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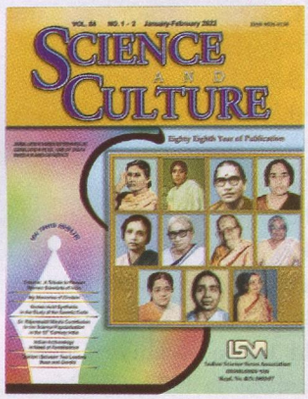
SCIENCE AND CULTURE

VOLUME 88 ❑ JANUARY-FEBRUARY 2022 ❑ NOS. 1–2

EDITORIAL

A TRIBUTE TO PIONEER WOMEN SCIENTISTS OF INDIA



Most Indians are aware that they have a great heritage, but few would include science in it. They believe that science is an import from Europe. Before the birth of Christ, people of the Indian subcontinent had acquired knowledge of science which can only be described as amazing. Relics of the Indus Valley civilization at Harappa and Mohenjo-daro (now in Pakistan) indicate that their cities were well-planned, with excellent water supply and drainage systems. The progress achieved in agriculture, brick-making, craft and industry was remarkable. Their clothes were made of cotton. It is still unknown that this civilization decayed and was lost.

The era from Aryabhatta to Bhaskara II (5th to 12th century C.E.) saw India enjoying a state of science that was advanced compared to other countries of the world. The golden age of science in India was from the fourth century B.C. to the sixth or seventh century A.D. With the prosperity of land, science flowered. There were renowned universities at Nalanda (the world's first residential university), Vikramshila and Taxila (now in Pakistan). India is famed for its rich contribution to the field of science and mathematics. In fact the concept of 'Zero' as a number and decimal system were inventions of brilliant mathematicians of ancient India (Bakhshali manuscript: 224-383 CE). Outstanding contributions were made to not only in mathematics but also in astronomy and medical science. A major benefit to Indian science during British rule was the spread of education in English, the language of modern science. The learning of science got a fillip in **1857 when three universities were created at Calcutta, Bombay and Madras. In 1876 a rich physician, Dr. Mahendra Lal Sircar, set up the first scientific research institution in Calcutta, known as the Indian Association for the Cultivation of Science**, which became the focus of scientific activities in pre-independence India.

A new page was opened in the history of science in India when the country became independent on **August 15, 1947.** There was a remarkable expansion of facilities for scientists and the research began and prospered in many fields. India is now a member of (i) the nuclear club, (ii) the space club, and (iii) the Antarctica exploration club. It has the world's third largest pool of trained technologists, next only to the USA and the Soviet Union, though it is still a developing nation. Now it is the role of Indian scientists including the women members to do much more to catch up with the advanced countries.

A society would advance ahead of others if it has an all pervasive scientific spirit receiving and assimilating the new scientific inventions and make the best use of them. The scientific spirit is the bedrock of any perceptible progress. Unfortunately, in a traditional society like ours, we are yet to create an effective and vibrant scientific temperament for science graduates. It is our fervent hope that **our** college students understand the evolution of science and the arduous path of the scientist so that they would be inspired to be scientific in their outlook and be receptive to new inventions and innovations.

Contributions of Women Scientists:

Women have made significant contributions from the earliest times. Women contributed the science of alchemy in the first or second centuries AD. The eleventh century saw the emergence of the first universities where women were excluded from university education. The attitude of educating women in medical fields in Italy appears to have been more liberal than in other places. The first woman

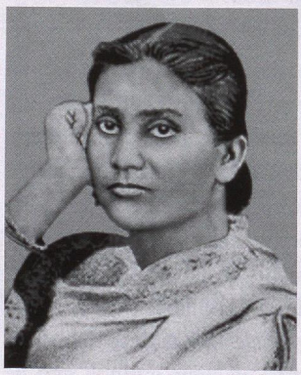
in the world to receive an academic degree from the University of Padua (founded in 1222) and in **1678** became the **first woman in the world to receive Doctor of Philosophy (D.Phil.) degree was Elena Cornaro Piscopia from Italy** (1646-1684). The first known woman to earn a university chair in a scientific field of studies was eighteenth century Italian physicist/scientist, Laura Bassi. **Bassi (1711-1778) was awarded a D.Phil (science) in 1732 at the University of Bologna (established in 1088, the oldest and first university in the world). She became the second woman in the world to earn doctorate degree but first in Science. She was the first female university Professor in Physics at a University in Europe.**

The Nobel Prize by Women Celebrities :

The Nobel Prize and the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel have been awarded to women 59 times and men 888 times between 1901 and 2021. Only one woman, Marie Curie has been honoured twice, with the Nobel Prize in Physics 1903 and in Chemistry 1911. From India only one woman **Mother Teresa** from Kolkata, was awarded Nobel Prize in Peace in 1979.

Celebrated Women Scientists of India:

1. Kadambini Ganguly (1861-1923): The first Indian woman to receive her degree as a Medical doctor in 1886 and the first female graduates of the British Empire and South Asian female physician trained in western medicine. First studied in Calcutta Medical College. She was also **one of the earliest working women in British India**.



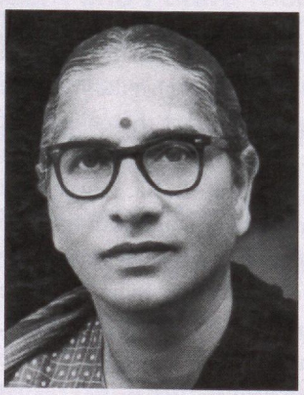
Kadambini Ganguly

Kadambini was one of the first two graduates from Bethune College in 1883 along with Chandramukhi Basu, in the entire British Raj. 1886 marked her record as one the first Indian women physician eligible to practice western medicine alongside Anandi Gopal Joshi. She received her GBMC (Graduate of Bengal Medical College) degree, allowing her to practice. She even left for the United Kingdom in 1892 to get more experience in her field and received various certificates from Edinburgh, Glasgow, and Dublin. After returning to India, she worked for a short period in Lady Dufferin Hospital and started her private practice later. Kadambini organized the Women's Conference in Calcutta for solidarity and served as its **President** in 1908. She died on 7th October 1923. As a champion of women's education and rights, Kadambini Ganguly may have long gone, but she will never be forgotten!

2. Janaki Ammal (1897-1984): A world-renowned botanist and cytologist paved the way for a lot of young woman to embrace science and progress in the 20th century. Janaki did her B.Sc. degree from Presidency College in 1921. She taught at Women's Christian College, Madras. After receiving the Barbour Scholarship, she moved to the University of Michigan from where she obtained her Master's degree in 1925. Again after receiving the first Oriental Barbour Fellowship she obtained her Ph.D. in 1931 (**India's first woman doctorate**) and D.Sc (honoris causa) in 1935 from the same university. After returning Janaki joined the Sugarcane Breeding Station at Coimbatore. Janaki's research in this field led to identifying hybrid varieties of high-yielding sugarcane. In 1935, CV Raman, the famous scientist and Nobel laureate founded the Indian Academy of Sciences and selected Janaki as a research fellow. But she left for London as an Assistant cytologist in the Innes Horticultural Institute. She also co-authored The Chromosome Atlas of Cultivated Plants with renowned biologist CD Darlington. Janaki relocated to India in 1951 when Prime Minister Jawaharlal Nehru personally invited her. She restructured the Botanical Survey of India (BSI) and served as the Officer on Special Duty in Calcutta in 1954.. Janaki was awarded **Padma Shri in 1977** by the Govt. of India and passed away on February 7, 1984 at the age of 87.

Janaki Ammal

3. Irawati Karve (1905-1970): A pioneering Indian Anthropologist, educationist from Maharashtra. She obtained Masters degree in 1928 in sociology from Bombay University. Then moved to Germany to have her doctorate degree working at the Kaiser Wilhelm Institute pf Anthropology, Human Heredity and Eugenics. Returning to India she



Iravati Karve

worked at the SNDT Women's University in Bombay, Deccan College, Pune as the head of the Department of Sociology and Anthropology and finally she founded the Department of Anthropology at the Poona University. She made significant contributions in the field of anthrometry, serology, Indology and palaeontology as well as collecting folk songs and translating feminist poetry. She was the **President of the Anthropology** Division of the National Science Congress held in New Delhi in 1947.

4. Kamala Sohonie (1912-1998): First Indian woman biochemist took 14 months to complete her Ph.D. degree from the Cambridge University in 1939 having thesis in 40 typed pages on 'Cytochrome C' which plays an essential role in the electron transport chain found in plants, human and animal cells. Returning from England she joined the department of Biochemistry at the Lady Hardinge Medical College, New Delhi to work on nutrition research. Later she moved to Bombay to join the Royal Institute of Science as Professor of Biochemistry. She worked on the nutritional aspects of legumes. She was finally become the first Lady Director, Institute of Science, Bombay. She was awarded theRashtrapati Award for her research work. She was also felicitated by the Indian Council of Medical Research (ICMR), New Delhi. The topper of Bombay University was refused admission by Sir C.V. Raman – India's Nobel Laureate. *"I am not going to take any girls in my institute" (1933). Kamala was to later recount —Though Raman was a great scientist, he was very narrow-minded. I can never forget the way he treated me just because I was a woman. Even then, Raman didn't admit me as a regular student. This was a great insult to me. The bias against woman was so bad at that time. What can one expect if even a Nobel Laureate behaves in such a way.*

Kamala Sohonie

5. Bibha Chowdhuri (1913-1991): She was a gifted particle physicist and the first Indian woman to earn a Ph.D. in Physics. She discovered mesons using nuclear emulsion, identifying new particles by studying their tracks in cloud chambers and on photographic plates and also on Kolar Gold Fields. The only woman student to complete M.Sc. (Physics) degree in 1939 from the University of Calcutta. She joined the Bose Institute and moved to the University of Manchester for her Ph.D. degree in 1949 under the supervision of Sir Patrick Blackett. She conducted research on cosmic rays and air showers. Returning to India she joined TIFR (Tata Institute of Fundamental Research) in 1949 and worked for eight years, then to Physical Research Laboratory in 1957 and finally to Saha Institute of Nuclear Physics, Kolkata in 1960 and continued her research until her death in 1991. The IAU has rechristened the **star HD 86081 as Bibha** (a yellow-white dwarf star in the constellation Sextans south of the celestial equator) after her.

Bibha Chowdhu

6. Asima Chatterjee (1917-2006): The first woman awarded a Doctor of Science by an Indian University in 1944, by the University of Calcutta. She was also the first woman to be elected as the General President of the Indian Science Congress in 1975. She was elected a Fellow of the Indian National Science Academy in 1960 and won several prestigious awards/position such as Premchand Roychand Scholarship of the University of Calcutta, Khaira Professor of Chemistry (1962-1982, the most prestigious and coveted chairs of the University of Calcutta). the Shanti Swarup Bhatnagar award (1961), the C V Raman award, and the P C Ray award; and is the recipient of the **Padma Bhushan** in 1975, the third-highest civilian award of the Govt. of India, in recognition of her contributions to the field of science. Her area of interest was natural products with special reference to medicinal chemistry. S*he published 400 research papers in reputed journals, about 15 books, supervised 60 Ph.D. theses and 3 D.Sc. theses.* She was nominated by the President of India as a Member of the Rajya Sabha from February 1982 to May 1990. Prof. Chatterjee also served ISNA Council for long time and also acted as one of the Vice-Presidents.

Dr. Asima Chatterjee

7. Kamal Ranadive (1917-2001): She is an Indian biomedical researcher best known for her groundbreaking cancer research and devotion to creating a more equitable society through science and education. She did her

Kamal Ranadive

research in the field of cytology at the Indian Cancer Research Centre and received Ph.D. from the University of Bombay in 1949, then proceeded to John Hopkins University, Baltimore, Maryland, USA obtaining a post-doctoral fellowship. After returning she joined ICRC, Bombay and for the first time established tissue culture laboratory in India in 1960. She was the pioneer woman scientist in animal modeling of cancer development. For the first time in India she proposed a link to the susceptibility of cancer and hormones and tumor virus relationship. Finally she worked as the Director of the ICRC in acting capacity for a term of 1966-1970. She published about 200 scientific research papers in the field of cancer and leprosy. Dr. Ranadive was awarded the first Silver Jubilee Research Award in 1964 of ICMR, the G.J. Watumull Foundation Prize in microbiology in 1964 and finally she received the **Padma Bhushan** (India's third highest civilian award) for Medicine in 1982 by the Govt. of India.

8. Anna Mani (1918-2001): She was an Indian Physicist and meteorologist from Travancore, Tamil Nadu.

Anna Mani

She was also a former Deputy Director-General of the Indian Meteorological Department, who made significant contributions in the field of meteorological instrumentation. She studied meteorological instruments from Imperial College, London and finally joined the Meteorological Department in Pune after returning to India in 1948. She published numerous papers on solar radiation and wind energy measurements. She also authored two books, "The Handbook for Solar Radiation data for India in 1980 and Solar Radiation over India in 1981. Anna Mani won the **K.R. Ramanathan Medal** in 1987.

9. Rajeshwari Chatterjee (1922-2010): She is the first woman scientist to pioneer the field of Microwave Engineering and Antennae Engineering in India. She was a very bright student securing First class First in B.Sc.(hons.) and M.Sc. Examinations in Mathematics in

Rajeshwari Chatterjee

1943, Then she joined IISC, Bangalore as a research student and after a short spell moved to USA and again took MS degree in 1949 from the department of Electrical Engineering and Ph.D. degree availing a Barbour scholarship in 1953 from Michigan University. She was the only Woman on the faculty in the Indian Institute of Science, Bangalore around 60 years ago. She mentored 20 PhD students, published about 100 research papers and authored seven books and finally retired as Professor and Chairperson of the Department of Electro-Communication Engineering, Indian Institute of Science, Bangalore. Dr. Chatterjee was awarded **J.C. Bose Memorial Prize** from the Institution of Engineers, **Mountbatten prize** from the Institute of Electrical and Radio Engineering(UK) and **Ramlal Wadha Award** from the Institute of Electronics and Telecommunication Engineers.

10. R. Rajalakshmi (1926-2007): A biochemist studied at McGill University, and worked at the University of Adelaide on a **Rockefeller ICMR** postdoctoral fellowship before retiring as the Head of the Department of Biochemistry at Baroda University in 1986. Both her children are scientists, too. **In 2009, her son, Venkatraman Ramakrishnan won a Nobel Prize in Chemistry.** Rajalakshmi passed away two years before this. Rajalakshmi's most important work was her book *Applied Nutrition*, which made the principles of nutrition relevant to Indian diets — keeping in mind available grains, vegetables, herbs, etc.

R. Rajalakshmi

Rajalakshmi held classes on language and nutrition for children from marginalised caste backgrounds. She encouraged children of all castes to share in the cooking and eating. Rajalakshmi acknowledged that sharing meals across castes was a "violation of unwritten codes and very much went against convention." Her attitudes towards nutrition, and building community across caste-lines were unusual in her time; they remain relatively rare even today.

11. Archana Sharma (1932-2008): A *renowned Indian botanist, cytogeneticist and cytotoxicologist. She had* her M.Sc. (1951), Ph.D. (1955) and D.Sc. (1960) degree from the University of Calcutta. She was the second woman to be awarded D.Sc. degree from C.U. She joined the Department of Botany at C.U. as a faculty in 1967, and remained there till her retirement. Archana was a pioneer in studying chromosome structure and developed techniques for chromosome labelling. Her book with A.K. Sharma"Chromosome Techniques- Theory and Practice" is a standard reference book for chromosome staining worldwide. S*he published 400 research papers, 8 books, supervised 70 Ph.D. theses. She was a founder of the cytology journal Nucleus, and remained its editor until 2007.* Additionally, Archana was actively involved in many policy-making bodies, and various committees of UGC, CSIR, ICAR, ICMR, DST, DBT and DOEn. In recognition of her contributions she won many awards like the **Shanti Swarup Batnagar Prize** (1976) by the Council for Scientific and Industrial Research, and the **Padma Bhushan** (1984) by the Govt. of India.

Archana Sharma

The Ministry of WCD, Govt. of India, has instituted Chair Professors in the name of Indian Women Scientists at Institutes across country to recognize and honour Indian Women Scientist's contribution to the field of science.

The progress of research being conducted by Indian women scientists in physical, biological, medical and pharmaceutical sciences and other allied disciplines are also commendable. Besides, it is also very pertinent to focus on the social and cultural issues of women scientists in the present society. Now we are paying our respectful homage and tribute to the celebrated Indian women scientists who brought name and fame to Indian science. The women scientists will lead the proper and the most significant pathway to proceed in right directions in the 21st century.

Here we have discussed about a few of the greatest Indian women scientists of all time. These women scientists changed the world through their talents and innovative ideas. They have made groundbreaking discoveries that have contributed to the betterment of human kind. Their lives are role models for all girls who aspire to make a mark and achieve excellence in STEM. ❐

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ARTICLE

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MY MEMORIES OF EINSTEIN

SIR RABINDRANATH TAGORE

I met Einstein during my first visit to Germany after the War. I was then deeply impressed by his great simplicity. There was nothing stiff about him – there was no intellectual aloofness. He seemed to me a man who valued human relationship and he showed toward me a real interest and understanding.

I recall that we talked on that occasion of whether or not I believed in modern industrial improvernents to help us in our modern life. I told him then, and I have no reason to change my opinion now, that they were essential to our physical well-being; and in as much as nothings could stop these improvements, we should seek to use wisely what man's ingenuity had created out of his necessity. For we had reached that degree of civilization when we could no longer scratch with our fingers; we were using our intelligence to over-come through machinery the weakness of our limbs. Both Einstein and I held similar opinion that it was necessary for us, by such means as mechanical invention offered, to make use of Nature's store-house.

When I again visited Germany in the summer of last year, I was inivited to come to see Einstein, this time in his own home in Kaputh, a short distance from Berlin. The Professor had a very beautiful retreat there, built high up on a hill. He came down to the road to meet me. His shock of white hair, his burning eyes, his warm manner again impressed me with the human character of this man who dealt so abstractly with the laws of geometry and mathematics. Together we walked slowly up the hill, and on his balcony we had afternoon tea. Between us was a sympathy which only the barriers of language made awkward. His mastery of English is not enough for conversation and I cannot speak German. the interpreter between us must have had a not too easy task.

My mind was full of the matter contained in my Hibbert Lectures which I had just delivered in Oxford, during May, 1930, and was now putting into book shape under the title of "The Religion of Man". Einstein's daughter Margaret, who is an artist, accompanied us to Russia. Later in the summer the Professor and I met again, at the home of Dr. Mendel, who is occupied with the investigation in the field of cancer. Once more I was able, in Einstein, to note the innate modesty of the man. He has a vitally acquisitive mind, and while I haven't much training to meet him on mathematical grounds, we had many discussions together which approached the boundary line of human and abstract conceptions of Reality.

I could readily see that Einstein believed my Universe was limited by human conception, and he was convinced that there was some Truth which was independent of human mind. I claim that the Individual has relationship with the Divine Man, who is within as well as beyond us. Our religion is not cosmic, but it concerns our personal being which lives and his its ideal of good and of evil. Science makes no such distinctions of a moral or aesthetic nature, and deals with one factor of existence. Science has nothing to do with personality. On the other hand Religion has nothing to do with mere knowledge of abstract Truth.

Einstein has often been called a lonely man. In so far as mathematical symbols help to liberate the mind from the trivialities, I suppose he is a lonely man. His is what might be called a transcendental materialism, which reaches the frontier of metaphysics, where there can be utter detachment from the entanglement of the world of self. To me both Science and Arts are expressions of our spiritual nature where they are above our biological necessities, and possessed of an ultimate value.

We talked long and earnestly about my "Religion of Man". Einstein is an excellent interrogator. He punctuated my thoughts with terse remarks of his own, and by his questions I could measure the trend of his own thinking. He asked me to explain fully what seemed to him my "purely human conception of the universe". It is a simple, irresistible conception. The Truth of this world whether perceived by our senses or conceived by our logic necessarily belongs to the human mind with all its limitation. Our reason in its harmony with the universal mind has a comprehensive view of things but that view is human as well as our reason and the universal mind has its human character only in perfection.

The Infinity of Humanity is the Perfect Man. Thus the future is merely a prolonged present. Not only is there a physical Universe but there is also moral perfection. Something within us urges us towards the more and more perfect. The tiger is not under this spell, but the savage, when he creates his first piece of art, shows that he is striving to go beyond himself, to extend his limits. This effort is drawn toward a point far away. The tiger, in physical well-being, is quite satisfied. But there is something in Man that is always bringing out his personality, his inner being, always suggesting further adventure. If there was nothing but blind groping, we would never desire to reach the goal of perfection. I see human progress in spite of its innumerable blunders has reached a far higher plane of meaning than what it had at the starting point. There is movement in humanity always going on toward a centre of gravity and this centre is the great Spiritual Man.

I believe this answered Einstein's desire to know whether I held that the Divine was isolated from the world. To me, the great Spiritual Man is a fact to which we belong, a fact not fully fathomed but existent and being realized from within and from without. The highest impulse that we have in our search is not for what we know but for what we do not know.

It is characteristic of the human being that he aspires toward the Unknown. if his search had no meaning for him, the attraction which he feels would lead him to idiocy. The Unknown has led Science, no one can deny that – from the vague to the gradual illumination. While the amoeba turns around in a perpetual repetition, Man's movement is always progressively toward an objective reality. His steadying pivot is his belief that Truth is there which beckons him even when he does not see it. This is the call to the Individual from the Universal Man – and it is this call that carries us toward the Universal. Animals are happy because they hear it not; Man is not happy, yet he is eager for the Adventure.

"So this is the realization of the human entity?" asked Einstein. He grasped that I regarded the Universal Truth of Existence not as an abstraction but as a reality spiritually related to personality. For such Truth can be valued by reason of its contribution to the dignity of our own being, to the realization in us of an inner fulfilment. Here, to my mind, is the call of Religion.

As a Poet I resort to figures of speech. The Infinite Being is like one who plays a flute. Through the music of beauty and love we are brought outside our own self-centered limitations. We sacrifice ourselves because the Central Ideal of Truth calls through these strains of Infinite Being. We become more true in others. we come into greater intimacy with our own Reality in others. There is an eternal spring of Love in the centre of all things. So it is with Truth. We are approaching nearer Central Truth perfected, and that is the meaning of our Evolution. But this Truth has its harmony with human mind, otherwise it would remain absolutely beyond our comprehension. the Truth as we know it or ever may know, whether physical or metaphysical is relative to our own knowing mind. I do not say that there may not be a Truth which is beyond our utmost capacity of knowledge but for us it is as good as naught.

I could see that Einstein held fast to the extra-human aspect of Truth. But it is evident to me that in human reason facts assume a unity of Truth which is only possible to a human mind. While Logic belongs to man's mind, I can conceive of another field of logic for another type of mind other than ours. So, when Einstein talked to me of Pythagorean geometry, I could conceive of an existence where Space is not the factor, but where time reigns as it does in music. It is not impossible that a mind can live in time and have no notion of space. For such a mind, existence might be the kind comprehended in music.

However the function of religion, according to me is to bring the individual into harmony in reason, in love in deed with the Supreme Man, the Universal being.

In August 1930, the two of us met again. I had just come from Coblenz, where the Youth Movement was in full blossom. In 1921, I was witness to the pathos of the young Heidelberg students who came to me emaciated from privation. They said, 'We have lost faith in our old teachers,' I felt that this was a glorious time for the young. They were rebellious against the old who had once guided them and had just betrayed them. they wished to build up the future through the fervour that stirred within them – a

new future unburdened by the old tradition which had led them to disaster. The young were entering an adventure of building anew, and they moved under an almost hypnotic spell. They desired freedom. This desire was more real to the German youth than to the youth elsewhere. These young people were sensing what I had long felt to be the salvation of civilised man: that we need the primitive life for the sheer vigour of it. With our own hands we must have contact once more with the soil. We must live a life of simplicity – a self-imposed return to nature – but not in the spirit of the Barbarian. Civilisation tends to grow blase, and in Coblenz, I found that only by going back to Mother Earth was youth being won over. They Youth Movement in Germany came to life under the Mother-touch of Nature. In civilisation one easily becomes sophisticated, but one does not so easily become wise. So that these young men, who in 1921 were so despondent, had now grown into the joyous realizations of the true functions of life. Machinery is not the be-all of their existence. Not that they do not know the uses and the value of machinery, but they have voluntarily gone back to certain aspects of the primitive humanity in order to find themselves in a renewal of life.

Possibly it was due to my recent illness of that summer that Einstein led me away from abstract matters after a few sallies into them. And so it was we had the following conversation which was taken down by a friend who was present on the occasion.

Note on the Nature of Reality

(A conversation between Rabindranath Tagore and Professor Albert Einstein in the afternoon of July 14, 1930, at the Professor's residence in Kaputh.)

[**T.** You have been busy hunting down with mathematics the two ancient entities, Time and Space, while I have been lecturing in this country on the eternal world of Man, the universe of Reality.]

E. Do You believe in the Divine as isolated from the Word?

T. Not isolated. The infinite personality of Man comprehends the Universe. There cannot be anything that cannot be subsumed by the human personality, and this proves that the Truth of the Universe is human Truth.

I have taken a scientific fact to illustrate this – Matter is composed of protons and electrons, with gaps between them; but matter may seem to be solid. [Without the links in spaces which unify the individual electrons and protons.] Similarly humanity is composed of individuals, yet they have their inter-connection of human relationship, which gives living solidarity to man's world. The entire Universe is linked up with us, [as individuals,] in a similar manner, it is a human universe. I have pursued this thought through art, literature and the religious consciousness of man.

E. There are two different conceptions about the nature of the universe: (1) The world as a unity dependent on humanity. (2) The world as reality independent of the human factor.

T. When our universe is in harmony with Man, the eternal, we know it is Truth, we feel it as beauty.

E. This is a purely human conception of the universe.

T. There can be no other conception. This world is a human world – the scientific view of it is also that of the scientific man. [Therefore, the world apart from us does not exist; it is a relative world, depending for its reality upon our consciousness.] There is some standard of reason and ejoyment which gives it Truth, the standard of the Eternal Man whose experiences are through our experiences.

E. This is a realization of the human entity.

T. Yes, one eternal entity. We have to realize it through our emotions and activities.We realize the Supreme Man who has no individual limitations through our limitations. Science is concerned with that which is not confined to individuals; it is the impersonal human world of Truths. Religion realizes these Truths and links them up with our deeper needs; our individual consciousness of Truth gains universal significance. Religion applies value to Truth, and we know Truth as good through our own harmony with it.

E. Truth, then, or Beauty is not independent of Man?

T. No. [I do not say so.]

E. If there would be no human beings any more, the Apollo of Belvedere would no longer be beautiful.

T. No!

E. I agree with regard to this conception of Beauty, but not with regard to Truth.

T. Why not? Truth is realized through man.

E. I cannot prove that my conception is right, but that is my religion.

T. Beauty is in the ideal of perfact harmony which is in the Universal Being; Truth the perfect comprehension of the Universal Mind. We individuals approach it through

our accumulated experience, Through our illumined consciousness - how, otherwise, can we know Truth?

E. I cannot prove, scientifically that Truth must be conceived as a Truth that is valid independent of humanity; but I believe it firmly. I believe, for instance, that the Pythagorean theorem in geometry states something that is approximately true, independent of the existence of Man. Anyway, if there is a *reality* independent of Man there is also a Truth relative to this reality; and in the same way the negation of the first endangers a negation of the existence of the latter.

T. Truth, which is one with the Universal Being, must essentially be human, otherwise whatever we individuals realize as true can never be called Truth – at least the Truth which is described as scientific and can only be reached through the process of logic, in other words, by an organ of thoughts which is human. According to Indian Philosophy there is Brahman. the absolute Truth, which cannot be conceived by the isolation of the individual mind or described by words, but can only be realized by completely merging the individual in its infinity. But such a Truth cannot belong to Science. The nature of Truth which we are discussing is an appearance – that is to say what appears to be true to the human mind and therefore is human, and may be called *Maya* or illusion.

E. So according to your conception, which may be the Indian conception, it is not the illusion of the individual. but of humanity as a whole.

[**T.** The species also belongs to a unity, to humanity. Therefore the entire human mind realizes Truth; the Indian or the European mind meet in a common realization.

E. The word species is used in German for all human beings, as a matter of fact even the apes and the frogs would belong to it.]

T. In science we go through the discipline of eliminating the personal limitations of our individual minds and thus reach that comprehension of Truth which is in the mind of the Universal Man.

E. The problem begins whether Truth is independent of our consciousness.

T. What we call Truth lies in the rational harmony between the subjective and [the] objective aspects of reality, both of which belong to the super-personal man.

E. Even in our everyday life, we feel compelled to ascribe a reality independent of Man to the objects we use. We do this to connect the experiences of our senses in a reasonable way. For instance, if nobody is in this house, yet that table remains where it is.

T. Yes, it remains outside the individual mind; but not outside the universal mind. The table which I perceive is perceptible by the same kind of consciousness which I possess.

E. [If nobody would be in the house the table would exist all the same – but this is already illegitimate from your point of view – because we cannot explain what it means that the table is there, independently of us.]

Our natural point of view in regard to the existence of Truth apart from humanity cannot be explained or proved, but it is a belief which nobody can lack – no primitive beings even.

We attribute to Truth a super-human objectivity; it is indispensable for us, this reality which is independent of our existence and our experience and our mind – though we cannot say what it means.

T. Science has proved that the table as a solid object is an appearance and therefore that which the human mind perceives as a table would not exist if that mind were naught. At the same time it must be admitted that the fact, that the ultimate physical reality of the table was nothing but a multitude of separate revolving centres of electric forces, also belongs to the human mind.

In the apprehension of Truth there is an eternal conflict between the universal human mind and the same mind confined in the individual. The perpetual process of reconciliation is being carried on in our science and philosophy and in our ethics. In any case, if there be any Truth absolutely unrelated to humanity then for us it is absolutely non-existing.

It is not difficult to imagine a mind to which the sequence of things happens not in space, but only in time !ike the sequence of notes in music. For such a mind its conception of reality is akin to the musical reality in which Pythagorean geometry can have no meaning. There is the reality of paper, infinitely different from the reality of literature. For the kind of mind possessed by the moth, which eats that paper, literature is absolutely non-existent, yet for Man's mind literature has a greater value of truth than the paper itself. In a similar manner, if there be some Truth which has no sensuous or rational relation to the human mind it will ever remain as nothing so long as we remain human beings.

E. Then I am more religious than you are!

T. My religion is in the reconciliation of the Super-personal Man, the Universal human spirit, in my own

individual being. This has been the subject of my Hibbert lectures, which I have called "The Religion of man".

14 July 1930

Einstein and Tagore

T. What has impressed me this time in Germany is the work of German Youth Movement. They are building up a community life on simple and large issues, not by reverting to medievalism but by applying the best gifts of the modern age to the service of a social ideal. Those splendid youths I saw in a Jugendherberge near Coblenz are not only managing their entire organisation of lecture-tour, village work, social unions, but even building their own houses, cooking their food, bringing fuel from the woods and personally attending to the minutest detail of the daily life without depending on outside help for it. They are full of enthusiasm for the living of life itself, and every function of life therefore is joyous to them, rousing the feeling of adventure and self-expression.

E. The Youth Movement we have in Germany to-day had, I believe, its origin in England.

T. Yes, may be, but England has nothing like what you have in this country – you are so thoroughly earnest and vital in all that you do here that every new idea finds somehow its full velocity. In England the one institution which delighted me is Woodbroke near Binningham, where the ideal of community life is maintained through social and educational activities related to our fundamental human aspirations. In Germany, however, as I have said, the vigour and the rich harmony of a complete life finds unique expression.

E. Do these young men near Coblenz permanently live in that colony or is it a centre which they occasionally visit?

T. Many of them live and work there and 1 believe, they also go out in batches on tours in their own country and outside. When once the centre is there, the element of adventure can also find its expression in works done elsewhere. It is this which makes their Youlh Movement natural and progressive.

I was discussing with Dr. Mendel to-day the new mathematical discoveries which tell us that in the realm of infinitesimal atoms chance has its play; the drama of existence is not absolutely predestined in character.

E. The facts that make science tend towards this view do not say goodbye to causality.

T. May be not; but it appears that the idea of causality is not in the elements, that some other force builds up with them an organised universe.

E. One tries to understand how the order is in the higher plane – the order is there where the big elements combine and guide existence, but in the minute elements this order is not perceptible.

T. This duality is in the depths of existence – the two contra-dictions of free impulse, and the directive will which works upon them and evolves an orderly scheme of things.

E. Modern physics would not say that they are contradictory. Clouds look one from distance but if you see them near they show themselves in disorderly drops of water.

T. I find its analogy in human psychology. Our passions and desires are unruly, but our character subdues these elements into a harmonious whole. Is it analogous to this in the physical world? Are the elements rebellious, dynamic with individual impulse and is there a principle in the physical world which dominates them and puts them into an orderly organisation ?

E. Even the elements are not without statistical order; elements of radium will aways maintain their specific order now and ever onward just as they have done all along. There is then a statistical order in the elements.

T. Otherwise the drama of existence would be too desultory – it is the constant harmony of chance and determination which makes it eternally new and living.

E. I believe that whatever we do or live for has its causality; it is good however that we cannot look through it.

T. There is in human affairs also an element of elasticity – some freedom within a small range which is for the expression of our personality. It is like the musical system in India which is not rigidly fixed as is the Western music. Our composers give a certain definite putline, a system of melody and rhythmic arrangement and within a certain limit the player can improvise upon it. He must be one with the law of that particular melody and then he can give spontaneous expression to his musical feeling within the prescribed regulation. We praise the composer for his genius in creating a foundation along with a superstructure of melodies, but we expect from the player his own skill in the creation of variations of melodic flourish and ornamentation. In creation we follow the central law of existence, but if we do not cut ourselves adrift from it we can have sufficient freedom within the limits of our personality for the fullest self-expression.

E. That is only possible where there is a strong artistic tradition in music to guide the people's minds. In Europe music has come too far away from popular art and popular feeling and has become something like a secret art with conventions and traditions of its own.

T. So you have to be absolutely obedient to this too complicated music. In India the measure of a singer's freedom is in his own creative personality – he can make permutations and combinations of notes according to the law of the melody prescribed but in all this he is guided by his own artistic conscience. He can sing the composer's song as his own if he has the power to creatively assert himself in his interpretation of the general law of the melody he is given to interpret.

E. It requires a very high standard of art fully to realize the great idea in the original music so that one can make variations upon it – in our country the variations are often prescribed.

T. If in our conduct we can follow the law of goodness we can have real liberty of self-expression. the principle of conduct is there but the character which makes it true and individual is our own creation. In our music there is a duality of freedom and prescribed order.

E. Are the words also free, I mean to say, is the singer at liberty to add his own words to the melody he is singing ?

T. Yes, In Bengal we have a kind of song – *Kirtan* we call it – which gives freedom to the singer to introduce parenthetical comments as he sings the song. This occasions great enthusiasm, as the audience is constantly thrilled by some beautiful spontaneous sentiment frestly added to the song by the singer – phrases which had not been there in the original song itself.

E. Is the meterial form quite severe ?

T. Yes, quite. You cannot exceed the limits of versification; in all these variations the singer must keep the rhythm and the time which is fixed. In European music you have a comparative liberty about time but not about melody, but in India we have freedom of melody but no freedom of time.

E. Can the Indian music be sung without words? Can one understand a song without words?

T. Yes, we have songs with unmeaning words - sounds which just help to act as carriers of the notes. We have two different types of songs in India. In Bengal poems and music combine with each other, in the north-west of India they have often songs with unmeaning or insignificant words. The idea is supplied by the music, the words remaining passive. In Bengal the words and the musical notes meet half-way and continue in the organic creation of a song.

E. In Greece there has been like what you have in Bengal – music with poems.

T. In North India music is an independent art not the interpretation of words and thoughts. The music is very intricate and subtle and is a complete world of melody by itself.

E. Is it not polyphonous?

T. Instruments are used not for harmony but for keeping time the music and for adding to the volume and depth.

E. European music is not older than 400 years; it was only from then that music, polyphonous music, has been introduced.

T. Has melody suffered in your music by this imposition of harmony?

E. Sometimes it does suffer very much. Sometimes polyphonous music swallows up the melody altogether.

T. Melody and harmony are like lines and colours in pictures. A simple linear picture may be completely beautiful – the introduction of colour may make it vague and insignificant. Yet colour may by combination with lines create great pictures so long as it does not smother and destroy their value.

E. It is a beautiful comparison; the line is also much older than the colour. It seems that the structure of your melody is much richer than here; Japanese music too seems to be so.

T. It is so difficult to analyze the effect of Eastern and Western music on our minds. I feel deeply moved by the Western music – I feel that it is great, that it is vast in its structure and grand in its composition. Our own music touches me more deeply by its fundamental lyrical appeal. European music is epic in character, it has a broad background and is Gothic in its structure.

E. Yes, Yes, this is very true.

T. But this music is immense – I can never forget that how much I was affected by its power once when a Hungarian lady played on her violin some pieces of music. both classical and modern.

E. When did you first hear European music?

T. At 17 I first came to know it intimately when 1

first came to Europe, but even before that time I had heard European music in our own household. I had heard the music of Chopin and others at an early age.

E. This is a question which we Europeans cannot properly answer, we are so used to our own music. We want to know whether our music is a conventional or a fundamental human feeling, whether to feel consonance and dissonance is natural or is it a convention which we accept.

T. Somehow Piano confounds me. Violin pleases me much more.

E. It would be interesting to study the effects of European music on an Indian who has never heard it.

T. Once I asked an English musician to analyze for me some classical music and explain to me what are the elements that make for the beauty of a piece.

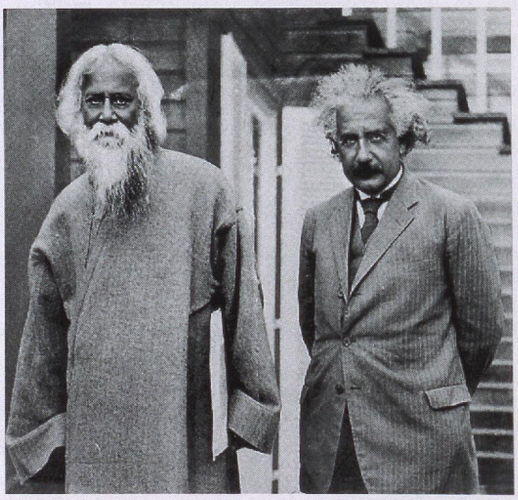
E. The difficulty is that the really good music whether of the East or of the West, cannot be analyzed.

T. Yes, and what deeply affects the hearer is beyond himself.

E. The same uncertainty will always be there, about everything fundamental in our experience, in our reaction to art, whether in Europe or in Asia. Even the red flower I see before me on your table may not be the same to you and me.

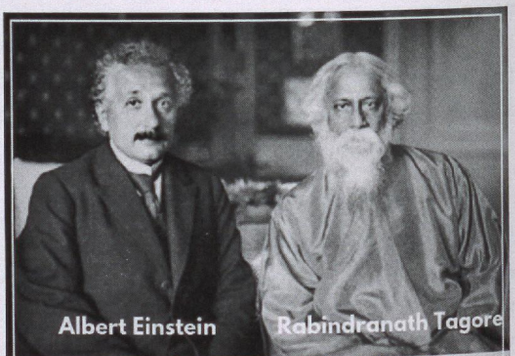
T. And yet there is always going on the process of reconciliation between them, the individual taste conforming to the universal standard.

Berlin, 19 August 1930. ❐



***Note by the Editor-in-Chief*:** This article *"My Memories of Einstein – Rabindranath Tagore"* is printed here to show our respectful homage and tribute to two great personalities of the world for their thoughts and ideas in true sense on science and culture in the global perspectives. This is very special to Albert Einstein as he received his Nobel Prize on hundred years ago i.e. 1922.

Rabindranath Tagore (First Nobel Laureate in Literature in 1913 for his book : Gitanjali –Song Offerings, from Asia and Africa) met Albert Einstein (Nobel Laureate in Physics selected in 1921 but received in 1922) at his home in Kaputh, in the outskirts of Berlin, on July 14, 1930. The two distinguished minds explored the concepts of science, religion, consciousness, and philosophy. The discussion between the two great men was recorded and was subsequently published in the January, 1931 issue of Modern Review.



Albert Einstein: I cannot prove, but I believe in the Pythagorean argument, that the truth is independent of human beings. It is the problem of the logic of continuity.

Rabindranath Tagore : Truth, which is one with the universal being, must be essentially human; otherwise, whatever we individuals realize as true, never can be called truth. At least, the truth which is described as scientific and which only can be reached through the process of logic—in other words, by an organ of thought which is human. According to the Indian philosophy there is Brahman, the absolute truth, which cannot be conceived by the isolation of the individual mind or described by words, but can be realized only by merging the individual in its infinity. But such a truth cannot belong to science. The nature of truth which we are discussing is an appearance; that is to say, what appears to be true to the human mind, and therefore is human, and may be called maya, or illusion.

The Nobel Prize in Physics 1921 was awarded to Albert Einstein "for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect". Albert Einstein received his Nobel Prize one year later, in 1922. During the selection process in 1921, the Nobel Committee for Physics decided that none of the year's nominations met the criteria as outlined in the will of Alfred Nobel. According to the Nobel Foundation's statutes, the Nobel Prize can in such a case be reserved until the following year, and this statute was then applied. Albert Einstein therefore received his Nobel Prize for 1921 one year later, in 1922.

Source: Nobel Prize.org.Nobel Prize Outreach/ www.nobelprize.org/prizes/physics/1921

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ARTICLE

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NUCLEIC ACID SYNTHESIS IN THE STUDY OF THE GENETIC CODE*

H. GOBIND KHORANA

1. Introduction

Recent progress in the understanding of the genetic code is the result of the efforts of a large number of workers professing a variety of scientific disciplines. Therefore, I feel it to be appropriate that I attempt a brief review of the main steps in the development of the subject before discussing our own contribution which throughout has been very much a group effort. I should also like to recall that a review of the status of the problem of the genetic code up to 1962 was presented by Crick in his Nobel lecture[1].

While it is always difficult, perhaps impossible, to determine or clearly define the starting point in any area of science, the idea that genes make proteins was an important step and this concept was brought into sharp focus by the specific one gene-one enzyme hypothesis of Beadle and Tatum[2]. The field of biochemical genetics was thus born. The next step was taken when it was established that genes are nucleic acids. The transformation experiments of Avery and coworkers[3] followed by the bacteriophage experiments of Hershey and Chase[4] established this for DNA and the work with TMV-RNA a few years later established the same for RNA[5,6]. By the early 1950's it was, therefore, clear that genes are nucleic acids and that nucleic acids direct protein synthesis, the direct involvement of RNA in this process being suggested by the early work of Caspersson[7] and of Brachet[8]. It was important at this stage to know more about the chemistry of the nucleic acids and, indeed, the accelerated pace of discovery that soon followed, was largely because of work at the chemical and biochemical level in the field of nucleic acids.

The structural chemistry of the nucleic acids, which developed over a period of some seventy years in many countries, progressed step-by-step from the chemistry of the constituent purines, pyrimidines and the sugar moieties, to work on the nucleosides and then onto the nucleotides. A distinct climax was reached in 1952 with the elucidation of the internucleotidic linkage in nucleic acids by Brown and Todd and their coworkers. (It was my good fortune to be associated with Professor, now Lord, Todd's laboratory before the start of our own work in the nucleotide field). Shortly thereafter, the Watson - Crick structure[10] for DNA was proposed, which focused attention, in particular, on the biological meaning of its physical structure. It is also about this time that the hypothesis that a linear sequence of nucleotides in DNA specifies the linear sequence of amino acids in proteins was born. A few years later, the enzymology of DNA got into its stride with the work of Kornberg and his coworkers[11] : their discovery and characterization of the enzyme DNA polymerase was a major triumph of modern enzymology and the methods developed distinctly aided the characterization, a few years later, of DNA-dependent RNA polymerase[12-16]. The discovery of this enzyme clarified the manner by which information in DNA is transcribed into an RNA, which we now equate with messenger RNA[17-21]. The last biochemical landmark to be introduced in the development of a cell-free amino acid incorporating system. Work on this really began with efforts to understand the biosynthesis of the peptide bond. The subject has a long history but critical progress began to be made in the early fifties. One thinks, in particular, of the pioneering work of Zamecnik and Hoagland[22], of Lipmann[23], of Berg[24] and in regard to the bacterial system that of Watson's laboratory[25], of Berg[26], and of the important refinement made in 1961 by Matthaei and Nirenberg[27].

* Nobel Lecture, December 12, 1968

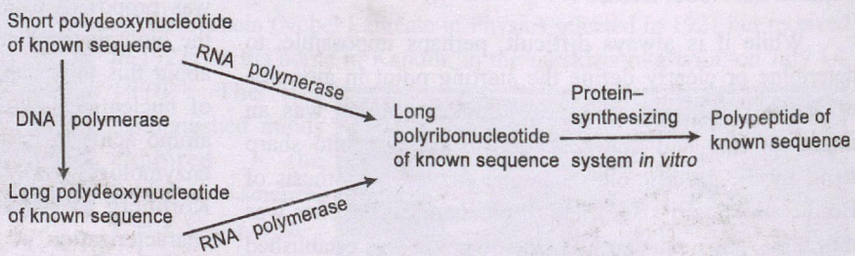
With the knowledge of the chemical structures of the nucleic acids, the two major tasks which faced the chemists were those of synthesis and sequential analysis. Chemical synthesis of short-chain oligonucleotides began to be a preoccupation in my laboratory. The types of problems that one faced were: (1) activation of the phosphomonoester group of a mononucleotide so as to phosphorylate the hydroxyl group of another nucleoside or nucleotide; (2) design of suitable protecting groups for the various functional groups (primary and secondary hydroxyl groups in the sugar rings, amino groups in the purine and pyrimidine rings, phosphoryl dissociation in the phosphomonoester group); (3) development of methods for the polymerization of mononucleotides and for the separation and characterization of the resulting polynucleotides, and (4) evaluation of approaches to the stepwise synthesis of polynucleotides of specific sequences.

While even at present, organo-chemical methods demand further investigation and refinement, nevertheless, synthesis of short chains of deoxyribopolynucleotides with predetermined and fully controlled sequences became possible in the early sixties. In addition, unambiguous synthesis of short ribooligonucleotides containing strictly the 3′ → 5′-internucleotidic linkages also became feasible. A discussion of the chemical aspects of these problems is out side the scope of the present lecture and reviews given elsewhere[28-33] should be consulted. The following review will be restricted to that part of the synthetic work which bears on the problem of the genetic code and attention will be focused in the main on the biochemical experiments made possible by the synthetic polynucleotides.

2. Polynucleotide Synthesis in Relation to the Genetic Code

A few words about the experimental development of the coding problem are now appropriate. In the fifties, possible rules governing the genetic code engaged the attention of many theoreticians, Gamow[34] being the first to speculate on the possible relation between DNA and protein structure. However, until 1961 the only experimental approach was that of direct correlation of the sequence of a nucleic acid with that of a protein specified by it. It was hoped to do this either chemically, for example, by working with the coat protein of a virus and its RNA, or by mutagenic techniques. An ingenious application of the <frameshift mutation> idea was, indeed, that of Crick and coworkers, who correctly deduced several of the fundamental properties of the genetic coder. These approaches, however, offered little immediate hope of getting directly at the coding problem.

The discovery which introduced a direct experimental attack on the genetic code was that of Matthaei and Nirenberg[27] who observed that polyuridylate directs the synthesis of polyphenylalanine in the bacterial cell-free amino acid incorporating system. The aim now was to use synthetic polynucleotides of defined composition as messengers in the *in vitro* system. A great deal, in fact, was learned during the years 1961-1963, both in the laboratories of Ochoa[35] and of Nirenberg and their coworkers[36], about the overall nucleotide composition of the coding units by using polynucleotides made by the agency of the enzyme, polynucleotide phosphorylase.



Scheme 1. Proposed reaction sequence for the preparation of high-molecular-weight RNA messengers and the subsequent in *vitro* synthesis of polypeptides of known amino acid sequences.

(a) Short chains of deoxyribopolynucleotides containing repeating nucleotide sequences*

The hope in my laboratory was to prepare

* The abbreviations used are as follows. The letters, A, C, G, T and U stand for the nucleosides *or* the nucleotides of adenine, cytosine, guanine, thymine and uracil respectively; the prefixes d and r represent deoxyribose and ribose series of polynucleotides, respectively. All the polynucleotides containing more than one kind ofnucleotide, which are used in the text, in Tables and in Figures, have strictly repeating nucleotide sequences and the repeating unit is shown. For example, poly-rUG and poly-rUAG represent polymers in which the dinucleotide, U-G, and the trinucleotide, U-A-G, sequences repeat. Polythymidylate containing eleven nucleotide units in the chain if abbreviated to dT11 and the hepta-deoxyadenylate if abbreviated to dA7. tRNA or sRNA stands for transfer RNA ; met-tRNAmet stands for the non-formylatable species of methionine- specific tRNA which has been charged with the amino acid and fmet-tRNAmet stands for the formylatable species of methionine-specific tRNA which has been charged with methionine and the latter residue subsequently formylated.

ribopolynucleotide messengers of completely defined nucleotide sequences. However, chemical methodology permitted at this time the synthesis of oligonucleotides containing but a few ribonucleotide units (see below for trinucleotide syntheses). In the deoxyribonucleotide series, chemical synthesis was a little more advanced and thesynthesis of longer, but still short, chains containing ten to fifteen nucleotide units was feasible. Therefore, it was decided to study the RNA-transcribing enzyme with the hope that this enzyme might use short chemically synthesized deoxyribopolynucleotides as templates in the manner that it uses biologically functional DNA.

The initial experiments with the RNA polymerase37 were, in fact, a followup of the observation first made by Hurwitz and coworker[38] that a mixture of chemically synthesized thymidine oligonucleotides served as a template for the synthesis of ribo-polyadenylate. Our aim was to obtain a ribopolynucleotidic product matching in chain length the deoxypolynucleotide used as the template. However, analysis showed that irrespective of the size of the short deoxypolynucleotide template, the RNA product was always much longer; it contained invariably more than 100 nucleotide units. At first sight, the results appeared to be discouraging in that we were losing control on the exact size of the product, despite our having carefully defined the size of the oligothymidylate template. However, it soon became apparent that this <slipping> or reiterative copying on the part of the enzyme could be a highly useful device to amplify the messages contained in the short chemically-synthesized polynucleotides. In a further study, attention was paid to understand a little better the conditions for the <amplification> to occur[39].

Some months later I visited Kornberg's laboratory (this was one of the many pilgrimages that I have made to this great laboratory) and started a few experiments with the DNA polymerase and here, again, very short synthetic oligonucleotides containing alternating A and T units induced the enzyme to bring about extensive synthesis of the previously characterized high molecular weight dAT polymer[40]. These encouraging results led to a generalized scheme (Scheme 1) for the *in* vitro studies of the coding problem. The amplifi - cation to produce DNA or RNA products was conceived at this time to be a general behaviour of the polymerases so long as there was a repeating pattern of nucleotide sequences (homopolynucleotides, repeating di- or tri-nucleotides) in the chemically-synthesized deoxypolynucleotide templates. Everything from this point on went remarkably well and the period starting with the spring of 1963 and ending with 1967 was a period, essentially, of uninterrupted success in work devoted to the genetic code.

The decision to synthesize deoxyribopolynucleotides with repeating nucleotide sequences was fortunate for another reason. The cell-free proteinsynthesizing system, being a crude bacterial extract, undoubtedly contained powerful nucleases and peptidases. The use of messengers with completely defined but strictly repeating nucleotide sequences could be expected to give unequivocal answers despite (1) the exo- and/or endo-nucleolytic damages to the synthetic messengers and (2) the corresponding activities of the proteolytic enzymes on the polypeptide products.

The actual choice of nucleotide combinations in the deoxyribopolynucleotides to be synthesized was influenced by the then available knowledge that, at least in the cell-free protein-synthesizing system, the messenger RNA appears to be used in the single-stranded configuration. In fact, the only DNA containing more than one type of nucleotide, whose sequence was completely known, was the above-mentioned poly-dAT. Although RNA polymerase nicely produces from it the expected poly-rAU containing the two bases in strictly alternating sequence, this product, because of self-complementarity, has a tight double-stranded structure and elicits no response from the ribosomes in the cell-free system. It was, therefore, clear that those combinations of nucleotides which would lead to overwhelming base-pairing in the polynucleotides should be avoided[30-32].

All of the chemical syntheses relevant to the genetic

Table 1 : Synthetic deoxyribopolynucleotides with repeating nucleotide sequences polynucleotides with repeating trinucleotide sequences. There is a theoret maximum of ten such sets that can contain more than one nucleotide base :

Repeating dinucleotide sequences		*Repeating trinucleotide sequences*			*Repeating tetranucleotide sequences*		
$\begin{Bmatrix} d[TC]_6 \\ d[AG]_6 \end{Bmatrix}$	$\begin{Bmatrix} d[TG]_6 \\ d[AC]_6 \end{Bmatrix}$	$\begin{Bmatrix} d[TTC]_4 \\ d[AAG]_4 \end{Bmatrix}$	$\begin{Bmatrix} d[CTT]_{3-5} \\ d[GAA]_{3-5} \end{Bmatrix}$	$\begin{Bmatrix} d[TAC]_{4-6} \\ d[TAG]_{4-6} \end{Bmatrix}$	$\begin{Bmatrix} d[CCA]_{3-5} \\ d[GGT]_{3-5} \end{Bmatrix}$	$\begin{Bmatrix} d[TTAC]_4 \\ d[GTAA]_2 \end{Bmatrix}$	$\begin{Bmatrix} d[TCTA]_3 \\ d[TAGA]_2 \end{Bmatrix}$
		$\begin{Bmatrix} d[TTG]_{4-6} \\ d[CAA]_{4-6} \end{Bmatrix}$	$\begin{Bmatrix} d[GGA]_{3-5} \\ d[CGT]_{3-5} \end{Bmatrix}$	$\begin{Bmatrix} d[ATC]_{3-5} \\ d[ATG]_{3-5} \end{Bmatrix}$			

code which were carried out are shown in Table I. First, we made the two sets of polynucleotides shown on the left, which contained repeating dinucleotide sequences: one set contains the hexamer of the dinucleotide with alternating thymidylate and guanylate residues and the hexamer of the dinucleotide with alternating adenylate and cytidylate residues; the second set consists of the hexamer of alternating thymidylate and cytidylate residues and the hexamer of alternating adenylate and guanylate residues[41]. This work was then extended to we prepared seven such sets[42 - 46]. Shown also in Table 1 are two sets of polymers with repeating tetranucleotide sequences[47,48]. Two additional considerations for the selection of the nucleotide sequences in them are: *(1)* they contain in every fourth place the chain- terminating codons and *(2)* this class of polymers can be used to prove the direction of reading of the messenger RNA[49-51]. Two general points about all the synthetic polynucleotides shown in Table I may be noted. The first point is that every set comprises two polynucleotides which are complementary in the antiparallel Watson-Crick base-pairing sense. A set of repeating trinucleotide polymers, which was complementary in the *parallel* sense, was found to be unacceptable to the DNA polymerase[52]. The second point is that it *was* necessary to synthesize segments corresponding to both strands of the DNA-polymer eventually desired (see below). DNA polymerase failed to bring about polymerization reactions when given only one of the segments of a set as a template.

(b) Double-stranded DNA-like Polymers with Repeating Nucleotide Sequences

In a part of the early work, short-chain deoxyribopolynucleotides with repeating sequences, for example, $(TTC)_3$ and $(TC)_5$, were directly used as templates for the RNA polymerase of *Escherichia coli.* While these experiments were successful[31,53], further work soon showed that use of the DNA polymerase as the first <amplification> device was preferable by far. Therefore, a major concern, following the chemical syntheses of the templates, was the study of the DNA polymerase and characterization of the DNA-like products produced by it in response to the short templates.

Scheme 2 lists the four types of reactions which have been elicited from the DNA polymerase, including the use of short homopolynucleotides. As seen, in reaction 1, a mixture of dT_{11} and dA_7 caused the extensive polymerization of dATP and dTTP to give a DNA-like polymer containing polyadenylate and polythymidylate in the two strands. In reaction 2, a mixture of the two short-chain polynucleotides with repeating dinucleotide sequences directed the extensive synthesis of a double-stranded DNA-like polymer containing exactly the sequences present in the short-chain templates[54,55]. In further work, similar reactions were demonstrated with short-chain templates containing repeating tri- as well as tetra-nucleotide sequencess[52,56]. Characterization of the high molecular weight DNA-like polymers was accomplished by a variety of methods. The techniques used included nearest-neighbor analysis, electron microscopy (in a part of the early work[55]), sedimentation velocity and banding in alkaline cesium chloride density gradients[57].

Many of the features of the DNA-polymerase catalyzed reactions are truly remarkable. Thus: (1) in all the reactions studied (Scheme 2) the enzyme shows complete fidelity in the reproduction of sequences; (2) the synthesis is exstensive, 50-200-fold, and the products are of high molecular weight (300000 to over 1 000000) ; (3) the enzyme thus amplifies and multiplies the information created by chemical methods; (4) finally, from the standpoint of an organic chemist, the most satisfying aspect is that the DNA polymers thus made can be used repeatedly for further production of the same polymers. It is unnecessary to go back to the time-consuming chemical synthesis for obtaining the templates again. DNA polymerase assures the continuity of these sequences.

$$dT_{11} + dA_7 + \begin{Bmatrix} dTTP \\ dATP \end{Bmatrix} \rightarrow poly-DA:dT \qquad (1)$$

$$d[TG]_6 + d[AC]_6 + \begin{Bmatrix} dTTP \\ dATP \\ dCTP \\ dGTP \end{Bmatrix} \rightarrow poly-dTG:dCA \qquad (2)$$

$$d[TTC]_4 + d[AAG]_3 + \begin{Bmatrix} dTTP \\ dATP \\ dCTP \\ dGTP \end{Bmatrix} \rightarrow poly-dTTC:dGAA \qquad (3)$$

$$d[TATC]_3 + d[TAGA]_2 + \begin{Bmatrix} dTTP \\ dATP \\ dCTP \\ dGTP \end{Bmatrix} \rightarrow poly-dTATC:dGATA \qquad (4)$$

Scheme 2. Types of reactions catalyzed by DNA polymerase. All of the DNA-like polymers are written so that the colon separates the two complementary strands. The complementary sequences in the individual strands are written so that antiparallel basepairing is evident.

Table II catalogues the different kinds of polymers which have so far been prepared and characterized. Thus, we have three classes of polymers: two double-stranded polymers with repeating dinucleotide sequences, four polymers with repeating trinucleotide sequences and two polymers with repeating tetranucleotide sequences.

Table II : DNA-like polymers with repeating nucleotide sequences

Repeating dinucleotide sequences	*Repeating trinucleotide sequences*	*Repeating tetranucleotide sequences*
Poly-dTC:GA	Poly-dTTC:GGA	Poly-dTTAC:GTAA
Poly-dTG:GA	Poly-dTTG:CCA	Poly-dTATC:GATA
	Poly-dTAC:GTA	
	Poly-dATC:GAT	

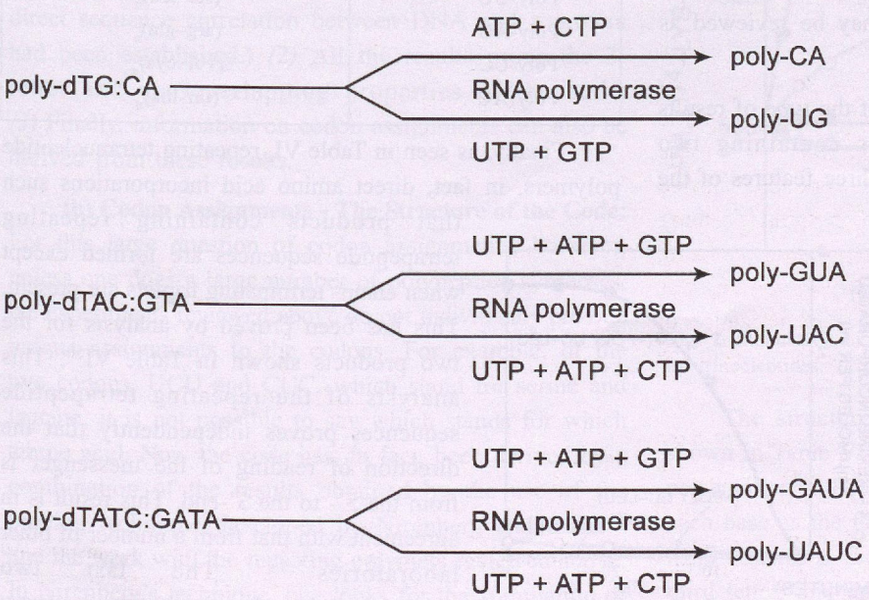
(c) Single-stranded Ribo-polynucleotides with Repeating Nucleotide Sequences

The next step was the transcription of the DNA-like polymers by means of RNA polymerase to form single-stranded ribo-polynucleotides. The principle used throughout is illustrated in Scheme 3. All of the DNA-like polymers contain two, or a maximum of three, different bases in individual strands. It is therefore possible, by giving the nucleoside triphosphates required for copying only one strand, to restrict the action of RNA polymerase to that strand. This is the case for all of the polymers, examples of which are shown in Scheme 3. Nearest-neighbor frequency analysis of all of the RNA products again shows that they contain strictly repeating nucleotide sequences[58-60]. The total RNA-like polymers prepared so far are listed in Table III.

Table III : Synthetic ribopolynucleotides with repeating nucleotide sequences

Repeating dinucleotide sequences	*Repeating trinucleotide sequences*	*Repeating tetranucleotide sequences*
Poly-rUG	Poly-rUAC	Poly-rUAAG
Poly-rAC	Poly-rGUA	Poly-rUAGA
Poly-rUC	Poly-rAUC	Poly-rUCUA
Poly-rAG	Poly-rGAU	Poly-rUUAC
	Poly-rUUG	
	Poly-rCAA	
	Poly-rUUC	
	Poly-rGAA	

The work described so far can be summarized as follows. By using a combination of purely chemical methods, which are required to produce new and specified information, and then following through with the two enzymes, DNA polymerase and RNA polymerase, which are beautifully precise copying machines, we have at our disposal a variety of high-molecular-weight ribo-polynucleotides of known sequences. Mistake levels, if they occur at all, are insignificant.



Scheme 3. The preparation of single-stranded ribopolynucleotides from DNA-like polymers containing repeating nucleotide sequences.

(d) Chemical Synthesis of the Sixty-four Possible Ribotrinucleotides

At about the time that the above methods for the synthesis of long ribo-polynucleotides of completely defined nucleotide sequences were developed, the use of ribo-trinucleotides in determining the nucleotide sequences within codons for different amino acids was introduced by Nirenberg and Leder (see below). As mentioned above, chemical methods in the ribonucleotide field developed in this laboratory had previously resulted in general methods for the synthesis of the ribotrinucleotides. In view of the importance of these

oligonucleotides in work on the genetic code, all the 64 trinucleotides derivable from the four common ribonucleotides, A, C, U, and G, were unambiguously synthesized and characterized. A separate report[61] should be consulted for the details of the chemical principles used in these syntheses. The use of the trinucleotides in work on the codon assignments for different amino acids is reviewed below.

3. *Polypeptide Synthesis in Vitro and the Genetic Code*

(a) Cell-free Polypeptide Synthesis Using Polynucleotides with Repeating Sequences : Polymers with repeating dinucleotide sequences, (AB)n, contain two triplets, ABA and BAB, in alternating sequence. Assuming three-letter, non-overlapping properties of the code, such polymers should direct incorporations of two amino acids in strictly alternating sequence. Repeating trinucleotide polymers, (ABC)n, contain three repeating triplets depending upon the starting point. These are: ABC, BCA, and CAB, Here one would predict that one amino acid should be incorporated at a time to form a homopolypeptide chain, and a maximum of three such chains should result. Similar considerations for polynucleotides withrepeating tetranucleotide sequences, (ABCD)n, show that *in vitro* polypeptide synthesis should give products containing repeating tetrapeptide sequences, irrespective of the starting point in the reading of the messengers. All these predictions have been fully borne out experimentally without a single exception. The results with the three classes of polymers may be reviewed as follows.

Shown in Fig. 1 is an example of the type of results obtained with ribopolynucleotides containing two nucleotides in alternating sequence. Three features of the amino acid incorporations shown in Fig. 1, and which are common for all the messengers of this class, are *(1)* incorporation of only two amino acids is observed; *(2)* incorporation of one of these amino acids is dependent on the presence of the second amino acid, and, *(3)* the incorporations of the two amino acids are equimolar. All these features suggest that in these reactions copolypeptides containing two amino acids in alternating sequence are being produced. This has been demonstrated by extensive analysis of all the four series of polypeptidic products which are listed in Table IV[58,62].

Table V shows the results obtained with repeating trinucleotide polymers. Thus, these polymers, have as a rule given three homopolypeptides[63,64] and it should now be emphasized that this was because in all the work with the cell-free system artificially high Mg^{2+} ions concentration was used and, therefore, polypeptide chains could initiate without a proper signal. Two polymers, poly-rUAG and poly-rAUG, were exceptions in that they stimulated the incorporation of only two amino acids[64]. These polymers contain each a chain-terminating triplet; UAG is the well-known amber triplet, and UGA is also now known to be a chain- terminating triplet.

Table IV : Cell-free copolypeptide syntheses using messengers containing repeating dinucleotide sequences

(System, *Escherichia coli* B)

Polynucleotides	Copolypeptides with 2 amino acids in alternating sequence
Poly-UC	$(ser–leu)_n$
Poly-AG	$(arg–glu)_n$
Poly-UG	$(vol–cys)_n$
Poly-AC	$(thr-his)_n$

Finally, as seen in Table VI, repeating tetranucleotide polymers, in fact, direct amino acid incorporations such that products containing repeating tetrapeptide sequences are formed except when chain- terminating triplets are present. This has been proved by analysis for the two products shown in Table VI[50]. This analysis of the repeating tetrapeptide sequences proves independently that the direction of reading of the messenger is from the 5′- to the 3'-end. This result is in agreement with that from a number of other laboratories[65,66]. The last two polynucleotides shown contain in every fourth place the chain-terminating triplets,

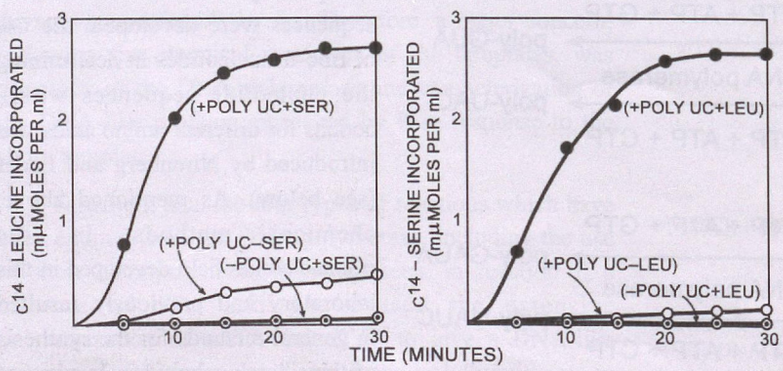


Fig.1. Characteristics of the incorporation of [^{14}C] serine and [^{14}C] leucine into polypeptide in the presence of poly-UC.

Table V : Cell-free homopolypeptide syntheses using messengers containing repeating trinucleotide sequences

(System, *Escherichia coli* B)

Polynucleotides	Homopolypeptides of single amino acids
Poly-UUC	phe, ser, leu
Poly-AAG	lys, glu, arg
Poly-UUG	cys, leu, val
Poly-CCA	gln, thr, asn
Poly-GUA	val, ser, (chain-terminator)
Poly-UAC	tyr, thr, leu
Poly-AUC	ileu, ser, his
Poly-GAU	met, asp, (chain-terminator)

UAG and UAA; for this reason, they fail to give any continuous peptides, but the formation of tripeptides has been demonstrated[51].

Table VI : Cell-free polypeptide syntheses using messengers containing repeating tetranucleotide sequences

(System, *Escherichia coli* B)

Polynucleotide	Polypeptide
Poly-UAUC	$(tyr\text{-}leu\text{-}ser\text{-}ileu)_n$
Poly-UUAC	$(leu\text{-}leu\text{-}thr\text{-}tyr)_n$
Poly-GUAA	di-and tri-peptides
Poly-AUAG	di-and tri-peptides

The results summarized above lead to the following general conclusions: *(1)* DNA does, in fact, specify the sequence of amino acids in proteins and this information is relayed through an RNA. (This was the first time that a direct sequence correlation between DNA and a protein had been established.) *(2)* All the results prove the 3-letter and non-overlapping properties of the code. *(3)* Finally, information on codon assignments can also be derived from these results.

(b) Codon Assignments - The Structure of the Code: For this large question of codon assignments, however, unless one does a large number of polypeptide syntheses, the experiments reviewed above do not individually provide unique assignments to the codons. For example, of the two codons, UCU and CUC, which stand for serine and leucine, it is not possible to say which stands for which amino acid. Now the code has, in fact, been derived by a combination of the results obtained by the use of the binding technique developed by Nirenberg and Leder[67] and the work with the repeating polymers reviewed above. In Nirenberg's technique, one looks for the stimulation of the binding of different aminoacyl-tRNA's to ribosomes in the presence of specific trinucleotides. An example of its use is shown in Fig. 2, where the question of which of the three sequence isomers, AAG, AGA, GAA, which codes for lysine, is investigated. One measures the binding of [^{14}C] lysyl-tRNA to ribosomes in the presence of increasing amounts of these trinucleotides. As seen in Fig. 2 the binding is specifically induced by AAG. The other trinucleotide which also promotes a strong binding is AAA and the experiment using this is also included in Fig. 2. The trinucleotides AAG and AAA are, therefore, the codons for lysine. This technique has been used extensively in Nirenberg's laboratory, and my own colleagues have also tested all of the 64 synthetic trinucleotides in this type of analysis. While extremely useful, the technique has not proved to be completely reliable. Often the effects are very small and there are cases where certain trinucleotides stimulate the binding of unexpected tRNA's. Conversely, there are cases where authentic trinucleotide codons do not give any binding. As already mentioned, most of the code actually has been worked out by using this technique in combination with the results from the repeating polymers and often by using evidence from a number of *in vivo* experiments.

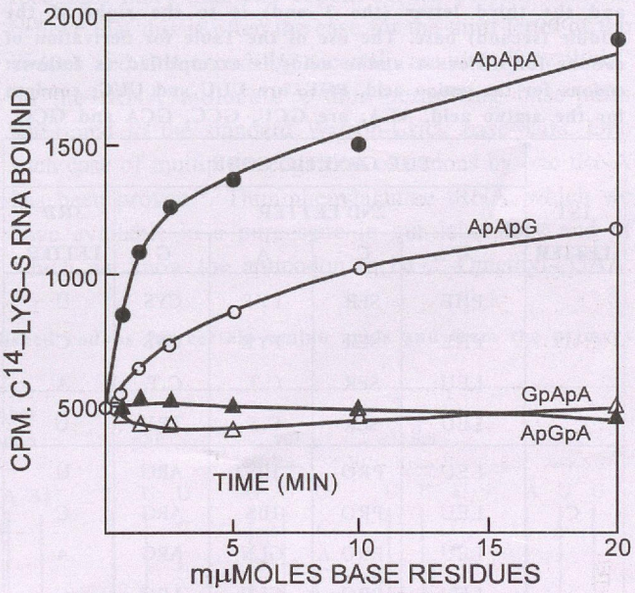


Fig. 2. Stimulation of the binding of [^{14}C] lysyl-tRNA to ribosomes by trinucleotides.

The structure of the code which has emerged is shown in Table VII. This is by now a familiar method of presentation[65]. There is a box in the left-hand column for each base as the first letter; within each box in the right-hand column is shown each one of the four bases as the third letter; and in the middle are four columns, one for each base as the second letter. (For use of the Table see the legend). Only a few general observations may be made.

(1) The code as shown is for the micro-organism *Escherichia coli* B, but probably will hold essentially for other organisms as well, although detailed and systematic checking in other systems (plants and animals) remains to be carried out. *(2)* There are entries for all of the sixty-four trinucleotides (there is no absolute nonsense). The code is highly degenerate in a semi-systematic way. Most of the degeneracy pertains to the third letter, where all of the four bases may stand for the same amino acid or where the two purine bases may stand for one amino acid and the two pyrimidines may stand for another ammo acid. An exception is the box with the first letter A and the second letter U. Here, AUU, AUC and AUA represent isoleucine while the fourth codon, AUG, stands for methionine. Three amino acids show additional degeneracy in positions other than the third letter: thus, leucine and arginine are degenerate in the first letter while serine is unique in changing its position with regard to, both, the first and the second letters. (3) While the code is now generally accepted to be essentially universal, it should not be inferred that all organisms use the same codons for protein synthesis. What the universality means is that a trinucleotide codon does not change its meaning from one organism to the next. After all, there is very great divergence in the DNA composition of diverse organisms and they therefore probably use different codons for the same amino acid to varying extents. (4) The codons AUG and GUG, which stand respectively for methionine and valine, are also used as signals for initiation of polypeptide chain synthesis (see also a later section for initiation of protein synthesis). (5) There are three trinucleotides, UAA, UAG and UGA, which cause termination of polypeptide chain growth. It is not clear which ones are used naturally and under what circumstances a particular one is used. More recent work (see the lecture by M. W. Nirenberg, p. 372) indicates that there may be protein factors which have specificity for the different termination codons.

Table VII : The abbreviations for amino acids are standard. C. T. stands for chain termination, *i.e.*, the trinucleotide sequence does not stand for any amino acid but probably signals the end of protein chain formation. C. I. stands as a signal for chain initiation in protein synthesis. The method of presentation used in this Table follows the conventional way of writing of trinucleotides: thus, the first letter (base) of the trinucleotide is on the left (the 5′-end) and the third letter (the 3′-end) is to the right of the middle (second) base. The use of the Table for derivation of codons for different amino acids is exemplified as follows: codons for the amino acid, PHE, are UUU and UUC; condons for the amino acid, ALA, are GCU, GCC, GCA and GCG.

1ST LETTER	THE GENETIC CODE				
	2ND LETTER				3RD LETTER
	U	C	A	G	
U	PHE	SER	TYR	CYS	U
	PHE	SER	TYR	CYS	C
	LEU	SER	C.T.	C.T.	A
	LEU	SER	C.T.	TRY	G
C	LEU	PRO	HIS	ARG	U
	LEU	PRO	HIS	ARG	C
	LEU	PRO	GLN	ARG	A
	LEU	PRO	GLN	ARO	G
A	ILEU	THR	ASN	SER	U
	ILEU	THR	ASN	SER	C
	ILEU	THR	LYS	ARG	A
	MET (C.I.)	THR	LYS	ARG	G
G	VAL	ALA	ASP	GLY	U
	VAL	ALA	ASP	GLY	C
	VAL	ALA	GLU	GLY	A
	VAL (C.I.)	ALA	GLU	GLY	G

Finally, it should be emphasized that large portions of the code have been derived or confirmed by the prolonged and intensive studies of Yanofsky and coworkers, by the studies of Streisinger and coworkers, by Whitmann and by Tsugita and others (for comprehensive accounts of these studies see ref. 65).

4. Transfer RNA Structures: The Anticodons and Codon Recognition

The eludication of the nucleotide sequence of yeast alanine tRNA by Holley and coworkers[68] has been followed by similar work on a number of other tRNA's. At present some six yeast tRNA's, four *E. coli* tRNA's, one rat-liver tRNA, and one wheat-germ tRNA, have been sequenced and it is likely that the structures of many more will be known in the near future. Dr. Raj Bhandary and coworkers[69] have determined the primary structure of yeast phenylalanine tRNA and this structure is shown in Fig. 3, the usual cloverleaf model being used. In fact, a common feature of all the tRNA's, whose primary structures are known, is that they all can adopt the cloverleaf secondary structure. As discussed in detail by RajBhandary and coworkers[69] and by others, there is a remarkable overall similarity in regard to many important physical features between the different tRNA's. It is not my intention here to dwell in detail on the broad and exciting subject of tRNA structure and its biological function. The following paragraphs will be confined to those aspects where

particularly relevant information has been forthcoming from the work of my own colleagues in Madison.

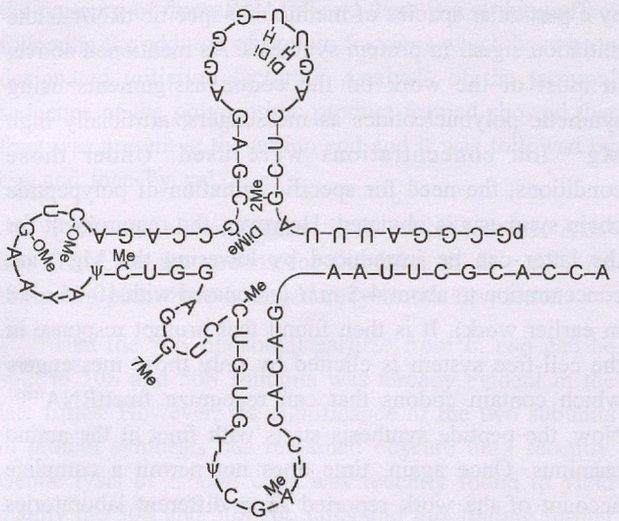


Fig. 3. Cloverleaf model for the secondary structure of yeast phenylalanine tRNA. The modifications in the minor bases are evident from the abbreviations shown against them. Ψ is pseudouridine while the nucleoside, Y, next to the presumed anticodon, G-A-A, is as yet unidentified.

The first general question that one can ask is: How are the trinucleotide codons recognized by the protein-synthesizing apparatus? The first impor tant advance here was the concept of an adapter molecule, which now is clearly seen to be a tRNA molecule. The experiments of Benzer, Lipmann and their coworkers[70] brought an elegant confirmation of this hypothesis. The next question is: What is the evidence that the recognition of codons, in fact, involves nucleotide-nucleotide interaction by virtue of base-pairing? If this is so, then one might expect to find in the primary structure of an amino acid specific tRNA three contiguous nucleotide units, <complementary> to the established codons for the particular amino acid. Indeed, the most encouraging common feature of all the tRNA's, whose primary sequence is known, turns out to be that they all contain an identical looped- out region in which such trinucleotide sequences are present. In Table VIII are assembled many of the known anticodons and the established codons for different amino acids. It can be seen that in every case the inferred anticodons show antiparallel Watson-crick base-pairing with the codons. Moreover, the findings *(1)* that a single nucleotide change in the anticodon of *E. coli* $tRNA^{TYR}$ brings about a change in the coding properties of the $tRNA^{71}$ and *(2)* that an oligonucleotide fragment of *E. coli* tRNAfmet containing the anticodon sequence binds to ribosomes specifically in response to the codons for formyl-methionine[72] give us confidence that the concept of an anticodon consisting of three adjacent nucleotides in all tRNA's is correct.

Another important aspect of the biological function of tRNA's deserves comment. Can one tRNA molecule recognize more than one codon? At the present time we believe that this is often the case for the third letter of the codons and this occurs by a certain amount of "wobble" on the tRNA molecule[73], thus permitting base-pairs additional to the standard Watson-Crick base-pairs. One such case of multiple recognition of codons by one tRNA has been proven[74]. Thus phenylalanine tRNA, which we have available in a pure state in our laboratory and of which we know the anticodon to be 2'-Omethyl- GAA,

Table VIII : Codon-anticodon pairing[a] as derived from established codons for certain amino acids and from the primary structures of tRNA's for the corresponding amino acids

amino acid	ala	tyr	tyr	amber codon	phe	val	ser	met
Codons	G C U C A	U A U C	U A U C	U A G	U U U C	G U U C A	U C U C A	A U G
Anticodons[a]	C G I	A Y G	A U G^b	A U C	A A G-OMc	C A I	A G I	U A C^c
(*tRNA source*)	yeast	yeast	*E.coli*	*E.coli* (tyr-suppressor trna)	yeast and wheat germ	yeast	yeast and rat liver	*E.coli*

a Codon-anticodon pairing takes place in the antiparallel direction. Thus, the anticodons, as distinct from the conventional way of writing oligonucleotides, are written in the reverse direction.

b The structure of this, evidently a derivative of G, is as yet unknown.

c The structure of this, a derivative of C, is as yet unknown.

can recognize both UUU and UUC which are the established codons for phenylalanine. This has been done by actual polyphenylalanine synthesis using precharged phenylalanyl- tRNA and the two polymers *(1)* polyuridylate and *(2)* poly-UUC which contains a repeating trinucleotide sequence (Fig. 4). There are other possibilities for multiple recognition. For example, it appears that inosine in the first position may recognize U, A and C[73]. Support for this pattern of multiple recognition has also been provided[75,76]. Possible biological implications of multiple codon recognition by tRNA molecules have been discussed elsewhere[75].

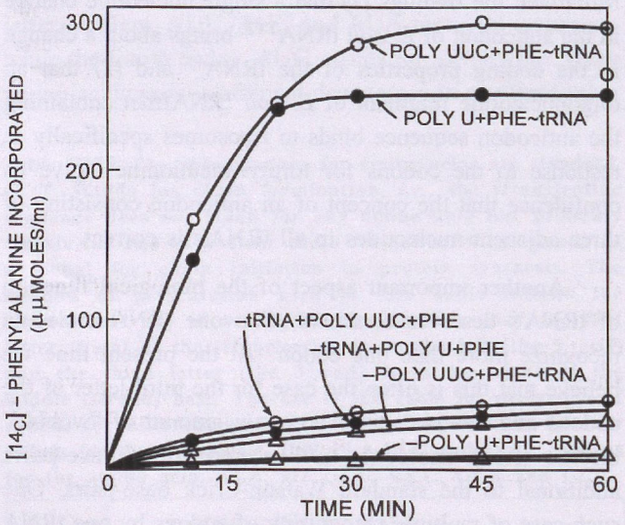


Fig. 4. Polyphenylalanine formation using *Escherichia coli* protein-synthesizing system and purified yeast phe-tRNA. Messengers are poly-U and poly-UUC.

Transfer RNA's are a unique class of molecules in the biological realm. They clearly have to perform a variety of functions. There is a good deal of evidence to suggest that in addition to a common secondary structure, these molecules possess a tertiary structure[65]. Further, a very plausible and attractive model for the anticodon loop has been put forward[77]. The very recent success in several laboratories[78-83] in obtaining crystals of tRNA's signifies in all probability a new era in the study of tRNA structure and function. The progress here would be very exciting not only for deepening our understanding of the mechanism of protein synthesis but also because of the possibility that a good part of the evolution of the genetic code is synonymous with the evolution of tRNA molecules.

5. Further Aspects of the Code and of Protein Synthesis

(a) Initiation of protein synthesis : As far as the initiation of protein synthesis in *E. coli* is concerned, a surge of activity occurred with the discovery of formylmethionyl-RNA by Marcker and Sanger[65]. It is now generally believed that formylmethionine (fmet) as carried by a particular species of methionine-specific tRNA is the initiation signal in protein synthesis. As mentioned above, in most of the work on the codon assignments using synthetic polynucleotides as messengers, artificially high Mg^{2+} ion concentrations were used. Under those conditions, the need for specific initiation of polypeptide chain synthesis is obviated. However, the requirement for the latter can be introduced by lowering the Mg^{2+} ion concentration to about 4-5 m*M* (compared with 10-15 used in earlier work). It is then found that prompt response in the cell-free system is elicited by only those messengers which contain codons that can recognize fmettRNA^{fmet}. Now, the peptide synthesis starts with fmet at the amino terminus. Once again, time does not permit a complete account of the work reported from different laboratories on this subject. My attention will be restricted to those experiments from my own laboratory which (1) permit derivation of codons involved in chain initiation in *E. coli*[84] and (2) shed a little light on the role of the ribosomal subunits in protein synthesis[85].

Poly-rAUG, as mentioned above, directs polymethionine synthesis. When this experiment is carried out at 5 Mg^{2+} ion concentration, the results shown in Fig. 5 are obtained. Thus, synthesis proceeds with a lag and poorly, when only met-tRNA^{met} is provided. Addition of fmet-RNAf^{fmet} gives a dramatic acceleration of the rate of polymethionine synthesis. It is therefore concluded that fmet-tRNAf^{fmet} is required for initiation and met-tRNA^{met} is required for chain propagation.

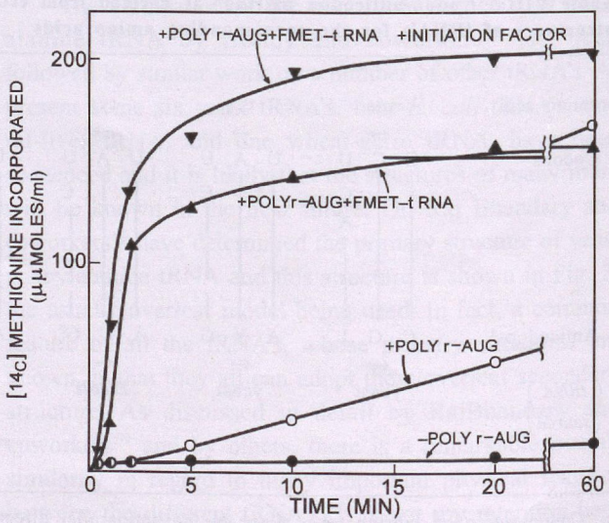


Fig.5. Polymethionine synthesis in the presence of poly-rAUG and [^{14}C]met-tRNA^{met}. The effects obtained on supplementing the system with fmet-tRNAf^{met} and initiation factors are shown.

Similarly, at 5 Mg^2 ion concentration, poly-rUG-directed synthesis of val-cys copolypeptide (Fig.6) requires the presence of fmet-tRNAf^{met} and there is a striking effect following the addition of protein fractions which have been designated initiation factors[65]. Analysis of the terminal sequence of the polypeptidic product formed showed that fmet was present at the amino end and it was followed by cys and then by val.

From the above results, it is concluded that AUG and GUG are the codons for initiation in *E. coli*[84]. An intriguing point here is degeneracy in the first letter.

That the 70S ribosomal particle from *E. coli* can be split to 30S and 50S subunits was already evident in the late fifties. However, the significance of the two subunits in protein synthesis has remained obscure until recently. Gentle lysis of *E. coli* cells was recently found to yield mainly the 30S and 50S sub units and this finding further suggested a role for the 30S-50S couples in protein synthesis[86]. It should be added that prior biochemical investigations had indicated at least two binding sites on the 70S ribosomes. More recently, Nomura and coworkers[87] showed that in the presence of the viral f2-RNA, fmet-tRNAf^{met} showed specific binding to the 30S particles, whereas the noninitiator tRNA's showed no binding to the 30S particles.

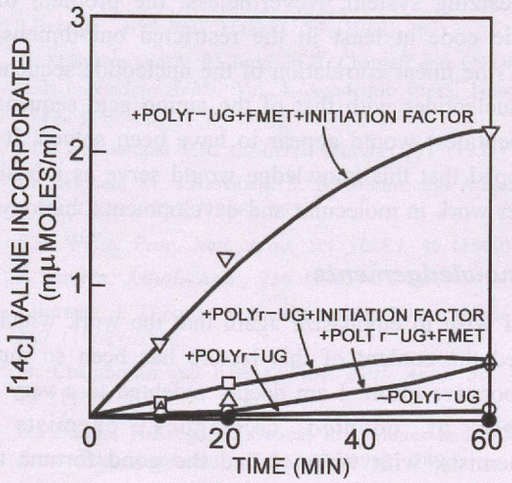


Fig. 6. The synthesis of val-cys copolypeptide as directed by poly-rUG. The synthesis was carried out at 5 mM Mg^{2+} ion concentration. The effects of fmet-tRNAf^{met} and of the initiation factors are shown.

A further study of the above-described polymethionine synthesis as directed by poly-rAUG gave results8 5 which can be summarized as follows. *(1)* The 30S particles bind fmet-tRNAf^{met} in the presence of poly-rAUG at 5 Mg^{2+} ion concentration. *(2)* The noninitiator rRNA, met-tRNA^{met} is bound only after the addition of 50S particles to the 30S particles. *(3)* It was possible to demonstrate the synthesis of the dipeptide formylmethionylmethionine (fmet-met) by stepwise formation of the appropriate complex containing all the components. Thus fmet-tRNAfmet was bound to the 30S particles in the presence of poly-rAUG and the <initiation factors). The complex was isolated by centrifugation, supplemented first with 50S particles and then with met-tRNA^{met}. The resulting complex, containing now 30S particles, poly-rAUG, fmet-tRNAf^{met}, 50S particles and met-tRNA^{met}, was again isolated by centrifugation. This complex when supplemented with the S-100 supernatant fraction gave the dipeptide fmet-met. Therefore, it is clear that both fmet-tRNAf^{met} and met-tRNA^{met} were being bound simultaneously to 30S + 50S ribosomal particles. The results provide direct evidence for the presence of two tRNA binding sites on 70S ribosomes. Furthermore, the picture of the role of the ribosomal subunits which emerges from this work is that the primary event in the initiation ofprotein synthesis is the binding of the initiator tRNA to 30S ribosome + messenger RNA complex. The resulting initiation complex is then joined by the 50S particles and is now able to accept another aminoacyl-tRNA so that a peptide bond may be formed. Nomura and coworkers[87] arrived at the same conclusion from their work and the above results support their conclusions. Several other laboratories have subsequently obtained similar results.

As mentioned above, certain protein factors that can be released from the ribosomes are required for the initiation of protein synthesis. These factors, the general chemistry of the ribosomal proteins and the ribosomal subunits themselves are all areas which are currently the subject of investigation in many laboratories. Very recently, striking progress has been made in Nomura's laboratory on the reconstitution of the 30S subunit. These and related studies are rapidly opening up new approaches to a deeper understanding of the mechanism of protein synthesis.

(b) Missense Suppression: tRNA Involvement : Another application of the ribopolynucleotide messengers with repeating nucleotide sequences was in the study of the mechanism of genetic suppression (missense to sense). From the work of Yanofsky and his coworkers it is known that many mutants of *E. coli* can only make a defective protein A of tryptophan synthetase. In one case, mutant A-78, one glycine residue in the A protein is replaced by cysteine. A suppressed mutant (A-78-Su-78) restores, to a small extent, the original glycine in place of cysteine. Using the cell-free protein-synthesizing system from *E. coli* B, it was shown88 that this system when supplemented with the tRNA from the strain A-78-Su-78,

incorporates [^{14}C]glycine in the presence of valine under the direction of poly-r-U G (Fig. 7). As reviewed above, the latter polymer normally directs the synthesis of valine-cysteine copolypeptide. Valine-glycine copolypeptide formed *specifically* in the presence of tRNA from A-78-Su-78 strain was thoroughly characterized[88]. Similarly, Carbon, Berg and Yanofsky[89] showed that another missense suppressor of glycine to arginine mutation in protein A also acted at the level of tRNA. Previously, tRNA had been shown to be responsible for suppression of an *amber* codon in a bacteriophage RNA[90,91]. As already described above, in one case amber suppression has now been shown to be due to a single nucleotide change in the anticodon of a tRNA[71].

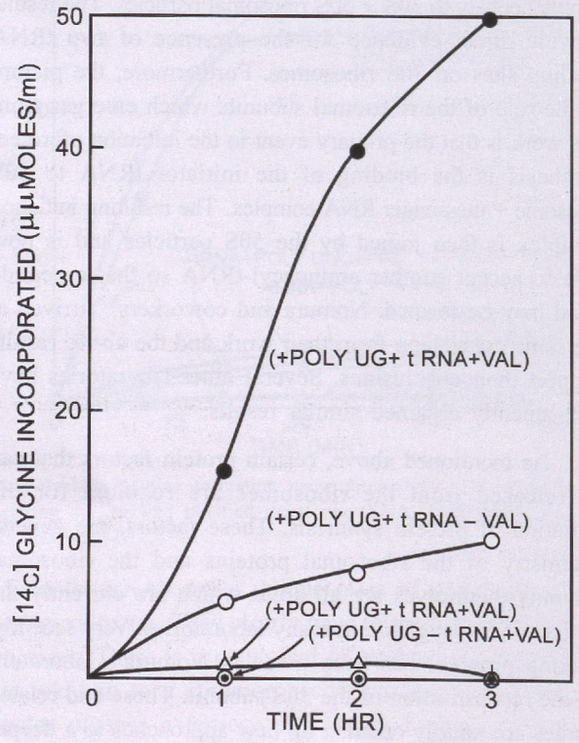


Fig. 7. The incorporation of [^{14}C]glycine into valine-glycinecopolypeptide as stimulated by poly-rUG in the presence of tRNA from A-78-Su-78 strain *of Escherichia coli.*

(c) Translation of Single-stranded DNA-like Polymers: Recently the striking finding was reported[92] that in the presence of aminoglycoside antibiotics such as neomycin B, denatured DNA stimulated the incorporation of amino acids in the bacterial cell-free protein-synthesizing system. A further study of these observations using single-stranded deoxyribopolynucleotides with defined nucleotide sequences, poly-dTG, polydAC and poly-dT, gave most encouraging results[93]. Thus, the response from the DNA-like polymers was excellent and, surprisingly, the mistakes were very rare and small. For example, poly-dCA directed the synthesis of thr-his copolypeptide and no other amino acid was incorporated. In addition to providing a further opportunity for the study of ribosome function, these results may have important practical applications in future work. As pointed out elsewhere[94], it is not inconceivable that the laboratory synthesis of specific proteins will be carried out using nucleic acid templates. For this purpose, protected trinucleotides representing different codons will be made in quantity and on a commercial basis, and these will be used in the synthesis of nucleic acid templates for proteins, the approach offering flexibility and selectivity in amino acid substitutions at the template level.

6. Conclusion

While clarity in some of the detailed aspects of the genetic code is still lacking, it has been a most satisfying experience in the lives of many of us, who have worked on the problems, to see complete agreement reached-in regard to its general structure. Evidence coming from a variety of techniques, genetic and biochemical, from *in vivo* and *in vitro* experiments, has furnished the codon assignments reviewed above. It is unlikely that any of the assignments would be revised. However, much remains to be done at chemical and biochemical level to obtain an adequate understanding of the very elaborate protein-synthesizing system. Nevertheless, the problem of the genetic code at least in the restricted one-dimensional sense (the linear correlation of the nucleotide sequence of polynucleotides with that of the amino acid sequence of polypeptides) would appear to have been solved. It may be hoped that this knowledge would serve as a basis for further work in molecular and developmental biology.

Acknowledgements

I wish to emphasize again that the work which has formed the content of this lecture has been so much a collaborative effort. I am deeply indebted to a very large number of devoted colleagues, chemists and biochemists, with whom I had the good fortune to be happily associated.

Work and progress in science becomes more and more interdependent: this certainly has been true in work on the genetic code. Many of the great scientists, who influenced directly or indirectly the work herein reviewed, have been mentioned in the text. I wish to make a personal acknowledgement to one more scientist. Fortunately, I was accepted by Professor V. Prelog of the Eidgenössische Technische Hochschule, Zurich, as a postdoctoral student. The association with this great scientist and human being

influenced immeasurably my thought and philosophy towards science, work and effort.

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Birth Anniversary of Nobel Laureate Har Gobind Khorana

Note by the Editor-in-Chief: We would like to pay our respectful homage and tribute to a celebrated scientist to mark the 100th birth anniversary of **Nobel Laureate Har Gobind Khorana** (09.01.1922 – 09.11.2011). Khorana (born in a village, Raipur, in Multan, Punjab, British India in a Punjabi Hindu family) was awarded the 1968 Nobel Prize in Physiology or Medicine along with Robert W. Holley and Marshall W. Nirenberg "for their interpretation of the genetic code and its function in protein synthesis," After his B.Sc.(1943) and M.Sc.(1945) from the Punjab University in Lahore, he moved to the University of Liverpool, England for research work leading to Ph.D. degree in 1948 under Prof. Roger J. S. Beer. Then he joined as a postdoctoral student with Professor Vladimir Prelog at ETH Zurich, Switzerland. Later he proceeded to England on a fellowship to work with George Wallace Kenner and Alexander R. Todd on peptides and nucleotides. He stayed in Cambridge from 1950 until 1952, then moved to Vancouver to join the University of British Columbia, accepting a scientific position with the British Columbia Research Council to conduct research work on "nucleic acids and synthesis of many important biomolecules".

In 1960 Khorana accepted a position as Co-Director at the Institute for Enzyme Research at the University of Wisconsin at Madison, USA and becoming a Professor of Biochemistry in 1962 with designation as Conrad A. Elvehjem Professor of Life Sciences. At the University of Wisconsin, "he helped decipher the mechanisms by which RNA codes for the synthesis of proteins" and "began to work on synthesizing functional genes". His work at the University of Wisconsin led him to share the Nobel prize. Har Gobind Khorana's role is stated as follows: he "made important contributions to this field by building different RNA chains with the help of enzymes. Using these enzymes, he was able to produce proteins. The amino acid sequences of these proteins then solved the rest of the puzzle." Finally in 1970, Khorana was the Alfred P. Sloan Professor of Biology and Chemistry at the Massachusetts Institute of Technology and later, a member of the Board of Scientific Governors at The Scripps Research Institute where he worked till 2007. Khorana passed away on 9th November 2011 at the age of 89. In an obituary for him, the MIT news office quoted his colleague Uttam Rajbhandary as saying Khorana was a very "modest" person. Khorana's daughter Julia is quoted in the same article saying, "Even while doing all this research, he was always really interested in education, in students and young people. After he retired, students would come to visit and he loved to talk to them about the work they were doing. He was very loyal to them, and they were very loyal to him, too." ***The Indian government awarded Khorana the Padma Vibhushan in 1969.***

NOTICE

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ARTICLE

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CONTRIBUTION OF DR. RĀJENDRALĀL MITRA (1822-1891) TO PUBLIC SCIENCE COMMUNICATION IN THE 19TH CENTURY INDIA

INDRANIL SANYAL*

Dr. Rājendralāl Mitra (1822-1891) was a versatile genius, the most prominent Indologist of the 19th century and one of the leading figures of Bengal Renaissance. He was among the first Indian cultural researchers and historians writing in English and was the first Indian to become the President of the Asiatic Society of Bengal. He had many talents, but his enormous fame as a leading patriotic intellectual of his time was primarily for his contribution to the methodical and scientific study of Ancient India during the 2nd half of the 19th century. Overshadowed by this fame, his significant contribution to the Public Science Communication and his bold initiative in creating a Scientific Temper in the society are less discussed. In 1851, he launched the first illustrated Bengali magazine 'Vividhārtha Saṃgraha'. In 1863, this monthly magazine was replaced with another magazine titled 'Rahasya Sandarbha'. These two periodicals contributed significantly to the Public Understanding of Science through Bengali language over a period of twenty years. Rājendralāl was also the pioneer in the studies of Physical Geography and Applied Sciences in India and was the first to use visuals and photographs in periodicals. He was also a pioneer in creating a Bengali glossary of scientific terms. Rājendralāl Mitra was widely hailed as the 'The Most Learned Man during the Bengal Renaissance'. The Nation will commemorate the 200th Birth Anniversary of this 'Renaissance Man' in February 2022.

Introduction

Rājendralāl Mitra (1822-91) was a renowned Indologist, a prominent Science Communicator and a leading and important figure of the 19th century Bengal Renaissance. Hailed as the 'The Most Learned Man' of the 19th century India, he contributed significantly to the Science Popularization in India and in creating a Scientific Awareness and Scientific Temper in the 19th century society. Rājendralāl (see Figure 1) was born on 16 February, 1822[Footnote 1] in Śuṁṛā (now Beliaghata) area of eastern Kolkata to an illustrious and prosperous Bengali Kāyastha family which was known for their education and knowledge. Rājendralāl's forefathers had reputations as scholars. Rājendralāl's great grandfather, Pitambar Mitra, was an officer in the Mughal Court in Delhi. His grandfather, Vrindavan Chandra, was a close associate of Raja Rammohun Roy. Rājendralāl's father, Janmejaya (b. 1796), was not only a renowned Brajabuli and Urdu poet, but was also the first Indian to study Western post-Lavoisier chemistry under the guidance of Schoulbraid.[1] Rājendralāl joined the newly founded Calcutta Medical College in 1837. He was a brilliant student at the Medical College and Prince Dwarkanath Tagore was very impressed with Rājendralāl's knowledge; Dwarkanath was ready to sponsor Rājendralāl's travel to England for higher studies in Medicine, but the family did not permit and Rājendralāl

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Footnote 1 : Some sources have indicated the year of birth as 1824. There are indeed confusions about the year for a long time. Not entering into controversy, we are, however, going with the generally accepted date of February 16, 1822 as the date of birth of Rājendralāl Mitra.

had to decline the offer.[2] In 1841, Rājendralāl was forced to drop out from Medical College after he refused to give testimonies against some of his classmates before the College authorities.[2a] But here he studied chemistry under Dr. William B. O'Shaughnessy who liked Rājendralāl very much, and who was later instrumental in laying the first telegraph cable in India from Kolkata to Diamond Harbour. O'Shaughnessy also succeeded James Prinsep as the President of the Royal Asiatic Society of Bengal after the untimely death of the latter. The O'Shaughnessy connection came handy in Rājendralāl's career later on. After quitting Medical College, Rājendralāl studied Law for some time, but could not sit for the final examination as the question papers had been leaked and the examination was postponed. Frustrated, he finally engaged himself in studying Sanskrit and Persian in the library of his father. In 1846 he joined the Royal Asiatic Society of Bengal as Librarian and Assistant Secretary. He devoted almost his entire life working for the Asiatic Society, rising to become its first Indian President in 1885. From 1856 to 1880, he was the Director of the Wards' Institute.[1a,3-5]

Rājendralāl made numerous contributions to the Society's journal and proceedings, numbering 120, and to the series of Sanskrit texts titled 'Bibliotheca Indica' (edited by eminent European and Indian scholars), editing 83 of the 266 Sanskrit fasciculi in it. He also made numerous contributions to the Journal of the Asiatic Society of the Great Britain and Ireland, Journal of the Anthropological Society of India, Calcutta Review Journal and Mookerjee's Magazine, in addition to many prominent newspapers of the time e.g. The Englishman, The Daily News, The Statesman, The Phoenix, The Citizen, The Friend of India, The Indian Field and The Hindu Patriot. He was the editor of The Hindu Patriot for several years.[6] Apart from this, he published a few separate books, namely, 'The Antiquities of Orissa' (2 vols. 1875 and 1880)[7,7a], illustrated with photographic plates, in which he tried to trace the origin of the image of Lord Jagannātha and the Ratha Yātra to ancient Buddhism; 'Buddha Gaya, the Hermitage of Śākya Muni' (1878)[8], an illustrated work and 'Indo Aryans' (2 vols., 1881)[9,9a], a collection of essays dealing with the manners and customs of the people of India from the Vedic era. His 'The Sanskrit Buddhist Literature of Nepal' (1882)[10] is considered as a milestone in the field of studies of history of that Himalayan kingdom. As the President of the Asiatic Society, he wrote the Society's Centenary History, published in 1885.

These works and a large body of works on ancient India, which he accomplished by collecting Sanskrit manuscripts from all over India and translating them into English and through which he made remarkable contribution to the Indological studies during the 2nd half of the 19th century, earned him the repute as the greatest Indian Indologist. His contributions earned him high appreciations from scholars all over the world that includes Prof. Friedrich Max Müller. He also developed mastery over various languages such as English, Sanskrit, Persian, Urdu, Hindi, Odia, French, Greek and Latin. He was fellow of various learned societies of Europe. In Kolkata, a large number of intellectuals gathered around Rājendralāl, which included poet Michael Madhusudan Dutta, and they made significant contribution to the Bengal Renaissance.[11]

Fig 1: Dr. Rājendralāl Mitra (1822-1891) A Polymath, an Indologist and a leading Public Science Communicator of the 19th century (Image Source: https://royalasiaticcollections.org/photo-24-024-Rājendralāl-mitra/)

Rājendralāl Mitra made important contribution to educative journalism, and particularly science communication, by editing 'Vividhārtha Saṃgraha', an illustrated monthly magazine with a focus on the popularization of science, from 1851 to 1859. In 1863 the 'Vividhārtha Saṃgraha' was replaced with another illustrated monthly magazine of the same kind, the 'Rahasya Sandarbha'. Rājendralāl edited this magazine for six years till its 66th issue. Rājendralāl published more than 300 science articles in these two magazines. 'Vividhārtha

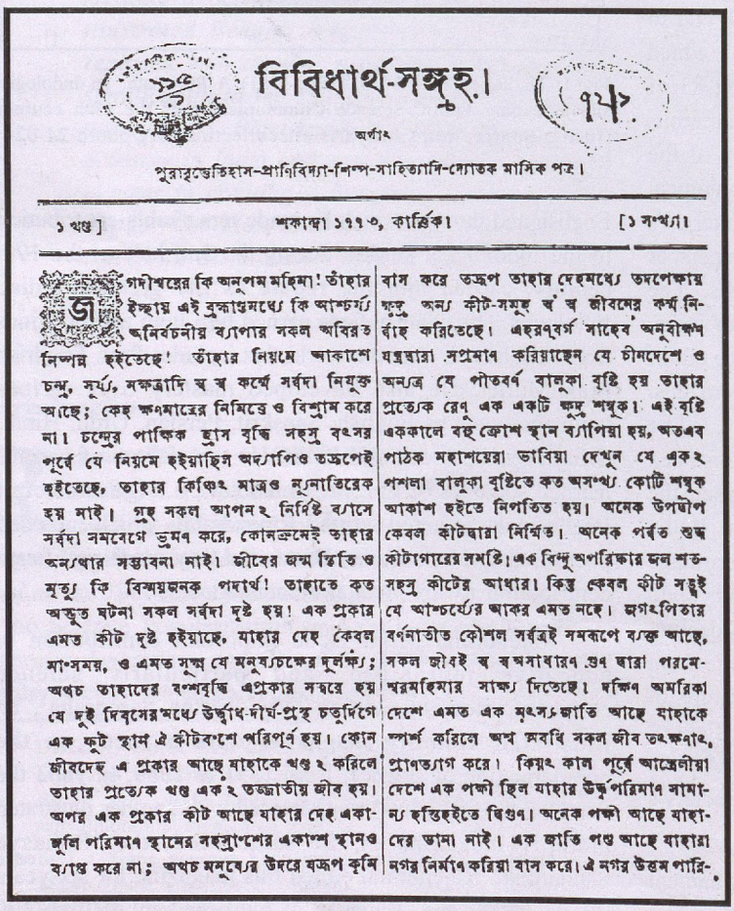
Saṃgraha' and 'Rahasya Sandarbha' had substantial impact on public understanding of science and in creating a scientific temper in the society. Their popularity owes not only to the novelty and diversity of the topics chosen for the articles, but also to the fluent writing style of Rājendralāl Mitra. Rājendralāl was also a pioneer in India of studying Physical Geography and Thematic Mapping (published 'Physical Geography or the Description of the Natural Phenomena on the Earth' in Bengali in 1854) and in Applied Sciences (published Śilpik Darśan in Bengali in 1860). He was the first in India to use Photographs and Visuals in science articles. He also made important contributions in developing norms for translation of Western Scientific Terms into Indian languages[12-14].

Rājendralāl also contributed a few scientific papers to the Proceedings of the Asiatic Society of Bengal, namely, 'On Scientific Technology' (1866), 'On a new species of Scincus' (1871), 'Electrotypes of two ancient seals' (1872), 'Reply to enquiry regarding the mention of leprosy by ancient Hindu writers' (1875) and 'On two astrolabes purchased for the Society by Prof. Maheshachandra Nayaratna at Allahabad' (1890). Rājendralāla Mitra was also one of the prominent intellectuals of Bengal who actively supported Dr. Mahendralal Sircar in establishing the Indian Association for the Cultivation of Science in Kolkata in 1876[15,16].

Rājendralāl Mitra received the honorary LL.D. degree (Doctor in Law) from the University of Calcutta in 1875, the CIE (Companionship of the Indian Empire) in 1878, and the title of Raja in 1888. He was a corresponding fellow of German Oriental Society (1864), an honorary fellow of the Royal Asiatic Society of Great Britain (1865), a foreign fellow of Royal Academy of Science, Hungary (1865) and an honorary fellow of the American Oriental Society (1867). He died in Kolkata on the 26 July 1891[17].

Public Science Communication: Vividhārtha Saṃgraha and Rahasya Sandarbha[18-21]

Rājendralāl's contribution to Public Science Communication began with Tattvabodhinī Patrikā when in 1848 he was selected as a reviewer of the articles to be published in the Patrikā and he himself contributed a few articles to it, though it is now difficult to identify them as the articles were anonymous. During 1848-50, he assisted Akshay Kumar Datta in editing the Patrikā. In 1851, with the funding from 'Vernacular Literature Committee' (Baṅgabhāṣānuvādak Samiti), a Govt. backed organization established in 1851 to provide a sound and useful 'Vernacular Domestic Literature for Bengal', he launched the first illustrated Bengali monthly magazine 'Vividhārtha Saṃgraha'. This 16 page (later 24) magazine was printed from Baptist Mission Press.



বিবিধার্থ-সঙ্গ্রহ।

অর্থাৎ

পুরাবৃত্তেতিহাস-প্রাণিবিদ্যা-শিল্প-সাহিত্যাদি-দ্যোতক মাসিক পত্র।

১ খণ্ড] শকাব্দা ১৭৭৩, কার্ত্তিক। [১ সংখ্যা।

জগদীশ্বরের কি অনুপম মহিমা! তাঁহার ইচ্ছায় এই ব্রহ্মাণ্ডমধ্যে কি আশ্চর্য্য অনির্ব্বচনীয় ব্যাপার সকল অবিরত নিষ্পন্ন হইতেছে! তাঁহার নিয়মে আকাশে চন্দ্র, সূর্য্য, নক্ষত্রাদি স্ব স্ব কর্ম্মে সর্ব্বদা নিযুক্ত আছে; কেহ ক্ষণমাত্রের নিমিত্তে ও বিশ্রাম করে না। চন্দ্রের পাক্ষিক হ্রাস বৃদ্ধি সহস্র বৎসর পূর্ব্বে যে নিয়মে হইয়াছিল অদ্যাপিও তদ্রূপেই হইতেছে, তাহার কিঞ্চিৎ মাত্রও ন্যূনাতিরেক হয় নাই। গুরু সকল আপন২ নির্দ্দিষ্ট ব্যাসে সর্ব্বদা সমবেগে ভ্রমণ করে, কোনভ্রমেই তাহার অন্যথার সম্ভাবনা নাই। জীবের জন্ম স্থিতি ও মৃত্যু কি বিস্ময়জনক পদার্থ! তাহাতে কত অদ্ভুত ঘটনা সকল সর্ব্বদা দৃষ্ট হয়! এক প্রকার এমত কীট দৃষ্ট হইয়াছে, যাহার দেহ কেবল মাংসময়, ও এমত সূক্ষ্ম যে মনুষ্যচক্ষের দুর্লক্ষ্য; অথচ তাহাদের বংশবৃদ্ধি এপ্রকার সত্বরে হয় যে দুই দিবসের মধ্যে ঊর্দ্ধাধ-দীর্ঘ-প্রস্থ চতুর্দ্দিগে এক ফুট স্থান ঐ কীটবংশে পরিপূর্ণ হয়। কোন জীবদেহ এ প্রকার আছে যাহাকে খণ্ড২ করিলে তাহার প্রত্যেক খণ্ড এক২ তজ্জাতীয় জীব হয়। অপর এক প্রকার কীট আছে যাহার দেহ একাঙ্গুলি পরিমাণ স্থানের সহস্রাংশের একাংশ স্থানও ব্যাপ্ত করে না; অথচ মনুষ্যের উদরে যদ্রূপ কৃমি বাস করে তদ্রূপ তাহার দেহমধ্যে তদপেক্ষায় ক্ষুদ্র অন্য কীট-সমূহ স্ব স্ব জীবনের কর্ম্ম নির্ব্বাহ করিতেছে। এহরণ্বর্গ সাহেব অনুবীক্ষণ যন্ত্রদ্বারা সপ্রমাণ করিয়াছেন যে চীনদেশে ও অন্যত্র যে পীতবর্ণ বালুকা বৃষ্টি হয় তাহার প্রত্যেক রেণু এক একটি ক্ষুদ্র শম্বুক। এই বৃষ্টি এককালে বহু ক্রোশ স্থান ব্যাপিয়া হয়, অতএব পাঠক মহাশয়েরা ভাবিয়া দেখুন যে এক২ পশলা বালুকা বৃষ্টিতে কত অসঙ্খ্য কোটি শম্বুক আকাশ হইতে নিপতিত হয়। অনেক উপদ্বীপ কেবল কীটদ্বারা নির্ম্মিত। অনেক পর্ব্বত শুদ্ধ কীটাগারের সমষ্টি। এক বিন্দু অপরিষ্কার জল শতসহস্র কীটের আধার। কিন্তু কেবল কীট সম্বন্ধেই যে আশ্চর্য্যের আকর এমত নহে। জগৎপিতার বর্ণনাতীত কৌশল সর্ব্বত্রই সমরূপে ব্যক্ত আছে, সকল জীবই স্ব স্ব অসাধারণ গুণ দ্বারা পরমেশ্বরমহিমার সাক্ষ্য দিতেছে। দক্ষিণ অমরিকা দেশে এমত এক মৃৎসর্জ্জাতি আছে যাহাকে স্পর্শ করিলে অশ্ব অবধি সকল জীব তৎক্ষণাৎ প্রাণত্যাগ করে। কিয়ৎ কাল পূর্ব্বে আষ্ট্রেলীয়া দেশে এক পক্ষী ছিল যাহার ঊর্দ্ধপরিমাণ সামান্য হস্তিহইতে দ্বিগুণ। অনেক পক্ষী আছে যাহাদের ডানা নাই। এক জাতি পশু আছে যাহারা নগর নির্ম্মাণ করিয়া বাস করে। ঐ নগর উত্তম পারি-

Fig 2: The first page of the first issue of Vividhārtha Saṃgraha (1851) (Image Source: http://crossasia-repository.ub.uni-heidelberg.de/446/)

The Committee extended a monthly grant of Rs. 80 to Rājendralāl with the help of which the magazine was launched in October 1851. Rājendralāl was the editor of first six volumes and most of the articles were written by him. 'Vividhārtha Saṃgraha' was modelled after Charles Knight's Penny Magazine (1832-45). It was not a Science Magazine; its first issue (Figure 2) declared it to be a magazine of *'History and Antiquity, Zoology, Art and Literature'*. Nevertheless, in course of time, it published large numbers of articles on various scientific and educative topics. Most of the science articles were on Zoology, Geography, Geology and Chemistry. Articles on Botany and Astronomy were a very few. There were some articles on Physics. In the first issue of the magazine, while

describing the diversity of the universe and the animal kingdom, Rājendralāl wrote, *'We shall not restrict ourselves in discussing Astronomy or Animal Kingdom only, but shall equally publish articles on Physics, Geology....'*

Vividhārtha Saṃgraha published large numbers of articles on animal kingdom. The most important features of these articles were their correct classifications of the animal kingdom, not seen in any previous science writings in Bengali. Moreover, most of the articles were illustrated. For this purpose, Rājendralāl imported printing equipment from Germany. The early issues published 2-3 articles on animals and birds each. For example, 'Homa bird' (a mythical bird of Iranian legend, however, the author has indicated that this bird is found in Molucca, New Guinea etc.) and 'Zebra' (1.1, Kārtika, 1773 SE), 'Toucan Birds' and 'Rhinoceros' (1.2, Agrahāyana, 1773 SE), 'Skunks' and 'Fowls & Pheasants' (1.3, Pouṣa, 1773 SE), 'Butterflies' and 'Parrot group of Birds' (1.4, Māgha, 1773 SE), 'Cassowary Birds', 'Dolphins' and 'Pythons' (1.5, Phālguna, 1773 SE) and 'Aracari Birds' (A medium sized Toucan, *Pteroglossus aracari*) and 'Kalong Bats' (Large or Malaysian Flying Fox, *Pteropus vampyrus*) (1.6, Caitra, 1773 SE).

Subsequently, more articles on animal kingdom were published, namely, 'Roach (*Rutilus rutilus*) & Dace (*Leuciscus leuciscus*) Fishes' (1.7, Baiśākha, 1774 SE), 'Walrus' and 'Harpy Eagle' (1.8, Baiśākha, 1774 SE), 'Chimpanzee' and 'Secretary bird' (*Sagittarius serpentarius)* (1.9, Āṣāṛha, 1774 SE), 'Birds' Nests' (1.10, Śrāvaṇa, 1774 SE), 'Yak' (1.11, Bhādra, 1774 SE), 'Porcupines' (1.12, Āświna, 1774 SE), 'Camel' (2.13, Pouṣa, 1774 SE), 'Bison' (2.18, Jaiṣṭhya, 1775 SE), 'Crocodiles' (2.19, Āṣāṛha, 1775 SE), 'Feline Family of animals' (2.21, Bhādra, 1775 SE), 'Methods of catching Elephants' (2.22, Āświna, 1775 SE), 'Description of Elephants' (3.25, Caitra, 1775 SE), 'Flying Fish' (3.25, Caitra, 1775 SE), 'Catla fish' (*Labeo catla*, 3.26, Baiśākha, 1776 SE), 'Ptarmigan birds' (*Lagopus muta*- Common ptarmigan and *L. lagopus* – Willow ptarmigan) and 'Giraffe' (3.27, Jaiṣṭhya, 1776 śaka), 'Tapir' (*Tapirus bairdii* -Central American tapir) and 'Snakes' (3.28, Āṣāṛha, 1776 SE), 'Squirrels' (3.28, Śrāvaṇa, 1776 SE), 'Siya Gosh' (*Caracal caracal* - Caracal cats , 3.30, Bhādra, 1776 SE), 'Carp or European Rohu fish' (*Cyprinus carpio,* 3.31, Āświna, 1776 SE), 'Aye-aye' (*Daubentonia madagascariensis,* a long-fingered lemur found in Madagascar, 3.33, Agrahāyana, 1776 SE), 'Trout fish' (Adriatic trout- *Salmo obtusirostris,* 3.34, Pouṣa, 1776 SE), 'Musk deer' (3.35, Māgha, 1776 SE), 'Capercaillie birds' (*Tetrao urogallus,* 3.36, Phālguna, 1776 SE), 'Hyrax' (*Procavia capensis*- a small herbivorous mammal, 4.37, Baiśākha, 1779 SE), 'Ibex or Mountain Goat' (4.38, Jaiṣṭhya, 1779 SE), 'The Narwhal' (or Narwhale, *Monodon monoceros*, a medium-sized toothed whale that possesses a large tusk from a protruding canine tooth, 4.42, Āświna, 1779 SE), 'Hares & Rabbits' (4.43, Kārtika, 1779 SE), 'Menura bird' (Lyrebird: Australian ground dwelling birds, *Menura novaehollandiae*- Superb Lyrebird and *Menura alberti*- Albert's Lyrebird, 4.45, Pouca, 1779 SE), 'African Wildebeest' (*Connochaetes gnou* - black wildebeest and *C. taurinus*- blue wildebeest, 4.47, Phālguna, 1779 SE), 'Hoopoe or Hud-hud' (Eurasian hoopoe, *Upupa epops,* 5.50, Jaiṣṭhya, 1780 SE), 'Mongoose family of Animals' (family *Herpestidae*, 5.54, Āświna, 1780 SE), 'Wild pigeons of North America' (*Ectopistes migratorius,* now extinct, 5.54, Āświna, 1780 SE), 'Microbes' (5.55, Kārtika, 1780 SE), 'Frogs & Toads' (5.56, Agrahāyana, 1780 SE), 'Springbok' (*Antidorcas marsupialis,* 5.57, Pouṣa, 1780 SE), 'Penguin' (5.59, Phālguna, 1780 SE), 'Coypus' (*Myocastor coypus*, also known as the nutria, is a large, herbivorous, semiaquatic rodent of South America, 6.61, Baiśākha, 1780 SE), 'Classification of Animal Kingdom' (6.62, Jaiṣṭhya, 1781 SE), 'A general description of Webbed-Foot Animals' (6.64, Śrāvaṇa, 1781 SE), 'Honeybees' (6.65, Bhādra, 1781 SE), 'The Pigeons and their congeners' (*Columba livia,* 6.66, Āświna, 1781 SE), 'The Ruminants and their congeners'(6.67, Kārtika, 1781 SE), 'Lemurs' (6.68, Agrahāyana, 1781 SE), 'Domestic Cattles' (6.69, Pouca, 1781 SE), 'Dogs' (6.72, Caitra, 1781 SE), 'Lizard' (7.78, Āświna, 1783 SE) and 'Animal Kingdom' (7.78, Āświna, 1783 SE).

Number of articles on Botany were limited. However, they were well written. Notable among them were 'Comments on the importance of Bay-tree' (1.5, Phālguna, 1773 SE, the author, however, did not discuss the European Bay tree), 'Upas Tree' (*Antiaris toxicaria*, a poisonous tree generally found in South East Asia, 1.7, Baiśākha, 1774 SE), 'The Forbidden Fruit of Lanka' (2.20, Śrāvaṇa, 1775 SE), 'Peepul Tree' (*Ficus religiosa,* 2.24, Agrahāyana, 1775 SE), 'Nutmeg & Mace' (3.36, Phālguna, 1776 SE) and 'Victoria Lotus' (a South American variety of giant water-lily, *Victoria amazonica* and *V. cruziana*, 4.42, Āświna, 1779 SE). Another important article on botany is 'Strange properties of Plants like Consciousness, Temperature etc.' (3.32, Kārtika, 1776 SE). In this article the author discussed Plant-Physiology with examples.

Articles on human/animal physiology are very rare. They are 'Electric Eel' (3.33, Agrahāyana, 1776 SE), 'On Breathing' (4.37, Baiśākha, 1779 SE), 'Respiration' (4.42, Āświna, 1779 SE), 'Embryology' (4.46, Māgha, 1779 SE), 'Description of Vertebrates' (6.63, Āṣāṛha, 1781 SE), 'How do we hear' (6.72, Caitra, 1781 SE) and 'Animal Physiology' (7.78, Āświna, 1783 SE).

The only well written article on Geology is 'Rocky Coal and its Mines' (5.53, Bhādra, 1780 SE). There were some articles on mining, e.g. 'Gold mines of India' (3.32, Kārtika, 1776 SE), 'Silver mines' (4.48, Caitra, 1779 SE) and 'The Salt Mine near Cracow' (5.54, Āświna, 1780 SE). The articles on Chemistry were application oriented. Important among them were 'Mercury' (3.33, Agrahāyana, 1776 SE), 'Iron' (3.35, Māgha, 1776 SE), 'Preparation of Saltpetre' (3.36, Phālguna, 1776 SE), 'Aromatics & Essences' (4.37, Baiśākha, 1779 SE), 'Camphor' (4.40, Śrāvaṇa, 1779 SE), 'Fundamentals of Chemistry' (6.63, Āṣāṛha, 1781 SE) etc. The articles are informative and the language is fluent. Some of the articles like 'Mercury' have also drawn historical references.

The only article on Physics published in this magazine 'Electric Telegraph or Electrical Message Carrier Machine' was published in the issue 3.30, Bhādra, 1776 SE. The article not only discussed the telegraph machine and telegraphic code, but also lucidly discussed the properties of electricity. The article suggested a method of sending Bengali messages by adopting the single needle recording instrument then in use for communication in English. The other article 'Mirage' (6.65, Bhādra, 1781 SE) borders between Physics and Physical Geography.

There were four articles on Astronomy. The first one is 'Comets' (4.44, Agrahāyaṇa, 1779 SE). The article briefly discussed origin and classification of Comets, their trajectories, tail of a comet etc. The other articles were about 'Year reckoning' (5.57, Māgha, 1780 SE), 'Strange Celestial Phenomena throughout the year' (5.57, Pouṣa, 1780 SE) and 'The Sun' (6.69, Pouṣa, 1781 SE).

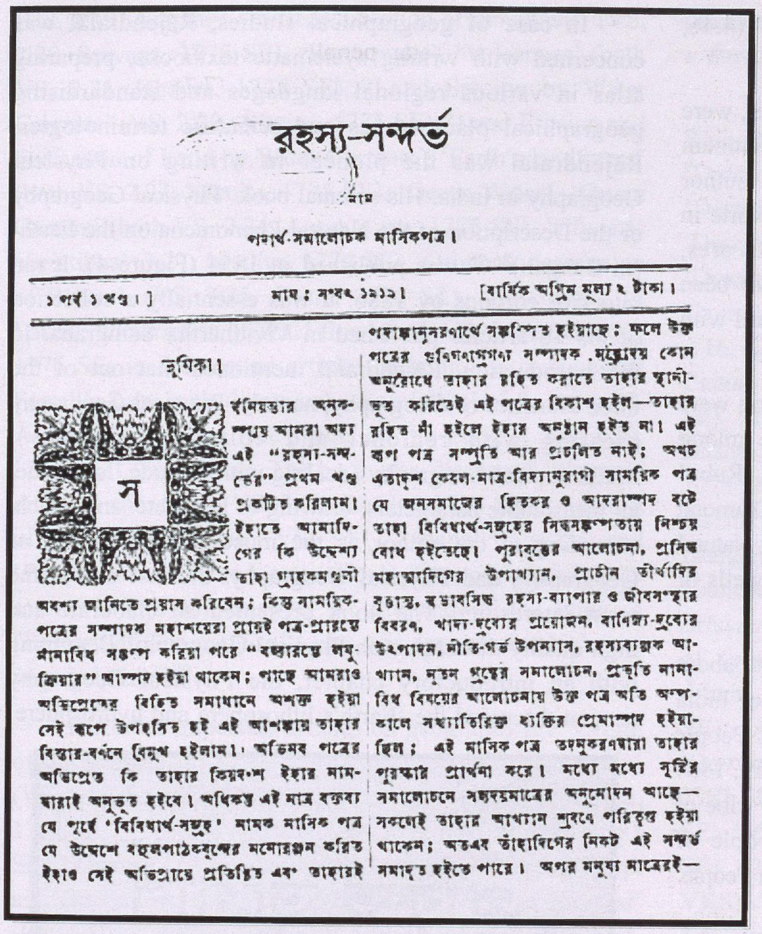
The article 'Natural Classification of Human Beings' (1.6, Caitra, 1773 SE) can be classified as on Anthropology. In Vividhārtha Saṃgraha, Rājendralāl wrote large numbers of articles describing people of various countries and several indigenous communities of India and the world such as, 'Description of Bhil people' (1.3, Pouṣa, 1773 SE), 'Polygars of Tirunelveli' (1.7, Baiśākha, 1774 SE), 'Doko people of Africa' (1.7, Baiśākha, 1774 SE), 'Description of Arab People' (1.8, Baiśākha, 1774 SE), 'Human sacrifice by the Aztec people' (2.18, Jaiṣṭhya, 1775 SE), 'Kuki people of Chittagong' (3.25, Caitra, 1775 SE), 'Nootka people' (a group of indigenous people of British Columbia, Canada, 3.31, Āświna, 1776 SE), 'Tupi people' (a group of indigenous people of Brazil, 4.37, Baiśākha, 1779 SE), 'Gypsies'(4.40, Śrāvaṇa, 1779 SE), 'Nilgiri and its Toda people' (4.41, Bhādra, 1779 SE), 'Korah Hottentots'(4.44, Agrahāyaṇa, 1779 SE), 'Eskimos'(4.45, Pouṣca, 1779 SE), 'Aborigines of Australia'(4.47, Phālguna, 1779 SE), 'The Indigenous People of North America' (5.49, Baiśākha, 1780 SE), 'Souliotes of Greece' (5.57, Pouṣa, 1780 SE), 'Description of Tatar people' (6.69, Pouca, 1781 SE), 'Description of the people of China' (7.76, Śrāvaṇa, 1783 SE), and 'Durūz people' (Druze people, an Arabic speaking community of West Asia which follows a syncretic religion of Shi'ite Islam, Christianity, Greek orthodoxy, Judaism, Buddhism and Jainism, 7.80, Agrahāyaṇa, 1783 SE). He also wrote an interesting article titled 'Indian Census of Population' (4.44, Agrahāyaṇa, 1779 SE).

Rājendralāl wrote most of the articles in Vividhārtha Saṃgraha. His fluent writing style was the main reason behind the popularity of this magazine. His main achievement was to create a scientific awareness in the society through this magazine.

After the publication of six volumes, Rājendralāl Mitra retired from its editorship owing to poor health. Kaliprasanna Singha, a noted writer, took over as the editor. Vividhārtha Saṃgraha continued irregularly for ten months. In the July issue of 1861, Kaliprasanna, while reviewing the newly published play book 'Nīldarpaṇ', criticised the British Indigo Planters in Vividhārtha Saṃgraha, as a gesture of protest against James Long's punishment in the court of law for publishing a translation of this play into English.. Consequently, he was forced to stop the publication of this periodical as the Government funded Vernacular Literature Committee was reluctant to release the grant for continuing its publication.

After the closure of Vividhārtha Saṃgraha, Rājendralāl launched Rahasya Sandarbha (Figure 3) in 1863. The magazine was again published by the Vernacular Literature Committee (by this time it merged with the School Book Society). Rājendralāl himself was the editor for first six years. During the subsequent two years, it was edited by Prananath Datta. The new magazine maintained the look, feel and philosophy of the old one. The Somaprakāś magazine (March 09, 1863) hoped that with little effort this new magazine could attain the status of Vividhārtha Saṃgraha.

Like its previous incarnation, most of the articles in Rahasya Sandarbha were also on Zoology. They were written in a fluent language but are inferior to the articles published in Vividhārtha Saṃgraha in respect of the content. Important among them were 'Musk Deer' (1.1, Māgha, 1919 VKS), 'Trogon Bird' (found in the woodlands of the Americas, there are 20 species, e. g *Trogon elegans* or Elegant Trogon, 1.3, Caitra, 1919 VKS), 'Scratching Birds' (1.6, Āṣāṛha, 1920 VKS), 'Moles' (Serialized from 1.8, Bhādra, 1920 VKS), 'Chameleons' (1.11, Agrahāyana, 1920 VKS), 'Sloth' (1.12, Pouṣa, 1920 VKS), 'The Otter' (2.13, 1864



রহস্য-সন্দর্ভ

নাম

পদার্থ-সমালোচক মাসিকপত্র।

১ পর্ব ১ খণ্ড।] মাঘ : সম্বৎ ১৯১৯। [বার্ষিক অগ্রিম মূল্য ২ টাকা।

ভূমিকা।

সর্বনিয়ন্তার অনুকম্পায় আমরা অদ্য এই "রহস্য-সন্দর্ভের" প্রথম খণ্ড প্রকটিত করিলাম। ইহাতে আমাদিগের কি উদ্দেশ্য তাহা গ্রাহকমণ্ডলী অবশ্য জানিতে প্রয়াস করিবেন; কিন্তু সাময়িক-পত্রের সম্পাদক মহাশয়েরা প্রায়ই পত্র-প্রারম্ভে নানাবিধ সঙ্কল্প করিয়া পরে "বহ্বারম্ভে লঘুক্রিয়ার" আস্পদ হইয়া থাকেন; পাছে আমরাও অভিপ্রেতের বিহিত সমাধানে অশক্ত হইয়া সেই রূপে উপহসিত হই এই আশঙ্কায় তাহার বিস্তার-বর্ণনে বিমুখ হইলাম। অভিনব পত্রের অভিপ্রেত কি তাহার কিয়দংশ ইহার নাম-দ্বারাই অনুভূত হইবে। অধিকন্তু এই মাত্র বক্তব্য যে পূর্বে 'বিবিধার্থ-সংগ্রহ' নামক মাসিক পত্র যে উদ্দেশে বহুলপাঠকবৃন্দের মনোরঞ্জন করিত ইহাও সেই অভিপ্রায়ে প্রতিষ্ঠিত এবং তাহারই পদার্থানুসন্ধানার্থে সঙ্কল্পিত হইয়াছে; ফলে উক্ত পত্রের সুবিখ্যাতগুণ সম্পাদক মহোদয় কোন অনুরোধে তাহার রহিত করাতে তাহার স্থানীভূত করিতেই এই পত্রের বিকাশ হইল—তাহার রহিত না হইলে ইহার অনুষ্ঠান হইত না। এই রূপ পত্র সম্প্রতি আর প্রচলিত নাই; অথচ এতাদৃশ কেবল-মাত্র-বিদ্যানুরাগী সাময়িক পত্র যে জনসমাজের হিতকর ও আদরাস্পদ বটে তাহা বিবিধার্থ-সংগ্রহের নিরবচ্ছিন্নতায় নিশ্চয় বোধ হইতেছে। পুরাবৃত্তের আলোচনা, প্রসিদ্ধ মহাত্মাদিগের উপাখ্যান, প্রাচীন তীর্থাদির বৃত্তান্ত, স্বাভাবিক রহস্য-ব্যাপার ও জীবসংস্থার বিবরণ, খাদ্য-দ্রব্যের প্রয়োজন, বাণিজ্য-দ্রব্যের উৎপাদন, নীতি-গর্ভ উপন্যাস, রহস্যব্যঞ্জক আখ্যান, নূতন গ্রন্থের সমালোচন, প্রভৃতি নানাবিধ বিষয়ের আলোচনায় উক্ত পত্র অতি অল্পকালে সর্বাতিরিক্ত ব্যক্তির প্রেমাস্পদ হইয়াছিল; এই মাসিক পত্র তদনুকরণদ্বারা তাহার পুরস্কার প্রার্থনা করে। মধ্যে মধ্যে সৃষ্টির সমালোচনে সজ্জনমাত্রের অনুমোদন আছে—সকলেই তাহার আখ্যান শ্রবণে পরিতৃপ্ত হইয়া থাকেন; অতএব তাঁহাদিগের নিকট এই সন্দর্ভ সমাদৃত হইতে পারে। অপর মনুষ্য মাত্রেরই—

Fig 3: The first page of the first issue of Rahasya Sandarbha (1863) (Image Source: http://crossasia-repository.ub.uni-heidelberg.de/914/)

CE), 'Marsupial Animals' (2.14, 1864 CE), 'Racoon' (2.18, 1864 CE), 'Ocelot' (2.20, 1865 CE), 'Chinchillas' (A South American tree dwelling rodent, like old world squirrels, there are two species: *Chinchilla chinchilla* and *Chinchilla lanigera,* 2.20, 1865 CE), 'Chiggers or Berry bugs' (*Trombicula alfreddugesi* and other species, a hard biting arachnid found in the USA, Western Europe and East Asia, 2.21, 1865 CE), 'Deinotherium' (a prehistoric Elephant-like animal, 2.22, 1865 CE), 'Australian frogmouth birds' (Papuan frogmouth, *Podargus papuensis*, 2.23, 1865 CE), 'Coatimundis' (a small mammal found in Central and South American rainforest and Andean slope land, similar to Racoon and Mongoose, genus: Nasua and Nasuella, 3.28, 1922 VKS), 'The Dangerous Insect of Bukhara' (4.40, 1923 VKS), 'Bellbird' (4.43, 1923 VKS), 'Apteryx or Kiwi Bird' (*Apteryx mantelli*, 4.44, 1923 VKS), 'Flamingo' (4.45, 1923 VKS), 'Nilgai' (5.53, 1927 VKS), 'Prehistoric Animals' (5.55, 1927 VKS), 'Dodo' (5.56, 1927 VKS), 'Highflying birds' (5.57, 1927 VKS), 'Strange Prehistoric Animals' (5.57, 1927 VKS),'Pelicans' (5.57, 1927 VKS),'Mocking Birds' (5.58, 1927 VKS), 'Opossum' (5.58, 1927 VKS), 'European Weaver bird or Bottle Tit' (*Cyanistes caeruleus*, 6.61, 1928 VKS), 'Strange Food' (6.64, 1928 VKS),'Mammoth or pre-Historic Elephant' (6.64, 1928 VKS),'Tree climbing Cat' (6.65, 1928 VKS),'Tigerfishes' (African Tiger Fish, *Hydrocynus goliath* and *Hydrocynus vittatus*, but there are other species, 6.66, 1928 VKS), 'Bulbul bosta' (*Sylvia luscinia*, a song bird found in Europe, North Africa, West Asia and Iran, 7.70, 1279 BE), 'Messenger Pigeons' (7.73, 1279 BE), 'Flying Fish' (New Series, 1.2, 1280 BE), 'Whale' (New Series, 1.3, 1280 BE) etc. 'Language of Birds' was serialized from New Series, 1.7, 1280 BE. Good articles on zoology were rare, notable exceptions being 'Locusts' (7.77, 1929 VKS) and one or two more.

There were very few articles on Botany, namely, 'Rubber or Caoutchouc' (1.4, Baiśākha, 1920 VKS), 'Manna Tree' (*Alhagi maurorum*, a spiny-branched shrub, native to Turkey, 2.20, 1865 CE), 'Sea Coconut' (*Lodoicea maldivica*, a variety of coconut endemic to some islands of Seychelles, 2.21, 1865 CE), 'Plantation by grafting' (4.44, 1923 VKS), 'Tea' (4.44, 1923 VKS), 'Physical characteristics of Plants' (5.51, 1927 VKS) and 'Consciousness and Movement in Plants' (5.54, 1927 VKS), the last two being on Plant Physiology. Articles on Agriculture were 'Exhibition on Agriculture' (1.10, Kārtika, 1920 VKS), 'Strange Jackfruit or Breadfruit' (*Artocarpus altilis*, 6.66, 1928 VKS) and 'Cultivation of Cinnamon' (New Series, 1.1, 1280 BE). Among articles on Human Physiology were 'The Brain' (1.2, Phālguna, 1919 VKS) and 'How do we see' (1.5, Jaiṣṭhya, 1920 VKS). Articles on Health & Hygiene appeared for the first time, namely, 'Harmfulness of Tobacco' (5.56, 1927 VKS) and 'Physical Exercise' (Serialized from New Series, 1.4, 1280 BE).

Unlike articles on Zoology and Botany, we can see good quality articles on Physics. For example, 'Echo' (2.22, 1921 VKS). The article is informative as well as well written. Another article titled 'Electricity' (3.34, 1922 VKS) was presented in question-answer form. In another on electricity titled 'Electricity and Electrical Conducting Rods' (New Series, 1.7, 1280 BE), the author discussed the safety measures to avoid electrocution. His article titled 'Natural Sciences' (Naisvargika Vijñāna) was serialised from Rahasya Sandarbha's New Series, 1.2, 1280, BE. In this article while discussing various forces, Rājendralāl dealt upon 'Attractive Force', 'About Chemistry', 'Electricity', 'Magnetic Attraction' etc. There were more articles on Physics, namely, 'Fascinating Mirage' (4.37, 1923 VKS),

'Sea & Its Colour' (5.52, 1927 VKS), 'The Moon' (4.46, 1923 VKS) and 'The Sun' (5.58, 1927 VKS).

Articles on Chemistry, though a few in number, were well written; e.g. 'Sulphur' (4.45, 1923 VKS) and 'Platinum Metal' (4.47, 1923 VKS). In the first article, the author discussed Sulphur ore and properties of Sulphur, while in the second one, extraction of Platinum from its ores, properties of metallic Platinum and its uses have been discussed. Both the articles are of very high standard with correct scientific information and scientific attitude.

In this journal, articles on minerals and mining were less numerous than Vividhārtha Saṃgraha, notable among them were 'Diamond' (1.4, Baiśākha, 1920 VKS), 'Ruby' (3.31, 1922 VKS), 'Quartz' (3.35, 1922 VKS), 'The Diamond Mine of Sambalpur' (4.37, 1923 VKS), 'The Burning Natural Gas Fire of Baku' (4.38, 1923 VKS), 'Petroleum wells of Burma' (7.70, 1279 BE) etc.

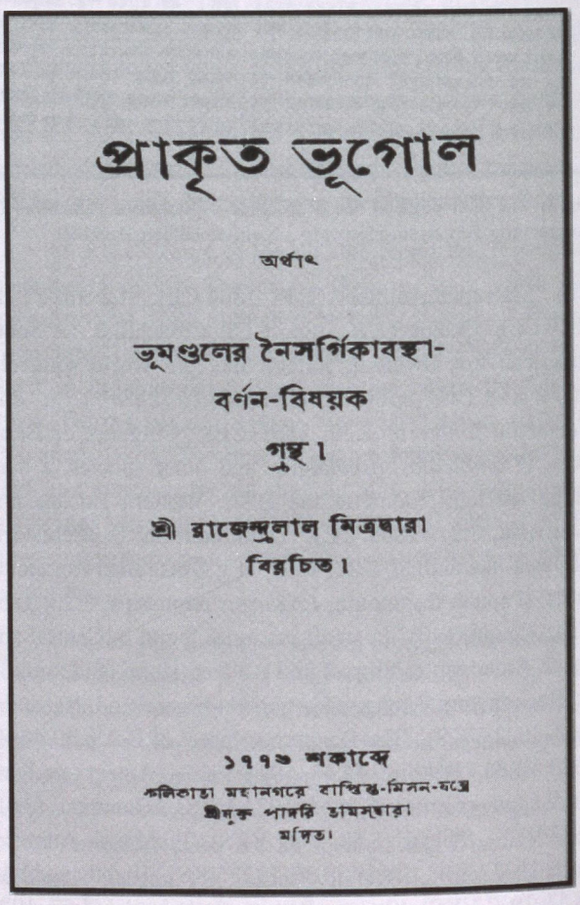
Like Vividhārtha Saṃgraha, Rājendralāl wrote about people of various countries and of different parts of India in Rahasya Sandarbha. They included 'Indigenous People of Australia' (1.12, Pouṣa, 1920 VKS), 'Gypsies' (2.19, 1864 CE), 'People of Kutch' (5.56, 1927 VKS), 'Patuya tribe of Odisha' (5.59, 1927 VKS), 'Description of People of Andaman' (5.59, 1927 VKS), 'Description of African People' (7.73, 1279 BE) etc.

We have mentioned that in Vividhārtha Saṃgraha, Rājendralāl wrote an article on Population of India. The first Census result of India was published in 1872, but the work had started much earlier. In Rahasya Sandarbha too, he wrote two articles on Census, namely 'Total Population of the World' (1.9, Āświna, 1920 VKS) and 'Population of Kolkata' (3.33, 1922 VKS). Other important articles published in Rahasya Sandarbha were 'Childhood of Sir Isaac Newton' (2.17, 1864 CE), 'Paper Currencies of China' (4.40, 1923 VKS), 'Science News' (New Series, 1.11, 1280 BE) etc.

A Pioneer in the Studies of Physical Geography in India[23,24]

Rājendralāl was the first to feel the importance of the study of geography in order to understand history and therefore, he tried to infuse historical elements in geographical research and vice versa. This is evident from his article 'A treatise on Sivaji' published in VS, 4.38, Jaiṣṭhya, 1779 SE, in which he began with four chapters with geographical descriptions e.g. i) Description of Deccan, ii) Description of Gondwana, iii) Description Telangana, Dravida and Karnat and iv) Description of Maharashtra[25].

In case of geographical studies, Rājendralāl was concerned with writing systematic textbooks, preparing atlas in various regional languages and standardising geographical place names and scientific terminologies. Rājendralāl was the pioneer in writing on Physical Geography in India. His seminal book 'Physical Geography or the Description of the Natural Phenomena on the Earth' (in Bengali)[26-28] was published in 1854 (Figure 4). It ran into five editions by 1886. It was essentially a collection of his 18 articles published in Vividhārtha Saṃgraha. In the Introduction, Rājendralāl mentioned that out of the three branches of Geography, namely, Practical Geography (dealing with regional and cultural geography), Mathematical Geography (dealing with latitude, longitude, all measurable parameters, drawing of maps etc. and which, according to the author, is the most difficult branch of Geography) and Physical Geography, the last one is the most interesting. The book presented an elaborate and high quality discussion on Physical Geography. Beginning with an introductory chapter, the Physical Geography section discussed the 'Earth's lithosphere and hydrosphere'


প্রাকৃত ভূগোল

অর্থাৎ

ভূমণ্ডলের নৈসর্গিকাবস্থা-
বর্ণন-বিষয়ক
গ্রন্থ।

শ্রী রাজেন্দ্রলাল মিত্রদ্বারা
বিরচিত।

১৭৭৬ শকাব্দে
কলিকাতা মহানগরে বাপ্তিষ্ট-মিসন-যন্ত্রে
শ্রীযুক্ত পাদরি ডামস্দ্বারা
মুদ্রিত।

Figure 4: The title page of Rājendralāl Mitra's book 'Physical Geography or the Description of the Natural Phenomena on the Earth' (Image Source: https://archive.org/details/in.ernet.dli.2015.357417)

(VS, 2.19, Āṣāṛha, 1775 SE), 'Creation of mountains' (VS, 2.20, Śrāvaṇa, 1775 SE), 'Earthquake', 'Volcanoes' (both VS, 2.21, Bhādra, 1775 SE), 'Land Erosion by Water Currents' (VS, 2.22, Āświna, 1775 SE), 'Land Erosion and Formation of Land by Water Currents', 'Earth's landforms' (both VS, 2.23, Kārtika, 1775 SE), 'Ocean Water', 'Ocean Current' (both VS, 2.24, Agrahāyana, 1775 SE), 'Climatic Variations' (3.27, Jaiṣṭhya, 1776 SE), 'Origin & description of Rivers', (VS, 3.25, Caitra, 1775 SE), 'Description of Lakes', 'Description of Wind-flow' (both VS, 3.26, Baiśākha, 1776 SE; in the second article the author also discussed Ferrell's Law with diagrams), 'Rainfall' (Vol 3, Issue 28, Āṣāṛha, 1776 śaka), 'Ice sheets on the Earth' (VS, 3.29, Śrāvaṇa, 1776 SE) etc. The book also discussed 'Plants in different countries' (VS, 3.30, Bhādra, 1776 SE), 'Animals of different countries' (VS, 3.31, Āświna, 1776 SE) and 'People of different countries'. The presentation is scientific and informative. At the end of the book, a Glossary of Geographical terms was appended, which was very helpful.[29,30]

His other important articles on geography are 'Origin of the Ganges' (VS, 2.21, Bhādra, 1775 SE), 'Dust rain' (VS, 5.55, Kārtika, 1780 SE), 'Waterfalls' (VS, 5.57, Pouṣa, 1780 SE), 'Icebergs and Glaciers' (VS, 6.65, Bhādra, 1781 SE), 'Khāmsin' (A dry, hot, sandy local wind affecting Egypt and the Levant, RS, 5.50, 1927 VKS), 'Weather forecast' (RS, 5.59, 1927 VKS) and 'The Swamp Land' (RS, 6.62, 1928 VKS)[31,32].

Rājendralāl was the pioneer of thematic mapping in India. He was the first to prepare a Bengali map in 1850 and to make the first globe with Bengali characters in 1857. Between 1853 and 1855, he prepared maps of India in Hindi and Urdu and also a map of Asia in Persian for the government of Oudh. During the same period, at the request of the Governor of North-West Frontier Provinces (NWFP), he prepared an 'Atlas of NWFP' in Hindi and Persian scripts. With his initiative, Calcutta School Book Society published a few maps in Bengali. Rājendralāl himself prepared maps of districts of Bengal, Bihar and Odisha in Bengali. His 'Atlas of Bengal Presidency' or 'Bengal Atlas' was published in 1871. It contained a series of 21 maps of various districts of Bengal based upon Revenue Survey maps and various Government records. Under the patronage of Sārasvat Samāj (which he cofounded with Jyotirindranath Tagore in 1882 and of which he was also the President), Rājendralāl compiled a draft glossary of Geographical terminologies in Bengali. The terminology 'Mānacitra' for Map was first coined by Rājendralāl[33,34]. Rājendralāl explained, 'Map comes from the Latin 'Mappe'- a Napkin, and 'Mānacitra' from Māna (measure) and Citra (drawing)-for the compound meaning- a drawing on scale'[35].

To create interest about geography among children, Rājendralāl described diverse lands and places e.g. 'Description of Kamchatka' (VS, 1.8, Baiśākha, 1774 SE), 'Description of Kutch', (VS, 1.11, Bhādra, 1774 SE), 'Description of New Zealand' (VS, 1.12, Āświna, 1774 SE), 'Description of Kashmir' (VS, 2.14, Māgha, 1774 SE), 'Ellora Caves' (VS, 2.15, Phālguna, 1774 SE), 'Lanka Island' (VS, 2.16, Caitra, 1774 SE), 'Description of Delhi' (VS, 2.16, Caitra, 1774 SE), 'Salsette Island' (VS, 2.17, Baiśākha, 1775 SE), 'Prayag'(VS, 2.19, Āṣāṛha, 1775 SE), 'Kanpur' (VS, 2.21, Bhādra, 1775 SE), 'Description of Persia'(VS, 2.23, Kārtika, 1775 SE), 'Description of Utkal country (Odisha)'(VS, 3.26, Baiśākha, 1776 SE), 'Sandwich Islands' (Hawaiian Islands)(VS, 3.30, Bhādra, 1776 SE), 'Currency of African countries' (VS, 3.36, Phālguna, 1776 SE), 'On the City of Srīkṣetra' (Puri, VS, 4.40, Śrāvaṇa, 1779 SE), 'Description of Java' and 'The Leaning Tower of Pisa' (both 4.42, Āświna, 1779 SE), 'Ajanta Caves' (VS, 5.55, Kārtika, 1780 SE), 'A visit to the Alps'(VS, 5.58, Mgha, 1780 SE), 'Description of Wallachia & Moldavia'(VS, 6.61, Baiśākha, 1781 SE), 'Description of Egypt' (VS, 7.75, Āṣāṛha, 1783 SE), 'Moscow' and 'Algeria' (both VS, 7.79, Kārtika, 1783 SE), 'Description of New Zealand' (RS, 1.6, Āṣāṛha, 1920 VKS), 'Description of Utkal country' (RS, Serialized from 1.5, Jaiṣṭhya, 1920 VKS; it is different from another article published on Odisha in VS), 'The Buddha Statues of Bamiyan' (RS, Serialized from 1.7, Śrāvaṇa, 1920 VKS), 'Description of Polynesia' (RS, 1.8, Bhādra, 1920 VKS), 'Description of Greenland' (RS, 1.8, Bhādra, 1920 VKS), 'Description of Iceland' (RS, 1.11, Agrahāyana, 1920 VKS), 'Description of Jaipur State' (RS, 2.17, 1864 CE), 'Sambar Lake' (RS, 2.20, 1865 CE), 'Guyana Province' (RS, 2.23, 1865 CE), 'City of Baghdad' (RS, 3.26, 1922 VKS), 'The Floating Garden of Mexico' (RS, 3.26, 1922 VKS), 'Agra' (RS, 3.29, 1922 VKS),'Etawah' (RS, 3.30, 1922 VKS), 'Karnat' (RS, 3.32, 1922 VKS), 'Singapore' (RS, 3.33, 1922 VKS),'Vijayanagar' (RS, 3.26, 1922 VKS), 'Canara State' (RS, 3.34, 1922 VKS), 'Niti-pass of the Himalayas' (RS, 3.36, 1922 VKS), 'Tanjore State' (RS, Vol 4, Issue 39, 1923 VKS), 'Travancore State' (RS, 4.1 40, 1923 VKS), 'Bombay' (RS, 4.41, 1923 VKS), 'Bhubaneswar town' (RS, 4.42, 1923 VKS), 'Bhopal State' (RS, 4.43, 1923 VKS), 'Arakan' (RS, 4.45, 1923 VKS), 'Description of Arabia' (RS, 4.45, 1923 VKS), 'Mathura' (RS, 4.47, 1923 VKS), 'Nepal' (RS, 4.47, 1923 VKS), 'Dwarka' (RS, 5.49, 1927 VKS), 'Rampur State' (RS, 5.51, 1927 VKS), 'Garh State (Chhattisgarh) and Rani Durgāvatī' (RS, 5.52, 1927 VKS), 'Chicago City' (RS, 7.69, 1279 BE), 'The Temple of Ceylon' (RS, 7.72, 1279 BE), 'Shwedagon Pagoda' (RS, 7.73, 1279 BE), 'Tajmahal' (RS, New Series, 1.3, 1280 BE),

'Assam' (RS, New Series, 1.4, 1280 BE), 'Barcelona City & Port' (RS, New Series, 1.5, 1280 BE) and 'Mahavalipuram' (RS, New Series, 1.9, 1280 BE)[36,37].

Biographies of explorers were also published, namely, 'Life of Columbus' (VS, 4.48, Caitra, 1779 SE), 'Life of Captain Cook' (VS, 5.57, Pouṣa, 1780 SE) and 'Life of Mungo Park' (VS, 6.69, Pouṣa, 1781 SE). To entertain his readers, Rājendralāl, based on the German writer Rudolf Erich Raspe's 1785 book *'Baron Münchhausens Erzählung über seine wunderbaren Reisen und Feldzüge in Russland'* (Baron Munchausen's Narrative of his Marvellous Travels and Campaigns in Russia), wrote 'Baron Munchausen's Narrative of his Marvellous Travels' (VS, 4.42, Āświna, 1779 SE)[38,39].

An Emphasis on Applied Sciences[40]

Rājendralāl Mitra was a prominent leader of the movement for applied science and technology. He was perhaps the first of the 19th century thinkers to lay emphasis on the applied sciences. In 1854, he wrote an article in Vividhārtha Saṃgraha titled 'Introduction to Technology' (VS, 3.33, Agrahāyana, 1776 SE). His book 'Śilpik Darśan' or 'Industrial Science' was published by Vernacular Literature Committee in 1860. The book had 18 chapters. In the foreword, the author informed that in response to the request of some people, the book was published as a compilation of articles published in Vividhārtha Saṃgraha, such as 'Indigo production process' (1.7, Baiśākha, 1774 SE), 'Making of Shawls' (2.13, Pouṣa, 1774 SE), 'Methods of production of Silk' (2.14, Māgha, 1774 SE), 'Methods of production of Opium' (2.20, Śrāvaṇa, 1775 SE), 'Methods of production of Salt in Tamluk factory' (3.25, Caitra, 1775 SE), 'Artificial Pearl' (3.30, Bhādra, 1776 SE), 'Making of Printed Cloths' (4.45, Pouṣa, 1779 SE), 'Process of Lamp-making' (4.48, Caitra, 1779 SE), 'Sugar production methods' (5.50, Jaiṣṭhya, 1780 SE), 'Narcotics: Tobacco' (5.58, Māgha, 1780 SE), 'Narcotics: Bhang, Charas, Marijuana and Cannabis' (5.59, Phālguna, 1780 SE), 'Method of Cleaning Hides' (5.60, Chaitra, 1780 SE) etc. in addition to articles on Rocky Coal, Iron etc. which we have mentioned earlier. The author also informed the readers that except for the article on Coal, other articles were written by one particular author, presumably by Rājendralāl himself, and as no single person could have such diverse knowledge, there was possibility of factual inaccuracy[41,42].

Other articles on technology and technological wonders were 'The Tunnel under the River Thames' (VS, 1.4, Māgha, 1773 SE), 'Junk' ships of China' (VS, 1.6, Caitra, 1773 SE), 'Llama and Alpaca clothes' (VS, 1.10, Śrāvaṇa, 1774 SE), 'Mode of building River Bridges' (VS, 2.24, Agrahāyana, 1775 SE), 'Railroad' (VS, 6.62, Jaiṣṭhya, 1781 SE), 'Lighthouse' (VS, 6.63, Āṣāṛha, 1781 SE), 'Glass Utensils' (The author has discussed the glass making techniques and its history in detail, RS, 2.15, 1864 CE), 'Methods of Making of Glass Tumbler' (Very detail, RS, 2.16, 1864 CE), 'Methods of Decoration of Glass' (RS, 2.17, 1864 CE), 'Roses & Itr' (RS, 2.18, 1864 CE), 'Chinese Silk' (RS, 3.29, 1922 VKS), 'Pearl' (RS, 3.30, 1922 VKS), 'Matches' (RS, 3.35, 1922 VKS), 'Wool from Merino Sheep' (RS, 4.45, 1923 VKS), 'Metallic Wires & Threads' (RS, 5.49, 1927 VKS) and 'Paper' (RS, New Series, 1.7, 1280 BE)[43,44].

Alok Ray has discussed why this great scholar embarked on discussing these apparently petty topics when he himself had no first-hand knowledge about them. Perhaps, Ray feels, Rājendralāl could not overlook the public enthusiasm about science and technology and large numbers of small scale industries that started coming up in Bengal after 1850s[45]. There were demands from the society too, as Biswas (2012) has put, *'Lahore Literary and Scientific Institution founded in 1854 and the Lahore Chronicle pleaded for 'more electricity, electric telegraph, steam engine, geology' The Hindu Patriot wrote on 6 April 1854: "The resources of the country will never be developed unless the children of the soil learn the way to develop them". ..... He (Rājendralāl) described in The Morning Chronicle 22 April 1854 how 'the ancient system of confining the cultivation of industrial art to particular classes, and those the least educated in the community, constituted the barriers to progress.'*[46]

In 1854 Rājendralāl founded (in collaboration with Colonel H. Goodwyn, a British military engineer), 'The Society for the Promotion of Industrial Arts' and subsequently 'The School of Industrial Arts (SIA)'. In 1855, the SIA sought Governmental aid 'to arrange instructions on the arts of engraving, modelling, printing, architectural design, ornamental pottery and porcelain manufacture etc., so as to open new branches of employment for middle and educated classes'. Later, photography and lithography were added to it and the school was re-named as the 'Government College of Art and Craft'[47,47a].

Importance of Visuals and Photography[48-50]

Rājendralāl Mitra was among the first Indians to understand the increasing value of the visuals and photography in scientific publications. To supplement his creative imagination, he cultivated technical skill in reproductions of lithographs and paintings that resulted in the publication of Vividhārtha Saṃgraha with a strong visual component in 1851 when photography was a

relatively new technique. Almost all articles of this magazine (and of Rahasya Sandarbha too) were accompanied with graphic or photographic illustrations. Vividhārtha Saṃgraha was indeed the first illustrated magazine of its kind in India.

Rājendralāl Mitra took great interest in Photography and he was among the early Indians who foresaw the importance for the photography in scientific and other researches. He was the founder member of Photographic Society of Bengal in 1856. Next year he became its treasurer. Soon, he started a journal of the Society and himself contributed five articles in the first three issues, including translations of French essays from Le Pays and La Lumière. However, this predominantly European organization (comprising professional photographers, amateurs and army officers) expelled Rājendralāl from the Society following his comments on Ilbert Bill and the indigo planters, only to readmit him within a few years. Rājendralāl continued his role of advisor on interpretation and understanding of photographs. We do not know whether Rājendralāl took any of the photographs that substantiated his work, he certainly took great care in selecting and arranging those that were to accompany his writings, often being in personal touch with the photographers.

Vernacularization of Scientific Terms

Creating a Scientific Glossary in Bengali was an important issue in the 19th century. This was more important in the light that Medical courses and other science courses were taught in Vernacular medium too. At the same time, communicating science to the public in a non-technical language was a challenge to the science writers. In the inaugural issue of Vividhārtha Saṃgraha, Rājendralāl Mitra addressed this issue and outlined his own solution, *'There is a great chance that the experts will be displeased with our way of writing, but I trust that they will keep in mind the purpose of the periodical, and forgive us. So that common people have easy access to knowledge, so that the trader and the shopkeeper can learn about the world in the little time they have from the pursuit of their professions, so that girls and boys can extend their knowledge as they read this periodical as part of their games or even as a book of stories, so that the youth can put aside sensually exciting books and take interest in useful things, so that the aged can engage in serene discussion of good things, we have tried to create a periodical that will fulfil these aims and we take the fulfilment of this aim as our bounden duty. The learned wise ones can easily understand colloquial and impure mixed language, but pure language, that is, 'sādhu bhāṣā', and any deep meaning precepts imparted in it, will be difficult for untutored people to grasp. Hence, the adequate clothing of language for this periodical is the adulterated colloquial language that is used in conversation in civilised society'*[51].

Bose (2006) elaborates the situation, *'It was not easy to present to the reader the various subjects of scientific knowledge and learning in simple language. In the initial stages of the dissemination of scientific knowledge, there were no Bengali equivalents for scientific terms, ... there were many debates about definitions, as well. So dissemination of scientific knowledge meant the preparation of language for this purpose. Many people accepted the fact that this language should not be limited, that its treasury of words should be continuously replenished, especially when novel subjects were being written about in Bengali. What the language of a periodical should be, whether it should be generally acceptable to all, whether it was possible for the periodical to fulfil its aims by using such a language, and whether the language was able to express the complexities of the subject being discussed-these were the issues that Rajendralal Mitra, as an editor, had to consider in detail'*[52].

In his articles in Vividhārtha Saṃgraha and Rahasya Sandarbha, Rājendralāl consistently used Bengali names of animals, birds, plants etc., many of which were his own translations and in most cases they are difficult to identify in the absence of a standard vocabulary of scientific terms in the mid-19th century. Rājendralāl made the situation worse for his readers by not providing English synonyms in the brackets, perhaps it was not the practice of the day. During 1850s and 1860s, modern Bengali prose styles were evolving in the hands of Vidyasagar and others. Rājendralāl himself was also an important contributor, though his prose style did not survive. The patriotic intellectual in him prompted him to create Bengali equivalent of all English terms, but in course of time, Rājendralāl perhaps felt the difficulties of his readers. He took up a more liberal stand on translating Western scientific terms into Bengali and launched a massive translation programme with a pragmatic approach. In his book 'Physical Geography', he stressed on the uniformity of translation and spelling in Indian languages in case of Geographical place names like Peshawar or Geographical terms such as Peninsula, Strait etc[53].

In 1871, Govt. of Bengal constituted a committee for preparing the norms for writing Medical texts in Bengali for Calcutta Medical College. Rājendralāl expressed his

opinions as a member of the committee, which was later published as 'A Scheme for Rendering of European Scientific Terms in India' (1877). Rājendralāl opined against the literal translation of Western scientific terms into Indian languages like 'the copying of Chinese characters'. He rather preferred either to retain the original Western term in transliterated form or to continue with existing Indian words or to adopt a hybrid word compromising the sense and meaning to a certain extent. Whenever there is a need to create a scientific term in Bengali or any other Indian languages, Rājendralāl was in favour of borrowing words from Sanskrit. However, Rājendralāl felt that though in case of literature, freedom of the translator may be allowed, but in case of Scientific texts, a set of rules must be formulated; otherwise, there would be non-uniformity and chaos in definitions and scientific descriptions[54]. In the 19th century, stalwarts of Bengal Renaissance dreamt of a resurgent India where higher education would be possible in Indian languages. In Calcutta Medical College, courses were taught in both English and Bengali since 1852, and there was high demand for Bengali terminology of European terms. Rājendralāl tried to accomplish this through Sārasvat Samāj. Only a scholar of his calibre and repute was capable of doing this[55].

Promoting a Scientific Temper in the Society

Unlike his contemporaries e.g. Ishwarchandra Vidyasagar, Young Bengals or leaders of the Brahmo Samaj, Rājendralāl Mitra was not a social reformer. Like the 'Penny Magazine' of Charles Knight, whose form and philosophy Rājendralāl followed, his emphasis was not on 'changing the world' but on 'understanding it'. Yet he fought the social evils in his own way, much like his mentor Akshay Kumar Datta, through the propagation of science and creating not only a Science Awareness in the society, but also nurturing a Scientific Temper in the society.

Amitabha Ghosh[56] cited young Satyendranath Tagore's (elder brother of Poet Rabindranath Tagore and who later became the first Indian to qualify for the prestigious Indian Civil Service) article 'Baconian system of Philosophy' (VS, 4.47, Phlguna, 1779 SE). Francis Bacon (1561-1626), the British statesman and a contemporary of Galileo, stressed upon the importance of inductive logic, natural observation and experimental evidences as the prerequisites for useful sciences as opposed to Socrates, Aristotle and Plato, who propounded the idea of science as pure thought. Satyendranath Tagore did not discuss Plato, but much later Rahasya Sandarbha published the biographies of Socrates, Aristotle and Plato, where Rājendralāl wrote *"Plato propagated the doctrines of Socrates and those doctrines were analogous to the Vedantic ones in our country. That is to say, Plato was the Śankarācārya of Greece"* ('Life of Plato', RS, 5.53, 1927 VKS)[57].

Rājendralāl was consistent in his battle against superstitions, social prejudices and occult. In a number of articles published in Vividhārtha Saṃgraha and Rahasya Sandarbha, he ridiculed social evils such as Kaulinya Prathā and polygamy, child marriage, Ganga-Yātrā, Antarjali (abandonment of a dying patient on the banks of the Ganges) etc. In an article on Superstitions and Traditions (RS, 1.12, Pouṣa, 1920 VKS) the author wrote: *"Born out of the wedlock of Dread, the groom, and Ignorance, the bride, Superstition had her birth shortly after the world was created. Wed to local customs, she in turn gave birth to Myth, her son"* (translation taken from Arun Kumar Biswas)[58,59].

Much like his illustrious contemporary, Vidyasagar, Rājendralāl was an uncompromising crusader against all that is regressive in our tradition. Cleaning of hides and tanning of leather are generally considered as a lowly job in India and is generally performed by the people in the lowest strata of the society and people of the higher echelon of the Hindu society abhor this profession. However, in Vividhārtha Saṃgraha (5.60, Caitra, 1780 SE)[60] Rājendralāl mentioned that *'Man has been using leather from prehistoric time; there are references about the use of leather in Ṛg Veda and other ancient texts and it is not unnatural.'* Similarly, in Rahasya Sandarbha (6.65, 1928 VKS)[61], Rājendralāl wrote, *'Nowadays all the Hindus look down upon leather as an unholy substance, but in Ṛg Veda there are references to skins of cattle, water bags made of leather, wines being stored in leather containers'.* Similarly, he tried to dispel the prejudices and misconceptions prevailing in the Hindu society about beef eating in his seminal article, 'Beef in Ancient India' (Journal of the Asiatic Society of Bengal, 1872, later incorporated into 'Indo-Aryans'.)[62]. Thus S. K. Saraswati commented, *"He was the first Indian to challenge the sanctity of tradition, break away from its entangling meshes and establish the need for scientific objectivity in Indian historical thinking"*[63,64].

It is interesting to note that, though he was a leading Indologist, Rājendralāl, unlike the Vedantists of the 19th century, was not a revivalist. In the words of Gunderson[65], *"He had few illusions about the past, and unlike Tagore, did not suppose that it could provide a model for the present. When it was proposed to add Sanskrit to the list of subjects examined by the University of Calcutta, Mitra*

led the opposition in the University Senate. Himself a leading Sanskrit scholar, he declared that Sanskrit was a dead language and of no use to modern students. What they needed was knowledge of the English language and a western education." Rājendralāl, as we understand, was a man with true Scientific Temper.

An Assessment

Rājendralāl Mitra's scholarly qualities were widely appreciated even during his lifetime. Commenting on Rājendralāl, noted German Indologist Prof. Max Müller wrote in 1868, '*He has edited Sanskrit texts after a careful collection of manuscripts, and in his various contributions to the Journal of the Asiatic Society of Bengal, he has proved himself completely above the prejudices of his class, freed from the erroneous views on the history and literature in India in which every Brahman is brought up, and thoroughly imbued with those principles of criticism which men like Colebrook, Lassen and Burnouf have followed in their researches into the literary treasures of his country. His English is remarkably clear and simple, and his arguments would do credit to any Sanskrit scholar in England*'[66,67].

Rājendralāl Mitra was born and brought up in a society that embraced the Western education and modern science with a hope of building a new India empowered with Western knowledge, particularly that of Science, Technology, Western Medicine, Western Literature & Philosophy and Modern Political Science, which would help develop a progressive social order in India, liberated from the age old conservatism and superstitions. The leaders of this liberation movement intended our children to be empowered with the knowledge of modern Science, so that they could challenge the Europeans intellectually[63].

Historians have highlighted the role of English education, development of modern Bengali Literature and a series of Social Reform Movements as the catalysts for the 19th Century Bengal Renaissance, but generally overlooked the role of Science and Science Communication, particularly the contribution scientists and science enthusiasts in this regard that includes Ishwarchandra Vidyasagar, Akshay Kumar Datta, Rājendralāl Mitra, Radhanath Sikdar, Father Eugene Lafonte, Mahendralal Sircar, Nawab Abdul Lateef, Bhudeb Mukhopadhyay, Krishna Mohan Bandopadhyay, Bankimchandra Chattopadhyay, JC Bose, PC Ray, Chunilal Bose, Sir Ashutosh Mukherjee, Upendrakishore Ray Chowdhury, Ramendrasundar Tribedi, Jagadananda Ray and others. Outside Bengal, Sir Syed Ahmad Khan's 'Aligarh Scientific Society' (1864), Maulana Imdad Ali's 'Bihar Scientific Society' (1868) and individual efforts by Bal Shastri Jambhekar in Pune, Master Ramachandra in Delhi, Ruchiram Sahni in Punjab and others made significant contributions to public science communication. Among this galaxy of the patriotic intellectuals, Rājendralāl Mitra's contribution was perhaps the highest, the popularity of Vividhārtha Saṃgraha among all sections of the society is a testimony to this[69].

Long after the death of Rājendralāl Mitra (1891), Rabindranath Tagore reminisced him in his 'Jībansmṛti', hailing Rājendralāl a 'Sabyasācī' (all-rounder) and an 'Institution by himself'. To quote from Tagore, *'Rājendralāl Mitra mahāśay used to publish a picture-filled monthly called Vividhārtha Saṃgraha. A bound collection of this lived in sejdādā's cupboard. I had got hold of it. I still remember the pleasure of reading the*

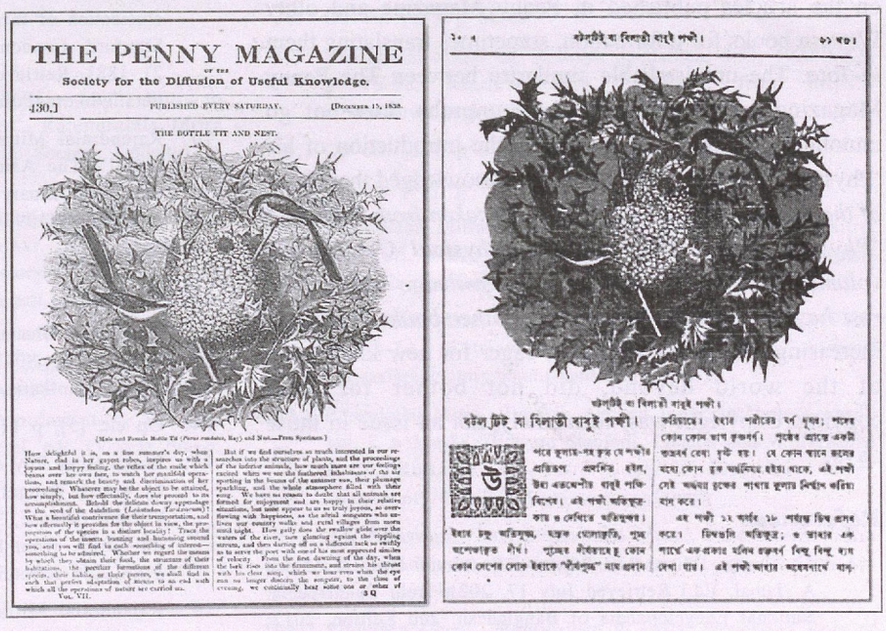


Fig 5: The Unmistakable Similarity between 'The Penny Magazine' (left) and 'Vividhārtha Saṃgraha' (right)
(Image Source: The Penny Magazine of The Society For The Diffusion of Useful Knowledge 1838, Issue 430, December 15, 1838, pp 481 & http://crossasia-repository.ub.uni-heidelberg.de/451/)

book again and again clutching that large square book to my chest. I stretched out on the bed in my room reading accounts of the Narwhal whale or the curiosities of justice as administered by the Qazis of old days, or the romantic story of Krishna-kumari etc. spending many a holiday afternoon. Why is there not even one such publication anymore?' (trnaslation taken from Arun Kumar Biswas, 2012)[70].

Tagore further elaborated the role of Vividhārtha Saṃgraha in Jībansmṛti, '*In England, the periodicals such as Chambers' Journal, Castle's Magazine, Strand Magazine etc. are communicating knowledge at the popular level; and such simplified knowledge communication is particularly useful to the common public*'[71].

Rājendralāl was a voracious reader and his Encyclopaedic mind helped him find out and reproduce highly interesting facts about the animal and plant life, physics, chemistry, astronomy, the Earth's lithosphere and atmosphere, geography, countries, places and people from different parts of the world and what not! While discussing the content of the Vividhārtha Saṃgraha in the early 20th century, Tagore lamented the absence of *'unpretentious miscellanies which the ordinary person can read in comfort';*[71a] and the list of miscellany is fascinating: how many of our students of today have heard of 'Aye-aye' or 'Coypus' or 'Coatimundis'? Rājendralāl depended heavily on the articles published in Penny Magazine and other Western books for information, sometimes translating them *in-Toto*. The unmistakable similarity between The Penny Magazine and the Vividhārtha Saṃgraha does not go unnoticed (Figure 5). Similarly, in the introduction of his 'Physical Geography', Rājendralāl acknowledged that *'Most of the content of this book have been taken from Johnson's 'Physical Atlas' and from the 'Physical Geography' volume of the 'Library of Useful Knowledge' series. The rest have been taken from several other books'*[72]. But an increasingly literate population, eager for new knowledge of the world beyond, did not bother for such copying. Copyright was, fortunately, not an issue in those days. ❐

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Abbreviations used

Vividhārtha Saṃgraha	VS
Rahasya Sandarbha	RS
Volume (numeral) and Issue(numeral)	Volume. Issue (in numeral)
Śaka Era	SE
Vikram Saṃvat	VKS
Bengali Era	BE
Current Era	CE

Note by the Editor-in-Chief: Dr. Rajendralal Mitra was born on 16th February 1822. Publishing this paper is a homage to him to mark the 200th birth anniversary of the first Indian President of the Royal Asiatic Society of Bengal in 1885, on behalf the Editorial Board of Science and Culture and also of the Council of the Indian Science News Association, Kolkata. Dr. Mitra made significant contributions to the public science communication and also taking bold initiative in creating a scientific temper in the society. He launched the first illustrated Bengali monthly magazine *"Vividhartha Samgraha"* in 1851 and acted its editor for first six volumes containing articles on various scientific and educative topics related to zoology, geography, geology, chemistry, botany, astronomy and also physics. Dr. Mitra was regarded as ***"The Most Learned Man during the Bengal Renaissance"*** .

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INDIAN ARCHAEOLOGY IN NEED OF RENAISSANCE

PHANI KANTA MISHRA*

Archaeology is the less travelled path through which one can reminiscent the past. By definition, archaeology is the study of the past through material remains. Thus archaeology is scientific as well as a social discipline. It incorporates activity involved in the creation of history that may be local, national, or even global in scale and complexity. Archaeologists are usually defined by what they excavate and the subsequent analysis and reporting of their findings. The moment that an archaeologist begins to dig they enter into a whole series of professional and academic obligations. This blog is sort of a manifesto demanding urgent action to safeguard standards in both academic and commercial archaeology accuses the Government of "driving a cycle of decline" by deploying rhetoric that it is claimed risks portraying the profession as "having little value or relevance".

Early Days of Indian Archaeology

From the beginning days of colonial expansion European, orientalises began to take interest in the culture and literature of Asia. As a very first step to investigate the numismatic and epigraphical wealth of India, the Asiatic Society was founded by Sir William Jones in January 1784. Under which a journal containing descriptions of many ancient ruins of India was published. There was, however, no systematic exploration of the antiquarian remains in the country during the early years. In 1848, Alexander Cunningham published a paper in the *Journal of the Calcutta Society,* in which he urged that the Government of India should help in the preservation of ancient monuments by the appointment of a suitable officer. In 1866, under the Viceroy of Lord Mayo, Cunningham was made the Director-General of Archaeological Survey of India. During his tenure of service, he published twenty-one volumes of reports of the Archaeological Survey of India. He was guided in many ways by the English translation of Hiuen Tsang's travels. Cunningham's activities were confined in North Western Provinces and Bihar. In 1874, the activities of the Survey were extended to Western and Southern India. Time passed and the need for systematic archaeological preservation was felt and in 1878 the Indian Treasure trove Act was passed. Following these efforts in 1881 ten folio volumes under the title *Preservation of National Monuments in India* were produced, containing illustrations of some of the most famous monuments. After Cunningham doyens of Indian archaeology like Sir John Marshall, Rakhaldas Banerji, Daya Ram Sahani, Sir Mortimer Wheeler, conducts large-scale and small-scale excavations all over India. The identification of Harappan culture in 1924 and later excavations at Harappan sites in Panjab, Haryana, Rajasthan, and Gujarat by ASI from 1945 to the recent past has established India as a home of the three earliest civilization of the world. Their zeal and determination to know the unknown history helped to build a strong archaeological foundation in India. Archaeology in India has developed as a main function of Govt., as a result, Archaeological Survey of India [hence fourth mentioned as ASI], with a few exceptions of Indian archaeological society and Deccan college of postgraduate research Institute PUNE, held almost a monopoly of archaeological fieldwork in the country. However, after the 90's the glory days of Indian archaeology soon started fading. Very slowly Indian archaeology started developing various problems which resulted in turmoil in Indian history.

Excavation Problems

The excavation is a 'scientific destruction', as a site once excavated cannot return to its original state. This is

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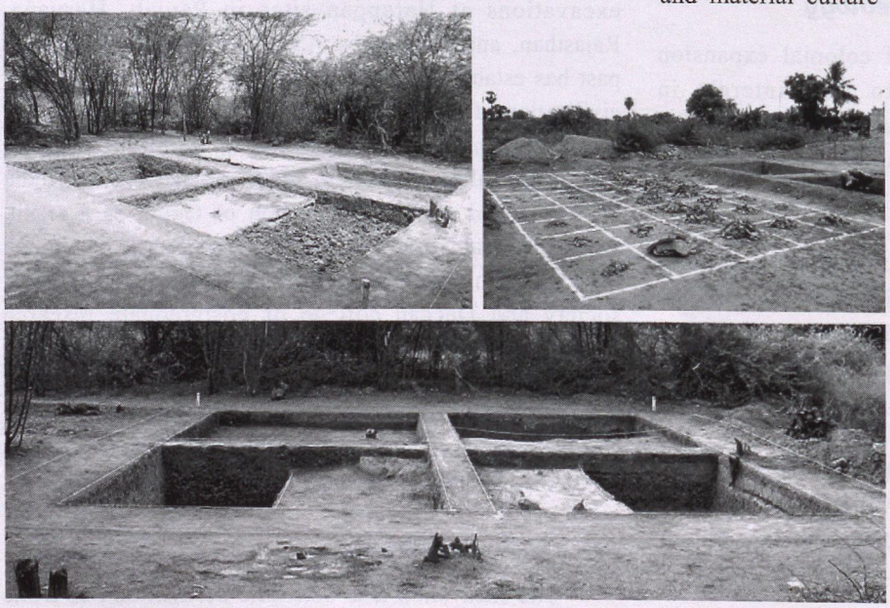
the reason every aspect of any archaeological site needs to be recorded accurately. The screening of the proposal for excavations and exploitation is done by the Standing Committee of CABA which is sent to be approved by DG ASI. After which Licence for exploration and excavations is issued by D.G.ASI under AMSR rules 1959 to the universities, State archaeology, research institutions, ASI and foreign institutions. However In recent times due to mishandling, inexperience, and lack of guidance archaeological site are being dug up without any proper care. Excavation of an ancient site is very slow work and should not be done like digging a well. Each Quadrangle measuring 10x 10 m will have 4 trenches of each measuring 4.50.x.4.50 M, leaving a baulk of 0.50 M. on either side of the trench. Crowbars should not be used in the excavations and the work should be carried out by pickaxes, Knife and bushes. On the discovery of Gold and Silver Coins there in situ photographs, marking the find spot on planned to get this valuable numismatic evidence weighed in the presence of staff at the spot and to send the details and photographs of the find immediately to his Head of Office to avoid later comments. Each finding should be recorded in the Site Note Book along with its drawing. To ensure the standard of excavation, quality of documentation, and report writing, ADG, JDG, and Director EE have to visit the excavations wheher by ASI or other licensed institutions at least twice in a working season.

Lack of Trained Officials

In theory, trained officials of ASI and of state governments, university professors and heritage enthusiast are taking up the responsibility of excavating several archaeological sites scientifically. Howeve3er the reality is far more concerning as presently the standard excavation norms and principles laid down by experienced Archaeologists in India are not strictly followed by the Dept of Archaeology & Museums of several State Governments. There is no properly trained Staff in many State archaeological departments. It is really a pity that there is no control of ASI on excavations conducted by the State Dept of Archaeology and also by few Universities. In order to solve this problem proper recruitment of staffs in ASI, state archaeological department and Universities is required. In ASI half the posts are vacant. However, there are under ASI thus to maintain proper works flow many senior officers are given endless additional charges, which creates hindrance in the proper operation of the organization. The Lack of proper staff will a recurring problem as the process of recruiting assistant archaeologist is sort of a joke. Candidates who have cleared the SSC examination but have no proper training are recruited as archaeologists while properly experienced students of archaeology are given no preference and. These officers treat the excavation and other archaeological works as a job and they very much lack and zeal and admiration noticed in the founding fathers of Indian archaeology. Thus due to the absence of proper training, most of these SSC recruits lack a proper understanding of the complex process of excavation, recording and analysing. They have no idea how to record accurate facts of any excavation like the plan of the site, its stratigraphy, relationships of exposed structures and material culture and precise account of work done. Because of this reason, several archaeological sites are facing irreversible damage and important links of Indian history are getting lost.



Excavation work carried out under the Hon'ble Minister's Announce– Pattaraiperumbudur, Tiruvallur District

The Excavation, not a Vacation

Excavation is quintessentially a team effort. While that the top of the team is the director the day to day works are generally done by the Site supervisor. In a large scale excavation, even he is unable to keep track of every trench. The Excavation Team should consist of Trained Archaeologist, Surveyor for plotting the site on a grid pattern, Draughtsman for preparing

the drawings, Photographer for photographing the site, Pottery Assistant for maintaining Pottery Yard at the site, and Site Supervisor with Post Graduate Degree for each Trench for supervising the excavation. Site supervisors also do works like marking of different layers with excavation knife, for writing Site Note Book. Besides them, it is trainee archaeologists and skilled labours who significantly contribute to the whole process. Thus archaeologist and site Supervisor needs to be punctual, devoted to his duty, honest and should be present at the site at least 15 minutes before the commencement of work so as to mark the muster of the labour. If he himself is not punctual to his duty, he cannot control the labour. The presence of a site supervisor is essential as the labour may unknowingly damage any new evidence. Late coming labourers may not be permitted and they may be asked to go back for maintaining strict discipline at the site. Labour may be allowed to attend their nature calls only at the time of Tea break. Attendance may also be watched when the work is closed for the day in the evening. All necessary facilities may be given to the labour but while on work no lenience should be exhibited at the time of work. Drinking water and the First Aid Box facility should be provided to the labour. The labour should be alerted with the ringing of a bell or gong at the beginning and closing of work daily. Mess facility may be made in the camp with minimum facilities. At the end of work, a meeting of Site Supervisors may be convened leisurely to discuss the proceedings of that day's work and plan for the next day. If permission of CABA is granted to any Agency, it should be mandatory to the Concerned Circle Head to inspect the excavation site periodically and to guide the Excavator in his work The excavation team should stay in the temporary camp at the site or nearer to the site to save their valuable time and energy.

The Drive for Fame and Finding Discovery of the Century

The general bias towards more attractive artefacts to create media, the frenzy is a very common treatment of recent Indian archaeologists. In order to glorify every excavated site archaeologists completely ignore artefacts that are not one of a kind. Because of this the overall narrative of archaeological sites is being changed, making the results of the excavation erroneous. Also, archaeologists of recent times have a tendency of ignoring mediaeval or later period remains which also give rise to unfinished and at times wrong conclusions. Hasty conclusions and cheap publicity gimmicks have put the archaeologist in a spot. It is extremely unfortunate that in India wherein every street we have a one of a kind tangible or intangible heritage flourishing but only a handful of tangible and almost no intangible heritage is listed in the UNESCO world heritage list. Today this official apathy has resulted in only very few Indian sites figuring in the Heritage list, in spite of rich ancient treasures that India houses, while smaller ones, in the west, boast of a much higher number. Add to it, the disinterest of the officials who are rather too preoccupied in petty politics to indulge in anything constructive.

Sever Lack of Multidisciplinary Approach

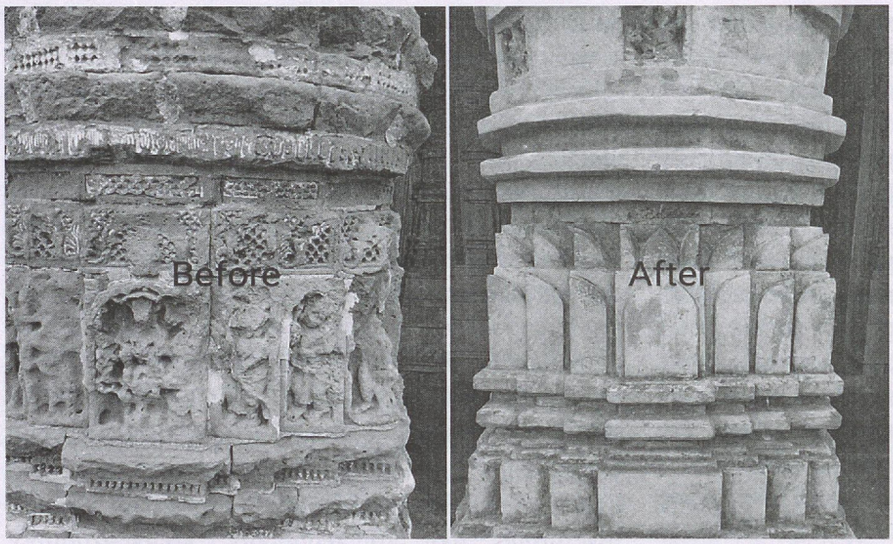
As mentioned before most of the excavations do not follow any scientific protocols. Excavators refrain from participation in a multidisciplinary excavation. Such excavation should include experts from diverse scientific disciplines like archaeobotany, archaeozoology, anthropology, geology, skeletal biology, history etc. Thus sites do not yield the maximum amount of data, which could have been possible from a multidisciplinary approach. Even if in any site a multidisciplinary approach is taken there are very few from where scientifically and systematically archaeobotanical, archaeozoological and dating samples are collected. Thus major excavation agencies need to establish proper scientific branches where trained officials can conduct such academic work.

Post Excavation Works

The creation of a post-excavation inventory and storing them in scientific, systematic storage is as essential as digging up those artefacts. It enables one to take up future reference and to do the post-excavation research work. Also preparation of an inventory of excavated materials in the uniform templates as approved by D.G.ASI under AAT ACT 1972. Yet most of the major excavated sites inventory is not at all maintained. Most of the pottery and sometimes even skeletal remains are stored in an extremely unscientific way. While no proper accession number is given to other artefacts also. It is only justifiable to remove the antiquity from its original context only to make them a heap at a corner of storage.

Lack of Proper Conservation Work

After the excavation artefacts require proper scientific conservation to ensure their longevity. These artefacts are taken out from the state in which they were kept for thousands of years and then come into human contact. So they require certain chemical or structural conservation. So setting up a conservation laboratory with a proper conservationist being in charge is essential. Yet sadly in ninety per cent of Indian archaeological site there are no



Evidences of restoration Rasmondir of Gar Panchkot

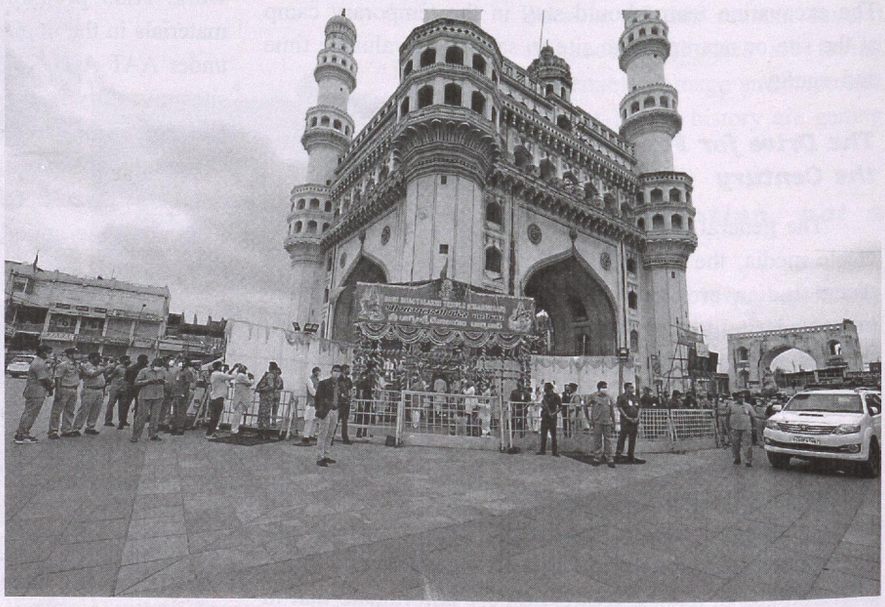
proper arrangements for any sort of onsite conservation. Even in the case of architectural conservation many sites conserved by ASI or State archaeological department have evidence of unethical conservational work which has caused irrevocable damage to historical monuments. Archaeological norms and principles of keeping the ancient monument at its original state are not followed anymore. Many monuments lose their aesthetic and historical value after original structures are changed.

Previously archaeologists were the final authority to decide the Conservation work, but now their role is restricted. Due to this problem sites are being damaged, monuments Conservation is jeopardized as now the modern experts have no experience of Archaeological Conservation. This deterioration is seen in the past 5 years prominently. Structural Conservation is rarely taken up these days. A team of Archaeological conservators should be appointed for such works to safeguard the monuments of the country. All monuments should be documented, digitized to check vandalism, etc. One needs to understand that archaeological conservation is different from building modern monuments. Primarily the building techniques and binding materials of the ancient building are different. The conservators of recent buildings may use cement as a binding material but in an ancient building, a mixture of lime mortar will be proper to use. Every monument needs a breathing space around it to enhance the landscape. Here also the problem of encroachment appears. Around various ancient temples, modern houses and apartments are erected which is almost attached to the temple structure. Unauthorized occupations begin like temporary selling places which gradually turned into permanent structures. Several local temples organizing committee members for their own gain have created this problem. Unless this is curbed at the initial stages, it is hard to evacuate them at a later period. Archaeologists can take the help of a proper administrative body however the administration rarely cares for Indian archaeology.

Due to lack of funds, several buildings under state government or ASI lacks serious conservation work. Even the Dehradun branch of ASI which specialises in chemical conservation restricts their activity in very few endeavors.

Lack of Publication

In Indian archaeology, the biggest problem to date is the irregular publication of excavation reports. Major archaeological sites excavated by eminent archaeologists still lack a proper published excavation report, which is



Encroachment under Char-minar

Magnificent site of Dholavira, the excavation report is still awaiting

extremely unfortunate as the main objective of any excavation is to destroy the site in order to interpret the overall habitation. Although if the report is not published the whole effort of archaeologists the economic imputes given by governments are in vain. Also, the academic loss which is done by destroying a site is currently a sad but true part of Indian archaeology. At a present large number of excavation reports are outstanding from ASI, State archaeology and universities. Even if the reports are published the quality of such writing has considerably deteriorated. Accumulations of pending excavation reports have not only tarnished the image of ASI but also adversely affected the archaeological research in India.

A proper archaeological reports writing should start with academic design, a detailed literature survey of the history of the site and the periods found in it, knowing about the geochronological studies, making of proper site survey, archaeological site map and section drawings. Taking into consideration all the archaeological features to reconstruct the socio, political and religious life. A multidisciplinary study of archaeozoological, archaeobotanical study can give a rare glimpse of ancient dietary, diseases, and day-to-day life.

Lack of Homage to Predecessors

Lastly, it is unfortunate that in Indian archaeology several governmental organizations have failed to pay homage to its seniors who are no longer involved with the organization. The monopoly of excavators who did not prepare and submit their report during their service tenure and made it as a source of their post the retirement benefit is an extremely unfortunate truth of Indian archaeology. For example Ramayana and Mahabharata project, Banawali, Dholavira, Semthan, Sanghol, Hanoi, etc. have been pending despite the facts that a huge amount of funds in crore are spent on these projects for a long. These defaulted are not only obliged by ASI but also honored by Govt. for their laxity. However the eminent archaeologists like A Ghosh, S.R. Rao, Y.D.Sharma, K.V. Sounderrajan, K.V.Ramesh, D.Mittra, Vijay Kanta Mishra, J.P. Joshua had been ignored by ASI. To overcome the above-mentioned problem, it is suggested that the Eminent retired archaeologists who are still willing should be given a proper chance to educate and properly train newcomers so Indian archaeology do not face loss of tangible and intangible heritage. This will indeed improve the quality of excavation but will undoubtedly help in clearing the arrears of pending excavation reports and interim reports. A rule should be strictly imposed that the Excavation Reports should be published within a year after the completion of excavation by either ASI or State Departments or by Universities failing which necessary legal actions should be taken.

Lack of Site Management Plan

Archaeological site and landscape management encompasses a variety of issues and concerns, including conservation, interpretation, sustainable tourism, research, and local community participation. Reactive intervention is not sufficient to ensure the sustainability of the resource, or the needs of contemporary society. Expanding cultural tourism and globalization, coupled with the impact of short-term economic strategies are some of the reasons why integrated and holistic management has become, in recent years, an appealing approach to both the conservation and sustainable use of cultural resources. However in India this the idea is still new and has not been implemented in many the archaeological site. They lack proper conservation and the idea of community involvement is

something very new in Indian archaeology and is mostly not implemented.

Public Archaeology and Indian History:

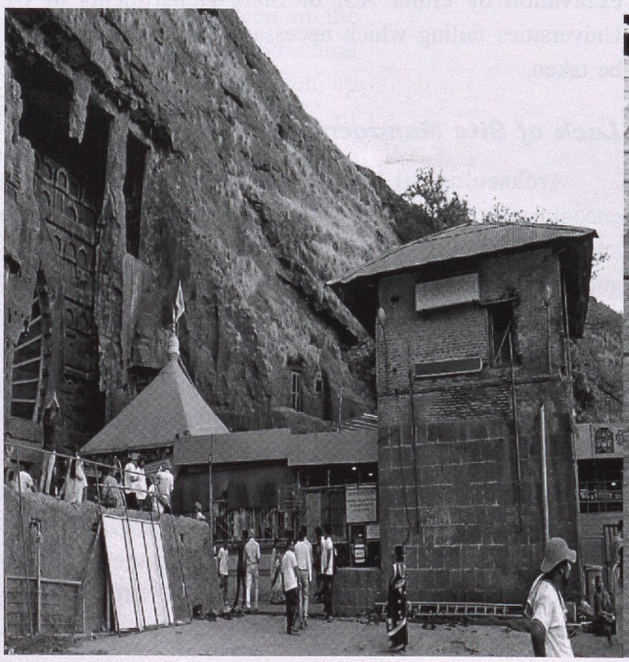
Public archaeology is used to describe archaeology's relationship with the public. It is essentially 'archaeology by the people for the people. According to Uzi Baram (New College of Florida), public archaeology:

- Stimulates public interest in the study of archaeology through the demonstration of archaeological techniques and analyses, workshops, training in excavation and recovery of artifacts and features, site tours, displays, and exhibits, or the development of educational programs and materials
- Promotes awareness of cultural resources and heritage preservation
- Fosters individual or collective efforts to advance the ethical practice of archaeology the scope of public archaeology comprises of many facets.

However, in India, the situation of public archaeology is really poor. Due to lack of awareness Too many mounds/ Land and protected area are encroaching by local people, many people also take away bricks from historical sites, living religious architectures built on the archaeological mounds can cause serious damage due to digging and making illegal construction. Every day there are reports in newspapers about heritage buildings being demolished or ancient buildings getting damaged. While ASI and other state archaeological departments are trying to safeguard our future with the help of public archaeology. One instance of public archaeology is seen in Kerala but rest of the India needs to be more careful about it.

Epigraphical Branch and its Problems

Epigraphy is the study of inscriptions, or epigraphs, like writing; it is the science of identifying graphemes, clarifying their meanings, classifying their uses according to dates and cultural contexts, and drawing conclusions about the writing and the writers. Epigraphy is considered a primary source of information. According to D. C. Sircar, one of the doyens of Indian Epigraphy, "there is no aspect of the life, culture, and activities of the Indians that is not reflected in inscriptions." According to the UNESCO Atlas of the World's Languages in Danger. Every two weeks a language dies with its last speaker. Thus, there is no uncertainty about the fact that the ancient language and script require special attention. As the nature of epigraphy is quite multidisciplinary, it requires a lot of knowledge of scripts, language, textual data, linguistic understanding and there is a gradual decline in the overall interest of students in this subject. Although from the 19th century several erudite scholars have deciphered and published a plethora of inscriptions and the process is still continuing, epigraphy in the Indian subcontinent still possesses a lot of scope for further study. Mysore epigraphy branch has worked has a large collection of stumpage. In twentieth-century many inscriptions were published in several volumes of Epigrapia Indica and corpus inscription indicium. But the institute is silent for many years now.



Numerous stampede brought are kept in office without deciphering it and later ants destroy them.

Broken foundation Stone of Mir Alam Tank in Hyderabad, date 1804

A particular example of the negligence of the Nagpur epigraphy branch of ASI is evident in the fact that the inscription of the Buddha bowl for which experts were sent on government cost to Afghanistan is still not deciphered and published. The ancient Brahmi script is clearly seen and above is an overlap of Persian but Nagpur epigraphist who visited Kabul has not submitted the translated copy even after 8 years have passed. Because of this the bowl is still not declared as the alms bowl of Buddha.

Lack of Underwater and Salvage Archaeological Department

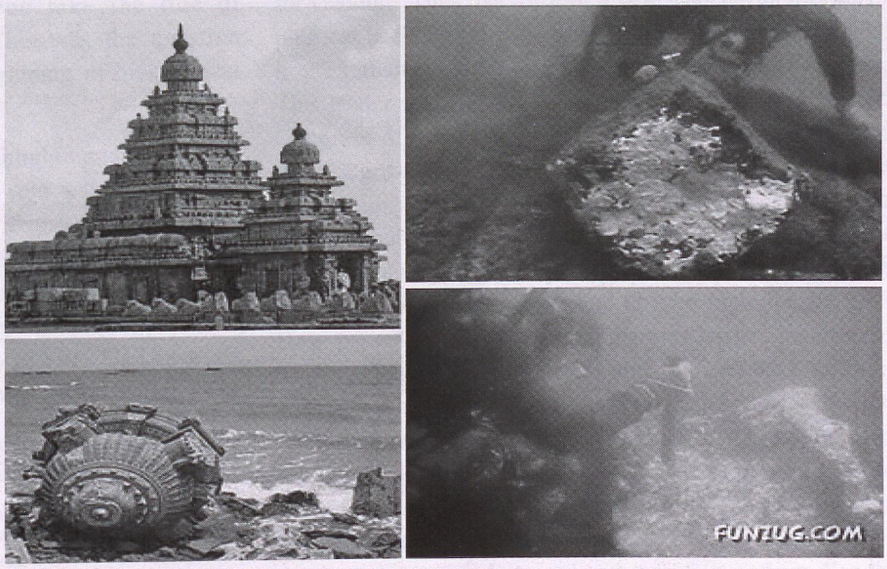
The mandate of the central advisory board of archaeology is to promote archaeological research in India through various means such as the use of science and technology, the introduction of underwater archaeology, and salvage archaeology. There are some wonderful and very scientific examples of an underwater archaeological expedition in India: some being the excavation of Dwarka, the excavation at Mahabalipuram, etc. However, the zeal with which the department started operating soon was lost, and practically for the last few years, it is almost not operating. The same goes for the salvage archaeology situation in India. As the salvage program in Nagarjunikonda is groundbreaking work. Nagarjunikonda a Buddhist site that was at the risk of being submerged is India's first case of Salvage archaeology. The whole site was transferred to a hill however since then there are very

Bowl of Buddha

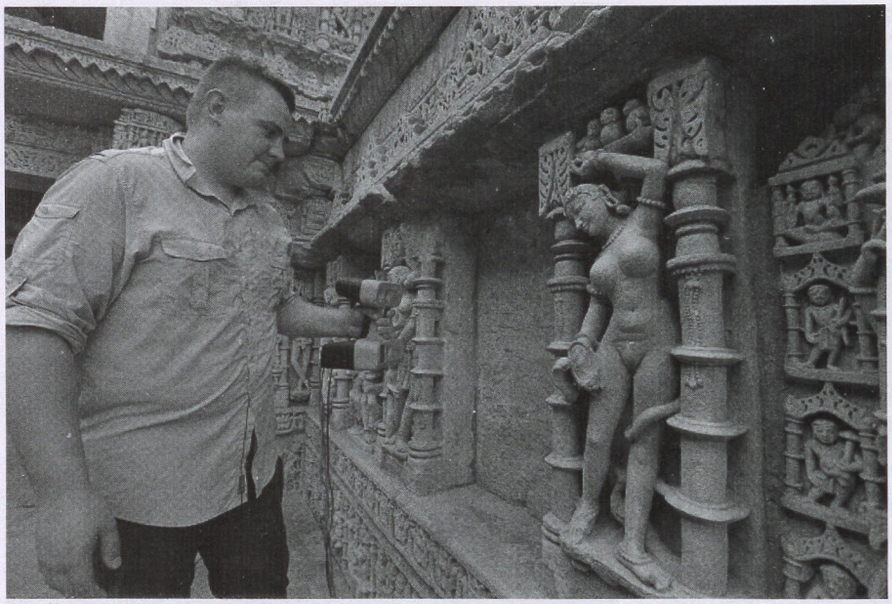
few examples of such wonderful work and activities of such archaeological branch are extremely limited and currently non-existing.

Use of Modern Technology for the Advancement Archaeological Investigation

Modern archaeology relies on technology. The days of surveying with the naked eye and digging random plots are over. Today's archaeologists use soil analysis, lidar scanning, and the Internet of Things to answer questions without damaging artefacts. CT scanning and advanced 3D



Underwater archaeological investigation in India



Artec 3d modelling

modelling are making it possible. For the first time, previously unreadable artefacts can be virtually unrolled to fully see what's inside. This ability has a compounding effect: The more hidden texts archaeologists can uncover, the better they can understand languages and identify patterns in existing materials. However in India due to lack of proper infrastructure, most of the sites refrain themselves from doing these kind of work very few sites use proper modern technology to fully uncover the potentials of the archaeological site.

Conclusion

Archaeology in India is facing something of a perfect storm. We have university departments proposing and enacting cuts and closures, a shortage of archaeologists and a planning process which undermines the safeguards for archaeological remains and our heritage. However these problems are global in nature. Sheffield University in London has announced plans to close its renowned archaeology department due to university cuts, skills shortages and potential planning rules changes which threatens to irreversibly damage the UK's world-leading reputation in the discipline . The terrorist activities in middle east is causing the loss of ancient vestiges. As a concluding remark it should be added that the whole purpose of any excavation is to make provision for the future archaeologists, to have access of information to them. However in recent times it is not happening at all. In India ASI is nowhere near in use of sciences in archaeological investigations compared to world trends and some universities like Deccan. We know that our archaeological treasures are irreplaceable and we are determined to protect them. Proper planning to reforms will build on the strong protections already in place – universities and governmental organizations need to working with key archaeological bodies to develop detailed proposals for the Planning bill. ❐

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BETWEEN TWO LEADERS : BOSE AND GANDHI

RANJIT SEN*†

Sizing up a Gigantic Obstacle

Subhas Chandra Bose began his political career at a time when opposition to the British rule had become a settled phenomenon. This opposition varied from class to class and, therefore, it was diverse in its origin and incidence. "The Industrial bourgeoisie found in the absolute control of India by British an obstacle to carry through its programme of unfettered industrial development. The educated classes found in the monopoly of key posts in the State machinery by the British an obstacle to their just ambition to secure jobs. The sons of the soil, the peasantry, found in the new land revenue systems introduced by British the basic cause of their progressive impoverishment. The proletariat found in the British rule a foreign undemocratic agency preventing it from developing class struggles for improving their conditions of life and labour and finally for ending the wage system itself under which they were exploited."

In this condition should one take the line of confrontation with the British? This was the question which rocked Subhas from the beginning of his political career.

Since 1919 one method of highlighting confrontation as a valid approach to the British rule was to reject the new constitution ushered in by the British under the name of the Government of India Act, 1919. C. R. Das upheld rejection and he was supported by B.C. Pal and B.Chakraborty from Bengal. Gandhi was opposed to rejection of reforms. On the last day of 1919 Gandhi wrote very forcefully in his weekly paper *Young India:* "The Reforms Act coupled with proclamation is an earnest of the intention of the British people to do justice to India. And it ought to remove suspicion on that score ... our duty, therefore, is not to subject them to carping criticism, but to settle down quietly to work so as to make them a thorough success."

The conflict between the two viewpoints was thus apparent. But the conflict was resolved by a compromise resolution adopted at the Amritsar Congress. It read thus: " ... the Reforms Act is inadequate, unsatisfactory and disappointing ... this Congress further urges that Parliament should take early steps to establish full Responsible Government in India in accordance with the principle of self-determination. Pending such introduction, this Congress trusts that, so far as may be possible, the people will so work the Reforms as to secure an early establishment of full Responsible Government...."

This compromise resolution was virtually a victory for Gandhi. "Thus the voice of a new leader with a brilliant political background, who was destined to playa vital role. in the Indian struggle, was heard at the Amritsar Congress. This leader was Gandhi and a year after, from the Nagpur. Congress of 1920 he 'emerged as the virtual Dictator of the Congress'." Two points are worthy of note. First, the Bengal line of confrontationist opposition to the British rule was sublimated and eventually sunk. And secondly, a new colossus had just begun to emerge in Indian politics just at the time when Bose had arrived in India. In 1920 Bose passed the Civil Service Examination in England. In May 1921 he resigned his post and "hurried back to India with a view to taking" what he thought his rightful "place in the national struggle that was then in full swing". He reached at Bombay on 16 July 1921. The same year Gandhi commissioned into action his famous non-violent noncooperation movement. Bose's joining the freedom movement thus synchronized with two things. First, Gandhi

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emerged as the sole authority of the Indian National Congress - the 'virtual Dictator' as Bose said and secondly, the Bengal confrontationist school carne to suffer a defeat by a compromise resolution. It is strange that - Gandhi's emergence took place along with his broad failure to read into the British mind and assess the political situation of the country. This failure was apparent in his behaviour and in his speech. At the Amritsar Congress in 1919 Gandhi spoke for cooperation. At the Nagpur Congress in 1920 he pleaded for non-cooperation with the British Government. Between these two Congresses the Amritsar massacre had taken place. Gandhi's psychology suffered and this eventually caused his political volte face. He made no secret about the changes that had come in his mind. Before Broomfield, the British judge who tried him for writing seditious articles, Gandhi said: "But in spite of the foreboding and the grave warnings of friends at the Amritsar Congress in 1919, I fought for cooperation in working of the Montagu-Chelmsford Reforms hoping that the Primo Minister would redeem his promise to the Indian Mussalmans, that the Punjab would be healed and that the Reforms, inadequate and unsatisfactory though they were, marked a new era of hope in the life of India .... "But all that hope", Gandhi continued, "was shattered. The Khilafat promise was not to be redeemed. The Punjab crime was whitewashed and most culprits went not only unpunished but remained in service and some continued to draw pensions from the Indian revenue, and in some cases were even rewarded, I saw too that not only did Reforms not mark a change of heart, but they were only a method of further draining India of her wealth and of prolonging her servitude."

Father of India Mahatma Gandhi and Netaji Subhas Chandra Bose

At the Threshold of a Change

The conspiracy of the colonial government was laid bare. How did Gandhi stand vis-a-vis this? As a disillusioned man? Or a man ready to take advantage of the lapses left open by the government? Clearly he was at the crossroads of his career. From cooperation Gandhi turned to non-cooperation in 1921 - a determined bid to take firm step in the next decisive stage in his career. The platform was the Nagpur Congress. Gandhi urged the people to go in for nonviolent non-cooperation with the British Raj. The people were for the first time exhorted to plunge themselves into the mainstream of the freedom movement. The aim was *Swaraj* and the period of attainment was one year that ended on 31 December 1921.

When Subhas relinquished his affiliation to the British colonial administration – his job in the civil service – things had gone to such a pass as this. A disillusioned leader had sudderily become an activist almost to the point of rebel. Political activists always combine dreams with gimmicks. Gandhi did this at a conference with the ex-revolutionaries of Bengal in 1921. He said "that he was so sure of getting *Swaraj* before the end of the year that he could not conceive of himself as living beyond December 31st, without having won *Swaraj"*. This was at once a dream and a gimmick combined essentially as a trick to spur mass-mobilization. What happened at the backdrop of non-cooperation was unique. The All India Trade Union Congress was set up in 1920. "The tide of rising mass unrest, which had swept forward in 1919, was still advancing in 1920 and 1921, and was to be further intensified by the economic crisis which began to develop, in the later part of 1920. The first six months of 1920 saw the greatest height of the strike movement, with no less than 200 strikes involving one and a half-million workers."

Thus Gandhi or no Gandhi the ball was set rolling. The economics and sociology of the British rule had done the job. The people were awakened. They were on the march. Gandhi gave them the necessary stimulus. He defined for them their target and supplied them the flag

they needed. Subhas found Gandhi at this psychological hour of a take-off.

In the middle of July 1921 Subhas landed in Calcutta from Bombay. At Bombay he met Gandhi who directed him to Deshbandhu Chittaranjan Das and Das immediately acknowledged him as "just the man he needed sp badly to assist him in his great mission and work". In September 1921, Gandhi came to Calcutta and stayed with the Deshbandhu. At every meeting Gandhi held in his house there was a session of questions and answers and "the task of noting down what came from Mahatrnaji in answer to the questions, fell upon Subhas". This was how Subhas was poised vis-a-vis the Mahatma and by the side of the Deshbandhu. Within a week of his arrival at Calcutta Subhas was given a very important political assignment. The Executive Council of the Bengal Provincial Congress Committee (BPCC) with Das as the President, Birendra Nath Sasmal as the Secretary and Nirmal Chandra as the Treasurer met. They placed the PubliCity Board of the BPCC under Subhas Chandra Bose." There was protest against it and the question was raised "as to how could the important and responsible Board be placed in charge of an unknown youth, simply because he gave up service?". But Das quashed all opposition and he was firm in favour of Subhas. He said, "Don't worry. I can see through persons. He will never belie my expectation, and he will be the right man who would do justice to the place." This was how the beginning was made. Subhas was brought in touch with the Executive Committee of the BPCC and when Gandhi came to Calcutta he was allowed to perform Secretarial functions for Gandhi. Besides contact with leaders contact with the cadre was also essential. Das left no stone un turned for him. "Besides his duties", writes Hemendra Nath Dasgupta, "as Secretary, PubliCity Board, he was also made the Principal of the National College which, aloffis with the BPCC Office, was also located at the Forbes Mansion at 11, Wellington Square."

As the Principal of the National College, Subhas came in contact with the students – the youth force of the country. "The number of students" of the College, writes his biographer, "was large and he used to take a keen interest. There was on one occasion a social function at the college when the renowned novelist Babu Sarat Chandra Chatterjee was also a speaker." This was significant. Subhas was given a platform where he could meet social mobilizers like Sarat Chandra Chatterjee. A smart beginning indeed. Poised between leaders, placed in charge of an office, surrounded by students and the youth and patronized by social mobilizers, Subhas seemed to be happy with his own station in the Congress. These opportunities given a man could hardly be a non-conformist and Subhas was hardly a non-conformist at the outset. He toed Gandhi's line as his master Deshbandhu had toed it. In a speech to the students he said: "To make our Non-Cooperation with the Britishers successful, we must have fullest cooperation amongst ourselves." Subhas's beginning was thus different from that of Gandhi. Gandhi started with a note of cooperation with the British in 1919. Subhas started with a note of non-cooperation.

Subhas's first programme of action then was non-cooperation. "Then towards the end of September 1921", writes his biographer, "Subhas came to the South Calcutta Congress Office and wished me to organise picketing in shops of South Calcutta to make the boycott successful. The next morning Subhas, myself and only four more workers marched through Russa Road from Purria Theatre (then Russa Theatre) to Jogoo Babu's bazar and this marked the beginning of *Subhas's march."* The whole of South Calcutta was roused by this march and the biographer comments: "The whole South Calcutta was re-organised once again (once it had been so done to raise Tilak Swaraj Fund) and Subhas used to lead the march through the streets of South Calcutta ...."

Gandhi's Flag-Bearer

From the above observation it is clear that Subhas began his political career in Calcutta with the flag of Gandhi on his shoulder. Was Bose convinced of the superiority of Gandhi's programme? The answer would be broadly - 'No'. As C.R.Das lifted Gandhi's flag in 1921 and decided to carry it through Subhas had. no option for he was in the train of Das. We have a picture of how Das-Gandhi partnership in non-cooperation moment operated in 1921. We have it from the pen of one who happened to be the biographer of both Das and Bose, the *guru* and the disciple. "That was the time", he writes, "when the Congress under the lead of Mahatmaji wanted to complete the programme of the boycott of foreign cloth within the month of September 1921. In all meetings held at Calcutta with Mnhntmaji on the chair and Deshbandhu Das appearing for boycott, We saw incessant showers of clothes coming and afterwards Muhutmaji setting fire to the bundles. The same enthusiasm was perceived wherever this scene repeated itself." The Non-cooperation was an enthusiastic political game and Subhas was caught in this enthusiasm. When he left his 'heaven-born service' in May 1921 he showed enough of his enthusiasm for the struggle

of Indian Freedom. He landed in Bombay on 16 July and his juvenile enthusiasm took him straight to Gandhi and his first rebuff started here. In *The Indian Struggle* he spoke eloquently about his interview with Gandhi. But the tone was negative. "I desired to obtain", he wrote, "a clear understanding of the details – the successive stages – of his (Gandhi's) Plan, leading on step by step to the ultimate seizure of power from the foreign bur eaucracy. To that end I began to heap question upon question and the Mahatma replied with his hohitual patience. There were three points which needed elucidation. Firstly, how were the different activities conducted by the Congress going to culminate in the last stage of the campaign, namely, the non-payment of taxes? Secondly, how could mere non-payment of taxes or civil disobedience force the government to retire from the field and leave us with our freedom? Thirdly, how could the Mahatma promise 'Swarai' (that is, Home Rule) within one year – as he had been doing ever since the Nagpur Congress? His reply to the first question satisfied me .... The Mahatma's replies to the other two questions were not convincing."

It was not Gandhi's ideology but his political method which did not seem convincing to Subhas. His scepticism was essentially a part of his youth but with it he mingled a charged frankness tha t came from the interior of his philosophical soul. He wrote: "But though I tried to persuade myself at the time that there must have been a lack of understanding on my part, my reason told me clearly, again and again, that there was a deplorable lack of clarity in the plan which the Mahatma had formulated and that he himself did not have a clear idea of the successive stages of the campaign which would bring India to her cherished goal of freedom." From an unclear position, Subhas thought, Gandhi was arguing for *Swaraj* in one year. His rebellion against Gandhi began at that point. "The promise of 'Swaraj' within one year", Bose vituperated later, "was not only unwise but childish."

Bose's early disenchantment with Gandhi became in later years a subject of academic research and at the end scholars proved to be consistent in their wisdom: "Why a first class colonial and imperial power like Great Britain would grant 'Swaraj' without any consistent anti-imperialist movement simply baffled his [Bose's] understanding. He himself, in fact, was 'prepared to work for a much longer period'."

From Gandhi at Bombay, Bose oscillated to the other end – C.R. Das at Calcutta. With Gandhi he found patience, sobriety and vision, all compounded into one virtue of a matured politician, namely serenity that bred translucent dreams - dreams for *Swaraj*. With Das at Calcutta, he met the opposite of all these - enthusiasm, youthfulness and vivacity mingled with a clarity of thought and a promise of action. Das mesmerised Bose and Bose enthroned him as his guru. The whole action was a gift of a few moments. The political baptisement of Bose was complete. The process of this baptisement was inter recalled thus: "During the course of our (between Das and Bose) conversation I began to feel that here was a man who knew what he was about who could give *all* that he had and who could demand from others all they could give - a man to whom youthfulness was not a short-coming but a virtue, By the time our conversation came to an end my mind was made up. I felt that I have found a leader and I meant to follow him."

Turning away from Gandhi was no escape from Gandhi. To be in the embrace of Das in 1921 was no guarantee to be separate from Gandhi. Bose's tragedy lies here, C.R. Das in Calcutta in 1921 was "one of the chief lieutenants of Gandhi". By submitting to Das Bose eventually surrendered himself to Gandhi. This was his fate and this fate was pitiless from the beginning to the end of his career. ❐

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Research Communication

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Tiger-widows in Indian Sundarbans and Risky Vocation of Mud Crab Collection

***Abstract*: Edible mud crab collection from wild waters have emerged as a profitable vocation with prospect of high returns in Indian Sundarbans in West Bengal; fetch high market price in domestic and international markets. There have been incidences and reports about professional adult mud crab and crablet collectors of Hingalganj, Kultali, Gosaba and other brackishwater Blocks falling prey to Royal Bengal tigers during this practice in deeper parts of Indian Sundarbans. Usual method of mud crab collection followed by inhabitants, including the tiger-widows, i.e., surviving wives of crab, fish and honey collectors killed by man-eating tigers in recent past and few alternative livelihood options for them towards improved living are presented in this communication.**

Inland fishery and aquaculture practices provide food and nutritional security, employment opportunities in rural sector and are source of foreign exchange earnings. Capture and collection of adult ones of economically-important edible green mud crab *Scylla serrata* and orange-clawed mud crab *Scylla olivacea* from nature (tidal creeks and brackish water river channels), stockable-sized crablets (25-60gm) to a lesser extent, grow-out mud crab culture and their fattening in tide-fed earthen chambers have emerged as livelihood generating activities in estuarine Indian Sundarbans region in West Bengal (WB). These vocations are encouraged entirely by good demand of mud crabs from China (Beijing, Shanghai, Kunming and other cities), Taiwan, Thailand, Singapore, Malaysia, South Korea and Japan[1]. Suitable conditions of inter-tidal and sub-tidal soft sediments of Sundarbans mangrove forest ecosystem in North and South 24 Parganas districts, WB harbour these two important export commodities as aqua-food. In afore-mentioned region, quite a few village persons as *aratdars* and crab fatteners are professionally producing good quality mud crabs of large size (weighing between 200-1000gm) meant exclusively for export in live condition to those countries almost every day and earning a lot. These two crustacean species gained importance in corporate sector due to export value; their export from WB increased over the last fifteen years.

Mud Crab Collection by Men and Women: In nature, proper growth of early juveniles of crabs take place in favourable environment of creeks and estuarine environment in Indian Sundarbans and they attain adulthood in these lesser-saline areas. Live *S. serrata* and *S. olivacea* are caught by crab collectors (both men and women) in different sizes (2.5-6.0 nos/kg) from the mudflats, creeks (Gajirkhal, Burir Dabar, Katuajhuri and others), canals and rivulets of Sundarbans forest and estuary of Matla, Herobhanga, Bidya, Thakuran and Roymangal rivers; Dhona, Metey, Pirkhali, Gazi, Chamta, Harintara, Bagmara, Netidhopani are few names of forests. For crab collection, every Sundarban-dependent group of crab fisher collect Boat License Certificate for country boat to enter into deeper Sundarbans by a group of 3-6 members from local office of Forest Department.

At Satjelia village in Gosaba Block, crab collectors usually set off for the forest in teams of three persons. Per month they need about 5kg of crab-feed *i.e.,* pieces of dried shark early in the season. After the monsoon months, fresh skin-peeled small frogs are substituted for dried shark pieces. They catch around 50kg of crabs in one trip[2]. During winter, at least three people are required for catching crabs. In Indian Sundarbans region, crab fishing villages include Jharkhali 1, 2, 3 and 4, Balikhal, Laskarpur, Sahidnagar, Tridibnagar (all under Jharkhali Coastal PS); Annpur, Jamespur, Bali, Mollakhali, Sonagaon, Mathurakhanda, Kalidaspur, Amlamethi, Satjelia, Harikhali, Radhanagar, Keoratala-Doiney, Chorkhoda, Kedokhali, Sajnekhali, Kholakhali, Jamespur, Johar Colony, Dayapur, Imlibari, Luxbagan, Rangabelia, Kumirmari, Bijoynagar (under Gosaba PS); Jojerhat, Muipith, Koikhali, Chituri, Deulbari, Dongajora (under Kultali PS); Samsernagar, Arbesey, Dhasekhali, Uttar Chara, Dakshin Chara (under

The journal is in the category 'Group A' of UGC-CARE list and falls under the broad category of Multidisciplinary Sciences covering the areas Arts and Humanities, Science and Social Sciences.

Hingalganj PS), which are in South and North 24 Parganas districts of WB.

Riding on 18-32 feet long oar-driven country boats, crab fishermen set out and venture into deep forest 2-3 times a month (during full moon and new moon) mainly during October to mid-February; each trip of 4-6 days period comprise 3-4 persons and it is 9-16 hours journey from their home (30-40km) to reach crab fishing zones. Crab fishing boats are made up of wood from Sal (*Shorea robusta*), Segun (*Tectona grandis*), Khirish (*Albizia saman*), Babla (*Vachellia nilotica*), Sundari (*Heritiera littoralis*) and Arjuna (*Terminalia arjuna)*. Creeks, surrounded by Hetal (*Phoenix paludosa*) and Goran (*Ceriops decandra*) trees are 12-15 feet and 35-40 feet wide (depth: 4-6 feet) during ebb tide and high tide respectively. In 'Done' (a colloquial Bengali term) type of crab collection, 600-1200mts stretch of thick nylon rope is used along shallow region of creek/canal and thin nylon strings tied to it at 1.5 feet interval one after another, which hang down upto bottom mud of water column. Lumps of 2-3 inches thick flesh of *Monopterus cuchia*, *Anguilla bengalensis* or large riverine catfish *Aorichthys* sp are tied to each string as baits (locally called 'Chaar'). Nylon rope is positioned along length of creek during ebb tide and vertically-placed strings with baits along with rope submerge during high tide.

Swarm of mud crabs move into creeks/canals from deeper waters in search of food and are trapped in such 'hook and line' fishing when they catch hold the baits. Main rope is uplifted manually by crab fishers from one end when boat is propelled along waterway till the other end of rope. Maximum catch is obtained during post-monsoon and winter and in each trip, total 60-140kg crabs are caught. These crabs (100gm and above) are bought by aratdars at Canning Bazar and other places @ Rs 250-750/-/kg from men and women crab collectors; each member of group (with BLC) get an income-cum-profit of Rs 10,000-30,000/-/month. Such a group of 4 persons gets a profit of Rs 30,000-35,000/- from crab collection in one trip [Information courtesy: Sri Anil Biswas and Sri Sukumar Mahato, mud crab traders/aratdars and Sri Tapan Mondal, crab wholesheller (*paikar/bepari*) at Kalinagar village, Sandeshkhali PS, North 24 Parganas district; personal communication]. Marginal fishermen who live in-and-around Sundarbans often make longer 8- to 12-day fishing trips, during which they collect as many adult crabs as possible from the creeks of this mangrove forest.

Although crab-catching involves methods different from fishing, many fishermen in the Sundarbans diversified into catching crabs. With the rapid escalation in mud crab prices, this trend appears to be on the increase[3]. In South and North 24 Parganas districts, adult mud crabs are available at Najat, Sorberia, Amtoli, Malancha, Brindaban Bazar, Chunokhali, Taldi, Canning wholesale fish and shellfish markets. They grow up along the rivers and canals namely Saptamukhi, Thakuran, Matla, Bidyadhari, Gosaba, Herobhanga and Roymangal in Indian Sundarbans, also reckoned as estuaries. Important mud crab landing areas are Basirhat, Basanti, Sonakhali, Port Canning, Kakdwip, Sathjelia, Kumirmari, Kalindi, Himnagar, Chingrikhali, Mollakhali and Namkhana. Crab fishers sell their catch (which has international demand) to depots installed by traders, middlemen and exporters in small towns surrounding Indian Sundarbans region. Price for adult mud crabs paid by crab aratdars of Dhamakhali crab wholesale market to men and women crab collectors during August-September is mentioned in Table-1.

Table-1: Price for adult mud crabs paid by crab aratdars of Dhamakhali crab wholesale market to men and women crab collectors during August-September

Males		
Grade-A	500gm size and above	Rs 750-850/-/kg
Grade-B	400gm size	Rs 650/-/kg
Grade-C	300gm size	Rs 550/-/kg
Grade-D	200-300gm size	Rs 450/-/kg
Grade-E	150gm size	Rs 400/-/kg
Grade-F	100gm size	Rs 300/-/kg
	400gm (PD soft-shelled)	Rs 400/-/kg
	400gm (tight-shelled with solid meat)	Rs 650-700/-/kg
Females		
Grade-A	180-300gm size	Rs 750/-/kg
Grade-B	150-180gm size	Rs 550-650/-/kg
	200gm (PD soft-shelled)	Rs 400/-/kg
	200gm (tight-shelled with well-developed ovary)	Rs 650-700/-/kg

Crab Collectors Falling Prey to Tigers: Let us have a glimpse into some sorrowful News headlines: 1) 'A 50-year old man lifted by a tiger while he was collecting crabs in Pirkhali forest in Sundarbans' (Source: The Times of India, September 8, 2009); 2) 'Sheba Mridha was widowed couple of months ago when a Royal Bengal Tiger killed her husband Ramesh Mridha (aged 32) as he was catching crabs in the creeks of Sundarbans Tiger Reserve' (Source: The Economic Times, October 27, 2009); 3) 'In March 2015, Amal Mandal, a man of Emilybari in Satjelia GP of Gosaba Block, was mauled by a tiger while collecting crabs in the forest creeks near the island of Pirkhali, a core area within

the Sundarban Tiger Reserve. He is survived by his 26-year-old wife, a daughter studying in 4th standard, and a differently-abled son. His family has been left penniless and without food'; 4) 'Basudeb Sarkar and two others from Kumirmari village ventured into Sundarbans National Park to catch crabs, tiger attacked Sarkar from behind and dragged him into deep forest' (Source: The Hindu); 5) 'In May 2018, Sumitra Midha's husband fell prey to a big cat as the couple went crab catching in the restricted area of the Sundarbans Tiger Reserve' (Courtesy: https://india.mongabay.com); 6) 'After husband's death, Namita Mondal became the family's sole breadwinner and ventured to the same dense forest to catch crabs and get firewood to provide for her three daughters' (Courtesy: https://www.aljazeera.com); 7) 'At Malipara village in Jharkhali, Shibani Mistry's husband went crab fishing for extra income four years ago - only to die from a regrettably familiar cause on this West Bengali island: a tiger attack' (Courtesy: S. Dhar, https://www.usatoday.com, October 4, 2017); 8) 'Banalata Tarafdar of Gosaba, aged 50, was dragged away by a tiger in Pirkhali in the core area of Sundarbans, where she had gone to catch crabs' (Source: Hindustan Times, July 10, 2019).

Likewise, there have been quite a few similar reports appeared in bulletins and daily newspapers in WB in last 25-30 years about professional men and women crab collectors falling prey to tigers in Indian Sundarbans region in this state. Every year, scores of fishermen in the Sundarbans are killed by tigers while catching crabs in the creeks (Source: Telegraph India, May 12, 2018). Crab collectors are often taken by tigers at times when they are concentrating on their catch at collection sites. In addition to above, author has been seriously keeping an eye and collecting news on incidences of crab collectors in WB falling prey to tigers published in Bengali daily 'Bartaman' since January 2020 till date.

Author's Meet with Some Tiger-widows: Several distant villages in the mainland or islands of Sundarbans forest in WB are home to underprivileged women whose husbands have been unlucky enough to be killed by man-eating Royal Bengal tigers while they were concentrating on their means of living, *viz.*, honey collection, jungle wood collection, fishing and mud crab hunting (collection). They are the Tiger-widows ('Bagh Bidhoba' or 'Beghro Bidhoba' in Bengali vernacular) (Courtesy: K. Joseph, https://theplaidzebra.com). Following footsteps of husbands, tiger-widows of Gosaba Block and other parts of Indian Sundarbans, once homebound, now fetch out into the territory of tigers and saltwater crocodiles to earn a living and meet their hunger. In this communication, we will discuss about tiger-widows in context of mud crab collection only. Present author, while explaining the management practices involved in the remunerative vocation of farmed mud crab production *i.e.*, grow-out culture and fattening of two species of mud crabs in tide-fed small ponds to village women at Dakshin Bijoynagar village under Bali-II Gram Panchayat, Gosaba Block, Dist. South 24 Parganas, made intimate conversation with fifteen aged tiger-widows of this Block and noted their experiences. All of them are into mud crab collection as means of living.

As the profession followed by their husbands, these distressed fifteen women are crab hunters. They collect adult mud crabs from Durgaduani, Tentulberia, Gazirkhal, Keoratoli creeks and other brackishwater river channels and creeks surrounded by Hetal and Goran trees near Pirkhali and Pakhiralay forests in Indian Sundarbans and supply it in live condition to local crab *paikars* or directly to well-established crab traders at crab wholesale markets at Sandeshkhali, Najat, Dhamakhali, Gosaba and other places. Durgaduani creek runs between Gosaba island and Bali-Bijoynagar island. Among caught and supplied adult crabs, soft-shelled ones selected by crab *aratdars* are fattened for next 21 days in small ponds and intact hard-shelled ones sent directly to Kolkata-based companies as export product. Female mud crabs with eggs ('ghilu/ghinu' in local dialect) fetches high price. Adult crabs are transported in quick time to Canning town crab market.

State-of the-art of Crab Fishing by Tiger-widows: Elderly tiger-widows Kamala Sarkar, Sourabhi Roy, Basanti Mali, Namita Mondal and others explained to author that in 2-3 days a month during ebb tide, preferably on the days 12th and 13th day from fullmoon and newmoon, i.e. '*Dwadosi*' and '*Triyodosi*' in Bengali calendar month, every two or three of them set off for the forest from their thatched roofed huts in 5.4-6.8mt long oar-driven country boats (sometimes locally termed 'Dingy' or 'Ghughu') at 3.00am, travel 32-45km distance to reach at crab fishing zones at 7.30-8.00am where water depth is 1.80-2.20mt. After harvest, they move towards home at 2.00pm or later during high tide. In crab fishing, some of them use 28-30nos hooks for long nylon rope (main line) 120-180 hands in length ('haath' in local dialect, 1 haath/hand = 17-21 inches) and total bait used 4-5kg. As for baits, they mostly use 28-30nos roundly-cut pieces of freshwater mud eel *Monopterus cuchia*, immersed in salt solution before use. About 9kg bait used for 3-4 times longer ropes.

Baits are attached to hooks or iron jigs which are used, one in each at bottom end of branch nylon strings. Some other women respondents use iron hooks amounting to 8kg and 800-850 in number and same number of cut

pieces of *M. cuchia* used as baits ('char' in local dialect) for every rope 1000 hands in length. To set the crab trap, one woman drives boat forward and other two women tie baits to the end of many nylon strings attached at intervals to main nylon rope.

After 20-45mins of placing (setting) the hooks and nylon rope (set at 8-18 inches water depth before onset of high tide), boat is slowly rowed back, rope is uplifted from one end when boat propelled along waterway till other end. While harvesting the trapped crabs, one woman on rear end row the boat forward with oar, woman in front slowly lifts up the main rope and short nylon threads from water level and woman in middle catch hold of the crabs or jerks it off from baited hooks one after another using a hand-net kind of semi-circular landing net. Next those are transferred into aluminium container (*Hundi*) or bamboo baskets and the pair of chelate legs of each crab are firmly tied with body using jute thread. Often a single woman does the works of lifting nylon threads and separating crabs from hooks. Smaller ones are undisturbed and released back into water. During high tide, 4-5kg and 8-10kg crabs (150-400gm each, males more in number) are harvested by women per boat in each of three days in summer and winter months respectively. Harvested crabs 150gm in size are sold by these tiger-widows @ Rs 80-150/- / kg and those 300-400gm in size @ Rs 350-450/- / kg. Adult crabs move into creeks during high tide and catch hold the baited hooks. Women are able to catch in greater amounts during winter season and in narrow tidal waterways (sometimes locally termed 'Nasi' or 'Bharani') in Indian Sundarbans region. Every group of two women earn Rs 4000-5500/- / month, plan and give efforts collectively. They have to pay money to owner of country boats they use. Discarded lumps of body part of poultry birds may be used as baits, some of them stated.

In general, tiger-widows as crab collectors also stated that both men and women crab fishers in different islands of Indian Sundarbans do crab fishing during the months of October-November to the end of first half of February. They fetch out in small groups into estuaries namely Herobhanga, Matla, Bidyadhari and Roymangal. River water inflates during Krishna paksha (dark fortnight), Shukla paksha (lunar fortnight from new moon to full moon) and Amavasya (new moon) and is the time when adult crabs enter into upper reaches of brackishwater rivers of Indian Sundarbans from estuaries. Thick nylon ropes may lengthen 600-800mt, many branch nylon threads 12-15 inches long (may be 8-10 times lengthier individually) are tied to it at 18-20 inch interval and bait tied to thread knots at open end. Women crab hunters set it over river bed exposed during ebb tide, which remains sinked down with support of medium-sized brick pieces during high tide. Main rope remains close to river bed. According to them, adult mud crabs can be caught more in number in tidal waterways in deeper areas of Sundarbans (that claimed the lives of their husbands), at waist- to chest-height water depth inside thick mangrove forest on the other bank of Ganral river at Gosaba delta and other places, where the risk is also greater. Estuarine crocodiles of Sundarbans region enter into such shallow and narrow brackishwater channels to give birth to young ones.

End note: Women in Alternative Livelihood-oriented Fishery Activities: 'In an adjoining village of Malipara at Jharkhali, Aparna Shiyali, aged 30, is a tiger widow who now risks her own life to go crab fishing' (Courtesy: S. Dhar, https://www.usatoday.com, 4/10/2017). It may be said that daily lives of Smt. Shiyali and other tiger-widows in Indian Sundarbans, with whom author met and of others whose names appeared in newspapers, are impoverished, fragile and vulnerable. All the fifteen tiger-widows as crab collectors consider themselves as ill-fated, have lost their husband, and few of them even their only son; who went for crab fishing but did not returned back home. Tiger-widows have to risk their lives in this kind of livelihood, which makes them vulnerable to tiger attacks and crab collection is their predominant means of living. Tidal brackish water creeks in Indian Sundarbans offer mud crabs and these women try to exploit the most of it.

Women in rural areas of WB, especially from marginalized and underprivileged section of the community, have contributed and played important role in livelihood-oriented fishery and pisciculture sectors. Participation of women in such activities have improved economy of rural families and enhanced their nutritional status. Women-friendly technologies like breeding and rearing of high-valued freshwater and brackish water ornamental (aquarium) fishes in rectangular cemented cisterns in home premises, farming of economically-important nutritious catfish 'desi Magur' *Clarius batrachus* in such cisterns, breeding and seed production of exotic carp *Cyprinus carpio* in cloth enclosures in ponds during winter, formulated farm-made (pellet-type) feed preparation in backyard mini feed mill for edible fishes and ornamental fishes, nursery rearing (from 3-5gm crab instar stage to 25-70gm crablet stage in cloth hapa enclosures or small ponds), farming and fattening of mud crabs *S. serrata* and *S. olivacea* in tide-fed small ponds in brackish water Blocks in Indian Sundarbans region - these may be easily implemented by rural women with Government support and adopted on small- to medium-scale for income and employment generation

(individually or in form of SHGs) without jeopardizing their household activities. Four aspects must be carefully considered in crab farming, *viz.*, maintenance of water quality, proper feeding, properly-fenced ponds, placing hide-outs and preventing cannibalism among growing crabs. Under different projects, efforts have been made to develop skill and empower rural women in Indian Sundarbans region and other places in WB in sustainable fish farming technologies on small to medium scale. Different packages of practices were introduced through demonstrations and participatory trials in many parts of WB.

Time and again, fishers in Indian Sundarbans have demanded viable alternatives. They have mentioned the need for technical and other support for setting up fish farms and mud crab farms, poultries, piggeries and goat farms[3]. In addition to male persons as mud crab fatteners, appropriate training and extension services are expected to enhance the skill and knowledge of women involved in crab fattening in deltaic Sundarbans[4]. It is believed that if hatchery-produced healthy seeds (fry, advanced fry) of economically-important cultivable freshwater and brackish water finfishes and also supplementary feed are provided to underprivileged women of this region, they can stock it in their homestead freshwater ponds and propagate upto marketable size, which will fetch a good price for them in market. These fishes have good market demand all over WB as foodfishes. It is hoped that ultimately it will (in addition to other afore-mentioned activities) establish itself as a sustainable income-generating avenue alternative to mud crab collection for tiger-widows and other distressed rural women. ❐

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Can We Prevent Another Pandemic?

We have faced many pandemics and epidemics before some of which are remarkably like the Antonine plague[1]. It took place in 165-180 AD. It rapidly spread through the public baths in Rome. Smallpox took place in 1870[2] and rapidly spread through the air in enclosed settings. Edward Jenner developed the Vaccine of smallpox. More than 500,000 people were killed by it. The very next year Cholera took place, water and food-borne disease caused by *Vibrio cholerae* bacteria. It affected three to five million people and caused 1.3 million deaths per year. Spanish flu took place in 1918-1919[3], caused by RNA virus influenza same as Covid and vaccines couldn't be made for this as it goes through several genetic changes. More than 50 million people were killed. Another deadly disease like AIDS took place in 1981 caused by HIV virus[4] of class retrovirus which contains RNA as their genetic material. HIV attacks the human immunity system leaving the human body more vulnerable to be attacked by other pathogens. It spreads rapidly due to having unprotected sex with an infected partner. More than 75 million people were infected and almost one million people died due to this deadly disease. Among the aforementioned diseases, the most infectious is covid-19[5] which is being caused by Coronavirus which is also an RNA virus. So far more than 260 million people have been infected by Covid-19 and more than 5 million lost their lives. Vaccines have been made but it takes time as Coronavirus is going through genetic changes. The world has lost many lives due to pandemics. So we need to prevent the next pandemic. Here comes the question can we prevent the next pandemic? Yes, we can, if we follow some health measures we can prevent the next pandemic.

First of all, we all need to be more health-conscious. We need to maintain physical distance, avoid public gatherings; we also need to keep ourselves in a healthy environment. But it also has some drawbacks like if we stay in a clean environment our immunity system gets weaker and when we expose ourselves to the outer world due to a weak immune system it is easier for any pathogen to attack our body. Also if exercise is not done by staying in a very clean environment it can leave some long-term effects on the body. Not going out also makes a human lazier and affects mental health. According to WHO (World Health Organisation) health is defined as a state of complete physical, mental and social well-being. So having good mental health is very important. We also need to be socially healthy by staying in a comfortable environment. We also need to follow a balanced diet that provides all the nutrients required by the body in the correct proportion. These all are necessary to keep an individual healthy. But what to do if the question comes to keep a huge number of people healthy? We all know everyone needs to be healthy to prevent a pandemic or epidemic. The following measures may be taken to prepare for the next global health emergency situations like Covid-19.

1. We have seen that COVID-19 has swept across the world so rapidly practically giving no time to halt the outbreak which causes disrupting health systems, economies and threatens vulnerable populations. This has led many governments to wake up to the importance of pandemic preparedness. Covid-19 has shown us that even in the 21st-century global medical facility is not capable to face any challenge caused by any Covid-19 like pandemic. The reason for such a helpless situation is due to Antibiotic resistance[6]. Antibiotic resistance is one of the greatest challenges to global health, food security, and overall progress today. The Government and Healthcare Industry have a nontrivial role in this matter. They should take major action plans and invest in the research and development of new antibiotics, vaccines, diagnostics, and other related fields.

2. The present pandemic has taught us a stupendous lesson that even the so-called developed countries have been struggling with their existing medical facilities to save the lives of their citizens while

The journal is in the category 'Group A' of UGC-CARE list and falls under the broad category of Multidisciplinary Sciences covering the areas Arts and Humanities, Science and Social Sciences.

the positivity rates are at the summit. Public-private partnerships are needed that harness the best available experience, insights to provide the best health care. We must work to strengthen hospital capacity and infection prevention and control measures while improving surveillance and testing.

3. Government should strengthen and enforce the existing international connections and augment funding for programs that monitor wildlife trade. Government should impose a ban on National and international trade of high-risk species like bats, rodents, etc. because they cause infectious diseases. The public and private sectors should work together in wildlife monitoring programs.

4. Initiatives must be taken to increase education and awareness on animal handling, as many diseases are supposed to be transmitted to humans from animals.

5. People who live on wildlife for food need to be supported so as to stop meat trading.

6. Public and private sectors should come forward and invest in research in developing technologies on early detection of diseases such as creating a library for virus Genetics that could be used to point out the source of newly emerging pathogens, early enough to stop the spread.

7. Steps should be taken by the Government to reduce tropical deforestation which diminishes biodiversity and increase the risk of disease pandemic such as Covid-19[7].

8. We must create community awareness.

9. Emphasis must be given in developing artificial antibodies[8] such as monoclonal antibodies; they grab onto the virus and disable it just like the immune system. This can reduce death rates by 80%.

10. We need to develop a global awareness program. If there are any new infectious pathogens, we need a group of infectious disease responders to get into action. This concept may be related to firefighters. If there is any new type of disease with unusual symptoms, the infected person must consult a doctor and not take action by himself or hide it. Doctors also need to prioritize new types of diseases.

11. Every single one of us shall try to save our brothers and sisters who share the same sky with us. We have to make a global village to make a better world in the future. ❐

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Notes and News

Release of Bigyan Kahon: A Bengali Science *E*-Paper

In the post independence era of India, various scientific developments brought about a wide transformation in different technologies leading to a much sustainable living. But unfortunately a concern remains, even when we celebrate our 75th Independence Day, that, a large section of our society is quite ignorant about the advancements and are not getting the opportunity to avail the benefits of scientific living. In order to bridge this gap premier educational institutions of India are trying to promote scientific temper and reach to the people at large to deliver the science knowledge. In this endeavour Indian Science News Association (ISNA) has always played a significant role and quite efficiently been able to promote science communication and its popularisation among the masses.

To continue the legacy even while the pandemic situation prevails and the world desperately tries to cope with and find new with reach to people, ISNA has been actively organising various online programme to communicate science to the masses. As a part of series initiatives, ISNA had successfully launched an English e paper '*Scientifica Communica*' on August 15 in collaboration with Vigyan Prasar, DST, New Delhi, focusing on theme of post independence scientific development of our country. ISNA always tried consciously to communicate science in vernacular, especially in Bengali for this part of the country, and to further extend this initiative, on the most memorable day of October 6, birth anniversary of the legendary scientist Professor Meghnad Saha, ISNA launched '*Bigyan Kahon*', science *e*-paper in bengali, in collaboration with Vigyan Prasar, DST, New Delhi.

The day was also the festive evening of Mahalaya, and on the online inauguration program, Dr. Amit Krishna De, Honorary Secretary ISNA, extended a formal welcome to all the dignitaries and participants present in the online inaugural session. This was followed by the welcome address delivered by the eminent science journalist, Sri Pathik Guha. He delivered an official address to the participants highlighting the objective of the particular publication and also mentioned about the utility and opportunity of such ventures. Prof. Manas Chakrabarty, Honorary Secretary ISNA, explained that the idea of ISNA to launch the Bengali e-paper '*Bigyan Kahon*' was to popularise and communicate the scientific developments among the general Bengali community. Prof. Chakrabarty went on to congratulate the successful outcome of the dream vision of ISNA, in spite several obstacles.

Then came the most important and awaited event of the inaugural session. Professor Asis Chattopadhyay, Pro-Vice-Chancellor (Academic Affairs), University of Calcutta, inaugurated through audio visual curtain raiser of *Bigyan Kahon*' and delivered his address in lucid manner. His quite informative delivery emphasised the basic utility and reasons for such science article being published in Bengali. He also explained the essence of linkage of scientific insight observed in the timeless literatures of Gurudev Rabindranath Tagore and therefore the need of bengali science journal and science journalism, which is merely existed. He appreciated the initiative of ISNA and Vigyan Prasar, for extending the legacy of Prof S N Bose and Prof Meghnad Saha, the true architect of remarkable establishment of Bengali science journalism.

Sri Prasanta K Bose, Chief Editor of '*Bigyan Kahon*' shared and explained his experience about the journey of '*Scientifica Communica*' to '*Bigyan Kahon*'. He explained the entire process of making the association of science communicators who contributed article of diverse themes and he humbly acknowledged all the editorial and technical team members of '*Bigyan Kahon*' for their persistent effort. Sri Bose gave a brief introduction about the chief guest of the session, Sri Rajat Ray, an eminent journalist and one of the most successful communicator associated with pioneer print media publication houses delivered his speech in a very composed style and appreciated the publication of '*Bigyan Kahon*' and mentioned the reasons why bengali science journals are necessary to reach the masses and aware them about the scientific way of living to have a better life, in their mother tongue. He also said how the knowledge of science is useful for a journalist to communicate science and how the actual perception of science journalism can break the barriers of orthodox belief, superstition and socio political stigma of our country.

The event was presided over by Prof Sunil Kumar Talapatra, Vice-President, ISNA, who delivered his brief

address about the objectives of Bengali science journalism and explained how budding scientist can get new opportunities in such e publications. He conveyed his special thanks to the dignitaries, guests and participants of session to make the event more successful. The session ended with the formal vote of thanks delivered by Dr. Aranab Kumar Banerjee, Editor of '*Bigyan Kahon*', who acknowledged ISNA and Vigyan Prasar and all contributors for their sincere association. ❐

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Hans Bethe's Nobel Prize Medal given to Library

How do stars keep on shining? Physicist Hans Bethe solved this cosmic puzzle early on in his over 60-year teaching career at Cornell, earning a Nobel Prize in Physics in 1967 for his theory on the energy production of stars.

Recently, Bethe's family donated his Nobel Prize medal to Cornell University Library, where it holds a special place among the pioneering physicist's **archived papers** kept in the library's Division of Rare and Manuscript Collections (RMC). The archive includes Bethe's notes and calculations; interviews and correspondence on nuclear physics, arms control and other topics; and documents related to his teaching and administrative roles for Cornell's Department of Physics.

In a statement, Bethe's family members said they were grateful to Cornell for maintaining his archive and pleased to bring the medal home to Cornell. "A Nobel prize represents a pinnacle career achievement, and when you hold one in your hand you can feel the weight of the medal and the work of the individual that led to their receiving the recognition," said Evan Earle '02, M.S. '14, the Dr. Peter J. Thaler '56 Cornell University Archivist. "It's great fun to share the Nobel with students when teaching about Professor Bethe's legacy," Earle said. "Perhaps it can even serve as inspiration for them in their own careers."

After emigrating from Germany to the United States, Bethe joined Cornell in 1935. During World War II, he was a key figure in the Manhattan Project, but later became an advocate for nuclear arms control. He retired from teaching undergraduates in 1975 and continued to hold his office at Cornell until his **death in 2005**. He is **remembered at Cornell as a legendary educator** who elevated the physics program and galvanized generations of scientists. ❐

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Indian Scientist Hashima Hasan, who helped launch NASA Telescope

Dr Hashima Hasan, an Indian-origin scientist has played a key role in the launch of the National Aeronautics and Space Administration's (NASA) Webb Space Telescope. Post her education, she embraced the opportunity to work as a Senior scientist at the NASA headquarters in Washington DC. One of her significant

Dr. Hashima Hasan is the James Webb Space Telescope Deputy Program Scientist and the Education and Public Outreach Lead for Astrophysics. (Source: Nasa.gov)

roles is that of the Deputy Program Scientist at James Webb Space Telescope (JWST), which succeeded the Hubble Space Telescope. Her roles included oversight during the mission development phase to make sure that the science requirements were being met, and the best science observation program selected for the operation phase. She is currently serving as a spokesperson for the James Webb Space Telescope (JWST) to the media and delivers talks to school students.

In a recent NASA podcast, she revealed that while she was in class 6, a teacher told students that anything can be achieved if they worked hard for it. The teacher's statement had a profound impact on her and that is when she chose science as a core subject for higher studies.

Hasan's well-educated family also played a major role in shaping her interest in science. Her uncle Dr. Husain Zaheer, was the former Director-General of the Council of Scientific and Industrial Research (CSIR). The scientific temper of her aunt, Dr Najama Zaheer, who was a Biologist, also motivated her. The NASA scientist then recalled that her mother had complete faith in her and was a driving force who pushed her to pursue her ambitions. Hasan developed an interest in space science in 1957 when the whole family assembled in the backyard to watch USSR's first satellite Sputnik fly by.

Growing up in India, newly liberated from British rule, and at a time when there were few women scientist role models, I still dreamed of being one. When the Russians launched Sputnik and my grandmother gathered the whole family early one morning to see the satellite pass overhead, I wanted nothing more than to explore space. When NASA landed a man on the moon, I promised myself that one day I would work for NASA. Encouraged by my mother and teachers, I strongly believed that if I worked hard I would achieve my goals of going to Oxford University in England and working for NASA in America. I doggedly pursued my dreams and won a scholarship to Oxford University and received my doctorate in Physics in 1976. Joining NASA took a little longer.

On her road to working at NASA, however, Hasan was forced to overcome numerous barriers to further her scientific studies. In her blog post, Hasan recounted the difficulties she faced learning about STEM, a field reserved for men when she was a child. Students at the Roman Catholic girl's school she attended in Lucknow were restricted from learning any scientific subject except for botany. Hasan was only able to begin learning science when an overseas teacher joined the faculty. Even then, qualified female science teachers were hard to find. Hasan and her classmates were forced to study together from their textbooks, talking with each other to learn the subject material. At home, she would teach herself mathematics from her brother's textbooks. "I had no formal mentors while growing up, no one to guide me or tell me what step to take next," Hasan writes. "In fact, it was an almost hostile environment where a young woman wishing to pursue a scientific career, rather than getting married and raising a family, was viewed with suspicion."

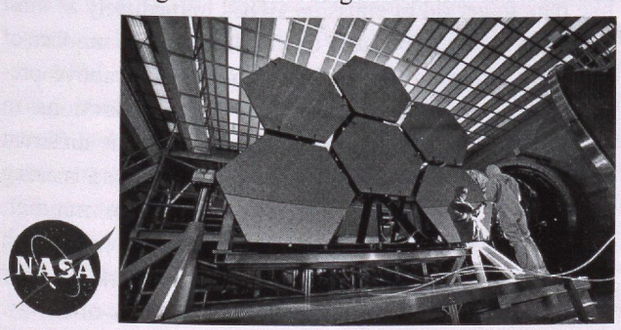
The road to a scientific career was not easy. When my girls-only school offered an opportunity for the most talented girls to study science in high school, I worked to earn my chance. Women teachers were difficult to find; my classmates and I often taught ourselves by reading our text books and discussing amongst ourselves. I taught myself mathematics from my brother's textbooks to qualify for college. Girls were treated with awe at the University, particularly those who excelled in Mathematics. I experienced this even at Oxford, where saying that I was studying Theoretical Physics was such a conversation stopper at parties that I stopped telling people my major! Rather than be discouraged, I was motivated to show to the world that I could be the best. I won the Gold Medal in Physics when earning my Masters Degree, in addition to several prestigious scholarships. I did my BSc degree from Lucknow University and went on to pursue Masters degree in Physics from Aligarh Muslim University (AMU), graduating as a Gold Medalist. Hashima then went on to pursue a PhD from AMU under Dr Zillur Rahman Khan. Post that, she received the Commonwealth Scholarship and joined the University of Oxford, and pursued a D.Phil. in Theoretical Nuclear Physics. After earning my doctorate at Oxford, I returned to India and joined the Tata Institute for Fundamental Research as a research scientist and one of the two female Physicists. A year later, I was selected for the faculty of Poona University. Hassan was later awarded the Resident Research Associateship by the U.S. National Research Council. As part of the fellowship, she pursued Atmospheric Science.

But new challenges emerged. Although I was financially independent and on a solid career path, I was under tremendous pressure from my family to get married. The only concession my parents gave me was to meet with the men they considered and to give my consent. When my father brought the man who became my husband, we had two hours at the Taj Hotel in Bombay to meet and let my father know our decision. I had to leave a promising career in India and come with my husband to the USA, where immigration visa restrictions closed many doors for me. But I was determined not to give up my science career.

I continued my research on a limited basis until we received permission to stay in America. It was sheer will power that helped me keep my scientific abilities alive.

My connection with NASA started in 1985. I joined the Space Telescope Science Institute (STScI) to develop the software simulating the optics of the Hubble Space Telescope (HST) and its science instruments. After it launched and was orbiting the Earth, we realized the mirror wasn't reflecting clear pictures. I analyzed the errors of the mirror, so that the telescope could be kept in the best focus possible to enable science, till a fix was designed. As a lead woman scientist, I provided mentorship to young women graduate students and technicians. When I see those women well placed in leadership positions today, I feel rewarded. As a young woman in 1985 with two toddler sons, a first generation American with no family support, and at a time when day care centers and summer day camps were rare, I faced the inevitable challenge of balancing work and family. I got tremendous support from my husband, also a scientist. My sons are now both successful – one as a lawyer, and the other as an engineer. I'm so grateful for support from the management at the Space Telescope Science Institute and later at NASA Headquarters whenever I needed to be home – either with a sick child or any other reason. This part of my life is as much a part of my NASA story as my professional work.

I joined NASA Headquarters in 1994 as a Visiting Senior Scientist to manage the Ultraviolet, Visible and Gravitational Astrophysics program. Thanks to my boss, Dr. Edward Weiler, I learned about grants management, budgets, Program Scientist duties, and how the Federal Government worked. I came to NASA with the intent of getting management experience for a year. It soon became clear to me that working at NASA and serving the public was more a calling for me than a profession. When I saw my first Shuttle launch in 1995, it gave me goose bumps. My second launch was in 1996 when the mission, for which I was the Program Scientist, launched. I have been fortunate enough to be the Program Scientist for several Astrophysics missions, including the Hubble Space Telescope, and now the James Webb Space Telescope. I qualified for the NASA Senior Executive Service (SES) in 2003, after training in the SES Candidate Development Program (SESCDP).



Indian American Scientist launches Telescope for NASA
(NASA Photo *via Wikimedia Creative Commons*)

Today, according to her NASA bio, she works as a Program Scientist for initiatives such as the Keck Observatory, NuSTAR, and ADCAR. Most recently, Hasan served as the Deputy Program Scientist for the James Webb Space Telescope, which launched on Christmas day, 2021. According to NASA, the telescope will "fundamentally alter our understanding of the universe" by using infrared radiation technology to study the cosmos, including exoplanets, nebulae, stars, galaxies, and other astronomical bodies millions of miles away from the earth. "I wanted nothing more than to explore space," Hasan wrote in a blog post for Women in NASA. "[Later], when NASA landed a man on the moon, I promised myself that one day I would work for NASA."

Today, Hasan remains a key part of NASA's staff. She is now a Deputy Program Scientist, applying her expertise to Hubble's successor, the Webb telescope. However, she also prioritizes teaching others, serving as the Education and Communication Lead for Astrophysics. Remembering the women who supported her throughout her career, she places a special emphasis on mentoring female graduate students and technicians who are as passionate about space and STEM as she was. "When I think of the unlikely dream I had as a little girl in an underdeveloped country, I marvel at where I am today," Hasan writes. If my story inspires others, then I've continued [the women who supported her] legacy." ❐

Source: https://www.siasat.com/meet-indian-scientist-hashima-hasan-who-helped-launch-nasa-telescope-2257764/

A Report of Webinar on "Global Challenges of Climate Change"

Tropical cyclones have become more frequent as a result of climate change and the associated temperature rise in the ocean surface, wreaking havoc on both natural and man-made elements. The most recent storms Fani, Amphan and Yaas have had a wide-spread impact of damage that not only caused an inundation in Odisha and West Bengal coastal region but also resulted in heavy economic loss.

'Climate change' is probably the most severe

challenge facing by our planet during the 21st century. Human interference with the climate system (mainly through the emission of greenhouse gases and changes in land use) has resulted in an increased in the global and annual mean air temperature at the Earth's surface by roughly 0.8°C since the 19th century. This trend of increasing temperatures will continue into the future: by 2100, the globe could warm by another 4°C or so, if emissions of greenhouse gases are not conclusively reduced within the next decades. As an obvious impact, we can expect more such cyclones, more drought and wildfire, shift in rainfall pattern and a global rise in mean sea level.

To discuss the various causes, challenges and impacts of climate change, National Environmental Science Academy (NESA), West Bengal Chapter organised a webinar on "GLOBAL CHALLENGES OF CLIMATE CHANGE" on 3rd December, 2021 jointly with Indian Science News Association (ISNA).

Over the past years National Environmental Science Academy (NESA), West Bengal Chapter has been working in organising National and International events which are mainly related to the environment , creating awareness by publishing various research findings in three popular newsletter - Biochem News, Environews and Poribesh o Bigyan the to reach the wider community.

Dignitaries from various fields, scientists, academicians, researchers and many students participated in the above mentioned webinar on 3rd December. Prof. Devesh Walia, Department of Environmental Studies, NEHU, Shillong and Professor Aniruddha Mukherjee, Department of Environmental Science, University of Calcutta graced the occasion as invited speakers. The lectures were chaired by the former President, Institute of Engineers, India, Er. Sisir Banerjee. The programme was formally introduced by Dr. Amit Krishna De, Honorary Secretary, ISNA and Founder Secretary, NESA, WB Chapter. The inaugural speeches were delivered by Prof. Arup. K. Mitra, Chairman, NESA, West Bengal Chapter, Dr. K Muraleedharan, President, ISNA and Prof. Manas Chakrabarty, Honorary Secretary ISNA.

After formal inauguration Dr De requested Er. Banerjee to take over the responsibility of chairing the lecture session and formally introduced the first speaker of the webinar, Prof. Devesh Walia. Prof. Walia is presently working as a professor in the Department of Environmental Studies, NEHU, Shillong. His main thrust area are - Structure and Tectonics of NE Indian region and the research areas where significant contributions have been made include magnetotellurics; radon emanation studies; micro-seismology; global positioning system, seismic disaster management and mitigation; Earthquake forecasting; Remote Sensing and GIS. He has a big number of publications in reputed national and international journals. Prof. Walia is also academically involved in various reputed Institutes like Institute of Physics of the Earth, Russian Academy of Sciences, Moscow; Earth Observatory of Singapore, NTU, Singapore; Indian Institute of Geomagnetism, Navi Mumbai; National Geophysical Research Institute, Hyderabad.

Prof. Walia has talked about various causes of climate changes. A number of factors actually control the climate, they are called climate drivers. Climate drivers are responsible for change in the climate over the years. They are classified based on the absolute temperature changes and the amount of time over which the drivers operate. According to Prof. Walia there are four classes of such drivers - the 1st order climate drivers are solar luminosity, solar system geometry, greenhouse atmosphere that have been working for 10^{11}-10^{12} years. Plate tectonics, sea floor spreading, mountain building activities have been considered as 2nd order driver, that has been working for 10^{6}-10^{9} years and affecting the climate. The 3rd order climate drivers, which have been shaping climate change for 10^{3}-10^{6} years are orbital and solar variability and long ocean tide. El nino, solar storm and Human interference are considered only as 4th order climate driver which is affecting the climate for less than 10^{3} years. By human interventions, we mean any activity of humans that cause emission of greenhouse gas. A sudden increase in GHGs for recent years leads to more 'trapping' of infrared radiation, resulting in increasing the planet's temperature. Other anthropogenic effects like emission of pollutants through aerosols which in turn can reflect the light might also result in warmer atmosphere. Prof. Walia suggested that all 29 states in our country India are very much susceptible to climate change, where Jharkhand has the highest vulnerability towards climate change and Maharashtra, the lowest. It is also difficult for a country like ours to get rid of emission GHGs immediately as most of us are highly dependent on fossil fuel for a number of purposes. Limiting global warming to 1.5°C above pre-industrial levels would require major reductions in greenhouse gas emissions in all sectors. But different sectors are not independent of each other, and making changes in one can have implications for another. Therefore, it is necessary to act in concert, both Government and private agencies should work together and think more on usage of alternative sources of energy.

The second speaker of the webinar was Prof.

Aniruddha Mukherjee from Department of Environmental Science, University of Calcutta. Prof. Mukherjee's thrust area are Environmental Biotechnology, Pollution treatment, Bioremediation and Toxicology. He has actively participated in several national and international seminars. He has several research publications and actively engaged in several research projects. Prof. Mukherjee has discussed the impacts of climate change in various aspects. When we are considering the impact of climate change with respect to our own country, we should remember, India has witnessed 13 out of 15 warmest years in the past 100 years, all came in the last 15 years i.e. from 2002 to 2016, the warmest decade was the last decade only, i.e. 2001 to 2010. In the last 30 years, due to lots of warming years, rainfall has increased by 7%. But, the distribution of rainfall is uneven which leads to flooding in some places and drought in some other places. Anthropogenic interference induced change in climate has affected all sectors especially the Agriculture, Energy and biodiversity. The most vulnerable sector is the agriculture sector in which yields and production are highly affected. Also, change in weather has caused direct health impacts by extreme events like heat waves, floods and storms and indirect health impacts by infectious disease. India is one of the 17 mega biodiversity countries of the world. In India we have 21.64 % of forest cover, it contains approximately 45,000 species of Flora and 90,000 species of Fauna. India consists of 8% of all the recorded species on the planet. Due to Climate Change the process of seed germination, growth, flowering, pollination, seed dispersal in plants are very badly impacted while the animals are losing their food sources and habitats - their lives are also at stake and facing the big challenges of survival.

The 2021 United Nations Climate Change Conference, more commonly referred to as COP26, was the 26th United Nations Climate Change conference, that was held at the SEC Centre in Glasgow, Scotland, United Kingdom, from 31 October to 13 November 2021. The result of COP26 was the Glasgow Climate Pact, negotiated through consensus of the representatives of the 197 attending parties. The pact was the first climate deal to explicitly commit to reducing the use of coal. It included wording that encouraged more urgent greenhouse gas emissions cuts and promised more climate finance for developing countries to adapt to climate impacts. Prof. Mukherjee expressed his concern over acceptance of the pact as countries like India mostly depend on fossil fuel and coal as a source of energy. Therefore nature based adaptation strategies are required to adopt; involvement of alternate source of energy, engagement of local indigenous people that respects their cultural and ecological rights should be given priority to fight the worst impacts of climate change on biodiversity and environment.

The sessions were very much enriching as many questions were asked from the audience. At the end of the programme, Dr Subhendu Bikas Patra, Convener, NESA, WB Chapter thanked the resource persons, the organisers and the audience and formally concluded the webinar. ❐

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Report: Seventh International Conference on Environment and Ecology

The Seventh International Conference on Environment and Ecology (ICEE) was jointly organized by International Foundation for Environment and Ecology, Kolkata, Department of Environmental Science, Bharathiar University, Tamil Nadu, Department of Zoology, Government Degree College(Post Graduate), Bhaderwah , Jammu and Kashmir and Department of Zoology, Mahishadal Raj College, West Bengal via google meet on 26th to 28th November, 2021

The three days International Conference was attended virtually by eminent personalities ,top-notch environmentalists, scientists, academicians , research scholars and students from different parts of India as well as out of 'India who contributed and presented their research papers pertaining to the theme of the conference which was *"Make India Clean as well as Cleaning up Technologies"*

The inaugural session of 7th ICEE was graced by Prof. (Dr.) Manimekalan. A from Dept. Of Environmental Science, Bharathiar University, Coimbatore, Tamil Nadu, Dr. Tridib Bandopadhyay, President of International Foundation for Environment and Ecology (IFEE), Kolkata, West Bengal, Dr Dilip Kumar Jha from Agricultural and Forestry University, Rampur, Chitwan, Nepal, Dr. Binay Chakraborty from Bangladesh Agriculture, University, Dhaka, Bangladesh, Dr Dipankar Bandopadhyay, Hony General Secretary of IFEE, Dr Subhamoy Das, Associate Professor and HOD of Post Graduate Department of Zoology, Mahishadal Raj College, West Bengal and renowned scientist Dr Amit Krishna De who is also the advisor of Indian Science Congress Association, Ministry of Science and Technology, Govt of India and Hony Secretary, Indian Science News Association, Kolkata.

After the welcome address and speeches by the dignitaries about the purpose of the conference amidst such harrowing times Dr Amit Krishna De delivered the key note address, he spoke lucidly on Climate Change and its impact on Environment. He emphasized on non conventional sources of Energy which should be adopted to reduce carbon emissions. Dr De further spoke on Bio Solar Leaves, the Biosolar Leaf technology purifies the air through photosynthesis of microscopic plants thereby removing the greenhouse gases from the environment and generating breathable oxygen at the same time. On the second day of the International Conference academicians delivered plenary lectures on plethora of topics .Dr Puja Ray of Presidency University spoke on Menace of Water Hyacinth which is considered as an invasive noxious weed, for its tendency to multiply uncontrollably, clogging waterways. Dr Wahied Khawar Balwan from Department of Zoology ,Govt Post Graduate College, Bhaderwah delivered lecture on disadvantages of genetic engineering methods used to enhance crop cultivation in India. India being an agrarian country, the farmers should resort to conventional methods of farming to accelerate food production. Dr Rwitabrata Mallick of Amity University, Madhya Pradesh discussed vividly on Covid 19 and its impact on the environment. Due to lockdown for prolonged period and closure of industries air , water and noise pollution reduced drastically, but waste pollution exacerbated.

The plenary session was followed by technical sessions which were presided by reputed professors and associate professors of different educational institutes. Research scholars presented their research papers either in oral or in poster mode. Shazia Amruna from Department of Zoology of Mahishadal Raj College spoke on Nesting of House Crow at Rural and Urban Area in Pre COVID And Post COVID Period. She asserted that the number of crows were more before Covid 19, the deadly virus has adversely affected the nesting of house crows. It has been seen that the crows usually built nests on trees like Bot, Neem, Assath and Krishnachura approximately at a height of about 37.83 feet. Due to the ongoing pandemic the birds are now building nest at a lower height, the probable reason may be the scarcity of food. Tarikul Islam Golder ,Assistant Professor in the Department of Geography spoke on El Nino and its Varied Impact. El Niño is a naturally occurring phenomenon characterized by the abnormal warming of sea surface temperature in the central and eastern equatorial Pacific Ocean. During El Niño episodes, normal patterns of tropical precipitation and atmospheric circulation are disrupted, triggering extreme climate events around the globe.

The Seventh International Conference on Environment and Ecology was formerly concluded on 28th November. The valedictory session was an interactive event where all the participants gave their valuable feedbacks. Dr Tanmoy Rudra , a well known figure in Environmental Science and Former Pro Vice Chancellor of Seacom Skill University adorned the last session. He motivated the young scholars to pursue their research work. After a brief freewheeling interaction with the delegates Dr Wahied Khawar Balwan from Department of Zoology, Govt Post Graduate College, Bhaderwah extended sincere gratitude to all the dignitaries and delivered the vote of thanks. ❐

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NOTICE

Members who have opted for collecting their respective issues of *Science and Culture* from the office of *Science and Culture* are hereby informed that a copy of a given issue will be available for distribution between 25th of the last month of the issue till the end of the next month. As an example, January-February 2022 issue will be available for pick up from 25th February till 31st March, 2022. Members can also authorize someone to pick up the issue on his/her behalf.

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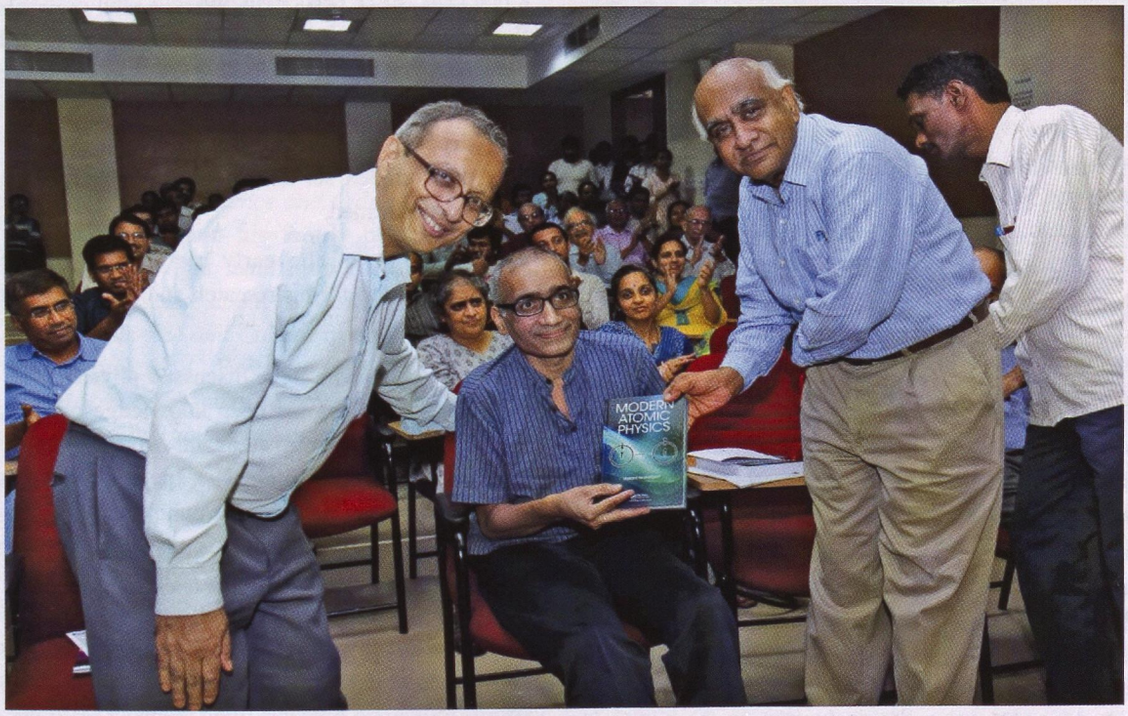
Obituary

Sci. and Cult. 88 (1–2) : 69-72 (2022)

A TRIBUTE TO PROFESSOR VASANT NATARAJAN (1965-2021)



Arnab Rai Choudhuri, Vasant Natarajan and T.V. Ramakrishnan FRS at the ceremony to release the book *Modern Atomic Physics*

Vasant Natarajan – simply 'Vasant' to his many friends and students – the first experimental physicist to produce cold atoms in India and a very active Editorial Board member of *Science and Culture*, breathed his last in the early morning hours of 29 December 2021. He was only 56.

Vasant was born on 11 December 1965 in Chennai (Madras at that time) in a middle-class Tamil family. His father, with an electrical engineering degree from Banaras Hindu University, worked as an engineer for the South-Eastern Railways. This being a transferable job, Vasant's childhood was spent in different cities and towns where the South-Eastern Railways has important hubs. The family spent a few years in Varanasi, where Vasant's mother worked as a school teacher. This experience of living in several Indian states and coming across people with different cultural backgrounds helped Vasant to develop a cosmopolitan outlook from his childhood. He was staunchly against anything which creates barriers among human beings – caste or religion – though he would make innocent fun of our cultural differences. He would tell me: "You are not an authentic Bengali: you do not call me 'Bashonto' like some of my Bengali students."

A brilliant student with impeccable academic record, Vasant obtained BTech in Electrical Engineering from IIT Madras and then went on to do his MS in the same field from Rensselaer Polytechnic Institute, USA. At that stage in his career, he decided to shift from electrical engineering

to physics. He got the opportunity of joining the graduate school of Massachusetts Institute of Technology (MIT), where he worked in the laboratory of David Pritchard, regarded as the creator of the field atom optics. Vasant wrote the following about his formative years at MIT in the Preface of his book *Modern Atomic Physics*:

> Coming from an engineering background, I learned to think "Physics" for the first time. The intuitive way of thinking and speaking physics – *the MIT way* – cannot be learned from courses. You *imbibe* it from the experience of being there. Two people at MIT have greatly influenced my way of thinking. One, of course, is my thesis advisor Dave Pritchard. He took this young engineer from India, and molded me into a physicist trained in precision measurements. The second person to influence me is Eric Cornell, my co-graduate student when I began studying for my PhD. It was from him that I learned that if you understand the basics well, the advanced stuff is a breeze.

For readers not knowing this, I may mention that Eric Cornell went on to win the Nobel Prize in 2001.

After completing PhD at MIT, Vasant worked for two years in another top laboratory of the world in this field – the AT&T Bell Labs. His well-wishers – especially his guru Pritchard – strongly advised Vasant to stay back in the United States, fearing that a return to India would jeopardize his promising career. But Vasant was determined that his motherland should benefit from the knowledge he had acquired. As he started exploring job opportunities in India, Vasant faced a challenge. Most of the physics departments in India at that time were hesitant to appoint a faculty member who did not have BSc and MSc degrees in physics. However, the Physics Department of Indian Institute of Science (IISc) – due to the visionary initiative of T. V. Ramakrishnan who was professor there – took the unusual decision of offering faculty positions to three young men who had undergraduate degrees in engineering and then shifted to physics at the time of PhD. Vasant was one of the three. When Ramakrishnan was visiting Princeton, he had a meal with Vasant (then a postdoc at nearby Bell Labs) and convinced Vasant that IISc would be the right place for him. Vasant joined IISc in 1996 and remained there till the end.

Vasant's first two PhD students Ayan Banerjee and Umakant Rapol (now professors at two leading Indian organizations) have given an excellent summary of the research carried out in Vasant's laboratory at IISc. I quote from them:

> [Vasant] can be considered the pioneer of the field of laser cooling and trapping of neutral atoms in India, with his 'Laser lab' at IISc having – for the first time in this country – produced a cloud of trapped laser-cooled Rubidium atoms in 2001. His laboratory also set the path for high precision frequency metrology and quantum optics experiments employing precision atomic spectroscopy – another field hitherto not very well explored in India. The most special thing about his career as a physics experimentalist was his staunch belief in setting up things absolutely from scratch, and developing entirely in-house infrastructure and expertise for almost every component required in the complex set of atomic physics experiments his lab performed.

Vasant was one of the early recipients of the Swarna Jayanti Fellowship for his research and also a Homi Bhabha Fellow.

Those of us who have discussed physics with Vasant have been amazed by his deep knowledge of virtually all areas of physics – even areas far from the field of his research expertise. As might be expected from somebody with such a command over the whole of physics, Vasant was a dedicated and meticulous teacher. His acclaimed textbook *Modern Atomic Physics* (2015, CRC Pres), written in the years of his declining health, bears testimony to his superb skills for pedagogical presentation. Vasant also published a collection of his non-technical writings on various topics of physics titled *Physics Matters* (2016, World Scientific).

An account of Vasant's research and teaching gives only a partial glimpse of the multi-faceted personality that Vasant was. He passionately believed that a scientist should not live in an ivory tower and an engagement with the society must be an important part of a scientist's commitment. Vasant was very much involved in nurturing the programme Kishore Vaigyan Protsahan Yojana (KVPY) in its early years and played a role in making it a nationally important programme for encouraging young students to take up science. His interest in conveying science and its functions to the common person made him involved with two magazines *Resonance* and *Science and Culture,* for both of which he wrote many articles over the years. Vasant also wrote articles in newspapers like *The Hindu.* When he perceived something to be wrong with the practice of science, he would fearlessly speak up against that and

would not hesitate to express views that may displease people in positions of power.

Vasant was deeply interested in the history of science – on which I had many discussions with him. M. N. Saha and P.C. Ray, the founders of *Science and Culture*, were two of his heroes in Indian science. Vasant considered it important to preserve their legacies for present-day Indians. His family donated Rs. 25 lakhs to the Indian Science News Association for supporting *Science and Culture*, Vasant's mother Mrs Maya Natarajan handing over the cheque to the Association in a solemn event – see an Editorial (*Science and Culture* 2016, Vol, 82, p. 341) and a news item (*Science and Culture* 2017, Vol. 83, pp 54). It is very characteristic of Vasant that he never told me about this donation, although we discussed about Saha's legacy and *Science and Culture* on many occasions. I came to know of this donation only from Suprakash C Roy, who was the Editor-in-Chief of *Science and Culture* at the time of the donation. Vasant and his family believed in the maxim that, when the right hand makes a donation, the left hand should not know about it. Vasant served in the Editorial Board of *Science and Culture* from 2018 onwards. I heard from Suprakash C Roy that he used to receive valuable advise from Vasant on many important matters connected with *Science and Culture* even before that.

It may be mentioned that Vasant was a fierce critic of all outlandish claims about scientific achievements of ancient Indians – following the tradition of M. N. Saha's writings against "Everything in the Vedas" mentality. Vasant told me several times how much he admired those writings of Saha. Vasant put together and edited a volume of the selected essays on socially relevant issues by M. N. Saha, B. R. Ambedkar and Noam Chomsky. In the incisive Introduction of this volume, Vasant wrote:

> Modern science works on the principle of making knowledge accessible to everyone – *i.e. democratic* – so that any one can build on this knowledge. By contrast, whatever little science was done in ancient India was couched in Sanskrit, the language of the elite Brahmin caste. This, and the rigid caste system, were sure ways of stifling progress, as the history of India shows. . . The Brahminical notion that intellectual pursuits are "higher" than anything done with the hands has led to a pernicious disconnection between the mind and the body, especially in scientific research.

Although many of us would not agree with all of Vasant's views regarding the history of Indian science and I had sometimes argued with him, I admired the fearless conviction with which he could speak up.

When Vasant was barely in his mid-40s, he was diagnosed to have progressive neuro-degeneration – an incurable disease which gradually wasted his body during the next few years. With the extraordinary support from his wife Dr. Gayathri, a renowned paediatrician, the way Vasant fought this debilitating disease became a wonder for all of us around. He kept working as long as he could, without complaining even to his close friends that fate has been so unkind to him. His doctors advised him that he should spend some time in the sunlight to strengthen the bones of his increasingly frail body. One image which will remain indelibly etched in the minds of all his colleagues is the image of Vasant in his wheelchair sitting in the slanting beams of morning sunlight at the portico in front of our physics department. When any of us walked up to him, he would greet with a smiling face and would try to carry on a normal conversation, though his voice became increasingly slurred. Finally, death snatched away Vasant from us at a time when he should have been at the peak of his creative career.

Vasant was not only a critic of the disconnect between the head and the hand in ancient India, he also deplored the present-day excessive compartmentalization between theoretical physics and experimental physics. Being an experimenter with a deep understanding of theoretical physics, he insisted that students joining his laboratory must take a few rigorous theoretical courses. He would also often admonish theorist colleagues like me – usually half-jokingly – that we should pay more attention to practical applications of physics to society. When I told him that I was thinking of writing a graduate-level textbook on electromagnetic theory – a subject which he had taught on several occasions – he was very excited and gave me many tips. He also told me that I must not make it a book of very formal mathematical theory and should include some sections on such practical applications as wave guides and antennas. Sensing the inadequate knowledge of a poor theorist like me, Vasant volunteered to help me in writing on those topics. Unfortunately, soon after our discussion (one of the last long discussions I had with him), his health took a sharp downturn and the COVID pandemic started. It will remain my eternal regret that I did not get a chance of finding out how Vasant would have liked to present those practical topics of electromagnetic theory to students of physics.

Finally, above everything else, Vasant was a wonderfully warm human being – a loving son, husband and father; an exceptionally caring supervisor to his students; and somebody who would always remember even the smallest gestures from his friends. Although his

uncompromising views on many things may give the impression of his being stern and serious, Vasant was a charming and fun-loving person with a good sense of humour who could enjoy lighter things in life. Vasant finished his book *Modern Atomic Physics* when his physical abilities were already much impaired. As the book finally rolled out of press about a year later, he no longer had the strength to organize an event to celebrate this proud landmark of his career. I organized a book release ceremony where T. V. Ramakrishnan FRS (who was instrumental in getting Vasant to IISc) released the book. I almost completely forgot about this small thing I had done for Vasant. I was overwhelmed when Gayathri told me at the crematorium that even a few days before his death Vasant mentioned of being very happy and grateful that I organized this ceremony.

Vasant leaves behind wife Gayathri, daughter Akanksha and mother Mrs Maya Natarajan. I must also mention his laboratory assistant S. Raghuveer, who followed Vasant like his shadow in the years of his declining health and ensured with selfless dedication that Vasant could remain academically active till the very end. While Vasant is no more, his indomitable spirit will continue to inspire all of us who had the privilege of knowing the extraordinary person that Vasant Natarajan was. ❐

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Indian Science News

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Students Award on Basic Science Research

Indian Science News Association (ISNA) with donation received from Professor Mrinal Kanti Dewanjee, USA, is inviting nomination from students currently studying in XI and XII standard students for two awards one in Physical Science and other in Life Sciences. Each award contains a cash prize of Rs. 10,000.00 (Rupees ten thousand) and a certificate.

Procedures

i. A write-up on a proposal (no more than 2000 words) on the importance of Basic Science Research including Translational Research and their impact on Society is to be submitted to the Honorary Secretaries, Indian Science News Association, 92, A.P.C. Road, Kolkata 700009.

ii. Applicants must be residents of West Bengal.

iii. At least 85 % average marks received in Science Subjects in Class X board examinations.

iv. Application should be forwarded through the Head of the Institution.

v. Last date of receiving application **25th April, 2022**.

vi. The write up will be screened by an expert committee appointed by the competent authority.

vii. Selected candidates are required to present the proposal stated in the write up before an expert committee as decided by the competent authority.

viii. Awardees are required to give a seminar during award-giving ceremony.

Brief Profile of Professor Mrinal K. Dewanjee

Prof. Dewanjee completed his M.Sc. in Chemistry from Dacca University (Bangladesh) and Ph.D. in nuclear chemistry/physics from McGill University, Canada. In early 1970s, Dr. Dewanjee was the humble beneficiary of "Lab Bench-to-Bedside" Translational Research on developing the radioactive tracers for noninvasive imaging and measuring tools in cardiovascular diseases (Myocardial infarct [MI]-Heart attack) at Harvard Medical School, Boston, Coronary thrombosis, Mayo Clinic, Rochester, MN) and neurovascular disease (Stroke; Brain attack, University of Miami, FL) in animal models with clinically relevant endpoints. He made the algebraic equation for measuring platelet density on injured walls of artery and artificial surface of cardiovascular prostheses. After getting Federal Drug Administration's (FDA), USA, approval with preclinical evaluations, they used the noninvasive nuclear imaging methods for imaging site of MI and arterial platelet-thrombi and evaluated the effect of several platelet-inhibitors in animal models and patients (Aspirin, Plavix, Prostacycline and recombinant Hirudin). At present Dr. Dewanjee is an Honorary Guest Scientist at Neurobiology, Neurodegeneration & Repair Laboratory, National Eye Institute, National Institutes of Health, USA. His present interest is on STEM Cell Research, one of the latest and advanced biomedical research to treat some of the deadly diseases, e.g. stroke, retinal blindness, Alzheimer's and Parkinson's disease.

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2. K. Gottfried, Quantum Mechanics (Benjamin, New York, 1966) Vol. I, p.153.

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