

..... the prevailing backwardness of the country was due to backwardness of science and that the solution was in the vigorous pursuit of the sciences by original research

The great visionary Mahendra Lal Sircar wrote this in 1869 and in the opinion of the author, it is valid even today

Abstract

This article is divided into five parts. In the first part, we will discuss a few of the significant contributions made by mathematicians, scientists, and technologists in India before the 16th century, which was followed by a dark period. In the second part, we will discuss the transition to the formal university education around the middle of the nineteenth century and the beginning of high-quality scientific research in India. In the third part we will discuss a few of our recent achievements and as to why there has to be great emphasis on education, science and technology. In the fourth part, we present a few remarks, and finally, in the fifth part, we discuss Swami Vivekananda's thoughts on these issues and their relevance in today's society.

Part 1. Our Heritage

During October 2017 — March 2018, there was an exhibition at the London Science Museum which

takes you on a journey through the remarkable history of Indian innovation and discovery, which has been influencing and changing people's lives for 5000 years.

I had the good fortune to see that exhibition in 2018. To quote from the website of the London Science museum:¹

From some of the earliest cities to interplanetary exploration, Indian innovation in science, technology and mathematics has dramatically shaped the world we live in today.

One of the exhibits at the exhibition displayed remarkable engineering feats of the Indus Valley Civilization; this civilization, apparently dates back² to 5000 BC. Apparently, the reservoirs and the network of water channels they supplied were unrivalled in

¹<https://www.sciencemuseum.org.uk/see-and-do/illuminating-india-5000-years-science-and-inno>

²See https://www.ancient.eu/Indus_Valley_Civilization.

the ancient world (see Figure 1). The following³ tells us that, in the past, our knowledge of mathematics, astronomy, metal purification, civil engineering and architecture were at par (if not better) with the rest of the world:



Figure 1: To quote from the display at the London Science Museum The reservoirs and the network of water channels they supplied (during the Indus Valley Civilization – about 5000 years back) were unrivalled in the ancient world; photograph taken by the author at the London Science Museum.

1. The decimal system was already in place during the Harappan period, as indicated by an analysis of Harappan weights and measures; it is believed that the Harappan period was around 2000 BC.
2. There are references in the Vedic literature that suggest that copper vessels were coated with tin to prevent milk from turning sour.
3. Arithmetic operations (which we call *Ganit*) such as addition, subtraction, multiplication, fractions, squares, are enumerated in a manuscript by Ved Vyas, which was written about 1000 BC.
4. Pythagoras, the famous Greek mathematician and philoso-

³Some of the dates here have been taken from the book by Venkataraman [1] and also from the internet site http://india_resource.tripod.com/mathematics.htm.



Figure 2: The Iron Pillar in Delhi (built in the 5th century) appears to have been protected from rust by the application of a thin coating of manganese dioxide.

pher (born around 550 BC), was familiar with the Upanishads and learnt his basic geometry from the Sulva Sutras written about 800 BC [2].

5. Around 300 BC, Kautilya's manuscript on Arthashastra had a section outlining the processes for metal extraction and alloying.
6. Around the fifth century, the iron pillar (in south Delhi) was built, which has withstood the vagaries of weather for over 1500 years without showing any signs of rust (see Figure 2). The pillar is made of wrought iron with an iron content of 99.72% and appears to have been protected from rust by the application of a thin coating of manganese dioxide.
7. Nalanda University (see Figure 3) was founded in 427 AD. According to the official website of Nalanda University⁴

Nalanda has been a renowned centre for learning from the 5th century until Bakhtiyar Khilji destroyed it in the 12th century. ...According to Dr. Geoffrey Durham, Nalanda is proclaimed as, "One of the most important universities in the world, was

⁴See <https://www.nalandauniv.edu.in/about-nalanda/vision/>.



Figure 3: Nalanda University; photograph adapted from the website of Nalanda University; photograph adapted from the official website of Nalanda University: <https://www.nalandauniv.edu.in/about-nalanda/history-and-revival/>.

developed not in the medieval west, but right here in India: Nalanda University. . . was instrumental in producing people who are capable of understanding and articulating what it means to have universal knowledge, knowledge that is applicable across cultures and across times.”

In an article published in 2006 in New York Times, Jeffrey Garten wrote⁵

Nalanda University was founded in 427 in northeastern India, not far from what is today the southern border of Nepal, and surviving until 1197, Nalanda was one of the first great universities in recorded history. It was devoted to Buddhist studies, but it also trained students in fine arts, medicine, mathematics, astronomy, politics and the art of war. The university was an architectural and environmental masterpiece. It had eight separate compounds, 10 temples, meditation halls, classrooms, lakes and parks. It had a nine-story library where monks meticulously copied books and documents so that individual scholars could have their own collections. It had dormitories for students, perhaps a first for an educational institution, housing 10,000 students in the university’s heyday and providing accommodations for 2,000 professors. Nalanda was also the most global university of its time, attracting pupils and scholars from Korea, Japan, China, Tibet, Indonesia, Persia and Turkey. The university died a slow death about the time

⁵Quoted from <http://www.nytimes.com/2006/12/09/opinion/09garten.html?ex=1166331600&en=4171c5ec7d0ff35e&ei=5070&emc=eta1>.

that some of the great European universities, including those in Oxford (in England) and Bologna (in Italy), were just getting started, and more than half a millennium before Harvard or Yale were established. Its demise was a result of waning enthusiasm for Buddhism in India, declining financial support from successive Indian monarchs and corruption among university officials. The final straw was the burning of the buildings by Muslim invaders from what is now Afghanistan.

Jeffrey Garten further wrote:

But Nalanda represents much of what Asia could use today — a great global university that reaches deep into the region’s underlying cultural heritage, restores many of the peaceful links among peoples and cultures that once existed, and gives Asia the kind of soft power of influence and attraction that it doesn’t have now. The West has a long tradition of rediscovering its ancient Greek and Roman roots, and is much stronger for that. Asia could and should do the same, using the Nalanda project as a springboard but creating a modern, future-oriented context for a new university.

8. Around the 7th century, a highly durable cement came into use in the construction of important monuments that survive to this day.
9. By the 12th century, construction engineers were using iron girders and beams on a scale unknown in any other part of the world. The most significant use of iron beams could be seen in the temples of Puri and Konarak.
10. In the year 1734, the Rajput king Sawai Jai Singh II completed the Jantar Mantar monument in Jaipur (see Figure 4), which is a collection of nineteen architectural astronomical instruments;⁶ as mentioned in these websites, the term "Jantar Mantar" literally means "instruments for measuring the harmony of the heavens". Most likely, at that point in

⁶For more details, see https://en.wikipedia.org/wiki/Jantar_Mantar,_Jaipur and <http://amerjaipur.in/Amer-monuments-description.php?mid=10&name=Jantar%20Mantar%20Jaipur> and references therein.

time, astronomers in India were not aware of Kepler's model of planetary motion.

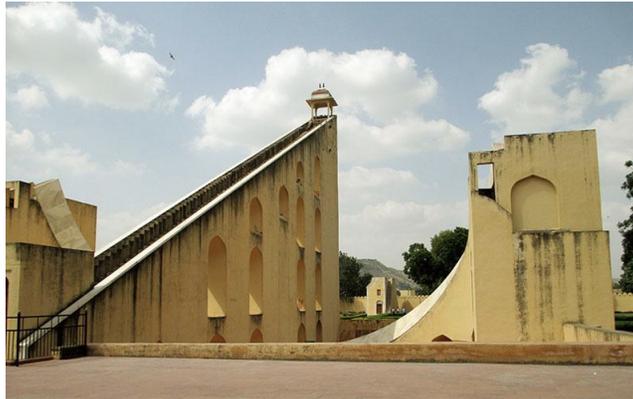


Figure 4: The sun dial in Jantar Mantar in Jaipur, an astronomic observation site, built in the early 18th century. The sundial can give the local time to an accuracy of 2 seconds. The sundial can provide the local time with an accuracy of 2 seconds. Photograph adapted from <http://amerjaipur.in/Amer-monuments-description.php?mid=10&name=Jantar%20Mantar%20Jaipur>.

And of course, there was an enormous amount of work on Ayurveda and medicinal research. In fact, during the early British period, India was so technologically advanced that ships were getting exported from India to Europe. That is probably the reason why people wanted to come here and rule.

Around the 17th and 18th centuries, the study of mathematics and science slowed down, and colleges and universities were converted to *madarsahs*. This was the dark period in the development of science and technology till about the beginning of the 17th century was also a dark period in Europe; on 17 February 1600, Giordano Bruno, a brilliant thinker, was burned to death by the church because he believed that the Earth went around the Sun and not the other way around. To quote Frank Gaglioti:⁷

He was taken from his cell in the early hours of the morning to the Piazza dei Fiori in Rome and burnt alive at the stake. To the last, the Church authorities were fearful of the ideas of a man (Giordano Bruno) who was known throughout Europe as a bold and brilliant

⁷See <https://www.wsws.org/en/articles/2000/02/brun-f16.html>.

thinker. In a peculiar twist to the gruesome affair, the executioners were ordered to tie his tongue so that he would be unable to address those gathered. . .

In Europe, the scientific revolution began around the end of the 16th century. During this period, we had Tycho Brahe (1546-1601), who was one of the greatest observational astronomers. Then early in the 17th century Johannes Kepler (1571-1630), who was born in Germany and had access to Tycho Brahe's excellent measurements, proposed that planetary motion was due to a force emanating from the Sun which deflects the planets from their "natural" motion, causing them to follow curved orbits. This led him to state

planets revolve around the sun, in ellipses with the sun at one focus.

In the early 17th century, Galileo Galilei (1564-1642) pioneered the use of experiment to validate physical theories (see Figure 5); he is often called the "Father of Modern Physics". Even Galileo was condemned by the Roman Catholic Church in 1633 for his support of heliocentrism; to quote from Wikipedia:

Heliocentrism is the astronomical model in which the Earth and planets revolve around the Sun at the center of the Solar System. Historically, Heliocentrism was opposed to geocentrism, which placed the Earth at the center.

Because Galileo believed in heliocentrism (whereas the church believed in geocentrism), he was sentenced to indefinite imprisonment (in 1633) and was kept under house arrest until he died in 1642. Galileo would have also been sentenced to death (like Bruno), but his friends advised him that if he would confess that he did not believe in heliocentrism, he would be given a lighter punishment. Galileo confessed to that, which resulted in house

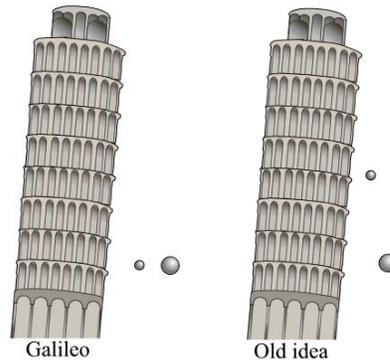
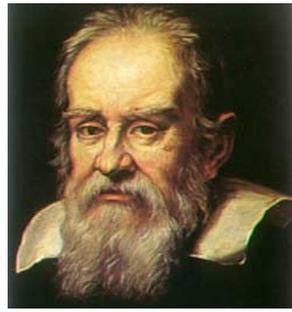


Figure 5: Galileo Galilei (1564-1642) carried out his famous experiment that all objects take the same amount of time in falling through a certain height; he is often called the “Father of Modern Physics”; diagram adapted from <http://www.bitlanders.com/blogs/newtonian-physics-galileo-film-annex-and-afghan-proverbs/60820>.

arrest and not the death penalty!!! According to a report in the New York Times⁸ (published on October 31, 1992)

More than 350 years after the Roman Catholic Church condemned Galileo, Pope John Paul II is poised to rectify one of the Church’s most infamous wrongs – the persecution of the Italian astronomer and physicist for proving the Earth moves around the Sun.

Isaac Newton (1642-1727) was born the year Galileo died; he laid the foundation of modern science and mathematics (see Figure 6). After Galileo and Newton, many scientists and technologists in Europe contributed to the scientific and industrial revolutions. This industrial revolution began around 1760 and involved, for example, transitioning from hand-based production methods to machine-based ones (see Figure 7) and the development of the steam engine. However, this Industrial Revolution did not occur in India.

⁸See <http://www.nytimes.com/1992/10/31/world/after-350-years-vatican-says-galileo-was-right.html>.



Figure 6: Isaac Newton (1642 – 1727) made revolutionary contributions to science including explanation of planetary motions. The diagram showing planetary motion adapted from <https://physics.aps.org/synopsis-for/10.1103/PhysRevD.92.064049>.



Figure 7: Model of the spinning machine (1764); adapted from https://en.wikipedia.org/wiki/Industrial_Revolution#/media/File:Spinning_jenny.jpg.

Part 2: The Emergence of Higher Education in India

In 1811 Lord Minto had observed that

Science and literature are in a progressive state of decay among the natives in India.

On 20th January 1817, the Hindu College in Calcutta was formally opened with 20 scholars (of different religions). In 2017, we commemorated 200 years of this College, which was the first institution of higher learning in the modern sense in Asia. The foundation committee of the college was headed by Raja Ram Mohan Roy, who, along with six others, donated their wealth to es-

establish the college (see Figure 8). In 1855, it was renamed Presidency College, and on July 23, 2010, it became Presidency University.

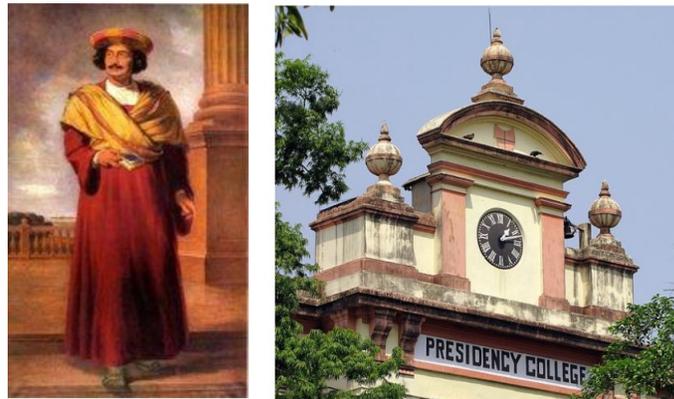


Figure 8: (left) Raja Rammohan Roy (right) Presidency College.

In 1857, three universities were set up: in Bombay, Calcutta, and Madras (see Figure 9) — similar to the structure of the University of London; this was the starting point of science education (in the modern sense) in India.

In 1869, the great visionary Mahendra Lal Sircar wrote an article in the Calcutta Journal of Medicine; the title of the article was “On the desirability of a national institution for the cultivation of sciences by the natives of India”. In his article, Sircar argued:⁹

that the prevailing backwardness of the country was due to backwardness of science and that the solution was in the vigorous pursuit of the sciences by original research

With about 20% of our population below the poverty line, the above statement (made in 1869) is true even today! Sircar further wrote (which is so poignant):

We should endeavour to carry on the work with our own efforts, without seeking aid from the Government. However, we will accept aid from the Government (or from anyone else) if it comes to us without any conditions and restrictions. . . I want freedom for the

⁹Quoted from Venkataraman’s book [1]

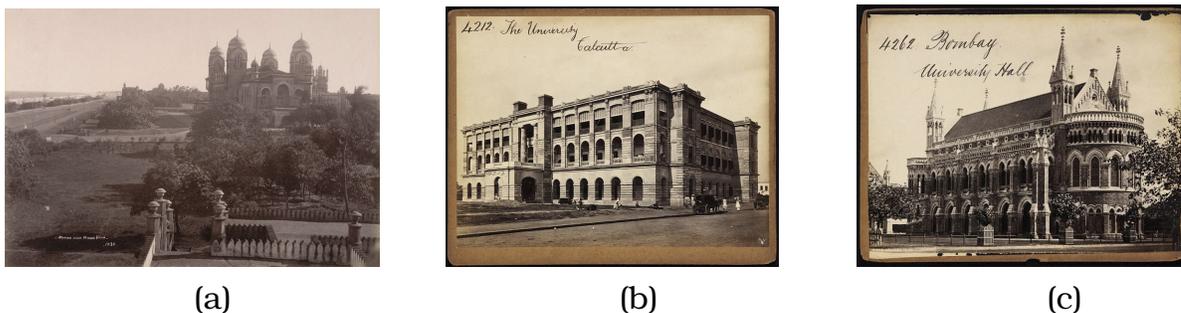


Figure 9: In 1857, three universities were set up: in Madras, Calcutta, and Bombay — similar to the structure of the University of London. (a) Photograph of the Madras University Senate House and Marina Beach, 1905; adapted from https://en.wikipedia.org/wiki/University_of_Madras#/media/File:MadrasUniversitySenateHouse1905.jpg. (b) Photograph of Calcutta University in the mid nineteenth century; adapted from <http://oldkolkata.blogspot.in/2013/05/oldest-known-university-in-calcutta.html>. (c) Photograph of Bombay University in the mid-nineteenth century; adapted from <https://www.oldindianphotos.in/2010/11/bombay-mumbai-university-hall-19th.html>.

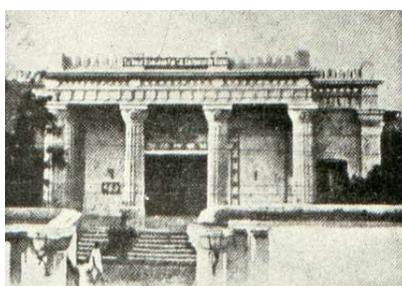


Figure 10: The old campus of IACS, which was inaugurated at 12, Bowbazar Street, Calcutta campus on July 29, 1876. photographs adapted from the official website of IACS: Ref. <http://iacs.res.in/history.htm>.

Institution. I want it to be entirely under our own management and control. I want it to be solely native and purely national.

Subsequently, on 29th July 1876, Mahendra Lal Sircar founded the Indian Association for the Cultivation of Science (abbreviated as IACS) at 210 Bow Bazar Street, Calcutta (see Figure 10) – supported by generous public contributions.¹⁰ The original objective of the Association, which continues even today (quoted from the official website of IACS)¹¹ “was to cultivate science in all its de-

¹⁰Figure 11 shows the new campus of IACS at Jadavpur, Kolkata.

¹¹See <https://www.iacs.res.in/>

partments with a view to its advancement by original research and its varied applications to the arts and comforts of life.”



Figure 11: The new campus of IACS at Jadavpur, Kolkata; on the lawns of the new campus are the statues of Dr Mahendra Lal Sircar (who was the founder of IACS) and of Professor Meghnad Saha (who in 1948 prepared a master plan of the Jadavpur Campus of IACS [3]); photographs taken by the author in February 2018.

This was therefore the first institute in India devoted to the pursuit of fundamental research in the frontier areas of basic sciences. Sircar organized numerous public lectures featuring renowned individuals such as Professor Jagadish Chandra Bose, Professor Asutosh Mukherjee, Pandit Ishwarchandra Vidyasagar, and many others. However, during his lifetime (he died in 1904), he was unable to witness any active research being pursued at IACS. In 1907 CV Raman arrived in Calcutta (working as a civil servant in the Indian Finance Department), had discussions with his son Amrita Lal Sircar¹² and in his free time he carried out research work at IACS. His research work at IACS eventually led him to win the 1930 Nobel Prize in Physics. To quote again from the official website of IACS:

Mahendralal’s cherished dream took shape when the Indian Association for the Cultivation of Science was inaugurated at the 12, Bowbazar Street campus on July 29, 1876. The founder secretary

¹²Both Mahendra Lal Sircar and his son Amrita Lal Sircar visited Sri Sri Ramakrishna Paramhansa at Shyampukur on October 18, 1885; there is a lovely discussion with *Thakur* that has been recorded in *The Gospel of Sri Ramakrishna* (published by Sri Ramakrishna Math, Mylapore, Chennai) pp 850-851.

to the Association was Mahendralal himself, with the first Trustee Board comprising persons like Pandit Ishwarchandra Vidyasagar and Keshab Chandra Sen. . . The IACS entered a new phase with the emergence in the scene of C V Raman in 1907. He initiated serious research in IACS as a part-time worker, while carrying out his duties in the Accountant General's office in Calcutta - under the inspiring leadership of Dr. Sircar's son Amrita Lal Sircar — the then secretary of IACS. The rest was history. The celebrated Raman Effect was discovered in 1928, which culminated in Raman's receiving the Nobel Prize in Physics in 1930. Raman started a vibrant school of research. . .

In 1946 the Association embarked upon a new development plan under the dynamic leadership of Dr. Meghnad Saha envisaging the creation of an active research school for investigation on the problems continuing with the fundamental studies in X-rays, Optics, Magnetism, and Raman Effect in which the Association had specialized in early years. . . . By 26th February 1948 Dr. M. N. Saha with the help of prominent architects in Calcutta prepared a master plan of the Jadavpur Campus of IACS (see Figure 11).

In 1917, Sir Asutosh Mukherjee, then Vice Chancellor of Calcutta University and a man of great vision, appointed C.V. Raman as the Palit Professor of Physics. Subsequently, the department had, in addition to C.V. Raman, great scientists like Satyendra Nath Bose, Meghnad Saha, and S.K. Mitra. Figure 12 shows a historic 1930 photograph of a few eminent scientists in Calcutta, all dressed in typical simple Bengali attire.

We may note that the pioneering discoveries of Jagadish Chandra Bose (in physics and plant physiology) and Prafulla Chandra Ray (in Industrial Chemistry) were made in the laboratories of Presidency College. Many believe that Jagadish Chandra Bose (1858-1937) was the first to demonstrate wireless communication in 1895; however, the Nobel Prize for wireless communication was awarded to Guglielmo Marconi in 1909. Prafulla Chandra Ray (1861-1944) was the founder of Bengal Chemicals & Pharmaceuticals, India's first pharmaceutical company. The Royal Society of Chemistry honored his life and work with the first-ever Chemical

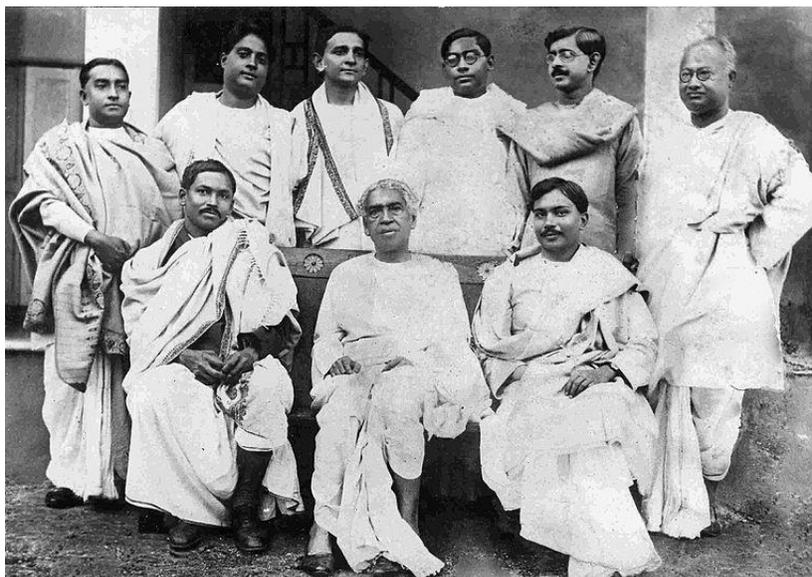


Figure 12: A photograph of great scientists taken in Calcutta in 1930. Seated (L to R): Meghnad Saha, Jagadish Chandra Bose, Jnan Chandra Ghosh. Standing (L to R): Snehamoy Dutt, Satyendranath Bose, Debendra Mohan Bose, N R Sen, Jnanendra Nath Mukherjee, N C Nag. Photograph in public domain.

Landmark Plaque outside Europe.

Many feel that the outstanding work of Satyendra Nath Bose (whose 1924 paper led to the famous Bose-Einstein statistics) should have also earned him the Nobel Prize. According to a 2012 report,¹³ Professor Rolf-Dieter Heuer, the then Director General of CERN (European Organization for Nuclear Research), said “it is unfortunate that the pioneering Indian physicist Satyendra Nath Bose did not win the Nobel Prize for work on quantum physics in the 1920s that provided the foundation of the Bose-Einstein statistics and the theory of the Bose-Einstein condensate, a dense collection of bosons or particles with spin named after Bose. Though several Nobel Prizes have been awarded for research related to the concepts of the boson, Bose-Einstein statistics and Bose-Einstein condensate, Bose never got the award in his lifetime.”

¹³See <https://timesofindia.indiatimes.com/home/science/Satyendra-Nath-Bose-deserved-Nobel-sa-articleshow/16243796.cms>.

The CERN Chief also said:

It is ironical that Bose was not given the award despite his immense contribution to science. But it in no way undermines his stature as one of the leading physicists the world has had.

In an article entitled *What Were The Greatest Nobel Prize Snubs In Science History?*, Professor Ethan Siegel (an American theoretical astrophysicist) wrote:¹⁴

While multiple Nobels have gone to work on boson-based systems, most recently in 2001, Bose remains one of the greatest scientists never to win the prize for his Nobel-caliber work.

I have named only a few of our outstanding scientists in pre-independent India because of their affiliation with Presidency College. Of course, there were many, many more scientists (like Homi Bhabha, S S Bhatnagar, Amal Kumar Raychaudhuri, Birbal Sahni, K.S. Krishnan, Prasanta Mahalanobis, and of course, C.V. Raman, Srinivasa Ramanujan, and many more) who immensely contributed to the development of science and technology in pre-independent India.

Part 3: Some Recent Developments

India became independent in 1947. After independence, due to the foundation laid in the 19th and early 20th centuries, India placed a strong emphasis on higher education and research, resulting in numerous significant achievements in science and technology. In February 2017, the Indian Space Research Organization (usually abbreviated as ISRO) launched a record-breaking 104 satellites from a single rocket from its satellite launch center

¹⁴See <https://medium.com/starts-with-a-bang/ask-ethan-what-were-the-greatest-nobel-prize-snu>

Sriharikota¹⁵ (see Figure 13); 96 satellites were owned by companies in the US, three were owned by companies in India, and the rest were owned by companies based in Israel, Kazakhstan, the Netherlands, Switzerland, and the United Arab Emirates.¹⁶ Earlier, in September 2014, ISRO had successfully guided a spacecraft to orbit around Mars.



Figure 13: India has a largely indigenous space program. (a) In 2017, the Indian Space Research Organization (ISRO) created a world record by sending 104 satellites in a single rocket. (b) Vikram Sarabhai and (c) Satish Dhawan were great Indian visionaries and founders of the Space program. (d) APJ Abdul Kalam contributed immensely to the space program and was known as the “Missile Man of India.”

India has also made very significant achievements in Nuclear Energy:¹⁷

India has a flourishing and largely indigenous nuclear power programme and expects to have 14.6 GWe nuclear capacity on line by 2024 and 63 GWe by 2032. It aims to supply 25% of electricity from nuclear power by 2050

Another very significant (indigenous) achievement has been the Green Revolution (see Figure 14). According to a report from the Tata Energy Research Institute:¹⁸

¹⁵Earlier record was when Russia launched 37 satellites in 2014.

¹⁶See <https://www.theguardian.com/science/2017/feb/15/india-launches-record-breaking-104-sat>

¹⁷Quoted from <http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx>.

¹⁸See <http://edugreen.teri.res.in/explore/bio/green.htm>.

The world's worst recorded food disaster occurred in 1943 in British-ruled India. Known as the Bengal Famine, an estimated 4 million people died of hunger that year in eastern India (which included today's Bangladesh). . . .When the British left India in 1947, India continued to be haunted by memories of the Bengal Famine. . . .The Green Revolution, spreading over the period from 1967/68 to 1977/78, changed India's status from a food-deficient country to one of the world's leading agricultural nations. . . .The term 'Green Revolution' is a general one that is applied to successful agricultural experiments in many developing countries. India is one of the countries where it was most successful.

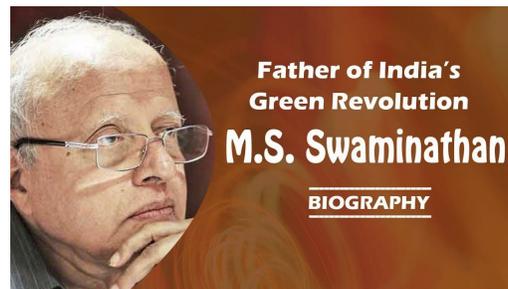


Figure 14: The Green Revolution, spreading over the period from 1967 to 1977, changed India's status from a food-deficient country to one of the world's leading agricultural nations.

The White Revolution refers to the rapid development in milk production, which was achieved by Dr. Verghese Kurien, often referred to as the "Milk Man of India" (see Figure 15). I still remember that when I came back from the USA in 1964, rice and milk were scarce; the White Revolution began in 1970.

In recent years, there has been a lot of work on generating electricity using solar energy (see Figure 16); solar panels and the use of LED bulbs are illuminating remote villages. As of March 2025, India's solar power installed capacity was about 105 GW; it accounts for about 6% of India's total electricity generation.

Additionally, we have witnessed tremendous all-around technological growth in India, including the introduction of TV in villages, the widespread adoption of mobile phones, the presence of computers in many schools, and the increasing availability of the

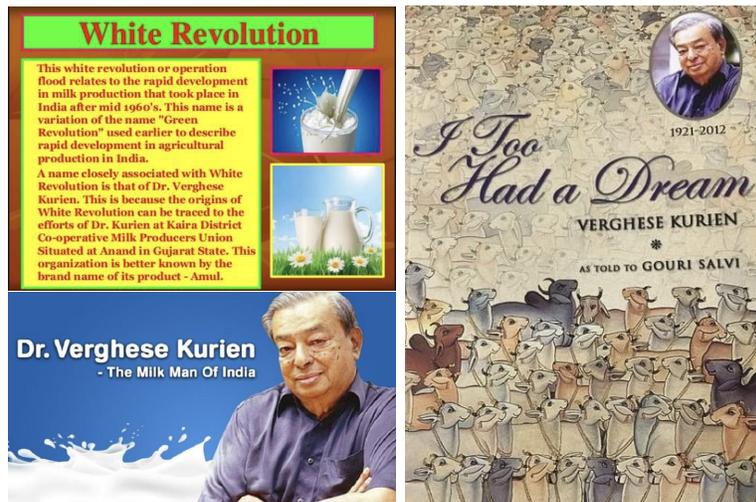


Figure 15: The White revolution began in 1970 under the leadership of Dr. Verghese Kurien who is often referred to as the Milk Man of India.



Figure 16: As of March 2025, India's solar power installed capacity was about 105 GW.

Internet in remote areas. The Delhi Metro is a unique engineering success story; Dr. Sreedharan was the chief architect of the Delhi Metro (see Figure 17).

According to Wikipedia,¹⁹ India has about 1.2 billion mobile phones in use (with a population of about 1.4 billion); China is at the top of the table with about 1.3 billion mobile phones (with a population of about 1.4 billion) and USA is 3rd in the list with about 328 million mobile phones (with a population of about 318 million). Through satellites, one can predict cyclones many days in advance, thereby saving thousands of lives in coastal areas.

Then, as we have seen during the COVID period, India is now one

¹⁹See https://en.wikipedia.org/wiki/List_of_countries_by_number_of_mobile_phones_in_use.

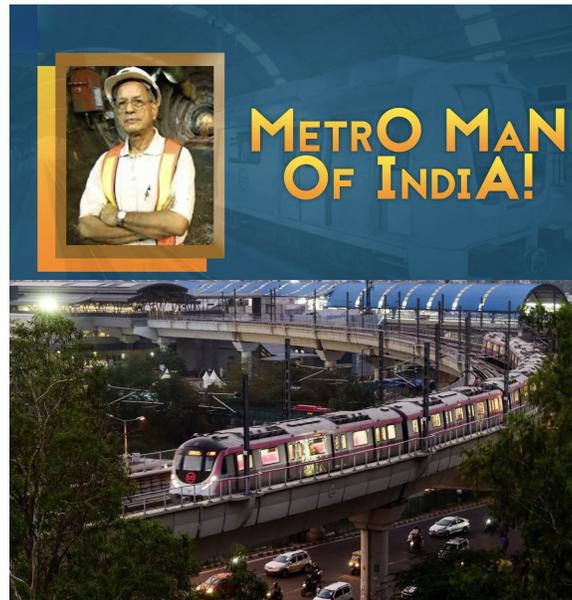


Figure 17: Delhi Metro is an unique engineering success story.

of the largest producers of vaccines.

All achievements mentioned above (and many other achievements, such as the manufacturing of drugs and motor cars) require enormous indigenous efforts. This has occurred due to the great emphasis on education and the widespread adoption of new technology in our country. However, we have achieved so much, but then according to recent newspaper reports (see Figure 18)

Sewers in Delhi becoming killing fields for Safai Karmacharis.

(*Safai Karmacharis* are Hindi words meaning “cleaning workers”).

In a TEDx talk (in 2012) on *Photos That Bear Witness To Modern Slavery*, Lisa Kristine tells us²⁰ the plight of more than 27 million souls enslaved worldwide. Although slavery is illegal in almost every country, it nevertheless persists in many nations, including (unfortunately) in India. Children and grown-ups are enslaved for generations, because once upon a time, their father (or uncle or grandfather) had borrowed about 15-18 \$ from the

²⁰If you visit YouTube and search for ‘Photos That Bear Witness To Modern Slavery by Lisa Kristine,’ you will be able to access the website <https://www.youtube.com/watch?v=9TPFLHvn024>, where you can view the TEDx talk.



Figure 18: The top photograph was in a news item on August 23, 2017. The photographs below show a young man getting down into the sewer. Photograph adapted from <https://newsclick.in/sewers-delhi-become-killing-fields-safai-karamcharis>. The bottom photographs adapted from <https://thewire.in/tag/manual-scavenging/>.

local businessman, and the slaves (and their families) have to pay up the debt with a lot of interest. According to Lisa Kristine, slavery is about “commerce” as it generates a profit of more than 13 billion dollars worldwide. Figure 19 shows the slavery in a brick manufacturing company in India, where numerous children and grown-ups are engulfed in dust at 44 degrees Celsius, carrying bricks and stones from morning to evening.

Figure 20 shows that according to The Economic Times (dated October 16, 2022), India ranked 107 out of 121 countries in the Global Hunger Index.

Looking at Figures 18, 19 and 20 (and we can create many such photographs), we feel that despite our achievements, a lot remains to be done. . . . And I feel more convinced that this can be achieved only through education (with great emphasis on ethics) and, of course, science and technology.

Fortunately, the internet is widely available in India and is rel-



Figure 19: Slavery in a brick manufacturing company in India. According to Lise Kristine, entire families can be carrying bricks or stones from morning to evening in extreme heat and engulfed in dust. Adapted from Lisa Kristine's TEDx talk: https://www.ted.com/talks/lisa_kristine_glimpses_of_modern_day_slavery#t-252317.



Figure 20: According to The Economic Times (dated October 16, 2022), India ranked 107 out of 121 countries in the Global Hunger Index.

atively affordable. IITs and IISc Bangalore are involved in programs that have uploaded carefully prepared classroom lectures of a large number of courses (in basic sciences and engineering) on YouTube; these courses have been of immense benefit not only to students but also to teachers. Now sitting in a remote village in Tamil Nadu, Bihar or in Assam, one can learn subjects like Theory of Differential Equations, Laser Physics, Signal Processing, Quantum Theory, Computer Engineering, Digital Electronics ...and many many other areas. We are all aware of Khan Academy Lectures, which have also made a significant contribution to the teaching of basic science and mathematics at the school level. All these lectures, which have been uploaded to

YouTube, have made an important contribution not only to people in India but also globally. We can therefore utilize YouTube in educating people in remote areas and also in skill development, such as making solar lamps.

A Few Remarks

In an article entitled *Our Value System And The Future Of India*, Professor C.N.R. Rao has written:²¹

It is not enough if we say that India will be an international centre for producing machines and materials or for a specific service sector. It is not enough if we take pride in the export of certain goods from India. In these days of economic boom, we should think equally about export of ideas and philosophical thoughts from India, if we have to be a major global player in a future knowledge-powered world. Let us not forget that the countries in past history that we admire most are not necessarily the economically prosperous ones, but those that made major contributions to our cultural heritage. Our aim should be to make India a country that is recognized throughout the world and throughout history as a country that has significantly advanced the progress of science, art, and literature. Our rulers and planners should therefore come out with an enlightened policy that provides the environment necessary for scientific discoveries and creative successes. While government funds generally imply greater control and less freedom, we need to create a general atmosphere where there is the realization that good accounting, while necessary, does not lead to good science, art or poetry.

Swami Vivekananda (1863-1902), one of India's most renowned spiritual leaders, proposed ways to create a harmonious synthesis of Western Science and Eastern Philosophy. He had tremendous respect for the development of science and technology in India. In 1893, Swami Vivekananda and Jamsetji Tata were on

²¹See <http://www.thehindu.com/todays-paper/tp-opinion/our-value-system-and-the-future-of-india/article18500166.ece>.

board the Empress of India, a ship that sailed from Yokohama, Japan, to Vancouver, Canada. Swamiji asked Jamshetji Tata where he was going and what his mission was. Jamsetji said, “Swamiji, I am going with a mission to bring steel industry to country”. To which Swamiji said, “It is indeed a beautiful mission. My best wishes. However, I would like to give you a small caution. Whatever amount you spend to get the process of making steel, simultaneously you should learn the metallurgical science of making steel also. I would prefer you to start an Institute, a laboratory to do advanced research on the subject.” What a great visionary Swami Vivekananda was! Mr Tata was deeply influenced by Swamiji's idea of self-reliance. Inspired by Swami Vivekananda, Mr Jamshetji Tata pledged Rs 30 lakhs of his wealth to create the Indian Institute of Science in Bangalore, which is now the most premier institute of our country; at that time, 30 lakhs (= 3 million) was a massive amount of money and would be equivalent to about 200,000 British Pounds. Offering Rs 30 lakhs for the setting up of a research institute, Jamsetji Tata made an announcement which appeared in the Times of India on September 28, 1898, in which he said:²²

To induce the students of this country to undertake researches on the problems of tropical diseases or tropical chemistry, to investigate the vast and neglected materials of our national history and Indian philology, it is necessary to found laboratories and libraries, where students may work under the direction of great teachers.

Conclusions

Kōichirō Matsuura, former Director-General of UNESCO, said:²³

We live in difficult times when peace and human security are facing new challenges at the individual and global level. . . Education is

²²See <http://icast.org.in/news/2004/jul04/jul24aa.html>.

²³See https://lovedoc.org/the-philosophy-of-money.html?utm_source=values-education.

the key dimension of the long term process of building peace, tolerance, justice and inter-cultural understanding — the reorientation of education to create a better world is truly urgent.

As mentioned by Professor Kankan Bhattacharyya, Mahendra Lal Sircar delivered his last secretarial speech from his deathbed, and it was read (as he was unable to attend the meeting due to his illness) at the annual meeting of IACS on 26th November 1903. In this last letter, he wrote:

I reiterate my conviction that if my country is to advance at all and take rank and share her responsibilities with the civilized nations of the world, it can only be by means of science. . .

Swami Vivekananda's famous words were:

Teach yourself; teach everyone his (or her) real nature. Call upon the sleeping soul and see how it awakes. Power will come, glory will come, goodness will come, purity will come, and everything that is excellent will come, when this sleeping soul is roused to self-conscious activity.

I conclude by mentioning what Dr. A.P.J. Abdul Kalam, former President of India, had said at the opening ceremony of Swami Vivekananda's Ancestral House and Cultural Center, Kolkata, on October 1, 2004:

...let us work for the evolution of enlightened citizen which is the mission of Vivekananda heritage. Such an enlightened citizen should have a strong body and indomitable spirit. Swamiji said "**Arise, awake and stop not till you reach the goal.**" The goal is a prosperous India with peace in itself and giving to the whole world.

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