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SCIENCE & TECHNOLOGY

for Civil Services Exam

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SCIENCE & SOCIAL TRANSFORMATION

■ Science, Technology & Its importance in various Spheres of Society

- The words science and technology are often used interchangeably. But the goal of science is the **pursuit of knowledge for its own sake**, while the goal of technology is to **create products that solve problems** and improve human life. Simply put, **technology is the practical application of science**.
- One of the most important aspects of Science and Technology is that it has solution to the difficult of the difficult problems, the problems which have the potential to become major bottlenecks to the overall growth of the country. Some of these problems could be:
 - ▶ Health aspects
 - ▶ Standard of education
 - ▶ Availability of healthy food and safe drinking water
 - ▶ Infrastructure
- On the other hand, once mitigating solutions are found for these problems, then the second major issue is the under-development in the field of scientific research and technology that directly affects the development of the country's economy, infrastructure, higher education, and a few other fields listed below:
 - ▶ Development of nuclear technology
 - ▶ Defense technology
 - ▶ Development of satellites
 - ▶ Biotechnology
 - ▶ Meteorological science
 - ▶ Space technology
 - ▶ Nanotechnology
 - ▶ Wireless communication, etc.
- All these technologies, in turn, provide favorable conditions for the country's growth and increase healthy competition nationally and also internationally.

■ Science in everyday life

- **Science made communication possible**
 - ▶ Have you ever wondered how different our life will be **without** the mobile phones, landlines and internet services that we use today? GPS systems, telephone, telefax, laptops, etc. everything is a gift of science and

there is no way we can imagine our life without these. **New forms of communication like social media (fb, twitter, instagram etc.)** have helped us connect to international community. All these inventions of science has brought the world close to us and has made the sharing and transfer of information possible from one corner of the world to another.

◉ In the field of medicine

- ▶ We know that the advancement in science is the reason why today we have found the cure for millions of diseases and ailments. **Heart transplants, surrogacy, organ transplant, MRI scan** etc. and various such critical medical procedures are only possible due to science and its innovations. Doctors can see the inside of our body with the help of X- ray which is yet another notable discovery of science.

◉ Source of energy

- ▶ The discovery of atomic energy, wind, solar geothermal and tidal energies have made it possible for us to invent all the advanced forms of energy that we use in our everyday life. Electricity is also a result of this innovation which has given man the power to turn his nights into days and hence work for longer hours. The television and radio that provide us with entertainment and relaxation are **also gifts of science**.

◉ Each and every machine that we use

- ▶ Starting from a simple calculator to using high end home appliances, science is a part of our existence. Starting from the time when we wake up using an alarm clock to the time when we hit the bed at night, each and everything we do in office and at home involved the use of science.

◉ Kids playing in the playground

- ▶ The flying of a simple kite involves science in the fact that it involves the angle of elevation, speed as well as distance.

◉ Cooking also involves science

- ▶ An ice cube that we make at our homes is a perfect example of melting as well as freezing. The processes of evaporation and condensation involved in cooking are also a proof that science is all around us.

◉ Wastage of food is also science

- ▶ So, you have left a piece of bread and mould formation takes place on it. Or let us talk about tinned peas, pineapples, peaches, etc. This decomposition and preservation phenomenon is also science.
- ▶ Whether you believe it or not, even the blowing of wind involves an essence of science in it.

■ Science & Technology in Ancient and Medieval India

- ◉ Science and Technology in ancient and medieval India covered all the major branches of human knowledge and activities, including mathematics, astronomy, physics, chemistry, medical science and surgery, fine arts, mechanical and production technology, civil engineering and architecture, shipbuilding and navigation, sports and games.
- ◉ Ancient India was a land of sages, saints and seers as well as a land of scholars and scientists. Ancient India's contribution to science and technology include:
 - ▶ **Mathematics** - Vedic literature is replete with concepts of zero, the techniques of algebra and algorithm, square root and cube root. Arguably, the origins of Calculus lie in India 300 years before Leibnitz and Newton.

- ▶ **Astronomy** - Rig Veda (2000 BC) refers to astronomy.
- ▶ **Physics** - Concepts of atom were explicitly stated by an Indian Philosopher around 600 BC.
- ▶ **Chemistry** - Principles of chemistry did not remain abstract but also found expression in distillation of perfumes, aromatic liquids, manufacturing of dyes and pigments, and extraction of sugar.
- ▶ **Medical science & surgery** - Around 800 BC, first compendium on medicine and surgery was compiled in ancient India.
- ▶ **Fine Arts** - Vedas were recited and recitation has to be correct, which gave rise to a finer study of sound and phonetics. The natural corollary were emergence of music and other forms of performing arts.
- ▶ **Mechanical & production technology** - Greek historians have testified to smelting of certain metals in India in the 4th century BC.
- ▶ **Shipbuilding & navigation** - Sanskrit and Pali texts have several references to maritime activity by ancient Indians.
- ▶ **Sports & games** - Ancient India is the birth place of chess, ludo, snakes and ladders and playing cards.

Was scientific temper part of our ancient society?

■ Mathematics

- Mathematics represents a very high level of abstraction attained by human brain. In ancient India, roots to mathematics can be traced to Vedic literature, which are around 4000 years old. Between 1000 BC and 1000 AD, a number of mathematical treatises were authored in India.
- **Will Durant**, American historian (1885-1981) said that **India was the mother of our philosophy of much of our mathematics.**
- It is now generally accepted that India is the birth place of several mathematical concepts, **including zero, the decimal system, algebra and algorithm, square root and cube root.** Zero is a numeral as well as a concept. It owes its origin to the Indian philosophy which had a concept of '**sunya**', literal translation of which is 'void' and zero emerged as a derivative symbol to represent this philosophical concept.
- Geometrical theories were known to ancient Indians and find display in motifs on temple walls, which are in many cases replete with mix of floral and geometric patterns. The method of graduated calculation was documented in a book named "Five Principles" (Panch-Siddhantika) which dates to 5th Century AD. A. L. Basham, an Australian Indologist, writes in his book, **The Wonder That was India that** "... the world owes most to India in the realm of mathematics, which was developed in the Gupta period to a stage more advanced than that reached by any other nation of antiquity.
- The success of Indian mathematics was mainly due to the fact that Indians had a clear conception of the abstract number as distinct from the numerical quantity of objects or spatial extension.
- Algebraic theories, as also other mathematical concepts, which were in circulation in ancient India, were collected and further developed by Aryabhata, an Indian mathematician, who lived in the 5th century, in the city of Patna, then called Pataliputra. He has referred to Algebra (as Bijaganitam) in his treatise on mathematics named Aryabhattiya.
- Another mathematician of the 12th century, Bhaskaracharya also authored several treatises on the subject - one of them, named Siddantha Shiromani has a chapter on algebra. He is known to have given a basic idea of the Rolle's theorem and was the first to conceive of differential calculus.
- In 1816, James Taylor translated Bhaskaracharya's Leelavati into English. Another translation of the same work by English astronomer Henry Thomas Colebruke appeared next year in 1817.

- The credit for fine-tuning and internationalizing these mathematical concepts - which had originated in India - goes to the **Arabs and Persians. Al-Khwarizmi**, a Persian mathematician, developed a technique of calculation that became known as "algorism." This was the seed from which modern arithmetic algorithms have developed. Al-Khwarizmi's work was translated into Latin under the title *Algoritmi de numero Indorum*, meaning The System of Indian Numerals. A mathematician in Arabic is called *Hindsa* which means from India.
- The 14th century Indian mathematician Madhava of Sangamagrama, along with other mathematicians of the Kerala school, studied infinite series, convergence, differentiation, and iterative methods for solution of non-linear equations.
- Jyestadeva of the Kerala school wrote the first calculus text, the *Yuktibhasa*, which explores methods and ideas of calculus repeated only in seventeenth century Europe.

■ Astronomy

- Ancient India's contributions in the field of astronomy are well known and well documented. The earliest references to astronomy are found in the Rig Veda, which are dated 2000 BC. During next 2500 years, by 500 AD, ancient Indian astronomy has emerged as an important part of Indian studies and its affect is also seen in several treatises of that period. In some instances, astronomical principles were borrowed to explain matters, pertaining to astrology, like casting of a horoscope. Apart from this linkage of astronomy with astrology in ancient India, science of astronomy continued to develop independently, and culminated into original findings, like:
 - ▶ **The calculation of occurrences of eclipses**
 - ▶ **Determination of Earth's circumference**
 - ▶ **Theorizing about the theory of gravitation**
 - ▶ **Determining that sun was a star and determination of number of planets under our solar system**
- The Great Bear's Old Tamil name *elu-meen* 'seven-star' corresponds to the combination of the pictograms '7' + 'fish', which alone constitutes the entire text of one finely carved Indus seal. The Satapatha-Brahmana states that the six Pleiades were separated from their husbands on account of their infidelity; other texts specify that only one of the seven wives, Arundhati, remained faithful and was allowed to stay with her husband: she is the small star Alcor in the Great Bear, pointed out as a paradigm of marital virtue to the bride in the Vedic marriage ceremonies.
- Evidence for the Harappan origin of this myth is provided, among other things, by Indus seals which show a row of six or seven human figures; their female character is suggested by the one long plait of hair, which to the present day has remained characteristic of the Indian ladies.

■ Physics

- The root to the concept of atom in ancient India is derived from the classification of material world in five basic elements by ancient Indian philosophers. These five 'elements' and such a classification existed since the Vedic times, around 3000 BC before. These five elements were the **Earth (prithvi), Fire (agni), Air (vayu), Water (Jal) and Ether or Space (Akash)**. These elements were also associated with human sensory perceptions: earth with smell, air with feeling, fire with vision, water with taste and ether/space with sound. Later on, Buddhist philosophers replaced ether/space with **life, joy and sorrow**.

- From ancient times, Indian philosophers believed that except space, all other elements were physically palpable and hence comprised of small and minuscule particles of matter.
- They believed that the smallest particle which could not be subdivided further was paramanu (can be shortened to parmanu), a Sanskrit word. Paramanu is made of two Sanskrit words, param meaning ultimate or beyond and anu meaning atom. Thus, the term "paramanu" literally means 'beyond atom' and this was a concept at an abstract level which indicated the possibility of splitting atom, which is now the source of atomic energy. The term "atom" however should not be conflated with the concept of atom as it is understood today.
- Kanada, a 6th century, Indian philosopher was the first person who went deep systematically in such the orization. Another Indian, philosopher Pakudha Katyayana, who was a contemporary of Buddha, also propounded the ideas about the atomic constitution of the material world. All these were based on logic and philosophy and lacked any empirical basis for want of commensurate technology. Similarly, the principle of relativity (not to be confused with Einstein's theory of relativity) was available in an embryonic form in the Indian philosophical concept of 'sapekshavad', the literal translation of this Sanskrit word is theory of relativity.



■ Chemistry

- Ancient India's development in chemistry was not confined at an abstract level like physics, but found development in a variety of practical activities. In any early civilization, metallurgy has remained an activity central to all civilizations from the Bronze Age and the Iron Age, to all other civilizations that followed. It is believed that the basic idea of smelting reached ancient India from Mesopotamia and the Near East. Coinage dating from the 8th Century B.C. to the 17th Century A.D. Numismatic evidence of the advances made by smelting technology in ancient India.
- Nataraja the God of Dance is made of five metals Pancha-Dhatu.
- In the 5th century BC, the Greek historian Herodotus has observed that Indian and the Persian army used arrows tipped with iron. Ancient Romans were using armor and cutlery made of Indian iron.
- In India itself, certain objects testify to the higher level of metallurgy achieved by the ancient Indians. By the side of Qutub Minar, a World heritage site, in Delhi, stands an Iron Pillar. The pillar is believed to be cast in the Gupta period around circa 500 AD. The pillar is 7.32 meters tall, tapering from a diameter of 40 cm at the base to 30 cm at the top and is estimated to weigh 6 tonnes. It has been standing in the open for last 1500 years, withstanding the wind, heat and weather, but still has not rusted, except very minor natural erosion. This kind of rust proof iron was not possible till iron and steel was discovered few decades before.
- The advance nature of ancient India's chemical science also finds expression in other fields, like distillation of perfumes and fragrant ointments, manufacturing of dyes and chemicals, polishing of mirrors, preparation of pigments and colours. Paintings found on walls of Ajanta and Ellora (both World heritage sites) which look fresh even after 1000 years, also testify to the high level of chemical science achieved in ancient India.

■ Medicine & Surgery

- Ayurveda as a science of medicine owes its origins in ancient India. Thus, the literal meaning of Ayurveda is the science of life or longevity. Ayurveda constitutes ideas about ailments and diseases, their symptoms, diagnosis and cure, and relies heavily on herbal medicines, including extracts of several plants of medicinal values.
- Ancient scholars of India like Atreya, and Agnivesa have dealt with principles of Ayurveda as long back as 800 BC. Their works and other developments were consolidated by Charaka who compiled a compendium of Ayurvedic principles and practices in his treatise Charaka-Samahita,.
- 'Charaka-Samahita' deals with a variety of matters covering physiology, etiology and embryology, concepts of digestion, metabolism, and immunity. Preliminary concepts of genetics also find a mention, for example, Charaka has theorized blindness from the birth is not due to any defect in the mother or the father, but owes its origin in the ovum and the sperm.
- In ancient India, several advances were also made in the field of medical surgery. Specifically these advances included areas like plastic surgery, extraction of cataracts, and even dental surgery. Roots to the ancient Indian surgery go back to at least circa 800 BC.
- Shushruta wrote a medical compendium called 'Shushruta-Samahita. This ancient medical compendium describes at least seven branches of surgery: Excision, Scarification, Puncturing, Exploration, Extraction, Evacuation, and Suturing. The compendium also deals with matters like rhinoplasty (plastic surgery) and ophthalmology (ejection of cataracts). The compendium also focuses on the study the human anatomy by using a dead body.
- In ancient India Medical Science supposedly made many advances. Specifically these advances were in the areas of plastic surgery, extraction of cataracts, and dental surgery. There is documentary evidence to prove the existence of these practices.
- Yoga is a system of exercise for physical and mental nourishment. The origins of yoga are shrouded in antiquity and mystery. Since Vedic times, thousand of years before, the principles and practice of yoga have crystallized. But, it was only around 200 BC that all the fundamentals of yoga were collected by Patanjali in his treatise, named Yogasutra, that is, Yoga-Aphorisms.
- In short, Patanjali surmised that through the practice of yoga, the energy latent within the human body may be made live and released, which has a salubrious affect on the body and the mind. The application of yoga in physiotherapy is also gaining recognition.
