A Brief History of Science, Part 15
Rebirth of Science in India

Soumitro Banerjee*

Introduction

We have seen earlier that India had a great scientific tradition, created mainly in the Siddhantic period (around 6th century BC to 11th century AD). Indian contribution to science was focused on astronomy, medical science, metallurgy, and branches of mathematics like arithmetic, algebra, number theory, and trigonometry. We have dealt in details with these contributions in an earlier issue (Vol. 17, No. 3, February 2015).

We have also seen that, starting from about 9th century AD science in India declined, and after 12th century AD, practically nothing was left (except for the Kerala School of Mathematics, which flourished in the 14th-16th centuries). India lapsed into a "dark age". The cultural conditions prevailing during this medieval period has striking similarity with that during the Dark Ages in Europe. Beliefs and superstitions ruled the Indian mind. There was blind faith in the scriptures, and answers to all questions were sought in the writings of ancient sages. Casteism was practised in a virulent form, which relegated a considerable section of Indian people — the lower castes — into the wretched life of untouchable community. The oppressive casteism in the Hindu society induced a large section of the lower caste people to embrace Islam. But by then, Islam also had lost its character of patronage for science and was on the way to becoming another bastion of blind faith and superstition. Thus, India lost touch with the science created on its own soil.

In the 17th century, the Europeans — Portuguese, Dutch, French, and British — set foot on Indian soil as traders. Out of these, the British slowly gained ground by utilizing the internal contradictions between the Indian rulers, and the British East India Company occupied vast stretches of land by defeating the Mughals. The other European powers became limited to a few pockets like Pondicherry, Goa, Daman, Diu, Chandannagore, etc. Even though the East India Company was a private enterprise, it represented British colonial interest in the subcontinent. In order to perpetuate its rule, the Company installed a postal system, railways, roadways, courts, tax collection departments and other arms of administrative machinery.

By 1818, the revenues from India rose to about one third of the total revenues of the British government. Such exploitation of the wealth of India required a large manpower, but the British citizens stationed in India were a mere handful in number. Thus, the East India Company had to install an education system to train some Indians to serve the British in various capacities of the administrative machinery.

*Dr. Banerjee is a Professor at the Indian Institute of Science Education & Research, and General Secretary of *Breakthrough Science Society* .

Statue of Raja Rammohan Roy in Bristol, where he spent the last 3 years of his life in an effort to influence the British parliamentarians to support his reform movement.

One would have expected that they would install an education system similar to that in Britain, where science is given due importance. But, no. Their intention was not really to enlighten the Indian people. The British rulers' outlook towards education was to train up a sufficient number of clerks and lower level administrators who would help a smooth running of the Government machinery. They carefully avoided dissemination of the modern ideas born through the European renaissance. For this, the existing model of education — the learning of ancient texts through the medium of Sanskrit — suited them fine. By promoting Indian beliefs and social practices, British rulers actually tried to foster traditionalism.

Raja Ram Mohan Roy

But through the British, the English language entered India, which opened a window to the ideas born in the European enlightenment. One of the first Indians to absorb these ideas and to appreciate their importance was Raja Ram Mohan Roy (1772-1833). He was an extraordinary scholar, well versed in many languages, and exposed to the highest traditions of the Hindu, Muslim and European literature. He realized that the way forward was to usher in the ideas of European enlightenment. But that was not what was in the minds of the rulers. So he engaged in a struggle with the British, making a strong case for a modern scientific education system.

We get a glimpse of his opinions from a letter he wrote in 1823 to Lord Amherst, the then Governor General of India. Ram Mohan expresses his utter dismay that instead of installing an education system based on modern science, "we now find that the Government are establishing a Sangscrit school under Hindoo Pundits to impart such knowledge as is already current in India. This Seminary (similar in character to those which existed in Europe before the time of Lord Bacon) can only be expected to load the minds of youth with grammatical niceties and metaphysical distinctions of little or no practicable use to the possessors or to society. The pupils will there acquire what was known two thousand years ago, with the addition of vain and empty subtleties since produced by speculative men, such as is already commonly taught in all parts of India."

"If it had been intended to keep the British nation in ignorance of real knowledge, the Baconian philosophy would not have been allowed to displace the system of the schoolmen, which was the best calculated to perpetuate ignorance. In the same manner the Sangscrit system of education would be the best calculated to keep this country in darkness, if such had been the policy of the British Legislature." He urged the government to "promote a more liberal and enlightened system of instruction, embracing mathematics, natural philosophy,

chemistry and anatomy, with other useful sciences which may be accomplished with the sum proposed by employing a few gentlemen of talents and learning educated in Europe, and providing a college furnished with the necessary books, instruments and other apparatus."

It is to be noted that Ram Mohan was well aware of the various shades of philosophy current in Western thought at that time. Out of these, he wanted the introduction of a particular line of thinking, based on Baconian philosophy (for an exposition, see Part 5 of this series in Vol.16, No. 4, January 2014) which was, at that time, recognized as the philosophical grounding behind the development of science.

We are fortunate that Ram Mohan succeeded in persuading the British to accept his views, at least partially. But what was installed was a mixture of Sanskrit scripture based oriental education and a bit of English literature and arts.

However, Ram Mohan tried to bring in social reform through a religious reform, by trying to make the practices of the Hindu religion more humane and rational. To achieve that, he preached a monotheistic form of religion, called Brahmo Dharma, based on *Vedanta*. In this we see an apparent contradiction: while Baconian philosophy urged people to observe the material world intently and to derive its laws by applying inductive logic, Vedanta considered the material world as *maya* or illusion, and urged people to look away from it. Ram Mohan was aware of this contradiction, but somehow lived with it.

Ishwar Chandra Vidyasagar

In the next stage, the fight was taken up by Ishwar Chandra Vidyasagar (1820-1891). He was an erudite scholar in Sanskrit grammar and literature who earned fame (and the title Vidyasagar — ocean of knowledge) at a very young age. He was also well versed in English, science, and familiar with various schools of philosophical thought of the West. Most importantly, he was completely free of the prejudices of his time and was the first representative of secular humanism on Indian soil.

Vidyasagar joined the Sanskrit College in Calcutta in 1846 as Assistant Secretary, at the age of 26. At that time the curriculum comprised mainly Sanskrit grammar and specialized in the scholarship of Indian tradition, philosophy and religion. He immediately proceeded to prepare a blue-print for drastic reform of the curriculum, proposing to introduce science and mathematics as developed in the West, and to make English compulsory. The proposal received a hostile response from the then Secretary of the College, Rasomoy Dutta, who refused to forward it to the Government's education department. Vidyasagar resigned from the College, and took up writing and publishing independently.

What did he write on? One of his books, *Jeevan Charit*, focused on the life struggles of scientists like Copernicus, Galileo, Herschel, Newton, Linnaeus, etc., in simple, elegant Bengali language. Another one, *Bodhodaya*, discussed the basics of zoology, physiology, botany, mathematics, physics, chemistry, geography, etc. These books were an instant success, as they introduced the Bengali readership to the highest products of the European renaissance and enlightenment. He also wrote books like *Varna Parichay* as a primary level textbook for learning reading and writing Bengali.

Meanwhile, a small number of Englishmen who understood the value of this man prevailed upon the Education Department, and Vidyasagar was brought back to the Sanskrit College as Secretary. He immediately proceeded to implement his plan of

Ishwar Chandra Vidyasagar (1820-1891)

curricular reform. The majority of British functionaries of the education department were alarmed. They ordered a review of the proposed reform by Mr J R Ballantyne, Principal of the Sanskrit College at Benaras, and a prominent oriental scholar.

Mr. Ballantyne visited the Sanskrit College, Calcutta, reviewed the new curriculum, and submitted a report to the Education Department. While he greatly appreciated the erudition of Vidyasagar, he did not agree with most of the recommendations. In reply, Vidyasagar sent a long rejoinder on 7 September 1853, countering Ballantyne's arguments one by one. This has gone down in history as the famous 'Vidyasagar-Ballantyne debate'.

Ballentyne felt that Vidyasagar was putting undue importance to the work of John Stuart Mill. Mill had to be taught, but one could do with an abridged version of his work, he felt. Vidyasagar did not buy the argument and steadfastly stuck to his point that the students should be exposed to the great thinker's work in its original.

Ballantyne had argued that along with the work of other philosophers, the idealist philosopher Bishop Berkeley's writings should also be a part of the curriculum. Vidyasagar's remark on this point deserves special attention: "With regard to Bishop Berkeley's Inquiry, I beg to remark that the introduction of it as a class-book would beget more mischief than advantage. For certain reasons, which it is needless to state here, we are obliged to continue the teaching of the *Vedanta* and *Sankhya* in the Sanscrit College. That the *Vedanta* and *Sankhya* are false systems of philosophy is no more a matter of dispute. These systems, false as they are, command unbound reverence from the Hindus. Whilst teaching these in the Sanscrit course, we should oppose them by sound philosophy in the English course to counteract their influence. Bishop Berkeley's *Inquiry*, which has arrived at similar or identical conclusions with the *Vedanta* or *Sankhya*, and which is no more considered in Europe as a sound system of philosophy, will not serve the purpose. On the contrary, when, by the perusal of that book, the Hindu students of Sanscrit will find that the theories advanced by the *Vedanta* and *Sankhya* systems are corroborated by a philosopher of Europe, their reverence to these two systems may increase instead of being diminished. Under these circumstances, I regret that I cannot agree with Dr. Ballantyne in recommending the adoption of Bishop Berkeley's work as a class-book."

Vidyasagar's proposal to counter the influence of wrong and obscurantist philosophies by sound and modern philosophies in the English course also met with opposition from Ballantyne, who felt that two different philosophies taught in different courses may induce the students to believe that "truth is double". Vidyasagar retorts:

"Truth is truth if properly perceived. To believe that "truth is double" is but the effect of an imperfect perception of truth itself — an effect which I am sure to see removed by the improved courses of studies we have adopted at this institution."

Thus countering Ballantyne, Vidyasagar proceeded to state clearly his vision regarding education. "What we require is to extend the benefit of education to the mass of people. Let us establish a number of vernacular schools, let us prepare a series of vernacular class-books on useful and instructive subjects, let us raise up a band of men qualified to undertake the responsible duty of teachers, and the object is accomplished."

What did he mean by 'a band of qualified men'? He says, "They should be perfect masters of their own language, possess a considerable amount of useful information and be free from the prejudices of their country." ··· "To raise up such a useful class of men is the object I have proposed to myself and to the accomplishment of which the whole energy of our Sanscrit College should be directed. That the students of our Sanscrit College, when they shall have finished their college course will prove themselves men of this stamp we have every reason to hope."

Thus we see that he had clearly set out the task before himself, and defended his right to proceed along this line. And in this, he succeeded.

Apart from the drastic change in the curriculum, he brought many other far-reaching changes. At that time, only upper caste Hindus from well-to-do families were admitted to the Sanskrit College. He changed the rules to allow students from all sections of the society to join the college.

He also took lead in another direction. He travelled, mostly on foot, to far-flung villages of Bengal, and established hundreds of schools. He also took the first initiative to start schools for girls. These schools would impart education through the mother tongue: "Vernacular Education on an extensive scale, and on an efficient footing, is highly desirable, for it is by this means alone that the condition of mass of the people can be ameliorated." He also had very concrete opinion regarding what should be taught in these schools: "Mere reading and writing, and a little arithmetic should not comprise the whole of this education; Geography, History, Biography, Arithmetic, Geometry, Natural Philosophy, Moral Philosophy, Political Economy and Physiology should be taught to render it complete."

In those days mathematics used to be taught using Bhaskaracharya's *Lilavati* (for arithmetic and mensuration) and *Vijaganita* for algebra. These books were not written as textbooks that demand systematic exposition. In fact, *Lilavati* was written as a collection of mathematical puzzles. Vidyasagar demanded introduction of modern mathematics with modern pedagogical techniques: "These two works are very meagre. ··· The examples are very few. The study of mathematics in Sanscrit should be discontinued. It is not to be understood from this that I undervalue a knowledge of Mathematics as an essential element of a complete education. Far from it. I wish to substitute the pursuit of it in English, whence in less than half the time now given to it an intelligent student will acquire more than double the amount of sound information that he could obtain by the most perfect acquaintance of all that exists in Sanscrit language in the subject."

Thus he ensured, firstly, that education reaches the common people, and secondly, that the students who come up to college level get a truly modern and scientific education. Other schools and colleges around

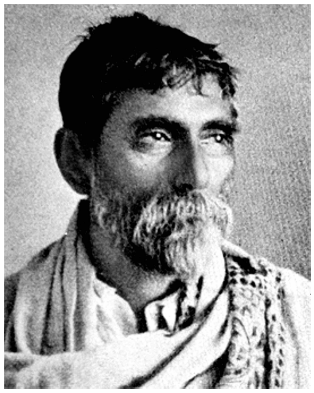
India soon emulated the example, and the 'Vidyasagar model' took root in the Indian education system much to the displeasure of the colonial rulers.

The results flowed surprisingly fast.

The decade of 1860-1869 saw the birth of a band of people who would shape the Indian cultural and political scenario in the later years. This includes Rabindranath Tagore, Madan Mohan Malaviya, Swami Vivekananda, Motilal Nehru, Ashutosh Mukherjee, Lala Lajpat Rai, V S Srinivasa Shastri, Mohandas Karamchand Gandhi, Jagadish Chandra Bose, and Prafulla Chandra Ray. They could become what they were because of the modern education they received in the 1870s and 1880s, which exposed them to the ideas of democracy, freedom, and science. *That* was the vision of Vidyasagar.

The upsurge in science

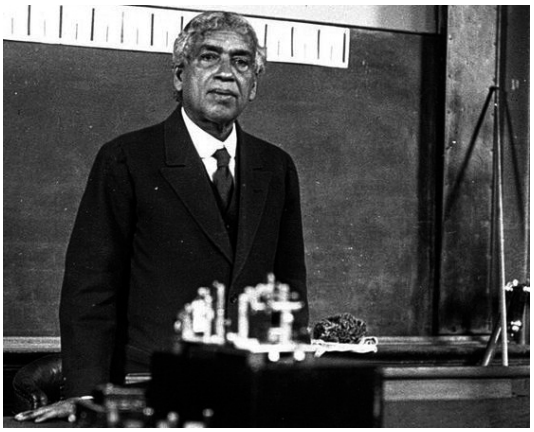
Two young friends, Jagadish Chandra Bose and Prafulla Chandra Ray, joined the Presidency College, Calcutta, in the late 1880s. At that time there was no facility or environment for scientific research in any college in India. The two friends took upon themselves the task of initiating scientific research — J C Bose in physics, and P C Ray in chemistry — despite the lack of funding and equipment, and indifferent attitude of the English administrators.



Acharya P C Ray (1861-1944)

By then Maxwell had shown that electromagnetic waves are possible, and Hertz had experimentally demonstrated the existence of such waves. Bose started research in this area, and soon developed a method to produce waves of much smaller wavelength than what Hertz had produced (about 5 mm, which we now know to be microwaves). Then he developed a technique to detect these waves at a distance from the emitter — in fact he was the first to use semiconductor material in the detector. He gave a public demonstration at the Calcutta Town Hall in 1895, in which he ignited gunpowder from a distance. All this work was of path-breaking importance in the development of wireless telegraphy. He refused to patent his inventions and made his discoveries public. The Italian inventor Marconi took advantage of this knowledge and developed the world's first commercially usable wireless telegraphy.

Bose later turned his attention to botany, and used local expertise to build extremely sensitive instruments for measuring growth of plants and their response to stimuli.

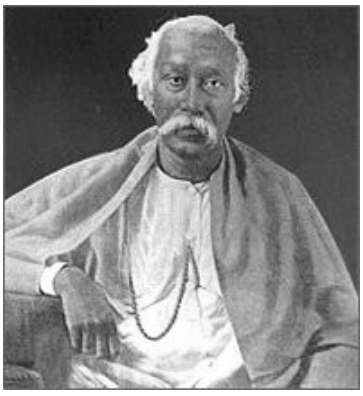


Jagadish Chandra Bose delivering a lecture at the Royal Society, London.

He was truly a pioneer in scientific instrumentation. He also built an institute for scientific research, now called the Bose Institute.

P C Ray started working in inorganic chemistry, particularly on synthesizing compounds of mercury. Soon he made an unexpected discovery — that of mercurious nitrite $Hg_2(NO_3)_2$. With the rudimentary equipment at his disposal, he characterized the new substance, which has turned out to be correct in the light of modern crystallographic techniques. This earned him accolades from around the world. He continued to work on other nitrites and on coordination chemistry, published in leading scientific journals including Nature and the journal of Royal Society of Chemistry.

He trained a band of students who spread all over India and built the edifice of chemistry research in the nation. They included Jnan Chandra Ghosh (Director of IISc Bangalore and the founding Director of IIT Kharagpur); Panchanan Niyogi (founding Principal of the Raja Manindra Chandra College, Calcutta); Nil Ratan Dhar (who started physical chemistry research in Allahabad University); Priyada Ranjan Ray (Calcutta University); and Biresh Chandra Guha (Founder of biochemical research in India). The eminent indologist Sylvain Levy said "his laboratory was the nursery from which issue forth the chemists of new India".



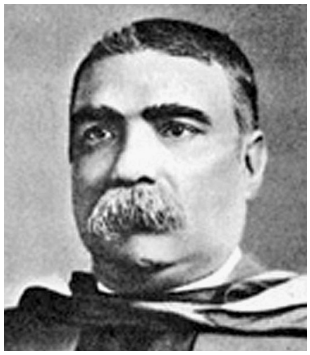
Mahendralal Sarkar (1833–1904)

C V Raman (1888-1970)

Mahendralal Sarkar, a doctor by profession, realized early on that an important component on India's emancipation should be scientific research. But at that time there was no place to conduct scientific research in the country. So he singlehandedly founded a small scientific institution called the 'Indian Association for the Cultivation of Science' in 1876 that was funded, run, and managed solely by Indians. Individuals could join the IACS and could use its very meagre facilities to conduct scientific research. It also organized public lectures on scientific topics to disseminate scientific ideas among the people.

In 1907, a young South Indian man named C V Raman, then working as a civil servant in Calcutta, noticing the IACS signboard on a building on Bowbazar Street, simply went in and asked if he could work there during his free time. The rest is history. He discovered the celebrated Raman Effect in 1928 while working at the IACS, and received the Nobel Prize for it in 1930. He worked there from 1907 to 1933.

The University of Calcutta had been founded in 1857, but was initially administered by the British. The progress



Sir Ashutosh Mukherjee (1864-1924)

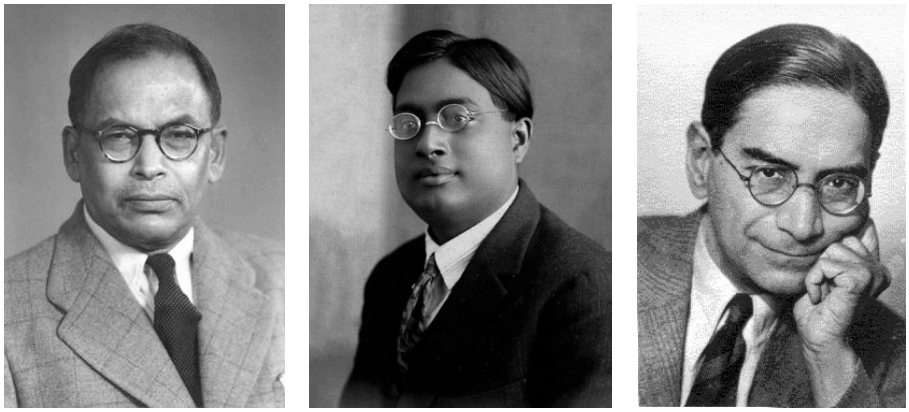
was slow, with teaching confined to a few arts subjects. Its fortune changed when the mathematician and lawyer Sir Ashutosh Mukherjee took charge as the Vice-Chancellor in 1906. During his tenure the British educational administration lost grip on the university and threatened to stop its funding. Ashutosh accepted the challenge, and appealed to the people to support the University so that it can satisfy the educational aspirations of the nation. He received generous support from Indian donors, and proceeded to create science departments, envisioning these to become cradles of advanced scientific research and teaching.

Ashutosh Mukherjee had a keen eye for spotting talent. He realized the potential of C V Raman at least 12 years before the discovery of the Raman Effect, and felt that his employment in the Indian Finance Department was a sheer waste of scientific talent. So he invited Raman to join the University College of Science. Raman joined the University in 1917, and continued his scientific research at the IACS, where he made his key discovery.

Two classmates, Satyendra Nath Bose and Maghnad Saha (both students of J C Bose and P C Ray), did their master's degrees from the Presidency College in Applied Mathematics in 1915. At that time Ashutosh Mukherjee was contemplating starting master's degree in physics. He spotted their talents and invited both of them in 1916 to join Calcutta University as lecturers in the subject of physics. They took up the challenge, learned the new advancements in physics (relativity and quantum mechanics) that was happening at that time, and started teaching these at the university. At that time most of the scientific literature was in German. So they had to learn German and had to read the original papers in German. In fact, the two young friends were the first in the world to translate Einstein's epoch-making paper on General Theory of Relativity, and the English version was published by the Calcutta University in 1920.

Soon they started creating their own footprints. While teaching Planck's derivation of the black-body radiation curve, Bose managed to derive it in an entirely different way, showing that light emitted by a black body would not follow the Maxwell-Boltzmann distribution because light quanta are indistinguishable from each other. He wrote up the new derivation and sent it to Einstein. Einstein realized

Srinivasa Ramanujan (1887–1920)



The three famous class-mates: Meghnad Saha, Satyendra Nath Bose, and Prashanta Chandra Mahalanobis.

the importance of the approach, translated it into German, and got it published. In addition, Einstein worked out the statistics to be followed by any particle that have similar properties. These particles are now called bosons, and the statistics they follow is called Bose-Einstein statistics.

Meghnad Saha, on the other hand, started working on ionization of gases at high temperatures that exist in the stars, and derived an equation that is followed in thermal ionization. The equation is now called the Saha equation.

Another classmate of theirs, Prashanta Chandra Mahalanobis, joined the Presidency College and started research on statistics. He later founded the Indian Statistical Institute, which is a premier institution for teaching and research on mathematics and statistics even today.

Srinivasa Ramanujan, with very little formal training in pure mathematics, started working in isolation on areas such as number theory, analysis, infinite series, continued fractions, etc., and soon obtained results that later startled mathematicians. In 1913 he started writing to the English mathematician G H Hardy. Upon realizing his extraordinary talent, Hardy arranged for Ramanujan to travel to Cambridge. There he produced important results such as the Ramanujan Prime, Ramanujan theta function, mock theta functions, etc. These opened entirely new areas of work and inspired a vast amount of further research.

Thus an age of science was dawning on India. There was excitement in the air, and India was making its presence felt in the world of science. The dreams of Rammohan and Vidyasagar were coming true.

Struggle between science and belief systems

Space for science cannot be created anywhere without launching a struggle against unscientific beliefs and practices. The doyens of Indian science did engage in this struggle, and tried hard to dispel the miasma. Rammohan and Vidyasagar had to fight against orthodox Hindu fanaticism. While Vidyasagar worked to spread a scientific education system, people like Akshay Kumar Dutta (1820-1886), and Rajendralal Mitra (1824-1891) stood by him by spreading scientific thought through numerous writings.

Acharya P C Ray waged an uncompromising struggle against casteism and the

superstitious behaviour and beliefs prevailing in the society. Even in the chemistry classes he would try to dispel unscientific notions prevailing in his students. For example, he would burn a piece of bone in bunsen burner, and then would drop it in his mouth. Some students would shudder: being a Hindu, which animal's bone did he consume? Prafulla Chandra would then explain: After it is burnt what remains are just inorganic compounds calcium carbonate and calcium phosphate! Thus he would not only teach chemistry; he would also inculcate a scientific bent of mind.

He was mostly successful, but not always. In one of his writings he lamented, "I have been teaching for half a century, and in that period I have told thousands of students that eclipses do not happen because demons called *Rahu* and *Ketu* devour the sun and the moon, and that eclipses do not end when the demons, satisfied by the worship of the earthlings, release the heavenly bodies. These are just myths, products of pure imagination. When I tell these with scientific explanation, my students understand and accept. But on the day of the eclipse, when people come out to the streets chanting *mantras* to please the demons, these truth-seekers also join them, and throw away their food."

Meghnad Saha was also very active in propagating a scientific bent of mind, and waged a polemical battle with the protagonists of orthodox Hinduism. In 1938 he gave a lecture at Shantiniketan with the title 'A new philosophy of life' in which he criticized various Hindu beliefs and customs. After it was published, there was a deluge of protests from people belonging to devout religious circles, who argued that all ideas of modern science can be found in the Vedas. Saha then read the Vedas in original Sanskrit, and showed, quoting the shlokas, that this is not true.

Thus we see that most scientists and social reformers of that era engaged in public dissemination of scientific ideas and in fighting unscientific beliefs. As long as and to the extent this outlook prevailed and guided the scientific community, science advanced in rapid strides.

Unfortunately this phase did not last long and did not embrace all spheres of life. Towards the close of the 19th century, a revivalist trend of thought arose and took shape in various forms of Hindu religious movements that sought to establish an ideal and purified Hinduism as the guiding ideology in all spheres of life including science. Indian nationalism grew in such an environment in the last quarter of the 19th century and at the beginning of the 20th century, which was based on religious sentiments and a sense of pride in an imaginary glorious past. Even though leaders like Netaji Subhas Chandra Bose and Bhagat Singh opposed it ardently, the dominant trend in the nationalist movement remained national pride based on Hinduism. As a result, the nationalist movement failed to achieve unity of different religious communities, and was beset with caste and communal prejudices. Even in meetings of the Indian National Congress there were separate kitchens for each community, a practice severely criticized by Acharya Prafulla Chandra.

As science's struggle for a foothold in the social psyche waned, the Indian renaissance started losing ground to different faith systems. But by then the age of science and technology had arrived. So science could not be ignored. Thus science education and research continued, but its revolutionary core, the scientific way of thinking began to be left behind. Science became reduced to being a mere gateway to a career.

During the days of freedom struggle a

sense of idealism — fighting against the British, taking the country forward — fired the young community. The scientists of that time also viewed science that way. They wanted to serve the country through science. They wanted to show the world that India can also make her mark in modern science. After independence, that nationalistic fervour in doing science disappeared. The value system that once propelled advancements in science became ineffective and was reduced to an instrument for privilege for a few.

While the number of scientific institutions have multiplied after independence, while a far larger number of scientists are working in these organizations, while the research facilities have significantly improved compared to the pre-independence era, still we are unable to produce scientists of eminence comparable to J C Bose, P C Ray, C V Raman, M N Saha, S N Bose, S Ramanujan, etc. We have been unable to produce a single Nobel Laureate since independence.

The flame lit by the doyens of the Indian renaissance has begun to dim. The task before the science movement today is to rekindle it and to make it burn brighter so that it lights up the whole nation freeing the society of unscientific beliefs and encouraging people to practice science as a way of thinking and a way of life. We now need to release a new current of struggle to build a society free of oppression of man by man, where the pursuit of science will be motivated solely by an urge to unravel the laws of nature and to serve the society. □

(*End of the series*)