EXAMINING HIS PATRON, KING KANISKA

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 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 Agniveshathantram, which gradually merged with Caraka Samhita .

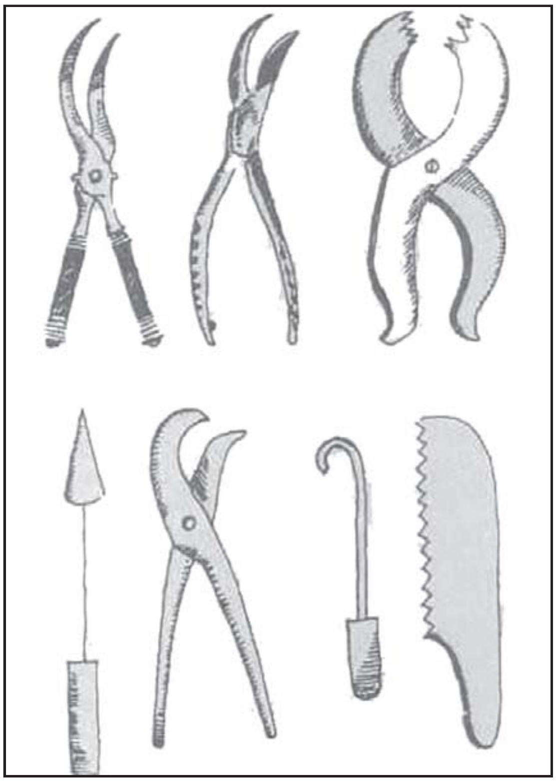
BHELA SAMHITA: This is one of the oldest texts on Ayurveda. But we have got only an incomplete manuscript of this text. The references of this in other texts clearly demonstrate its antiquity and its importance.

CARAKA 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,



SURGICAL INSTRUMENTS USED BY SUSRUTA

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 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, sublimation, 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.

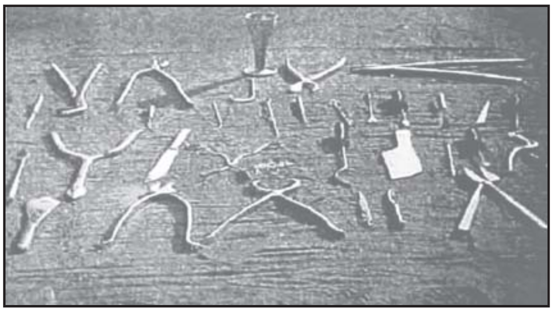
GAVAYURVEDA

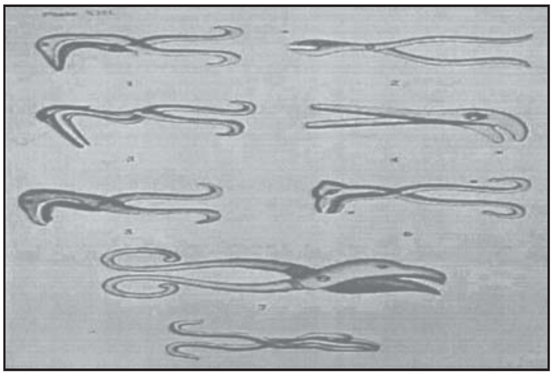
Gouthama's *Gavayurveda* is a book, which deals only with the medical aspects of cows.

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.





SURGICAL INSTRUMENTS DESCRIBED IN SUSRUTA SAMHITA

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

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 reemerged 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 Indian 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)

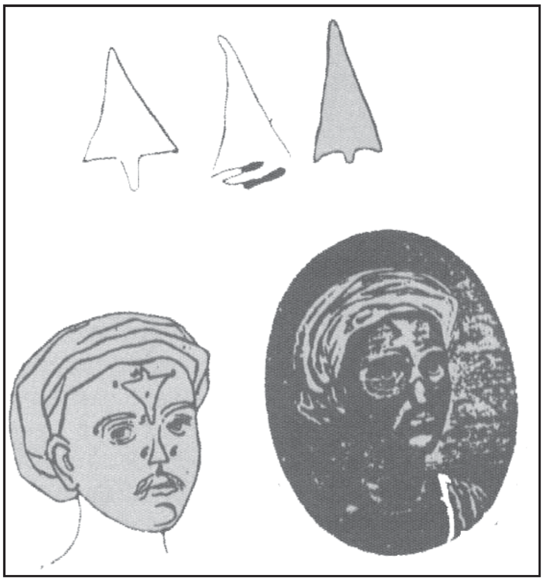
Plastic Surgery In Ancient India

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, grouped 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

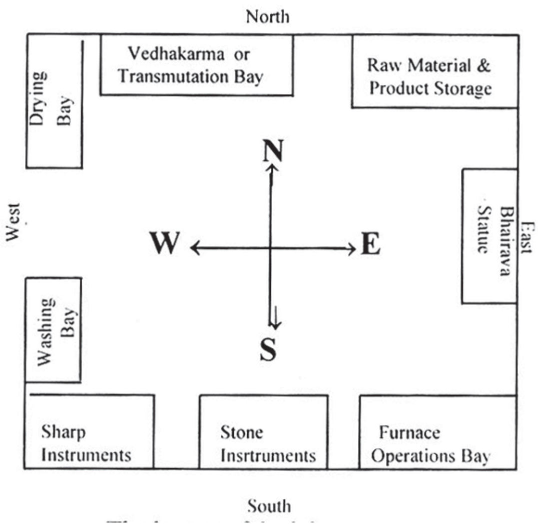
India was considered to be the industrial workshop of the world till the end of the 18th century. Everyone is familiar with the chemical excellence of cast iron produced in ancient and medieval India. The tempering of steel was brought to perfection in India when it was unknown to Europe. Alexander received 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



THE LAYOUT OF THE LABORATORY

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, ear-rings, amulets, wires and rods. Gold and silver were used for jewellery and

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

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.

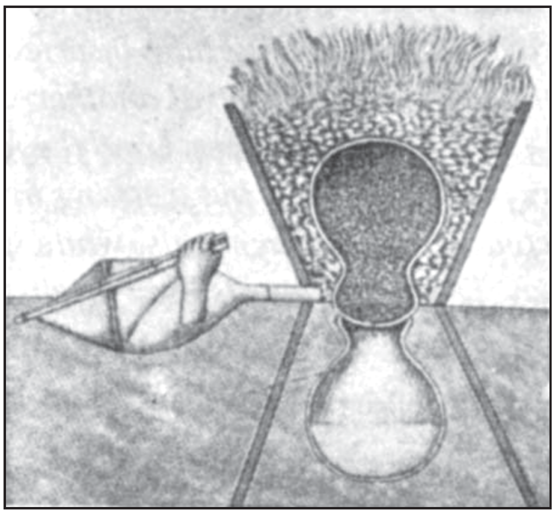
It is evident that the technology of extracting Gold, Silver, Copper, Lead, Tin and Iron was known and that there were professional experts who were smiths, potters, carpenters and chariot builders. However, we do not find the details of metallurgical operations in the ancient literature.

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

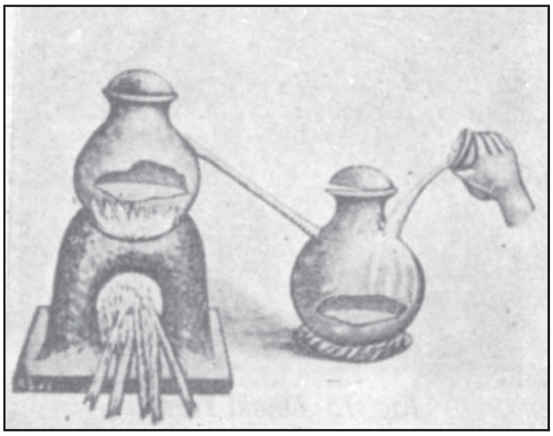
Several methods of preparation of variety of chemicals and drugs are given in old works on Indian Alchemy, known as 'Rasa Vidya', after a large number of trails and errors. These experiments were conducted in a Chemical laboratory is described in one of the most well known works on ancient Indian chemistry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



KOSTHI YANTHRA

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



TIRYAK PATANA YANTRA

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") 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 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

Our ancestors has also 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

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 picutured 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 *Shevetaswataro-panishat* - "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).

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Life Sciences in India

Science and Technology play a pivotal role in the development of human society and in the progress of the nation as a whole.

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 (BC 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. The only agriculture equipment that we got from Mohenjodaro and Harappa was a large hoe. Application of wooden ploughs was also suspected.

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.

The Harappans also selected the right kind of plants for the right purpose, attesting their knowledge of economic botany. The wood of *Cedrus deodara* and *Dalbergia latifolia* were used for the construction of coffins. The strong wood of

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

Shorearobusta was used to prevent bank erosion in the river Ganges.

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 community there.

There are a series of flourishing literature in Sanskrit to deal with Medical science. The first authentic work on medicine is the Caraka Samhita written by Caraka 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.

Vrikshayurveda

In *Arthasastra, Agnipurana* and *Brahasamhita* there are separate chapters dealing with Botany. *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. It also classified plants based on their morphology.

Kautilya's Arthasastra narrates the role of agricultural officer. *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.

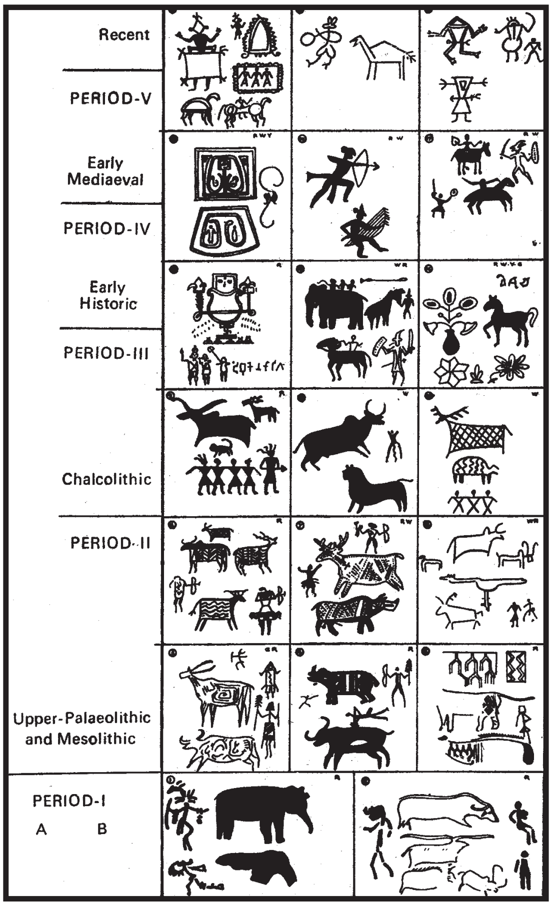
The plants were believed to germinate from the fertilized seed and were classified into monocotyledonous and dictyledonous types. The role of air, water and climate (temperature) for seed germination was better realized. Parasara explained that the growing plants absorb nourishment initially from the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

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.

Vakthrenolpala nalena
Yathordhvam jalamadadeth.
Tadhapavana samyukthah
Padaish pibathi padapah.

(Mahabharata XII - 177)

If one end of lotus stem is immersed



CHRONOLOGICAL AND STYLISTIC DEVELOPMENT OF ROCK PAINTINGS IN INDIA in water and air is sucked through the other end, gradually water will reach the mouth. Thus plants absorb water through the roots with the help of air. Is it not the first record of water transport by the plants?

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 plant 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

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

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

Phototropism

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

Genes

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* (A.D. 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. Cultivation of flowering plants also began during this period.

Debiprasad Chattopadhyaya in his book *History of Science and Technology in Ancient India* (1991) says 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. Further, he developed a very promising unified theory of man and nature having far reaching consequences for the history and philosophy of science.

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.

Sukracharya studied Indian flora, mainly from a utilitarian view-point. In Sarangaradara's *Padhati* (an encyclopedic Sanskrit treatise of the 13th century), a chapter called *'Upavana-vinoda'*, includes several aspects of plants, especially of arbori horticultural nature. Dhanvantri's *Rajanighantu* and Bhavamisra's *Bhavaprakasa* are primarily of medicinal importance and contain much information on medicinal plants.

During Mughal period rice, wheat, barley, millets, pulses, oil seeds, sugar cane and cotton were 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 flower was 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. Sowing machine was first believed to be fabricated in India during this period.

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. Associated with agriculture was the development of practices of irrigation system.

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, 17th, 18th and 19th centuries because of colonization, political unstability, lack of recognition for scientific pursuits, caste system and tradition-bound nature of people.

The study of plants

The Dutch medical doctor Garcia da Orta studied the medical 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, 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 during 1674-75 period. He published this information 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 then 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.

Flora of British India by Joseph Dalton Hooker, *Plantae Asiatical Raireyorse* by Nathaniel Valliach, *Prodromus Florae Peninsulae Indie Orientalis* by Robert White and Walter Arnot, *Flora Indica* by Thomas Thompson, *Flora of Bombay Presidency* by Theodar Cook and *Trees of Bengal* by Praine are the note-worthy publications on plant sciences.

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 the era of "ship to mouth" or "begging bowl" was over and India is now self-sufficient in food grain production and is now actually exporting it.

Zoology

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 only enabled them to draw these pictures so precisely. In depth 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.

The zoological informations of Vedic period remain scattered in various classics of that period. Nature was the force that kindled the ideas for the literary works of Vedic Indians. There were efforts to formulate hypotheses to explain the nature and origin of life during this period.

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. Nearly 28 types of arthropods were mentioned in 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 nasyathyabho-janath*). 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 contemporaneous with king Ramapada ruler of Angadesa. *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. The concept of *ahimsa* became deep rooted in Jaina-Budha period. *Abhayaranyas* (national parks) were established for the first time to project wild animals. Kautilya in *Arthasastra* described various methods of fish culture and capture.

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 *jangama* (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, protege of king Saundadeva (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. The biographies of Mughal emperors show their love towards nature and living organisms. 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 that information about the animals he saw 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 under the supervision of Hamilton-Buchanan 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

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

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), Rondon (bears), R. C. Roten (rodents), Moore, Elvis 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 that 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.

Some of the publications from India dealing with Zoology published during 19th century are listed in Table below.

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.

Since independence, India is trying to develop a modern nation and hence there is need for developing science and technology in the right direction. *The present education systems fail to project the rich scientific heritage of India. The foundation of our education should be based on this culture and heritage. At the same time do not consider that everything worthwhile in modern science was already achieved by the ancient sages of the Vedas. For us the destiny is far away and for reaching the goal we have to take firm steps, and the responsibility is now with the students.*

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Agriculture in India

Modern Science asserts through techniques such as carbon dating that agriculture was started by man during the neolithic age. Neolithic age is just ten thousand years old. It is an indisputed fact that agriculture was a factor which exerted decisive influence on human civilisation. It was agriculture which induced man to reside permanently at one place. It provided him the opportunity for rest and thinking which proved helpful for many other inventions. All research studies on the subject indicate that it was with the beginning of agriculture that domestic life, art and culture, science and so on originated and developed. But it is on the question of where such a settlement around agriculture was first established, that we have to make a digression.

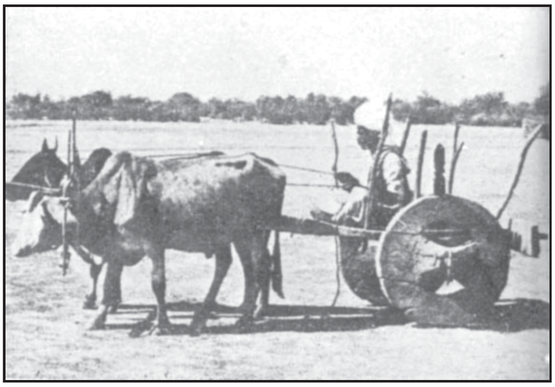
Historians of science claim that signs of the most ancient agriculture were obtained from a township named' Jasno' lying between the present day Iran and north-eastern Iraq. The antiquity assigned by them to the farming in this hilly region situated in the upper reaches of the Tygris is between 9000 to 1100 years. Later research studies have shown that this community moved later to the Tygris -Euphretes valley which was more suited for farming. It was these people that subsequently laid the foundation for the Mesopotamian civilisation. The collection of maize grains obtained from the Okabo caves indicates that the foundation for a flourishing agricultural civilisation had been laid in Mexico also during the same period. There is a conjucture that a group of people had reached America crossing the sea,centuries before Columbus set foot on the continent. If the fact that the peculiar civilisation of the Aztees of Mexico and the Mayans characterised by worship of the sun and other forces of nature bears pronounced similarity with the customs and traditions of the Hindus is taken into account,it could not be wrong to infer that their Asian forefathers are none but Indians. Certain evidences examined recently go on to confirm this inference. To migrate from Asia to America, there should be arrangements for long navigation. With view to finding an answer to this question of how it became possible in very ancient Aimer,the Norwegian adventurer. Thor Heardal ventured upon a daring journey across the sea, Christened Ra Expediction. The sailors numbering seven started in raft made of papaya stems from the Egyptian port of Safi with the help of ocean currents alone reached the American shore safely. The Ra expediction proved that the ancient people could conduct sea voyages successfully from Asian-African coasts to the American continent.

The chromosome structure of the cotton plant is another proof of very ancient Asian-American connection. The first question of hybrids brought about by central hybridization of different species of plants would often be sterile. The reason for this is that the species will differ in their chromosome structure (gene structure). But when the chromosome number of such a barren hybrid plant doubles itself accidently the plant may abruptly became sterile. The emergence of such alaploids is a significant stage in plant evolution The cotton varities cultivated in India from very ancient times were the indigenous ones with 26 chromosomes. But the cotton variety that was brought in to India from America in the 18th century was what is known as 'Compodia cotton' with 52 chromosomes. When the chromosome structure of this variety was subjected to detailed studies, it was found that 50 per cent of these chromosomes were those of indegenous cotton varieties of India. This means that the present quadrupted American cotton is the result of hybridization of Indian indigenous cotton and an American wild cotton in some prehistoric past. Here the question that perplexes us is this; how did the indigenous cotton varieties of India reach the American continent in the prehistoric period, crossing the Pacific ocean which is more than 2500 kilometres wide? Since the Ra Expedition, no one considers the inter continental migration of man during the pre-historic period impossible. Evidences of how much India had advanced in ship building and sea voyages are available from the temples of Jawa believed to have been constructed during the Chola period.

Some other agricultural findings showing that a highly civilised group of men from Asia had reached America much before Columbus set foot on the continent, are also available now. One of them is the two wild maize varieties recovered from the forests of Sikkim which is situated near the northern border of India (Established text book information is that America is the birth place of maize. Still no wild vareities of maize could be found in America. At the same time we have been able to identify wild relatives of maize from the forests of the Himalayan valley. When these facts are correlated we see that the aforesaid story of intercontinental migration acquires greater credibility. There might have been a very ancient period when maize had been cultivated in India as a major cereal crop. It might be an Indian of this period who ventured on a sea journey to unknown coasts, with the seeds of cotton and maize. There are a number of evidences of this type earlier than the Chola period to show that the journeys were a thrill for ancient Indians. The fact is that clay seals which are a relic of the Harappan civilization have been recovered from Mesopotamia.

Harappan-Mohanjodaro Civilization-the Cradle of World Agriculture.

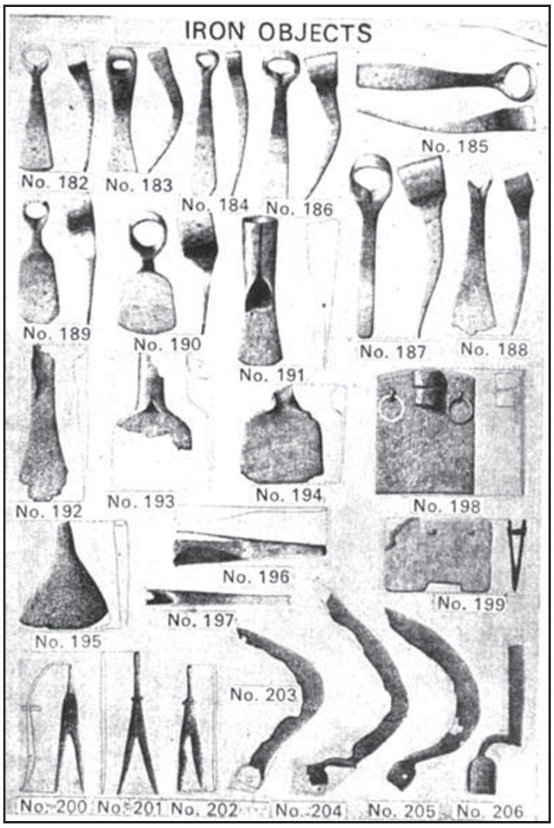
Plenty of signs have been obtained from the Harappa-Mohanjo Daro areas believed to be of the same antiquity as Mesopotamian civilisation, indicating that the cultivation of barely, wheat, sesamum, Bengal gram, cucumber varieties, date palm, mustard varieties and cotton was prevalent there. The recovery of Harappan seals from Mesopotamia is evidence of trade relations that existed between the two areas. There is every reason to think that India even in those days, was renowned for her excellant cotton textiles. There is ample proof to infer that India was the birth place of cotton cultivation and cotton textiles. The fact that cotton got the name Sindhu in Babilonia and in Greece confirms this. The influence of a large number of



BULLOCK CART USED BY THE HARAPPANS

earthern pots shaped like coconut and pome-granete fruits among the Harappan relics prove that these two crops were being grown there in those days. Coconut is described by most of the scientists as a plant which originated in the Pacific islands and reached India only in the epic age. Such an influence is the result of there being no reference to coconut in any of the Vedas. The fact that fossils of coconut have later been obtained from the Rajastan doesn't, however, toples the chronological calculation of our text book history. The fact that today's desert is yesterday's forest is not unknown to us.

A number of evidences indicate that the reason behind the untimely ruin of the Harappan-Mohanjo Daro townships which represented the first man made urban complex was also the destruction of forests. The major timber trees of that period were deodar, rosewood, teak, vaka, and *Eugina racemosa*. Relics of coffins made of rosewood and Deodar, have been obtained from there. Furniture and agricultural implements were made in other types of timbers. Sailing boats (ships) were made with Teak wood. The consequence of the agricultural progress of that period was a spurt in population. It was this increase in population that led to the urbanisation of both these settlements. Multi-storeyed buildings constructed with burned bricks points to the fact that brick making was an important industry then. At that period, as at present, it was fruit trees that man depended upon for luxurious living. Many historians say that ecological problems created by excessive destruction of forests destroyed the Harappan civilisation (as well as the Mesopotamian civilisation). It was perhaps because of the lesson learnt from this destruction that the forests were given a sacred place in the Vedic culture that followed.



IRON OBJECTS USED IN AGRICULTURE (330 BC)

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.

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.

An Exhibition Ground of Crops

The agricultural wealth of Kerala is one which exhibits astonishing diversity. The possibility of most of the yearly crops grown in the world being collected in one or other of the Indian states is quite high. The Indian subcontinent maintains great diversity in climate and the fertility of the soil. Out of the eleven original sources of agricultural crops, as many as three are in India. India's various agricultural zones are related to the origin of all the major crops cultivated through out the world such as paddy, some wheat varieties, sugarcane, different vegetable crops, mango, banana, pulses, oilseeds, citrus fruits and large number of medicinal plants. When it is recalled that India is credited with an agricultural heritage that starts with the commencement of farming in the world and continues uninterruptedly to the present, even a brief description of the history of agriculture in India would run into thousands of pages. It was such a venture that was undertaken by Dr. M.S. Romdhava through the gigantic series of volumes. This will be helpful to those who wish to study the history of Indian agriculture from the Vedic period to the beginning of the five year plans in India. What is attempted below is a brief account of the same of the major crops grown in India.

Paddy and Wheat

Paddy occupies the second place, next to wheat, among the food crops of the world. While the staple food of the advanced countries is wheat products, rice constitutes the staple food of the Asian-African countries. As far as India is concerned, rice accounts for 43 per cent of the production of foodgrains. India produces about 80 million tonnes of rice annually. While the world average of productivity is 3.5 tonnes of paddy per hectare,the Indian average is about 1880 kilogram per hectare.

It is universally informed that the paddy plant known by the scientific name *Oriza sativa* had its origin in India. It is the fact that even the wild varieties of paddy are cultivated in the Indian sub-continent which led to the reference to India as the birth place of paddy.

In India the most extensive cultivation of paddy is found in the southern states of Tamil Nadu, Andhra, Karnataka and Kerala.

Owing to various socio-economic reasons paddy cultivation has been progressively declining in Kerala during the past three decades. The area under paddy which was 8.75 lakhs hectares in Kerala in 1960-61, dwindled to 5 lakhs hectare now. The reasons why paddy cultivation is dwindling in Kerala are the failure of the income from paddy cultivation to keep pace with the increasing agricultural wages and the tendency to convert paddy fields into coconut gardens to be used as house sites in the wake of shortage of dryland for construction of houses. The predicament of having to import from outside an essential item of consumption like rice is likely to create problems for Kerala in future. The reason is that the globalisation policy pursued by India is attracting farmers to the more lucrative commercial crops.

The History of the Green Revolution

Some of the outstanding economists of the advanced countries had predicted that by the middle of the twentieth century disastrous famines and starvation will grip the Asian-African countries owing to the growth in population outstripping the increase in food production. But what actually happened was a great leap forward in foodgrains production belying such predictions, during the sixties and seventies of the century in the south east Asian countries including India. It was the high yielding paddy varietyof IR-8 and the new wheat varieties brought out by International Wheat Research Centre in Mexico,which started off this agricultural revolution known by the name 'Green Revolution'. This spurt in production in paddy and wheat was caused by certain developments in agricultural research efforts which may be termed quite accidental. An ordinary farmer of Taiwan brought an isolated dwarf paddy plant to the nearby Paddy Research Centre. It was the low height of the paddy plant which attracted the attention of that farmer. The rapid progress was obtained when the pollen grains of the dwarf variety called 'Dejeevugen' was used by the researchers to hybridize the tall' 'indica' variety of paddy. The hybrids were found to be capable of giving upto four fold yields compared to the ordinary varieties. TN- 1 was the first miraculous paddy variety brought out by the Paddy Research Centre, Taichund Netive in Taiwan. When this paddy variety reached the International Rice Research Station in Philippines, some new hybridation trials were started. As a result of this, they brought one high yielding variety IR-8 in 1960. This variety, when tested in paddy research centres all over the world was found to retain its high yielding capacity in all climates and soils. This paddy variety was brought to India also during the period. The paddy variety 'Annapoorna' brought out from Pattambi during that period had the genetic quail ties of the Taiwan variety. Subsequently, a large number of high yielding varieties containing the genes 'Dejeevugen' wre planted in all the paddy zones of India. As the cultivation of these varieties spread,the average yield rose to 3000 kg per hectare and in the favourable areas cultivated with special care, it reached the 5000 kg mark. About 50 high yielding varieties of paddy were issued during the period 1960 - 1999 from the various Paddy Research Stations of Kerala,with names such as *Triveni, Jyothi, Sabari, Eharathi, Jayanthi, Nila, Kairali, Athira, Iswarya, Bhadra, Kanakarn, Arathi* and so on. The last of the series, *Uma* gave an average production of 7000 kg per hectare and was resistant to pests and diseases. In the same way, seeds suited to the main rice-producing zones of Andhra Pradesh, Karnataka, Madhya Pradesh, Orissa, etc. had been brought out by research centres of the respective areas. At the national level the Integrated Project for Rice Research functioning in Hyderabad had produced and popularised high yielding paddy seeds suited for cultivation through out India. The paddy seed *Jaya* is an example of such seed. It has the capacity of producing upto 5000 kg per hectare under proper mode of cultivation. Jaya is a paddy seed produced and distributed on a wide scale by the National Seeds Corporation.

During the same period,an agricultural expert named Dr.Norman Bourlog had evolved and brought out certain high yielding wheat varieties in the International Wheat Research Centre in Mexico. It was the popularisation of such new wheat varieties that expedited the green revolution.

Two to three fold increase with production of rice and wheat simultaneously with the manner described above helped to bring about food self- sufficiency in our country. Today taking a further stride, we are exporting rice and wheat to other countries as a source of foreign exchange running into crores of rupees.

Coconut Cultivation

The wild variation of coconut known by the scientific name Cocos *nucifera* have not been identified any where in the world. However, since the greatest diversity of the species are met within the Pacific Islands, they are believed to be the birth place of coconut palms. Scientific conclusion is that it was within the the last 3000 years that cocount reached Eastern and Western coast of India. But, evidences of the existance of coconut palms in India even during prehistoric period, obtained from some excavations done in history, are an indication that India is the birth place of coconuts. Coconut is referred to in very ancient books like *Krishi* sookthi also. Kerala had the pride of first place is coconut cultivation till recently. But today coconut cultivation has already spread greatly into an neighbouring states of Tamil Nadu, Karnataka and Andhra Pradesh. But of the 17 lakh hectares of land under coconut in India, Kerala's share is at 9 lakh hectares now. The coconut production of Kerala which was formerly 90 percent of the all India production has now declined to 40 per cent. The productivity of coconut palms in Kerala is one-third of that in Andhra Pradesh and Tamil Nadu. The coconut cultivation in Kerala, fragmented into more than 50 lakh homesteads, has lost its lusture before the scientific cultivation on plantation scale of the neighburing states.

Rubber Cultivation

The success story of natural rubber in India is a clear proof of the practicability of creating miracles even in the productivity of a long standing crop through scientific policy formulation and the existence of a strong extension machinery for reaching new technology to the farmers without time lag. It was the British who collected the seeds of rubber which was growing as a wild tree in the forests of South America (Brazil) and started to raise rubber plantation is their colonies. It was in Malaysia, Sri Lanka, Singapore and India that rubber grew well and formed large scale plantations. The productivity of these ordinary (wild) varieties was as low as 200 to 500 kg per hectare. After independence Rubber Board, an autonomous body was constituted with Kottayam as head quarters for development of rubber cultivation. A research organisation, the Rubber Research Institution of India (RRII) also came into existence later. Following this a number of high yielding varieties (clones) came out as a result of four decades of research. Rubber Board provided necessary financial assistance (loans and subsidies) also for cutting down the old trees and replacing them with the new high yielding clones, consequently the productivity of the rubber plantations in India, rose from 200-500 Kg per hectare of the 1950 to 1130 kg per hectare by 1991-92. As the process of cultivation of new area and replacement of the old plantations with new clones continued further, the production of rubber kept rising. According to the recent estimates (1995-96) the productuvity of rubber in India is 1422 kg. dry rubber per hectare. As a result of the efforts of the last 50 years, the productivity and total production of rubber increased almost ten fold. It may be noted that much a leap forward in crop could never be achieved by any other country in the world.

Kerala occupies a unique position in the growing of rubber in India. Kerala accounts for 90 percent of the rubber cultivation of India. The State's share in rubber production is still higher at 96 per cent. But unfortunately in recent years, as a result of globalisation, rubber prices in India have fallen in confirmity with those in the world market. We can hope that the demand for natural rubber at the global level increases so that the Indian rubber market will also acquire resilience.

Cashew Cultivation

Cashew tree *(Anacardiun occidentate)* was an unwanted tree brought by Portugeese to India four centuries ago to prevent soil erosion. It is only the capacity of it to survive even on low fertility laterite and sandy soils depending solely on rain fall which prompted the colonialist rulers to bring it into India four centuries ago. But in later years the kernal of its seeds turned out to be an excellent food item containing fat (47 *%)*, protein (2 1%), starch (22%), minerals and vitamins (10%). Cashew cultivation which originated in Brazil in South America is now most developed in India. Even though India has a monopoly in production, processing and export of cashew nuts, India has as present a total area of 6.34 lakh hectares under cashew, the total production of cashew nuts in the country in only 4.17 lakh tonnes. The average prodution of cashew in India is at the pathetically low level of 616 Kg per hectare. At the same time, the high yielding varieties of cashew brought by our own research stations have been found to be capable of yielding up to 1000 kg of cashew per hectare on an average. If, through systematic planning, extension of technology and provision of financial assistance, a programme for promotion of new cultivation and replanting is implementd as in the case of rubber, it would be possible for us to save the foreign exchange of Ps. 600-700 crores spent on imports and to earn an equal amount of foreign exchange through exports.

Black Gold and its Allies

In ancient times when methods for preserving meat were not available as at present, the people of Europe used a mixture of salt and pepper for the purpose. The pepper needed for this reached China through Arab traders and from there it went to Europe by land routes. In those days, pepper was more valuable than gold. That was why pepper used to be called black gold in English. Along with pepper other spices like dry ginger, cardamom, cinnamon, turmeric and sandal wood also had become popular in the European markets. It was as the source of such rare spices that many stories about India had acquired currency in Europe during that period.

The monopoly of pepper cultivation in India was with Kerala, from the very beginning. The exception to this was a few pockets along the western part of Karnataka. Pepper which was grown along in 86000 hectare till four centuries ago has now spread to 2 lakhs hectares. Production has increased from 27000 tonnes to 60,000 tonnes over the same period. But in the matter of productivity per hectare, we are still backward.

With an average yield of 2925 Kg of pepper obtained in foreign countries, the average production per hectare in India is still around 300 Kg. At the same time many of the enlightened farmers are producing upto 2000 kg. of dried pepper per hectare. All this points to the fact that we have not been able to create an extension wave in pepper cutivation as in the case of rubber. The condition of our cardamom cultivation is also not different.

Oil Seeds

Although coconut is the main oil seed crop of Kerala, it does not come under the oil seeds statutorily defined at the all India level. The reason is that only annual crops like sesamum, groundnut, mustard varieties, soyabeans and sunflower are included in oil seeds according to the definition.

Technology Mission

The Central Government has set up an autonomous body called Technology Mission for Oil seeds (TMO) in 1986 for the development of oil seeds at national level. The aim of the TMO was to raise the production of oil seeds, which attributes the necessary fat to the diet, so as to supplement the unprecedented growth in food production achieved by us during sixtees and seventies through the green revolution. It was Dr. V. Kurien, the architect of the Anand Model, who made a grand success of the milk production programme, who was appointed in charge of TMO's working. As the activities of the TMO continued for a decade, giving the necessary financial and technical assistance to the oil seed farmers and procuring the produce at a good price, the production of oil seeds increased from 10.6 million tonnes in 1986 to 22 million tonnes now. At present India imports only which is available at the lowest price in the world market.

> *"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 original 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 their hand at reproducing 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 19^{th} 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 pillar 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.

The excellent state of preservation of the Iron pillar despite exposure for 15 centuries to the elements has amazed corrosion technologists 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 retorts. 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 when Russia 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 so 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.

VIKRAM SARABHAI

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.

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

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

programme. On November 21st 1963, a two stage rocket called Nike-Apache was launched from Thumba Equatorial Rocket Launching Station near Trivandrum. 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 precursors 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, meteriology 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 distribution 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 programmes.

An integrated missile development programme has 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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> *"....The importance of the creation of the zero mark can never be exaggerated. No single mathematical creation has been more potent for the general on go of intelligence and power."*
>
> G.B. Halsted

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 processing 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 momentous 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 poised 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(DoE),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 setup 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 ensured that the common man benefitted from IT. 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 direction. 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.

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, 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 to get a foothold in this industry, India 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 supercomputing machine, it was a dream come true.

In fact, the "PARAM-10000", based on an open-frame architecture, is considered to be the most powerful super-computer in Asia, outside Japan. So far, only U.S.A. and Japan have built up a proven capability to build similar types of super-computers. As it is, "PARAM-10000", has catapulted India into the ranks of the elite nations that, already, are in the rarefied world of tera flop computing which implies a capability to perform one trillion calculations per second. In this context, a beaming Dr. Vijay P. Bhatkar, Director, of C-DAC, says, "We can now pursue our own mission critical problems at our own pace and on our own terms. By developing this, India's esteem in Information Technology (IT) has been further raised."

"PARAM-10000" is finding applications in areas as diverse as long-range weather forecasting, drug design, molecular modelling, remote sensing and medical treatment. "We want to preserve our timeless heritage in the form of a multimedia digital library on "PARAM-10000", says Dr. Bhatkar, That C-DAC could manage to build a "PARAM-10000" machine in less than five years is a splendid tribute to the calibre and dedication of its scientists and engineers.

C-DAC has been developing various computer intensive applications using the PARAM series of computers. The important applications are weather forecasting, seismic data processing and applications related to space.

Other scientific applications in physics, chemistry, biotechnology and business applications in banking financial modelling, insurance, telecom and electronic governance have been also developed.

Since the launch of PARAM 10000, C-DAC has been also concentrating on the usage of such high-end technology in education to address the important need of generating high-end labour in the next millennium.

Usage of this high-end technology by Indian educational institutes will help provide experienced manpower in the cutting-edge technology to work for industry and the national institutions in the near future.

C-DAC is India's national initiative in high performance computing and has been engaged in research and development and high-end solutions based on high-end computing.

C-DAC's HPCC (High Performance Computing and Communication) initiatives are aimed at designing, developing and deploying advanced computing systems, tools and technologies that impact strategically important application areas.

PARAM Padma is C-DAC's next generation high performance scalable computing cluster, currently with a peak computing power of One Teraflop. The hardware environment is powered by the Compute Nodes based on the state-of-the-art Power4 RISC processors, using Copper and SOI technology, in Symmetric Multiprocessor (SMP) configurations. These nodes are connected through a primary high performance System Area Network, PARAMNet-II, designed and developed by C-DAC and a Gigabit Ethernet as a backup network.

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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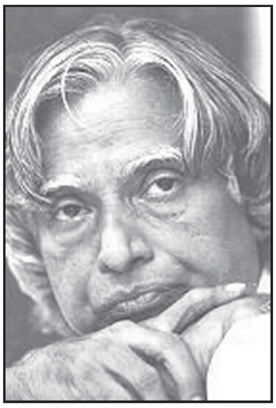
The Scientists of India

A.P.J ABDUL KALAM



Avul Pakir Jainulabdeen Abdul Kalam was born on 15th October 1931 at Rameswaram in Tamilnadu. As a child, Dr.Kalam remembers being fascinated by the flight of seagulls. He grew up with his parents on the island of Rameswaram in south India and endeavored to understand the fundamental truths revealed by his father that there exists a divine power that can lift one up from confusion, misery, melancholy and failure and guide one to one's true place. From a humble beginning, Dr. Kalam had an unparalleled career as an Aerospace and Defense scientist. He became the architect of an Indian Guided Missile development programme and led to the successful nuclear experiments. Dr. Kalam envisioned a system for realizing "Developed India" within 20 years.

Education

A graduate from St. Joseph's College, Tiruchirapalli, Abdul Kalam later studied Aeronautical Engineering in the Madras Institute of Technology (MIT) which was regarded as the crown jewel of technical education in South India in fifties. After passing out as a graduate aeronautical engineer, Abdul Kalam joined the directorate of Technical Development and Production under the Ministry of Defense. In later years he joined the Indian Committee for Space Research (INCOSPAR) as a Rocket engineer. During the later half of 1962 he had decided to set up the Equatorial Rocket Launching Station at Thumbha. He became a member of a team led by Prof. Vikram Sarabhai which aimed at organizing an integrated national space programme for the manufacture of rockets and launch vehicles indigenously. After that he led a team for the design and development of Satellite Launch Vehicle, SLV III which was successfully launched on 18th July 1980, injecting Rohini satellite into low earth orbit. He later became Director of ISRO Launch Vehicles/ Systems and contributed for the evolution of launch vehicle configurations.

Professional Career

Dr. Abdul Kalam was appointed Director of the Defense Research and Development Laboratory, Hyderabad in 1982. Under his leadership, a model high technology research centre with very advanced technical facilities like an inertial instrumentation laboratory, full scale environmental and electronic warfare(EMI / EMC) test facilities, a composites production centre, high enthalpy facility, and a state-of-the art missile integration and check out centre was established. As a Director, DRDL, he was the Chief of Integrated Guided Missile Development Programme and led to the successful completion of Prithvi and Agni missiles. Immediately after the perfect launch of Agni (an itermediate range ballistic missile), President Venkitaraman called from Simla, "it is a tribute to your dedication, hard work, and talent" The I.G.M.D.P had also demonstrated our competence in crucial areas of re-entry technology and with tactical missiles like Prithvi (a surface to surface battlefield missile) and Trishul (a quick reaction surface-to-air missile) and with successful launch of Nag(antitank guided missile) and Akash(a swift, medium range surface-to- air missile) and Trishul(a quick reaction surfae to air missile), India had achieved major technological breakthrough. After this he was appointed as the Scientific Advisor to the Defence Minister, Secretary to Department of Defense Research and Development and Director General of Defence Research and Development Organisation in 1992. Many new technology projects towards building self- reliance in defense and also spin-off to society emerged during this period. Later he became the Principal Scientific Advisor to the Government of India in the rank of Cabinet Minister and served in this capacity from November 1999 till November 2001. He was primarily responsible for evolving policies, strategies and missions for the generation of innovations in technology development for multiple applications through Government departments, academic institutions and industries as partners. Dr. Kalam was also the Chairman, Ex-officio of the Scientific Advisory Committee to the Cabinet (SAC-C). He strongly believes that Technology can be used as a tool for national development. In December 2001 he moved over to Anna University as Professor of Technology & Societal Transformation.

Awards

Dr. A.P.J Abdul Kalam's, contributions to science fetched him Padma Bhushan in 1981, Padma Vibhusan in 1990 and Bharat Ratna in 1997. He was also conferred the degree of Doctor of Science (D.Sc. Honoriscausa) by twenty eight universities. I.T.T (Bomaby) while awarding the dgree described him as " an inspiration behind the creation of a solid technological base from which Indian future aerospace programs can be launched to meet the challenges of the 21st century". Dr. Kalam is confident that India will have its own satellite in geostationary orbit 36,000km away in space, positioned by its own launch vehicle and India will become a missile power. He is the recipient of several awards including the National Design Award, Dr. Biren Roy Space Award, Prof. Y. Nayudamma Memorial Gold Medal (1996), GM Modi Award for Science (1996), R.K Firodia Award for Excellence in S&T (1996), Veer Savarkar Award (1998), and Indira Gandhi Award for National Integration (1997):

Apart from these he is a Pellow of many professional societies including Aeronautical Society of India, National Academy of Engineering, Indian Academy of Sciences and Institution of Electronics and Telecommunication Engineers.

Though a great scientist, Dr. Kalam is a connoisseur of Indian art and literature. He loves classical Carnatic music and learned to play Veena. In literary field he finds time to write Tamil Poetry. Seventeen of his poems were translated into English. The compilation was published in 1994 as a book entitled "My Journey". He is also the author of three books in English: "India 2020: A vision for the New Millennium", "Wings of Pire:

an Autobiography " and "Ignited Minds- unleashing the power within India". A bachelor and a teetotaler, Kalam had a routine of reciting holy Quran and the Bhagvad Gita and is equally at home with both holy scriptures.

One of his noticeable achievements India never forgets is the nuclear tests at Pokhran in the Rajasthan desert on May 11 and 13 1998. "I remember the earth shaking under our feet," he recalls of that fateful experience.

His Dreams

Abdul Kalam is a frontiersmen and

has spent all his life near the three water frontiers of India. The newspaper boy of Rameswaram coast on the Indian Ocean spent 20 years dreaming of space frontiers at Thumba space centre on the Arabian Sea. The dreams of the next 20 years were mostly conjured up on the shores of the Bay of Bengal at Chandipur where he test-launched missiles and checked on vehicles that re-enter the atmosphere from space.

The dreamer of these oceanic frontiers is also one of India's frontiersmen in technology. A technology that not only fired Agnis, ignited Prithvis but also can green the barren lands, provide foods to the starving, and profit in world commerce. A first dream for a third world nation.

It is a dream he shares with Yagnaswami Sundara Rajan, another technologist who had his stints in the Indian space Research Organisation, the department of space contributing significantly to the communication satellite program, the remote sensing programme and satellite meteorology and mapping systems. Dr.Kalam and Rajan believe that as a nation, India should aim to reach at least the fourth position by 2020 and nobody is going to help us reach there, except ourselves. As the globe is shrinking into village, there is also simultaneous denial of technologies

From the sea frontiers and space frontiers, Dr.Kalam now dreams of frontiers of technology-driven prosperity for one billion people. In this he is inspired as much by the grain-rich fields of the green revolution as by the successes of remote-sensing satellites and re-entry vehicles. He sees infinite energy that can be released not only from thermonuclear explosions but also from the human resource latent in the ordinary people of India.

Visions

Dr. Abdul Kalam had three visions for India.

- Vision of freedom -the vision, which started in 1857 for the War of Independence must be protected and nurtured.
- Vision of Development- for last fifty years we have been a developing nation. It is time to see ourselves as a developed nation.
- Vision that India must stand up to the world. We must have military as well as economic power.

Pokhran

He believed that the same sense of purpose that made Pokharans and Prithvis(surfaceto surface battlefield missile) possible can propel whole populations into prosperity. In the book, India 2020 a Vision for the New Millennium, published by Viking-Penguin India, the bricks of technology that could build the dream have been identified precisely. In todays world , Kalam observes technological backwardness leads to subjugation. Can we allow our freedom to be compromised on this account? It is bounden duty to guarantee the security and integrity of our nation against this threat. His dream, vision and staunch dedication to India make him responsible to take over as the President of the Republic of India on July 25, 2002. On the occasion of the assumption of office of the President of India Dr.Kalam spoke that, “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 recognized by every Indian as a national priority. Indeed, making India strong and self-reliant-economically, socially and military - is our foremost duty to our motherland and to us and to our future generations." He is a great Team leader and inspired the youth and students of the country as it's President. He remained the President of India from 2002 to 2007.

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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."

Dr. Kalam in his speech on the occasion of his assumption of the office of President of India on July 25, 2002.

C.V. RAMAN

Chandrasekahara Venkata Raman, a native of Tiruchira-pally, Tamilnadu was born on November 7, 1888. Raman's maternal grand father Saptarshi Shastri was a great Sanskrit scholar, who in his younger days traveled on foot to distant Bengal (over 2000 km) to learn Navya Nyaya (modern Logic).

While he was in Madras, he failed to find a suitable scientific job there and joined the Indian Finance Department in 1907. He was posted to Calcutta. Soon after his arrival there, he discovered Sarkar's Indian Association for the Cultivation of Science. He began his research here before and after office hours until 1917 Sir Asutosh Mookerjee invited him to take up the post of Taraknath Palit Professorship in Physics at the new University College of Science, in 1917. Raman was elected as Fellow of the Royal Society of London in 1924, in recognition of his outstanding contributions to physical optics, molecular diffraction of light, X-ray scattering.

Raman's initial research was focused on acoustics and musical instruments. He studied a number of musical instruments viz. ectara, violin, tamburu, veena, mridangam, tabala etc, and published a monograph on his extensive studies on the violin. It was during a trip to England in 1921 that he was fascinated by the blue colour of the Mediterranean. Though the phenomenon was earlier predicted by Hendrick Anthony Kramers (1894-1952) and Heisenberg (1901-76), Albert Einstein (1879-1955) wrote; "C.V.Raman was the first to recognize and demonstrate that the energy of photons can undergo partial transformation within matters. I still recall vividly the deep impression that this discovery made on all of us.......".

With a very simple experiment he convinced himself that the blue of the sea was due not only to reflection of the sky, as proposed by Lord Rayleigh and others, but mainly to the scattering of light by water molecules. On his return to Calcutta he began a systematic study of the scattering of light by different liquids, culminating in the discovery of a totally new kind of radiations predicted by the quantum theory and named after him. 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 state of molecules. Raman was awarded the Nobel Prize in 1930. He was the first Asian to win Nobel Prize. He became the Honorary Secretary of the Indian Association for the Cultivation of Science and in 1939, however, he left Calcutta to join the Indian Institute of Science at Bangalore and held the post of Director. There, for achieving academic excellence he himself trained a team of talented students in Physics and started along quality research in many fields of Physics. He also initiated basic research in fields like quantum mechanics, crystal chemistry, vitamins and enzyme chemistry by recruiting outstanding faculty. Raman developed a vibrant and excellent school of Physics.

Raman Effect

When a beam of monochromatic light passes through a transparent substance (a substance which allows light to pass through it), the beam is scattered. Raman spent a long time in the study of the scattered light and observed two low intensity spectral lines corresponding to the incident mono- chromatic light. Years of his labor had borne fruit. It was clear that though the incident light was monochromatic, the scattered light due to it, was not monochromatic. Thus Raman's experiments discovered a phenomenon which was lying hidden in nature. The 16th of March 1928 is a memorable day in the history of science. On that day, he announced the new phenomenon discovered by him to the world. He also acknowledged with affection the assistance given by K.S. Krishnan and Venkateswaran, who were his students. The phenomenon attracted the attention of research workers all over the world. It became famous as the '**Raman Effect**'. The spectral lines in the scattered light were known as 'Raman Lines'.

Is light wave-like or particle-like? This question has been discussed from time to time by scientists. The Raman Effect confirmed that light was made up of particles known as 'photons'. It experimentally demonstrated that that the light – quanta and molecules do exchange energy which manifests itself as a change in the colour of the scattered light.

Raman radiation helped in the study of the molecular and crystal structures of different substances. It carries vital information about the internal structure of the scattering molecules, and have proved to be of immense importance in studying molecular structures.

Investigations making use of the Raman Effect began in many countries. During the first twelve years after its discovery, about 1,800 research papers were published on various aspects of it and about 2,500 chemical compounds were studied. Raman Effect was highly praised as one of the greatest discoveries in experimental physics in the last decade.

Acoustics and Optics

Among his other discoveries, contributions on acoustics, ultrasonic, optics, magnetism and crystal physics were remarkable. His work on the musical drum of India was epoch-making and it revealed the acoustical knowledge of the ancient Indians. During his student days Raman independently undertook original investigation in acoustics and optics. He was the first student of the Madras Presidency College to get a research paper published that too in a prestigious international journal. His first paper on 'Unsymmetrical diffraction bands due to a rectangular aperture' was published in the Philosophical Magazine (London) in November 1906, describing the method of measuring the angles of a prism using an ordinary spectrometer.

Raman had series of Radio talks. The texts of his nineteen radio talks were brought out in a book form titled 'The New Physics'. Talks on aspects of Science was published by the Philosophical Library of New York.

Despite his scientific background his parents insisted him to join Financial Civil Service (FCS) examination, but his scientific interest drove him back into the pursuits of science. He joined "Indian Association for the Cultivation of Science", and had a better acquaintance with Ashuthosh Dev who was to be Raman's assistant for 25 years. Mahendra Lal Sircar (1833-1904), a man of vision, established this Association in 1876. This was the first institute established in India solely for carrying out scientific investigation. During his research work, he had published his research findings in leading international journals like Nature, the Philosophical Magazine and Physics Review.

He established the Indian Academy of Sciences Bangalore(1934) and Raman Research Institute (1948). The Government of India awarded him the title of "Bharat Ratna" in 1954.

After his retirement from the Institute he concentrated his attention in building an institute of his own- the Raman Research Institute (RRI). Raman was of the view that science alone could solve India's problem. He said " there is only one solution for India's economic problems and that is science and more science."

Raman loved children and he derived immense pleasure in indicating the spirit of science within them. He believed that "the true wealth of Nation consists not in the stored up gold in the coffers and banks, not in the factories, but in the intellectual and physical strength of its men, women and children". He was a man of boundless curiosity and a lively sense of humor. His spirit of inquiry and devotion to science laid the foundations of advanced scientific research in India, and he won honor as a scientist and affection as a teacher and a man.

Raman died on November 21, 1970. As per his desire he was cremated in the gardens of his Institute.

Raman Spectroscopy Today

A field that evolved soon after the discovery of Raman Effect was the Raman Microscopy. In Raman microscopy, the Raman frequency shift is analyzed at different points in the sample. Raman microscopy can resolve parts with different chemical composition in a sample, and, together with infrared microscopy, is sometimes referred to as chemical imaging. It has been applied to the study of thin films, coatings, microelectronic integrated circuits, mineral inclusions, and pigments in art works, identification of narcotics and plastic explosives, biological tissues, and others.

Raman spectroscopy became an increasingly important tool for study of molecules with a large number of applications when lasers became available. The laser is basically a highly monochromatic and coherent light source capable of high intensity. Of course, from a technical point of view, the Raman spectroscopy does not require any new principles of light scattering beyond what was already known in the pre-laser era. The advent of laser led not only to the discovery of processes far beyond what Raman did, but to the emergence of several new techniques and devices as well.

Raman spectroscopy can characterize minerals, detect trace amounts of organic substances and identify biological substances such as proteins, DNA, amino acids and plant pigments. The method often is used in medicine for tasks that range from analyzing genes to detecting microbes! A planetary Raman spectroscope can press a probe into the soil, then fire the laser repeatedly on the probe and scan the sample. A special filter would remove scattered light that had not changed color. Raman shifted light would pass through the filter, then pass through a grating and bend according to wavelength. In not too distant a future, perhaps in 2008, a rover on Mars will carry a compact Raman spectrometer along with microscopically thin laser beam, press its Robotic arm against a rock and look for the sign of any organic life and any sign of life that might have existed there. In the more distant future, a space craft hardened to withstand Jupiter's intense radiation may land on the icy moon Europa.

To commemorate the legacy of Sir C.V.Raman, 28 February has been designated as the National Science Day, the day when Raman Effect was discovered, at the initiative of the National Council for Science and Technology Communication, Department of Science and Technology, Govt. of India on a suggestion of Swadeshi Science Movement.

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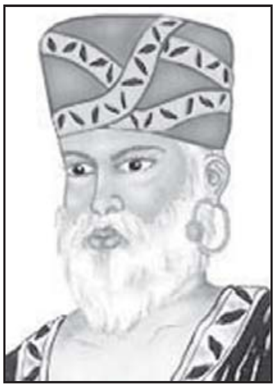
On the occasion of awarding Hughes Medal of the Royal Society of London, Lord Rutherford (1871-1937) commented on Raman's scientific achievements as follows: "Sir Venkata Raman is one of the leading authorities in optics, in particular on the phenomenon of the scattering of light. In this connection, about three years ago, he discovered that the light's color could be changed by scattering. This had not been found. The 'Raman effect' must rank among the best three or four discoveries in experimental physics in the last decade; it has proved and will prove (to be) an instrument of great power in the study of the theory of solids. In addition to important contributions in many fields of knowledge, he (Raman) has developed an active school of research in physical sciences in the University of Calcutta".

"There is only one solution for India's economic problems and that is science and more science". "If you ask me what is the greatest industry of a Nation ....the key industry- I have no hesitation in saying that it is the production and diffusion of knowledge... There is no nobler work for a man or an institution than to bring up young generation in health and strength and in and in the vigour of intellectual and physical activity".

"One aspect of Indian culture was its profound understanding of Nature. Much of India's philosophy related itself to the understanding of the rationale and the meaning of the phenomena of Nature."

Raman strongly espoused the cause of women. He once said: "I have a feeling that if the women of India take to science and interest themselves in the progress and advance of science as well, they will achieve what even men have failed to do. Women have one quality— the quality of devotion. It is one of the most important passports to success in science. Let us therefore not imaging that intellect is a sole prerogative of males only in science."

CARAKA



Ayurveda the "Knowledge of Life" is a living practice in India and Sri Lanka. This system of healing according to an official estimate caters to nearly 75% of our people. The practice of Ayurveda, thus is a subject of utmost importance, because the health and life of a major segment of our society, particularly of rural population depend on it. We must note that this traditional science of healing has to be developed in present day to trace its origin and growth, and throw some light on one of its greatest ancient monuments- the Caraka Samhita.

According to the narration given in Caraka Samhita, Ayurveda was first created by the Supreme Being (Brahma), then Brahma, re-composed it and passed it to Daksha Prajapati, who passed it to Aswinstwins, and the Aswins to Indra. Indra transmitted this knowledge to Rishi Bharâdvaja, who passed it to Atreya Purvasu, who communicated it to his six disciples, of them Agnivesa wrote a samhita based on Atreya's teachings, and that book became popular as Agnivesa Samhita, which, after reast and revision by Caraka, came to known as Caraka Samhita. Caraka was a physician who lived between 1st century B.C and 1st Century A.D. In fact 'caraka' literally means a 'wanderer' is identified with the family Physician of King Kanishka who ruled India in the 1st & 2nd A.D century. The style and language of Caraka Samihita allow us to place it in the period of Saka (Kanishka) ruled in India (ie.100 A.D). Caraka was the first scientist to present the concept of digestion, metabolism and immunity. The Caraka Samhita gives detailed description of the methods of diagnosis. A healthy constitution depended on the uniform proportions of *tridosas – vatta, pitta and kapha.* The predominance of any one of these result into a disordered constitution. The theory of tridosa is the back bone of Ayruvedic Medicines.

Like all other works of Ayurveda the Caraka Samhita enumerates the eight branches, especially therpautics .

Kavya - Therapeutics
Bala - Paediatrics
Graha - Psychiatry
Salakya - ENT and Ophthalmology
Salya - Surgery
Visha - Toxicology
Rasayana - Rejuvenation
Vejikarma - Virilization

It is explained in eight different sthanas in 120 chapters.

1. Sutrasthana - 30 chap. Deals with general principles philosophy etc.
2. Nidana - 8 chap. Causes of diseases.
3. Vimana - 8 chap. Tastes, nourishment, general pathology.
4. Sarira - 8 chap. Anatomy and embryology.
5. Indriya - 12 Chap. Diagnosis and prognosis
6. Chikitsa - 30 Chap. Treatment of diseases
7. Kalpa - 12Chap. Pharmacy
8. Sidhi - 12 Chap. Cure of diseases.

The main contribution of Caraka can be summarised as follows.

1) Advancement of basic concepts – He refined vedic medical knowledge and placed on a sound scientific footing.
2) Development of Rational attitude – He pointed out that there should be proper co-relation of theoretical knowledge and practical skill.
3) Organisation of Symposia- For advancement of knowledge and research, he adopted a method of discussion among experts.
4) Psychosomatic approach – Mind effects body and vice versa.
5) Individual Constitution- Man is not a machine and as such, can't be operated equally in uniform law.
6) Expansion of discipline – Ayurveda is divided into eight well demarcated specialties, which are mentioned in Caraka Samhita.
7) Importance of nature – Caraka Samhita lays emphasis on

Swabhavoparama (recession by nature).

8) Emphasis on Promotion of health and prevention of diseases.

9) Scientific study of drugs - Materia Medica of Caraka Samhita is very rich and has been fairly thoroughly investigated and studied on the basis of five primary elements and tridosa theory.

Caraka divides all diseases into three kinds:

Physical (nija), accidental (âgantu) and mental (mânasa) and three causes of diseases are described as

1) The excessive, deficient and wrongful administration of sense objects;

2) The climatic characteristics of heat and cold; and

3) The misuse of intelligence.

Caraka Samhita, Materia Medica is very rich and has been fairly thoroughly investigated and studied on the basis of the five primary elements and the tridosic theory. They have been classified under different categories according to their nature of origin as minerals, vegetables and animals and also according to their properties and actions as carminative, digestive etc.

The theory of classification (Vibhajya vidya) is a special feature of the Caraka Samhita. Each drug is given a different name, and their medical properties, actions, botanical descriptions, habitat etc. are elaborately enumerated. Thus, the Caraka Samhita constitutes a considerable mass of information on nutrition and on the effects of drugs. All this information needs to be verified by modern research.

It is difficult to enumerate the contribution of Caraka in toto, only the very important ones have been mentioned above.

Translations of Caraka Samhita are also available in Hindi, Marathi, Gujarathi, Persian and English. This was translated to Arabic in 8th century and the name is Sharaka Indians. There exist a number of commentaries on Caraka Samhita. the best being Chakrapani Dattas, Ayurveda Dipika (1060 A.D).

Reference :

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HOMI JEHANGIR BHABHA

Homi Jehangir Bhabha was born in Bombay on October 30, 1909. His parents were Jehangir Bhabha, once a student of Oxford University, and Meheran. Bhabha was educated at the Cathedral and John Cannon High School. Later he entered Elphinstone College and the Royal Institute of Science, Bombay. He continued his studies here for two years. Mathematics and Physics were his favorite subjects but his father wanted him to become an engineer. Bhabha respected the wishes of his father. He left India for Cambridge to study engineering and passed the Mechanical Engineering Tripos in the first class in 1930. He then pursued his studies in Theoretical Physics as a Research Scholar.

Even as a boy Bhabha was a lover of Nature. He was deeply interested in painting, music and literature. He took full advantage of his good collection of books and records. Bhabha was fortunate to come into close contact with famous scientists like Rutherford, Fermi Dirac, Niels Bohr and Heitler. This association greatly influenced his research and way of life. Bhabha was awarded the Rouse Ball Travelling Studentship for two years in 1932. He worked with W. Pouli in Zurich and Enrico Fermi in Rome. During this period he was awarded the Isaac Newton Fellowship in 1934 and Exhibition Studentship in 1936.

Homi Bhabha is one of the pioneers in the field of science in modern India. His role in the history of science in free India is of great significance. He is the architect of nuclear science in India. His far sightedness, powers of organization, and the encouragement and guidance young scientists received from him, built up an invaluable asset for scientific work in India.

The Study of Cosmic Rays

Bhabha's original contributions to Physics lie in the fields of cosmic radiation, theory of elementary particles and quantum theory.

Bhabha presented, with Heitler, the 'Cascade Theory of Electron Showers', in 1937. It is called the 'Bhabha-Heitler Cascade Theory'. It is a unique contribution to the world of Physics. This research brought fame to Bhabha. This theory explains the process of electron showers in cosmic rays. Cosmic rays are primary rays, which are fast moving and sub-microscopic particles. They comprise protons, electrons and gamma rays. When some of them happen to approach the earth and enter its atmosphere, they collide with atoms in the air. They then breed new nuclear particles. Bhabha's new theory explains clearly the processes and effects of the mutual reaction. It throws light on one of the most puzzling mysteries of cosmic rays.

Bhabha recognized heavy electron particles, 'Meson' in cosmic rays. Bhabha's mastery of mathematics can be seen in the 'Classical Theory of Spinning Particles'. This work received wide recognition. Bhabha returned to India for a holiday in 1939 during the time of the Second World War and he did not return to England. This was indeed fortunate for India.

In 1940 Bhabha joined the Indian Institute of Science as Reader in Theoretical Physics. He shouldered the responsibility of building a new department to undertake research on cosmic rays. In 1941 he was elected a member of the Royal Society. When this great distinction was conferred on Bhabha, he was just 31 years old. Not many have been so honored at such a young age by the Royal Society. Bhabha became a Professor in the Institute in 1942. The University of Cambridge also awarded the Adams Prize to him.

The young Bhabha dreamt of the 'great adventure' of building a modern India. In the salubrious climate of Bangalore he studied the background of the great culture of India. He analyzed the socio-economic problems of the country. He was quite convinced that science was the only means for the progress of India.

Bhabha's love of classical music, dance and sculpture deepened. This keen interest made him worship art throughout his life. It also influenced the pattern of his life.

Far-sighted

In those days the equipment and facilities needed for research in Atomic Physics were not available in India. Realizing this, Bhabha formulated a plan to meet this need and wrote a letter to the Dorabji Tata Trust on March 13, 1944. In the course of the letter he said:

'When nuclear energy has been successfully applied to 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.'

Bhabha wrote this letter almost a year before the atom bombs fell on Hiroshima and Nagasaki! This letter clearly illustrates his far-sightedness and patriotism. Bhabha's plan was an embryo from which a school of nuclear physics was born.

Tata Institute of Fundamental Research (TIFR)

The Tata Trust founded the 'Tata Institute of Fundamental Research' in 1945. The establishment of the Institute was mainly due to the initiative of Bhabha. The Bombay Government and the Government of India gave financial support to the Institute. The hills of Trombay have today blossomed into a fine research complex. The Institute is one of the world's top research centers in nuclear research and enjoys a great reputation. Thanks to the guidance and tireless efforts of Homi Bhabha the Institute is indeed a symbol of scientific tradition in India. It is Bhabha's contribution to the country's advancement of science and technology.

Bhabha was appointed its first Director, and he assumed the responsibility of shaping the Institute. India thus took the first step on the journey of nuclear science.

Research work in pure mathematics, theoretical and applied physics, computer technology and geophysics was undertaken at the Institute. The study of the principles of atomic explosion, the production of isotopes and the purification of uranium formed part of the work of the Institute. Thus Bhabha built up a group of cutting edge technologies.

Towards Deeper Study of Atomic Energy: Atomic Energy Commission

India got independence on August 15, 1947. Eleven days later, on August 26, 1947, Bhabha addressed the Atomic Energy Research Committee as follows:

"We meet today at the beginning of a new chapter in our history. We have great hopes that this new chapter will be a glorious one. The development and use of atomic energy is a question of national importance. We hope to establish soon an Atomic Research Center comparable with those in the most advanced countries." A year later, the Atomic Energy Commission was formed. Bhabha was appointed Chairman of the Commission. The major responsibilities of the Commission were: a survey of Indian soil for the materials required for nuclear research, the construction of atomic reactors, the purification of atomic materials, conducting fundamental research and the formulation of training program.

The Commission utilized the services of scientists at the Tata Institute of Fundamental Research. The scope of the work of the Commission was enlarged. The Atomic Energy programme took a concrete shape. The Department of Atomic Energy thus came into existence as a separate department of the Government of India in 1954, under the direct control of Prime Minister Nehru. Bhabha became the Ex-officio Secretary of the Department.

Shortly after the formation of the Department of Atomic Energy, it was decided to create the Atomic Energy Establishment for application of atomic energy to peaceful purposes. Bhabha became its first Director. The Establishment was formally inaugurated by Jawaharlal Nehru on January 20, 1957.

Thus India began to win new laurels for the study of atomic energy. Bhabha worked ceaselessly and enriched the sphere of science in the country. Through out his career, he emphasized indigenous know-how to make the country self-reliant in the nuclear field.

Atomic Reactors

It is a meeting of men and circumstances that sometimes stimulates progress. It is therefore providential that Nehru had Bhabha and Bhabha had Nehru.

Canada came forward to build a Reactor in India. On August 29,1955, Bhabha sent a cable from Geneva to Nehru and requested him to approve the, acceptance of this offer. Within three days, Bhabha received the consent of the Prime Minister. The Canada-India Reactor 'Cirus' was born.

'Apsara', 'Cirus' and 'Zerlina' are the three reactors built by the Trombay scientists and engineers, with foreign assistance. Bhabha took the leadership in establishing these reactors. 'Apsara', India's first reactor was taken up in 1955 to fulfill the needs in the fields of neutron physics, radiation, chemistry and biology and also the production of radioisotopes. It became critical' on August 4, 1956. The uranium fuel for the reactor was obtained from the United, Kingdom. The erection of 'Apsara' gave self-confidence to the Indian scientists and engineers.

'Cirus' was built in 1960 -and 'Zerlina' in 1961. The construction of 'Cirus' took some four years, and 1200 engineers and skilled artisans worked for the completion of the reactor.

Atomic Energy for power production

The consumption of energy in the world is on the increase. Naturally available resources of energy like coal and oil are on the decrease. Added to this, there is shortage of hydel energy in certain places. Realizing this, Bhabha declared that atomic energy is the only foundation for the progress of industries in India. He suggested that producing electricity could affect economy by nuclear methods.

Having set up the reactors, Bhabha planned to take up the actual construction of atomic power plants. The atomic power plant of Tarapur in Maharashtra, and two other plants situated at Rana Pratap Sagar in Rajasthan and Kalpakam in Tamil Nadu will appreciably contribute to the reduction of electricity in India. Bhabha's imagination and dynamism contributed to this.

The Trombay Institute

Bhabha worked very hard for the development of Trombay Institute. His time and energy were entirely devoted to the Institute. Reactors like Apsara, uranium and zirconium plants, the Van de Graff and cyclotron equipment - all are the gifts of Dr. Bhabha. Top priority is given to research relating to the application of radiation to preserve perishable food and protect it from the attacks of parasites. This work has made it possible to preserve fish, fruits, vegetables and other edible products for a long time. The process of curing seeds for better yields is also being studied. A seismic array station has been set up at Gauribidnur, about 80 kilometers from Bangalore, to detect earthquakes and underground nuclear explosions.

Nuclear Materials

It has now been possible to produce plutonium, a valuable nuclear material, and other useful fuel at Trombay. Work on thorium is also in progress. India has the largest reserves of thorium in the world. Thorium is a promising material for India's nuclear power program. More than 250 radioisotopes used in agriculture, industry, medicine and biology are now made available in large quantities. Today, over 350 radioisotopes and other radioisotope products are produced to meet a countrywide demand and also for export purposes. Radioisotopes play an important role in the study of the functions of a human body.

Electronic Corporation of India

Electronic instrumentation is required in all spheres of atomic energy work. Bhabha prepared blueprints for various projects relating to electronic instruments. Nuclear instruments worth a few millions are fabricated at Trombay every year. At present Trombay turns out over 2,000 electronic instruments annually. They include radiation survey meters, amplifiers and spectrometers.

The Electronic Corporation of India also manufactures many electronic instruments. All this has been possible because of the far-sightedness of Bhabha.

Linkages with research centers

He had close contact with the universities and research laboratories in India and abroad. The Saha Atomic Research Center (Kolkotta), the Physical Research Laboratory (Ahmedabad) and other laboratories got assistance from the Department of Atomic Energy. The Thumba Equatorial Rocket Launching Station of Kerala, the High Altitude Research Center of Kashmir, the Uranium Mine of Bihar and the Heavy Water Plant of Nungal are also the undertakings of the Atomic Energy Establishment.

Honours

Bhabha was a recipient of many honors. He was awarded honorary doctorates by several Indian and foreign universities. Among these universities are London, Cambridge, Padova, Perth, Banaras, Agra, Patna, Lucknow, Allahabad, Andhra and Aligarh. In 1948 he received the Hopkins Prize of the Cambridge Philosophical Society. He was elected the President of the Indian Science Congress in 1951. In 1954 the President of India gave him the Padma Bhushan award for his outstanding contribution to nuclear science. In 1963 he was elected as the President of the National Institute of Sciences of India. He was an honorary fellow of many earned institutions. Laurels came to Bhabha from all corners of the world throughout his lifetime.

Bhabha was a member of many scientific advisory committees of the United Nations and the International Atomic Energy Agency. He also served as the Chairman of the Scientific Advisory Committee to advise the Government of India. In 1955 Bhabha was elected as the President of the first International Conference on the 'Peaceful Uses of Atomic Energy', organized by the United Nations at Geneva. The conference was another step in international cooperation. Bhabha was the first to advocate, from international forums, the peaceful uses of atomic energy.

Building Up A Team of Scientists

The early atomic age of India was a period of transition. At that time Bhabha gave a clarion call to all young scientists who were staying abroad; "Return to Trombay; return to the motherland." Many young scientists listened to his call and came to Trombay. They are today among the reputed scientists in the country. Bhabha took personal care to provide necessary amenities to them.

Duty Bound

His duty was Bhabha's first love. It was more pronounced in scientific research, planning and direction. When Bhabha was invited to become the Minister of Atomic Energy in the Union Cabinet, he declined: Science was dearer to Bhabha than the charm of being a Minister.

Life is for Living

Bhabha was a bachelor. When once asked about his marriage, he said: "I am married to creativity."

In 1938 Bhabha wrote in one of his letters: 'You can give a new direction to everything in life-except death.' These words show clearly the degree of his self-confidence.

Bhabha believed that life was worth living. He sought to understand the true values of life and believed that art, literature and music enhanced the beauty of life.

The Tragic End

Bhabha was going to attend an international conference on a mission of peace. The Air India Boeing 707 'Kanchenjunga' in which Bhabha was travelling crashed in a snowstorm on January 24, 1966 at Mount Blanc. Bhabha thus met with a tragic end. He died comparatively young and at the height of his fame. It was a loss too deep for tears. In the death of Dr. Bhabha, India lost an eminent scientist and one of her great sons.

Bhabha had disliked the practice of

stopping work when someone passed away. He considered that the best homage was hard work. When the members of the staff at Trombay heard the news of Dr. Bhabha's death, they worked as usual and thus paid their respect to their departed leader.

As a tribute to Dr. Bhabha, the Atomic Energy Establishment, Trombay, was renamed as the Bhabha Atomic Research Center (BARC), on January 12, 1967.

India's first nuclear explosion

On May 18, 1974, India conducted its first nuclear explosion for peaceful purposes, at Pokhran in Rajasthan and joined the galaxy of nations with atomic energy. It thus became the world's sixth nuclear power. The other five countries with the nuclear know-how are America, Russia, Britain, France and China. India's explosion of a nuclear device is a great milestone in the path of technological progress. This achievement was based entirely on Indian effort. The foundation, which Bhabha had built in nuclear science, had contributed to this success. India is now on the world map of nuclear power.

"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."

Bhabha

J.C.BOSE

Jagadish Chandra Bose was born on the 30th November 1858 in Faridpur (Dacca District) which was a part of India until 1947; now it is in Bangladesh. His mother Banasundari Devi Bose was a tender-hearted and affectionate woman. His father Bhagawan-chandra Bose was a man of excellent qualities. Young Bose wanted to know about everything that happened around him he was a born scientist. Even as a boy he had many hobbies which showed his scientific interest. In London he first studied medicine and then Natural Science at Cambridge. He passed the Tripos Examination with distinction. He also passed the Bachelor of Science Examination of London University.

The Young Scientist

Jagdish Chandra Bose was back in India and joined the staff of the Presidency College, Calcutta. He wanted to do research, to widen his knowledge and discover new things.

Generally Marconi's name is associated with the invention of wireless. (This made possible the use of the radio.)

Who invented the wireless

But who invented the wireless? All these years we have been hearing of only one name – Marconi. But do you know that the machine used by Marconi for the first transatlantic wireless communication was not an original invention? A group of scientists at the US based Institute of Electronics and Electrical Engineers (IEEE) has stumbled upon evidence to show that the diode detector used by Marconi was actually invented by the famous Indian Scientist Jagadish Chandra Bose.

It was their research into the origin and use of the solid-state diode detector that led them to some missing links in the history of wireless. The findings were formally publicized at a conference, in January 1998, at Calcutta, in a special volume to be brought out to mark the 100 years of solid state diode and 50 years of transistor. This carry evidence to prove that the iron-mercury-iron coherer with telephone detector, used by Marconi in 1901 was in fact invented by J.C. Bose way back in 1898.

Bose, in 1895, had proved that signals

could be sent even without using wires, Using wireless signals he has successfully ignited gunpowder and rung a bell at a distance.

In 1896, Bose came to London on a lecture tour. Marconi was already in London then, conducting wireless experiments for the British post office. British Scientists doubted his credentials. But Bose was full of praise for Marconi's work.

While still in London in 1897, Bose presented a paper at the Royal Society on his work with radio waves. This pioneering work with radio waves of 5mm wavelength led to the creation of the solid-state diode detector. In wireless telegraphy the radio waves, electro magnetic in nature, are used to send and receive messages.

Communication by this mode requires a transmitter, an antenna for propagation, a medium of propagation and a receiver. The weak signal is resonated or tuned in the receiver. It is then amplified and demodulated or detected to recover the original signal.

Coming back to history, in 1899 Bose announced the invention of a mercury coherer coupled with the telephone detector at the Royal Society. Dust particles in air, when electrified, cohere. This is the principle on which a coherer works. Strangely enough, Bose lost his diary containing an account of his invention while on a lecture tour.

Here, it is worth mentioning that the world's first patent on solid state diode detector was taken in the United States of America. Left to himself, it is doubtful whether Bose would have gone for a patent. It was the great saint and messenger of Indian spiritualism Swami Vivekanada who persuaded him to patent his work. Both Vivekananda and Rabindranath Tagore, were aware of his inventions. In a letter to the poet, Bose had clearly expressed his disdain for commercializing his findings. "I will not be able to do anything once I get drawn towards making money," he wrote to Tagroe.

The new invention attracted the attention of the telegraph companies. A multimillionaire approached Bose with an offer to patent his work, requesting him to keep his invention a secret. Bose refused to oblige "But I cannot find heart to give any part of my life for money-making pruposes", he wrote in his diary.

While Bose discouraged all attempts to commercialise his work, Marconi was quick to recognize the market – value of the invention. His friend Luigi Solari in the meanwhile started experimenting with Bose's invention. Marconi found this detector to be highly sensitive. The other prevalent equivalents incapable of receiving long – distance signals.

The main problem in developing a detector was the choice of the right metals. Bose's iron-mercury-iron detector was the right solution. The next problem was how to connect these metals. Bose, had used a U-shaped glass tube filled with mercury and a very thin iron wire. By introducing an iron plunger into the tube he had created the correct pressure to enable contact with the metals.

Sensing a great opportunity, Marconi made a few minor modifications, like using a straight tube instead of a U-shaped tube, and went for the kill.

On Dec. 12, 1901 at 12.30 p.m. Marconi picked up the wireless signals across the Atlantic and made history. Soon after, he took a patent with no acknowledgement to Bose. A section of the scientific world doubted the authenticity of this claim. Official acknowledgement, however settled all disputes. And the final judgment was delivered when he won the Nobel Prize for Physics in 1909 for "designing and constructing the first wireless telegraph."

After 100 years, the puzzle that has been intriguing the world of Physics is finally being solved. This will secure Bose's place in the history of long-distance communication. So far he has been known for his botanical works only. This multifaceted genius of India, however, lacked the commercial foresight. The IEEE'S effort should pave way for world – wide recognition long due to this great son of India.

Jagadish Chandra Bose had also conducted independent research in the same field. Marconi was able to announce the result of his work and showed how wireless telegraphy worked, earlier than Jagadish Chandra Bose.

In the year 1896 Bose wrote a research article on electro-magnetic waves. This impressed the Royal Society of England (which is famous all over the world). He was honoured with the Degree of Doctor of Science. Later, Cambridge University honoured him as Professor and in 1920 he was honoured as a Fellow of Royal Society (FRS).

Electricity was then his special field of work. He had successfully worked on transmitting electro-magnetic waves from one place to another. He had designed the type of instruments required both at the transmitting end and at the receiving end. Bose demonstrated his discoveries at the Royal Society of England which won the appreciation and admiration of scientists. Following his presentation at the Royal Society of London he was invited for giving lectures in France, Germany, America and Japan besides England.

Electrical Stimuli in Plants

When electricity is passed through a living being (human being, plant or animal) the being gets a 'shock'. Bose developed an instrument that would show such a reaction of the organism on a graph. When electricity was passed through zinc, a non-living substance, a similar graph was obtained. He concluded that living and non-living things are very similar in certain reactions.

He lectured on this similarity between the living and the non-living things in the talks delivered at Paris and London. While explaining his discoveries he said that the Indian sages had understood such principles thousands of years ago and added that his discoveries were an insignificant part of the great truth that ancient sages of India had realized.

Challenges

Bose demonstrated that plants can feel pain like animals; they die in a few minutes after they are poisoned.

Jagadish Chandra Bose continued his work and made more novel discoveries. He found that plants shrink a little during the night. Why plants always grow towards light even if they have to bend, and the reason why some plants grow straight and some do not. He explained that this is due to the 'pulsation' in plants which quickens by heat and slows down by cold in plants. The instruments that he had developed were used in several foreign countries too. As some people opposed these conclusions the Royal Society delayed publishing his valuable work in its publications. He was sure that years of research had led him to the truth, so he did not feel that it was very necessary to depend on scientific journals only. He wrote books and published them on his own.

By this time Bose had made a name for himself as a great scientist.

Touch- me- not

Most of us have seen a peculiar kind of plant called the mimosa (touch-me-not) which spreads on the ground. It has very small leaves. It is extremely sensitive. If we just touch one leaf, that leaf and the leaves nearby all fold up. The greater the force we use, the larger the number of leaves which fold up. The whole row of leaves of the branch can be made to fold like this by touching it with a little greater force. Why does only this plant react like this? Bose found that other plants also react to a man's touch in the same way. The only difference is this: We cannot see the reaction of other plants but we can see the reaction of the mimosa. But Bose wanted to study the reaction of other plants, too. He designed delicate instruments that would show such reactions in them. No one had done work of this kind in Biology. It was news that plants could also experience different sensations like us. He experimentally proved that plants react to temperature changes.

Natural Inclination of Plants

Plants do not grow in a perfect straight line. There are small twists and turns, Why? The answer Bose found out is very interesting. He said, that plants have positive and negative charges. If one of these pushes a part of the plant forward, the other pushes it backward. The growth of the plant is affected by these pushes and it becomes slightly curved instead of being straight. Plants grow towards light even when kept in a dark place, why? The roots of plants always grow downwards, why? Bose found answers to all these questions.

We all know that the lovely flower, the lotus, opens up as the sun rises in the sky. When the sun sets the lotus closes its petals. The popular belief is that this is because the lotus loves the sun. But Bose explained this peculiar behavior of the lotus. It opens when there is a raise in the temperature and closes as the temperature drops. The same is true of the sunflower. He called this peculiarity 'the thirst for light'. The other peculiar thing he demonstrated was the way plants behave differently at different times of the day. By observing trees in his neighborhood he established that from 6 in the morning to 3 o'clock in the afternoon the plants behave in one way; and from 3 in the afternoon to 6 in the morning plants behave differently. This is attributed to change in the temperature.

Water is very essential to plants. The root of the plant absorbs water. But even without roots plants can take in water. This was demonstrated by Bose. He showed that when the root is cut and the plant stem is placed in water it starts taking in water. Suppose you remove the plant from the soil, and place it upside down (with the branches below and the roots above); what happens? The leaves and the stem absorb water. Bose proved this by means of experiments.

The cells of a plant function like a man's heart. The heart contracts and expands to pump blood; in the same way, the cells of a plant expand and contract. Bose himself devised delicate instrument, which could measure the response of plants to external stimuli.

A Temple of Research

Bose established 'Bose Research Institute' in Calcutta. More than sixty-five years ago, he had realized the importance of a research institution in India. While inaugurating the Bose Research Institute he said, "This is not a laboratory but a temple." Such was his devotion to work. He felt everybody must have the same enthusiasm for research and for conducting research in Botany and Physics, the two branches of science in which Bose had won recognition and fame.

Jagadish Chandra Bose has a permanent place in the world of science, especially in Botany. He died in November 1937. To the very end he was busy with research. Wealth and power never attracted him. He toiled for science like a saint, selflessly. This great scientist is a great example to all.

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Dream 2047, October 2002, Vigyan Prasar, New Delhi.

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

J.C. Bose

JAYANT VISHNU NARLIKAR

Jayant Vishnu Narlikar was born in Kolhapur, in the state of Maharashtra, India on July 19, 1938. His father, Vishnu Vasudeva Narlikar was an eminent mathematician and general relativist. He was Professor and Head of the Department of Mathematics at the Banaras Hindu University, Varanasi. His mother, Sumati Vishnu Narlikar was a sanskrit scholar. Jayant grew up in an academic and scholarly environment at home with a liking for both mathematics and sanskrit. In 1966, Jayant Narlikar married Mangala Sadashiv Rajwade who has a Ph.D. in mathematics from Mumbai University. They have three daughters, Geeta, Girija and Leelavati.

Education

After graduation he went to Cambridge University, U.K. for higher studies in Mathematics. He joined the Fitzwilliam House, Cambridge in 1957 and obtained his Cambridge degrees B.A., in 1960, M.A., in 1964 and Ph.D. in 1963. While at Cambridge, he became Wrangler (in 1959) and achieved distinction at the Part III of the Mathematical Tripos along with the Tyson medal in astronomy in the following year. He won the coveted Smith's Prize in 1962. Later on he went on to win the prestigious Adams Prize at Cambridge in 1967. In 1976 he received the Sc.D. degree of Cambridge University for "**Distinguished Research".**

Academic and Professional Career

Narlikar did his Ph.D. under the inspiring guidance of Fred Hoyle. On return to India in 1972 he took up Professorship at the Tata Institute of Fundamental Research (TIFR), Mumbai where he was in charge of the Theoretical Astrophysics Group, which he developed into a strong centre for astrophysics. He became Senior Professor in 1983, and upon leaving the TIFR in 1989, he held the position of an Honorary Professor there for three years.

J.V. Narlikar participated from 1986 to 1990 in several national committees particularly the "Science Advisory Council" for the Prime Minister, from 1985 to 1989 in "Indo-US Sub-Commission on Education and Culture". In 1994 he became President of the "**Commission Cosmologie**" of the "**International Astronomical Union**".

In 1988 the University Grants Commission set up the *Inter-University Centre for Astronomy and Astrophysics* (IUCAA) at Pune. At the invitation of the U.G.C. Chairman, Professor Yash Pal, Narlikar became the Founder-Director of IUCAA in 1988, first in an honorary capacity and then as a full-time Director since 1989.

Research Contributions

Narlikar has made important contributions to theoretical physics, astrophysics and cosmology. He is considered a leading expert and defender of the steady state cosmology against the more popular big bang cosmology. His work on conformal gravity theory with Fred Hoyle demonstrated how a synthesis could be achieved between Einstein's general theory of relativity and Mach's principle.

His works with Hoyle concerned the theory of the steady state universe. This work gave for the first time an efficient theory to describe the continuous creation of matter in the setting of the "General Relativity Theory" of Einstein'. Hoyle and Narlikar also gave a complete description of the quantic electrodynamic as good as the classical one. Their work on electrodynamics led to a new theory of gravitation that is now known as the "**conformal theory of gravity**".

In India Narlikar continued his work

in cosmology and in astrophysics. He studied the supplementary implications of his gravitation theory and his work with P.K. Das of the **Indian Institute of Astrophysics** provides an explanation for abnormal redshifts of quasars.

Honours and Awards

Jayant Narlikar has been honoured by several awards for his research, including the S.S. Bhatnagar award for physical sciences (1978), the F.I.E. Foundation's Rashtrabhushan award (1981), the B.M. Birla award (1993), etc. He is Fellow of the Indian National Science Academy, the Indian Academy of Sciences, the National Academy of Sciences of India, the Cambridge Philosophical Society and the Third World Academy of Sciences. He has honorary doctorates from the Burdwan University and the Banaras Hindu University. He was decorated Padmabhushan by the President of India in 1965.

Science Popularization

Apart from his research work, Jayant Narlikar has established a name in the field of science popularization. He has used the print and electronic media for this purpose, with English, Hindi and Marathi as languages for communication. For his contributions to science popularization efforts he has received the Indira Gandhi Award of the Indian National Science Academy (1990) and the Kalinga Award of UNESCO (1996). While in the U.K. Professor Narlikar also developed into a public speaker and gave popular talks to undergraduate societies in the U.K. The list of publications of his popular articles presently runs to over 400 and covers his contribution in English, Marathi (his mother tongue) and Hindi (the National Language of India).

Professor Narlikar's efforts in science popularization had also extended to book writing in Hindi, Marathi and English as well as his technical writings. These books have been translated to other Indian languages also. His Marathi book 'Akashashi Jadale Nate' on astronomy for the lay reader became an instant success. His popular books in English in-

the 'Seven Wonders of the Cosmos'. In addition, Narlikar has also written science fiction stories and novels in these three languages and they have generated considerable response from the Indian readership. In his science fiction writing, Narlikar has tried to depict the Indian environment and highlighted the ongoing interaction between society and science, besides projecting it into the future. His science fiction story "Dhoomaketu" (the Comet) has been made into a 2-hour film by the Children's Film Society of India.

MEGHNAD SAHA

A pioneer in Astrophysics

Dr. Meghnad Saha, a renowned Indian Physicist was born on October 6, 1893 AD in a small village Saoratali, about 45 km from Dacca (now in Bangladesh). He was the fifth child of Shri Jagannath Saha a shopkeeper, and Bhubaneswari Devi. As per the social and economic background the parents had no means for educating their children beyond the primary education. Jainath Saha, his elder brother after getting into a job helped him to provide a sponsor, Dr. Ananta Kumar Das who offered all financial as well as dwelling facilities to Dr. Saha provided he attends minor house hold works.

Publications

Dr. Saha acquired international fame at the age of 27, for his remarkable contributions in the field of astrophysics. In

1916, he joined Calcutta University as a lecturer in Physics, and investigated significant fundamental problems in Physics. He published his first paper in 1917, 'On Maxwell's Stresses' on electromagnetic theory of radiation in the Philosophical Magazine. During the period 1917-19, he published several papers on a new theorem of elasticity, dynamics of electron, pressure of light, mechanical and electrodynamical properties of electrons, fundamental law of electrical action and on the influence of finite volume of molecules on the equation of state. Based on these works, in 1919 he was awarded the degree of Doctor of Science. He published four papers on his astrophysical research in the first six months of 1920 in the Philosophical Magazine viz. "Ionisation of the Solar Chromosphere" (March 04, 1920), "On the Harvard Classification of Stars" (May 1920), "On Elements in the Sun" (22 May 1920) and "On the Problems of Temperature-Radiation of Gases" (25 May 1920). In these papers Saha formulated his Theory of Thermal Ionisation. His thesis on the 'Origin of Lines in Stellar Spectra' won him the Griffith Prize of the Calcutta University in 1920. He travelled to Europe and there he had connections with a number of famous scientists at that time.

He made his major and famous contribution in the theory of Stellar spectra. The absorption lines in the spectra of stars vary over a wide range in their elemental abundance. Some stars show only hydrogen and helium lines, while other show numerous metal lines. In 1920, Saha showed that these facts did not necessarily represent a true variation in the elemental composition of the stars, but a different degree of ionization of the metal atoms. He treated light made of quanta as suggested by Einstein, and demonstrated that the radiation pressure acting on a particular type of atom depends on two factors: 1. the type of absorption frequencies which are available in the atom and 2. The intensity of the blackbody spectrum at those frequencies. Under such conditions, only particular atoms could absorb the quanta of the photosphere, thus experiencing the radiation pressure. Thus under this effect they are thrown out of the photosphere.

Till 1930 Dr. Saha published 52 research papers. Most of his papers belong to the subject of astrophysics. He contributed significantly on Radiation and Ionization, which improved the understanding of the stars. He wrote several papers on Measurement of the pressure of Radiation, Physical Theory of Stellar Spectra, and Physical theory of Solar Corona. He also investigated the problem of mass of a monopole using the Dirac's quantization condition.

His main contribution was a derivation of 'Saha Ionization Equation', which connects temperature, electron pressure, rates of ionization with the fraction of atoms in an ionization process. This equation explained the sequence of stellar and solar spectra, and various physical conditions, which they embody. This behavior of stars is related to temperature of the stars through Saha's equation for a monatomic gas. At high temperatures, the metal atoms become very weak. The temperature of the stars thus can be estimated using the proportions of the various ions of the same metal. Russell used Saha's results to obtain an estimate of quantity of hydrogen in the Sun.

He wrote, with B.N Shrivastava, 'Treatise on Heat', which is world famous classic on the subject. He also wrote 'Treatise on Modern Physics', 'Theory of Thermal Ionization of Gases' and was a co-author of 'Principles of Relativity'. For his outstanding effort he was nominated for the Nobel Prize. He put a great deal of effort to promote science in India. He established Uttar Pradesh Science Academy, in 1930, which is now known as National Academy of Sciences. With his strenuous effort he set up a laboratory with a cyclotron, accelerator machine to speed up nuclear particles, for nuclear research at the Calcutta University. After independence Saha Institute for Nuclear Physics, at Calcutta was established. This laboratory produced the first generation of nuclear scientists in India.

He considered science as the vehicle of social consciousness. In this direction, he started publishing Science and Culture, a magazine to bring science and society close together. He also paid special attention to social and national problems in the country and wrote more than 50 articles on problems such as river water management national planning, natural resources and industrialization. He was elected, as an Member of Parliament in 1952. This great son of India passed away on February 16, 1956 due to heart attack, causing a big loss to the country.

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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."

Saha

MOKSHAGUNDAM VISVESVARAYA

Mokshagundam Visvesvaraya is one of the ablest engineers, India had ever seen, is the creator of the Vrindavan Garden and a prominent builder of modern India. In industrialization, education and planning, Visvesvaraya proved his dedication and was ranked high among those who promoted industrialization of India. He is known for his dictum 'Industrialise or Perish'. He served as an engineer and as a Dewan of Mysore State.

Mokshagundam Visvesvaraya was born on August 28, 1860 at Muddenhalli, a village in Kolar district of the then Mysore state. He was the son of Srinivasa Sastry and Venkatalakshamma.

Education

He had his early education at Bangalore and later he joined the Central College from where he graduated with distinction. In 1883 he passed Civil engineering degree examination in first rank from the College of Science (in those days College of Engineering was so named) Poona (Pune). Indian Institute of Science (IISc), Bangalore conferred the Honorary Fellowship on Visveswaraya along with Jawaharlal Nehru and Sir C.V.Raman.

Irrigation Works

During 1884- 1908 Visvesvaraya served the Government of Bombay as Engineer in the Public Works Department. Among his biggest achievements were the 'The Block system of Irrigation' a scheme prepared by him at the instance of the President of the Indian Irrigation Commission, Sir Colin C.Scott Moncrieff, to make irrigation works in the

Bombay Presidency more popular and profitable and yield a reasonable return on the outlay that the Government had incurred on them'. The main objective of the Block System of Irrigation was 'to distribute the benefits of an irrigation work over a large number of villages and to concentrate the irrigation in each village within blocks of specified limits and in selected soils and situations'. The irrigation system was a great success.

Public Works Department

In the Public Works Department, Visvesvaraya was also engaged in design and construction of roads, maintenance of public building and laying out plans for city developments in many important towns. Along with it he was consulted by the Bombay Government on matters like flood relief and strengthening of embankments and construction of water works. Under his schemes the provision of water supply to the cities of Kolhapur, Dharwar , Belgaum, Bijapur and the construction of water works at Sukkur in Sindh was taken up. All these works earned him recognition inside and outside India.

Visvesvaraya designed automatic gates for increasing the storage of water level in dams. These gates were first used at Khadakvasla Dam to control the flood of the Mootha Canal flowing through Poona. His services were requisitioned for organisation of irrigation, sanitary and water works in all parts of the Bombay Presidency. Admired by his remarkable services British Government deputed him to the Port of Aden to layout an effective underground drainage system and to prepare a scheme to provide drinking water. After his accomplishments he was recognised worldwide for his far sightedness and was awarded the Kaiser-i-Hind medal.

On November 15, 1909 Visvesvaraya joined the Mysore service as Chief Engineer. There he setup two committees one for technical education and other for industries. Under his chairmanship the committee for industries took the form of the Mysore Economic Conferences. The other important works that he undertook were:

1) Large irrigation and hydro- electric scheme
2) Reorganisation of the railways in the State

Builder of Modern India

In 1913, The Government of Mysore nominated him to the Council of Indian Institute of Science, Bangalore. Here he gave new orientation to the Institute's work. He strived to "secure proper correlation between pure and applied research. Several new departments like those of Power Engineering, Chemical Engineering, Aeronautics, Industrial Combustion and Engineering etc. were opened." Visvesvaraya believed that "progress on modern line is a necessity. We cannot afford to ignore scientific discoveries which have almost vivified material nature. Past ideals were for past times. We must adopt ourselves to the ever lasting conditions of existence or be content to be left behind in the race for material prosperity."

Visvesvaraya was associated with the Tata Group of Industries. He helped them in the management of their steel and iron factory. He was also the President of the All India Manufactures' Association (AIMO). Here he had drawn up a Rural Industrialisation Scheme and it was submitted to the Government of India in 1949. He believed that without advancement of life in village communities no long range improvement could be ensured for the country. He insisted on organising the villages into efficient economic units.

Visvesvaraya is undoubtedly the best known engineer of India. He was an able administrator, educationist, foresighted planner and an internationally renowned expert in irrigation engineering.

He played an important role in controlling the rivers Ganga, Sindhu, Mahanadi, Moosi, Easi, Kaveri, Tungabhadra and others.

In recognition of his distinguished public service Mokshagundam Visvesvaraya was awarded with Bharat Ratna in 1955. He died on April, 12, 1962 at the age of 102.

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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".

Visvesvaraya.

PRAFULLA CHANDRA RAY

Prafulla Chandra was born on 2nd August 1861 in Raruli-Katipara, a village in the District of Khulna (now in Bangla Desh). His father, Harish Chandra Ray was a landlord well versed in Sanskrit, Persian and English languages.

When barely ten years old, Prafulla learnt Latin and Greek (Languages of

ancient Europe and histories of England, Rome and Spain. In 1879, he passed the Entrance Examination and joined the Metropolitan Institute (now called Vidyasagar College).

The education

At the Metropolitan Institute, Prafulla Chandra came under the influence of great teachers like Surendranath Banerjee and Prasannakumar Lahiri. They instilled in him a burning desire to achieve the freedom of India and to improve the condition of the people. Pedlar's lectures influenced Prafulla Chandra to take up Chemistry for his higher studies in B.A., although his first love was literature. In 1882, he won the coveted 'Gilchrist Prize Scholarship' for studies at the University of Edinburgh. Prafulla Chandra took the B.Sc. degree in 1885. In 1887 when he was only 27 years old he was awarded D.Sc. degree. Even as a student he tried to make Englishmen in England understand what India suffered in slavery.

The Professor – Scientist

In 1888 Prafulla Chandra returned to India. For about a year he spent his time working with Jagadish Chandra Bose in his laboratory and in the following year he was appointed as Assistant Professor of Chemistry in the Presidency College at Calcutta. He would quote slokas from 'Rasa Ratnakara', a book written by an ancient Indian Chemist, Nagarjuna. He advocated the use of the mother-tongue as the medium of instruction in schools.

Why Should Our Patients Depend On Other Countries for Medicines?

A century back, Prafulla Chandra came to realize that the progress of India was linked with industrialization. Without this there could be no salvation. Even drugs for Indian patients had to come from foreign countries at that time. He ventured upon to manufacture drugs in India and formed a company named, 'The Bengal Chemical and Pharmaceutical Works'. Directly or indirectly he helped to start many other factories. Textile mills, soap factories, sugar factories, chemical industries, ceramic factories and publishing houses were set up with his active co-operation. He was the driving force behind the industrialization of the country, which began at that time.

Scientist – Author

During his service at the Presidency College, he was also actively engaged in research in his laboratory. His publications on Mercurous Nitrite and its derivatives brought him recognition from all over the world. He guided many students in their research in his laboratory. Even famous scientific journals abroad began to publish their scientific papers.

The History of Indian Chemistry

Prafulla Chandra was from the beginning interested in the work of the early Indian chemists. After reading the famous book 'Greek Alchemy' by the great French scientist Berthelot his interest in Indian Chemistry grew into a passion. He started reading many ancient books in Sanskrit, Pali, Bengali, and other languages, which contained information on the subject. He wrote an article about a famous Sanskrit treatise 'Rasendrasara Sangraha' and sent it to Berthelot. The French scientist published it with an introduction praising it as an extremely interesting article. He wrote to Prafulla Chandra asking him to continue his research into the ancient texts and to publish a whole book on Indian Chemistry. After several years of study, Prafulla Chandra published his famous book, - 'The History of Indian Chemistry' which received great praise from scientists all over the world. In this book he has given a very interesting account to show that Indian scientists knew about the manufacture of steel, about distillation, salts, mercury sulfides etc., from very early times.

A 'Doctor of Floods'

In 1901 Prafulla Chandra met Mahatma Gandhi for the first time. He knew how hard he worked to help the poor and the needy. When floods caused great suffering and destruction, Prafulla Chandra worked very hard to bring relief to the victims. This made Gandhiji call him a 'Doctor of Floods'!

In 1904 Prafulla Chandra proceeded to Europe on a study tour to England, Germany, France and other European countries. They praised his famous work on Mercurous Nitrite, Ammonium Nitrite etc. Some universities conferred honorary Doctorates on him. He made the acquaintance of famous scientists like William Ramsay, James Dewar, Perkin, Van't Hoff and Berthelot. Prafulla Chandra also knew that it is not enough to be proud of our past, we should follow the example of our ancestors and seek knowledge and progress in science.

In 1916 he retired from the Presidency College. Sir Asuthosh Mukherjee, the Vice-chancellor of Calcutta University, appointed him as Professor of Chemistry at the University Science College. According to the rules of the college, all the Professors had to be Indians. Perhaps because of this the British Government did not provide adequate grants to the college. In 1936, when he was 75 years old, he retired from the Professorship.

Prafulla Chandra was very affectionate towards his students. He was overjoyed when they received awards of honors. He used to repeat the Sanskrit saying, 'A man may desire victory always but he should welcome defeat at the hands of his own disciples'. Famous Indian scientists like Meghnad Saha and Shanti Swarup Bhatnagar were among his students.

Prafulla Chandra was the President of

the National Council of Education. He believed that the students should rather get technical education and start their own business. Young men should enter trade and industries by themselves. He said that the medium of instruction in schools and colleges should be the mother tongue.

It was his strong desire that Indians should set right the defects in their society like untouchability, child marriage and the giving of dowry. He severely opposed these evils Acharya Prafulla Chandra Ray was a great scientist who was endowed with noble human qualities. He was also a great patriot and social worker.

Acharya Prafulla Chandra Ray passed away on the 16th of June 1944; he died in the same room he had occupied for twenty-five years. He was 83 years old.

"An Indian scientist who won fame in many countries. Eighty years ago he began the manufacture of medicines in India. A great teacher, he gave his salary to students interested in science. A great man and a true patriot."

Y.S.Lewis

SHANTI SWARUP BHATNAGAR

Shanti Swarup Bhatnagar was born on 21 February 1894 at Bhera in the district of Shapur in Punjab. He belonged to a very educated elite family. His father Parmesh-wari Sahai Bhatnagar, a distinguished graduate of the Punjab University was a headmaster in Bhera High School. His mother Parbati Bhatnagar, was a daughter of distinguished engineer (he was one of the first to qualify as an engineer from the Roorkee College of Engineering). Bhatnagar not only developed a taste for engineering and science but also became interested at a very early age in his grand father's instruments, geometry and algebra and in making mechanical toys.

Bhatnagar had his early education in private 'Maktab' and then studied at the A.V High School in Sikandarabad in Uttar Pradesh. Bhatnagar passed the Matriculation Examination in the first division and secured a University Scholarship. He studied physics and chemistry and took up an Honours course in Physics. He was taught Physics by J.M Benade, who had done research with Arthur Hilly Corporation (1892-1982), the Nobel Laureate in Physics. It may be noted here that Bhatnagar did his first research work with Benade for his M.Sc. degree on the subject of surface tension. Chemistry was taught by P. Courty Speers who used to the regarded as father of technical education in the University.

Bhatnagar's scientific work was active, during his tenure in Punjab University Lahore. While his major fields of study were the colloidal chemistry and magnetic chemistry he did considerable work in applied and industrial chemistry, in 1928 Bhatnagar along with K.N.Mathur, invented an instrument called the Bhatnagar Mathur Magnetic Interference Balance. The balance was one of the most sensitive instruments for measuring magnetic properties.

In the filed of chemistry, Bhatnagar did considerable work. He undertook the development of a process to convert bagasse (peelings of sugarcane) into food cake for cattle. The important achievements of Bhatnagar in applied and industrial chemistry was the work he did for Attock Oil Company. In this company the mud used for drilling operations coming in contact with the saline water got converted into a solid mass which hardened further, the solid fraction of the mud rendered all drilling operations impossible. Bhatnagar elegantly solved this problem by the addition of an Indian gum which had the remarkable property of lowering the viscosity of the mud suspension and of the increasing at the same time its stability against the flocculating action of electrolysis. For this attempt M/s Steed Brothers offered a sum of Rs. 1, 50,000 to Bhatnagar which he placed at the disposal of the university. The grant helped to establish the department of Petroleum Research under the guidance of Bhatnagar. Investigation carried out under this collaborative scheme included deodourisation of waxes, increasing flame height of kerosene and utilization of waste products in vegetable oil and mineral oil industries.

Bhatnagar played a significant role along with Bhabha, Mahalanobis, Sarabhai and others in building post-independant India's science and technology infrastructure and policies.

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Dream 2047, March 2000, Vigyan Prasar, New Delhi.

"I have always been associated with many prominent figures eminent in other ways, but Dr. 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

SISIR KUMAR MITRA

Sisir Kumar Mitra, son of Joykrishna Mitra and Sarat Kumari was born in Kolkata on 2nd October 1890. He had his school education in the Bhagalpore zilla, and later joined the T.N.J. College, Bhagalpur. In 1908 he joined Presidency College and there he came into contact with J.C. Bose and P.C. Ray, the two pioneers of modern scientific research in India. He was very much fascinated by the instruments designed and constructed by J.C. Bose for studying the properties of microwave and to detect various responses of plants.

Mitra was very much influenced by the environment of the Presidency College and wanted to do scientific researches under J.C.Bose. But to help his mother run the family, he took up as lecturer in the T.N.J. College at Bhagalpur. In this college he had limited resources to do researches. But he started designing ingeneous demonstration experiments with whatever he could collect from the imperished college laboratory, for illustrating his class lectures. Later he joined physics department in University College of Science and there he got an opportunity to carry out his research activities. In this college C.V. Raman joined the department as Palit Professor and under his guidance Mitra worked in the laboratory of C.V. Raman in the Indian Association for the Cultivation of Science.

In 1920 Mitra went to the University of Sorbonne in Paris to join the research group of Charles Fabry (1867-1945, who had discovered ozone in the inner atmosphere in 1913. There he worked on the determination of wavelength standards in the region 2000-2300 angstrom of copper spectrum. From here he went to work under Marie Curie at the Institute of Radium. But it was with Prof. Gutton who was working on radio valve circuits in the Institute of Physics at the University Nancy, Paris that Mitra made up his mind to make his career in radio research.

To have an understanding of the significance of Mitra's work one should have an idea of ionosphere. The presence of ionosphere is vital in long distance radio communication. Ionosphere is a region of the upper atmosphere that reflects short radio waves enabling transmission to be made round the curved surface of the earth by sky waves. All regions of our atmosphere are defined in terms of ionization, temperature and composition. The region which extends from 60 km to several thousands km above the earth is called ionosphere. The Scottish physicist Balfour Stewart first suspected the existence of an ionized layer in the atmosphere or the ionosphere in 1882. But his prediction remained mostly unnoticed till 1901 when Guglielmo Marconi (1874- 1937) succeeded transmitting wireless signals across the Atlantic Ocean, a distance of about 2800 km. To explain the propagation of radio waves the existence of an electrically conducting air layer, as proposed by Stewart, was again involved and in 1902, Oliver Hearside and Arthur Kennelly proposed that such a layer situating above at a height of 80 km in the atmosphere would act as a repeater station by reflecting radio waves at a considerable distance beyond the horizon. The proposed layer came to be known as Kennelly-Heaveside Layer, the existence of which was experimentally proved in 1924 by Edward V. Appleton and Samuel Jackson Barnett. They devised two alternate methods, the angle of incidence method and the frequency change method to determine experimentally the location of the ionized layer which vary in behaviour with the position of the sun with sunspot cycle.

Appleton's experiments influenced Mitra and he decided to conduct similar investigation in his newly established laboratory. His group could measure the heights of the different layers of ionosphere by an instrument designed and built indigeneously. It provided the first general picture of the ionospheric condition in a subtropical region of low altitude like Calcutta and along with it his group also threw considerable light on the effect of thunderstorm, magnetic storm and meteoric shower on upper atmospheric ionization. Mitra also gave a theory of the D-layer, which was first reported by Appleton in 1928. D-layer is an absorbing layer formed during the daytime just below the E-layer, the echo from this layer is occasionally observed. They conclusively established the existence of this layer.

Mitra and his coworkers constructed another transmitter and installed in the newly established wireless laboratory in the University College of Science in Calcutta. Its call sign was 2 CZ. It is worth while to note that there was a time when Mitra's transmitter in his Wireless Laboratory and the Radio club's transmitter at Dalhousie Square were the only one broadcasting regular programme in the Eastern region of India.

The wireless laboratory established by Mitra started working on the measurement of the atmosphere and for this purpose a huge ariel connected to a valve amplifier and an automatic recording devise was setup.

With the financial assistance from the Council of Scientific and Industrial Research, Mitra established a field station for ionospheric work at Haringhata near Calcutta. His well-known treatise, "The Upper Atmosphere", was his major scientific contribution and it was a milestone in atmospheric sciences. It considered for the first time the atmospheric environment as a whole, neutral and ionized, it's thermal structure and distribution of constituents, its motions, the interaction of solar radiation and particle stream with these gaseous constituents, and the mechanism of airglow.

In another work Mitra got involved was that of active nitrogen, which he thought would solve the problem of the night sky luminescence. According to Mitra, the after glow is emitted in the act of neutralization of nitrogen ions by recombination with electrons which is a three body collision process. The persistence of the glow as due to the fact that the third body is rarely found in the upper atmosphere and so the recombination process was delayed.

Mitra's concern for industrial development in the country is well known. He initiated two industrial schemes in his laboratory. The first was the production of microphones and loud speakers, which resulted in the development of a carbon microphone and loudspeaker with raw materials available indigenously. The second scheme was on the production of electron tubes, which lead to the fabrication of radiovalves for the first time in India. Though this scheme was abandoned in 1954, the experience gained and the equipment assembled led to the establishment of Electron Tube Laboratory of the institute of Radio Physics and Electronics.

Sisir Kumar Mitra, a pioneer of radio research died on 13th August 1903 leaving unfinished two tasks he had set for himself-a third revised edition of "The Upper Atmosphere" and a "Text Book of Quantum Mechanics" based on lectures he delivered in the post graduate classes.

Reference:

Dream 2047, March 2003, Vigyan Prasar Publication, New Delhi-16.

Sisir Kumar Mitra's decision to change over to radio research was undoubtedly a bold one. Radio was then a newborn science still in its teething stage. It had not found place in the curriculum of any of the Indian universities, not to speak of research facilities in the subject. Mitra recognized this difficulty but was not deterred.

J.N. Bhar

SRINIVASA RAMANUJAN

A Remarkable Mathematical Genius

Sreenivasa Ramanujan was a mathematical genius of India of the 20th century. According to S. Chandra-sekhar (1910-95), the Indian born astrophysicist who got Nobel Prize in 1983, almost all the mathematicians who reached distinction during the three or four decades following Ramanujan were directly or indirectly inspired by his example. Ramanujan worked on the contemporary mathematics of his time but his approach was typically in the tradition of Indian mathematician which laid great stress on intuition rather than an exclusive deductive reasoning. He was a fabulous mental calculator, able to perform arithmetical computation without the help of pencil or paper. G.H Hardy of Cambridge University compared Ramanujan to Euler and Jacobi for his sheer manipulative ability.

Ramanujan's life is full of strange contrasts. He was born on December 22, 1887 at Erode. His parents were K. Sreenivasa Iyengar and Komalatammal. His school education was completed in 1904 at Kumbakonam, in his father's native place. He joined the Govt. College for F.A and failed twice in examinations as his total concentration was focused on mathematics. While at school he came across a book entitled 'A Synopsis of Elementary Results in Pure and Applied Mathematics' by G. S Carr. This book had a great influence on Ramunajan's career. Ramanujan took it upon himself to solve all the problems in the book and compiled the results in three note books, which later became Ramanujan's frayed notebooks.

Born into poverty, Ramunajan's remarkable dedication and love for mathematics enabled him to steer his way through the turmoil's of penury. His unparalleled devotion to mathematics, in course of time, won him very influential sympathizers and admirers. He worked as a clerk at the Madras Port Trust and later he got a scholarship from Madras Government to devote all his time for research.

Encouraged by his well wishers Ramanujan wrote a letter to G.H Hardy on January 16, 1913, requesting Hardy for his advice and help for getting his papers published. This letter has become an important historical document. His communication with Hardy opened the gates for Ramunajan's international renown. Ramanujan joined the Trinity College in 1914. He was awarded B A degree in 1916 for his work on 'Highly composite Numbers' and in 1918 he became a Fellow of the Royal Society. On 13th October 1918, he became the first Indian to be elected as a Fellow of Trinity College, Cambridge.

Much of Ramunajan's mathematics came under the heading of number theory-a purest realm of mathematics. The number theory is the abstract study of the structure of number systems and properties of positive integers. It includes various theorems about prime numbers. Prime number is a natural number other than 1, divisible only by itself and 1. Or, any natural number, which has precisely two devisors. The following numbers are prime: 2, 3, 5, 7, 11, 13,........37,.....5521. Every natural number greater than 1 may be resolved uniquely into a product of prime numbers: e.g., 8316= 2^2 x 3^2 x 7 x 11. In the case of a prime number 'p', the product has to be interpreted as 'p' itself. Number theory includes analytic number theory, originated by Leonhard Euler (1707); geometric theory – which uses such geometrical methods of analysis as Cartesian co-ordinates, vectors and matrices; and probabilistic number theory based on probability theory. What Ramanujan did will be fully understood by a very few. In this connection it is worthwhile to note what Hardy had to say of the work of pure mathematicians: "what we do may be small, but it has certain character of permanence and to have produced anything of the slightest permanent interest, whether it be a copy of verses or a geometrical theorem, is to have done something beyond the powers of the vast majority of the men." Ramanujan's theory of constants, theory of partitions and his recognition of the multiplicative properties of the coefficients of modular forms (cusp forms) played a more central role in the modern mathematics. Ramunajan's work has application in particle physics or in the calculation of the value of Π. His zeta-function have been applied to the pyrometry, the investigation of the temperatures of furnaces. His Partition Numbers is applied in new fuels and fabrics like nylons.

Ramanujan died of tuberculosis in Kumbakonam on April 26,1920. The achievement of Ramanujan was so great that those who can really grasp the work of Ramanujan may doubt that so prodigious a feat had ever been accomplished in the history of thought.

Some of the contributions of Ramanujan

1. Nested Square roots

To find the value of $\sqrt{(1+2)}\sqrt{(1+3)}\sqrt{(1+4)}\sqrt{\ldots\ldots}$

Solution: we have n (n+2)

$= n\sqrt{(n^2+4n+4)}$

$= n\sqrt{[1 + (n+1)(n+3)]}$

Let $f(n) = n(n+2)$

Then $f(n) = n\sqrt{[1+f(n+1)]}$

$= n\sqrt{[1+(n+1)]}\sqrt{[1+f(n+2)]}$

Or $f(n) = n(n+2)$

$= n\sqrt{[1+(n+1)]}\sqrt{[1+(n+2)]}\sqrt{[1+f(n+3)]}$

Putting n=1, we get, 1(1+2)

$= \sqrt{(1+2)}\sqrt{(1+3)}\sqrt{(1+4)}\sqrt{\ldots\ldots} = 3$

2.Partition of Natural Numbers:

The number of ways in which a given

natural number n can be split up in to smaller numbers such that their sum is n is called the partitioning of n denoted by P(n)

For example, for n = 4 and 5, the partitions are as follows.

4; 3+1, 2+2, 2+1+1, 1+1+1+1
: P(4) = 5

5; 4+1, 3+2, 3+1+1, 2+2+1, 2+1+1+1, 1+1+1+1+1 : P(5) = 7

3. The Ramanujan Number:

Ramanujan was mainly interested in problems which had solutions and in providing formulas for the solutions.

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. 1729 can be expressed as sum of cubes of 1 and 12 as well as sum of cubes of 10 and 9.

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

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

Ramanujan number can be written as the sum of cubes of another numbers also in two ways

$1^3 + 6^3 + 8^3 + 10^3 = 1729$

$1^3 + 3^3 + 4^3 + 5^3 + 8^3 + 10^3 = 1729$

Ramanujan also discovered the smallest number which can be expressed in two different ways as the sum of the 4^{th} power of two numbers. The number is 635318657 which can be written as:

$158^4 + 59^4 = 635318657$

$134^4 + 133^4 = 635318657$

Some approximations of π

$4/\pi = 1+7/4\ (1/2)^3+13/4^2\ (1.3/2.4)^3 + 19/4^3\ (1.3.5/2.4.6)^3 + \ldots\ldots\ldots$

$\pi = 12/\sqrt{130}\ \log\ [\ (2+\sqrt{5})(3+\sqrt{13})] / \sqrt{2}$

$9/5 + (9/5)^{1/4} = 3.141592652.....$

Reference:

Dream 2047 , December 2001, Vigyan Prasar, New Delhi.

Ramanujan : Twelve Lectures on the Subjects suggested by His Life and Works, (1940), G.H. Hardy, Chelsea Publishing Comapnay, New York.

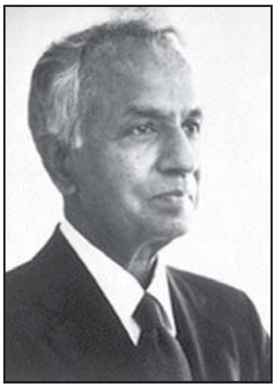
"Sheer intuitive brilliance coupled to long, hard hours on his slate made up for most of his educational lapse. This 'poor and solitary Indian pitting his brains against the accumulated wisdom of Europe' as Hardy called him, had rediscovered a century of mathematics and made new discoveries that would captivate mathematicians."

Robert Kanigel in The Man who Knew Infinity: A life of the Genius Ramanujan

"I still say to myself when I am depressed and find myself forced to listen to pompous and tiresome people, Well, I have done one thing you could never have done, and that is to have collaborated with both Littlewood and Ramanujan on something like equal terms."

Godfrey Harold Hardy

SUBRAMANYAN CHANDRASEKHAR



Subramanyan Chandrasekhar belonging to a Tamil Brahmin family was born in Lahore (then a part of British India) on 19^{th} October 1910. His father Chandrasekhara Subramanya Ayyar an officer in Government service in the Indian Audits and Accounts Department in Lahore and mother Sita a woman of highly intellectual attainments provided great strength to him.

Education

His early education was at home and later in Madras he attended the Indian High School, Triplicane. In 1925 - 30 he joined the Presidency College and took a bachelor's degree B.Sc. (Hon.) in Physics. In 1930 he was awarded Government of India scholarship for graduate students in Cambridge, England. Here he became research student under the supervision of Professor. R.H. Fonter.

Three years later in 1933 he took Ph.D and was elected to a prize Fellowship at Trinity College for the period of 1933-37. In his short visit to Harward University he was offered a position as Research Associate at the University of Chicago by Dr. Otho Struve and President Robert Maynard Hutchins.

Scientific Works

Chandrasekhar's scientific work was followed with a certain pattern motivated, principally, by quest after perspectives. In practice this quest led him to a certain area, which appeared amenable to cultivation and compatible to his taste, abilities and temperament. After some years of study, he was well prepared to present his point of views in a coherent account with order, form and structure. In this account he had divided his scientific career into seven periods.

1) Stellar Structure - including the theory of white dwarfs (1929 - 1939)
2) Stellar dynamics - including the theory of Brownian motion (1938 - 1943)
3) The theory of radiative transfer, including the theory of stellar atmospheres and the quantum theory of the negative ion of hydrogen and the theory of planetary atmospheres, including the theory of the illumination and the polarization of the sunlit sky (1934-1950).
4) Hydro dynamic and hydro magnetic stability, including the theory of the Rayleigh - Bernard convection(1952-1961).
5) The equilibrium and the stability of ellipsoidal figures of equilibrium, partly in collaboration with Newman R. Laboritz (1961-1968).
6) The general theory of relativity and relativistic astrophysics (1962 - 1977).
7) The mathematical theory of black holes (1974-1983).

The Nobel prize in Physics for 1983 was shared by Prof. S. Chandrasekhar, University of Chicago, USA, for his theoretical studies of the physical processes of importance to the structure and evolution of the stars and by Prof. W.A. Fowler.

Astrophysics is one of the areas in physics which has developed most rapidly during recent years. Through satellite technology it has become possible to study the different physical processes which are taking place in stars and other astronomical objects. Space has become a new and exciting laboratory for the physicist. It is true that experiments, in the proper sense of the word, cannot be carried out, but one may observe phenomena which can never be observed in terrestrial laboratories. In space we find matter in the most extreme forms; stars at immensely high temperatures and with enormously high densities, and particles and radiation with an energy which we cannot reach, even with our largest accelerators.

The common theme for this year's prize in physics is the evolution of the stars. From the moment of their birth out of interstellar matter until their extinction, the stars exhibit many physical processes of great interest. In order to put this year's prize in perspective, it is perhaps appropriate to give a short description of the evolution of the stars.

Stars are formed from the gas and dust clouds which are present in galaxies. Under the influence of gravity, this matter condenses and contracts to form a star. During these processes energy is released which leads to a rise in the temperature of the newly formed star. Eventually, the temperature becomes so high that nuclear reactions are initiated inside the star. Hydrogen, which is the primary constituent, burns to form helium. During this process pressure builds up which prevents further contraction, the star stabilizes, and may continue to exist for millions or thousands of millions of years. When the supply of hydrogen has been used up, other nuclear reactions come into play, especially in more massive stars, and heavier elements are thus formed. A particularly effective type of nuclear reaction is the successive addition of neutrons. Finally, the star is, to a large extent, composed of heavier elements, mainly iron and neighbouring elements, and the supply of nuclear fuel is exhausted. When the star has evolved this far it can no longer withstand the pressure of its own gravitational force and collapses, the product of collapse depending on the mass of the star.

For lighter stars with a mass roughly equal to that of the Sun, the collapse results in a so-called white dwarf. The star is so named because of its reduction in size, leading to an increase in its density to about 10 tons per cubic centimetre. The mechanism for the collapse is that the electron shell structure is crushed, so that the star consists of atomic nuclei in an electron gas.

For somewhat heavier stars, the collapse can lead to an explosion, the visible result being a supernova. This is accompanied by a short-lived but intense neutron flux which leads to the formation of the heaviest elements. In these heavy stars the collapse can go even further, the atomic nuclei and the electrons combining to form neutrons. This results in a so-called neutron star which has the enormously high density of 100 million tons per cubic centimetre. A star with a mass of 1 to 2 times that of the Sun may be compressed so that the radius is only about 10 km. A neutron star is essentially a sphere of neutrons in a fluid form surrounded by a solid crust which is very much harder than steel.

The collapse of still heavier stars can lead to an even more exotic object, a black hole. Here the gravitational force is so strong that all matter which is sucked into the hole loses its identity, and is compressed into an infinitely small volume, i.e. a mathematical point. Not even light, emitted from within the black hole, may escape into the outside world, hence the name, black hole. The existence of a black hole may be revealed through the radiation which is emitted by matter which, when being sucked into it, undergoes a considerable increase in temperature before finally disappearing. Certain strange objects called quasars may possibly be a black hole in the centre of a galaxy.

It should now be clear that during their evolution stars exhibit many different physical processes of fundamental importance. Many scientists have studied the problems involved with these processes, but especially important contributions have been made by Subrahmanyan Chandrasekhar and William Fowler.

Chandrasekhar's work is particularly many-sided and covers many aspects of the evolution of stars. An important part of his work is a study concerning the problems of stability in different phases of their evolution. In recent years he has studied relativistic effects, which become important because of the extreme conditions which arise during the later stages of the star's development. One of Chandrasekhar's most well known contributions is his study of the structure of white dwarfs. Even if some of these studies are from his earlier years, they have become topical again through advances in the fields of astronomy and space research. NASA' s Advanced X-Ray Astrophysics Facility (AXAF) war renamed as Chandra X-Ray Observatory (CXO) in honour of S. Chandrasekhar. The combination of high resolution, large collecting area, and sensitivity to higher energy X-Rays will make it possible for CXO to study extremely faint sources.

Chandrasekhar Limit

The name of Chandrasekhar is immortalized 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 supemova. The restriction of mass to 1.44 solar mass for white dwarf to be stable is called *Chandrasekhar limit*.

Dr. Chandrasekhar, was married to Lalitha Doraiswamy a junior to him at the Presidency College in Madras. Her patient understanding support, and encouragement had been the central facts of his life. He passed away on August 21, 1995.

Reference:

Subramanyan Chandrasekhar- Autobiography (2003), Science India, Swadeshi Science Movement, Cochin.

SUSRUTA

Susruta lived during the 6th century B.C. and was a descendant of Viswamitra. He learnt the science of surgery from Dhanvanthari at Varanasi. In the science of Medicine, as in all other branches of study, it was believed that knowledge was derived from the gods, through direct revelation. Susruta in his Samhita has described the Ayurveda as a subdivision (*upanga*) of Atharva Veda. The Ayurvedic compendium is the oldest known work that vividly describes the plastic surgeries of nose, ear and lip. Susruta was the first to carry out 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 known as "Caesavium" operation. He was an expert in removing urinary stones and treating fractures and doing eye operations for cataract. He put forth the concept of asepsis several years before Joseph Lister.

Susruta Samhita

Susruta Samhita pays special attention to surgery. The work primarily deals with Salya and Salakya, two of the eight division of Ayruveda. This work also teaches the use of blunt instruments, cutting instruments, caustics, cautery together with diagnosis and treatment of inflammation. Salakya deals with diseases of ears, eyes, nose, mouth and other parts of the body above the clavicle.

The Susruta Samhita composed in Sanskrit verse and prose, is divided into 5 sthanas, comprising 120 chapters. According to Susruta Samhita legend, Indra taught Ayurveda to Dhanwantari, who transmitted his knowledge to Susruta and other disciples.

Like Caraka Samhita, the Susruta Samhita is also not the work of a single author. Nagarjuna was the redactor (reconstructer) of the compendium, but does not offer any other information about him. The present Susruta Samhita seems to have been composed in early Christian era.

Susruta Samhita is divided into 5 Sthana in 120 chapters and Hara Tantra, 66 chapters The division is as follows.

1. Sutra Sthana - 46 chapters- deal with basic doctrines, surgical and allied therapies, training methods, duties of army Surgeon, evolution, etc.
2. Nidana - 16 chapters- Pathology
3. Sarira - 10 chapters. Describe cosmic origin of life, embryology, anatomy, gynaecology and obstetrics.
4. Chikitsa - 40 chapters deal treatment with surgical procedures, rejuvenation and Panchakarma
5. Kalpa - 8 chapters deal with toxicology, vegetable and mineral poison, animal poisons, snake venom, etc.
6. Uttaratantra - 60 chapters- is the big-

gest section, deal with diseases of eye, ear, nose, head and their therapies, psychic disorders and other general ailments (ophthalmology)

Sushruta Samhita describes that 63 combinations can be made out of the 6 rasas or tastes (bitter, sour, saltish, astringent, sweet, and hot) taking them one, two etc. at a time. (note that we get 6, 15, 20, 15, 6 and 1 combinations, which add up to 63.)

Thus Susruta Samhita is a comprehensive treatise dealing with all the eight branches of Ayurveda with greater importance to surgery.

Major Contributions

The main contributions of Susruta can be enumerated as follows.

1) Plastic and Rhino plastic operations.
2) Lithotomic and Laparotomic operations -
3) Amputations –
4) Ophthalmic Surgery – of the 76 varieties of ophthalmic diseases, Susruta holds that 51 are surgical. The mode of operation in each case has been elaborately described.
5) Midwifery - It is in the region of practical midwifery that one becomes so much impressed with the greatness of Susruta.
6) Dissection – study of practical anatomy.
7) Two kinds of surgical instruments – different kinds of surgical operations 14 varieties of bandages.
8) Susruta's theory of cosmogony – is based on old Sankhya system of philosophy.
9) Ayurvedic embryology.
10) Study of practical physiology and marmas.
11) Study of practical Surgery- Blunt-yantra -101, Sharp yantra 20
12) Uttaratantra deals with 76 eye diseases and their treatments.

Dissection of Human Body

In the Susruta Samhita, at the end of the fifth chapter of Sarirasthana there is a unique record of dissection of a dead human body. Here Salya means a branch actually "anything causing pain" as a branch of medicine and the sort of dissection described in the Susruta Samhita might have been performed partly for acquiring some anatomical knowledge and mainly for discovering the various marmas (protection of ligaments, veins, muscles, bones or bone-joints) of the human body, because it was believed that a person injured in any of the manner dies shortly.

Marmas and Surgical Instruments

In Susruta Samhita, 107 marmas are classified into five groups and says that the proper knowledge of the marmas covers half of the scope of Salyatantra (surgery). For surgical instruments Susruta Samhita describes two branches of surgical instruments: blunt(yantra) and sharp (sastra). In this there are 101 blunt instruments which were divided into six groups, and in Sastra, there are 20 instruments. In the field of plastic surgery of the ear, nose and lip, the surgeons of ancient India greatly excelled. Susruta had described 15 methods of cut-up ear lobes.

Commentaries of Susruta Samhita

Numerous commentaries of Susruta Samhita are available now. Of them, important one is 'Bhanumati Vyakhya' by Chakrapani Datta. This is translated to Arbaic under the title of 'Kitab Shawasoon al-Hind of Susrud', and also to Persian, and Indian languages. Persian Physician al-Razi (860-925 A.D.) quotes Susrud as an authority on surgery. In India the school of Susruta did not flourish as much as Caraka's School of therapeutic medicine, even today the Ayurvedic medicine is mainly therapeutics. For centuries the Samhitas of Susruta and Caraka were regarded as standard treaties of ayurvedic medicines. Their fame travelled far and wide beyond the boarders of India.

Reference:

Dream 2047, July 2000, Vigyan Prasar, New Delhi.

VIKRAM SARABHAI

Vikram Ambalal Sarabhai was born in Ahmedabad on 12 august 1919. He had his early education in the family school directed by his mother, Saraladevi. This was not a school as then commonly understood, run on lines inspired by the theories and practical teachings of Maria Montessori; it was a veritable nursery of the ideals and aspirations cherished by his parents, which the children imbibed as their personality developed and matured. On completing his secondary school studies, Vikram joined Gujarat College, Ahmedabad, but before graduating, he joined St.John's College, Cambridge(UK), and in 1940, took his Tripos in natural sciences. The outbreak of World War II necessitated his return to India where he took up research in cosmic ray physics at the Indian Institute of Science, Bangalore. He worked under the inspiring guidance of the Noble Laureate, Sir.C.V.Raman. After the war, he returned to Cambridge and conducted research in photo fission at the Cavendish Laboratory. In 1947, he was awarded a doctorate degree by Cambridge University for his thesis. "Cosmic Ray Investigations in Tropical Latitudes".

Business Interests

On his return to India, Dr. Sarabhai continued his scientific activities and in 1947 founded the Physical Research Laboratory in Ahmedabad, which he personally directed till 1971 as a centre of excellence in scientific research. He also took over responsibilities connected with family business interests, applying to them the analytical and organizational skills he had so amply displayed as an experimental physicist In 1947 he founded the Ahmedabad Textile Industry's Research Association (ATIRA) of which he was the first Honorary Director, a post he actively held till 1956.

Industrialist

During the years 1950 to 1966, Dr. Sarabhai was instrumental in establishing a number of industries in Baroda, namely, Sarabhai Chemicals, Sarabhai Glass, Suhrid Geigy Limited, Synbiotics Limited, Sarabhai Merck Limited and the Sarabhai Engineering Group. In Bombay, he took up the management of Swastika Oil Mills, introducing new techniques of oil extraction, manufacture of synthetic detergents and cosmetics. In Calcutta he took over the management of Standard Pharmaceuticals Limited where he introduced large scale manufacture of penicillin, besides a range of pharmaceuticals products. In 1960, he set up the Sarabhai Center, in Baroda, for investigation of natural and synthetic medicinal products.

Management

Management was among Dr. Sarabhai's major interests. In 1957 he had founded the Ahmedabad Management Association and in 1960 the Operations Research Group (ORG) now located in Baroda. To meet the great need for professional management in India he founded in 1962 the Indian institute of Management in Ahmedabad and was its Honorary Director up to 1965.

Incospar

In 1962, Dr. Sarabhai took over responsibility for organizing space research in India as Chairman of the Indian National Committee for Space Research (INCOSPAR). In his direction Thumba Equatorial Rocket Launching

Station (TERLS) and was set up later and initiated a programme for the manufacture of French Centaur sounding rocket in India. He was the guiding spirit behind the development of rockets of Indian design at Thumba: Rohini and Menaka are among them. The Indian payloads no longer neede to be launched by French rockets. Prof. Sarabhai considered the collective understanding of the problem the main attributing of effective leadership and announced the programme what he considered as the best: India should without loss of time, concentrate on making our own rockets, our own Satellite Launch Vehicles (SLVs) and our own satellites, concurrently and not one-by-one multi-dimensional manner.

In 1966, Dr. Sarabhai became the Chairman of the Atomic Energy Commission and Secretary to the Department of Atomic Energy, Government of India.

SITE

Dr. Sarabhai saw tremendous potential in using science to help the process of development. Science was a passion for him and a useful tool to finally sculpt out social, economical and educational change in India. He drew up plans to take modern education to the remotest villages by using satellite television which was later implemented as the Satellite Instructional Television Experiment (SITE). He was ardent visionary and had brilliant ideas on how to link atomic power development with the industrial development of large backward areas. His proposal concerning the development of Agro-Industrial complexes in the Gangetic Plain and the arid area of Kutch, are examples. His visionary insight had led the use of satellite communication to bring the benefits of television to the hundreds of villages in India. This was the profile he had sketched for India's development during the seventies. His interest in education resulted, in establishing the Community Science Centre in 1965 at Ahmedabad. It was a science education institution for children where new ideas in science education could be tried out. He often said that, on retirement, he would like to spend time with young children talking to them about science.

The Community Science Centre was the first fruit of another institution, the Nehru Foundation for Development which Dr. Sarabhai was instrumental in setting up. For his outstanding services to the nation he was awarded the Shanti Swaroop Bhatnagar Memorial Award for Physics in 1962 and was honoured with the Padma Bhusan in 1966 and the Padma Vibhushan was awarded to him posthumously by the Government of India.

Affiliations

The responsibilities he held during his tenure were the President of the Physics section of the Indian Science Congress 1962, Chairman of the Electronics Committee of the Union Department of Defense Supplies and the Electronics Corporation of India Limited, besides being a member of various other important national and international committees. He was a fellow of Indian Academy of Science, the National Institute of Science in India, the Physical Society, London and the Cambridge Philosophical Society. Dr. Sarabhai was a member of the International Council of Scientific Unions(1966); Chairman of the Panel of Experts and Scientific Chairman of the UN conference on the Exploration and Peaceful Uses of outer Space(1968); President, 14th General Conference, International Atomic Energy Agency, Vienna(1970); and Vice-President, Fourth UN Conference on the Peaceful Uses of Atomic Energy(1970).

Cultural Interests

Apart from his scientific interests Dr. Sarabhai was a man of deep cultural interests. Music, photography archaeology, and the fine arts-all these and more fell within his range. In 1948, with his wife Mrinalini, an internationally renowned exponent of classical Indian dances he started Darpana an institution devoted to the performing arts. The objectives of the institution included the propagation of the ancient culture of Indian , the creation of an environment where artists could study and work in an atmosphere of freedom, giving full scope for new experiments in dance and drama base. He was ever convinced that a scientist should never shut himself up in an ivory tower or ignore the problems of society in a mere academic pursuit of 'pure' science, though "pure science" was in his heart. It was this acute awareness of the scientist's obligation to the community that urged him to float project after project for the utilization of audio-visual communication activity. It also included television, as an aid to agriculture extension, promotion of family planning and spreading of education in rural areas.

Dr. Vikram Sarabhai combined the best of being "modern" and "Indian" blending aesthetics with science. He consistently encompassed the true role of the administrator as an innovator rather than as a conservator. Of work he was never tired and often put in about 18 hours a day. "Stretch your working hours" he told his students. Despite his stupendous workload, he could take time off to watch "squirrels and birds". A warm human being, he was sensitive and intensely responsive to the beauty of life around him.

Karma Yogi

Vikram Sarabhai lived the life of karma yogi-doing his self-allotted duties, swadharma, with selfless and tireless devotion. He was the remarkable successor of Dr. Homi J. Bhabha, Chairman of the Atomic Energy Commission. His work was commendable and showed his capacity to direct and continue successfully the work of the Commission.

This great scientist widely recognized internationally in space and nuclear research was in Trivandrum on 29th Dec 1971 at Rocket Launching Station, Thumbha where he expired in his sleep. The man who at birth was blessed by Lakshmi, the goddess of Wealth, but who worshipped Saraswathi, the Goddess of learning, died when he was busy with his research. He was then 52.

Vikram Sarabhai married Mrinalni Swaminathan, the famous dancer in 1942. They had a son Karthikeya and daughter, Mallika, a celebrity in classical dance.

Annexure:

Prof. Sarabhai organized an integrated national space programme for indigenous production of rockets and launch facilities. This encompassed an extensive scientific programme for development of rocket fuels, propulsions systems, aeronautics, aerospace materials, advanced fabrication techniques, rocket motor instrumentation, control and guidance system, telemetry, tracking systems and scientific equipments for experimentation in space.

Indian aerospace programme triggered with the Rohini Sounding Rocket (RSR). For the benefit of senior students of Science Dr. Kalam had explained the distinction of a Sounding rocket from satellite launch vehicle (SLV) and from a missile. There are three different kinds of rockets. Sounding rockets are normally used for probing the near-earth environment, including the upper regions of atmosphere. While they carry a variety of scientific pay-loads to a range of latitude they cannot impart the final velocity needed to orbit the pay-load. On the other hand, a launch vehicle is designed to inject into orbit a technological pay-load or satellite. The final stage of a launch vehicle provides the necessary velocity for a satellite to enter an orbit. This is a complex operation requiring on board guidance and control systems. A missile, though belonging to same family is a still more complex systems. In addition to the large technical velocity and on board guidance and control, it must have the capability to home onto targets. When the targets are fast moving capable of manoeuvering, a missile also required to carry out target – tracking functions.

VARAHAMIHIRA

Varahamihira is one of the most celebrated exponents of Indian astronomy and natural science. According to sage Battotpala, Varahamihira is an incarnation of the Sun God himself. He was a prolific writer and produced several works which had a tremendous impact on later astronomers, particularly astrologers. He was well versed in all (i) *Tantra* or *siddhanta* (Astronomy) (ii) *Hora* (horoscopy) and (iii) *Samhita* (astrology). Basically he was an astronomer but his masterly knowledge in many other disciplines was remarkable.

We know very little about the life of Varahamihira. There are differences of opinion about his date of birth. Most of the scholars are of the view that Varahamihira must have lived in between 505 and 587 A.D (in 6^{th} century A.D). There is a popular quotation regarding his death which states that 'Varahamihiracharya' passed away in 'Saka 509' (587 A.D).

In his Brhajjatakam, Varahamihira himself state that 'he was the son of Adityadasa – from whom he obtained knowledge – who was blessed by Sun-God at Kapitthaka and lived in Avanti (Ujjayini), compiled the beautiful hora work after studying the views of sages. Battotpala calls him a Magadhadvija (Magedha Brahmna). Since Ujjayini was not in Magadha, it is possible that Varahamihira or his forefathers might have migrated from Magadha to Avanti seeking royal patronage. The word Maga means 'worshipper of the Sun' and Magadha indicates the region where worshippers of the sun reside. A true scholar, he was the first to claim that some "force" might be keeping the bodies to fall and to stick on the surface of the earth (similar to force of gravity). He had observed and studied 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. He was a master of Sanskrit grammar and had a poetic style to present his ideas.

Important Works of Varahamihira

The three major works of Varahamihira are *Panchasiddhantika*, *Brhat Samhita* and *Brhajjataka*. Beside these works he composed *Brhadvivahapatala*, *Brhadyatra* and the abridged version of these works.

I. Panchasiddhantika

As the name indicated, the work contains summaries or extracts of the five earlier *siddhantas of Paitamaha, Vasistha, Paulisa, Romaka and Surya*. The siddhantas formulated by Varahamihira are the earliest available records of scientific astronomy of the Indians. Varahamihira describes the merits of the Siddhantas as 'the Siddhanta made by Paulisa is accurate near to it stands the siddhanta by Romaka; more accurate is the Savitha (surya); the remaining two have strayed far away from truth.

(i) Vasistha Siddhanta

Vasistha Siddhanta a fully developed lunar calendar where the *tithi* is a chronological unit of calculation, the subdivision of the eclipses into 12 *rashis* ; *amsas* and *kalas* the derivation of the *lagna* at any particular time and computations of the length of the sidereal year as 365.25 days are same of the features of the *Vasistha Siddhanta*.

The remaining three Sidhantas are more accurate and under the influences of Greek and Babylonian astronomy they were remodeled, retaining the basic fundamentals of ancient Indian Astronomy. The calculations of *ahargana* (the numbers of *Savana* or evildays that have elapsed) from a given epoch in common to the three siddhantas. *Surya siddhanta* is the most accurate. The calculation of Kendra (anomaly), *Ksepaka* (latitude) and the measurements of *Jya* (sines) and Karna (hypotenuse) were introduced in surya siddhanta. It is periodically revived by many authors and was highly honored as a standard astronomical work for centuries.

2. Brahat Samhita:

The word Samhita means compilation and accordingly the work of Varahamihira contains extract from various Sasthras and branches of knowledge prevalent in his time. It is an encyclopedic work consisting of about 4000 Sanskrit verses divided into 105 chapters. The contents of the Brat Semite may be broadly classified under the following discipline. (i) Astronomy , (2) Geography, (3) Calendar, (4) Meteorology, (5) Flora, (6) Portents, (7) Agriculture, (8) Politics and Economics (9) Engineering, (10) Physiognomy, (10) Botany, (12) Zoology, (13) Industry, (14) Architecture and fine Arts, (15) Hygiene, (16) Gemology etc. It also contains minute details about different regions of India of his time. Equally important for the history of science and technology is the materials on weights and measures, coinage and Jovian cycles etc.

Prospecting for Ground Water

Varahamihira has given an ideal directive and methodology of identifying the enriched potential aquifer exclusively for getting regular and continuous supply of water through dug wells, perched water and confined water bodies in Chapter 54 entitled in "Dakargalam' of his Brahat Samhita. His contribution is to identify the source of water by identifying the species of trees, shrubs and grasses. In his visionary venture he has identified not only pheratic (i.e. water table) bodies but also confined and perched water bodies as well at varying depths by encountering sweating and oozing of the capillary zone followed by unitary or multiple springs and on channels leading to poor moderate or prolific aquifer bodies . Thus he discovered a boarder line science for identification of pheratophytic species in nature by conjunctive venture of Hydrogeology and Botany under one umbrella. This was centuries before the dawn of hydrogeology in the thirties of the 20th century in U.S.A and modern hydrogeology in Indian in 1955 (P.G.Adyalkar, Ground Water Consultant, Nagpur-440010).

Varahamihira does not claim originality for the contents of his work. He gratefully acknowledges his predecessors like Garga, Parisara, Kasyapa, Devala, Nandini and Rsiputra.

3. Greek influence on Varahamihira

Varahamihira's works show that he had thorough knowledge of greek astronomy and astrology. Varahamihira in his astrological treatise, Brhjjataka gives the names of the twelve signs of the Zodiac as *Kriya, Tavwi*, etc. instead of the usual Sanskrit names *Mesa, Varsabha*, etc. Obviously, the names given by Varaha bear similarities with Greek names.

Varahamihira had many progressive ideas. He gave the scientific explanation for the eclipse and he advocated constant revision of the calendar so as to make it tally with the *drkpratya*. But he vehemently refuted Aryabhata's revolutionary theory of the Earth's rotation. Varaha has highest praise for women and he was against the practice of polygamy and suttee.

Reference:

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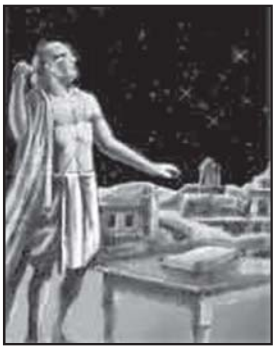
OTHER SCIENTISTS

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 Leelavathi 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 "Leelavathi". There has been a popular saying that who so ever is well-versed with " Leelavathi" can tell the exact number of leaves on a tree.

One part *of Leelavathi* deals with arithmetic while the other three parts called *Bijaganitha*, *Goladhyaya* and *Grahaganitha* deals 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 10.6pm. 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 Indian Statistical Journal.

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 of 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 contributions 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 discover 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 1976 August. 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.

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 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.

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.

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. 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 tagged 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. 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. He has been described by the United Nations Environment Programme as ''the Father of Economic Ecology" and by Javier Perez de Cuellar, Secretary General of the United Nations, as "a living legend who will go into the annals of history as a world scientist of rare distinction". He was Chairman of the U.N Science Advisory Committee set up in 1980 to take follow-up action on the Vienna Plan of Action. He has also served as Independent Chairman of the FAO Council and President of the International Union for the Conservation of Nature and Natural Resources.

A Plant geneticist by training Prof. Swaminathan's contributions to the agricultural renaissance of India have led to his being widely referred to as the scientific leader of the green revolution movement. His advocacy of sustainable agriculture leading to an ever-green revolution makes him an acknowledged world leader in the field of sustainable food security. The International Association of Women and Development conferred on him the first international award for significant contributions to promoting the knowledge, skill and technological empowerment of women in agriculture and for his pioneering role in main streaming gender considerations in agriculture and rural development. Prof. Swaminathan was awarded the Ramon Magsaysay Award for Community Leadership in 1971, the Albert Einstein World Science Award in 1986, the first World Food Prize in 1987. Volvo Environment Prize in 1999 and the Franklin D Roosevelt Four Freedoms Award in 2000.

Prof. Sawminathan is a Fellow of many of the leading scientific academies of India and the world, including the Royal Society of London and the US National Academy of Sciences. He has received 43 honorary doctorate degrees from universities around the world. Recently, he has been elected as the President of Pugwash Conference on Science and World Affairs. He currently holds the UNESCO Chair in Ecotechnology at the M S Swaminathan Research Foundation in Chennai (Madras), India.

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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 god.

Rasaratnakara deals with preparations of *rasa* (Mercury) compounds, principles of 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 have shining.

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.

P. MAHESWARI

Panchanan Maheswari was a famous botanist who invented the technique of test tube fertilisation of angiosperms (flowering plants)during the first half of 1950s. Till then no one thought that flowering plants could be fertilized in test tubes. Maheswari was born on Nov.9, 1904, in Jaipur, Rajasthan. In 1931, he secured D.Sc. from Allahabad University for his study on Growth of Plant Embryo. In 1949, Maheswari became Head of Botany Department of Delhi University. Maheswari is considered to be one of the founders of the subject Plant Embryology. His discovery that flowering plants can be grown in test tubes had immediate applications in economy and applied economy and immense help to plant breeders. He received FRS in 1965. Maheswari died on 18, May 1966.

P. C. MAHALANOBIS

Prasantha Chandra Mahalanobis was the first Indian statistician to receive world recognition. The history of Stastistics in India is his personal history.

Mahalanobis was studying Mathematics in Kings College, London when he came across the volumes *Biometrica and Biometric tables*. In 1915, he came back to India to take a up a lectureship in Physics at Presidency College, Calcutta. He also continued to study Statistics. Statistics deals with large numbers and relationships between them. Mahalanobis applied Statistics to recommend examination reforms in Calcutta University. He applied Statistics to Anthropology, Demography and Meteorology. He also applied Statistics in the control of floods in Mahanadi and Damodar Valley using proper drainage path and dam constructions.

In 1958, he started material sample survey to give proposal to the second five year plan. He made Statistics a popular subject in Universities and founded Indian Statistical Research Institute in Calcutta, which has now branches all over the country.

Tools of Statistics he invented like *Mahalanobis Distance and ractile graphical analysis* have wide applications. He became an FRS in 1945. He died in 1972 at the age of 79.

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.

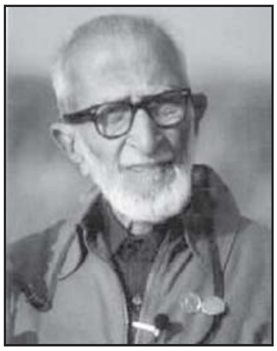
S. N. BOSE

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 l925 even predicted a new type of phenomenon, which is later on known as Bose-Einstein condensation. About 70 years later scientists produced Bose-Einstein condensation 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 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 alternate 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 send 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.

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 dire 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.

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.

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.

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Special Topic-1

Smart Materials

Presently, our understanding of the physics and chemistry of solids is now sufficiently advanced that we can design and create entirely new synthetic materials to meet specific needs. By creating these materials, we can increase our wealth, improve our health and help our environment. We can take the 100 or so elements and mix them to design in order to obtain synthetic materials covering three main areas, namely structural material (like shape memory alloys), biomaterials and functional materials (like electronic materials and magnetic materials). These are SMART materials, which can be made to react to change in stimuli such as temperature, moisture, electric or magnetic field and perform sensing and actuating functions.

Shape memory alloys, is a typical example of smart material which is presently in use. After fabrication, these alloys can be bent to assume various shapes, but, when heated to above certain transition temperature; they will come back to the original shape. Their applications include locking mechanisms in inaccessible joints, dental arches in braces for constant pressure against teeth etc. The alloy presently popular is known as Nitinal (Ni, Ti base).

A second group of smart materials include piezo electric ceramics, such as lead zirconium titanate that quickly translates pressure or vibration into electric current and vice versa, making them useful as sensors or actuators. They are used, for example, in greeting cards that play tunes when opened. They can also be used in burglar alarms which work when a window breaks or to a movement such as walking on a mat.

Embedded sensors offer a way to monitor the health of a structure that undergoes lot of wear and tear- concrete bridges, icebreaker propellers etc.

Modern LEDs – solids that directly emit light – offer advantages over tungsten filament lamps in terms of efficiency and life. They are made by mixing gallium, arsenic and phosphorous. Red LED gives an efficiency of 100 where the standard light bulb gives 17. Replacement of the traffic lights using LED will save enormously on the electricity cost for the cities.

Prospective application of smart materials include robotic parts, in machine tools for damping vibration, microelectronic circuits and health monitoring of bridges of buildings. The future appears to belong to these advanced materials.

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NANOPARTICLES AND NANOSCIENCE

Nano Materials and Technology

Nanoparticles have sizes between the molecular and bulk solid limits with an average size between 1-50nm. This technology provides answers to challenges faced in a single molecule based experiments and developments which has great potential to realize newer devices.

A Nano device can have many desired properties such as:

- Getting essentially every atom placed in desired way.
- Making structures which have specified molecular arrangement.
- Achieving reasonable and acceptable manufacturing cost.
- Getting very quick responses and so on.

This technology can find applications in high purity crystals. Electronic industry can bring out miniature-sized devices. Even desired protein structures and DNA is a possibility by this technology.

Main concepts followed in this field are:

1. Position accurate by placing molecular parts in desired places.
2. Self-replication process, which can help to resize products of comparatively lower cost.

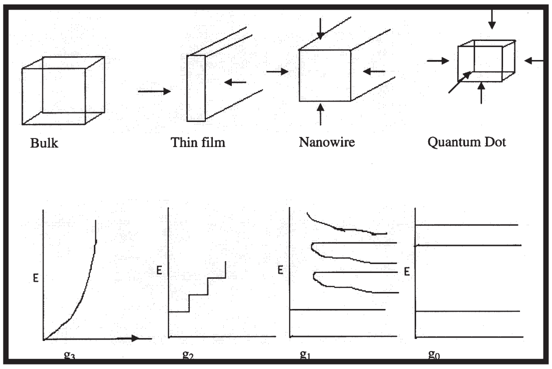
Nano Technology can realize structures like Nano tubes and Nano Composites in future. They will be the structures of future generation. They will be advanced structures of cleaner, stronger, lighter and more precise in nature.

Physical and Chemical Properties

They exhibit physical and chemical properties different from either the individual molecules or the extended solid, because of the increase in the surface to volume ratio and also because of the drastic changes taking place in the structure of the material due to quantum mechanical effects with decreasing particle size. For example the melting point of bulk CdS is ~1600° C while a typical 2.5 nm single crystal of CdS crystallite melts at about 400° C. such a depression in the melting point is due to higher surface energy of the nanoparticles compared to the bulk.

Optical and Electronic Properties

Apart from the effect of large surface area the material properties undergo drastic changes in their optical and electronic properties as a function of the size below a certain regime. In nanoparticles,



the density of states are confined to the quantum dot region i.e. the change carriers are confined to a narrow region along the three directions in space. (Figure I)

Semiconducting nanoparticles exhibit distinctive changes in their physical properties compared to those of the bulk for sizes below the exciton Bohr radius, a_B of the bulk semiconductor at sizes comparable to and less than a_B, the exciton binding energy and the oscillator strength increase due to the enhanced overlap between the electron and the hole wave function. An interesting consequence of the changes in the electronic structure is seen in the variation of the band gap with size in the semiconductor nanoparticles. E.g. band gap of bulk CdS (2.4 eV) increases to 4.5 eV for 20 Å nanoparticles.

Nanoparticles exhibit a pronounced variation in the optical properties upon the variation in the size. Emission form the nanoparticles of CdS upon excitation with UV radiation can be tuned from red end of the visible spectrum to the UV range incorporating impurity atoms into the semiconductor lattice. This process is known as doping. This produces new states in the band gap region of the semi conductor region. The doped nanoparticles provide an alternate pathway for the recombination of electron hole pair, thus giving rise to an emission at an energy different from that of the host semiconductor. Incorporation of magnetic impurities into the host semiconductor lattice also opens up the interesting possibility of exploiting both the charge and spin degrees of freedom in the same material and therefore such materials can be employed for processing and storing data and the same device, now known as spintronic devices.

Technological Applications

Many existing technologies such as catalysis and photography employ nanoscale process. The immediate goals of science and technology of nanomaterials is to explore and establish nanodevice concepts and systems architecture and to generate new classes of high performance materials for use in nanoelectronics and computer technology and as well as in medicinal health care. Besides, a conventional tools of characterization such as X-ray diffraction, sophisticated methods involving scanning probe microscopy, high resolution electron microscopy, atomic force microscopy and magnetic force microscopy are to be employed to investigate nanomaterials.

Some of the important applications and technologies are listed below:

1. Production of nanopowders of ceramics and other materials
2. Nano composities and other nanostrctured high strength materials
3. Development of MEMS and NEMS
4. Application of nanotubes for hydrogen storage and other purposes
5. DNA chips and chips for chemical and biochemical assays.
6. Gene targeting and drug targeting
7. Nanoelctronics and nanodevices.

Applications of nanoelectronics and nanodevices is the most important and difficult are which include new lasers, nanocomputers (based on nanotubes and other materials), defect free electronics for future molecular computers, resonant tunneling devices, spintronics, combination of biological motors with inorganic nanodevices and nanosensors. The field of nanotechnology is a truly inter-disciplinary one encompassing, physics, chemistry, biology, materials and engineering. Hence, interaction amongst scientists with different specialization will create a new branch of science and, in particular, new materials with unforeseen technological possibilities. Nanotechnology is expected to bring about a revolution in human abilities, like that brought by agriculture or power machinery.

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Special Topic-3

Recent Archaeological Discoveries

Archaelogical site preceding Harappan civilisation found:

Marine archaeologists in the country have stumbled upon an archaeological site in the Gulf of Camby off the Gujarat coast which preceded the Harappan civilization by about 3000 years.

"This is for the first time in India that such important discoveries dating back to 7500 BC have been reported from the off-shore region". Union Minister for science and Technology Murli Manohar Joshi told reporters.

Hitherto, the early civilization known to mankind were in the valley of summer around 3500 BC. Egyptian civilization (3000 BC) and Harappa (2500 BC).

This is for the first time that such an important discovery has been made in the off-shore region near the Dwaraka site, where underwater archaeological exploration was in progress. All the findings have been alongside a Paleolithic age river course traced up to 9 km south of the Saurastra coastline.

"Some of the artifacts recovered by the National Institute of Ocean Technology (NIOT), Chennai, which carried out a series of surveys in the area, from the site such as the wood log that is an indicative of a very ancient culture in the present Gulf of Cambay, which got submerged subsequently, " Joshi said.

"Carbon dating on the log carried out by the Birbal Sahni Institute of Paleobotany (BSIP), Lucknow and the National Geophysical Research Institute (NGRI), Hyderabad suggested that it could date back to 7500 BC and these settlements are the oldest Neolithic sites discovered in the country." He said. To link these evidences together and carry out further research at the site, the government has decided to form a group of archaeological experts from National Institute of Ocean Technology, National Institute of Oceanography, Archaeological Survey of India, Physical Research Laboratory, BSIP and NGRI.

Prof. S,.N. Rajguru, former Head of Department of Archaeology, Deccan College, Pune, said, "The discovery could have been a coastline settlement when the sea level was low."

Joshi said, "Pieces of pottery stuck with material used for plastering have also been recovered which clearly indicate human intervention." He said. "The Findings would be submitted to scientific journals within 10-15 days. "Joshi also stressed the need for the country to have a strong marine archaeology department.

(*Reference:* 'the Hitavada', dated January 17, 2002)

Discovery of ancient metro fuels debate on civilization

The discovery of an ancient metropolis off the west coast of India, suggesting that civilization may have started 5000 years earlier than previously believed, could have world wide implications for theories of civilization and has evolved conflicting views from historians and geologists.

Some experts are heralding the find as confirmation that the history of civilization needs radical revision.

Fragments of pottery, carved wood, bone and beads have been recovered from the site, 65 km off the coast of Gujarat with initial tests dating two of the artifacts to 7500.B.C.

Until now, the earliest human civilizations- the Harappan and Indus Valley communities – had been dated to about 2500 B.C . however, experts have speculated that 'civilized' communities may have existed much earlier but were lost as sea levels rose at the end of the Ice age around 8000 B.C.

Traces of the cities, located at a site that was once the fork of river, were detected by a team of Indian oceanographers carrying out pollution checks. Sonar scan of the area revealed a six –mile long conurbation, with a second smaller settlement 13 km to the south.

Dr. S. Kathirodi, the Director of National Institute of Ocean Technology, Chennai, Said, "The find had astonished him and his team , who returned three times to check their results."

"The sonar scans we were carrying out picked up these many large, regular, geometric patterns, the sort of shapes you would never expect in the sea. We then went back many times to explore the site, when we discovered many artifacts," he said.

Graham Handcock, who had spent ten years investigating the earliest civilizations, said, "the discovery finally confirmed that complex communities existed in the Ice Age. For three years Hancock has been working on a book 'Underworld: Flooded Kingdoms of the Ice Age'.

Dilip K. Chakrabarti, a Lecturer in South Asian Archaeology at the University of Cambridge, said, "The discovery changes our view not only of history but of the much-mocked 'caveman', transformed in a strike from bonehead hunter-gatherer to highly-sophisticated, evolved human being capable of building cities."

Announcing the first results, the Indian Government, according to a report in 'The Times' daily here, said the discovery could have world –wide implications for theories of civilization, which would become clearer as further tests were conducted.

Hancock recently visited the site in India and said, "The scans had shown foundations that suggested buildings upto three storeys high and walls running for more than 400 feet."

"It is also highly geometric. The scans show large rectangles and squares, which number in their hundreds, even thousands."

Hancock said, "It was extremely likely that other civilizations had been at the end of the Ice Age, when 15 million square miles of land were submerged by the sea."

"It was a catastrophic period of climate change. The most obvious areas that people would have settled would have been on fertile land near the coasts, and it was these areas that were lost with the rise in sea levels". On the other hand, Kennett said, "If this is true, we are looking at a period of about a thousand after the end of the Ice Age with cavemen building cities."

"Up until now, we knew that from about 9000 BC to about 4000BC, there was a period of village economics and people farming. The transition to urbanization was slow. This discovery would change that completely."

A grid of geometric structures thought to be the foundations of two cities, each more than 8 km wide, has been detected 3.66 km below sea level in the Gulf of Khambhat.

As well as indicating many large square and rectangular structures, the foundations also suggested more complex shapes, believed to be a staircase and a courtyard.

Other items retrieved from the site included what appeared to be construction material, broken pieces of sculpture and a fossilized jaw-bone.

Kathirodi said, "The first carbon dating tests – on two carved logs sent to separate laboratories – had shown both samples dated from about 7500 BC. A large stone slab covered in impressions was being studied to see if it was one of the earliest discovered forms of writing."

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SPECIAL TOPIC-4

5. VEDIC MATHEMATICS

5.1 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 Sanskrit Association in July, 1899 when he was still in his 16^{th} 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 mediatation, 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 4^{th} 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 Shrada Peetha Sankaracarya 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.

5.2 Mathematical Applications

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 2^{nd} 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!!!!

Suppose you are asked to find the product of 98 and 93.Both the given numbers are close to 100. The difference of these from the base (nearest power of 10) is -2 and -7 (98-100 and 93-100)respectively. Write the numbers and their differences from the power of 10 as shown.

98 -2 93 -7

To find the product, multiply -2 by -7 mentally. You get 14 as the last part of the product. 98-7 (the difference of second number from base)or 93-2(the difference of first number from the base)=91 is the first part of the product.

98-7 = 93-2 = 91

Hence the product is written as 91, 14

In the same manner, you can write the product 95x 97 as

95 - 5 (the difference 95 from the base)
97 - 3 (the difference of 97 from the base)

92 15

First part 92 = 95 -3 or 97-5

Second part = 15 = (-5) X (-3)

You may workout product of 98 x 97 as

98 -2
97 -3
95 06

Here, the product of -2 and -3 is written as 06.This is because the number of digits in the second part should be equal to the number of zeros in the base number which is 2 in this case . Hence (-2) X (-3) is to be written as 06.

Yet another example is:

96 x 98 is written as

96 -4
98 -2

94, 08

The procedure is self explanatory.

Let us find the product of 998 and 995.

Writing the numbers and their difference form the nearest power of 10 in this case 1000, and following the same procedure, we get

998 -2
995 -5
993, 010

By cross-subtraction, 998-5= 995-2= 993 and 2 x 5 =10 but as the base number 1000 has zeros, 10 is written as 010.

You may work out the following examples using the above method and find the products.

1) 95 x 99 = 94,05
2) 89 x 95 = 84,55
3) 90 x 93 = 83,70
4) 993 x 995 = 988,035
5) 992 x 998 = 990, 016
6) 975 x 995 = 970, 125

876 -124 (Nikhilam of 876)
999 -1
875, 124

Here one of the numbers, 999 is just 1 short of the nearest power of 10; ie.1000. Both figures have 3 digits each. In such case, the product can be written simply as the first part and the complement of first number from the nearest power of 10,ie, 1000-876=124 as the last part. Hence the product is 875,124.

Here, the two numbers have the same number of digits and the second number contains only 9s. In such cases, first part of the product is one less than the first number and the second part is got by subtracting the digits of the first part from 9.

Let us apply this principle to another example.

Find 5767 x 9999.

Hence the I st part of the product is: 5767-1=5766

The second part is the complement of 5767 from 10000-4233 or subtract every digit of first part from 9.

The final product can be found mentally, as 5766, 4233.

How much time do you need to find the product of 9876543211 x 9999999999 = 98765432100123456789?

Just the time to write 20 digits!

Do you observe any specialty in the numbers used in the above example which reflects on the product?

Now if number of '9' in the second figure is more than that in the first, we have to just insert the excess '9's in the space between the first and last parts.

For example, 578 x 999999

Here, the first number has 3 digits and the second has 6 digits.

Hence the difference in the number of digits = 6-3=3

Write three '9's in the intermediate space as 577/999/422.

On similar lines, 3765 x 99999 = 3764/9/6234.

Can you discover the method to find the product of numbers which are not near to 10 based numbers like 64 X 43?

To Find The Square Of A Number

'Yavadunam Thavadunikritya, Vargamcha yojayet' To find the square of a number, the Sutra used means that whatever the deficiency of the given number has from the base is subtract that deficiency from the given number and put the square of the deficiency to right hand side.

For example, to find 8^2

8 is 2 less than the base 10, so, the first part of the answer is 8 – 2 =6

The second part is square of the deficiency= 2^2 = 4

So, 8^{2} = 6, 4

Similarly 9^2 = (9-1), 1^2=8, 1

Similarly 98^2 = (98-2), 2^2 = 96, 04

Here the base number is 100 and hence 2^2 = 4 should be written as 04. ie the number of digits should be made equal the number of zeros in the base by to fixing prefixing zeros

Again 96^2 = 96- 4 / 4^2= 92,16

994^2 = 994 – 6 / 6^2= 988, 036

6^2 is written as 036-why?

Note: If the number of given exceeds the base, the difference from the base is to be added to the number to get first part of the square.

For eg: $108^2 = (108+8) / 8^2 = 11664$

$103^2 = 103+3 / 3^2 = 10609$

$1025^2 = (1025+25) / 25^2 = 1050,625$

Perhaps you now think that the base number should always be power of 10. In fact you can choose any convenient base. This is illustrating by the following example.

Let us find square of 21, Here we can take the base as 20 conveniently which is 2 x 10.

Number 21 = 20+1

The difference is the given number from the assumed base 20 = 21 – 20 = 1

Add this to the given number 21 + 1 = 22

Since the base 20 is 2 X 10, multiply 22 by 2 giving 44 this form the first part of the result.

The last part found as usual as $1^2 = 1$

Hence the square of 21 = 44, 1

$(21+1) \times 2, 1^2 = 44, 1^2 = 44, 1$

$22^2 = (22+2) \times 2, 2^2 = 48,4$

Similarly

$23^2 = (23+3) \times 2, 3^2 = 52,9 = 529$

$208^2 = (208+8) \times 2, 8^2 = 432, 64$

$209^2 = (209+9) \times 2, 9^2 = 436,81$

$307^2 = (307+7) \times 3, 7^2 = 942,49$

$54^2 = (54+4) \times 5, 4^2 = 290,16 = 2916.$

Recurring Decimals

If the divisor is a prime number other than 2 or 5, we get a recurring decimal. If the divisor of a fraction is a large prime number the division will become tedious and time consuming. But Vedic mathematics gives simple methods to find the recurring decimals.

For example, express 1/19 as recurring decimal. The denominator 19 is a prime number. The total number of recurring digits in this case is 18. To find this we can use the Sutra called " Ekadhikena Purvena", this means add one to the first part of the number . The first part of the number 19 is 1. Adding one to this gives us 2. Now, ignore 19 and divide by 2 .At every stage of division, the new dividend is formed by the remainder and the quotient and the process continues till we get the recurring number. The procedure is as follows.

When the number 1 is divided by 2, quotient is 0 and remainder is 1.

New dividend when divided by 2	Quotient	Remainder
10	5	0
05	2	1
12	6	0
06	3	0
03	1	1
11	5	1
15	7	1
17	8	1
18	9	0
09	4	1
14	7	0
07	3	1
13	6	1
16	8	0
08	4	0
04	2	0
02	1	0

The same number is repeated as recurring decimal.

Hence $\frac{1}{19} = .\dot{0}5263157894736842\dot{1}$.

A unique feature is that the last 9 digits of this number are complements from 9 of the first 9 digits.

This is evident as

	0 5 2 6 3 1 5 7 8	I half
	9 4 7 3 6 8 4 2 1	II half
Total	9 9 9 9 9 9 9 9 9	

The last digit of the recurring decimal is that number which when multiplied with the divisor will give a number ending in 9.

i.e. 19 x the last digit=..9.

Hence the last digit in this will be 1.

The same decimal form can be obtained by continuous multiplication form the last digit by 2 and carrying over as.

$$\frac{1}{19} = \text{...........}947368421$$

Here 1 x 2 = 2, 2 x 2 = 4,

4 x 2= 8, 8 x 2 = 16 Here 6 is written in the place and 1 is carriend forward as

6 x 2 + 1 =13 and so on.

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SPECIAL TOPIC-5

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 5 main types: Atmospheric or Air Pollution, Water Pollution, Soil and Landscape Pollution, Radioactive Pollution and Noise Pollution.

1. ATMOSPHERIC (AIR) POLLUTION

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

Causes of Air Pollution: Man is the

major cause of air pollution, but nature also contributes to it.

a) Man: Man has been polluting the air ever since he started using fire. Industrialization and invention of automobiles have speeded up the pollution of air. Overpopulation, deforestation, nuclear explosions and explosives used in wars are also contributing to air pollution.

b) Nature: Volcanic eruptions release gases that pollute the air. Pollution of air by volcanic eruptions in certain geological periods seems to have changed the earth's climate. Electric storms and solar flares produce harmful chemicals. Forest fires release harmful gases. Natural organic and inorganic decays release harmful dust and sulphurous gases. Dust storms are another factor in the pollution of air. Pollen, spores, cysts, bacteria and marsh gas are natural pollutants. Marsh gas (methane, CH_4) is a light, colourless inflammable hydrocarbon gas formed by decay of vegetable matter in marshy places and coalmines.

Atmospheric pollution existed before the evolution of man. Man has only aggravated the air pollution. It has been estimated that human activities contribute only a fraction. (Out of the total annual emissions of 1×10^{12} tonnes entering the earth, only 5×10^{8} tonnes are added by human activities (0.05%)) of the total annual emissions into the air.

Air pollution affects man, other animals, plants, building and climate. The various effects of air pollution are mentioned below.

1. Humans: The effect of particulate pollutants depends on the size of the particles. Particles larger than 2 mm are trapped in nasal hair and bronchial mucus, hence they are passed out. Smaller particles reach the lung alveoli with inhaled air. Here they may be engulfed by phagocytes or absorbed into the blood.

(i) Air-borne organic materials such as spores, pollen, bacteria, fungi, fur, feathers produce allergic reactions, bronchial asthma, emphysema, tuberculosis and lung cancer.

(ii) Dust and smoke particles and smog cause bronchitis, asthma and lung diseases. People living near thermal plants often contract these troubles. Soot and tobacco smoke are carcinogenic (cancer causing). Cotton dust causes lung fibrosis. The latter also affects the coal miners and flour mill workers.

(iii) The effect of gaseous pollutants depends upon their solubility in water, which allows their diffusion into the tissues.

(a) Sulphur dioxide causes drying of the mouth, sore throat and eye irritation. It may change the tissues by forming sulphuric acid.

(b) Sulphur trioxide, Nitrogen oxides and carbon monoxide combine with haemoglobin of the blood and reduce its oxygen- carrying capacity. Nitrogen oxide impairs the working of lungs by causing accumulation of water in the air spaces.

(c) Peroxy Acyl Nitrate causes irritation of eyes and throat and respiratory diseases (bronchitis, lung cancer).

(d) Hydrocarbons cause cancer.

(e) Carbon dioxide causes headache and nausea.

(f) Lead interferes in the formation of haemoglobin.

2. Animals: Domestic animals in and around industrial area are affected by air pollutants just like humans. Ingestion of fluorine compounds deposited from the air on fodder causes fluorosis (excessive calcification of bones and teeth), which leads to lameness, frequent diarrhoea and loss of weight. Microbes cause diseases in animals also.

3. Plants: Sulphur dioxide causes chlorosis, plasmolysis, membrane damage, metabolic inhibition and death. It does a great harm to forest trees. Fluorides and PAN damage leafy vegetables such as spinach and lettuce. Ozone and hydrocarbons cause premature yellowing and fall of leaves and flower buds, and discolouration and curling of sepals. Nitrogen oxides reduce yield of crops. Dust, smoke and smog reduce sunlight and form a thin layer on the leaves, thereby retarding photosynthesis. Microbes cause diseases in plants too.

Air pollution kills lichens, the hardy organisms. Death of lichens is a sure indicator of air pollution.

2. WATER POLLUTION

Definition: 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.

Causes of Water Pollution: Man is the main cause of water pollution. Some pollution occurs naturally too. Soil particles enter water by its erosion; minerals dissolve in water from rocks and soil; animal wastes and dead fallen leaves fall into water sources. Decaying of organic matter also pollutes water.

Water pollution has reached alarming proportions in the recent years in large cities and industrial areas. Surface water, underground water and sea water are all polluted to a greater or lesser extent.

A. Surface (Inland) Water Pollution

There are two types of sources of water pollution: point and diffusion. Flow of pollutants into water through regular channels (sewerage system) is called the point source. Passage of pollutants scattered on the ground into water is termed the diffusion source. Fertilizers and pesticides are the examples of such pollutants.

Types of Water Pollutants: Water sources (ponds, tanks, lakes, streams and rivers) receive 6 main types of pollutants: organic materials, pathogenic organisms, chemicals and minerals, radioactive wastes, solid particles, and heat.

B. Underground Water Pollution

Underground water is no more pure and safe, particularly in cities and industrial area. The common sources of underground water pollution are sewage and industrial effluents spilled over the ground; fertilizers and pesticides used in fields, refuse dumps, septic tanks, and seepage pits. The pollutants filter through the soil to enter underground water.

3. SOIL AND LANDSCAPE POLLUTION

1. Soil Pollution: Soil supports plants life, which in turn supports animal life. Hence, soil pollution affects all organisms. The process of soil formation is so slow that the soil may be regarded a non-renewable resource. This makes the problem of soil pollution more acute. However, the pollution of soil is generally limited to the field affected, unlike the pollution of air and water, which spreads to long distances.

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

Soil Pollutants: Substances that reduce productivity of the soil are regarded soil pollutants.

Types of Soil Pollutants (Sources of Soil Pollution): Many materials adversely affect the physical, chemical and biological properties of the soil and reduce its productivity. These include (i) chemicals, (ii) pesticides, (iii) fertilizers and organic manure, (iv) radioactive wastes, and (v) discarded foods, papers, clothes, leather goods, bottles, cans, plastics and carcases. Chemicals present in the industrial waste reach the soil directly with water or indirectly through air (acid rain). These include iron, lead, tin, copper, mercury, aluminium, zinc, cadmium, cyanides, acids, alkalies, etc. Pesticides are sprayed on crops to protect them from the pests. Fertilizers and manure are added to increase crop yield. Radioactive dust from mining and uranium processing finds its way into water and then into the soil. Discarded household materials are added by man.

Effect of Soil Pollutants: The chemicals and pesticides alter the basic composition of the soil. This may kill the essential soil organisms which contribute to structure and fertility of soil.The chemicals and pesticides may also make the soil toxic for plant growth. Many pesticides may also make the soil toxic for plant growth. Many pesticides or their degradation products are absorbed by plants and may reach animals and humans via food chains, and proved harmful. The use of inorganic fertilizers spoils the quality of the soil in the long run. Use of human and animal excreta (faeces and urine) as manure pollutes the soil besides promoting crop yield. Excreta may contain pathogens that contaminate the soil and vegetable crops and affect the health of man and domestic animals. However, biological pollutants play only a minor role in changing soil composition. Radioactive dust may find its way from the soil into crops, livestock and humans via food chains.

4. RADIOACTIVE POLLUTION

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

What is Radioactivity? Radioactivity is the property of certain elements (radium, thorium, uranium etc.) to spontaneously emit protons (alpha particles), electrons (beta particles) and gamma rays (electromagnetic waves of very short wave length) by disintegration of their atomic nuclei (Atomic nucleus is called nuclide). The elements that give off radiation as they disintegrate are said to be radioactive.

Types of Radioactive Pollution: Radioactive pollution is natural as well as man-made

(i) Natural (Background) Radiation: This includes the (a) cosmic rays that reach the earth from the outer space, and (b) terrestrial radiation from nuclides of radioactive elements present in the rocks, soil and water. These elements are radium 224, uranium 235, uranium 238, thorium 232, radon 222, potassium 40 and carbon 14. The background radiation is not a health hazard because of its low concentration. Man has been exposed to it since his appearance without any appreciable effect.

(ii) Man-made Radiation: Man-made sources of radioactive pollution include mining and refining of plutonium and thorium, atomic explosions (nuclear fall-out), atomic reactors and nuclear fuel, and preparation of radioactive isotopes.

5. NOISE POLLUTION

Noise pollution is the result of modern industrialized urban life and congestion. We are exposed for much of the time to annoying and often damaging sounds of industries (textile mills, printing presses, metal works); transport vehicles (scooters, motor-cycles, cars, buses, trucks, trains, jet planes); agricultural machines (tractors, harvesters, lawn mowers, tube-wells); defence equipment (tanks, artillery, rocket launching, explosions, shooting practices); domestic gadgets (pressure cookers, mixers, exhaust fans, desert coolers, air conditioners, vacuum cleaners); entertaining equipment (radios, record players, television sets); public address systems, and demonstrations. The operations, such as blasting, bulldozing, construction work, stone crushing etc., and use of crackers on festive occasions are other sources of noise.

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Special Topic-6

Some Salient Contributions of India

- India invented the number system. Zero was invented by Aryabhata.
- India never invaded any country in her last 1,000 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 pi 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 used number 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.
- Susrutha 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 equipments 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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Special Topic-7

8. Contributions of Indian Mathematicians

8.1 Indian Mathematicians - in brief

India had a glorious past in every walks of knowledge. Their contributions in medicine and architecture are well known since such works were directly dealt with the public. Indian systems of medicine like Ayurveda are now accepted by the public and the policy makers. Their architectural skill is visible in the innumerable structures of temples and palaces. However, the Indian contributions to Mathematics and Astronomy are not so well known. This section gives the famous contributors to the fields of Mathematics and Astronomy from Vedic to late medieval period.

The sulbakars

The sulba period was a period of specialization during the vedic period (before 200 BC) during which geometrical constructions occupied the central stage. Geometry was important in the construction of various types of Yaga vedis and fire alters. Along with the geometry Astronomy was also flourished since the proper times or muhurtas were fixed according to the positions of the heavenly bodies.

There were seven famous sulbakars namely,

Baudhayana, Apastamba, Katyayana, Manava, Maitrayana, Varaha and Hiranyakesi. The oldest of the sulbaksra was Baudhayana whos birthplace was in Andhra in south. His work Baudhyana-sulbasutra, in three chapters describes various geometrical constructions. His works include general enunciation of what is commonly known as the Pythagoras theorem and obtaining the square root of 2 correct to the five decimals.

The Sulbakar Apastamba also belonged to Andhra. He describes detailed descriptions of geometrical constructions

The Jaina sect of religion was wide spread during 500- 300 BC. The literature of Jaina is generally classified into four groups: 1) Dharmakathanuyoga (exposition of Principle of Religion 2) Ganitanuyoga (exposition of Mathematical principles 3) Samkyana (theory of numbers) and 4) Jyotisha (Astronomy). Umasvati (150 BC) of Kusumapura (ancient Pataliputra) near Patna was a famous Jain Mathematician. He belonged to a school originated by Jaina Saint Bhadrabahu (300BC). The culture of Mathematics and Astronomy were flourished in India during this period and for many centuries to follow. Aryabhata (5^{th} century AD) might have taken his lessons from the Jaina School.

Many Indian works were originated during this period. Eighteen siddhantas were composed after their respective authors. They are Surya, Patiamaha, Vyasa, Vasishta, Atri, Parasara, Kasyapa, Narada, Garga, Marichi, Manu, Angira, Lomasa, Paulisa, Cavana, Yavana, Bhrigu and Saunaka. However only five siddhantas are survived and remaining are lost. Of these Surya Siddhanta is famous. Paulisa Siddhanta, Romaka Siddhanta, Vasishta Siddhanta and Paitamaha Siddhanta are other survived works.

8.2 Mathematicians of Early Medieval Period (9 AD 400 to AD 1200)

Aryabhata I (Birth 476 AD)

Aryabhata belongs to Kodungallor near Ernakulam, Kerala. He had his education at Kusumapura near Patna. His famous book Aryabhatiya was written in 499 AD at the age of 23.

The approximate vale 3. 1416 of π

Aryabhata (India) in his Aryabhatiya (499 A.D.) states thus: "add 4 to 100, multiply by 8 and add 62,000; the result is approximately the circumference of a circle whose diameter is 20,000."

Appollonius (262 – 190 B.C.) of his Quick Delivery probably gave this value; Ptolemy (150 A.D.) used the value 377 / 120 in his Almagest.

Cube – root of an integer

Aryabhata in his Aryabhaitya (499 A.D.) gives the rule for the extraction of the cube root of a number. "As regards cube roots, we have so far no evidence of the method (given by Aryabhata) having been known earlier."

Liber Abaci (1202 A.D.) of Leonards Fibonacci or Leonaro of Pisa contains a chapter on square – roots and cube – roots.

Indeterminate equations of the first degree (known as linear Diophantine equation)

Aryabhata in his Aryabhatiya (499 A.D.) disucsses the method of solving (in integers) equations of the type:

$N = ax + c = by = d$ or $ax – by = k$.

Apparently the Indian mathematician Brahmagupta was the first one to give a general solution of the equation $ax + by = c$, where a, b, and c are integers. This was in 628 A.D. Brahmagupta knew that if a and b are relatively prime, all the integral solutions of the equation are given by $x = p + mb$, $y = q – ma$, where m is an arbitrary integer and $x = p$, $y = q$, a solution of the equation.

Diophantus (250A.D.) of Alexandria had been satisfied to give one particular solution of an indeterminate equation.

Varahamihira (505 - 587 AD)

Varahamihira was a native of Avanti and a student of his father Adityadasa. His original family came from Magadha. His work Panchasiddhantika is an exhaustive work in Astronomy. It describes five siddhantas namely Paulisa, Romaka, Vasishta, Surya and Paitamaha .

Bhaskara I (600 AD)

One does not know the native place of Bhaskara I. He was the most competent exponent of Aryabhat I. Mahabhakariya, Aryabhatiyabhashya, and Laghbhaskariya are his famous works.

Brahmagupta (628 AD)

Brahmagupta was the most prominent Indian Mathematician belonging to Ujjain School. His father's name was Jishnu. In 628 AD he wrote his magnum opus Brahmasphutasiddhanta at the age of thirty. He wrote the book Khandakhadyaka in 655 AD.

Diplomantine Quadratic equation $y^2 = 1 + px^2$ (named mistakenly for John Pell (1611 – 1685)

Brahmagupta solved the equations for p = 83 and 92.

The Indian mathematician Bhaskara (1114 – 1185 A.D.) solved the equations for p = 8, 11, 32, 61 and 67. For p = 61, he gave the solution x= 226, 153, 980 and y = 1, 776, 319, 049. This is an impressive feat in calculation, and its verification alone will tax the efforts of the reader.

Archimedes (287-212 B.C.) of Syracuse proposed the Cattle Problem, which involved the solution of the above equation for p = 26 and 30.

The identity $x^2 = (x-y)(x+y) + y^2$

Brahamgupta's *Brahma Sphuta Siddhanta* (628 A.D.) contains this.

This result was known to the Greeks and is called the formula of Nicomachus (c.100 A.D.) of Gerasa.

Area and Diagonals of a cyclic quadrilateral

The Indians Brhamagupta (628 A.D.) and Mahavira (850 A.D.) gave the following formulae for the area and diagonals of a quadrilateral:

Area $=\sqrt{(s-a)\ (s-b)\ (s-c)\ (s-d)}$, where a, b, c, d are the sides and s is the semiperimeter; and diagonals are

$\sqrt{(ab+cd)\ (ac+bd)\ /\ (ad+bc)}$ &

$\sqrt{(ac=bd)\ (ad+bc)\ /\ (ab\ +cd)}$

The formulae are correct only for the cyclic quadrilateral; both Brahmagupta and Mahavira do not mention this.

The first of these formulae was rediscovered by W. Snell, who gave it in his edition of Van Ceulan's works.

Brahmagupta was a bitter opponent of Aryabhata I. However, during his later years he recognized the merits of Aryabhata. His works were translated into Arabic during the 8th century AD.

Lalla (768 AD)

Lalla belonged to Kusumapura School and the son of Bhatathrivikrama, His Sisyaddhivardhida is a work in Astronomy in 100 Slokas. This contains important informations about trigonometry. He also wrote two books Patiganita and Siddhantatilaka, both of which are lost. Patiganita was a book of Mathematics while Siddhantatilaka was similar to Brahmasphutasiddhanta.

Govindaswamin (800 - 850 AD)

Govindaswamin who wrote commentary on Mahabhaskariya of Bhaskara I belonged to Kerala in Mahodayapuram . His work Govindakriti was a sequel to Aryabhatiya and is lost. His works have been quoted extensively by Sankaranarayana (869AD) and Udayadivakara (1073 AD) and Nilakantha.

Skandasena (beginning of 9th century)

Skandasena systematized methods of multiplications described in Patiganita. He also gave geometrical interpretations of arithmetic series. However his works are lost.

Mahavira (850 AD)

Mahavira, a famous Jain Mathematician wrote Ganitasarasangraha which is considered to be a brilliant work. He had associations with the school of Mysore and lived in the court of Rastrakuta monarch in Mysore. He showed ability in arithmetic and geometrical series as well as in permutations and combinations. He dealt with quadratic equations and indeterminate equations.

Mahavira is, perhaps, the world's first mathematician to give the general formula

nCr = [n(n-1)(n-2) ....

(n-r+1)] / 1.2.3 ....r

This occurs in verse 218 of his *Ganita Sara Sangraha* (850 A.D.)

Sridhara (850 - 950)

We are not sure of the native place of Sridharachrya. Most probably he belonged to south India. He dealt with multiplication, division, square, cube, square–root, cube root etc. He for the first time gave a rule of extraction of roots of quadratic equations and is called Sridhara's formula.

Aryabhata II (950 AD)

Aryabhata II wrote Mahasiddhanta in 18 chapters which describes three branches of mathematics namely, pati, kuttaka and bija. He advised corrections in the treatment of solutions of simultaneous indeterminate equations. The subject kuttaka made popular by Aryabhata II

Sripati (1039 AD)

Sripati was a Jaina Mathematician and Astronomer. He wrote Ganitatilaka, Siddhantashekhara and Bijaganita. His book Bijaganita is lost. Ganitatilaka deals with arithmatics and Siddhantashekhara contains Astronomy and algebra vyaktaganitadhyaya and Avyakta-ganitadhyaya.

Bhaskara II or Bhaskaracharya (1114 - 1200 AD)

Bhaskaracharya belonged to Bijalabida in Modern Karnataka . He had association with Ujjain School. His fame rests on three books Lilavati, Bijaganita and Siddhantasiromani. He also wrote a commentary on Siddhantasiromani called Vasanabhashya and a treatise on planetary motion called karanakuthuhala. He wrote Siddhantasiromani when he was 36 years old. This work contains the result

Sin (A+B) = sin A cos B + cos A sin B.

Narayana Pandita (1356 AD)

He was a pure Mathematician and developed a number of techniques to handle infinite series .His book Ganitakaumudi contains a number of innovative techniques in Arithmatics and algebra.

Madhava (1400 AD)

Madhava was one of the well known Mathematician who wrote a tratise called Venvaroha. He was an authority in spherical astronomy and was known as golavid 9 expert on spherical mathematics). Madhava belongs to Samgama Village (Irinjlakkuda) in Kerala. He is famous for the correct determination of the value of pi as infinite series. It is now called Madhava-Gregary Series.

Parameswara (1430)

Parameswara belonged to asvathagrama (Alattur Village) in Kerala. His house vatasseri was on the bank of the river Nila (Bharatapuzha). He was the founder of drgganita system of Astronomy. He wrote commentaries on all the popular classical works on astronomy and mathematics. His commentaries are Bhatadipika (on Ayabhatiya), Parameswari (on Laghubhaskariya, Siddhantadipika or Karmadipika (on Mahabhaskariya), vivarana (on Suryasiddhanta) and Vyakhya (on Lilavati).

Nilakantha Somayaji (1443- 1543)

Nilakantha was from Trikkantiyur near Tirur of Kerala. His famous works are Aryabhatiyabhashya and Tnatrasamgraha. He was a student of Damodara, son of Parameswara. He also wrote Golasara and Chandracchayaganita.

Chitrabhanu (1475 - 1550), Sankara Variyar (1500 - 1560), Jyeshtadeva (1500 - 1600), Achyuta Pisharoti (1550 - 1621), Munisvara (1603), Kamalakara (1616 - 1700).

8.3 Aryabhata Misunderstood

Aryabhata the famous Mathematician-Astronomer wrote Aryabhatiya in 499 AD. In this book he developed necessary mathematics for explaining some of the astronomical phenomena.

Aryabhata was misunderstood by later interpreters due to errors in translation from the Sanskrit text. The finer aspects of Sanskrit grammar make this language a great one. If the text is not properly analyzed one will reach to erroneous conclusions. This was what happened with the interpretation of some of the formulae given by Aryabhata. Even some of the famous commentaries of Aryabhatiya say that Aryabhata was wrong when he gave formulae for volume of a pyramid and sphere. In the following section we show how these conclusions were reached.

The second part of Aryabhatiya contains a verse (verse 6)

Tribhjasya phalasarira
samadalakotibhujardhasamvargah
Urdhvabhujatatsamvargardham sa
ghanah sadasrir iti

Interpretation: Half (ardh) the product (samvargah) of the base (bhuja) and the height (koti) of an equilateral (samadala) triangle (tribhuja) forms the area (phala) of the solid (sariram) formed. Half (ardha) the product (samvaga) of this (area)and the perpendicular (urdhvabhuja) or the height is the volume (Ghana) of the solid with six edges (sadasri) or triangular pyramid.. This popular interpretation gives the formula for the volume as ¼ bh^3, which is obviously incorrect.

Commentators like Kurf Effering and Conrad Muller gave following interpretation:

Half the product of the base and the height of an equilateral triangle forms a solid by its area. Half the product of this area and the perpendicular of the solid forms a rectangular solid whose volume is equal to six (sad) pyramid (asri).

In the first interpretation, sadasri is taken as six-edged solid while in the second analysis it is split into sad (six) and asri (peak) or pyramid.

The triangular pyramid is made by dividing an equilateral triangle and folding up the three peripheral triangles over the central one. The total surface area of the pyramid is equal to area of the original triangle. Six such pyramids took together will have a volume equal to half the product of the original triangle and the height of the pyramid. Aryabhata describes in various contexts the volume of pyramid which give correct results. One wonders why even famous commentarians mistook the meaning of the verse.

Second example is about the volume of a sphere. This also is due to misinterpretation of the word nijamula in the verse. Nijamula is taken by the majority interpreters as nijamula which is square root and volume of the sphere is Öp p R^3 instead of 4/3 p R^3 . However Effering interprets nijamula as own base and in the present context is radius R. Then the verse deals with curved area of a hemisphere and is given by the correct formula $2pR^2$.

The two examples shown above proves the fact that in order to understand ancient Indian text of Mathematics or Philosophy one should be expert in both the subject as well as in the Sanskrit. Such combinations are rare.

8.4 Numbers - How Large and how Small

Indian contributions to science and technology date back to antiquity. Human interactions with the external world necessitated the treatment of large and small numbers. For example duration of a yuga or the size of an atom demanded numbers of unimaginable magnitude. It was the time when the Greeks did not have number-names beyond myriad (10^4 – then thousand) while Romans did not go beyond Mille (thousand).

Indians described numbers to the power of ten systematically attributing names to each. These names appear in old texts like Vedas, upanishads, puranas etc. Ofcourse there seems to have no unique names for some large numbers, Yajurveda, and thaithariya upanishads describes following numbers in powers of ten:

Ekam	1	10^0
Dasam	10	10^1
Satham	100	10^2
Sahasram	1000	10^3
Ayutham	10,000	10^4
Niyutham	100,000	10^5
Prayutham	1000,000	10^6
Arbudam	10,000,000	10^7
Niarbudam	100,000,000	10^8
Samudram	1000,000,000	10^9
Madhyam	10,000,000,000	10^{10}
Anthyam	100,000,000,000	10^{11}

Pancavimsa Brahmana uses names nikharvam, vadavam and akshiti after niarbudam. Samkyana Sutra attributes names nikharvam, samudram, salilam, anthyam and anantham after niarbudam. In the Indian Epic Ramayana Suka, the spy of Ravana, describes the size of Rama's army as

$10^{10} + 10^{14} + 10^{20} + 10^{24} + 10^{30} + 10^{34} + 10^{40} + 10^{44} + 10^{52} + 10^{57} + 10^{62} + 5$ men !

In Lalithavisthara, a Buddhist text , Bodhisatva recites numbers as powers of hundreds beyond koti (0ne crore , 10 million) as follows:

100 koti	=	1 ayutham
100 ayutham	=	1 niyutham
100 niyutham	=	1 kunkaram
100 kunkaram	=	1 vivaram
100 vivaram	=	1 kshobhyam
100 kshobhaym	=	1 vivaham

the number 1 vivaham will be 10^{19} or 19 zeros after 1! Lalithavisthara goes on giving names to still higher numbers beyond vivaham as ulsangam, bahulam, nagabalam, thidilambham, vyavasthan-prajnabdhi, hethuvila, kamahu, hethwindriyam, samapthalambham, gamgagathi, thiravadyam, mudrabalam, sarvabalam, visajnagathi, sarvajnam, vibhuthangamam and thallakshanam. It can be seen that 1 thallakshanam will be 10^{53} or 53 zeros after the digit 1!

Anuyogadwarasutra mentions a number shirshaprahelika which is 10^{140} Sreedhara names the powers of ten as ekam, dasam, satham, sahasra, ayutham, laksham, prayutham, koti, arbudam, abjam, kharvam, nikharvam, mahasarojam, sanku, sarithapathi, anthyam, madhyam and parardham. Parardham is 10^{17}

According to Mahavira number names are ekam, dasam, satham, sahasram, dasasahasram, laksham, dasalaksham, koti, dasakoti, sathakoti, arbudam, niarbudam, kharvam, mahakharvam, padmam, mahapadmam, kshoni, mahakshoni, sankham , mahasankham, kshiti, mahakshiti, kshobham and mahakshobham. Mahakshobham is 10^{23}.

Famous textbook of Mathematics, Leelavathi, written by Bhaskaracharya gives the most popular names for the eighteen place values through the following quartet-

Ekadasasatha sahasrayutha
lakshaprayutha kotaya: kramasa:
Arbudamabjam kharvanikharva
mahapadma sankuvasthamath
Jaladhischanthyam madhyam
pararthamithi dasagunothara: sajna:
Samkhyaya: sthananam
vyavahararartham krutha: purvai:

One of the problems in understanding the place values as described above is the nonuniformity in naming them. Sometimes this will create some hurdles in the proper description of the ancient texts. The classic example is the definition of the unit of distance yojana. Under various contexts, one yojana has different definitions like four, six, nine, ten, twelve kilometers.

The large numbers were used by our ancients to describe the cosmology and vastness of space and time. Jains and Buddhists were quite at home in handling large numbers. Jains have a measure of time called Purvis which is equal to $750X0^{11}$days (or 750 niarbudam days). Then one sirsha prahelika =($8400000)^{28}$ purvis which is number of 194 digits! The text Anuyogadwarasutra indicates the world population as 2^{96} which is a number of 29 digits.

What about small numbers? One does not have much information about it. However, Kerala had a system of description of small numbers which were in daily use till about two generations ago.

Ara (half)	=	½
kal (quarter)	=	¼
arakkal - (half quarter)	=	1/8
makani	=	1/16
mavu	=	1/20
kani	=	1/80
munthirika	=	1/320
keezhkal	=	1/320 (¼) = 1/1280
keezhmavu	=	1/320(1/20) = 1/6400
keezhkani	=	1/25600
keezhmunthirika	=	1/102400

Thus the prefix keezh will provide 1/320th number like the modern use of milli which is 1/1000th of a number.

Immi	=	1/21 (1/102400)
Anu	=	1/21 Immi

Thimirima = 1/22 anu
Thalavaravu = 1/22 anu
Chathuranu = 1/51 thalavaravu

One can see that one chathuranu is 10^{-12}

It is quite surprising that Indians were handling numbers of such a large dynamical range from 10^{-12} to 10^{140} that too with respective nomenclature. One need not wonder since our forefathers were contemplating on universe from micro to macro scales – from the size of an atom to the size of the whole universe!

8.5 Sulba Sutras- Indian Contribution to Geometry

Indians were concentrated on higher studies of astronomy and algebra. They devised geometry to support astronomical calculations as well as the construction of Yaga alters. In ancient days geometrical constructions were made using thread (sulba) based on established sutras or formulae. This is the origin of the field Sulba Sutra. Later on it was changed to Rekha ganitham or diagrammatic mathematics. Essentially SS contains methods of constructing various types of yaga vedi or pooja alter with complicated patterns. SS is an important component of Yajurveda which describes the detailed construction technique of yagavedi. Famous SS mathematitians are Baudhayanan, Apasthambhan, Kathyayanan and Maithrayanan of which Baudhayana's work contains more rigorous mathematical treatments. Baudhayana Sulbasutra contains three chapters and 525 formulae and constructional details of complicated yagavedis. It also describes the shapes of individual tiles to be used for such constructions.

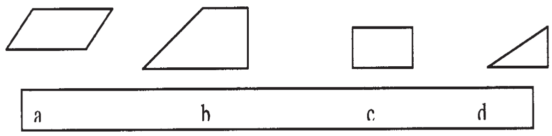
Areas and shapes of yagavedi should be strictly adhered to the rules similar to the accuracy of mantra chanting.

What are the geometrical problems arising out of the design of yagna and pooja vedis? One may have to construct alters of different shapes but of equal or multiples of a basic value of area. For example it was believed that an emperor who conducted 101 ashwa medha yaga are unvincible even by god. When yaga is repeated, each time the yagavedi and pooja alter should get enhanced by a fixed amount by modifying the dimension of the vedi. This is an important geometrical problem.

One of the shapes of a yaga vedi has a shape of a falcon with stretched wings and tail. The first layer of this vedi contains 136 bricks of four shapes as shown below:

Concept of Surds

Indeterminate numbers like $\sqrt{2}$ are called surds. For example the hypot-



enuse of an isosceles right angled triangle of sides unit magnitude is $\sqrt{2}$. Indians called such numbers as karani. An achievement of SS is the formula for evaluating the Ö2.

They gave the value as

$$\sqrt{2} = 1 + 1/3 + 1/(3X4) - 1/(3X4X34)$$

Paythagoras Theorem

Pythagoras theorem is well known relationship between three numbers as

$A^2 + B^2 = C^2$ and the three numbers are called Pythagorian triplets. Examples are 3, 4, 5; 5, 12, 13; 8, 15, 17 etc. In fact this fact was known well before Pythagoras (lifetime ~ 540 BC) to Indian mathematicians.

8.6 Laws of indices and logarithms

Jains and Buddhists were fond of large numbers. In famous work Anuyogad-varasutra infinity with different dimensions are noted. To generate large numbers they used raising of a number with itself and was called varga samvargita.

For example

The first samvargita varga of a = $a^a=b$

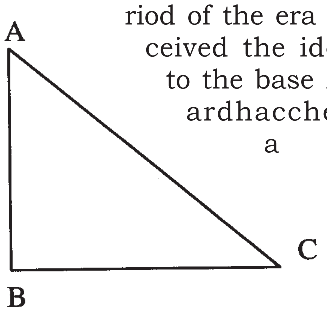
The second samvargasamvargita of a = $b^b==c$

The third samvarga samvargita of a = c^c

For example the third samvargita of 2 becomes 256^{256} a number higher than the total number of electrons in the whole universe. Jaina authors during 300 BC devised rules of indices what is now called the laws of indices like

A^m X a^n = a^{m+n}

We know that 23 = 8. This was denoted by Napier (1550-1617) through logarithm as Log^z 8 = 3. During the period of the era of BC Jains conceived the idea of logarithms to the base 2, 3 and 4 called ardhaccheda, trikccheda and caturthaccoheda. Log log x is known as vargasalaka of x.



However, Indians did not develop logarithams further. This may be due to the fact that Indians had techniques to handle large numbers without the concept of logarithms. The main use of logarithm is to handle the calculations using large numbers.

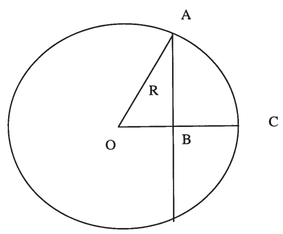
Trignometric ratios are familiar in school mathematics.

In the given right angled triangle ABC

BC/ AC = sin A

AB/ AC = cos A

BC/ AB = tan A



Nobody might have thought of the literal meaning of the terms sine, cosine. If there are few, they might have attributed them to some nonsensical words used by eccentric Mathematicians. In fact it was Aryabhata who introduced the specific names for such trigonometric ratios while describing a method to evaluate length of a chord in a circle using its radius.

Jay A = AB = R Sin A
Kojya A = OB = R Cos A
Utkramajaya A = BC = R (1 - Cos A)
= R Versin A
Jay, Kojya and Utkramajya were used extensively by Indians to develop Geometry and Astronomy.
They also calculated the trigonometric ratios for any angle derving standard relationship.

Chord of a circle is jya, arc is chapa, diameter is vyasa and radius is vyasardha. OA is vyasardha or radius, AB is ardhajya or half -chord length and AC is chapa or arc. From the diagram it is clear that AB = ardha jya = OA sin O or R sin O where OA is radius R. Obviously length of the chord decreases as the angle O subtended by the arc AC. Aryabhata tabulated values of ardha jya for various values of the angle O based on a sloka or quartet. Thus ardha jya is the modern R sin O. Thus sin O is jya of a circle of unit radius.

Later on ardha jya was replaced by simply jya. Another name for jya is jiva. When jiva was transliterated by Arabs it became jiba. This word does not have any meaning in Arabic language and hence it was changed to jaib which means bay or inlet. When the work was translated to Latin name sinus was used which means bay . Thus the name sine came into existence. Note how the meaning has been completely changed during translation. Chord became bay!!. Cosine is Kojya.

Division of a Circle

Circle and its properties were important topics for Indians in the context of Astronomy. They devised twelve zodiac signs along with the Sun travels with the earth as the center. To describe the movement of sun accurately along the zodiac sign, the circumference of the circle was divided in two ways.

Method I

Circumference = 1 rasis
1 rasi = 30 bhagas or amass
1bhaga = 60 kalas or liptas
1 kala = 60 vikalas

In modern terminologies, 1 bhaga is 1 degree, 1 kala is 1 minute and 1 vikala is 1 second This means that 1 bhaga of arc of a circle of unit radius will subtend 1 degree of angle at the center.

Method II

Circumference = 21,600 (=360X60) ilis
1 ili = 60 vilis
1 vili = 60 talparas
1 talpara= 60 pratalparas

Radius of a circle in terms of ilis is 3437 ilis, 44 vilis, 48 talparas and 22 pratalparas or

In katapayadi system it is remembered as Sresto devo visvasthali bhrgu

Which means 3437,44,48,22. each comma separatesilis, vilis, talparas and pratalparas. Note that ili and vili are same as kala and vikala.

The radius 3437,44,48,22 corresponds to 57 degrees, 17 min. and 44.8sec. which is 1 radian according to modern terminology.

8.7 Keralese Calendar

Here we take a detour. The year 825 A.D. was a historic one for Keralese astronomers. By mid-August of the year a new era was launched. It is called Kolla – varsham in Malayalam and Malabar Era (abbreviated M.E. in English). Ravi Varma Kulasekharan was the Cera king at that time. He was a mathematician and the author of a mathematical treatise. According to some researchers, an additional era called Parasurama Era commenced in 1176 B.C. Stray references to this era occur in some works; details of the mode of reckoning and applications are not available.

Ancient astronomers of many civilizations observed that the moon and planets were never at very great angular distances from the ecliptic (apparent annual path of the sun); They imagined a belt in the sky extending to eight degrees on either side of the ecliptic and called it the zodiac. Twelve groups of stars or constellations were spotted in zodiac. Twelve groups of stars or constellations were spotted in zodiac; further they noticed that the sun took a month to 'traverse' each constellation. The constellations were named according to their shapes as Aries (ram), Taurus (bull), Gemini (twins), Cancer (crab), Leo (Lion), Virgo (virgin), Libra (scale), Scorpio (scorpion), Saggitarus (archer), Capricornus (goat), Aquarius (water-bearer) and Pisces (fish). These are known as 'signs of the zodiac'. We come across this list, with some variations, is several civilizations. Some countries adopted these 'signs' as names of the twelve months of the year, Kerala was one, as the following table shows.

An analysis of Keralese calendar for 105 years (0161 M.E. to 1165 M.E) gives average durations of different months as follows:-

Name of month Keralese Calendar	meaning of the word denoting Calendar	Duration in name of month	Gregorian days (correct to 2 dec. places)
August	Chingam	Lion	31.03
September	Kanni	Virgin	30.46
October	Tulam	Scale	29.93
November	Vrishcikam	Scorpion	29.54
December	Dhanu	Bow	29.39
January	Makaram	Sea-monster	29.49
February	Kumbham	Water-pot	29. 83
March	Meenam	Fish	30.35
April	Medam	Ram	30.90
May	Edavam	Bull	31.33
June	Mithunam	Twins	31.58
July	Karkatakam	Crab	31.42
August			
			365.25

Note the variations of words : ‘bow’ for ‘archer’, ‘sea-monster’ for ‘goat’ and ‘water-pot’ for ‘water-bearer’

Keralese term ‘sign’ is rasi. Each rasi was, to them, an arc of a circle facing an angle of 30 degrees at the center. They calculate the time of ‘entry’ of the Sun in each rasi. The interval between the times of entry into two consecutive rasis is a (theoretical) month. The ‘entry’ into a rasi can occur at any time of the day but a month cannot. For practical purposes they have to follow some conventions. One is that a month begins on a day if the ‘entry’ takes place before noon, otherwise the next day. Table given below shows average durations of ‘theoretical months’ calculated by Keralese astronomers. Calculation is too involved and elaborated to be included here. This table was supplied by an eminent calendar maker Prof. P.U. Krishna Variyar of Kottayam, Kerala, to whom thanks are due. The durations are subject to an error of up to 9 minutes because of perturbations:-

Name of	Days month	hours	minutes	Days (in decimals)
Chingam	30	23	51	30.99375
Kanni	30	11	48	30.49166
Tulam	29	23	38	29.98472
Vrishikam	29	14	31	29.60486
Dhanu	29	10	39	29.44375
Makaram	29	12	59	29.54097
Kumbham	29	20	58	29.87361
Meenam	30	08	38	30.35972
Medam	30	21	02	30.87638
Edavam	31	06	44	31.28055
Mithunam	31	10	57	31.45625
Karkatakam	31	08	24	31.35000
	365	06	09	365.25622

Both tables show that five consecutive months Tulam, Vrischikam, Dhanu Makaram and Kumbham each has less than 30 days on the average and that seven months Meenam, Medam, Mithunam, Karkatakam, Chingam and Kanni each has more than 30 days on the average (a majority close to or more than 31 days); moreover the tables show that the durations of months increase from Dhanu to Mithunam and then decrease from Mithunam to Dhanu, completing a cycle every twelve months.

Now we can explain this phenomenon invoking the first two laws of planetary motion enunciated by Kepler (1571-1630 A.D.) namely : (i) each planet moves in an elliptical orbit with the sun at one of the foci and (ii) the straight lines drawn from the sun to a planet (i.e., the planet’s radius vector) sweeps equal areas in equal times. How did Keralese astronomers design such a calendar, more than seven centuries before Kepler?

Al-bruni, celebrated mathematician and astronomer, came to India in the wake of the invading forces of Mahmud of Ghazni in the eleventh century. His Enquiry into India, popularly known in its original Arabic version as Tarikhu’l hind, is erudite and, as a historical chronicle of its kind, a classic. There is much in this chronicle that reads like fiction, while being at the same time an objective records of the history, character manners and customs of India of that time. Al-biruni’s position in the court of Sultan Mahmud is not quite clear. He was some sort of a hostage, but an honoured one because of his scholarly attainments, particularly his high reputations as an astronomer and astrologer. However, his relations with Sultan Mahmud do not seem to have been very close or cordial. His famous work on India was prepared during the reign of Sultan Mahmud (around 1030) but he refers to the Sultan only on a few occasions and that too very tersely.)

Al-biruni's long account is divided into eighty chapters, each with a sub-heading indicating the topic or topics to which it relates. The first chapter is an introductory one in which Al-Biruni discusses the difficulties (difference of language, religious and racial prejudices, etc.) one had to face in preparing a dispassionate account of the Indian society, and explains the methodology adopted by him. This is followed by chapters on Religion and Philosophy (II-VIII), Social Organisation, Civil and Religious laws, Iconography (IX-XI), Religious and Scientific Literature (XII-XIV, XVI), Metrology, Weights and Measures, Alchemy (XV, XVII), Geography, Cosmography, Astronomy, Chronology and related subjects (XVIII-LXII), Social Life, Manners and Customs, Festivals, etc. (LXIII-LXXIX), and Astrology (LXXX).

I have studied the names of the orders of the numbers in various languages with all kinds of people with whom I have been in contact and have found that no nation goes beyond the thousand. The Arabs, too, stop with the thousand, which is certainly the most correct and the most natural thing to do. I have written a separate treatise on this subject.

Those, however, who go beyond the thousand in their numeral system are the Indians, at least in their arithmetical technical terms, which have been either freely invented or derived according to certain etymologies, whilst in others both methods are blended together. They extend the names of the orders of numbers until the 18th order for religious reasons, the mathematicians being assisted by the grammarians with all kinds of etymologies.

The 18th order is called Paradha, i.e. the half of heaven, or more accurately, the half of that which is above.....

The following are the names of the eighteen orders of numbers:-

1. Ekam
2. Dasan
3. Satam
4. Sashasrm
5. Ayuta
6. Laksha
7. Pryuta
8. Koti
9. Nyarbuda
10. Padma
11. Kharva
12. Nikharva
13. Mahapadama
14. Sanku
15. Samudra
16. Madhya
17. Antya
18. Parardha

So Brahamagupta says: "Scholars have declared that the globe of the earth is in the midst of heaven, and that Mount Meru, the home of the Devas, as well as Vadavamukha below, is the home of their opponents; the Daitya and Danava belong to it. But his below is according to them only a relative one. Disregarding this, we say that the earth on all its sides is the same; all people on earth stand upright, and all heavy things fall down to the earth by a law of nature, for it is the nature of the earth to attract and to keep thins, as it is the nature for it is the nature of the earth to attract and to keep things, as it is the nature of water to flow, that of fire to burn, and that of the wind to set in motion. If a thing wants to go deeper down than the earth, let it try. The earth is the only low thing, and seeds always return to it, in whatever direction you may throw them away, and never rise upwards from the earth."

Varahamihira says: "Mountains, seas, rivers, trees, cities, men and angels, all are around the globe of the earth. And if Yamakoti and Rum are opposite to each other, one could not exist. How could one say of one place of the earth that it is low, as it is in every particular identical with any other place on earth, and one place could as little fall as any other ...... For the earth attracts that which is upon her, for its is the below towards all directions, and heaven is the above towards all directions."

It is perfectly known to the Indian astronomers that the moon is eclipsed by the shadow of the earth, and the sun eclipsed by the moon. Hereon they have based their computations in the astronomical handbooks and other works.

[Extracts form Varahamihira's Samhita are quoted regarding the explanations for the phenomena of solar and lunar eclipses. Varahamihira is quoted as stating that "an eclipse of the moon is her entering the shadow of the earth, and an eclipse of the sun consists in this that the moon covers and hides the sun from us. Therefore the lunar eclipse will never revolve from the west, nor the solar eclipse from the east."]

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1. The Golden Age of Indian Mathematics (1998), S. Parameswaran, Swadeshi Science Movement, Cochin.
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❄❄❄

Special Topic 8

Atomic Energy in India

Homi Jahangir 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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