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Science INDIA

राष्ट्रहिताय विश्वमङ्गलाय

Connecting science and people with an Indian perspective

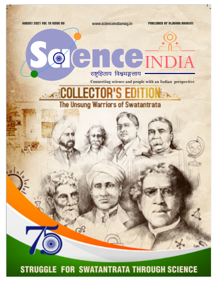
COLLECTOR'S EDITION 2.0

BRITISH ANNIHILATION OF INDIA

STRUGGLE FOR SWATANTRATA THROUGH SCIENCE

Second edition of Collector's Edition is much needed

The Collector's Edition (August 2021) was truly a collector's delight for the readers due to its rich, invaluable content and rare photos, which we don't get to see elsewhere.



Each and every story in the August 2021 edition was well-researched, special and rich with exclusive information.

The cover story — 'Untold Saga of The Struggle for Swatantrata Through Science' by Shri Jayant Sahasrabudhe is thoroughly revealing as it unfolds audacious scientific ventures of Indian scientists that helped create national impulse to achieve Independence.

The Editor's write-up on 'Science as a Tool of British Exploitation of India', is an eye-opener as it reveals the harsh truth that the colonial rulers brought scientific developments to India as an aid to their loot of the subcontinent's vast natural resources to fuel Industrial Revolution back home. It speaks volumes of the very objective of the greedy British rulers on the pretext of development.

But, it is not the end of the otherwise horrific story of status of Science during the British rule in the country. Beyond all odds, our scientists were able to make strides during those difficult days. The article, 'The Emergence of Nationalist Scientists', is a beautiful example of the same. This edition helped us know how Indian scientists in the 19th and early 20th centuries fought against British imperialism and domination using science as a tool.

I'm sure there's more to it. It will be great, if Science India could bring out a second edition of the Collector's Edition on its theme — Struggle for Swatantrata through Science —with untold stories and events.

In the field of science journalism, *Science India* magazine through its unique concept and content — stands out in the crowd. The need of the hour for *Science India* is to make a strong presence on the digital platform, so that more and more people can get to read *Science India* and join the Swadesh Science Movement.

In this 75th anniversary of our Independence, I wish *Science India* and its team a bright future and grand success.

Prof Kumud Das
Associate Professor
& Program Head,
School of Media & Journalism,
DY Patil International University,
Akurdi, Pune

Send your letters to editor@scienceindia.in

INTERNATIONAL CONFERENCE TO COMMEMORATE 161ST BIRTH ANNIVERSARY OF LEGENDARY INDIAN CHEMIST ACHARYA PC RAY

Commemorating the 161st birth anniversary of legendary Indian chemist, Acharya Prafulla Chandra Ray, a two-day international conference was organised at Delhi University as a part of Azadi Ka Amrit Mahotsav, on 2-3 August. An initiative of the Indraprastha Vigyan Bharati (VIBHA) in association with the Department of Chemistry, DU, and supported by the Union Ministry of Culture, the theme of the conference was 'Contributions of Acharya PC Ray as a Chemist and Freedom Fighter'.

The Union Minister of State for Education, Dr Subhas Sarkar, related the learnings of Ray to Atmanirbhar Bharat and Make in India projects. At the inaugural session, Prof Yogesh Singh, Vice Chancellor, DU and Dr Shekhar C Mande, former Director General, CSIR and president, VIBHA, respectively threw light on the National Education Policy 2020, and on the vision and initiative of VIBHA. While, Jayant Sahasrabudhe, National Organising Secretary, VIBHA highlighted the role of Indian scientists in the freedom movement, Padma Shri Dr Ramakrishna V Hossur, TIFR spoke on medicinal properties of various plants and the work done by Ray. A short science film, *Revolutionary in the garb of a scientist*, directed by filmmaker Nandan Kudhyadi was screened. Two exhibitions, titled 'Struggle for Swatantrata through Science: Untold Saga' and 'Emergence of Nationalist Scientists' were displayed.

"This is a milestone conference which will inspire the gen-next to learn about the foundations on which modern India was established. The main objective was to create awareness that scientists were also freedom fighters and led India to Swaraj. We received a huge response from school, college and university participants from all over India. Thanks to the Ministry of Culture for supporting this unknown facet of India's freedom struggle," said Prof Rajeev Singh, secretary, Indraprastha VIBHA.

CAMPAIGN

The Big British Loot in India

Let Sultanganj Buddha, an exquisite example of ancient India's scientific acumen, become an epitome for reclaiming all that colonial Britain looted from its prized colony

Image Courtesy: Wikipedia/ Creative Commons CC0 1.0 Universal Public Domain Dedication

The Sultanganj Buddha, a 7.5 ft (2.3 m) copper statue, is currently housed in Birmingham Museum and Art Gallery, UK

Debobrat Ghose

The stupendous success of the Collector's Edition (August 2021) and the way it was received both by the science community and the common man, made it a spectacular achievement for *Science India*.

In less than a year of its relaunch on 21 October 2020, *Science India* came up with the Collector's Edition — a bouquet of real life exclusive stories — in August 2021, on the contribution of Indian scientists of the 19th and early 20th centuries in freedom struggle.

The overwhelming response that this special edition received, compelled us to publish a mini Coffee Table Book — 'Struggle for Swatantrata through Science' — a first-of-its-kind publication from the *Science India* stable. Subsequently, the Coffee Table Book was translated in Hindi and Marathi, and in due course, we shall get it translated in other languages as well.

This time, we have come up with the Collector's Edition 2.0, which you are holding. Through exclusive, cutting-edge stories we have tried to show how the colonial British rule exploited, destroyed and damaged the rich heritage of India in almost every sector — be it agriculture or Ayurveda.

The sole purpose behind this colossal destruction was to loot India's wealth. The primary motive of introducing railways by the British was to transport our rich natural resources to harbours— that they looted and took away to England.

While India is aiming at a $5 trillion economy by 2025, the British had siphoned off a whopping sum of $45 trillion in 190 years — nine times to what we are aiming today!! To fuel its Industrial Revolution in England, the British looted 38 million pound sterling between 1757-80 from Bengal alone. The 190 years of the British Raj (including the East India Company's rule) in India (including first phase in Bengal) was a saga of a great loot from natural resources to artefacts.

The history of the British loot of India's cultural treasures under the wide-sweeping excuse of colonialism is so encyclopedic that it will always remain impossible to give a complete account of all that India lost to its colonial masters, to be displayed with pride in their museums.

Recently, the city of Glasgow in Scotland, UK, held a ceremony on 19 August to officially repatriate seven Indian cultural artefacts looted during the colonial rule. All the seven objects that will soon return to India, were looted from sacred places, such as temples and shrines, and given as gifts to the Scottish city's museum collections.

While this is a drop in the ocean of British loot of India's cultural artefacts, and it will be several years before awareness is raised enough for the former colonisers to feel responsible for their past actions and return the heritage where it belongs, this edition of *Science India* would like to focus on a cultural artefact that is also one of the prime examples of ancient India's scientific prowess.

It would not take a wild guess to realise that the object in question is the magnificent Sultanganj Buddha.

WHAT IS SULTANGANJ BUDDHA?

A prized possession of the Birmingham Museum and Art Gallery, Birmingham in the UK, Sultanganj Buddha is an exquisite statue of Lord Buddha that was found in Sultanganj— nearly 28 km from Bhagalpur in Bihar, in 1861-62, during the construction of a railway station by the colonial British government.

According to data available in public domain, the statue was discovered by EB Harris, a railway engineer, while the digging work was in progress for the East India Railway. He published a detailed account of the discovery according to which he stumbled upon the right foot of the Buddha statue ten feet under the surface, beneath a floor he considered to have been used to conceal the statue after it had been removed from its place. Harris had the gargantuan statue transported to Birmingham with the help of a businessman from the city, who offered it to the then-proposed Birmingham museum.

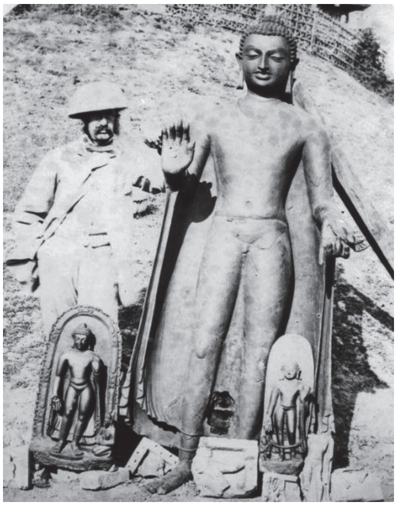


Image Courtesy: Wikimedia Commons/ Public Domain

English engineer EB Harris with the Sultanganj Buddha, 1861-62

The statue is dated between 500 and 700 AD, corresponding to the Gupta period of Indian history; it specifically relates to the transition period from Gupta era to the Pala era in present-day eastern India. It is 2.3 m high (7.5 feet) and 1 m wide (3.2 feet) and weighs over 500 kg. Made completely of copper, it is perhaps the only remaining metal statue of any size from the seminal Gupta period.

WHAT MAKES IT SPECTACULAR?

The Sultanganj Buddha — a dark metal statue of the standing Buddha in the Abhaymudra pose — is not just a magnificent work of art but is spectacular for the scientific process with which it was created. It is perhaps the only metal statue of the Buddha of such a size from that period, which involved massive amounts of copper. Complete with the robe, the statue was cast in pure, unrefined copper by the *cire perdue* or lost wax technique. According to publicly available data, the inside of the statue is made of clay, mixed with rice husks, which allowed radiocarbon dating.

The Sultanganj Budda statue is dated between 500 and 700 AD, the Gupta period of Indian history

The surface of the statue is now dark but it may have been brightly polished and light, almost gold, in colour in its original *avatar*; it is referenced from the mention of the Buddha statues in Buddhist scriptures of the period. The present dark shade owes to long period of exposure to atmospheric agents.

The sheer size of the statue speaks volumes of the scientific acumen of the metal workers of India of the period, the metallurgical science and skill that perhaps had parallels in only very few parts of the world in that age.

WHY SHOULD IT BE BROUGHT BACK TO INDIA?

There is no reason why the Sultanganj Buddha — along with every other Indian artefact stolen by colonial Britain — should not be brought back to where it belongs. There have been attempts by the residents of Sultanganj to raise awareness about bringing back the heritage wrongfully lying in Birmingham, but those have been feeble attempts that have not garnered sustained national attention as yet. It's time the citizens of this country — and not just Sultanganj — woke up to raise their united, determined voice to ask Britain to give India its heritage back.

Throughout former colonies, voices are being raised, demanding England to right its historical wrongs. Earlier in August, London's Horniman Museum and Gardens, agreed to return the famous Benin Bronzes (a set of 72 artefacts) looted by Britain in the late 19th century from its then colony, Nigeria.

India, too, must bolster its desire to reclaim its heritage. There wouldn't be a better time to do this than now as India currently enjoys an increasing heft in the global political dynamics, which would go a long way in putting pressure on Britain to wash off its colonial sins. A widespread campaign needs to be launched.

**The writer is Editor, Science India*

METALLURGY

Agonising Death-blow to India's Prowess in Metallurgy by British Raj

The country's indigenous knowledge in creating exclusive metal products, renowned all over the world, was decimated by colonial policies with the aid of science, a first in the world

■ **Prof BN Jagatap**

Image Courtesy: IRCTC 2017/Wikimedia Commons

The marvellous entrance to the Sun Temple in Konark, carved in granite. Its non-rusting iron beams have withstood the test of time since the 13th century

India had developed a great mastery over metal production very early in the history. She was centuries ahead of the rest of the world in iron, copper and zinc technologies. Colonisation of India annihilated the traditional metallurgy in a manner that the country became dependent on the metals which she was exporting for over about two thousand years or so.

The British rule adopted a multi-pronged strategy that included unfair policies and legislations as well as use of science as the basis for the discriminatory economic policies. It was perhaps for the first time that science was used to decimate indigenous knowledge developed over centuries. The result was to turn India into a huge market for goods manufactured in Britain.

MARVELS OF INDIAN METALLURGY

India boasted of production of several metals — gold, silver, copper, lead, tin, iron, zinc, mercury, antimony, etc. and their alloys and compounds.

Archeological evidences point to early iron making around 1800 BCE in the Lahuradeva site in Uttar Pradesh. Recent discoveries of iron artifacts dated 1800–2400 BCE in Telangana and Tamil Nadu may push back the start of the iron age by hundreds of years. Iron technology became mature by ~800 BCE. Iron surgical instruments were developed around 600 BCE. The technology for forge welding to obtain huge pieces of iron was developed during 100–500 CE. Indian steel, also known as wootz, was an advanced material of the ancient world. The process originated in south India around 4th to 5th century BCE.

Several monuments in India speak gloriously of her non-rusting wrought iron technology, e.g., the iron pillar of Delhi (4th century) and iron beams at Konark temple (13th century). Non-rusting property is due to high phosphorous (~0.114%), low sulphur (0,006%) and absence of manganese.

Wootz found its way to countries in the known world for centuries. It is said that the ancient Egyptians used tools

Image Courtesy: Rosemania/Flickr.com/Wikimedia Commons

Image Courtesy: Wikimedia Commons

Above: The 4th century coin of Samudragupta (in British Museum, London), speaks of the skills of ancient Indians to make alloys
Left: The 10th century Chola bronze Nataraja (at the Met Museum, New York), is another example of the felicity of Indians with the metals before the arrival of the British

made up of Indian steel to create the great stone monuments. Wootz was exported to the Arab world and Europe for making the famed Damascus swords until the 17th century. High quality Indian steel was even exported to England for the construction of Menai Suspension (1818) and Britannia Tubular Bridge (1846). The technology, thus, survived until the middle of the 19th century.

India was the first country to develop a process for zinc metal production. Archeological evidences show that zinc smelting began around 400 BCE. Zinc production at Zawar, Rajasthan is dated ~ 800 CE, which was expanded to semi-industrial level by 1200 CE. The process was based on reduction roasting of zinc ore followed by downward distillation to obtain zinc metal. This was an innovative process utilising a temperature of ~1200°C and extremely low oxygen partial pressure. It is estimated that about one lakh ton of zinc was produced at Zawar during the 13-18th century.

The copper statue of Gautam Buddha (5th century) excavated from Sultanganj (in Bihar) and currently in Birmingham Museum describes the expertise of Indians in making pure (99.7%) copper. It is estimated that during 1590–1895, about six million tons of copper ore were mined at the Khetri mines (Rajasthan) to produce about one lakh tons of copper metal.

Indians had mastered the art of making high quality alloys such as brass and bronze. The coin of Samudragupta (4th century), presently at the British Museum, and the statue of Nataraja (10th century), presently at the Metropolitan Museum, New York, serve as two examples of this mastery.

The Geological Survey of India was established in 1851 to create maps of mineral resources of colonial India with the aim to enrich the British empire

SCIENCE AS A TOOL FOR SUBJUGATION

The English East India Company established the Geological Survey of India (GSI) in 1851 for the purpose of creating maps of mineral resources of colonial India. The aim of GSI was to enrich the British empire; its reports included proposals on how profitably the geological findings could be used for the benefit of the empire. The GSI also played an active role in guiding the governmental policies on resource utilisation and conservation.

The initial work of GSI was in prospecting coal for its use in steam-powered river navigation and railways. By 1880, the surveys expanded to include the economic viability of about 90 minerals. The railway route in the mineral rich central India was a result of these surveys. Geologists also documented the indigenous practices of mining and metal production, which they reported as being primitive and environment unfriendly. GSI's reports and suggestions on conservation provided sufficient justifications for the government to enact laws which seriously affected indigenous metal production. This was not motivated by any serious environmental concerns, but in the interest of the industry of Britain.

The British geologists looked upon Indians as intellectually inferior. The story of Pramatha Nath Bose is well known in this context. He advocated manufacturing industries owned by Indians and helped the Tatas to establish modern iron and steel production at Sakchi at Jamshedpur.

GOVERNMENT POLICIES AND ACTS

The Indian Forest Acts of 1865 and 1878 gave complete control of forestry to the colonial government and

The initial work of GSI was in prospecting coal, which later expanded to include 90 other minerals. The railway routes in the mineral rich central India were the result of these surveys

restricted people's access to the forest land. These acts deprived the indigenous industry of the ore and charcoal needed for smelting processes. Smelters were forced to pay high taxes for the use of forest land, which made production of metals, in particular, iron and steel, highly uneconomical.

The enactment of the Arms Act of 1878 restricted Indians' access to arms. In India, guns were manufactured by welding pieces or rings of wrought iron. The British government was aware of the role of indigenous iron industry in supplying arms to the local rulers. The Arms Act led to the collapse of the weapons industry, which depended on indigenous iron production.

Industrial Revolution in Britain had made it possible to produce iron and steel in large quantities unparalleled to what the traditional Indian industry could produce. Valentin Ball reports in his compilation, *Geology of India, Part III, Economic Geology* (1880) that in 1873-74, iron imports by the state stood at Rs. 77,78,824, which rose to Rs. 1,22,93,847 in 1879-80. Import of cheap iron decimated the indigenous industry altogether. The iron smelters took to other professions for survival. The skills were lost and the technology developed over two thousand years was lost forever. Robert Curl, Chemistry Nobel Laureate of 1993, describes this as follows: "For the Damascus swords, Indians produced the raw material and exported it. Up to the middle of the 18th century, the steel swords depended on this particular material and when the mines in India stopped, they lost the technology."

An example of the unfair trade policies of the British Government is the Government of India Act that required the manufactured supplies required by the government be purchased through India office. This Act protected the monopolies of both the government in India and British industries. In 1883, the government revised this policy to support local industry, albeit with the exception of iron and steel.

Local manufacture of iron and steel

The 4th century iron pillar of Delhi is world renowned for its non-rusting property

Image Courtesy: Wikimedia Commons

by modern technology was also not supported by the British government. Valentin Ball observes that the total value of imported iron exclusive of that imported by the state between 1867 to 1879 amounted to Rs. 15,62,10,253; a large part of which might have been kept in India had the iron manufacture proved practical in India.

In fact, Ball was one geologist who favoured a new beginning of iron making in India, but in vain. If that were to happen, Indian mills would have been in direct competition with mills in Britain, which was contrary to the industrial policy of the colonial power. Tatas could get permission to set up their iron and steel factory at Sakchi principally due to the demand created by World War I.

Finally in 1901, Indian Mines Act was enacted to provide regulation and inspection of mines. However, by that time, the indigenous unorganised mining had come to a complete halt.

Image Courtesy: Shutterstock

Wootz, a steel invented in India, was an advanced material of the ancient world and in demand for making high quality Damascus swords

INDIAN INSPIRATIONS

Traditional Indian processes of production of wootz and metallic zinc provided sufficient inspiration to British scientists to replicate them through application of modern science.

In 1740, William Champion established zinc metal production at Bristol by a process based on downward distillation method of Zawar. Champion's process used the same arrangement as that of Zawar, the only notable difference being the use of glass retorts instead of the clay retorts of the Zawar process. SWK Morgan and PT Craddock observe, "Champion was notoriously close with details of the Indian process at Zawar; possibly a third party described the general principles of the process to Champion." Craddock conjectures that the proximity of the first settlement of the East India Company at Surat to Zawar could be responsible for this technology transfer.

As regards the carbon steel, D Mushet in 1800 took out a patent for converting malleable iron into cast iron. John Percy, a noted metallurgist, commented on this patent as follows: "It is curious that Mushet's process so far as relates to the use of malleable iron in the production of cast steel, should in principle, and I may add even in practice too, be identical with that by which the Hindoos have from ancient times prepared their wootz. I cannot discover any essential difference between the two."

RUMINANTS OF HIGHER ORDER SYSTEM?

Our current understanding of the Indian process of iron making is largely derived from the practices of tribes — Asur, Agaria, Brijias and Lohar. Interestingly, iron produced by them is rust-less. In this process, iron ore and charcoal are heated (1000-1200°C) in a bloomery clay furnace, wherein iron oxide is reduced by carbon monoxide to form iron and iron silicate which forms a liquid slag. Iron lumps are then hot hammered to release the entrapped slag out of iron mass, which finally yields wrought iron.

Our current understanding of the Indian process of iron making is largely derived from the practices of tribes — Asur, Agaria, Brijias and Lohar. Iron produced by them is rust-less

According to Valentin Ball, there were departures from the above discussed procedure. In Kathiawar, the furnaces were reverberatory type, while in Waziristan, the flux of limestone was added to the charge. In Birbhum, iron was produced in liquid conditions in large furnaces and was run into pigs, which were subsequently converted in open hearths into malleable iron.

Valentin Ball sums up his findings in the following words: "If we take a survey of the system of iron manufacture as practiced by natives of India, we meet here and there, traces of what may be the remnants of a higher system of working than those now existing."

Unearthing this higher system is still a challenge on hand. Rust-less iron that Indians produced is still a subject of research. Readers may refer to an interesting article entitled, "Uncovering the superior corrosion resistance of iron made via ancient Indian iron making practice", published by Australian researchers in *Scientific Reports* (2021).

**The writer is Professor, Department of Physics Indian Institute of Technology Bombay. He is also formerly Distinguished Scientist and Director, Chemistry Group, Bhabha Atomic Research Centre*

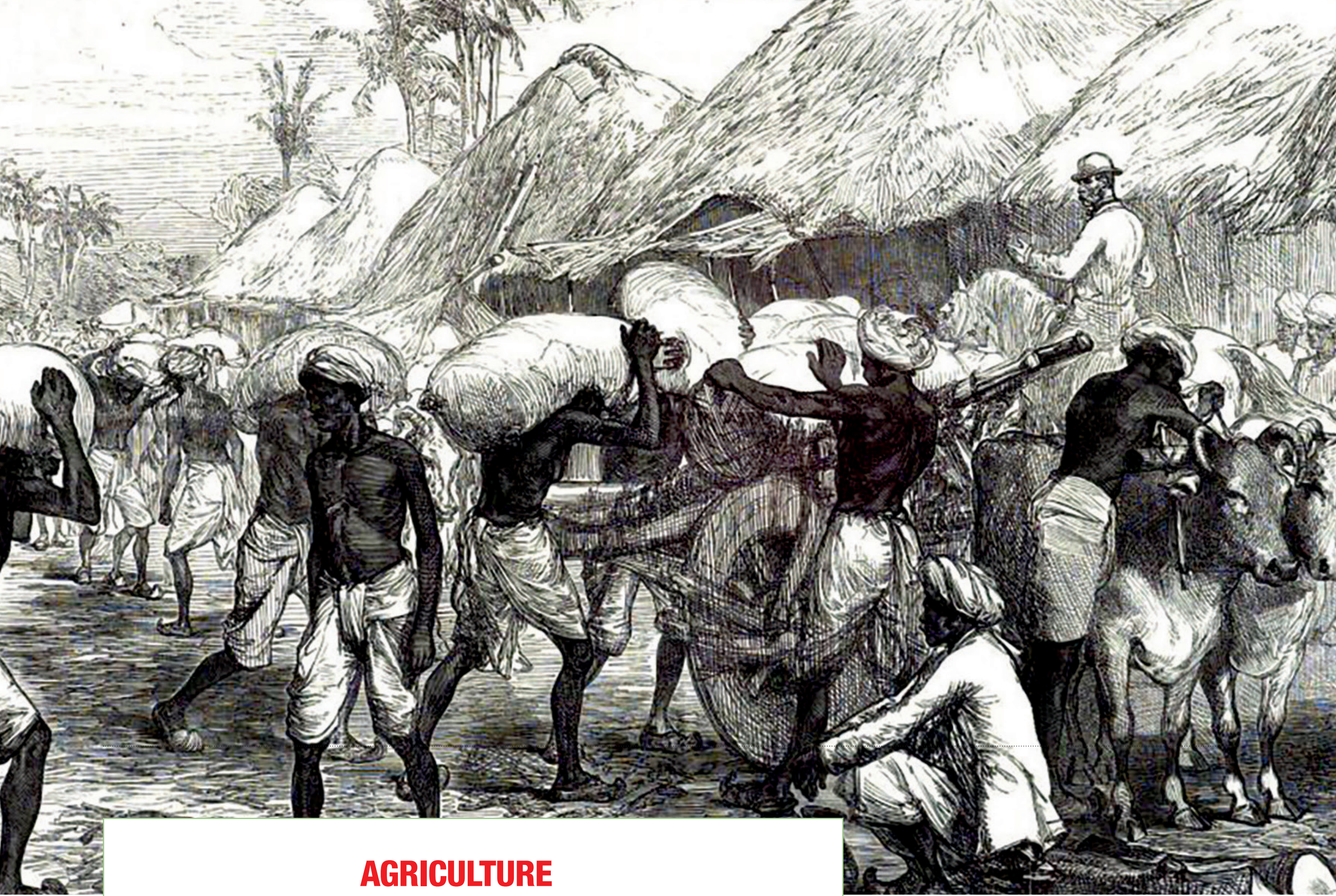


Image Courtesy: Pixabay

AGRICULTURE

Systematic Colonial Decimation of India's Agricultural Superiority

It's a heart-rending story of how the British destroyed India's thriving agricultural economy and left it gasping for breath by the time they quit in 1947

■ **Ambica Vankamamidi**

Irrigation marvels and innovations in agriculture were a part of India's agrarian economy from ancient ages. The Kallanai Dam on river Kaveri built around 2,000 years ago by Karikala Chola is one of the oldest water regulation structures in the world that is in use even today. Indus Valley had excellent water storage and drainage systems, water conservation of Dholavira through 16 reservoirs, artificial lake by King Bhoja of Bhopal are just a few engineering geniuses of ancient India.

Two Sanskrit works on our ancient agricultural techniques, *Balaramakrshisasthram* and Basava's *Krishisasthram*, written in the 16th or 17th century were traced by Jogi Raju, a farm manager working for a zamindar in

Far right: The skeletal Indian farmers as a result of famines, which were caused because the British forced Indians to cultivate cash crops instead of food crops, failing which they were severely punished

Right: To promote horticultural trade for Britain, horticultural societies and gardens were founded. This is the Horticultural Gardens in Madras, circa 1880s

Image Courtesy: peacocktrail.wordpress.com

Pithapuram, in 1920. According to these works, the definition of agriculture assigned a wider role than the present-day thoughts/ practices associated with agriculture. 'Agriculture includes production of food grains, sugar, flowers, fruits, thread and cloth from cotton, milk and ghee from cattle, blankets from wool, silk from the silkworm, and even salt from the sea and precious stones from the earth.'

Krishisasthram contains classification of soils according to colour, components, salinity, crops that suit different soils, and methods to improve soil quality. Our indigenous knowledge included division of the year into 27 periods, and crops to be sown in each period. Forecast of rain was calculated using astronomical methods. Agricultural methods and implements were developed depending on the local environment and topographical conditions.

Spices from India were in great demand in Europe for food and medicinal purposes. This was a major reason for Europe to discover a route for trade with India. It was Vasco da Gama who succeeded in providing a maritime route from Europe to India. Gradually, Europeans found colonisation more lucrative than controlling a few trading centres. The British established trading centres through the East India Company from 1757, the first step towards colonisation. Development in any form in India was always directed to aid the progress/ prosperity of England including technological applications such as telegraphy, railways, and shipping.

COLONIAL IMPACT ON INDIAN AGRICULTURE

Institutionalisation of agricultural science in colonial India took place in phases. The first phase saw the setting up of botanical gardens and societies for horticulture and agriculture. It was a trial phase, where exotic varieties were introduced in various pockets of the country. Britain looked towards gaining insight on the botanical collections that were collected during surveys conducted by botanists in India. These were crucial to understand the scientific

Grain boats on the Ganga during a famine in Bengal during British rule

Image Courtesy: The Illustrated London News 25 April 1874/Creative Commons

Image Courtesy: Illustrated London News, 1874/Creative Commons

basis for improvement of agriculture and plantations. In 1778, the colonial government established nurseries for spices at Tinnevelly district, Perambakkam, Madurantakam and Salavakkam in Chingleput district (all in present-day Tamil Nadu) for commercial purposes. Foreign spices such as nutmegs and clove plants were imported and raised at Courtallam Hills (in Western Ghats, Tamil Nadu). However, the expenses on these nurseries were much more than the income derived from them, and they were auctioned to private individuals.

To promote new varieties, horticulture societies were established. One such society was the Agricultural and Horticultural Society of Madras (AHSM), established in 1835. The society aimed to introduce new varieties, give awards for improved agricultural products, and develop horticulture through grants. In the following few years, experiments were carried out in various areas in India. New varieties were imported from places such as Australia. In 1856, seeds of the gum tree (Eucalyptus) were imported from Australia and planted at Ootacamund, which became the main source of fuel in the region. In 1866, cinchona trees from Peruvian Islands were transplanted to India to protect the British army from malaria.

For the first time, the imperial government introduced entomology as a branch of agricultural science. This was to investigate the causes of all plant diseases, as it continued to be a great loss of revenue to the government. Efforts to grow imported varieties in India met with little success because there was no importance given to local ecology and geological conditions.

The colonial government introduced entomology as a branch of agricultural science to investigate plant diseases that caused great loss of revenue to the British

FAMINES AND REVENUE

After an early phase of experiments, colonial rulers made efforts to have a policy on agriculture. Viceroy John Lawrence (1864-69) initiated the establishment of an agricultural department after the Orissa Famine in 1866. But this proposal was ignored. Viceroy Lord Mayo in 1869 again emphasised agricultural development in the country. Efforts of Lord Mayo and AO Hume, who was a member of the Bengal Civil Service, resulted in the creation of the Department of Revenue, Agriculture and Commerce in 1871. But again, the colonial government gave importance to revenue. The department was set up to aid cotton export to Manchester, and not work towards alleviating those affected by famine. In fact, a report recommended the abolition of the department as it failed in its duty of revenue enhancement. In 1879, the department was shut down due to insufficient funding, lack of staff and support from the government. Hume in his work, *Agricultural Reform in India*, stated the department could not exercise any effect on agriculture in the country. It was primarily to maintain records of settlements, agricultural statistics and land revenue.

In 1880, the Famine Commissioners headed by Richard Strachey stressed the requirement to disseminate scientific knowledge of agriculture and appoint officers with adequate knowledge on India's agrarian conditions. Following this, in 1882, the Department of Revenue and Agriculture was reinstituted. Despite stressing on the need for improvement of the agricultural system, the department again began focusing on revenues.

In 1905, a scheme was approved for reconstitution of separate provincial agricultural departments. Therefore, imperial and provincial departments were constituted in the agricultural policy. The Agriculture Research Institute

Image Courtesy: Wikimedia Commons

(present Indian Agricultural Research Institute) with a college for advanced agriculture training was established at Pusa in 1905. The institute came up with a grant of £30,000, and its director was the agriculture advisor to the Government of India until 1929.

Land records and economic facts of each district/ village were separated from agricultural activities. Experts, mostly from the West, were appointed to various specialised branches. Staff at the provincial centres was supposed to reach villages and address issues of local farmers. Experimental farms were expected to specialise in research in cropping and cultivation techniques required in the region. Lack of sufficient staff, slowdown of administration and the World Wars hindered the initiative. In 1868, Agriculture School at Saidapet, first of its kind in India, was established in Madras Presidency to train students as practical farmers. On the contrary, the college trained students were considered suitable only to occupy subordinate

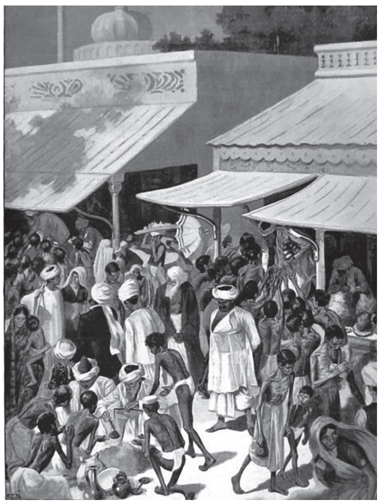


Image Courtesy: The Graphic 27 Feb 1897, Creative Commons

posts in revenue and other departments. The British desired to fill subordinate positions by Indians through non-farm training at the institute. Even if Indians succeeded in getting a diploma in agriculture, they were always offered assistant positions.

Agricultural colleges were established in Pune, Kanpur, Sabour, Nagpur and Lyallpur (now in Pakistan). An All-India Board of Agriculture was established in 1905 to connect provincial governments with each other and make recommendations to the government. On the recommendation of the Royal Commission on Agriculture, which reviewed the position of agriculture in India, the Imperial Council of Agricultural Research (present ICAR) was established on 16 July 1929. The institute was supposed to guide research activities of central and provincial departments all over India, and address the problems in agriculture. Policy guidelines and other factors saw that only a small portion of wealthy cultivators benefit from the scheme while small farmers were left out. The Imperial gov-

Above: Gobardanga Zamindar House in North 24 Parganas, West Bengal. The British created the class of zamindars with the Permanent Settlement of 1793 who lived lavishly at the expense of toiling farmers
Left: A grain market

ernment believed that big landlords and zamindars will help in percolation of the knowledge to smaller cultivators and tenants. This percolation of knowledge never happened.

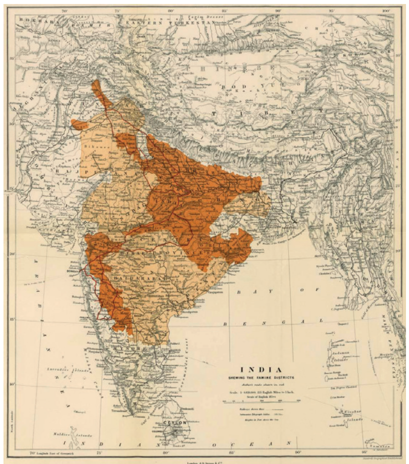
DYNAMICS OF LAND OWNERSHIP

A strong integration of foreign merchants with the Indian market ensured a heavy dependence on Indian merchant-middlemen. This further allowed the system of farmer dependence on merchant-trader groups. Traditionally, peasants had always sold their crops from a position of strength. However, once the commercialisation of crops commenced, peasants took money from merchants as advance before the sowing season resulting in selling their grains at a pre-determined rate. The village dynamics changed with the permanent land settlement instituted by Lord Cornwallis in 1793. A class of zamindars with a right to collect tax was created. The village communities split under this new imposition, where zamindars became landlords. Bengal, Bihar and Orissa were most impacted with this change. The peasants became debtors and not agricultural producers. Small cultivators required rural credit for various reasons such as higher investments for more acreage, dependence on food crops for their subsistence, harvest fluctuations, monetisation of rent and tax, etc. The British discouraged any improvement to our indigenous agriculture system. This was not because the system was incapable of improvement but it was perceived as a barrier to modern requirements.

Indian agriculture was dominated by subsistence farming in the pre-colonial era. Excess food grains cultivated were stored so that they could be used against any natural calamity. To suit the Imperial agenda, promotion of science in agriculture was always subjected to restricted growth. The pre-colonial rural structure was broken down, and pushed towards commercialisation. This resulted in a shift from cultivation for home consumption to cultivation for the market. The revenue generated from exports benefitted British business families, big farmers, some Indian traders

Image Courtesy: Indian Famine Commission, Creative Commons

Image Courtesy: The British Library/Creative Commons



Top: A map of India for the report of the famine commission showing British provinces and native States, 1879; Above: A map of the famine districts in India in 1898

and money lenders. Food crops were also channelised into various market networks. Rice and wheat began to be produced not just for primary consumption but for distant markets too. Unlike plantations, commercial crops such as indigo, opium, silk, sugarcane, cotton, wheat and jute were largely grown by small farmers who depended on merchants for their working capital.

The French revolution and consumption patterns of Europe saw an increased demand for sugar from India. Between 1884 and 1899, the area under sugarcane increased from 282,000 acres to 862,200 acres with Punjab, UP, Bihar and Bengal accounting for more than half of this surge. Again the Cotton Famine in 1861 increased the demand for cotton cultivation in India. A new cotton strain in South India was developed from local varieties called Karunganni by the agricultural department. This variety with better staple and fibre quality was promoted, increasing the acreage under cotton in the region. Rangpur, Mymensingh and Dacca in East Bengal accounted for a high percentage of jute acreage to meet the needs of jute mills in the region. George Blyn in his work *Agricultural Trends in India, 1891-1947: Output, Availability, and Productivity*, revealed that per annum increase in population

Studies indicate that India's GDP to world share was about 22% in 1600 AD. This came down to 4% in 1947

in 1891-1947 was 0.67%. However, the total food grain production increased by only 0.11% in this period. During this period, the per-acre production of food grains decreased by 0.18% per annum. The prices of highly commercialised non-food crops increased by 0.86% per annum while their total output grew by 1.31% per annum. Similarly, in the period 1901-41, Madras had an annual average rate of yield increase of 0.35 per-cent of food grains and 1.25 per cent increase of non-food grains. Gradually, Indian agriculture was systematically and scientifically reorganised to suit the needs of the British government.

Studies indicate that India's GDP to world share was about 22% in 1600 AD. This came down to 4% in 1947. The British successfully destroyed our agrarian market. Today, as part of our goal towards Atmanirbhar Bharat, we must take pride in our indigenous agrarian wisdom, and combine it with modern science to bring about a vibrant agricultural sector.

**The writer is Science Communicator, CSIR-Indian Institute of Chemical Technology, Hyderabad*

From Glory to Ruination: The Saga of Indian Textile Industry Under Colonial Rule

Systematic destruction of the Indian textile industry by the British reduced the world's largest textile producer to a mere market for finished foreign goods, and its skilled weavers to farm labourers

■ Dr Vivek Kumar

A woman at a handloom, weaving khadi, a traditional Indian fabric, spun and woven by hand and with natural material like cotton, silk or wool

Image Courtesy: Pixabay

The textiles of India is probably the oldest industry as accounted by historical evidence such as Indian muslin, which was used by the Egyptians for dressing their mummies even before 5000 B.C. Various archaeological findings and ancient texts manifest its existence. Indian textiles gained prominence during the ancient and medieval times; uniqueness and versatility in styles and aesthetics, artistry, dexterity in weaves and designs of textiles from various regions of the country illustrate the richness of this Indian tradition.

From Kashmir to Kanyakumari, every region in India has its own techniques to weave unique fabrics. From Pashmina of Kashmir to Kalamkari of Andhra Pradesh, from Bandhani of Gujarat to Muga silk of Assam, Indian textile still holds special status in the global panorama of textiles.

However, the colonial period destroyed the Indian textile industry and weavers. The British strategically broke the industry by exporting raw material from India and selling finished textile products back to India, which consequently affected the Indian economy. The significance of the Indian textile industry was recognised later and it became a huge part of the freedom struggle, thus establishing the Swadeshi Movement in 1905 for the revival of the Indian textiles or handloom.

INDIAN TEXTILES IN ANCIENT INDIA

The earliest fragment of cotton cloth with a Hansa (swan) design was dug from a site near Cairo in Egypt. There are several archaeological pieces of evidence found at various sites of the Indus-Saraswati Valley Civilization, namely Harappa, Mohenjodaro, Chanhudaro, Lothal, Surkotada and Kalibangan. These sites provide evidence for earliest specimens of spindle and spindle whorls of stone, clay, metal, terracotta and wood, dye vats, needles, woven and dyed textile fragments, wild indigenous silk moth species, and silk thread inside copper beads confirming that spinning of cotton, wool, weaving, sewing, dyeing, and use of silk was common.

Vedic literature, *Mahabharata*, and *Ramayana* give accounts for the prevalence of Indian textiles, weaving and spinning materials. In the *Mahabharata*, Lord Krishna was always described clad in Kashi Pitambara (silk of Banaras, Uttar Pradesh). The high frequency of clothing metaphors and several terms related to weavers in the Rigveda indicate that spinning and weaving were highly advanced and honoured occupations in the Vedic society.

During the Mauryan period (321 BCE – 185 BCE), Indian textile reached historical glory due to cross-fertilisation of ideas, culture, style and technologies. There is evidence of greater importance of textile in long distance trade exchanges of India established with Egypt, China, Iran, and the Mediterranean region during this period. Accounts of Megasthenes, a Greek ambassador to the court of Chandragupta Maurya, Kautilya's *Arthashastra*, *Jataka* tales, Buddha and Jain texts give vivid glossary of textile sector, indicating a well-developed and structured textile industry in ancient India.

Several sites of the Indus-Saraswati Valley civilisation have provided evidence of the earliest specimens of spindle and spindle whorls, as also dye vats and needles

In Deccan and southern India, the textile industry especially flourished under the patronage of the Satavahanas, the Pallavas and the Chola rulers. Indian textiles were ruling the international trade across the Indian ocean. Several outstanding centres of cotton and silk weaving came up during ancient times and the reputation of these centres still continues. Tales of the growth of cities like Madurai, Puhar and Kanchi-

Image Courtesy: Twitter

Image Courtesy: gandhimemorialcenter

Above: Mahatma Gandhi on the spinning wheel weaving Khadi (place unknown); Left: A young Indian woman spinning silk in the 1880s

puram, Tribhuvanam, Arni, Tirupparkkadal, Virinchipuram, Woraiyur, Tirupati, Kalahasti, Gugai, Salem, Sulur, Venkatagiri, Dharmavaram, Kumbakonam, Thanjavur and Vridhachalam speak of the glory of ancient Indian textiles.

The growth of Indian textiles continued in the Gupta and Vardhan reigns. The revered poet Kalidas and Chinese traveller Hiuen Tsang have given vivid accounts of the artistry and finesse of Indian textiles.

HANDLOOMS IN MEDIEVAL INDIA

The medieval period witnessed the Persian influence in the technique, motif and technology used in making textiles and fabrics in India. Court patronage led to increased production and trade of textiles. Skill of weavers reached the next level during medieval times. Amir Khusro once described Indian muslin as: 'A hundred yards of it can pass the eye of a needle, so fine is its texture, and yet the point of the needle can pierce through it with difficulty. It is so transparent and light that it looks as if one is in no dress at all but has only smeared the body with pure water.'

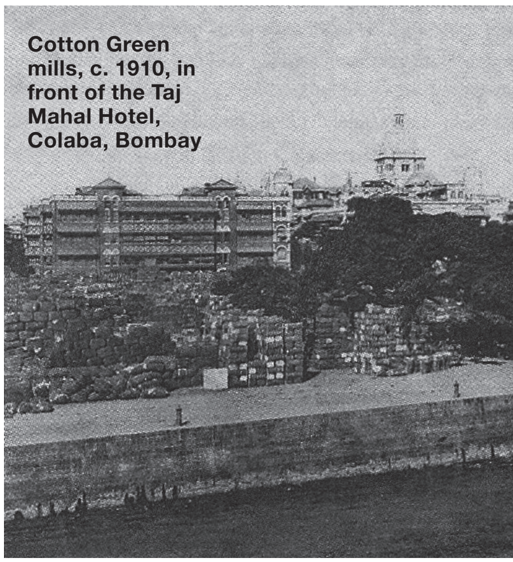
The textile industry became the largest industry during the Mughal regime with a huge European market

The textile industry became the largest industry during the Mughal regime with a huge European market. The muslin produced at Dacca (present-day Dhaka, in Bangladesh) reached its pinnacle and was considered the best by the rulers and the nobility.

During the rule of the Rashtrakutas (6th-10th centuries), Gujarat became a major production centre for cotton and silk, *zari* work, brocade and embroidery. The development and enhancement of advanced weaving techniques took place; these included *patola*, *kinkhab* and *tanchoi*, which were assimilated from China. Later, the demand for other craft fabrication, like textile printing, also rose, especially among the Europeans. White calicos were being exported to Persia, Arabia, Poland, Turkey, and Cairo.

In southern India, the Vijayanagara empire (1336-1646 AD) saw a time of dramatic increase in the scale of textile production to meet the demands of both external trade and an expanding elite within the empire. The organisation of textile production grew in scale and complexity. A new group of 'master weavers' emerged who controlled large numbers of looms and acted as merchants in the distribution of their products. By the late 15th century, individuals owned as many as 100 looms.

During the Pala rule (c. 750-1161



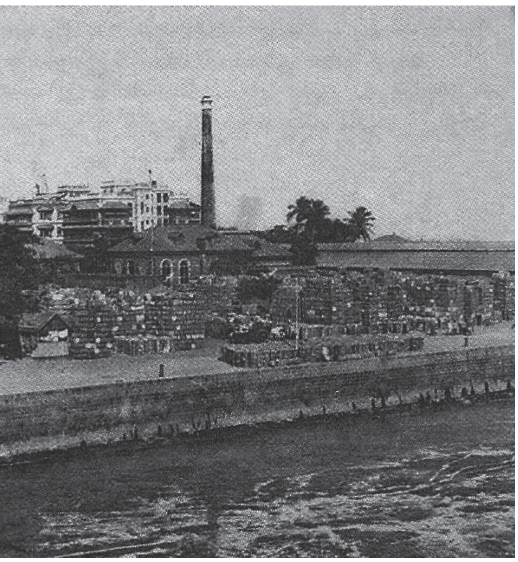
Cotton Green mills, c. 1910, in front of the Taj Mahal Hotel, Colaba, Bombay

Image Courtesy: Public Domain

AD), the textile sector contributed significantly to the flourishing of Bengal's economy. Textile products of Bengal villages were highly valued, sought after and enjoyed by people in many parts of the world. As a result, Bengal became the harbour of excellent quality cotton fabrics, resulting in brisk trade of cotton goods with distant countries, such as Arabia. Sericulture was also very popular in Bengal.

BRITISH PERIOD: DECLINE OF INDIAN HANDLOOM INDUSTRY

A large number of factories or centres called 'Kuthi'' were set up on the banks of Bhagirathi river by the British, Dutch, Portuguese and French to transport silk to the world. In the late 17th century, the English East India Company established its factories and centres at Coromandel, Surat and later in Bengal and imported cotton, mostly in the form of calico, a dyed or printed textile. Cotton textiles were hugely popular in Britain as they were much more comfortable than traditional wool clothing and much cheaper than silk. In 1700 AD, the Indian handloom fabric was so popular in England that King William III had to impose a fine of 200 pounds on those who wore Indian silk and calico. The Calico Acts (1700, 1721) banned the import of most cotton textiles into Britain to revive the British wool and silk industry, followed by restriction on the use and sale of most cotton items. It was a form of economic protectionism, largely in response to India which dominated world cotton textile markets at the time. When Britishers started taking control of the subcontinent, Bengal was the major hub for foreign merchants dealing in textiles, specially the silk clothes. Dacca, Murshidabad, and Cossimbazar used to be full of foreign merchants buying famous Dhaka or Bengal Muslin, Baluchari silk and Jamdani silk clothes. Bengal silk clothes were of premium quality. Textile products from other parts of the country too were major export items to the world.



In 1700 AD, the Indian handloom fabric was so popular in England that King William III had to impose a fine of £ 200 on those who wore Indian silk and calico

At the end of the 18th century and the beginning of the 19th century, the Industrial Revolution transformed the way goods were produced in Europe. It became possible to produce goods on a massive scale compared to handicraft and handloom industries. The industrialists driven by greed for money soon ran out of raw material and market to sell their finished goods in. This dual need was served by the colonies acquired by them. Thus, the rush to acquire new colonies for selling their finished goods and sourcing raw materials from, began. The declining Mughal power in the 18th century and internal power struggle in India provided a perfect opportunity to European trading companies to establish their control over Indian territory.

The English East India Company made its mark as a political power at the Battle of Plassey in 1757 and at the Battle of Buxar in 1764. It acquired Bengal and established its rule from Calcutta. In the changed scenario, the Britishers looked upon India as the proper destination for procuring cheap raw materials as well as a market for their products in post-Industrial Revolution times. British authorities persuaded Indian rulers to increase their authority over the Indian market. The local weavers were forced to sell at fixed rates, and were bound in contracts to sell exclusively to the British. The weavers could barely redeem 80% of the total cost of production, which forced them into extreme poverty over time. In 1835, only a minimal import duty of 2.5% was levied on cotton cloth from Britain, whereas an export duty of 15% was charged on the Indian cotton textiles. Furthermore, goods from England could be brought only in English cargo ships (This same principle was used by the British in other colonies as well, such as in America). As a result, Indian goods could not enter the British market while British goods flooded the Indian market and systematic destruction of Indian local industries took place. The English East India company also destroyed the silk industry of Bengal by introducing a new variety of mulberry silkworm in Bengal, and a new improved method of silk reeling. Further, the company started collecting high taxes on the sale of raw silk and controlled its prices. This reduced the local people and silk weavers to extreme poverty. Furthermore, after 1833, British factories were completely closed due to huge losses and led to complete destruction of the silk industry in Bengal.

Sudden decline of the Indian handicrafts and textile industry created unemployment for a large community of weavers. Left with no other alternative, many of them migrated to villages to work as agricultural labourers which in turn increased pressure on rural economy and livelihood and led to disguised employment. India used to manufacture 25% of the world's textiles in the 17th century, which was later reduced to just 2% by the end of colonial rule in 1947. Indian textiles, which once had a huge demand in Asia, Europe and Africa, were now deprived of the domestic market as well because finished, machine-made and cheaper British goods flooded the Indian market. In England, the ruin of the old handloom weavers was accompanied by the growth of the

Image Courtesy: Wikimedia Commons

Silk sarees woven at Kanchipuram, Tamil Nadu, are world renowned. The silk trade in Kanchipuram began under Raja Raja Chola I in the 10th-11th centuries

machine industry. But in India, the ruin of the millions of artisans and craftsmen was not accompanied by any alternative growth of new industrial forms. This led to a massive loss of jobs.

The economic policies of the East India Company and later that of the Crown rule were meant only to transform India into a consumer of British goods and in turn, to benefit the economy of Britain alone.

PRE INDEPENDENCE: KHADI - 'A FABRIC OF INDIAN INDEPENDENCE'

In 1867, Dadabhai Naoroji, 'The Grand Old Man of India', put forth the economic drain theory in his book, *Poverty and Un-British Rule in India*. He sought to prove that abysmal poverty in India was not a result of internal factors but was attributed to colonial rule which led to the drain of wealth and prosperity of India. Noted writer, poet and nationalist RC Dutt also noted: 'Taxation raised by the king is like the moisture sucked up by the sun to be returned to earth as fertilising rain; but the moisture raised from the Indian soil now descends as fertilising rain largely on other lands, not in India.'

In 1867, Dadabhai Naoroji noted that India's abysmal poverty was not the result of internal factors but the colonial rule which led to drain of India's wealth

Image Courtesy: Wikimedia Commons

The Priest King or Bearded Man found in Mohenjodaro (2200-1900 BCE) wears a shawl with trefoil pattern, giving an idea of textiles used by ancient Indians

The Indian patriotic leaders observed the unrestrained weakening of the Indian textile industry and in turn, the Indian economy. The Indian National Congress passed a resolution at its 7th Session in 1891 urging people to use only Indian goods and boycott imported ones and gave a clarion call for 'Swadeshi', or the use of Indian goods. With the partition of Bengal (1905), the movement reached its peak leading to the boycott of imported goods, particularly English cloth. In 1905, *dhoti*s reemerged in Bengal as a sign of incompatibility of Indian and British interests. The movement gained momentum with Gandhi's idea of Swaraj with his return to India from South Africa in 1915. He reintroduced hand spinning as Khadi, i.e., handspun and handwoven fabric, also known as *khaddar*, during British rule. Khadi played an important role as an agent of change and in giving birth to a unified India. Masses were encouraged to spin the yarn with *charkhas* (spinning wheels) and wear Khadi. It thus became a material to which people from diverse backgrounds could relate. The campaign to popularise this movement took many forms, including the organisation of exhibitions that demonstrated cloth production and sold Khadi goods. Khadi for Gandhi in a symbolic manner was the focal point of regeneration and diversification of the rural economy. Britishers tried to curtail the Khadi movement but, the more it was controlled, the more powerful and widespread it became. People burnt imported clothes and chose to wear Khadi, it became a mass movement and for the first time, women came out of their homes to join processions and picketing of shops selling foreign goods.

CONCLUSION

The existence of the Indian textile industry dates back to the Indus-Saraswati Civilization. In ancient and medieval times, India's cotton, silk, linen and muslin fabric were exported to many countries. It contributed a large share to the economy of India. Till the end of the 18th century, India was the major supplier of handloom textiles all over the world; however, such monopoly came to an end by the early 19th century. With political and economic supremacy, the British were successful in crippling the Indian handloom industry by fixing the prices, high taxation, violence, innovation of powerlooms and strategic theft of Indian motifs and designs, and by the end of 1813, Indian textiles had lost their domestic as well as foreign market base. The weavers lost their livelihood due to unfair competition from cheap British made goods. However, during the Indian Independence movement, Indian leaders promoted Khadi as a tool for India's freedom struggle. Spinning and weaving were considered as a symbol of self-reliance. Ultimately, the Khadi movement galvanised the post-World War recession of the British textile industry and the mills in Manchester were closed, which was a huge turning point in India's independence

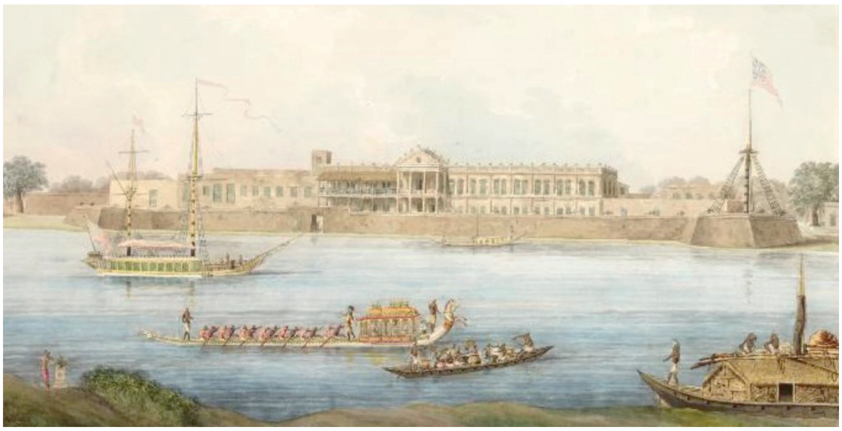


Image Courtesy: shoestringtravel

Image Courtesy: Wikimedia Commons

Above: A painting of the Cossimbazar Murshidabad Silk Factory of the East India Company
Left: A weaver at the loom weaving Muga silk, the golden silk exclusive to Assam and not produced anywhere else in the world

movement. The significance of the role of the handloom sector in the struggle of Indian independence can be understood by the fact that this age-old tradition of Indian handloom is celebrated on August 7 as Handloom Day to honour the country's first Swadeshi movement, which began in 1905.

**The writer is a Professor at CRDT (Centre for Rural Development and Technology), IIT Delhi*

The Blood-stained Blue Rebellion

Referred to as India's 'blue gold', indigo was one of the most lucrative trading commodities for the British Raj. But its importance lies in being the first commodity whose cultivators stood up against the colonial might

Image Courtesy: Old Indian Photos

Left: Beating of vat by hands at an indigo factory in Allahabad in 1877

Right: Indigo boilers and fecula table at an indigo factory in Allahabad in 1877

■ Prof Rajeev Singh

Are you wearing a pair of blue denim jeans while reading this article? Thank the indigo farmers of India. In 1873, when Levi Strauss launched the first pair of Double X Blue Denim 501s, it was the indigo dye from India which gave it the trademark blue colour.

Neel Vidroh or Indigo rebellion, was the first-of-its-kind revolt against the British which shook their economic and social terms, a dissent that united different classes of society against the British and made a permanent scar of 'oppressionist' on the face of England. This passive non-violent revolt can easily be termed as a prequel to what Mahatma Gandhi later adopted during the freedom struggle.

STATUS OF INDIA

Against the contrary belief of what we find in various internet sources, there are pieces of evidence that commercial indigo was being cultivated, manufactured, and traded from the Indian mainland since ancient times. The very first reference can be found in the ancient texts of *Atharvaveda*. Indigo finds mentions by various travellers and authors

— 'indikon', 'indicum' by Dioscorides (60 AD) and Pliny the Elder, respectively. Italian businessman, Marco Polo (13th century), writes about witnessing it at the port of Travancore. Tavernier (16th century) details the manufacturing process being followed in India.

For significant centuries, India remained an entrepôt of international trade; an Egyptian merchant's record dating first century CE, enlists indigo, cotton cloth, garments, silk, etc., as among the major international exports from the port of Barygaza (present-day Bharuch, Gujarat). The Indian brand of indigo had its international market presence much before the British arrived here. In the mid-17th century, three major varieties of Indian indigo were dominating the world market — Sarkhej, Biana, and Baroda — and were priced very competitively. The superior quality of the Indian product completely captured the European markets by sidelining the variety produced in Europe locally.

Very soon, a rivalry sprang up between the Portuguese and Dutch over control of the monopoly of trade with India. The Dutch East India Company soon started collaborating with Indian indigo producers and captured European markets by flooding them with the best quality Indian indigo. This troubled other European monarchs and many embargos were introduced against Indian businesses. French king Henry IV banned the use of indigo and issued a proclamation sentencing to death any person using it (funnily it still exists, as it has not been formally repealed). The English Parliament, through an Act and prohibitive regulations, declared the dye to be poisonous and its use forbidden. This Act remained in force until 1660.

In the meanwhile, England, through its East India Company, had started gradually consolidating its base in India, but a series of political events led to an almost complete suspension of indigo trade between the two countries. The change in economic value can be gauged from this data: Indian indigo export to England in terms of British imports which stood at a huge value of £2,00,000 per annum in 1660-63 was reduced to £54,000 pounds (1698-1710), and subsequently to £ 1,310 per year during 1741-60.

The Dutch soon started collaborating with Indian indigo producers and flooded the European markets with the best quality Indian indigo

ENGLAND ENTERS THE SCENE

For almost a decade, the indigo industry was forgotten by the world, although its cultivation continued on a smaller scale in India. In 1770, a French businessman visited Bengal and started establishing ties with Indian farmers. His endeavour was successful and immediately noticed by the East India Company present in

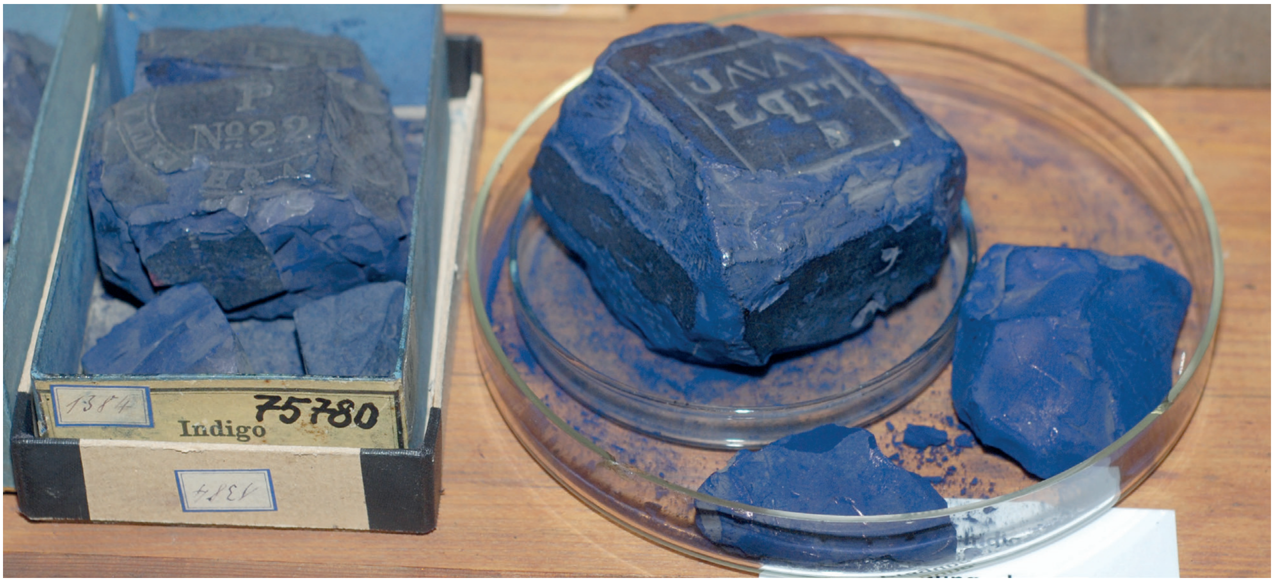


Image Courtesy: Shisha-Tom /Wikimedia Commons

Historical indigo dye collection at the Technical University of Dresden, Germany

Bengal at that time. Soon after, the company brought into India, British businessmen, planters from West Indies, and traders, and took important steps to revive its trade. Very soon, the company attained its peak of prosperity and the planters reaped huge wealth from their large farm estates and settled down in India to live a luxurious life. The chaotic rule of the company led to the deindustrialisation of local Bengal industries to promote the ones owned by the company's servants.

The English East India Company took complete monopoly of India's indigo trade with the world. Initially, the growth was slow and there were losses but then the company took a smart step in 1789, by declaring free trade of Indian indigo to the entire world (obviously, through them!). Soon, the fortunes turned and trade increased. The East India Company started using the resources of Bengal to feed the requirements of England. In 1793, Bengal was supplying only one-tenth of the total indigo requirements of England but within the next ten years, the exports doubled. From 1815 onwards, the state of Bengal was supplying the complete requirement of indigo for almost the complete world.

Although the cultivation of indigo in Bengal was not much before colonisation, the East India Company saw its potential. In a letter of 1786, from the Court of Directors to Governor General of Bengal, they observed, "When we reflect upon the cheapness of labor in Bengal, and the favorable climate it enjoys, we cannot harbor a doubt of the possibility of making indigo a most valuable article of importations; neither can we too strongly inculcate the necessity of your paying the most strict attention to it. We are confident that it might become one of the very best means of remittance to this country, and one of the least prejudicial exports from Bengal."

Huge enterprises like India Indigo Corporation were established by European settlers who kept on persuading the local Bengali farming communities to keep one portion of their land for indigo cultivation citing profits in this business. Indian indigo literally closed the worldwide businesses of the Spanish colony of Santo Domingo and the American (USA) states of Georgia and Carolina.

From 1815 onwards, the state of Bengal was supplying the complete requirement of indigo for almost the entire world

NEEL VIDROH (INDIGO REBELLION)

The lucrative indigo trade brought riches to the British (1786-1804) but gradually pushed Indian farmers into poverty as they were forced to cultivate indigo on their farmland instead of food crops. With the introduction of the Ryotwari system of cultivation of indigo, the farmers, now known as *ryot*s, were offered advance loans known as *dadon* at high-interest rates. The condition was that they would produce a prescribed quality of indigo in at least 25 percent of his land and sell the produce to the factory at fixed rates, the selling price would make up for the adjustments against advances given.

The easy access to advance money attracted the *ryot*s quickly but this system gradually led to gross abuses and tyranny. The farmers began to be forced to accept these advance loans and non-payment kept on multiplying the debt for the rest of their lives, which was eventually passed on to their heirs. Cultivating indigo was not at all profitable to the farmers, as they were given only 2.5 percent of the market price. Most of the time, the poor farmer was not able to pay the complete amount back to the planter, and this led to a vicious circle of debt in which the farmer got trapped for the rest of his life. A regulation of law (1833) was in force at that time which gave the indigo planter the right to take possession of the *ryot*'s land and property until the debt along with interest was completely paid by the *ryot*. These types of laws started frequent fights between the planters and farmers and since the laws favored the planters, they openly abused the farmers physically. Planters used the services of agents called *lathial*s whose function was to force the *ryot* into following the dictates of planters. In case they refused to follow, *lathial*s would loot and burn the house, snatch his draught animals and take control of the most fertile portion of the farmer's land.

The lucrative indigo trade brought riches to the British but gradually pushed Indian farmers into poverty as they were forced to cultivate indigo instead of food crops

These exploitative excesses led to a revolt by the cultivating farmers in the form of a non-cooperation movement against the planters. The non-cooperation of farmers to sow the indigo was mercilessly suppressed. Large contingents of police and military ruthlessly killed hundreds of unarmed farmers. The *ryot*s en masse refused to cultivate indigo and pay rent to the planters.

The mercilessness of the British police forced the humble farmers towards armed conflicts against the indigo manufacturing units in some places. Bishnucharan Biswas and Digambar Biswas led the first revolt in March 1859, which started in the villages of Gobindpur and Chanugacha in Krishnanagar, Nadia district, Bengal; quickly it spread to Murshidabad, Burdwan, Pabna, Khulna and Narail districts of the province. One of the rebels, Biswanath Sardar was hanged in a public show of trial at Assannagar, Nadia.

Image Courtesy: Old Indian Photos

Image Courtesy: Wikimedia Commons

Above: Cutting of indigo into cakes at an indigo factory in Allahabad in 1877

Left: Indigofera Sylvatica from *Curtis's Botanical Magazine* (William Curtis, circa 1830). Indigo dye is extracted from the small, green leaves of this plant

Men and women both came out against the atrocities being committed against the *ryots*. Men were armed with swords, bows, arrows, and spears, and women brought in kitchen implements to fight against the *gomastha*s, who were sent by the planters to collect rent. In fact, in many places, the village *pradhan*s (administrative heads) and *zamindar*s (landlords) also joined against the planters as they had been forced to sign the contracts under physical abuse by the *lathials* of planters. The revolt turned out to be one of the most significant farmer revolts of the world; it is known as the Neel Vidroh or the Indigo rebellion.

*Ryot*s started protesting in an organised manner and the movement spread all over Bengal. They were demanding a probe and reformation of the indigo cultivation system. The Indigo Revolt was mostly a non-violent *satyagraha* by the farmers of Bengal. The Lieutenant Governor of Bengal, JP Grant, while traveling along the rivers of Kumar and Kaliganga, witnessed nearly five million farmers all lined up along both the banks of the river in a never-ending line-up, praying for a government order and intervention to stop the forceful cultivation of indigo. Women along with children were also standing in groups to strengthen the cause of the revolt.

The government was thus forced by the Indian farmers to announce the appointment of the Indigo Commission on 31 March 1860. The revolt was documented by force into the notings of the Indigo Commission and the Landlords and Commercial Association (a body of indigo manufacturers). The Commission put the blame on planters whereas the association tried to show that everything was good between them and it was just a trivial issue. A witness at the Indigo Commission shared the fact that a small *ryot* who earlier cultivated around one *bigha* with indigo was now being forced to plough six *bigha*s of land for the dye industry owners. The commission gave recommendations in favour of the farmers, thereby leading to the gradual shutting down of all indigo manufacturing industries.

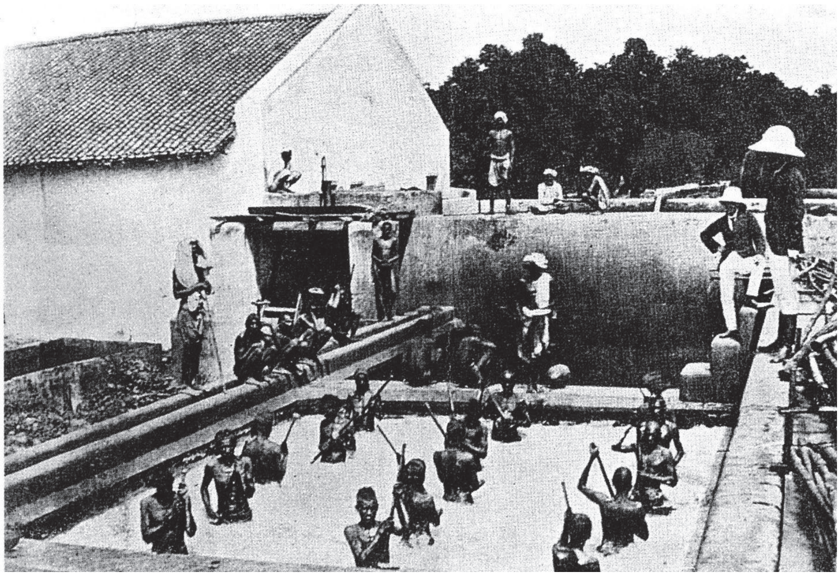


Image Courtesy: Old Indian Photos


Image Courtesy: Shutterstock

Above: Workers in an indigo factory in Allahabad, 1877; Left: Indigo House in Mongalganj, North 24 Parganas in West Bengal, built around 1777 for indigo trade and management by the East India Company

The echoes of the farmers' revolt reverberated throughout Bengal and many eminent leaders and academics came forward to highlight the issue. Dinabandhu Maitra in 1860 wrote a critically acclaimed Bengali play *Nil Darpan* (The Indigo Planting Mirror), which portrayed the social agitation and treatment being meted out to indigo *ryots*.

The entire episode of indigo cultivation and oppression deserves an apology by the British for the abuses, killings and suppressions it had heralded in India

THE END

The rebellion had already weakened the cultivation of indigo in Bengal and most of the businesses moved out to the state of Bihar. The final nail in the coffin came from the synthesis of artificial indigo, named "indigotin", by the German scientist, Professor Adolf von Baeyer, in 1865. Initially, the process devised was not commercially and financially successful but the German scientists kept on working on the improvements and perfecting the process. In 1897, German synthetic indigo flooded the markets and was immediately adopted, being cheaper than the imported indigo from India. The following decades saw a decline in indigo cultivation and production with the market price of naturally obtained indigo reduced to half. The closure of factories was disastrous for thousands of workers, managers, and assistants who were left jobless and searched for new positions.

CONCLUSION

This complete episode of indigo cultivation and oppression deserves an apology by the British as the abuses, killings, and suppressions ceased to exist once the modern synthetic system of artificial indigo dye manufacturing took over. Many *ryots* and their families lost their lives for a reason that vanished after a few years. The struggle of these unarmed *ryots* wrote a golden chapter in Indian history. Despite their poverty and oppression, the farmers raised their voices against injustice. Their resolve not to sow indigo again was so strong that the British were not able to force them again. The testimony of Panjee Mulla, in front of the Indigo Commission, expresses his courage, "I would rather be killed by bullets than sow indigo".

**The writer is Professor of Chemistry, ARSD College, University of Delhi*

Indian Railways
A Deceitful Largesse by the Colonial Power

This broad gauge steam locomotive, EM 922 (NWR), was built in Glasgow, Scotland, in 1907 and was used to haul passenger trains on the Great Indian Peninsula Railway and the North Western Railway in British India

The apologists of colonial rule have for long remained grateful for the gifts given by the British to India including the Railways, but nothing can be farther from the truth

■ **Sonam Singh Subhedar**

The railways have for long been viewed as one of the significant commitments by the British in India. It has been seen as the greatest example of India's infrastructural development under colonial rule. Starting around 1850, it has for long been believed to have fuelled the development of the Indian economy. Without doubt, it remains the mainstay of India's transportation system, and is also the greatest business supplier in present times.

In any case, in spite of the multitude of contributions of the railways, the justification of its launch in India is not without its share of malice. What was the requirement for presenting the railways? What was the immediate impact of railways on the economy? It definitely expanded the national income of the nation, yet did it build the life of individuals? Were the approaches and charges good for those who were transporting raw materials for trade and export?

The answer to all these questions is this — in India, the British created railways for their own advantage. They needed to send out raw materials from inner parts of India to their nation and furthermore supply their manufactured products in the interior hinterland. In this cycle, they needed to foster a rail route foundation in India. This could be easily proved by the fact that the export of wheat grew 22-fold from 1867 to 1877 and, surprisingly, kept on developing during the famine in 1876-78, showing an absence of sympathy toward the necessities of the ordinary citizens by the British Government.

Governor General Lord Hardinge argued in 1843 that the railways would be beneficial "to the commerce, government and military control of the country". From their very origin, the Indian railways were an instrument to exploit Indians and their wealth. The British made staggering amounts of money by financing the railways, where the government guaranteed returns double of government stocks, paid entirely from Indian taxes. Finally, at the expense of the Indian taxpayers, the first commercial train in India ran between Bombay and Thane on 16 April 1853. It was dedicated to Lord Dalhousie, who had served as the Governor General of India from 1848 to 1856. The train had 14 carriages and carried 400 passengers. It had three locomotives named Sultan,

Image Courtesy: Shamim Mohamed/Wikimedia Commons

Sindh and Sahib. The length covered by the train was 34 kilometres (approx. 21 miles) and the journey lasted for about 45 minutes.

Image Courtesy: Mumbai Port Trust

Above and facing page, above: Early images of railway construction at the Bombay port

HOW THE RAILWAYS AMUSED INDIA AND INDIANS

The first rail lines in India were pushed through rivers and forests. Infection and mishaps killed many workers and engineers, as did wild animals. The animals of the forests, particularly tigers, battled against this weird intrusion into their turf. Assaults on rail route workers and staff during the development of the lines and thereafter, were exceptionally normal. In 1889, a tigress that roamed the region around the rail line burrow near the recently developed Darekasa rail route station, presently in the Gondia district of Maharashtra, was recorded to have killed around 40 rail route workers.

When trains first came to the country in the mid-19th century, they were a wellspring of miracles and stunningness for the commoners. Indians alluded to it as the Great Rakasha or Rakas (phantom). No one was sure what it was — a devil, a machine, a magical animal or some wizard that would capture their land. People stayed away from it, saw glimpses of it and floated stories about it. They were terrified of the strong machine — what were these colossal, dark evil spirits breathing fire and smoke? At Hooghly, a businessman even flogged his horse to achieve the speed of steam trains. Somewhere else, close to the Bombay rail route line, there were reports that lives needed to be sacrificed to run trains and the steam run required a cadaver for each kilometre. People in Bombay called the train a 'lokhandi rakshas' ('iron demon' in Marathi).

ECONOMIC EXPLOITATION OF INDIA THROUGH THE RAILWAYS

The British created Indian Railways for their own benefit and it helped them to a degree. Indian fares, particularly passenger charges, were without a doubt high. The fares, which ought to have been 1/6th of the English fares, were 33% to two-thirds — far higher than whatever an average Indian could manage.

While choosing the areas for growing the rail organisation, the public interests were rarely thought of. The growth of the rail network was purely to serve economic benefits of the colonial rulers and therefore, it was laid accordingly in the regions that served this purpose. The railways were not intended for the benefit of the Indians and therefore, a large chunk of the population remained untouched by its advantages.

While the freight charges were diminished from 1853 to 1919, they were expanded dramatically after the British Government assumed control over the railway organisations.

Post-1920 is the period where the economic exploitation of India through railroads reached its pinnacle. In the pre-1920 period, there were not many endeavours made to fill the public needs through railways, for instance, the development of rail organisation, the utilisation of trains to move necessities during famines, and so on. In any case, the counter view that the starvations were large because of the after effect of major export of food grains and strain on both land and human resources, in

Gaekwar's Baroda State Railway Class A 4-6-0 steam locomotives (William Bagnall, Stafford 1933)

Image Courtesy: Mumbai Port Trust

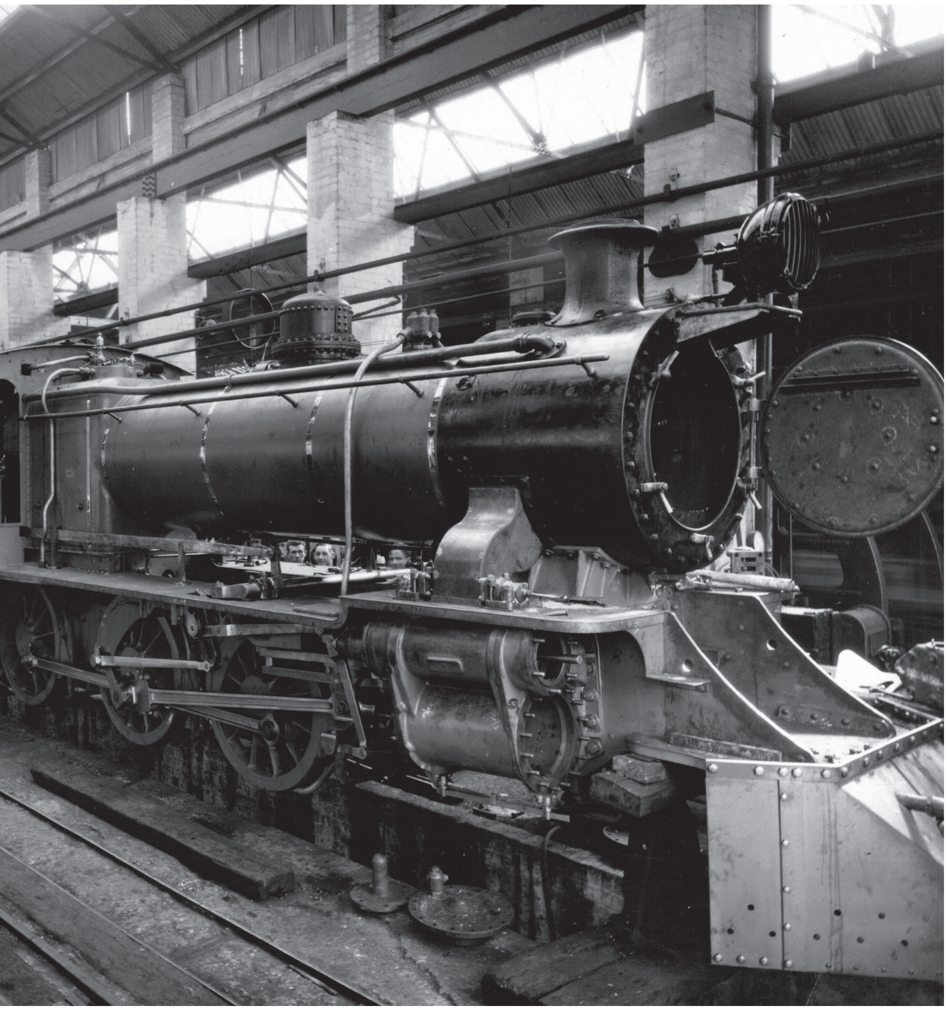


Image Courtesy: Historical Railway Images on Flickr

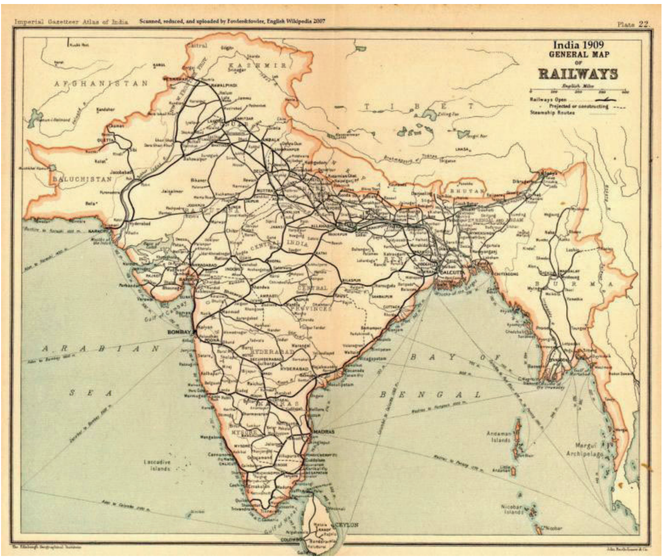
which railways had a significant part, can't be totally denied.

The freight charges increased substantially after 1919. The freight rate increased from 0.5 paise per ton-miles in 1919 to 1.5 paisa per ton-miles in 1934. The fare rates also increased from 0.35 paisa per ton-miles in 1919 to 0.83 paisa per ton-miles in 1934. The transport of raw materials from the cultivators to ports took place through trains. There was no significant development in rail networks during the post-1920 period due to insufficient investment and a lack of interest in public service. Transport of gold to the port of Bombay was done utilising the rail network during the Great Depression of 1931. This gold was shipped off to Britain to revive their economy. While the First World War impacted the rail lines gravely because of their abuse to ship grains and troops to the ports of Bombay and Karachi, the Second World War paralysed the railways.

The exports of grains like wheat and rice kept on ascending notwithstanding the normal event of famines e.g., during the famines of 1876-79 and 1896-1902, food grains were moved to ports via trains and afterwards sent out to Britain. Rail routes were utilised by the British to keep up with India as an exporter of raw material and merchant of finished products. This satisfied a significant goal of the British — forestalling the change of the Indian economy from agrarian to industrial.

THE REIGN OF RACISM THROUGH RAILWAYS

There was another source of mounting hostility: the treatment of third-class passengers who were generally all Indian. They were herded in third-class compartments, which had wooden benches and a total absence of amenities. However, whites-only compartments were soon discarded on grounds of monetary reasonability, Indians found the accessible reasonable space terribly inadequate for their numbers. There was even a long fight for Indians to have toilets on trains and conditions stayed filthy well into the 20th century. This ended up being an



Above: **The dense network of Indian Railways in 1909**
Right: A map of Indian Railways of 1871, prepared by the British Government India Office for presentation to the House of Commons Committee

Images Courtesy: Imperial Gazetteer of India via Wikimedia Commons

extraordinary source of difference and empowered nationalistic feeling. The creation that did most to hold the Indians under control ended up being twofold, animating the nationalistic powers which ultimately prevailed.

When it comes to railways jobs, Indians were neglected. The common view was that the railways would need to be staffed only by Europeans to 'safeguard investments'. This was particularly valid for signalmen, and the people who worked and fixed the steam trains. In the mid-twentieth century, every one of the key employees, from directors of the Railway Board to ticket authorities, were whites — whose salaries and extra benefits were likewise paid at European, not Indian levels.

Meanwhile, in 1862, the British laid out railway workshops in Jamalpur in Bengal and Ajmer in Rajasthan to maintain the trains. The Indian mechanics turned out to be proficient to such an extent that in 1878 they started building their own locomotives. Their talent frightened the British, since the Indian locomotives were basically the same, and significantly less expensive, than the ones made by the British. And therefore, in 1912, the British passed an act of parliament expressly making it non-viable for Indian workshops to manufacture locomotives. Between 1854 and 1947, India imported around 14,400 trains from England, and another 3,000 from Canada, the US and Germany.

The course of colonial rule in India implied financial misuse and ruin to millions, the annihilation of flourishing industries, the systematic negations of opportunities to compete, the removal of indigenous institutions of governance, and the transformation of lifestyles and patterns of living that had flourished since time immemorial, and the obliteration of the most precious possessions of the colonised, their identities and most importantly, their self-respect.

Colonial railways had a regressive impact on the land, environment and the people of India. Railway infrastructure accelerated the process of deindustrialisation, poverty and frequent famines. Railways and famines went hand in glove, as maximum food grains were transported to Europe, and Indians were forced to face terrible famines. The British exhausted each asset of India, yet, in the contention, everybody uses the expression that despite the fact that the British pillaged our assets, resources and most presumably harmony, they left us railways, cricket, education and tea. Railways were anything but a gift, very much like the English language, that was not a gift.

Assuming there were positive results for Indians from the foundations the British laid out and ran in India to their greatest advantage, they were never expected to help Indians, they were mere coincidences. Railways could have done so much more for India had it not been a colonial project. There was a fantastic missed opportunity. In an analysis of the impact of railways, John Hurd, an economist, in his essay, Railways and the expansion of markets in India, 1861–1921, concludes that India only enjoyed limited economic development under the British Raj and this happened because the railways were never allowed to be the stimulator for growth. Railways enabled the cheaper flow of goods, it also increased agricultural output, and created many jobs in modern industry and mining, but these changes "did not affect the basic structure of the economy. Not until Independence when economic development became a conscious and pursued policy did the railways begin to realise their potential for assisting in the transformation of the Indian economy."

**The writer is Associate Editor, Science India*

UNSUNG HERO

Kishori Mohan Bandyopadhyay

A Wronged Hero of Indian Science

In denying the young Indian credit for his vital assistance in the study of malarial parasite, Nobel laureate Ronald Ross exemplified the most bigoted face of British imperialism

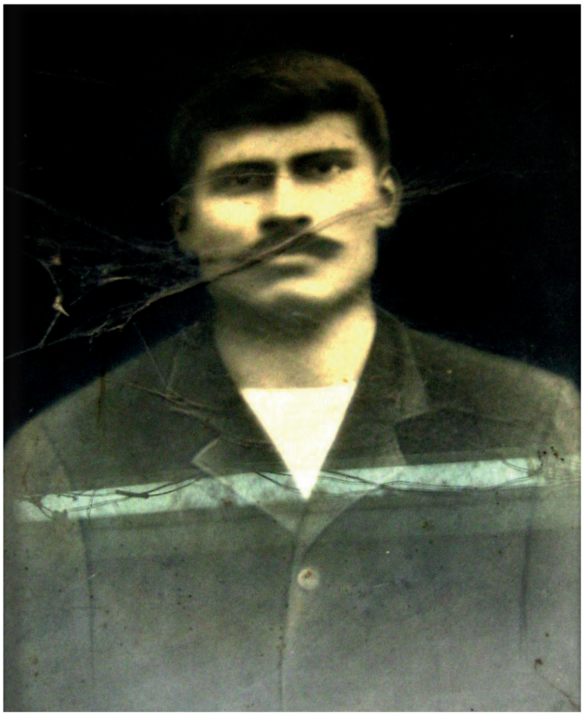


Image Courtesy: Kishori-Mohan-Bandyopadhyay/Facebook

■ **Prof Ayan Datta**

Have you heard of the top-secret mission of the Chinese dictator Mao Zedong called Project 523? It was a Chinese research project to find a cure for the choloroquine-resistant P. falciparum that would kill hundreds and thousands of people in China every year. In a hurriedly gathered meeting of scientists from different departments in May 1967, various ancient Chinese traditional medicine texts (the connection between Indian Ayurveda and Tibetan and Chinese medicine has been richly explored) were critically examined and by 1972, Tu Youyou (Nobel Laureate, 2015, in Medicine) discovered Artemisinin (extracted traditionally from sweet wormwood tree). Artemisinin reduced China's malaria caseload from twenty lakh to ninety thousand in the decade of 1980-1990. The work of Dr Tu Youyou has been a great example of how traditional knowledge can be improvised into modern context.

In the past, India has also been an active place to study Malaria. The most famous example has been the work of Dr Ronald Ross (Nobel Laureate, 1902, in Medicine). He demonstrated that the malaria parasite was transmitted by mosquitoes. Ross succeeded in showing the lifecycle of the parasites of malaria in mosquitoes, thus establishing the hypothesis of Laveran and Manson that that mosquitoes are connected with the propagation of the disease. One must note that he did not build his concept of malarial transmission in humans, but in birds. Sir Ronald Ross remained one of the most decorated British-origin scientists in the ~200-year-old Victorian rule of India. He was knighted, became FRS in 1901 and in 1926, became the Director-in-Chief of the Ross Institute and Hospital for Tropical Diseases, which was established in honour of his works. In fact, Ross fit exactly in the model of global British hegemony — the first British Nobel Laureate, and the first born outside Europe (Ross was born in Almora, now in Uttarakhand, India) to receive the award.

The very large body of the experimental work of Ross relied on sample collection for which he was supported by a team of several extremely bright native researchers. While the tropical and marshy land of Gangetic Bengal was a fertile ground for mosquito growth, yet, the cases of malarial fever had to be recognised and blood drawn from the patients within the time-line of the growth of the parasite. Ross desperately started looking for researcher and field assistant in this direction. Several advertisements were published in newspapers and yet hardly anyone suitable could be recruited. Luckily, a young man — Kishori Mohan Bandyopadhyay — showed the interest and dedication to work for Ross. This story is about this young man who was denied his due recognition by Ross and the British administration. He was neither acknowledged

Image Courtesy: kishorimohanbandyopadhyay.wordpress

Image Courtesy: Kishori-Mohan-Bandyopadhyay/Facebook

Above: A plaque at the entrance of the house in Panihati, in present-day North 24 Parganas district of West Bengal, where Kishori Mohan Bandopadhyay once lived

Left: Panihati Co-operative Bank founded by Kishori Mohan Bandyopadhyay and his friends

by Ross in his Nobel lecture, nor even mentioned in his memoirs having a full account of the great malaria problem and solution in 1923.

KNOWING KISHORI MOHAN BANDYOPADHYAY

Kishori Mohan Bandyopadhyay was born in 1883 in Calcutta. He joined as laboratory assistant for Ross in 1898 at the Calcutta Presidency General Hospital. Bandyopadhyay was a versatile genius — a scientist, social worker and nationalist. Ross quickly realised that he had hit a goldmine as Bandyopadhyay was immensely popular among local villagers. The reason being that his grandfather was a renowned practitioner of Ayurveda medicines who had sown the seed of scientific curiosity and love for exact sciences in his grandson too. Bandyopadhyay travelled to different villages, often very poorly connected by roads or railways, and convinced malaria patients to give blood samples for research. With the large sample of data available for Ross, it was rather straightforward to draw conclusions for the malaria cycle in birds.

In 1901 he passed the entrance examination for the Ripon Collegiate School. In 1903 he passed the F. A. examination from Ripon College as well as the Addya examination in Sanskrit. He later taught at B M S Girls School in Kolkata and thereafter at Trannath High School of Panihati where he worked till 1914. Two years later he passed the Bachelor of Laws at the University of Calcutta.

After Ross received the Nobel Prize, Upendranath Brahmachari, Acharya Jagadis Chandra Bose, Brajendra Nath Seal, Sivanath Sastri, Surendranath Banerjee and Acharya Prafulla Chandra Ray requested Lord Curzon to honour Bandhyopadhyay's contribution to the scientific achievement. This led to the presentation of King Edward VII's Gold Medal to Bandyopadhyay in 1903 during the Delhi Durbar by the Duke of Connaught. He was only 20 years old at that time! After his return from Delhi, several scholars, scientists and doctors felicitated Bandyopadhyay at an event in the Senate Hall in Kolkata. The programme was also attended by Dr Bidhan Chandra Roy, who would go on to become the first Chief minister of West Bengal.

After Ross' Nobel Prize, Lord Curzon was requested to honour Bandyopadhyay's contributions to the scientific achievement

FOOT SOLDIER AGAINST MALARIA

Bandyopadhyay was a noted social worker of his time. Under the influence of the revolutionary Mokhyada Charan Samadhyayi, he started imparting lessons on physical well-being and Swadeshi. On 24 March 1918, Dr Gopal Chandra Chattopadhyay started a public health movement to control the malaria epidemic. Bandyopadhyay became his ardent co-worker. A major contribution of Bandyopadhyay was the anti-malaria movement. He started the Anti-Malaria Cooperative Society at Panihati in Bengal.

Dr Gopal Chandra Chattopadhyay established that the spread of malaria could be controlled through the sanitary conscience of the common people. Chattopadhyay was the organisation's first president and Bandyopadhyay its first secretary. Within a short time, by cleaning ponds, drains of the village, removing garbage and spraying kerosene

Images Courtesy: wellcomecollection.org/Wikimedia Commons

Right: Portrait of Sir Ronald Ross, who won the Nobel Prize in medicine in 1902 for showing that malaria was transmitted by mosquitoes
Above: Ross on the steps of his lab at Calcutta in 1898, with his wife and assistants

oil, malaria was brought under control. This success story encouraged the villagers of the neighborhood, and Anti-Malaria Cooperative Societies were formed. That movement resulted in the formation of the Central Anti-Malaria Cooperative Society in a meeting held on 8 April 1919 at Rammohan Library Hall in Calcutta.

He started social campaigns in the villages of Bengal for the eradication of malaria. Bandyopadhyay started touring the villages with his Magic Lantern and slides depicting parasites, mosquitoes, patients, and steps for the prevention of the disease. He organised slide shows in order to educate the village folk about malaria or Sheet Jwar. The black-and-white slides were prepared by his photographer friend, Lakshminarayan Gangopadhyay who was one of the first roving photo-artistes of India. The black-and-white plates were coloured by Gangopadhyay with transparent dyes so that the slides generated excitement amongst the public. Bandyopadhyay communicated in simple mother-tongue the science of the malarial parasite and created awareness among the general masses.

In 1927, Bandyopadhyay started the Panihati Co-operative Bank which is still active. The bank became a great success

His regular visits to villages convinced him that the local population needed to be pulled out of the clutches of moneylenders. So, in 1927, he started the Panihati Co-operative Bank which is still active. The bank became a great success. In today's economics, this model would be micro-financing the poor for the poor. Unfortunately, the great life was cut short early in 1929 due to meningitis. Bandyopadhyay was only 46 then.

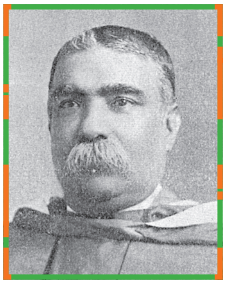
Any major scientific discovery often needs to have a collective effort of several people. It is therefore necessary that the contributors are acknowledged. This was clearly missing in the case of Ross. Whether Ross did it deliberately, out of jealousy or just that he thought that as a British origin person, he was entitled to be the beneficiary of the hard labour of natives — will remain a mystery. While past mistakes can hardly be undone, giving due credit to those deserving them creates a flatter world for grassroot innovations and germination of new ideas. In fact, the British society has realised this now and therefore, when the elucidation of the structure of DNA is discussed, credit is duly provided to Rosalind Franklin whose massive work was used by Watson and Crick for their discovery of the double-helical structure of DNA, which however, was never acknowledged by them. Kishori Mohan Bandopadhyay clearly remains a wronged hero in the history of science in India and it should be the duty of the enlightened readers of this magazine to seek proper academic credit for him.

**The writer is currently a Professor of Chemistry in the Indian Association for the Cultivation of Science. His research interests include computational materials and exotic molecular and materials properties at the mesoscopic and nanoscale dimensions. He is currently an Associate Editor of Bulletin of Materials Science, Indian Academy of Science and Editorial Advisory Board member of the Journal of Physical Chemistry, American Chemical Society. Coincidently, the author is an original resident of Panihati, the* karmabhoomi *of Kishori Mohan Bandyopadhyay*

PROFILES

Saluting the Science Warriors of India's Freedom Struggle

As we complete 75 years as an independent nation, here's an acknowledgement of the contributions made by those who fought battles outside the domain of politics



ASUTOSH MOOKERJEE

(1864-1924)

Mathematician, Barrister, Educator, Institution Builder

As Vice Chancellor of Calcutta University from 1906 to 1914, he blunted the colonial government's stranglehold on the university and created an atmosphere of research and higher studies for Indians by securing financial assistance from Indians. Was instrumental in the appointment of future Nobel laureate CV Raman as professor at Rajabazar Science College under the University of Calcutta.

BAL GANGADHAR TILAK

(1856-1920)

Nationalist Leader, Freedom Fighter, Teacher

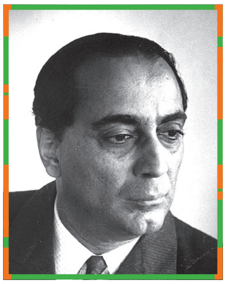
A multifaceted genius, he was a great driving force for freedom struggle. The British called him the 'Father of Indian Unrest'. He was given the title of 'Lokmanya' for his mass leadership across the country. Started the public Ganesh festival to unite people in their fight against the British. Great scholar of Astronomy and Mathematics and studied position of astral bodies in Vedas.

CHANDRASEKHARA VENKATA RAMAN

(1888-1970)

Physicist, Nobel Laureate

He is known for his work in the field of light scattering and won the 1930 Nobel Prize in Physics, the first for any Asian in the sciences, for the discovery of the Raman effect. The discovery was made on 28 February 1928 and the day is celebrated annually as the National Science Day in India. He established the Raman Research Institute in Bangalore in 1948.

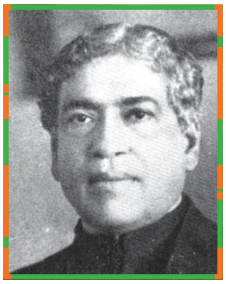


HOMI JEHANGIR BHABHA

(1909-1966)

Father of Indian Nuclear Programme, Physicist

Founding director, and professor at the Tata Institute of Fundamental Research (TIFR). Known as the Father of the Indian Nuclear Programme, Bhabha was the founding director of the Atomic Energy Establishment,Trombay (AEET) which is now named the Bhabha Atomic Research Centre (BARC) in his honour. Was nominated for the Nobel Prize in 1951 and 1953–1956.

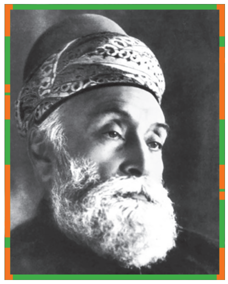


JAGADIS CHANDRA BOSE

(1858-1937)

Physicist, Botanist

Pioneered investigation of the radio and microwave optics, and made significant contributions to plant science by inventing the crescograph, a device for measuring the growth of plants. Was a major force behind the expansion of experimental science in India. He founded Bose Institute in 1917 in Calcutta and is also known as the father of Bengali science fiction.



JAMSETJI NUSSERWANJI TATA

(1839-1904)

Industrialist, Philanthropist, Institution Builder

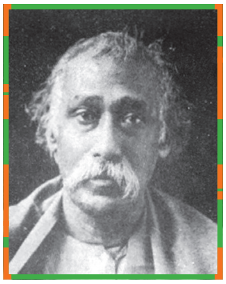
Jamsetji was a pioneer industrialist, who founded the Tata Group, India's biggest conglomerate. He founded the Tata Steel and established Jamshedpur city (Tatanagar in present-day Jharkhand). His contributions resulted in the establishment of the Indian Institute of Science, Bangalore, in 1909. Swami Vivekananda was a major influence in the scientific vision of JN Tata.

MADAN MOHAN MALVIYA

(1861-1946)

Scholar, Educational Reformer, Politician

Popularly called 'Mahamana', he founded the Banaras Hindu University (BHU) at Varanasi in 1916 and was its vice chancellor from 1919 to 1938. He helped establish the Hindu Mahasabha in 1906, which brought diverse local Hindu nationalist movements together. In 2014, he was posthumously conferred with the Bharat Ratna, the country's highest civilian award.



MAHENDRALAL SIRCAR

(1833-1904)

Medical Doctor, Social Reformer

He founded the Indian Association for the Cultivation of Science in Calcutta in 1876. Dr Sircar left Allopathy practice and adopted Homeopathy under the influence of Rajendralal Dutt. In 1868, Dr Sircar started publishing a new monthly journal, called the *Calcutta Journal of Medicine*, to convey his ideas and popularise the Homeopathic treatment.

MEGHNAD SAHA

(1893-1956)

Astrophysicist

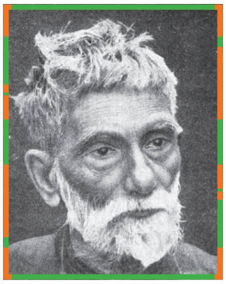
Developed the Saha ionization equation, used to describe chemical and physical conditions in stars. His work allowed astronomers to accurately relate the spectral classes of stars to their actual temperatures. The Saha Institute of Nuclear Physics in Kolkata is named after him. He was elected to the Parliament of India in 1952 from Kolkata.

MOKSHAGUNDAM VISVESVARAYA

(1860-1962)

Engineer, 19th Diwan of Mysore

He was the Chief Engineer of Krishna Raja Sagar dam in Mysore, Laxmi Talav Dam near Kolhapur in south-west Maharashtra, and served as one of the chief engineers of the flood protection system for the city of Hyderabad. He received Bharat Ratna in 1955. His birthday is celebrated as Engineers Day in India.

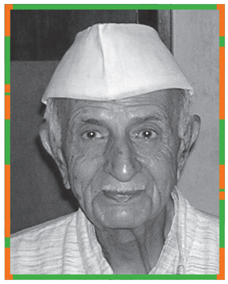


PRAFULLA CHANDRA RAY

(1861-1944)

Chemist, Educationist, Pioneering Entrepreneur

The father of chemical science in India, he established the first modern Indian research school in chemistry. Was the founder of Bengal Chemicals & Pharmaceuticals, India's first pharmaceutical company. He was the author of *A History of Hindu Chemistry from the Earliest Times to the Middle of the Sixteenth Century*.

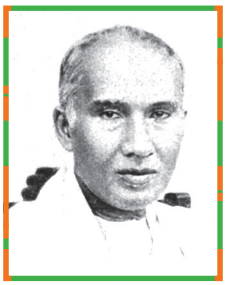


PRAHALAD CHUNNILAL VAIDYA

(1918-2010)

Physicist, Mathematician

Renowned for his instrumental work in the general theory of relativity. Specifically known for 'Vaidya Metric', which gave him worldwide recognition at the age of 24. 'Vaidya Metric' applies to a set of Einstein's equations. It has by now found many applications in gravitation theory. Also established the Gujarat Mathematical Society.



PRAMATHA NATH BOSE

(1855-1934)

Geologist, Palaeontologist

He was one of the early Indians to join the Geological Survey of India as a graded officer. He is credited with the setting up of the first soap factory in India and was instrumental in the setting up of Jamshedpur by writing to Jamsetji Tata about the rich iron ore reserves in the region. His efforts led to the establishment of the Bengal Technical Institute, now known as Jadavpur University.

RADHANATH SIKDAR

(1813-1870)

Mathematician

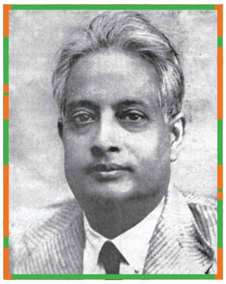
He was the first person to calculate the height of Mount Everest, in 1852. He had calculated the height at exactly 29,000 ft. His designation was that of a'computer,' and he earned a salary of 40 rupees per month. Without his efforts, Peak XV would have remained just another mountain in the Himalayas.

RUCHI RAM SAHNI

(1863-1948)

Physicist, Meteorologist, Educationist

He was India's first nuclear scientist and worked with the founder of nuclear physics Ernest Rutherford (1871-1937) in England. He was the first Indian officer to join the India Meteorological Department (IMD) in 1885. He demonstrated that vernacular languages could be successfully used as a medium of disseminating scientific ideas.

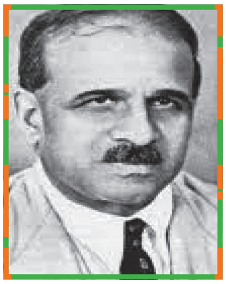


SATYENDRA NATH BOSE

(1894-1974)

Mathematician, Physicist

He is known for his work on quantum mechanics in the early 1920s, in developing the foundation for Bose statistics and the theory of the Bose condensate. He is also known for his collaboration with Albert Einstein. The class of particles that obey Bose statistics, bosons, is named after him.



SHANKAR PURUSHOTTAM AGHARKAR

(1884-1960)

Science Research Pioneer

Was the Founder Director (1946–60) of the Maharashtra Association for the Cultivation of Science. He explored the biodiversity of the Western Ghats where he discovered a freshwater jellyfish, only known to be found in Africa. The finding was published in *Nature* in 1912. Pune's Agharkar Research Institute is named after him.

SHANTI SWARUP BHATNAGAR

(1894-1955)

Chemist, Scientific Administrator, Institution Builder

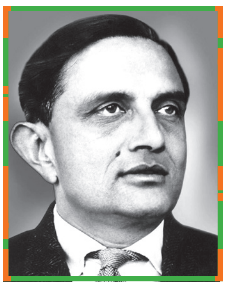
First director-general of the Council of Scientific and Industrial Research (CSIR), he is revered as the Father of Research Laboratories in India. Was the first Chairman of the University Grants Commission (UGC). In his honour, the CSIR annually awards the SSB Prize for Science and Technology, the most prestigious science award in the country.

SRINIVASA RAMANUJAN

(1887-1920)

Mathematician

Despite no formal training in pure mathematics, he substantially contributed to complex analysis, number theory, infinite series, and continued fractions. In 1914, Ramanujan found a formula for infinite series for pi, which forms the basis of many algorithms used today. His birth anniversary on 22 December is observed as National Mathematics Day.

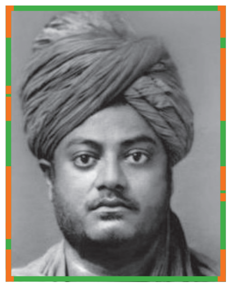


VIKRAM SARABHAI

(1919-1971)

Father of Indian Space Programme, Physicist

Father of the Indian space programme, he laid the foundation of what is now known as ISRO. He established the Physical Research Laboratory at Ahmedabad in 1947 and was the Chairman of the Atomic Energy Commission of India. Was honoured with Padma Bhushan in 1966 and Padma Vibhushan (posthumously) in 1972.



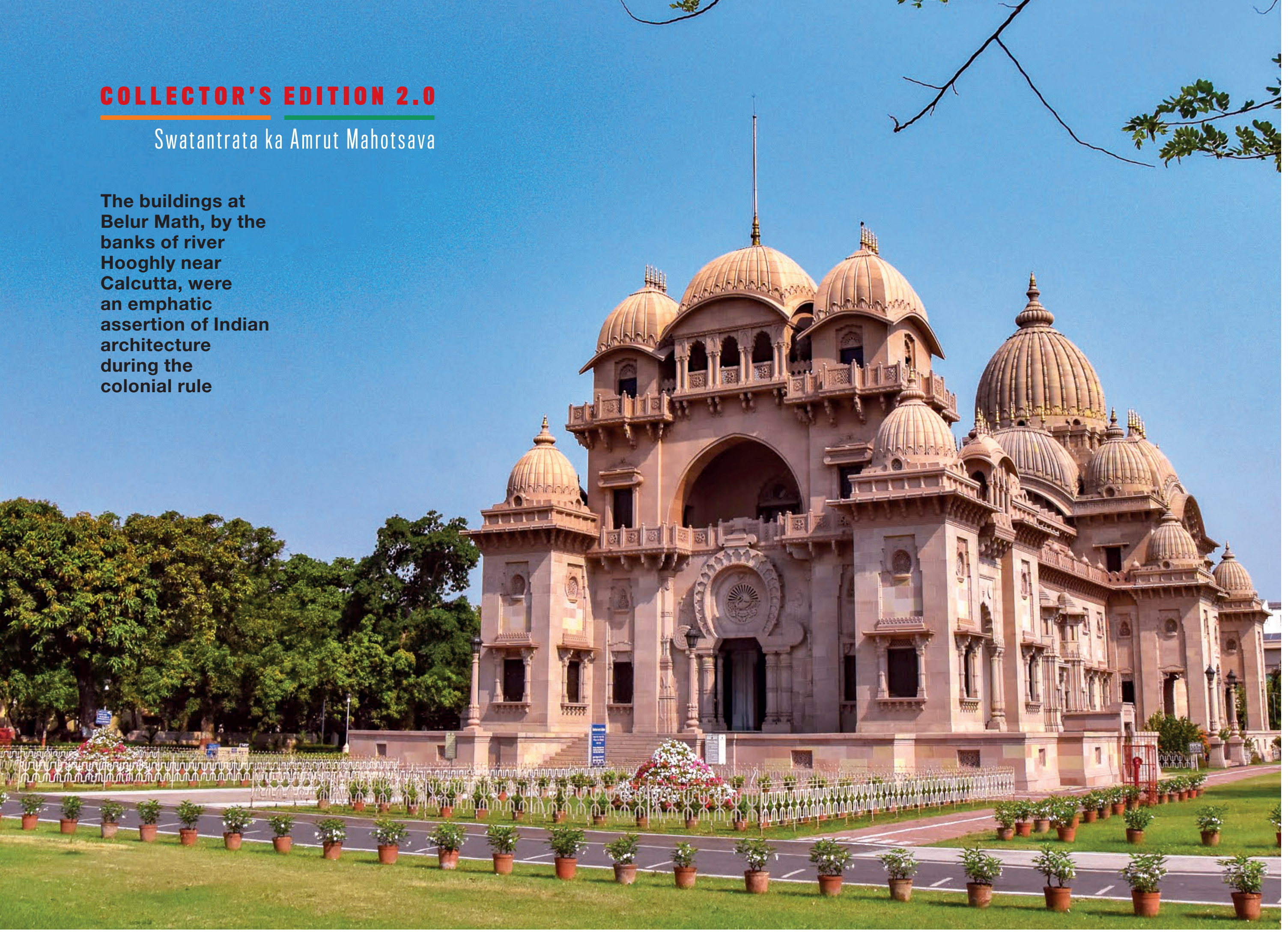
SWAMI VIVEKANANDA

(1863-1902)

Spiritual Leader, Philosopher, Patriotic Prophet, Humanist

Born as Narendranath Datta in Calcutta, he founded Ramakrishna Math and Ramakrishna Mission. His immortal speech at the Parliament of World's Religions in Chicago (1893) brought global attention to India's strengths from Vedanta to Science. He inspired scientists and industrialists in creating scientific infrastructure for and by Indians.

**Compiled by Sonam Singh Subhedar. The profiles have been arranged alphabetically.*

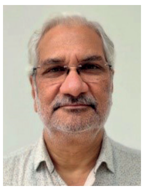


The buildings at Belur Math, by the banks of river Hooghly near Calcutta, were an emphatic assertion of Indian architecture during the colonial rule

ARCHITECTURE

Rejecting Colonialism with Edifices Suffused with an Indian Soul

The assertion of Indian identity during the freedom struggle was not restricted to the vanguard of politics alone but shone through in all aspects of life, including architecture



■ Prof Virendra Kumar Paul

The beginning of the freedom movement of Bharat from colonial subjugation in 1857 is well known. This also marks the renaissance of Hindu architectural identity, which was not just an expression of faith or religion but the soul of Bharat that had been immensely impacted under the sustained invasion of foreign cultures. Buildings and built form being the gross manifestation of assertion of cultural identity, the story of 'Freedom Struggle and Identity in Bharatiya Architecture' was also scripted concurrently in a subtle yet impactful way.

Civilizations have always celebrated advances in science, technology, art forms and political might through the buildings and associated built form. Nineteenth century architectural styles, such as Indo-Islamic, Indo-Gothic, Indo-Saracenic and European Art Deco had already established technological superiority and catalysed cultural submission in the Bharatiya psyche. The unsung struggle of resurrection of Bharatiya Architecture too needs to be acknowledged as we celebrate Azadi Ka Amrit Mahotsav.

SUBJUGATION OF INDIAN ARCHITECTURAL IDENTITY

The urbanisation during 1857-1947 both invaded and celebrated colonial architecture. One of the notable architects of the 19th century was Fredrick William Stevens who designed some of the key buildings in Bombay such as Victoria Railway Station and the Municipal Corporation buildings in distinct colonial style. The first architecture school in Asia was established in 1913 at Sir J. J. College of Art, Bombay, designed by George Twigge Molecey, in Neo-Gothic architecture style.

Calcutta was not far behind in 'colonising' architectural space with edifices in Greco-Roman and European neoclassicism. During the same period, Bhai Ram Singh was the foremost architect in Punjab. Patronised by the British, he designed some of the most celebrated buildings in West Punjab in Indo-Saracenic style. And, it has etched a strong colonial influence in the urban-scape. For his profound services to the cause of the British, he earned the Royal British honour of MVO (Member of the Royal Victorian Order). The influence of the works of Bhai Ram Singh continues to be so profound that Khalsa College, Amritsar is a 'must-visit' tourist destination even today. Literature suggests that Bhai Ram Singh also contributed to building the Governor's House at Shimla, in Tudor style, and housing paintings in Moorish style.

Thus, we note that the architecture during the second half of the 19th century was an expression of cultural glorification of the same class of rulers that the freedom struggle of Bharat was aiming to unshackle. Strategic use of iconography in the urban-scape has left an indelible impression that has resulted in obsessive imitation of colonial architectural style even today. Proliferation of alien architecture in India was a natural corollary to the majestic invasion mushrooming from urban centres like Bombay and Calcutta.

It is fair to infer that the propagation of colonial, Islamic and external architectural influences obscured the search for identity of Bharat not just in its architectural heritage but also plunging consciousness into cultural subjugation of Bharatiyata, or rather, leaving behind a legacy of cultural affinity towards the foreign class that India strived to break free of through Independence in 1947.

The 'Struggle of Identity of Bharatiya Architecture' during the period of freedom movement is a story of cultural valour.

Santiniketan edifices, such as Singha Sadan (above) and Udayana complex (left), were designed in Indian style, in a perfect blend of environment and architecture

ASSERTION OF BHARATIYA ARCHITECTURAL IDENTITY

The Visva-Bharati, Santiniketan, Kashi Hindu Vishwavidyalaya (BHU), Belur Math and DAV institutions are examples that need to be acknowledged for their emphatic assertion of architecture of Bharat while carrying forward the agenda of Bharatiyata through education and socio-cultural resurgence. The events of 1857 ignited a renaissance of Hindu identity through socio-cultural movements rooted in Vedic philosophy and resurgence of educational institutions to assert Bharatiya identity.

This was a distinct rebellion of architecture to expunge external influences and instil Bharatiyata as the soul of buildings. Rather than glorifying diversity through varied colonial, Mughal or other influences, these institutions used architectural expression of their buildings with distinct Hindu identity, built-form, scale, classical structural configurations and ancient Indic design embellishments. The aim was to impart experiential motivation of Indianness and ingrain cultural and national identity using iconography and expression consistent with philosophical narrative. It was another freedom struggle of Bharatiya Architecture yearning to purge irrelevant and non-contextual influences occupying our own rightful urban space.

ASSERTION OF INDIAN IDENTITY AT SANTINIKETAN

Architect Surendranath Kar was the mastermind for translating Gurudev Rabindranath Tagore's conviction of peace and brotherhood against tides of influences of the western civilization.

The context of Santiniketan can be traced back to Raja Rammohun Roy's revolutionary ideas of 1772 that were a significant starting point in the entire notion of them, the British, versus us, the Indians. Jorasanko Thakur Bari, where Gurudev was born in 1861 and died in 1941, was the epicentre of philosophical ideas and cultural fusion of Bengal art movement. Gurudev had inherited a rich legacy and propounded his conviction through poetic sensibilities from Upanishadic humanism. Gurudev carried forward *sansakars* leading to experiments in education, art and architecture at Santiniketan. This led to the creation of a unique Indian cultural identity around the architecture of Visva-Bharati, while the Non-Cooperation movement raged alongside.

The initial evolution of architecture was around local Bangla thatched structures and subsequently it was immensely influenced by Brahmanical architecture, the Indian cave monasteries and Jharokhas of Gujarat. Contrary to symbolic aggrandisement of the imperial power, the campus was designed on the principles of minimalism. It was an endeavour of fusion of Indian traditions and their application in the educational system. Gurudev believed in Indian folktales as part of education using metaphor and descriptions enshrined in the Puranas. In typical Indian style, Santiniketan is perfect blending of environment and architecture, converging on the goals of nationalistic education.

The architectural language was inspired by local styles visible in surrounding villages, thus leading to sustainable use of local materials as well. The traditional Guru Shishya Parampara was at the core of teaching that integrated learning within the space and outside in open. In Santiniketan, where the first school was established by Gurudev in 1901, the built form reflects unity in humanity where the world would form a single nest. Rejecting colonial influences invading India's cultural identity, the Visva-Bharati brought back the sense of Indianness, in dialogue with nature. It was truly an Indian sustainable philosophy that synthesised creativity and intellectual revolution rather than embracing subjugation to the language of the oppressors.

BENARAS HINDU UNIVERSITY: IN SEARCH OF INDIAN IDENTITY

When Pandit Madan Mohan Malviya decided to create a unique Hindu University, he approached Gurudev Rabindranath Tagore for the guidance on architectural character befitting Indianness. And, thus the services of Surendranath Kar were solicited to create an iconic university. A glance is enough to comprehend the essence of design, as described in the University Anthem as '...Primordial design of divinity alone, Mansions of Knowledge, center of all creation...'. It is an emphatic imprint of Hindu identity of architecture and the cultural values that University imbibes through its ambience. The aim was to bring Hindu community under a system of education and thus, Pt Malviya ji referred to the university as 'Vidya Mandir' in pursuance of 'passion for Indian culture'.

The crescent shape of the campus plan evolved from 'Karmuka' plan, symbolising the half-moon gracing the forehead of Lord Shiva and the temple of Lord Vishvanatha at the centre, the Garbhgriha (sanctum sanctorum), of the university, referred to as cosmogenic Banaras. The temple embodies Dwadasheshvar, the twelve Shiv-*linga*s with six sub-divisions (*upakhandas*) or blocks on north and south side of the radial path. Pt Malviya wished for the orientation such that students could see river Ganga in the east in the morning and recite the Gayatri Mantra.

BHU was hailed as 'India's own University', drawing inspiration from Shilpshastras. The architecture of BHU has a profound effect on the cultural identity that the institution aspires to pursue. Iconography is a tangible integral part of the Hindu ethos and intangible messaging entwined inseparably together. The result is the learning environment devoid of any distractions, focused at the all-pervading Bharatiyata. The transformational effect of Indian architecture-built form, perusal of cultural values, freedom from the mindset of colonial subjugation, combined with Indian architecture being the causal force behind.

BELUR MATH, A TRIBUTE TO RAMAKRISHNA PARAMHANSA BY HIS FAMOUS DISCIPLE

As a tribute to the Master — Ramakrishna Paramhansa — and house relics be-

When Pt Madan Mohan Malviya decided to create Benaras Hindu University (right), he approached Rabindranath Tagore for advice on its architecture

Left: The Lahore Museum was designed in the syncretic Indo-Saracenic style by renowned architect Sir Ganga Ram. It's construction was finished in 1894

Below: The Hindu renaissance architecture was visible in prominent buildings of pre-independence period, such as the DAV College, Jalandhar

longing to him, Swami Vivekananda had envisioned Belur Math to be a unique Indian icon of architecture. Swami Vivekananda believed in 'spiritually empowered man'. Swamiji's intent was carried forward by Swami Vijnanananda, another direct disciple of Ramakrishna Paramhansa. Belur Math was completed between 13 January 1929 and 14 January 1938. The Natmandir, or the congregational hall, the Garbhamandira, or the sanctum sanctorum, and Bhandar, the store of relics, are typical ancient Indic functional spaces, interpreted in the contemporary Indian context.

The Math instantly connects with Indianness, be that a subtle impression of Gopuram of South temples or elements of Bengal architecture. Belur Math is an edifice combining architectural expressions of rich Indian diversity, and the features of temple architecture to realise the underlying principle of universal brotherhood. The Math is an eye-feasting experience of Indianness. A celebration of Bharatiyata, it represents spontaneous assertion of Hindu Renaissance when invasion of colonial metaphors was resisting the inevitable Independence.

PURSUING FREEDOM STRUGGLE, EDUCATION AND ARCHITECTURE CONCOMITANTLY

When Lahore was at the centre of the battle of Hindu identity amidst colonial cultural aggression through architectural symbolism, led mainly by Bhai Ram Singh, the quest for freedom from the British underlined the need to rebuild society out of Vedic roots. Arya Samaj was already established in 1875 in Bombay but it transformed into a large-scale movement in Lahore almost a decade later. Lala Lajpat Rai and his colleague, Mahatma Hans Raj, founded the DAV College, Lahore in 1886. From there on, DAV educational institutions proliferated under emphatic Hindu identity, but providing modernist education while fanning aggression in the freedom struggle.

The effect of Hindu renaissance was so profound that it permeated into the architectural identity of Lahore also. Architectural expression of the first DAV institution in Lahore registered its presence by incorporating the *shikhara* (tower) of a Hindu temple on every corner of the building and typical Hindu iconography on entrance structures. This marked the cultural and Vedic theological revolution, safeguarding from missionary conversion influence. Thus, by resorting to education and rebellion through Hindu architectural symbolism, Indians implicitly rejected the overpowering colonialism. The stylised architecture can be observed in institutions that followed, such as Sain Das School and DAV College, both in Jalandhar.

During the freedom struggle, it is evident that architecture was employed as an effective tool to register Hindu identity and break free of colonial culture against its formidable tide. The institutionalised Hindu renaissance continues its impactful journey in the twenty-first century, only waiting to now tide over 'new age' challenges of 'modernism'.

**The writer is Professor and Head at the Department of Building Engineering and Management at School of Planning and Architecture, New Delhi*

Image Courtesy: Shutterstock

Recalibrating India's 'Planning' Attitude for Big League Ambitions

Amrit Kaal (2022-2047), as a lead up to one hundred years of India's Independence, will modify the nation from short-term to long-term and far-sighted planner

■ **Dr Chaitanya Giri**

Independent India never stopped the struggle to find the best socio- and techno-economic models suitable for its progress. After securing a republic in 1950, Indian policymakers have been grappling with ideological vicissitudes. There have been some who championed the execution of national policies based on indigenous necessities. Some were enamoured by the anti-colonial line of policymaking, which did not fit our native requirements. Then some sought bliss in continuing with colonial-era policies as they rationalised that the colonial policy-making mechanisms, including the legal structures, had been in place for nearly a century. For them, it made sense to continue with these mechanisms. And some have toyed with all three sensibilities in different permutations and combinations.

Bharat is an ancient civilisation that can think over long periods lasting centuries. But after independence, we somehow lost the ability to think over longer durations. Independent India began aping the communist nations and began planning for no more than a five-year horizon. Fortunately, we have gone past the aberration, and now, 25-year planning has been made possible, five times longer than the mundane. The Azadi ka Amrit Mahotsav has inspired Bharat to plan and execute things for the next 25 years before we celebrate the Azadi ka Shatak Mahotsav in 2047.

PLANNING & FARSIGHTEDNESS

When the Narendra Modi administration took charge in 2014, the first significant policy change it undertook was to rejig and rename the Planning Commission of India to National Institute for Transforming India Aayog, better known as NITI Aayog. The renaming demonstrated the willingness to break the low-ceiling created by short-duration five-year planning and widen it; although, NITI never informed what planning durations it was looking at. Executing any project requires meticulous planning, monitoring, and attaining of targets. Often, such marks are to be achieved at regular intervals, and 5-year planning makes sense if microscopic execution is to be undertaken. However, Indian policymakers could not execute targets set within the 5-year plans efficiently. They somehow did not realise the significance of planning over longer durations which is necessary to make those microscopic achievements in 5-year durations. India desperately needed to plan big and over longer time horizons — quarter or half-a-century at least — and ensure that several microscopic executions eventually led to the larger plan.

A 25-year plan and execution horizon attributed to Amrit Kaal (2022-2047) is an auspicious event for India. Firstly, it augurs very well for projects that have long gestation periods. Cutting-edge science is one of them. From Deep Ocean Mission to Indian Human Space Flight Programme; from International Thermonuclear Energy Reactor to LIGO-India (an advanced gravitational-wave observatory to be located in India); from International Solar Alliance to Earth BioGenome Project; from achieving Net Zero Emissions, Circular Economy, the execution of the 10-trillion-dollar economy mark will all depend on how India dreams, plans, executes and attains its targets during the Amrit Kaal. Twenty-five years down the line, the habit of looking at longer time horizons will get so entrenched in the minds of our executives, scientists, and planners that India will not return to the socialist era of short-sightedness. Indeed, Indians would never denigrate short-term achievements but would develop a penchant for accumulating short-term achievements to attain bigger ambitions.


Image Courrtesy: Adolfo Cj / Pixabay

The success of cutting-edge science missions like the International Solar Alliance will depend on how India executes its targets during Amrit Kaal

I must give here an example from my own professional life. I was 22 when I got selected to do my Ph.D. at the Max Planck Institute for Solar System Research in Germany. My PhD project, which eventually was also the title of my thesis, was titled "The Organic Composition of a Cometary Nucleus, the COSAC Experiment on Philae." The project was quite remarkable. I was to work on a ground-reference model, a laboratory-based prototype of the COSAC payload, flying on the European Space Agency's (ESA's) Rosetta spacecraft to the comet 67P/Churyumov-Gerasimenko. When I joined in 2011, the spacecraft was three years away from reaching the target comet. The spacecraft had begun its journey seven years earlier, in 2004. The instruments that flew on Rosetta had been designed roughly since 1995, whereas ESA began conceptualising the mission around 1986. The end-of-mission happened in 2016. So, what did I, and many like me who learned from the mission, experience? We experienced long-range planning and execution in the real world. The mission lasted — from concept to final closure — precisely for 30 years. The beauty of Rosetta was that three generations worked on them diligently, tirelessly, and with utmost efficiency. Landing on a 4-km wide comet with technology from the 1990s was no mean feat. It asked for 20 years of preparation, and it got it.

Twenty-five years on, the habit of looking at longer time horizons will get so entrenched in the minds of our planners that India will not return to the socialist era of short-sightedness

DILIGENCE FOR LONG-TERM BENEFITS

There's a difference between projects that get delayed excruciatingly and projects that demand excruciating diligence and commitments. To avoid delays in any project and to tirelessly work on long-gestation projects require meticulous short-duration planning. And therefore, this article does not look down upon short-duration planning. But imagine, what if those conceptualising Rosetta gave themselves only five-years? The mission certainly would not have flown at all.

Coming home to India, had Homi Bhabha not conceptualised a Three-Stage Nuclear Programme, today we would not have a thorium-based reactor. Had Nambi Narayanan not had a passion for liquid-fueled rocket engines in the 1960s and his love channelised by Vikram Sarabhai and Satish Dhawan, India would not have its VIKAS engines and nor would have India flown to the Moon in 2008.

Thinking science, planning science, doing science, and reaping comprehensive benefits from the achieved science is time-consuming. Any country or an international grouping that is habitual of successfully culminating such long-gestation projects, do take it from me, they are bound to acquire high geopolitical resilience, they can endure the strongest of economic turbulences, and they cultivate far-sighted and deep-rooted cultures. Overall these are the attributes of a superpower.

VISUALISING AMRIT KAAL

Amrit Kaal is an era of Tapasya (single-mindedness) for India. Regardless of external disturbances, internal turmoil, disasters, or wars, India will have to work hard on its scientific undertakings. During the Amrit Kaal, the Indian policymakers must ensure that the financial, regulatory, and resource support for science and technology, regardless of its antecedents — government, commercial or military labs — does not diminish. The Indian policymakers will have to ensure that delays are minimised, and patient support is offered to projects that inherently require time.

There is a genuine interest in comprehending what sort of ongoing scientific projects would continue in the next 25 years and what new would India kick-start in these years.

Let's start with astronomy; during the Amrit Kaal, India would have fully established and gained operational experience with its leadership and partnership, the Thirty Meter Telescope in Hawaii, the LIGO-India in Maharashtra, the ITER in France, and the Square Kilometer Array in Africa and Australia.

In Amrit Kaal (2022-2047), first Indians would venture into space through the indigenous Gaganyaan mission

Image Courtesy: ISRO

Many of these projects would cultivate cutting-edge capabilities in optics, optoelectronics, metamaterials, artificial intelligence, and big data.

By then, with biological sciences, India would have accomplished the large citizen-science megaproject 'MANAV Human Biology Atlas' initiated in 2019. In the next 25 years, the Atlas would generate voluminous data, thanks to the world's largest and most diverse national population, of great significance to global endeavours of raising healthy humanity. Given the current emphasis on Ayurveda, Unani, Siddha, Homeopathy, and other forms of traditional medicine, India, in these 25 years, would emerge as the global preventive- and holistic-health capital.

Coming home to India, had Homi Bhabha not conceptualised a Three-Stage Nuclear Programme, today we would not have a thorium-based reactor

On the front of chemical sciences, India, in the next twenty-five years, would have achieved a substantial chunk of its net zero emissions goal that it has set for achieving by 2070. India would accomplish this goal by promoting a circular economy, recycling, reusing, refurbishing, and recirculating chemi-

Image Courtesy: Shutterstock

The renaming of the Planning Commission to Niti Aayog in 2014 demonstrated the willingness to break the low-ceiling created by short-duration five-year planning and widen it

cal and physical processes. India would have evolved into the largest operator of clean fuel vehicles, primarily hydrogen and hydrogen-blended compressed natural gas. It would have substantially decarbonised its domestic rail and air travel. The cultural renaissance that has already begun in India would emphasise using ecologically friendly construction materials, packaging materials, dyes, paints, and other chemicals. India will also likely monetise the waste recycling industry, perhaps leading to a nation-wide plastic hunt that would accumulate littered plastics and convert them into valuable and cleaner materials.

On the energy front, India, during the Amrit Kaal, would have made tremendous strides with its partners in the International Solar Alliance towards the Green Grid Initiative. This initiative, operating towards the goal of 'One Sun, One World, One Grid,' aims to generate a whopping 2600 gigawatts of solar and wind power by 2050. The Green Grid Initiative would stimulate tremendous innovation in making solar and wind power generation more efficient than today's standards.

In outer space, by 2047, India would operate commercial and civilian space stations in the Earth's orbits, would have sent probes to nearly all planets of our Solar System, and the first Indians would have set their foot on the Moon during the Amrit Kaal. India, by then, would have launched several space-based astronomy observatories that would-be successors of the James Webb Space Telescope and India's very own ASTROSAT.

The Amrit Kaal will bring tremendous opportunities and challenges for India. The promising prospects are as laid in these priority projects mentioned above. The challenge is getting them executed effectively in both domestic and global arenas. However, the possibilities should not create a sense of complacency, nor should the challenges deter us from our goals. Those who remember India's 50th Independence celebration would know that back then, India was attempting to achieve a lot by the year 2020. The year 2020 has become a milestone for our numerous undertakings. However, the domestic political chaos led us astray, and we lost interest in achieving our targets. That does not mean that India did not progress, but we went at a pace slower than had we set our eyes on. We must put our eyes on 2047 as Arjuna would set on the fish's eye. By doing so, our nation would develop a great convention of thinking and acting strategically. Once we reach 2047, we will becoe habitual in setting and achieving targets for 2072 and 2097.

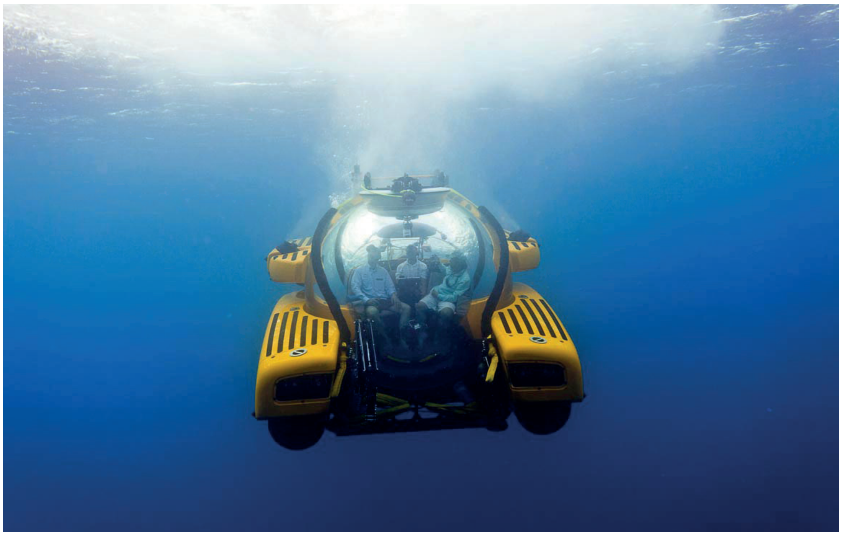


Image Courtesy: Public Domain

Deep Ocean Mission is one of the ambitious projects that India hopes to run successfully in the years leading up to the first century of our Independence

**The author is a Space Policy & Diplomacy Consultant at the Ministry of External Affairs' autonomous think tank, Research and Information System for Developing Countries (RIS), New Delhi. He has an award-winning PhD in Astrochemistry and spent his doctoral and postdoctoral years in Germany, France, Japan and the United States. He was a crew member of the European Space Agency's Rosetta Mission*

Early photographs of the Indian Institute of Science (IISc), Bengaluru, (left) and the Calcutta University

Courtesy for both the photos: Public Domain

Indian Struggle for a Progressive Science Education

This is as much a story of colonial suppression, discrimination and exploitation as it is about the inspiring grit and determination of Indians who laid the corner stone of modern science education

'The study of science should have a place in every system of liberal culture. It gives a man the knowledge of his place in nature and his mastery over it'

— **Nikhil Ranjan Sen** (1894-1963), Faculty, University College of Science, Calcutta

■ **Dr Jayanti Dutta**

India's long and ancient knowledge in matters of Science is well known. Knowledge of subjects like Astronomy, Ayurveda, Chemistry, Metallurgy and Mathematics was carried across generations in unbroken traditions through indigenous education system. However, 'Science education' in the context of training in Western empirical methods of scientific knowledge, was introduced in India by the British. An acquaintance with and comprehension of Science, more than anything else, brings with it intellectual liberation, material benefits and social development in a society. Though, for the colonial masters the introduction of Science education in India was not for philanthropic motives. It was for the myopic goal of creating minions trained to use scientific tools for furtherance of the empire's interests.

Initially, Science education was not a priority for British education. The Charter Act of 1813 enacted by the Parliament of the United Kingdom called for, 'the introduction and promotion of knowledge of Science among the inhabitants of British India' but the call remained only on papers. It was Raja Ram Mohan Roy who was foresighted enough to ask for first rate Science education in 'Maths, Chemistry, Astronomy and other useful Sciences' in 1823 through his petition to Amherst, yet the teaching of foundational Science took fifty more years. The British were primarily interested in exploiting India's resources to the full and focused attention on disciplines of Geography, Geology and Botany. However, in other areas, like Physics, Chemistry and Agriculture, in which scientific development was not imperative, no attention was paid.

ALIENATING SCIENCE EDUCATION

Even though the universities of Calcutta, Bombay and Madras were set up in 1857, degrees in Science were granted by these universities only from the 1870s onwards. By 1870, three institutes in Calcutta, the Medical College of Bengal, the Presidency College and the St Xavier's College were teaching the 'rudiments of modern Science'. In 1875, Calcutta University divided its BA into two branches — 'A' course, i.e., literary, 'B' course, i.e., Science. Madras University decided to examine its matriculation candidates in Geography and Elementary Physics, and Bombay University started granting degrees in Science. Obviously, these initiatives were not aimed at the transcendental goals of Science education like developing critical thinking, innovative spirit or a questioning attitude. The teaching of Science was totally textbook based till 1900 and the first Chemistry lab was established in 1901. Research was not mandatory at any of the universities. Being taught in English, with books printed in Britain, on western themed scientific philosophy, following the British educational model, this Science education alienated the students from the indigenous culture and burdened them with a deep inferiority complex towards their own nation and its age old wisdom. In fact, Calcutta University was locally called, 'Goldighir-Golamkhana' meaning the 'Slave house by the lake', implying the slavish mentality of its students. While the colonial rulers were interested in sourcing out young people as assistants to tighten their grip on the

Image Couurtesy: Archives and Publications Cell, IISc

Students outside the first women's hostel at IISc, in 1945. (L-R) Rajeswari Chatterjee, Roshan Irani, M Premabai, Miriam George and Violet D'Souza

country, the Indian leaders saw in western Science education an opportunity to reduce the gap between the modern and ancient knowledge and beat them in the sphere in which the British had always claimed superiority.

EARLY INDIAN STEPS IN MODERN SCIENCE EDUCATION

Mahendra Lal Sircar was one of the pioneers who could see through the clever ploy of the British to use Science as a means to achieve their exploitative ends and to counter that, he established the Indian Association for the Cultivation of Science (IACS), in 1876 as a purely Indian and private initiative in funding and management. Initially aimed to popularise science and scientific subjects, it gradually started fundamental research in Physics and Chemistry. Now, the time was ripe for qualified Indian teachers to be recruited for Science teaching. The British, however, discouraged such recruitments by using discriminatory service rules against Indian teachers. Howsoever qualified or experienced Indian teachers may be, they had to join the provincial services which were lowly paid and had lesser service benefits while their European counterparts enjoyed higher salaries and better facilities in the Imperial service. In 1885 and 1889, JC Bose and PC Ray respectively joined as faculty in the Presidency College. Though they were great teachers and were able to raise an army of worthy students by the dint of their merit and passion, however, their careers as Science lecturers were far from satisfactory. Differential financial benefits, heavy teaching load and complete lack of any monetary or other support for Science research by the government made the careers of Indian teachers an everyday struggle.

Mahendra Lal Sircar could see through the clever ploy of the British to use Science as a means to achieve their exploitative ends

Meanwhile, privately managed educational institutes affiliated to the universities were established in the suburbs, which became hotbeds of student political activities and burgeoning nationalism. The University Act of 1904 passed by Lord Curzon allowed the British to have a tighter control on these colleges through the authorities of the affiliating universities which were 'the most completely governmental universities in the world'. No additional financial support was provided to pay the university teachers and/or create university laboratories for teaching and research. It became obvious that neither Science teaching nor research could flourish in institutes under British control. As the Universities were left to their own devices to generate resources for the appointing teachers, different departmental structures were created in different universities.

A movement to establish institutes with full Indian funding and recruitment of Indian teachers to have autonomy of teaching and research free from Imperial control can be discerned during this period and a support system for Indian Science research and teaching was created. Asutosh Mookerjee, the Vice Chancellor of Calcutta University, raised funds from Indian sources to establish a University College of Science. This was the first college to offer a postgraduate degree in Science in India. He established two professorial chairs in Physics and Chemistry, called Palit Professorships, reserved for Indian scientists and appointed CV Raman and PC Ray on them.

DOMINO EFFECT OF ASUTOSH MOOKERJEE'S INITIATIVES

The success of Asutosh Mookerjee's initiatives spurred the promotion of research and quality post graduate Science education in universities at Lahore, Allahabad, Mysore, BHU, AMU, Dacca, Waltair, Baroda, etc. In 1904, an Association for the Advancement of Scientific and Industrial Education of Indians was formed. The objective was to send qualified students to Europe, America and Japan for studying Science-based industries. In 1909, another completely Indian organisation, the Indian Institute of Sciences (IISc), was established with monetary grant from Sir JN Tata and the Maharaja of Mysore. The institute conducted basic and applied research in many fields of science and technology. Annie Besant and Pandit Madan Mohan Malaviya laid the foundation stone of India's first research university at Varanasi in 1916.

Though research was carried out both in governmental universities as well as private institutes, these Indian institutions were very productive in terms of scientific research and collaboration. The research publication activities thrived during the mid-1930s. The maximum research activity was in the area of Chemistry followed by Agricultural and Biological Science. Considering it as a matter of national pride, the Indian scientists preferred to publish their research in Indian journals. *The Proceedings of the Indian Academy of Sciences* published by the Indian Academy of Science since 1934 was the most preferred journal of publication. The Indian Institute of Science (IISc), Bangalore, published more than 600 research papers within 30 years of its establishment. It is also observed that the authorship collaborations of pre-independence researchers were mainly restricted among the Indian authors with negligible collaborations with scientists of Britain, thus indicating their capacity to conduct independent research of international quality with indigenous resources. Despite the insurmountable troubles encountered by Indian teachers of Science in higher education institutes, they contributed immensely to the development of Science and finally the international scientific community had to sit up and take notice. The names of JC Bose, PC Ray, CV Raman as scientist teachers come up again and again in this context.


Image Courtesy: Wikimedia Commons

Pioneering reformer Raja Ram Mohan Roy (1772-1833)

The excellent quality of the first generation Indian Science teachers facilitated the harvest of the subsequent generations of brilliant students

These Indian teachers of Science also felt the onus to establish the 'Indian' perspective on modern Science which was to decide the future orientation of Science education in the country. JC Bose and PC Ray proved to be the pioneers in putting forth their original ideas of placing the ancient wisdom of India firmly as the foundation for the practice of modern Science. Situating Science in the context of scientific rigour, ethics and peoples' welfare gave a robust understanding of Indian Science to the students thus encountering the Imperial agenda of preparing mere assistants and helpers for British Science missions.

The excellent quality of the first generation Indian Science teachers facilitated the harvest of the subsequent generations of brilliant students such as Satyendra Nath Bose, Meghnad Saha, SK Mitra, SK Banerjee, JC Ghosh, JN Mukherjee and many more. Induction as research and teaching faculty of some of the University toppers in the newly created institutions spread across the country furthered the cause of Indian Science education. Some of them went on to establish new institutions which proved to be strong pillars in the domain well into the post-independence years.

The story of Science education of pre-independence India is as much a story of colonial suppression, discrimination and exploitation as it is an inspiring story of the grit and determination of Indian educationists, teachers and scientists who laid the corner stone of world class Science education which was modern and Indian at the same time.

**The writer is Faculty, Human Resource Development Centre, Panjab University, Chandigarh. In 2013, she was the recipient of National Award for the Best Short Film on 'New Drugs for Tuberculosis', conferred by the Council of Scientific and Industrial Research, Open Source Drug Delivery and Vigyan Prasar*

Rhinoplasty

India's Prime Right to Have its Nose in the Air

The complex surgery of nose reconstruction was innovated in India centuries before western science got a handle on it

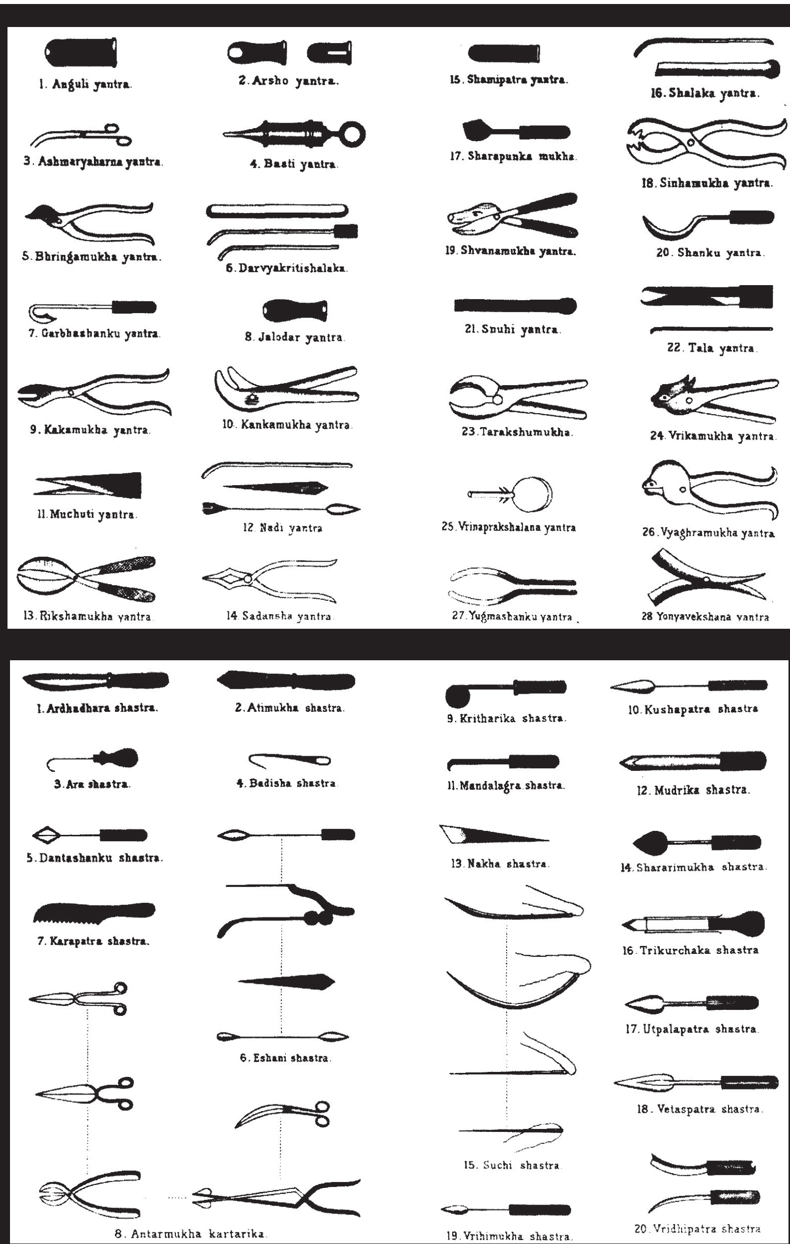
■ Dr V Ramanathan

Image Courtesy: semanticscholar.org

An illustration depicting a *vaidya* checking his patient's pulse

Dignity has been paramount and an inevitable part of human existence. Earning and safeguarding dignity has been a relentless pursuit for it is as essential as other basic existential necessities. If one couldn't visibly wear their dignity on their sleeves, they did carry it on their nose! This protruding appendage has been the vassal of human dignity and epicentre of psycho-social afflictions. Civilisations across the world have associated similar traits to this wonder organ which not only draws the air for the sustenance of life in the body but also gives a fillip to the ego. Hence, disfiguring it or mutilating it has been a method of indictment enjoying the approval of the ancient and medieval societies where the stigma was, paradoxically, even more than the capital punishment as the subject who had been thus physically reprimanded lived on to experience the humiliation throughout their life. Losing nose on getting defeated in a duel was also commonplace. For instance, the famous Danish astronomer Tycho Brahe lost a portion of his nose in one such duel following which, he used to wear a gold appendage affixed by a glue, throughout his life.

We have the famous stories across geography and instances involving the nose — from Surpanakha in Ramayana who ended up getting her nose mutilated as a riposte to her sinister amorous approaches, to the Italian fictional protagonist, Pinocchio, whose nose grew longer every time he lied. There are several allusions to nasal amputation as a form of punishment mentioned in the *Artha-*



A range of surgical instruments used by ancient surgeon Sushruta, as depicted in various treatises explaining his seminal *Sushruta Samhita*

Image Courtesy: The Principles of Surgical Practice: Sushruta Samhita and its Importance to Present Day Surgery

shastra. For instance, we come across the following:

"*Stenapaardaarikayoh saachivyakarmani striyaah sangraheetaayaashcha karnanaasaacchedanam panchashato vaa dandah; pumso dvigunah*" (4.10.10)

Meaning: A male adulterer as well as the woman who voluntarily yields herself for adultery shall have their ears and nose cut off or pay each a fine of 500 *panas*, while the male adulterer shall pay double the above fine.

Even as recent as of 2010, the acclaimed *Time* magazine featured young Afghan girl, Bibu Aisha, whose nose and ears were amputated because she tried to escape her husband. It is interesting to note that several languages have internalised such an association with nose and thus we have idioms like, 'keep one's nose clean', 'poke one's nose', etc., in English and similarly we have phrases like 'naak kat jaana' used in day-to-day parlance in the Indian languages. If one were to believe all what the Jesuit Father Giuseppe de Rovato wrote about Nepal, much to the chagrin of the nationalists of that country, the account of rechristening Kirtipur to Naskatapur (meaning: 'city with people having cut-nose) by the Gorkhas on ultimately being successful in dethroning the relentless Newar kings, stands testimony to the mass scale nasal mutilation to afflict insult on the captured population.

Thus, we see that rhinotomy or the mutilation of nose was commonplace. The human barbarity of nasal amputation was to be met with the human ingenuity of rhinoplasty and it was Bharat that was the beacon of hope and promise in restoring the lost dignity through its creative feat of plastic surgery.

It is widely agreed across the world that the first ever complete description of rhinoplasty is found in India in the medical texts like the *Sushruta Samhita* by Rishi Sushruta and *Ashtanga Hridaya* by Vagbhata. (Note: There are many scholars from Europe and America (S. C. Almast for one) who have written in their articles that the first ever account of nasal reconstruction is found in the text of Ramayana, particularly where Ravana consoles his sister Surpanakha and orders the royal physician to restore the nose. Several Indian authors have propagated this fact by further citing them. But I could not find any *shloka* in the entire text of Ramayana which indicated the nasal reconstruction.) In the 'Sutrasthana' chapter of the *Sushruta Samhita*, Rishi Sushruta writes thus:

विश्लेशितायास्त्वथ नासिकाया वक्ष्यामि सन्धानविधिं यथावत्।
नासाप्रमाणं पृथिवीरुहाणां पत्रं गृहीत्वा त्ववलम्बि तस्य ॥
तेन प्रमाणेन हि गण्डपार्श्वादुत्कृत्य बद्धं त्वथ नासिकाग्रम् ।
विलिख्य चाशु प्रतिसन्दधीत तत् साधुबन्धैर्भिषगप्रमत्तः ॥
सुसंहितं सम्यगतो यथावन्नाडीद्वयेनाभिसमीक्ष्य बद्ध्वा ।
प्रोन्नम्य चौनामवचूर्णयेत्तु पतङ्गयष्टीमधुकाञ्जनैष्च ॥
सञ्छाद्य सम्यक् पिचुना सितेन तैलेन सिञ्चेदसकृत्तिलानाम् ।
घृतं च पाय्यः स नरः सुजीर्णे स्निग्धो विरेच्यः स यथोपदेशम ॥
रूढं च सन्धानमुपागतं स्यात्तदर्धषेशं तु पुनर्निकृन्तेत् ।
हीनां पुनर्वर्धयितुं यतेत समां च कुर्यादतिवृद्धमांसाम् ॥

Image Courtesy: Gaspare Tagliacozzi/Wikimedia Commons

Left: An etching depicting the 'Italian method' of nasal reconstruction

Below: A statue of Gaspare Tagliacozzi, the 16th century surgeon hailed as the father of rhinoplasty in Italy, holding a nose in his hand, in an academic building at Bologna, Italy

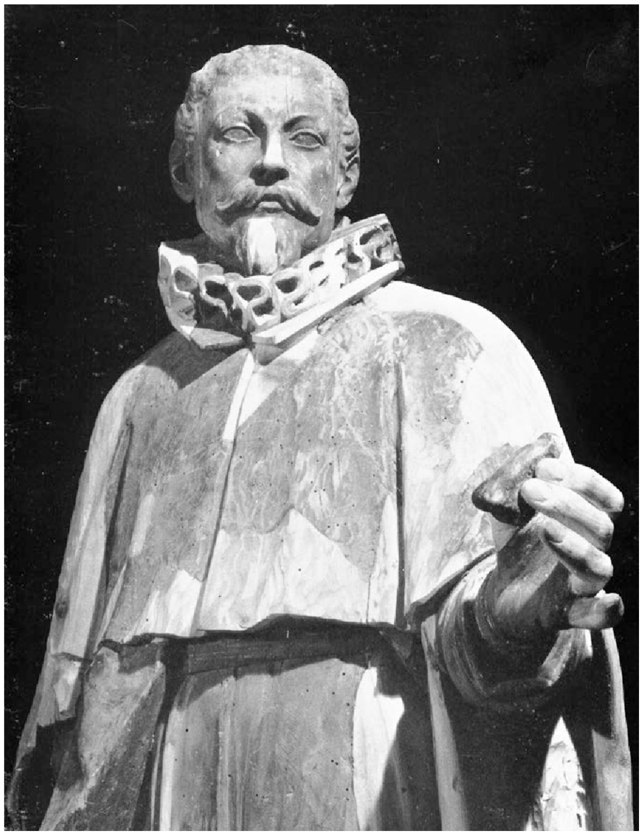


Image Courtesy: History of reconstructive rhinoplasty

(Ref: Sushruta Samhita, Sutrasthana Slokas 27-31)

The procedure of rhinoplasty is described in the above-mentioned *shloka*s from which the following procedure is inferred:

'The portion of the nose to be covered should be first measured with a leaf. Skin of the required size, gauged through the leas measurement, must be dissected from the cheek and turned back to cover the nose and not completely detaching the skin from the cheek. Care must be taken to scrap the damaged nose to bleed before placing the dissected flap. Two tubes must be inserted and the whole thing must be properly bandaged. Powders or red sandalwood, licorice, etc. must be sprinkled over it along with sesame oil. Ghee is used for internal oleation of the patient as well as therapeutic purgation.'

Like many texts of our country, the dating of *Sushruta Samhita* is also mired in controversy as there is exists a wide speculation from 1000 to 600 BCE. Interestingly, the procedure remained in vogue for over a millennium for we find a more refined and step-by-step procedure in the *Ashtanga Hridaya* by Vagbhata who is dated to the 4th century CE. Literal continuity for over 1000 years suggests the heightened demand of rhinoplasty as well as its active practice in the country.

EXPORT OF EXPERTISE FROM INDIA

Around the 8th century CE, several Indian texts were translated into Arabic (*Sushruta Samhita* was translated as Kitab-i-Susurd) and it was during the same time that the Arabs invaded the town of Sicily in Italy. Although there is no tangible record, it is widely believed by the historians that it was the Arabs who introduced the Indian texts and particularly the *Sushruta Samhita* to the Italians. For, in the 15th century CE, we get to know of a father-son duo named Branca being hailed as the master surgeons in reconstructing the mutilated nose. Their procedure matches exactly the way it was detailed in the *Sushruta Samhita* and *Ashtanga Hridaya*. The junior Branca although improvised the technique by taking the skin not from the cheek but from the arms of the person for whom the nose job was being done. They were considered pioneers in this field although they left no trace of literature from which one could either infer their training or details of their technique. They guarded the procedure with utmost secrecy.

The process of restoring dignity quickly spread wider and in 1502, Alessandro Benedetti recorded the procedure in medical literature. He carefully examined the patients treated by the 'Branca method' of rhinoplasty and noted that the restructured nose did not withstand severe winters and in some cases external hair started to grow on the nose. This method was further practiced and perfected by another Italian from Bologna called Gaspar Tagliacozzi who is hailed as the father of rhinoplasty in Italy. He published the complete details of the procedure in 1597 and this later came to be known as the Italian Method of Rhinoplasty. Interestingly Tagliacozzi was criticised posthumously and even the Church played an important role in preventing the promulgation of his treatise.

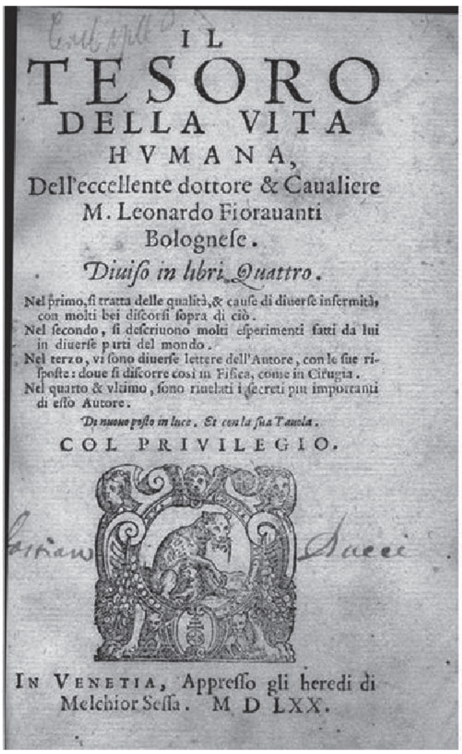
Back to India and fast forwarding to the 1700s, there was a serious political tension building in the subcontinent between Tipu Sultan and the Britishers. Tipu was not at all happy with the Britishers. He left no stone unturned to quash them. One of his strategies was to raid the convoy that supplied food and grains to the Britishers. The Sultan gave rewards for each nose, ear, or bullock brought back after a raid. Little did he know that such an act would indirectly spur interest in rhinoplasty. There appeared a 'Letter to the Editor' in the *Gentleman's Magazine*, in London, 1794, signed simply with the initials "B. L." It is speculated that these belonged to Cully Lyon Lucas, an English surgeon who learned the practice of total nasal reconstruction while working in Madras. Although the content of this letter was published seven months before in *Bombay Journal*, it was the English version published in 1794 that was responsible for the renaissance of nasal reconstructive surgery. The beginning portion of the letter is as follows:

"A friend has transmitted to me, from the East Indies, the following very curious, and, in Europe, I believe, a known chirurgical operation, which has long been practiced in India with success; namely, affixing a new nose on a man's face. The person represented is now in Bombay.

Cowasjee, a Mahratta of the caste of husbandman, was a bullock-driver with the English army in the War of 1792, and was made a prisoner of Tipu who cut off his nose and one of his hands. In the state of the Bombay army near Seringapatam is now a pensioner of Honorable East India Company. For about 12 months he has remained without a nose when he had a new one put on by a man of the brickmaker caste, near Puna. This operation is now common in India, and has been practiced from time memorial. Two medical gentlemen, Mr. Thomas Caruso and Mr. James Trindaley of the Bombay Presidency, have seen it performed as follows:"

And what followed is the procedure

Image Courtesy: History of reconstructive rhinoplasty


IL TESORO DELLA VITA HVMANA,
Dell'eccellente dottore & Caualiere M. Leonardo Fiorauanti Bolognese.
Diuiso in libri Quattro.
Nel primo, si tratta delle qualità, & cause di diuerse infermità, con molti bei discorsi sopra di ciò.
Nel secondo, si descriuono molti esperimenti fatti da lui in diuerse parti del mondo.
Nel terzo, vi sono diuerse lettere dell'Autore, con le sue risposte: doue si discorre così in Fisica, come in Cirugia.
Nel quarto & vltimo, sono riuelati i secreti piu importanti di esso Autore.
Di nuouo posto in luce. Et con la sua Tauola.
COL PRIVILEGIO.
IN VENETIA, Appresso gli heredi di Melchior Sessa. M D LXX.

Leonardo Fioravanti (far left) whose 1570 book, *Il Tesoro della Vita Humana* (left), contains the description of Vianeo's procedure of nasal repair

of rhinoplasty as described in *Sushruta Samhita* with a slight improvisation that this time the skin was not dissected from the cheek, but from the forehead. Definitely, the Indians were experimenting over several millennia and thus one is unable to precisely point out when the modification, preferring skin from forehead to cheek, happened in history.

REVIVAL OF INTEREST IN INDIAN RHINOPLASTY

An interesting foray into a small historiographical news must be retold at this juncture. The Venetian adventurer Nicolo Manuzzi had composed a detailed manuscript about the Mughal Empire in the 17th century towards the end of his life. Accurate details of rhinoplasty, as it was in vogue during that time, were present in his manuscript. Although this manuscript was returned to Europe from India in the early 18th century, it was not published. It was not until the Englishman William Irvine translated the manuscripts and published the first four parts in 1907 that the sections containing the Indian method of nasal reconstruction came to light once again in Europe. By this time the technique was widely known and practiced, thanks to the letter in the *Gentleman's Magazine* in 1794.

Joseph Carpue (1764–1840), an English surgeon at the York Hospital in Chelsea, was perhaps influenced by this article and was, most likely, the first European to practice the modified 'Indian Method' of rhinoplasty using the median forehead flap. He presented this technique in the European Surgical Honoratarium. The following abstract and portions from his 'Account of Two Successful Operations for Restoring a Lost Nose' published in 1816 are of historical interest:

"On undertaking the first of the two cases to be hereafter narrated, I was induced to make such personal inquiries as were within my reach in this country, concerning the Indian method. I did myself the honor to write Sr. Charles Mallet, who had resided many years in India, who obligingly confirmed to me the report that this had been a common

All Images Courtesy: Internet

Joseph Carpue (1764–1840) was likely the first European to practice the Indian method of total rhinoplasty

operation in India from time memorial; adding that it had always been performed by the caste of potters or brickmakers, and that though not invariably, it was usually successful."

It must also be noted that around this time, early 19th century, the Royal Society of Surgeons gets formed and for the first time, the English surgeons take up rhinoplasty, the Indian method, with much seriousness. In 1818, the German Carl von Graefe publishes his book *Rhinoplastik* in Berlin. Among the various chapters, this book included Carpue's work. It aroused the interests of both the lay and medical professionals. Surgeons across Europe and America turned to the total nasal constructions using the Indian method. The most notable reviews of surgical trials from the early 19th century include those of Delpech (1824), Labat (1834), Blanden (1836), Dieffenbach (1829–1834), Listen (1837), Zeus (1838), Velpeau (1839), Serve (1842), Von Aiman and Baumgarten (1842), and Jobert (1849). These forerunners of plastic surgery advanced the 'Indian method' for rhinoplasty. The last Indian who actively practiced rhinoplasty the way described in the Ayurvedic text was Tribhovandas Motichand Shah, Chief Medical Officer of Junagadh. He published a book titled *Rhinoplasty* in 1889, in which he is stated to have carried out 100 cases in four years.

The last Indian who actively practiced rhinoplasty as described in Ayurvedic texts was Tribhovandas Motichand Shah, Chief Medical Officer of Junagadh

Thus, we see that the humble beginnings of restoring dignity originating from India spread far and wide across the world. It has even inspired authors to an extent that novelist like Harry Turtledove who, in his fictional novel *Justinian*, mentions that the Byzantine Emperor Justinian II travelled all the way to India to have his nose reconstructed. When scientific or technological feats find mention in a piece of popular literature, it gets immortalised. Indeed, the Indian origins of rhinoplasty are so very much immortalised that when the famous *Science* journal ran a special issue on Bionic Man in Feb 2002, containing in it a chapter on historical highlights in bionics and related medicine, it elicited the following comment from Prof Rick Nelson of the Department of Surgery at the University of Illinois, Chicago, which was also published in the *Science* journal (April 2002 Vol 296 p 656):

Nasal Reconstruction in Ancient India

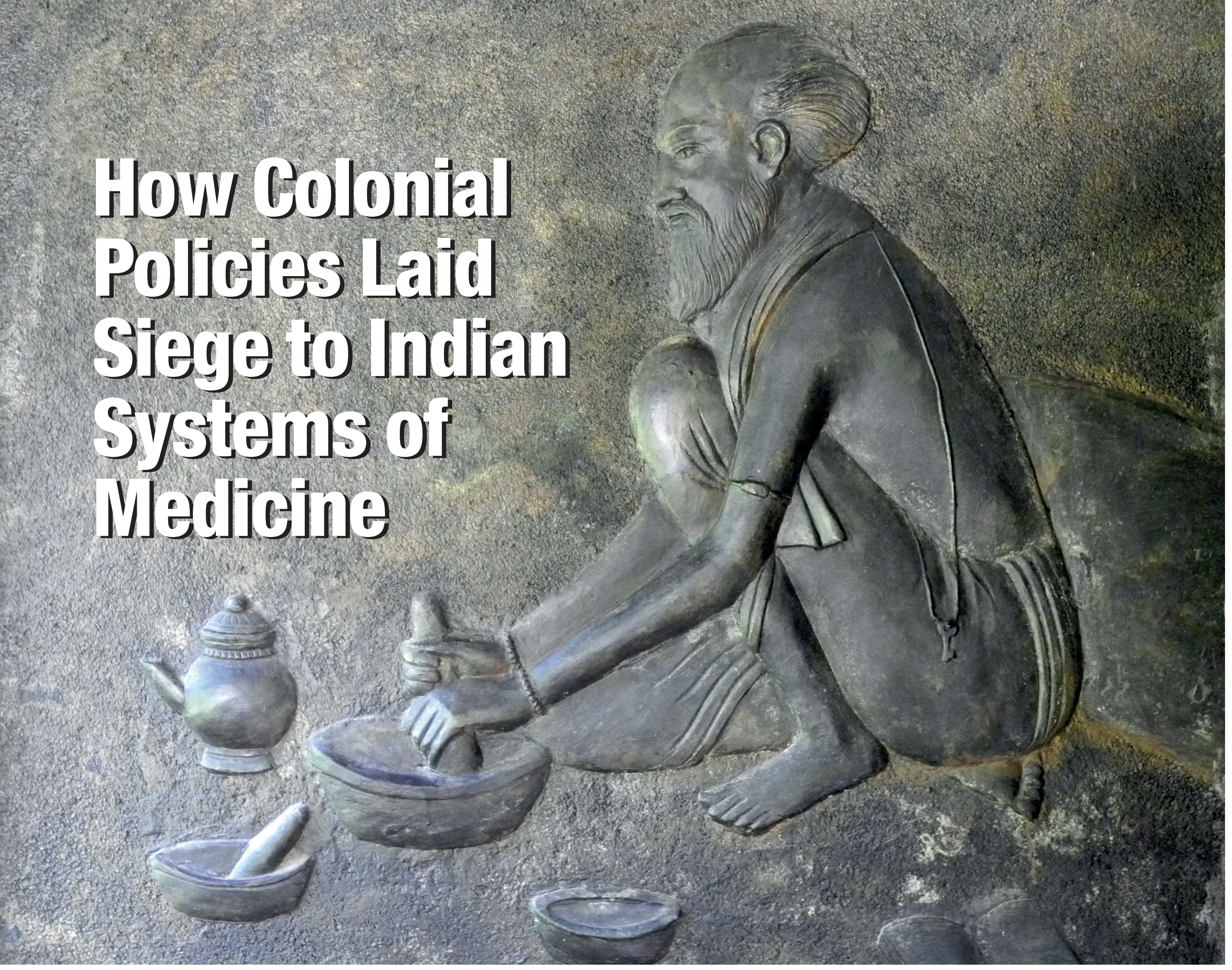
THE SPECIAL ISSUE ON THE BIONIC HUMAN (8 Feb.) was fascinating. However, the timeline ("Historical highlights in bionics and related medicine," p. 996) contained one error, dating nasal reconstruction with tissue flaps to 1597 A.D.

In ancient India, nasal amputation was a common form of punishment for adulterers, creating a broad need for nasal reconstruction. In a remarkably detailed and rational book written at the time of Vedic medicine, perhaps 1000 B.C., the Sushruta Samhita, nasal reconstruction using tissue flaps either obtained from the face or forearm is described (*1*). The first use of a mechanical tissue stapler is also described, intestinal injuries being repaired with the heads of black ants.

RICK NELSON

Department of Surgery, University of Illinois at Chicago, 1740 West Taylor, m/c957, Chicago, IL 60612, USA. E-mail: altohorn@uic.edu

**The writer is an Assistant Professor, Department of Chemistry, IIT (BHU) Varanasi*



How Colonial Policies Laid Siege to Indian Systems of Medicine

Image Courtesy: Shutterstock

Centuries-old Indian systems of medicine were consummately exterminated by the British Raj, and were also slapped with the tag 'inferior' causing lasting damage

■ Vaidya Preeti Bhosle

Since centuries, Indian indigenous medicine has been acknowledged for proficiency. There are no second thoughts about the fact that Indian medicine faced recession during the colonial era.

The East India Company, a British private entity, was on the verge of total domination after taking charge in Bengal and neighbouring areas. The British officials involved with the company were accustomed to consider Indian cultures and traditions as inferior. Similar ideology was evidently emphasised in books like James Mill's *The History of British India* (1817).

TRUTH BEHIND BRITISH "EFFORTS TO EDUCATE INDIANS"

In such a disdainful situation, the East India Company first laid the foundation of western system of medicine in the form of Native Medical Institution (NMI) in Kolkata (1822) and then abolished it 13 years later to pave way for the Medical College (Bengal, 1835). The reason behind NMI's foundation was the requirement of the company's military for qualified medical personnel. Although the preference was for western medical personnel, it was financially impractical and so NMI was created. British academicians at NMI created a wave of pride amongst the students for making them educated in western medicine and instilling an inferiority complex towards Indian systems of medicine (ISM).

William Bentinck, the governor-general, constituted a committee which strongly criticised NMI and recommended its replacement with a new institution that would teach medicine as in European medical colleges in English. The year 1835 marked the abolition of NMI and the formation of Calcutta Medical College (CMC). The first dissection by Indians happened in October 1836, led by Madhusudan Gupta, a former Ayurveda teacher at the NMI.

The British government then started recognising only 'Western medicine', leading to the formation of All-India Medical Association (1928) during a conference in Calcutta, heavily attended by CMC graduates. Bengal Medical Service was formalised for employing British surgeons in Bengal and 'superior' medical services came into being in Madras and Bombay. Soldiers in the company were the first Indians to receive medical treatment from British surgeons. Indians were recruited as medical assistants and orderlies from the 17th century. Thereafter, a Subordinate Medical Service (SMS) came into existence (1760) which co-existed with the 'superior' medical service till 1947. The Indian assistants were called 'native doctors.'

After the first hospital came up in Calcutta for all (1792), British surgeons began treating Indians. Vaidyas and Hakims were found all over India but were popular in local native communities receiving patronage from local rulers. The practice and teaching of ISM continued by students receiving training by *vaidyas*. British surgeons replicated some effective Indian remedies. To reduce drug imports, the company started scientific research on Indian medicinal plants. They established botanical gardens (1750) to cultivate/study local plants for use/export. Some medically trained Orientalists translated the Ayurvedic and Unani texts. Advances in Western medical science resulted in rapid decline in ISM. The Native Medical Institution (NMI) (1822) and Sanskrit College, Calcutta (1824), were set up to teach both Western and Indian medical concepts using Urdu as the medium of instruction.

CONSPIRACY OF MAKING US FEEL "INFERIOR" IN "OUR HOME"

Severe criticism of Indian thought and Indian medicinal practices lead Lord William Bentinck (Governor General of India, 1828–1835) to form a committee to support the criticism on lack of practicality/ rationalism in ISM, post which the company started training its personnel in Western medicine and stopped all support for ISM. With closure of Calcutta Institution (1835), the era of coexistence between the Western and Indian systems of medicine ended. Medical education at Sanskrit College was stopped. Calcutta Medical College was established (1835) to teach Western medicine in English along with colleges in Bombay and Madras, recognised by the Royal College of Surgeons. Registration with the General Medical Council (GMC) was mandatory (1858). After 1855, a competitive entrance test was conducted in London to recruit doctors into IMS (Indian Medical Service).


Image Couurtesy: mpositive.in

Khan Bahadur Sir Mohammad Usman, a *hakim* and a politician, affirmed the importance of Indian systems of medicine in his Usman Committee report

With the British succeeding in justifying their rule in India and Indians practicing Western medicine to attain higher social standing, the prestige of Indian systems of medicine declined

Registration with the GMC which was required for entry into IMS was made difficult after 1886.

Britishers continued to prove their supremacy in every field including medicine to justify their rule in India. Indian practitioners began advertising themselves as practicing Western medicine to attain higher social standing, resulting in a declining prestige of ISM. Some practitioners completely left ISM and accepted the 'rational' Western system. There were others who completely opposed modern medicine. They upheld the indigenous systems and advocated their practice in the purest forms. Supporters of 'pure Ayurveda' and the Azizi family of Lucknow were among such audacious ones. From the 1830s, the London Missionary Society in south India began to take up medical work as part of its activity. Allopathic practitioners often treated the indigenous practitioners as inferiors. Indian native knowledge was labelled unscientific/ irrational. Western medicine was applauded and given the status of official medicine with a visible discrimination and hostility towards ISM.

THE RISE OF ISM DEFENDERS

The interposition of Western medicine was disliked by the ISM practitioners and they openly defended their traditions. Benaras Hindu University developed a course (1920) which taught both Ayurveda and Western medicine. The *Journal of Ayurveda or the Hindu System of Medicine* argued (1928), 'Medical Education in India should be so devised that it should take into account not only the present-day medical education but also medical knowledge of the past... While Ayurveda cannot move on in an old groove, Allopathy should not be accepted in toto for India. While we should absorb the pathology of the 'seed of disease' from Allopathy, we must give the 'pathology of the soil' in disease to modern medicine. The two angles are at present different but should be harmonised.' The worst part is that the ISM practitioners are treated as 'inferiors' in India even today.

The Sharifi family of Delhi inseminated aspects of both Ayurveda and Western medicine into Unani-Tibb. Madrasa-e-Tibbia was established in Delhi by Hakim Abdul Majid of the Sharifi family. There was no help by the government, but nobles along with the affluent classes did provide patronage. Vaidya Gangadhar Ray (1789–1885) and Gangaprasad Sen (1824–1896) worked on developing Ayurveda post-1835 by training students in the system. Vaidyas established medicine companies to prepare and sell/ export Indian medicines. The Pharmacopoeia of India was published in 1868. Western practitioners increasingly used formulations with a single 'active ingredient,' thereby neglecting ISM ideology for the whole herb/ mineral. Formal training of Hakims and Vaidyas in western medicine began at the Oriental College in Lahore (1872). After severe criticism from Western practitioners, such trainings were stopped within a few years.

The committee headed by Sir Joseph Bhore coined the words: 'Modern Scientific Medicine' in its report (1946), with the sole purpose to denounce the ISM upfront as non-scientific/ outdated. A segment of Bhore Committee's opinion about ISM is stated verbatim, 'In considering the question of the place which the indigenous systems of medical treatment should occupy in any planned organisation of medical relief and public health in the country, we are faced with certain difficulties. We are unfortunately not in a position to assess the real value of these systems of medical treatment as practiced today as we have been unable, with the time and opportunities at our disposal, to conduct such an investigation into this problem as we would justify clear-cut recommendations. We do not, therefore, propose to venture into any discussion in regard to the place of these systems in organized state medical relief in this country. We do however say


Image Courtesy: Wikimedia Commons

Madhusudan Gupta, a former Ayurveda teacher, led the first team of Indians that carried out a dissection in a western setting in 1836

quite definitely, that there are certain aspects of health protection, which in our opinion, can be secured wholly or at any rate largely, only through the scientific system of medicine (modern medicine). Thus public health or preventive medicine, which must play an essential part in the future of medical organization, is not within the purview of the indigenous systems of medical treatment as they obtain at present. This in no way reflects upon these systems.' We feel that we need no justification in confining our proposal to the countrywide extension of a system of medicine (modern medicine), which in our view, must be regarded neither as eastern or western but as a corpus of scientific knowledge and practice belonging to the whole world'. The Bhore committee advocated de-recognition of the ISM.

Formal training of Hakims and Vaidyas in western medicine began at the Oriental College in Lahore in 1872

First formal recognition of Ayurveda was given by Bombay Medical Practitioners Act 1938 by the provincial government establishing the first separate register of practitioners of ISM. Madras Indigenous (Usman) Committee (1923) was the first committee established for promoting and regulating ISM. Khan Bahadur Sir Mohammad Usman (1884 –1960) was an Indian politician and Hakim who also served as the first Indian acting Governor of Madras (May 1934 – August 1934), abreast Sir Joseph Bhore. The Usman Committee affirmed the importance of Ayurveda in its report. Sir Joseph Bhore (chaired Health Survey and Development Committee, 1946), never paid attention to the Usman Committee report. It seems unlikely that Bhore was unaware of the Usman Report. The Usman Report was ignored with the sole purpose of neglecting ISM. Disgracefully, Indian nationals who were the members of committees constituted after independence also followed Bhore. Only difference was that they didn't have the courage to ignore ISM. First Health Ministers' conference (1946) passed a resolution for training and research in ISM. Thereafter came into existence committees like Mudaliar (1959), Bajaj (1983), etc., which advocated inclusion of Ayurveda in public health services thereby paving a way forward towards its inclusion and reprise.

The writer is Founder of Pratha Ayurveda & ex-Research Fellow, Department of Neurology and NMR, AIIMS, New Delhi

Agharkar Research Institute was established in 1946 by the Maharashtra Association for the Cultivation of Science as MACS Research Institute and renamed as ARI in 1992

Image Courtesy: Agharkar Research Institute

■ Dr Kishore M Paknikar

MACS: The Story of Grit, Dedication, and Personal Sacrifices

Brilliant scientists driven by a zeal for research for and by Indians came together under the leadership of Prof SP Agharkar to create this enduring institution

Pune (then called Poona) emerged as one of the major centers of nationalism under the leadership of its greatest icon, Bal Gangadhar Tilak. Apart from his social reforms and political movements, Tilak and educationist-thinker Gopal Ganesh Agarkar set up several educational institutes in Pune, like the Deccan Education Society and Fergusson College in 1885, soon after the first Universities in India were started in 1857. The objectives of university education were three-fold: (i) to broaden the base and spread liberal education to the masses, (ii) to diffuse scientific knowledge, and (iii) to prepare young graduates for technological work for the development and progress of the country in science and basic technology. However, although these early universities succeeded in educating the masses and spreading knowledge, they did very little in the first 75 years to generate new knowledge, especially in science.

With its numerous educational institutions and colleges, Pune had made striking advances in humanities, especially in Linguistics, Mathematics, Sanskrit, Archaeology, and History. However, despite excellent institutions and a great manufacturing centre like Bombay nearby, little or no efforts were made to foster the spirit of scientific research. Some were made only at individual levels and were unorganised. The need, therefore, was felt for carrying out scientific and technical research in a more organised way during the pre-independence period.

This problem became quite apparent to Prof SP Agharkar, who had retired as Ghosh Professor of Botany at Calcutta University in 1944 and made Pune his new home. He met Dr MR Jayakar, Dr DR Gadgil and other educationalists in Pune who were trying to upgrade the teaching in science to promote research.

By this time, there was a move to set up a new University in Poona. But it was thought better not to wait till the formation of the Poona University and explore the possibility of starting a Science Institute. The Indian Law Society took the lead in this matter. A meeting was organised at the initiative of

Image Courtesy: Agharkar Research Institute



From the archives of Agharkar Research Institute in Pune

Principal JR Gharpure of the Law College Poona, on 17 October 1944, under the chairmanship of Dr MR Jayakar in which Pune's eminent educationalists, scientists, agriculturists, and industrialists interested in promoting higher education and scientific research participated. It considered the steps to be taken for developing a nucleus for organising such a research institute for pure and applied science. The meeting appointed a committee comprising Dr Jayakar as the Chairman, and Principal JR Gharpure, NC Kelkar, Dr RH Bhandarkar and Mahamahopadhyaya DV Potdar as its members. The committee was expanded by co-opting Professor SP Agharkar, Prof SL Ajrekar, Prof PR Awati, Dr PJ Deoras, Prof DL Dixit, Dr KC Gharpure, Dr KV Joshi, Dr NV Kanitkar, Dr DB Limaye, Prof GR Paranjape, Prof HP Parajnpye, Prof GB Patwardhan, Dr DL Sahasrabuddhe and Prof NV Joshi, who was nominated as the Honorary Secretary of the Committee.

During 1945-46, the committee met several times. As a result of their deliberations, it was decided to start a science institute under the auspices of the Indian Law Society, that graciously provided two big rent-free halls in the basement of the Law College building for conducting research with particular emphasis on the requirements of rural areas. It was also agreed that an association of persons interested in this project would run the institute. Thus came into existence the Maharashtra Association for the Cultivation of Science (MACS) on 5 October 1946 with the following aims and objectives:-

(a) The promotion of Science, including its practical application to problems of national welfare; (b) Maintaining an institute or institutes for scientific research; (c) Establishing a science library; (d) Disseminating the knowledge of pure and applied sciences through lectures, publications, demonstrations, exhibitions, etc.

Its constitution was duly framed and registered under the Charitable Societies Act on 1 October 1946. Initially, a small fund was built from private donations and membership subscriptions. However, those were the pre-independence days, and it was not easy to get financial aid from the government. Therefore, a group of scientists who decided to organise it, offered to work in a purely honorary capacity without receiving any remuneration.

Prof SP Agharkar was unanimously elected as Founder Director of MACS in 1946. He was the most inspiring dynamic personality behind the whole initiative. The idea of starting a research institute in Poona was in his mind for a long time. He was the maker and main organising hand behind several scientific societies and institutions in Calcutta and elsewhere. He had gathered immense experience running scientific institutions all over the country. He was the Secretary of the Indian Science Congress Association for several years and the Secretary of the National Institute of Sciences, now Indian Science Academy, for over 10 years.

MACS or Maharashtra Association for the Cultivation of Science came into being in 1946 with initial funds from private donations and membership subscriptions. Scientists behind the association decided to forego remuneration and work in a purely honorary capacity

Prof Agharkar gathered a small group of senior scientists in Poona who were prepared to work without any remuneration in this new venture. The group included Prof NV Joshi, who created a nucleus for research in Microbiology and Biochemistry, Prof SL Ajrekar, who organised Mycology & Plant Pathology Department and Prof PJ Deoras who started investigations in Zoology. Prof Agharkar himself looked after the Botany and Soil-Science Departments. All these honorary workers tried hard to set up and organise departments in their respective subjects and ran them most economically. Prof SP Agharkar, Prof JJ Asana, Dr VN Likhite, and others donated their valuable personal collection of books, journals, and back volumes of periodicals consisting of important reference work worth more than Rupees 1.5 lakhs. This contribution served as a nucleus for the library of the institute. Senior scientists like Prof MN Kamat, Dr N Narayana, and Dr GB Deodikar, in their turn, persuaded other scientists and promising research workers younger than them and got them to work at the Research Institute. They attracted several young research workers

Then Maharashtra Chief Minister, YB Chavan, and Education Minister Shantilal Shah granted MACS about five acres of land in picturesque surroundings populated by academic institutions. Funds were also provided by the Government of India's Ministry of Education headed by Prof Humayun Kabir

and students to carry out their research problems with modest facilities.

These were trying times for the MACS. The financial position was not improving, and all the professors and research guides had to work purely in an honorary capacity. In the meantime, the health of its Founder Director, Prof Agharkar, deteriorated, and he passed away on 2 September 1960. The very existence of MACS became precarious. However, due to the guidance of the then chairman of its executive committee, Dr Sir Ragunath Paranjpye, the association was placed on a sound footing and continued its work. Dr GB Deodikar was elected as the director to succeed Prof Agharkar on 17 August 1960. He was helped by Prof N Narayana and Prof MN Kamat, senior professors at the institute. They ensured the continuity of work at MACS through their selfless efforts.

Meanwhile, the Indian Law Society had difficulties and could not spare the use of one of the basement halls in the Law College Building, where the office, library and laboratories of the Research Institute were located. It became necessary to shift the office and the library of the MACS from the Law College basement. The Servants of India Society and the Gokhale Institute of Politics and Economics came to the rescue. Prof DR Gadgil, the founder and director of the Gokhale Institute of Politics and Economics, made rent-free accommodation available in a spacious hall of his institute on the third floor of the newly constructed library building.

It was impossible to continue working like this indefinitely with temporary accommodation provided graciously by other research institutions. Moreover, the research activities of the MACS had considerably increased, and the need for a suitable building was felt. For this purpose, the executive committee of the MACS approached the Maharashtra government for help, as it could no longer function the way it had started. At this critical juncture, YB Chavan, the then Chief Minister of Maharashtra, and Shantilal Shah, the then Education Minister, who greatly appreciated the work of MACS and the problems it was facing, came to its help. As a result, the government of Maharashtra made a grant of land of about five acres to it free of cost in picturesque surroundings amid educational and academic institutions such as the Bhandarkar Oriental Research Institute, Law College, Commerce College and Gokhale Institute of Politics and Economics on the Law College Road, now called the GG Agarkar Road.

This generous grant by the government of Maharashtra gave MACS a locus to stand. An appeal for funds was made to the Ministry of Education, government of India. Prof Humayun Kabir, then Union Minister of Education, responded to it and deputed two senior secretaries, MU Rajaram and

Image Courtesy: Twitter

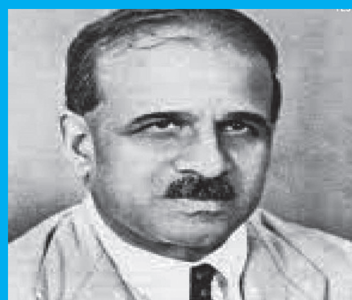


Image Courtesy: Public Domain

Above: Shankar Purushottam Agharkar, the founding director of MACS

Left: This photograph shows Lokmanya Tilak (4th from left, last row) along with his BA colleagues at Deccan College, Pune, in 1873

HKL Chaddha, to examine the urgent needs and problems of the institute and to report on them. They were favorably impressed by the work done at MACS Research Institute, by scientists working purely in an honorary capacity. They made suitable recommendations for meeting the urgent needs of the Research Institute of MACS. In pursuance, the Ministry of Education, government of India, provided it with an ad-hoc grant of Rs six lakhs during the Third-Five Year Plan to meet the expenditure on construction of a new building, maintenance and development. Accordingly,

Image Courtesy: Agharkar Research Institute

Left and above: The premises of the Agharkar Research Institute in Pune

a project for constructing a building on the piece of land given by the government of Maharashtra was undertaken and soon completed. After the establishment of the Department of Science and Technology (DST), the government of India placed MACS on the permanent list of Autonomous Research Institutions.

MACS owes so much to Prof Agharkar's devoted wife, who cooperated with him in his scientific and social activities. By his will, Prof Agharkar had provided for her maintenance. Mrs Agharkar used this provision very frugally and set aside her savings. These savings were augmented by the cash she realised by selling her ornaments. The entire amount thus raised was donated by her to the MACS, which speaks volumes for the devotion, courage and sacrifice of this great lady who fully identified herself with Prof Agharkar's dream. She breathed her last on 11 April 1981.

After the establishment of the Department of Science and Technology (DST), the Government of India placed MACS on the permanent list of Autonomous Research Institutions. It currently focuses research in Bioenergy, Biodiversity, Bioprospecting, Developmental Biology, Genetics & Plant Breeding, and Nanobioscience

The MACS Research Institute was renamed as Agharkar Research Institute in 1992 in honour and memory of its founder director, Prof SP Agharkar. Seventy-five years after its establishment, it is one of the prime autonomous research institutes of the Department of Science and Technology, government of India. It operates under the overall umbrella of MACS. The current research activities of the institute focus on six thematic areas, viz., Bioenergy, Biodiversity, Bioprospecting, Developmental Biology, Genetics & Plant Breeding and Nanobioscience.

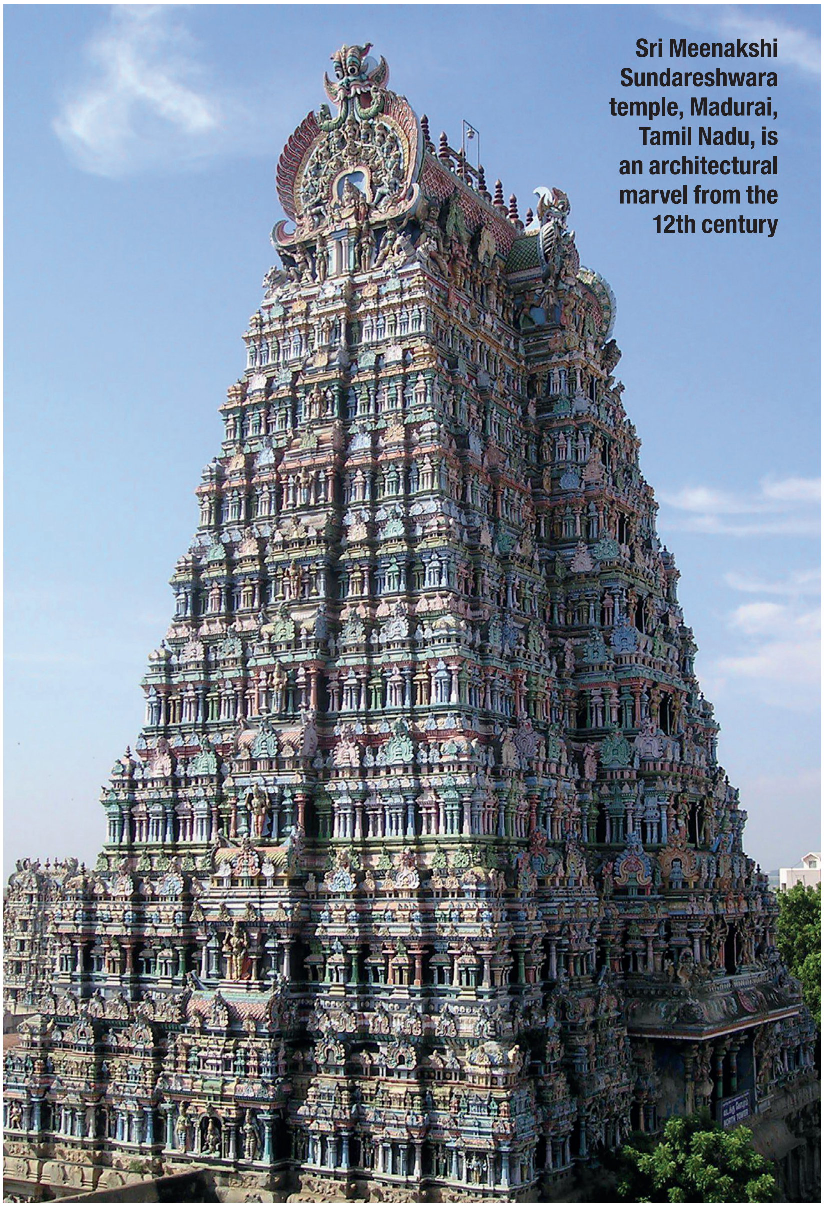
The MACS governing body continues the legacy of Prof Agharkar and its founding members by serving the society with utmost dedication, a sense of purpose, and without remuneration. As such, it stands tall among similar organisations in the country.

The writer is Former Director and Professor, Agharkar Chair MACS Agharkar Research Institute, Pune and Visiting Professor, Indian Institute of Technology Bombay

Bringing Spotlight on India's Metrological Strength

From uniform bricks of the Indus Valley Civilisation to gargantuan architectural structures in subsequent eras, there are ample proofs of India's adherence to scientific standards of measurements, which the country must build upon for progress in the current century as well

■ Dr RP Pant



Sri Meenakshi Sundareshwara temple, Madurai, Tamil Nadu, is an architectural marvel from the 12th century

Image Courtesy: Internet

A person goes to the market to buy commodities, he/she asks for 1 kg of sugar or 2 kg of mangoes, 4 metre clothes, etc. But what is 1 kg or 1 m? How do you define this amount as 1 wm or 1 kg? How can you ensure the amount you asked is what you get? All these questions are answered using metrology.

Metrology in simple words means the science of measurement. The measurement science is the backbone of any economically and technologically developed nation as it defines accuracy and precision of measure of any quantity. This helps to set laws and ways of enforcement to establish the standard of products and thereby ensure the quality of products used from daily life to industries. Therefore, measurement science is the basis of modern science, trade and technology, and consequently, the modern world. But what is this science of measurements? What was its status in the past? How did it evolve in India? Where do we stand in today's world? We try to find the answers to these questions in this article.

BRIEF HISTORY OF MEASUREMENTS IN INDIA

Prof Angus Maddison in his book, The World Economy: A Millennial Perspective, published by the Organisation for Economic Cooperation and Development (OECD) describes that before 1500 AD , India's GDP was almost two third of the world economy which reflects the prosperity of the nation at that time. This is a clear indicator that the measurement science and technology of India was very prominent during that period and rather much before that.

That metrology had been well developed in ancient India as evident through various historically significant relics spread across the country and abroad. If we look at the Indus valley civilization (4000 BC – 1500 BC), spread over an area of 1500 km x 1500 km and covering north-west India and present-day Pakistan, had an unbelievably uniform system of weights and measurements. All over the region, the construction bricks had one size with the length, width, and depth being in the ratio 4:2:1; measuring tools have been found too. This ratio leads to what is called in the construction technology as the English Bond system. It reveals that they had a proper legal measurement system. Perhaps, India was the first country in the world to officially enforce a system of weights and measurements. Indus valley civilization's town planning, drainage system, water supply, building design etc bear testimony to this.

Now moving forward in time to the Maurya empire (322 BC – 298 BC), the smallest unit of length was considered to be parmanu as given in Kautilya's Arthashastra. Eight (8) parmanu combine together to make 1 rajakhan which is basically 1 dust particle. To make it standard, the rajakhan (dust particle) from the chariot wheel was taken for measurement purposes. This rajakhan was the smallest visible physical standard as it could be seen by eye as a suspended dust particle in the air due to the scattering of light. Units of length were increased in multiples of 8, starting from parmanu to dhanurmushti. Thus, 1 rajakhan can be defined as 1/85 of dhanurmushti, which is roughly 3 micrometer in size as per current metric system. Thus, interestingly, the size of parmanu (= 1/8 rajakhan) comes of the order of nearly to the wavelength of visible light. In the modern world, length unit 'metre' has been standardised using distance travelled by light in vacuum in 1 second. But, with the fall of the Maurya Empire, the established unit system gradually vanished and was replaced by new measurement systems as new empires came into existence and kept changing with time.

Image Courtesy: Internet

Archaeological remains of the drainage system at Lothal, Gujarat

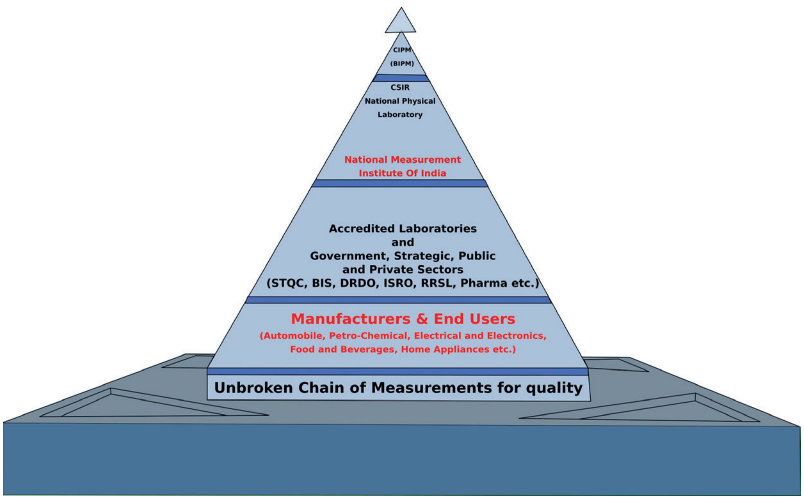
Whatever be the era, the units of measurements were always well standardised and enforced, which is indirectly evident from various archaeological structures made all across India during different eras. The making of such magnificent structures with such precision and durability cannot be possible without any proper measurement systems. For example, it is well know that during the equinox, the Sun is visible from one (1) window at a time out of five (5) windows of Shree Padmanabhaswamy Temple in Thiruvananthapuram, Kerala, starting from the top window and moving to the bottom window at an interval of roughly five minutes. This unbelievable engineering marvel shows precise construction of the temple windows. It took into account the alignment and accurate position of the Sun with time, windows dimensions, height from the ground and viewer position. These dimensions, of angles and timings, had to be measured with high precision and accuracy to make such structures possible. Similarly, the strong evidence of weight and measurement systems in various other fields like metallurgy, medicine, and astronomy in ancient India are depicted by historic relics.

STANDARDISATION OF MEASUREMENTS IN INDIA

Though India had established a measurement system since historic times, it varied from region to region and empire to empire. During the British India period, various attempts were made to establish uniform units and measurement systems taking into consideration local measurement systems like rati, masa, tola, seer, etc. In 1875, 18 European countries and other states signed the Convention du Metre at Paris to accept the common unit system (French metric system) on 20 May which is now celebrated as the World Metrology Day. In 1939, the Central Legislature passed the Standards of Weights Act applicable to the whole of British India and established the standard grain in terms of the platinum iridium 1b cylinder placed in the custody of the Mint Master Bombay. The act was enforced from 1 July 1942 and the Indian Standard Institute (ISI) was established in 1946.

After Independence, in 1955, India accepted the International System of Units (SI) officially and the national prototype no. 57 of mass standard taken as 1 kilogram made of platinum-iridium is preserved at the CSIR-National Physical Laboratory, the National Metrology Institute (NMI) of India by the Act of Parliament in 1957. The original prototype copy is kept at the International Bureau of Weights and Measures (BIPM), Paris, and is by definition taken as a unit of mass.

Now, seven (7) units, namely metre (m) for length, second (s) for time, kilogram (kg) for mass, kelvin (K) for temperature, ampere (A) for electric current, mole (mol) for amount of substance, and candela (cd) for luminous intensity, are defined as basic standard units and all the other units are derived from these basic units. The responsibility of defining units lies on the International Committee of Weights and Measurements (CIPM) and is accepted during the General Conference on Weights and Measures (CGPM). Thereafter, the units are realised at the national level by National Metrology Institutes (NMIs) of the respective countries. The national standard copies and primary instruments need to be matched with different NMIs at fixed intervals of time to maintain these primary value units in the country. The issue with the prototype based unit definition is that variations in them occur and error/uncertainty in its values arises with the passage of time. So, a need was felt to redefine more precise and constant values for standard units. Therefore, during the 26th CGPM meeting in 2018, a new definition of four basic units (mass, ampere, kelvin and mole) were accepted, based on universal physical constants, namely, the Planck's constant (h), electric charge (e), Boltzmann constant (kB) and Avogadro constant (NA), and enforced from 20 May 2019.



Traceability Pyramid at the National Physical Laboratory, New Delhi

ROLE OF NATIONAL METROLOGY INSTITUTES (NMIS)

Each nation has its own National Metrology Institute or simply NMI. The responsibilities of the NMIs are to develop, upgrade and maintain national measurement standards and disseminate SI units and if non-existent yet then to other internationally agreed references. It has to aid international recognition of national measurement standards and associated measurement capabilities (CMCs). The NMIs have to continuously sharpen/strengthen themselves to improve their CMCs by sharing through a metrological valid measurement data by a valid international laboratory comparison programs called key comparison, and then disseminate to the consumer. These NMI participate in CGPM meetings and international comparison of measurements to maintain the same standard as the rest of the world. Besides being custodian of standards and maintaining them, NMIs also provide various services pertaining to metrology, such as calibration, production of certified reference materials, and assigning value to in-house reference materials of customers, among others. Besides being the custodian of national standards, the CSIR-NPL has attained about 239 CMCs and disseminated more than 100 indigenous certified reference materials known as Bharatiya Nirdeshak Dravya (BND) in different categories for various parameters. These are the primary standards to ensure reliability and comparability of the measurements as a benchmark for quality assurance achieved through international networking. BNDs produced by CSIR-NPL are (i) in-house and (ii) in association with Reference Material Producers (RMPs) across the country as per ISO 17034 &17035. These standards are being produced through international key comparison, proficiency/round-robin testing, pilot study in various sectors like physico-mechanical, physico-chemical, foods, feeds, biomedical, environmental, health-care, agricultural etc.

DISSEMINATION OF SI UNITS

Now when the units are all defined and established, the question arises on how to ensure dissemination of these units and thereby provide accurate and precise measurements to the stakeholder. To measure '1 m', one takes a metre rod, for '1 L' of liquid, one takes a measuring cylinder. But how to ensure that '1 m' or '1 L' is exactly the same? The answer to this question is 'calibration'.

Calibration is defined in International Vocabulary of Metrology as operation performed on a measuring instrument or a measuring system that, under speci-

Image Courtesy: Internet

Shree Padmanabhaswamy Temple in Thiruvananthapuram is an engineering wonder as during the equinox, the Sun is visible from one out of five windows at a time, starting from top, at an interval of approximately five minutes

fied conditions: 1) establishes a relation between the values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and 2) uses this information to establish a relation for obtaining a measurement result from an indication. The purpose of calibration is to establish the traceability to the units of measurements. All the industries and business households, irrespective of their size, either get their instruments and machines calibrated from NMIs/national accredited laboratories or buy calibrated instruments/tools from certified companies. This chain of traceability starts from SI units moving to NMIs to accreditation authority to accredited labs and from there to manufacturers and finally consumers. If any step is missed from this chain, it destroys the credibility of the final product due to uncertainty during the measurements.

Each instrument or tool cannot be brought to the laboratories for calibration purposes. So for that, certified reference materials are used to calibrate such instruments or tools. Certified reference materials are defined as reference materials characterised by metrologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated error and a statement of metrological traceability. If the instrument gives the same value within the error as mentioned in the certificate, then that instrument is considered as calibrated and the value given by it as accurate and precise. This way, measurement traceability to SI units is maintained from large machines to everyday life, thereby ensuring the quality of life.

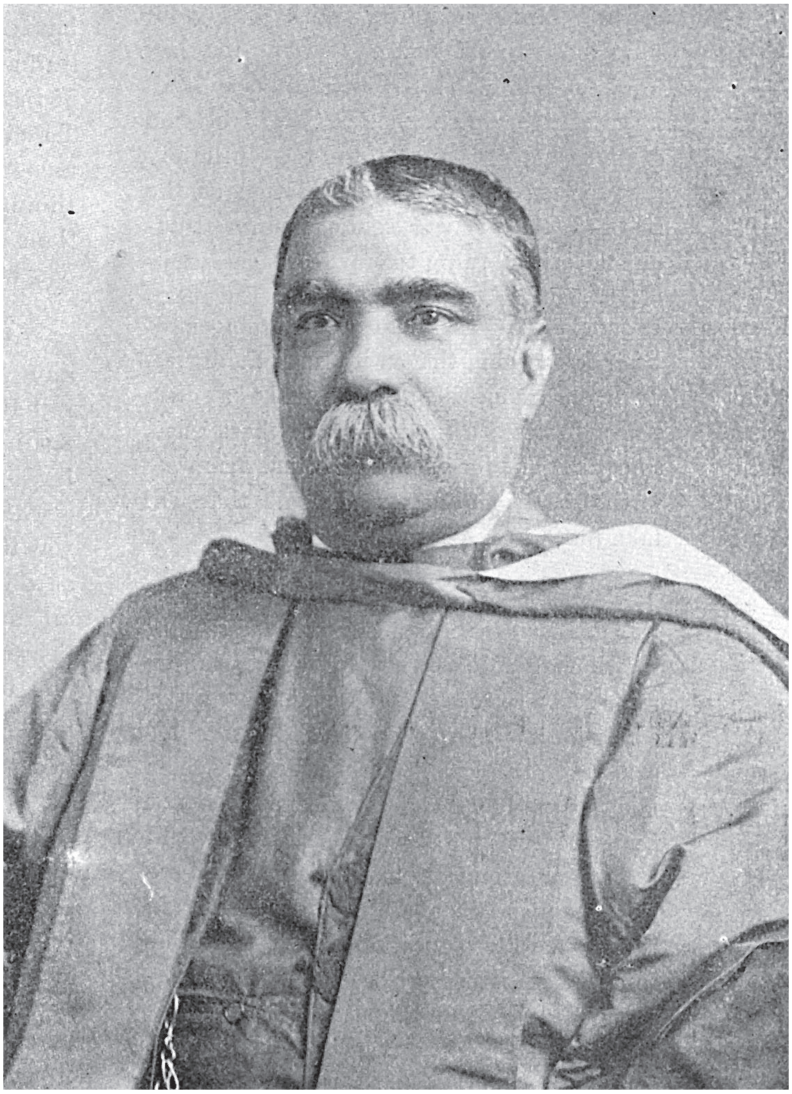
NEED OF THE CURRENT ERA

Earlier, India was a major trade centre of the world, and no doubt, metrology played a major role in it by establishing fine quality goods and technological services like architecture, metallurgy, medicine, astronomy, etc. In the current digital era with the target of taking the economy to USD 5 trillion by 2025-26, metrology has an even more important role to play to improve the quality of products and services. A conscious and elaborate effort is needed to establish test facilities and strictly enforce measurement standards at the grassroots level. It is needed to take initiative to develop synergy among regulatory bodies through QCI, BIS, legal metrology and other stakeholders which will bring enormous impact on quality system, employment generation, supply chain, economy and overall progressive growth of the country. At the same time, a nationwide awareness regarding various certificates and standards for end products needs to be created. Also, a focus on more accurate and precise measurements in production technology matching international standards and traceable to SI units has to be made.

— The author is Emeritus Scientist, CSIR-National Physical Laboratory, New Delhi

Sir Asutosh Mookerjee

(29 June 1864 - 25 May 1924)



"...I fervently hope that although the College of Science is an integral component part of the University of Calcutta, it will be regarded not as a provincial but as an All-India College of Science to which students will flock from every corner of the Indian empire attracted by the excellence of the instruction imparted and of the facilities provided for research."

— **Sir Asutosh Mookerjee** while laying the foundation of the new University College of Science, Calcutta, in 1914

Image Courtesy: Wikimedia Commons

August
2022

Celebrating Science This Month

AUGUST 2
Acharya Sir Prafulla Chandra Ray was born on 2 August 1861. Regarded at the Father of Chemistry in India, Ray established the country's first pharmaceutical company, the Bengal Chemicals and Pharmaceuticals, in Calcutta in 1901

AUGUST 6
This day is observed as Hiroshima Day annually in rememberance of the atomic bomb dropped on the Japanese city of Hiroshima by the US in 1945 during the second World War.

AUGUST 7
Indian geneticist M. S. Swaminathan was born on this day in 1925 in Kumbakonam, Tamil Nadu. He is called the Father of Green Revolution in India for pioneering the development of high yielding varieties of wheat in the country.

AUGUST 8
Central University of Jammu came into existence in 2011.

AUGUST 9
On this day in 1945, the US dropped the second atomic bomb on the Japanese city of Nagasaki, which brought about the surrender of Japan and led to the end of the second World War in the Far East.

AUGUST 10
Rohini Technology Payload (RTP) was launched onboard SLV-3 on its maiden flight from SHAR Centre on 10 August 1979. However, the satellite could not be placed into its intended orbit.

AUGUST 12
Since the year 2000, 12 August is observed annually as the International Youth Day by the United Nations, to bring attention to cultural and legal issues surrounding the youth.

Indian physicist Vikram Sarabhai, known as the Father of the Indian Space Programme, was born on 12 August 1919. After the launch of Sputnik — the world's first satellite — by erstwhile Soviet Union in 1957, Sarabhai set up the Indian National Committee for Space Research (INCOSPAR) that later transformed into ISRO.

AUGUST 15
India achieved Independence from British colonial rule on 15 August 1947.

ISRO or Indian Space Research Organisation was formed on 15 August 1969, to harness space technology for national development. ISRO embarked on its mission to provide the nation space-based services and to develop the technologies to achieve the same independently.

AUGUST 20
Akshay Urja Day is observed annually in India to raise awareness about the development of renewable energy in India.

World Mosquito Day is observed annually to commemorate British doctor Sir Ronald Ross's discovery in 1897 that female mosquitos transmit malaria between humans.

AUGUST 21
S Chandrasekhar, the Indian-American astrophysicist who was awarded the 1983 Nobel Prize for Physics with William A. Fowler for "theoretical studies of the physical processes of importance to the structure and evolution of the stars," died on 21 August 1995.

AUGUST 25
National Eye Donation Fortnight is observed annually from 25 August to 8 September, to raise awareness about the importance of eye donation.

AUGUST 26
The Central Glass and Ceramic Research Institute (CGCRI) was established in Calcutta on 26 August 1950, to focus on the area of glass, ceramics, mica, refractories, etc.

AUGUST 27
The GSAT-6 was launched on 27 August 2015 by GSAT-D6. Its mission life is about nine years.

AUGUST 29
The National Sports Day is celebrated every year on 29 August to mark the birth anniversary of India's greatest hockey player ever, Major Dhyan Chand. Born on in 1905 in Allahabad, Dhyan Chand was instrumental in India winning gold medal at the 1928, 1932 and 1936 Olympics.

IRS-1B was launched on 29 August 1991 from Baikonur Cosmodrome in erstwhile USSR by the Vostok rocket.

AUGUST 30
National Small Industry Day is observed annually on 30 August to support and promote small industries for their overall growth potential.

GSAT-7 was launched on 30 August 2013 from Kourou in French Guyana by Ariane-5 VA-215 rocket.

Swami Kuvalayananda, a researcher and educator who is primarily known for his pioneering research into the scientific foundations of yoga, was born on 30 August 1883 in Gujarat. He published the first scientific journal specifically dedicated to studying yoga, titled *Yoga Mimamsa*, in 1924.

Contributed by Surbhi Agrawal and Dr Rajeev Singh (University of Delhi)