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Monthly Newsletter of Vigyan Prasar

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VP News

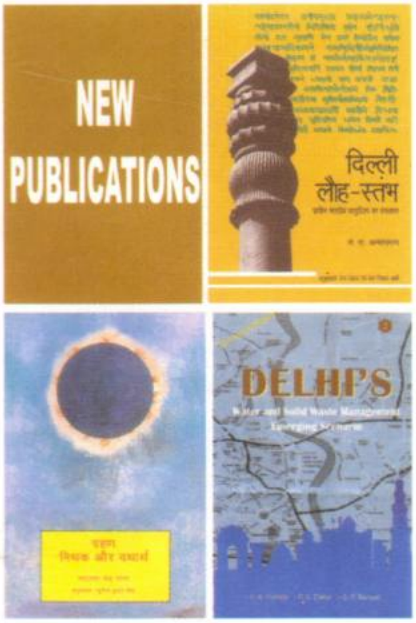
Inside

SCIENCE VIDEOS FROM VIGYAN PRASAR

Coverage of science in Indian mass media, especially television, has been very poor. One reason, often heard in media circles, is the absence of a mechanism to cover stories of latest R&D developments from the science and technology institutions in the country. To bridge the gap between Mass media and R&D institutions, Vigyan Prasar has recently launched a science video feature service on experimental basis.

Six feature stories have been produced last month. Three features on National Bureau of Plant Genetic Resources and three on latest developments from the National Physical Laboratory, New Delhi. The feature stories cover the profile of the largest gene bank in the world - the NBPGR, various *Ex-situ* techniques to conserve seeds and a report on the plant quarantine division.

The stories from NPL cover the 'Teleclock' service to transmit Time Data digitally through a telephone line, the SODAR - Sound Detection and Ranging technique for air pollution management and the piezoelectric Accelerometer PL-810 to measure vibrations. R&D organizations may write to us for covering interesting Research and Development works happening in their laboratories.



Delhi's Water and Solid Waste Management: Emerging Scenario

Vigyan Prasar has launched a series on India's Environmental Hotspots. The latest publication in this series is on Delhi's water and waste management scenario. This book provides adequate data on different aspects of Delhi's water and solid waste-related problems. The book authored by S.K. Rohilla, P.S. Datta and S.P. Bansal has been priced at Rs 100. Hindi edition of this book will be published soon.

Grahan: Mithak aur Yathartha

On the occasion of 24 October 1995 total solar eclipse Vigyan Prasar had published a booklet with the name *Myths and Legends Related to Eclipses*. It was authored by N.C. Rana. It is a compilation of prevailing superstitious beliefs and practices in different cultures. The author has also tried to put down the rationale originally underlying them. Hindi version of this booklet is available now. It is priced at Rs. 21.

Dilli Lauha-Stambha: *Prachin Bhartiya Dhatushilpa ka Chamatkar:* Vigyan Prasar under its series of monographs on the scientific heritage of India had published the first volume, *The Rustless Wonder: A Study of the Iron Pillar at Delhi* written by Prof. T.R. Anantharaman. Its Hindi edition has been brought out with the above name. The monograph documents every aspects of this technological marvel. The author has summarised all important studies and researches done on the pillar during the last century and half. It is priced at Rs. 150/-

... think scientifically, act scientifically ... think scientifically, act scientifically ... think scientifically, act...

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HAVE SCIENCE POPULARISATION EFFORTS IN INDIA MADE ANY DIFFERENCE?

Do we need to popularise science among people in India? Yes, we do! This question did get discussed years ago and apparently answered in the affirmative, without dissentions of any significance.

Should public (tax-payers') money be spent for this purpose? This question, concerning expenditure of public money for this purpose, too, had been answered long ago in the affirmative! The existence of government organisations like the NCSTC (National Council for Science and Technology Communication), Vigyan Prasar, and the NCSM (National Council of Science Museums) at the national level and of science popularisation programmes at the state-level in all States and Union Territories (UTs) provides ample proof, if any were required. Obviously, in all these cases, arguments in favour of public money being consciously and deliberately spent on science popularisation would have found ready support from all quarters — with few or no dissenting voices!

We have had organised programmes in India for popularisation of science for over two decades now! It is a good idea to have a look-back at what we have been doing and try answering the frequently asked questions: Have these programmes made any difference? Difference to common people's lives? Difference to various sections of our society? These are all valid questions and ought to be asked frequently.

Before we try answering these or similar questions, there are certain things that need to be stated — and understood by those who look at the answers and attempt to make sense out of them.

Let us recall where we were when we started, what we set out to do in the face of odds and ground realities at the time, and what sort of results could be reasonably expected out of the programmes and activities that were taken up and implemented. We need also to keep in mind the nature, size and magnitude of the problem(s) we set out to tackle — vis-a-vis the size of the effort(s) and investment(s) made for the purpose in terms of the human power and financial resources. Having said that we now attempt to answer questions that are often and frequently asked.

It can be stated without hesitation that science popularisation programmes in India have made a definite difference. Admittedly, this "difference" may not be very large, or even obvious to large sections of our population — especialy, those that have never been specifically targetted directly, or have never had a chance to associate with or participate in activities carried out or organised under these programmes. Also, for example, with an amount of less than rupees forty crores invested over a period of nearly two decades (on NCSTC and Vigyan Prasar programmes) their impact ought to be compared with output from investments in similar efforts in other areas.

Let us first try elaborating on the "definite difference" that, we claim, science popularisation programmes have made in India.

There are several aspects of the "outcome" of these programmes to which we will draw attention. Major and direct ones are: (i) Creation of basic infrastructure required for conducting science popularisation activities anywhere in the country, in terms of humanware (i.e. trained resource persons and training mechanisms), software (communication materials for different media), and institutional and organisational mechanisms and methodologies; (ii) creation of an atmosphere and environment alongwith a strong demand for such activities every where in the country; (iii) initiation and sustaining of activities at many places where there were none earlier; (iv) worked with State S&T Councils in all States and UTs to have their own science popularisation programmes, in addition to joint projects which they did every year with NCSTC and/or Vigyan Prasar.

In addition to the above enabling and empowering activities which have made a difference, some others carried out in the form of coordinated nationwide projects have had their impact in more ways than one. Major ones among these have been the Bharat Jan Vigyan Jatha (BJVJ) of 1987, the *Bharat Jan Gyan Vigyan Jatha* (BJGVJ) of 1992, the Eclipse-1995 and Eclipse-1999 campaigns and the National Children's Science Congress (NCSC) — an annual programme which has been making waves ever since it began in 1993. Mention must also be made here of publications, award winning films, videoserials and radio serials put out by NCSTC. "Bharat Ki Chhaap" was NCSTC's widely acclaimed 13-part serial of films on the history of science and technology in the Indian subcontinent; it was shown on Doordarshan's national network on a prime-time Sunday slot (1989). "Manav Ka Vikas" was a 140-part radio serial on human evolution, made in 18 languages and broadcast over 90-odd AIR Stations on Sunday mornings during June 1991 and February 1994. It remains the world's longest ever broadcast science serial. These have been pioneering projects in every way. For example, BJVJ (1987) was unique and the largest, the most effective and the most economical science communication experiment done anywhere in the world!

It would require a much longer piece to elaborate on all that the BJVJ (1987) was able to bring about and the "difference" it has made (and is till making) not only to the science communication scene in the country, but also in other areas. Let me briefly mention only some major ones: (i) For the first time crores of common people all over the country were reached (a few crores in 1987 and over 20 crores in 1992-94) and engaged in participatory and interactive science communication activities in their own language and relating to subjects of their own day-today interest and concern; (ii) thousands of governmental, non-governmental and voluntary organisations and tens of thousands of individuals from all walks of life directly or indirectly contributed to the detailed planning, coordination, organisation and conduct of these projects as well as in terms of cash, kind, time and intellect; (iii) a large number of old, dormant organisations got revived and reactivated and entirely new ones came into existence (during the *Jathas*) and have been active ever since and doing good science communication work; (iv) the recently (UNESCO) awarded National Literacy Mission (NLM) owes much of its success to the BJVJ methodology and the same set of voluntary agencies (brought together by NCSTC for the conduct of BJVJ-1987) which formed the core of the *Bharat Gyan Vigyan Samiti* (BGVS) and spearheaded the NLM; besides countless other smaller but important gains; (v) The year long Eclipse-1995 and Eclipse-1999 Campaigns helped enhance common people's understanding of the scientific aspects of the various eclipse phenomena, enthused lakhs and lakhs of people to view the total solar eclipses safely and confidently, overcoming a number of superstitions and age-old beliefs — and, in the process, also helped popularise astronomy and skywatching; (vi) the mass media — radio, TV and newspapers — took special interest in these events and helped a great deal in propagating the scientific view-point during the 1995 and 1999 campaigns; they carried articles as well as guidelines for safe-viewing of the solar eclipses; (some papers also gave plenty of space to astrologers' predicting dooms and disasters and propagating unscientific notions); (vii) with lakhs of children representing more than 400 districts in almost all States/UTs in the country, taking part every year, the National Children's Science Congress (NCSC) is fast turning into a movement; it

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PRASANTA CHANDRA MAHALANOBIS

"Not armies, not nations advance the race; but here and there, in the course of ages, an individual has stood up and cast his shadow on the world."

Prasanta Chandra Mahalanobis (PCM) was a visionary. He "was the brain that gave life to Nehru's grand vision of modern India. He set the Nation on the road to public sector-led planned development — the Second Plan was based on the Mahalanobis model". PCM was the chief architect of the post-independence statistical systems in India. Among his own statistical works some of the techniques developed by him viz. Mahalanobis D^2 in multivariate analysis, interpenetrating network of samples in sample surveys and fractile graphical analysis became part of standard statistical methodology. He was the founder of the Indian Statistical Institute (ISI). He was instrumental in establishing the Central Statistical Organisation (CSO), the National Sample Survey (NSS), State Statistical Bureaus and the Perspective Planning Division of the Planning Commission. PCM, a close associate of Rabindranath Tagore (1861-1941), the Indian poet, philosopher and Nobel Laureate, served the Visva-Bharati as Joint Secretary *(Yugma Karma Sachiva)* during its difficult formative years (1921-1931). He was actively associated with the *Brahmo Samaj* and tried to reform it against stiff resistance from the establishment. He was a great scientist, a promoter of scientific research and a great institution builder. PCM was a man of varied interests and he held many distinguished posts and at times some of them simultaneously. He was Director and Secretary of the Indian Statistical Institute from 1931 till his death; Professor of Physics of the Presidency College, Calcutta (1915-48); Principal of the Presidency College (1945-48); Director of Meteorology at Calcutta (1922-26); Head of the Department of Statistics of the Calcutta University (1941-45); Joint Secretary of Visva-Bharati (1921-31); Honorary Statistical Adviser to the Cabinet from 1949 till his death; and also served the Planning Commission (1955-67). He wrote many articles and essays on Tagore and his writings. He explored the ancient Jaina Dialectics of *Syvadvada* and showed 'certain interesting resemblances of that science to the probabilistic and statistical view of reality sparked by recent developments in quantum physics.' He developed a deep interest in architecture. He started a small printing press, the Eka Press in his house, which later developed into one of the best scientific presses of the region. It was PCM who brought the concept of statistical quality control in industry to India. He was an indomitable fighter and worked against all odds. He had a deep concern for the common man and love and sense of pride for his country.

Prasanta Chandra Mahalanobis (1893-1972)

Sir Ronald Aylmer Fisher (1890-1962), the British statistician and geneticist, who visited the Indian Statistical Institute, wrote on PCM : "In those early days, Professor Mahalanobis was a professor of physics, but he was no ordinary professor of physics. Instead of doing his duty and teaching his students, only that science and technology which led to the atom bomb, he thought he could serve his fellow men better by opening the door to knowledge obtained by statistical means, to the knowledge of the natural world and knowledge of the world of society in which we all find ourselves. Perhaps, he thought, as many of us think that most of the follies and crimes of the government are due to ignorance — ignorance of the people they serve, and the ignorance of the people they are all too willing to fight.'

Prasanta Chandra Mahalanobis was born on 29 June 1893 in Calcutta. His grandfather Guru Charan Mahalanobis (1833-1916) was an active member of the *Brahmo Samaj*. Guru Charan married a widow in March 1864. In those days, it was a rare act of courage, particularly when we consider the social taboo that existed against widow marriage in those days. He had to face a great deal of hostility even from some *Brahmos*. PCM's uncle Subodh Chandra Mahalanobis (1867-1953) was a teacher and educationist. Subodh Chandra became the Professor and Head of the Department of Physiology, Presidency College, and was raised to the Indian Education Service (IES). PCM's father, Probodh Chandra Mahalanobis (1869-1942) was a businessman. His mother Nirodbashini was the youngest sister of Dr. Nilratan Sarkar (1861-1943), the doyen of medical profession of his time, educationist and industrialist.

PCM studied in Brahmo Boys' School. This school was founded by his grandfather. After passing the Entrance Examination he joined Presidency College, Calcutta, in 1908 and graduated in 1912 with Honours in Physics. He went to England in 1913 and joined Cambridge University, where he took Part I of the Mathematical Tripos and Part II of the Natural Sciences Tripos in 1915. While he secured only a Third class in the Tripos Part I examination but he did very well in the Part II examination. He not only got a first class but was also awarded a senior research scholarship for standing first. After the Tripos he had plans for doing research in physics in the Cavendish Laboratory. But that did not happen. The same year he returned to India. At Cambridge PCM met Srinivasa Ramanujan, the great Indian mathematician, and the two became good friends.

Rabindranath Tagore greatly influenced PCM's thinking and activities. PCM's association with Tagore started in 1910 when the young PCM came to Santiniketan during his college vacation. Tagore's connection with PCM's family, of course, went far back in time. PCM's grandfather was initiated into the *Brahmo Samaj* by Tagore's father Devendranath Tagore (1817-1905). Tagore was 32 years older than PCM. Tagore got the Nobel Prize (1913) when PCM was just 20 years old. However, Tagore held PCM in high respect and had great faith in him. Once Tagore wrote to PCM : "I have always noticed how you are always capable to maintain objectivity in your judgement about people and I have always recognised that to be a great quality in you."

What is important to note is that Tagore had supreme faith in the literary judgement of PCM and wrote to him: "(Edward) Thompson has been saying that there ought to be a collection of translations of my writings. As such, someone should take-up the task of preparing chronological ordered manuscripts of my writings other than those of my *Gitanjali*. None other than yourself would be capable of undertaking the task."

Commenting on PCM's critique of Tagore's work for Buddhadev Bose, a Bengali poet, Tagore wrote to PCM: "What you have written after analyzing everything connected with my achievements and fame is altogether correct." Then on another article about Tagore's work written by PCM the Poet wrote : "I have liked your article very much. The way you have narrated the history of my humanism in an evolutionary perspective has made this aspect of mine clearer even to me." PCM was given the responsibility of editing a comprehensive collection *(Chayanika)* of Tagore's poems. He was also deeply involved in bringing out a special

Prof. and Mrs. Mahalanobis with Rabindranath Tagore

book of verse, *sphulinga* (spark), written by the Poet in imitation of Chinese and Japanese poetic style. The first edition was printed by PCM in Germany. It was PCM who negotiated with a publisher for the production of the first collected works of Tagore. PCM played an important role in recording of songs and recitation in Tagore's own voice in 1932. Tagore often consulted PCM on his stage productions, whether musical performances or dance-dramas.

PCM played a crucial role in shaping Tagore's vision of Visva-Bharati. He was an office-bearer of Visva-Bharati from its formal inception on 23 December 1921, being its Joint-Secretary alongwith the Poet's son Rathindranath Tagore. Tagore frequently consulted PCM on important affairs of Visva-Bharati. How much the poet depended on PCM is evident from the following extract from a letter he wrote to PCM : "Shantiniketan is facing most terrible crisis. I do not know we have the strength to overcome this ... You must certainly come here by the afternoon of Friday and help in solving the problem within week. You will also decide whether it would be good for anybody else to come ... We have to take merciless decisions about what to drop and what to retain. I entreat you not to make any delay ... Come and free me from these problems."

It should be noted here that PCM was not a blind follower of the poet. He did not hesitate to point out his disagreement with the poet on many occasions.

While PCM was not only an authority on Tagore's work, he also had deep insights of Bengali literature. This was evident from the fact that PCM was the principal consultant for Thompson for the volume "The Oxford Book of Bengali verse."

We will not go into details of PCM's contributions to statistics. For PCM statistics was not just another scientific discipline. He viewed statistics as 'new technology for increasing the efficiency of human efforts in the widest sense.' As mentioned earlier PCM's contributions to statistical theory, methodology and applications have had universal impact. PCM's work in anthropology, flood control, meteorology, crop estimation etc. were not only innovative and pioneering but also led to the development of new theoretical concepts in statistics. PCM's innovative techniques and methodology for large scale sample surveys have been internationally acclaimed. Harold Hotelling (1895-1973), a well-known US mathematical statistician, in his report submitted to the Indian Central Jute Committee wrote : "...no technique of random sample has, so far as I can find, been developed in the United States or elsewhere, which can compare in accuracy or in economy with what described by Professor Mahalanobis ..."

The Indian Statistical Institute (ISI) was formally established on 17th December 1931 and it was registered under the Societies Registration Act in April 1932. However, its origin can be traced back to the time when PCM started working after the first World War alongwith some young talented recruits. A Statistical Laboratory was established in the room of PCM in the Physics Department of the Presidency College. The ISI was also initially located in the Physics Department of the Presidency College. PCM had to struggle against all odds. In those days, when PCM was trying to advance the case of statistics in India, statistics was not recognised by the academic bodies or research institutes as a separate discipline. Fortunately three individuals viz. Brojendranath Seal (1864-1938), Nilratan Sarkar and Rabindranath Tagore, who had influenced PCM's personality and/or career, had realised the importance of statistics and provided the much needed moral support and encouragement to PCM to take up the study of statistics with the seriousness that it deserved. On the interest shown by Tagore in PCM's statistical work, PCM wrote: "Rabindranath Tagore used to take a keen interest in our statistical work from the very beginning, and visited the Statistical Laboratory in the Presidency College on many occasions; practically all of the early workers came to know him quite well. He had the imagination to appreciate the fact that we were engaged in pioneering endeavours in the midst of opposition and difficulties. It is difficult for me to express in words how deep was his influence."

The ISI received its first grant in 1936 (Rs. 5000 from the Government of West Bengal). Though the institute had a modest beginning its growth was phenomenal. To quote Calyampudi Radhakrishna Rao (1920-), one of the most outstanding students of PCM, Fellow of the Royal Society and who later became the Director of ISI : "The Institute was located in the Physics Department of the Presidency College in the beginning. There was only one part-time computer in the Institute in the first year, the total expenditure being Rs. 238/- (about £12). During the fifties the present premises of the Institute on Barrackpore Trunk Road was built and the office at Presidency College was vacated. At the time of the Professor's death the Institute at Calcutta and its branches at Bangalore, Baroda, Bombay, Delhi, Ernakulam, Giridih, Madras and Trivandrum had a total staff of over 2000, and the annual budget was about twenty million rupees (£1000000). The phenomenal development of the Institute within a period of forty years was mainly due to the individual efforts and imaginative planning by Mahalanobis".

While PCM was always too willing to take up work for the Government, he fought throughout his life to maintain autonomy of the Institute that is to have some flexibility for taking up innovative work. To quote PCM : "An institute like ours is, of course, in the public sector. It is in the public sector, but is not a Government department. This distinction is important. The Institute is undertaking mostly Government work, and is likely to continue to do so. It is entirely proper that an Institute like ours

JBS Haldane, P.C. Mahalanobis and Niels Bohr should serve the needs of the country. I submit that the Institute can best serve such needs if it is allowed to retain its initiative, its freedom to do its work as it thinks best — to have some scope for experimentation and development on its own... The Institute, of course, would work in accordance with the agreed plan, but the Institute should have the freedom to think out what is the best way of doing its own work — and even to make some mistakes and learn by experience. I venture to suggest that science can progress only through making experiments and, therefore, by taking the risk of making mistakes. Without making mistakes, I do not see how science can progress. Therefore, we claim that we should have the freedom of the scientist to have a little margin to make experiments, and also to make mistakes, in the hope and with firm conviction that we shall in the way, succeed also in devising new ways and better ways... The very success of a plan would depend on its providing a margin of freedom to make it flexible. Therefore, for the very acceptance of the idea of an overall plan, I plead that we must preserve the human initiative."

PCM did not view statistics as a narrow scientific discipline and this was very much reflected in the kind of activities undertaken by the ISI. To quote C.R. Rao : "Visitors are often intrigued to find such diverse and unrelated activities in the ISI, some of which may appear to be far removed from statistics and also a geological museum with a rich collection of palaentological material including dinosaur fossils. But to the founder of the institute such diversification of activities is a logical necessity. Though statistics had its origin in gambling and demography, it grew in importance as a principal tool in scientific investigations, and the large body of statistical methodology which constitutes the subject-matter of statistics as a separate discipline today has been evolved in studying live problems. As a consequence, Mahalanobis argued, improvements in statistical methods (statistical research) are possible only through new problems and situations arising in specific scientific investigations in the real world."

This unique institute attracted famous scientists and outstanding personalities for short and long visits. This list includes R A Fisher, A N Kolmogorov, Yu V Linnik, J L Doob, W Shewart, W E Deming, A Wald, J Neyman, N Bohr, M Curie and N Wiener. Among the visiting scientists JBS Haldane occupied the most important place. He alongwith his wife, Helen Spurway, joined the institute as full-time members of the staff in July 1957 and stayed there till the beginning of 1961. The relations between Haldane and PCM were far from cordial during the former's stay at the ISI.

Sankhya, the Indian Journal of Statistics was started in 1933. Within a few years of its beginning the journal received international recognition. The journal played an important role in the development of statistics in India. The late Professor Ashok Rudra, a well-known economist, thus wrote about the journal (in his biography of PCM) : "If Mahalanobis had done nothing else, if he had only founded *Sankhya, the Indian Journal* of Statistics, even so his contribution to science would have been outstanding and memorable. *Sankhya* is an international journal in the sense that it receives contributions from statisticians and probabilists the world over; international as in the sense of maintaining a standard comparable to the best in the world. And this has been from the very beginning. This is something that cannot be said of many scientific journals in the country."

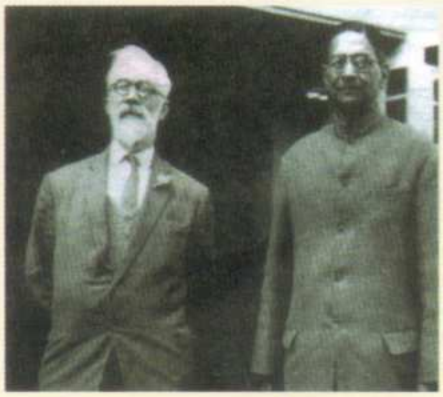
JBS Haldane and P.C. Mahalanobis with Sir Julian Huxley

Prof. Mahalanobis with Madame Curie

While explaining the reasons for choosing the title of the journal PCM wrote : "We believe that the idea underlying this integral concept of statistics finds adequate expression in the ancient Indian work *Sankhya*. In Sanskrit the usual meaning is 'number', but the original root meaning was 'determinate knowledge'. In the *Atharva Veda* a derivative from *Sankhyata* occurs both in the sense of 'well-known' as well as 'numbered'. The lexicons give both meanings. *Amara-kosa* gives *Sankhya - vicarana* (deliberation, analysis) as well as 'number'; also *Sankhyavan - panditah* (wise, learned)".

PCM was one of the first persons in India to recognise the importance of calculation technologies in scientific research and development work, especially statistical theory and practice. He kept himself abreast, till the end of his life, of the latest developments in calculation technologies; statisticians working under his leadership at the ISI were using desk calculators of the Facit variety and sorters and verifiers of the Hollerith variety as early as in the 1940s. PCM managed to have a large number of electromechanical data processing machines of different companies of the west viz. the IBM, the Hollerith and the Power Samas installed at the ISI. These machines were used to process NSS data. The ISI was among the very few institutes to take lead in starting computing activities in the country. The other institutions were 'Tata Institute of Fundamental Research (TIFR), the Indian Institutes of Technology (IITs) and some Defence Laboratories.' The ISI was the first institute in the country to acquire fully electronic computer — Hollerith Electronics Computer type a 2 M, or HEC - 2M and got it installed by its own engineers. HEC-2M was a modestly priced small-programme-controlled computer produced by the British Tabulating Machines Co. A large computer URAL was commissioned in 1959. This was obtained as aid from the erstwhile USSR through the United Nations. Thus during 1959-60, with the visionary initiatives of PCM, the ISI could meet the computational requirements of many important organisations in the country. The ISI rented an IBM 1401 system in 1964. This was done without any loan or assistance from the

Government or from other quarters. The rental to IBM was paid to IBM by selling 50% of the computation time to governmnet agencies and industry. The remaining 50% time was used by the Institute for its own scientific work, research and training. This kind of bold and risky step could be taken only by a person like PCM. The ISI's computer research was not confined to data processing. Research in the area of pattern recognition and machine learning undertaken by the scientists at the ISI was internationally recognised.


Prof. Mahalanobis with R.A. Fisher

PCM viewed science and science education as prerequisites for national development. He believed that science alone could bring about social transformation. This way PCM viewed the role of science in social transformation can be gauged from his following observations : "It is also necessary to develop the outlook of science and the experimental attitude of mind in order to acquire knowledge of natural and social forces and to invent new techniques for initiating material and social changes. This is the only way in which decisions can be made increasingly in a rational manner, in accordance with principles of objective or scientific validity based on relevant data and correct reasoning, instead of on the sanction of authority based on status and power or custom and conventional or revealed rules and laws. This may be called the scientific revolution."

Further he observed : "The transformation of all the advanced or rapidly advancing countries has been brought about by the acceptance, slowly at first, and now in increasing measure of a scientific and rational view of life and nature. This view has also permeated in a large measure the administrative bodies of the more advanced countries, tempering the outlook of individual executives, and increasing their ability to make responsible decisions, especially within the lower levels of the hierarchy of authority. This is the foundation of the modern age."

PCM "stressed the need of building up a system of school education with a definite orientation to science". But then according to him "It would be, however, a fatal mistake to establish an expensive system of education on the model of the advanced countries which would have little relevance to local needs and would be beyond the means of the national economy. It is necessary to evolve a system, through experimentation and trial and success, which would be within the means of the national economy."

It is pertinent to note PCM's observations on the state of Indian science which are still very much relevant. He remarked : "The tradition of science is not yet strong in India. There is no critical appraisal of scientific research. Most of the work is essentially imitative. Some competent work is being done but not much research of high quality. Less than 10 per cent of the R and D expenditure is being incurred in industrial enterprises in India in comparison with about 75 per cent in USA and 65 per cent in UK and Japan. A very large part of the research and development work, which is done in Government agencies or under direct government, control has little connection with production."

Throughout his life PCM helped his friends with money. He donated to institutions. The Brahmo Boys School was saved from financial crisis through his generosity. While making donations, PCM usually did not take receipts. According to the late Nikhil Chakravartty, the well-known journalist (as stated in Ashok Rudra's biography of PCM), PCM donated money to political parties. Incidentally Nikhil Chakravartty acted as a contact person between PCM and the Communist Party of India. Here it may be interesting to note that PCM lent some money to Meghnad Saha, the well-known physicist, against hand-notes. PCM was very fond of his pets — cats and dogs and he was also attached to his three cows.

Most of the people who worked with PCM were mortally afraid of him and many who know him will not hesitate to term him an autocrat. He had an acid tongue. His decisions often times were arbitrary. He had no tolerance for stupidity. He never liked people who tried to flatter him. But he was certainly an inspiring leader. This is evident from the fact that he could attract a large-number of talented individuals who later became outstanding statisticians.

The best quality in him was the ability to work under the most adverse circumstances. He was a man of indomitable courage and displayed immense tenacity in fighting for a good cause. To quote C. R. Rao,"Everybody knows him as the founder of the Indian Statistical Institute, the architect of the Second Five Year Plan, a close associate of Rabindranath Tagore and as one who had richly contributed to the social, cultural and intellectual life in Bengal. All those in the statistical profession were aware of his deep contributions to statistical theory, his efforts in providing a sound database to the Indian economy, and the part he played in placing India not far from the centre of the statistical map of the world. Those who have been closely associated with him have witnessed the indomitable courage and tenacity in fighting opposition for a good cause and clearing obstacles for propagating right principles."

PCM received numerous awards from academic societies all over the world. He was elected Fellow of the Royal Society, London (1945), Fellow of the Econometric Society, USA (1951); Fellow of the Pakistan Statistical Association (1952); Honorary Fellow of the Royal Statistical Society, UK (1954); Honorary President of the International Statistical Institute (1957); Foreign member of the USSR Academy of Sciences (1958); Fellow of the American Statistical Association (1961); and Fellow member of the World Academy of Arts and Science (1963). He received the Weldon Gold Medal from Oxford University (1944). The Czechoslovaki Academy of Sciences awarded PCM a gold medal in 1963. He was a founder fellow of the Indian National Science Academy (1935), and its president during 1957-58. He also received one of the highest civilian awards, Padma Vibhushan from the Government of India.

Prasanta Chandra Mahalanobis died on 28 June 1972.

In 1993 the Government of India released a postage stamp bearing his picture and the Institute he founded. The building of the National Sample Survey Organisation at its Calcutta headquarters has been named as 'Mahalanobis Bhavan'.

❑ **Subodh Mahanti**

For further reading:

1. *Prasanta Chandra Mahalanobis : A Biography* by Ashok Rudra. Oxford University Press, Delhi, 1996.
2. *Prasanta Chandra Mahalanobis* by C.R. Rao in Biographical Memoirs of Fellows of the Royal Society **19,** 455-492 (1973)
3. "Resonance", a monthly journal of Science Education of the Indian Academy of Sciences, Bangalore, in its April 1999 issue has reproduced PCM's Presidential address (Why Statistics?) to the 37th Session of the Indian Science Congress Association. It also contains two articles on PCM's work and a brief life-sketch.

FROM JANTAR-MANTAR TO KAVALUR

In 1947, the renowned American astronomer Harlow Shapley (1885-1972) lamented that although India produced great astrophysicists like Meghnad Saha (1893-1956) and Subrahmanyan Chandrasekhar (1910-1995), her observing facilities were practically nil.

In that first year of India's independence that remark, indeed, was in order. But during the last five decades the situation has radically changed. Now India possesses several first class facilities for astronomical observations. Now we have a number of radio telescopes in our country, the Giant Metre-wave Radio Telescope (GMRT) at Khodad near Pune being the largest of its kind in the world. At the time of independence India had only two, rather outdated, observatories : one at Kodaikanal and the other at Hyderabad. Now we have new observatories at Nainital, Mount Abu, Udaipur, Japal-Rangapur and Kavalur. The Kavalur observatory, named after its founder Dr Vainu Bappu, is one of the best equipped in the eastern hemisphere, its 2.3 metre aperture telescope being the largest in Asia.

It was after independence that one of our leading astronomers, Dr Manali Kallat Vainu Bappu (1927-82), was first elected Vice-President (1967-73) and then President (1979-82) of the International Astronomical Union (IAU). Also, for the first time in 1985 the IAU Assembly was held in India. All this shows that India has now attained a respectable position in astronomical research. The story of India's endeavours in this field is a fascinating one. But before we come to that it would be useful to have a cursory glance at ancient India's achievements in mathematics and astronomy, as both the subjects were studied together.


Sawai Jaya Singh II (1686-1743)

Ancient India made some big advances in science because it was in constant contact with other countries. After the conquest of the Indus basin by Darius around 520 B.C. India was thrown wide open to Babylonian influences. Through the Persians, India also came into contact with Greece. These contacts further increased during Alexander's campaign and again when the Greco-Bactrian kingdoms were established in North-West India. All these contacts greatly helped India in enriching her sciences, particularly astronomy.

This long period of intercourse with the west introduced many new ideas in the traditional system of Indian astronomy. The result was the advent of a class of texts called *Siddhantas*, characterised by a better scientific approach and more comprehensive treatment. There is ample evidence to show that Aryabhata (499 A.D.) and Varahamihira (6th century A.D.) were well-acquainted with Greek astronomy. The most celebrated astronomers after Varahamihira were Brahmagupta (b.598 A.D.), Lalla (8th cent.), Manjula or Munjala (10th cent.), Shripati (c.1039 A.D.) and Bhaskaracharya (b.1114 A.D.). In the post-Bhaskara period not much original work in astronomy and mathematics was done in India till modern times.

By the eighth century the Arabs had extended their conquests from Spain to Central Asia and to the border of India. Under the patronage of the Caliphs books of Indian, Persian and Greek science were translated into Arabic. In about 800 A.D. Aryabhata's treatise *Aryabhatiyam* was translated into Arabic under the title *Zij-al-Arjabhar*. Before that, in 772 A.D., Brahmagupta's two works, the *Brahmasphuta-Siddhanta* and the *Khandakhadyaka*, were taken to Baghdad and translated into Arabic. The knowledge of Indian numerals and the decimal place-value system reached the Arabs along with the Indian mathematical-astronomical works rendered into Arabic.

The Arab scientists, apart from analysing and commenting on what they inherited, made many original contributions of their own. The Islamic world produced great mathematician-astronomers such as al-Khwarismi (780-850 A.D.), al-Battani (850-929 A.D.), Tabit ibn Qurra (836-901 A.D.), al-Sufi (10th cent.), al-Biruni (973-1848 A.D.), Omar Khayyam (c.1048-1124 A.D.) and Nasir al-din at-Tusi (1201-1274 A.D.). The last one was in charge of the observatory at Maragha in Iran. In 1420 A.D., Ulugh Begh, grandson of Timur, built an observatory at Samarkand. Using very big but high-precision instruments he prepared a star catalogue which was much better than that of Ptolemy.

It was with the Islamic rule that Arabic/Persian astronomy came to be introduced in India. The earliest evidence of Arabic/Persian influence on Indian astronomy is of the second half of the fourteenth century. Mahendra Suri, a court astronomer of Firuz Shah Tughlaq (1351-88), composed in 1370 A.D. a treatise entitled *Yantraraja*. Based on Persian knowledge, it described the construction and use of astrolabe, that wonderful instrument developed to perfection by Arab astronomers. Another Indian astronomer who made use of Arabic/Persian knowledge was Kamalakara (b.1658 A.D.), who wrote a big treatise on astronomy called *Siddhanta-Tatva-Viveka*.

But it was Sawai Jaya Singh II who showed the greatest interest in Arabic/Persian astronomy. He was born in the ruling family of Amber in Rajasthan in 1686 A.D., one year after Newton published his *Principia*. He succeeded to the Amber throne at the age of thirteen. Later on he was appointed by Mohammad Shah governor of the province of Agra and then also of Malwa. From an early age Jaya Singh was very much interested in astronomical observations and had acquired thorough knowledge of its principles and rules.

Jaya Singh felt a great urge in reviving the study of astronomy in India. With the aim of preparing new tables, Jaya Singh at first started with the traditional brass instruments. Realising their inadequacy, he discarded them in favour of stone and masonry instruments of huge size. For observing the heavens Jaya Singh built observatories at five places : Delhi, Jaipur, Mathura, Ujjain and Varanasi. The first one was built in Delhi in 1924 A.D. These observatories, which in course of time came to be called 'Jantar Mantar', housed a wide variety of masonry and metal instruments,

Delhi Observatory (Jantar Mantar)

the most important among them were : *Samrata Yantra*, *Jai Prakash*, *Rama Yantra*, *Mishra Yantra* and *Rashi Valaya*. Among the metal instruments used by Jaya Singh the astrolabe was the most significant one.

Jaya Singh, making use of the masonry and metal instruments of his observatories, prepared the astronomical treatise *Zij-I - Muhammad Shahi* and dedicated it to the reigning monarch Muhammad Shah. The work was completed around 1727-28 A.D. Jaya Singh's court astronomer Pt.Jagannatha, who had mastered Arabic and Persian, translated from Arabic into Sanskrit works titled *Rekhaganita* and *Siddhanta-Samrata*. The translation of the former was completed in 1718 A.D. and of the latter in 1731 A.D.

Jaya Singh had established contacts with Jesuit missionaries in India and had also known the telescope. But he did not make use of the Copernican revolution ushered in Europe. He remained a firm follower of the geocentric system of Indian tradition and of Ptolemy. It seems that Jaya Singh had no knowledge of the works of Kepler (1571-1630) or Newton (1642-1727).

In spite of his best efforts for the revival of astronomical studies in India, Jaya Singh remained firmly attached to the medieval tradition. He died in 1743 A.D., exactly two hundred years after Copernicus (1473-1543). Today Jaya Singh's work is only a tradition and his observatories are nothing but archaeological remains.

Modern astronomy arrived in India along with the European merchants and missionaries. At the end of the 17th century the French Jesuit priests of Pondicherry were already using the telescopes. Jesuit priest Fr. Jean Richaud discovered from Pondicherry that the southern bright star *a Centauri* is in fact a double one.

The merchants of the East India Company also brought astronomical instruments to India. In 1792, they established their first observatory in Madras. The transit instrument of the Madras observatory was mounted on big granite pillars on which an inscription in Latin, Tamil, Telugu and Hindustani announced : "Posterity may be informed a thousand years hence of the period when the mathematical sciences were first planted by British liberality in India." The remains of these pillars are still extant in Madras (Chennai).

Manali Kallat Vainu Bappu (1927-1982)

The Madras observatory functioned for more than 100 years and carried out important astronomical obervations. The Indian astronomer Chintamani Raghunathachari, who was head-assistant at the Madras observatory, discovered a new variable star *R. Reticuli* in the southern sky in 1867. Also, it was from here, after 18 years of work, Thomas Glanville Taylor produced the *Madras General Catalogue* of 11015 southern stars, which was highly admired in Europe.

The British were more interested in the study of the Sun. Realising the benefit of India's sunny climate, observatories came to be established in Dehradun, Calcutta and Pune. But all of them were shut down much before India attained independence.

The Kodaikanal observatory was established in 1899 for studying physics of the Sun. John Evershed, who joined the observatory in 1907, personally built up several new instruments for solar investigations. Using one such instrument, in 1909 he made the important discovery : huge vortical motions of gases in sunspots (the Evershed Effect). After Evershed's retirement in 1923, the observatory continued to take solar pictures. It has a collection of solar photographs that now covers eight solar cycles.

After independence several new instruments were added to the Kodaikanal observatory. In 1958, a new solar telescope was purchased from the famous telescope makers of England, Grubb Parson & Co. Also, a Lyot filter for studying the chromospheric layers of the Sun was imported from France. In the International Geophysical Year (1957-58) the task of observing solar effects between Manila and Rome was given to the Kodaikanal observatory. That time Dr. A.K. Das was the director of the observatory. A crater on the invisible side of the moon is named after Dr. Das.

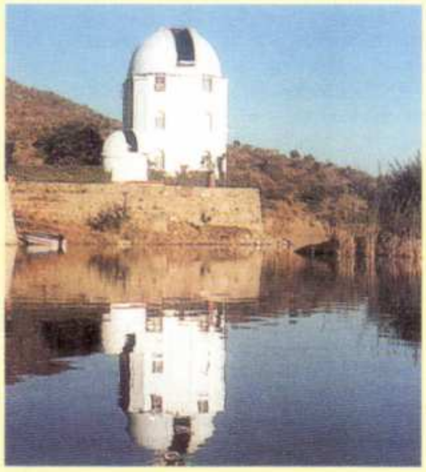
In 1909, a private observatory, later named as Nizamia (Nizam's) Observatory, was set up at Hyderabad. Its founder was Nawab Zafar Jung, an England-educated rich noble man. Taken over by the government in 1907, the observatory for years worked on an ambitious programme of photographing and charting a large segment of the sky. After independence the observatory received special grants for its modernization. When the 40 inch (1.2 metre) reflector arrived in 1968, it was erected at a new site named Japal-Rangapur after the two neighbouring villages not far from Hyderabad. In 1983 the Nizamia Observatory was also shifted from its old Begumpet site to a new building in the Osmania University campus. Now both the observatories, Nizamia and Japal-Rangapur, function under the Department of Astronomy, Osmania University.

In the first half of the 19th century a few other private observatories were also established in India. The Nawab of Oudh, Nasiruddin Hyder, established an observatory in Lucknow in 1832 and equipped it with some fine instruments. But it was soon closed down and was ransacked in 1857 at the time of the Mutiny. Another observatory was set up at Trivandrum in 1836 by the Raja of Travancore, Rama Vurmah, who desired "that his country should partake with European nations with scientific investigation". It also met the same fate as the observatory at Lucknow.

Thus, at the time of independence there were only two observatories functioning in India : one at Kodaikanal and the other at Hydrabad. At that time Shapley was quite right when he said that India's observing facilities were practically nil. But he had also said that India produced great astronomers like Meghnad Saha and Subrahmanyan Chandrasekhar. Saha in 1920 produced his famous Ionization equations, which were of great help in understanding stellar atmospheres. S. Chandrasekhar applied the theory of special relativity to problems of stellar structures in the 1930s and obtained results which later came to be known as 'Chandrasekhar limit' for which he received the belated Nobel Prize in physics in 1983.

A few years before independence efforts were made to establish some new scientific institutions in the country. To estimate the requirements of astronomical research, a committee was formed in 1945 with Prof. Meghnad Saha as its Chairman. The recommendations of the committee included several suggestions for improvement in the existing observational facilities. It also strongly recommended that efforts should be made to establish a fairly large observatory where Indian scientists could do astronomical research independently. But because of the political changes that followed and Saha's sudden death in 1956, it took a long time to implement the recommendations. The credit for making Saha's dream a reality goes to Dr. Manali Kallat Vainu Bappu.

In 1948, the American astronomer Harlow Shapley was in India. That very year Vainu Bappu had obtained his master's degree in physics. His father being an astronomer in Nizamia observatory, Vainu Bappu had developed a great interest in astronomy. He wanted to follow a career in astronomy and was in search of an opportunity. The opportunity came when Harlow Shapley was in Hyderabad, and Vainu Bappu met him in his hotel. The result was that Vainu Bappu found himself in Harvard in early 1949 on a Government of Hyderabad scholarship to do research in astronomy.



Udaipur Solar Observatory

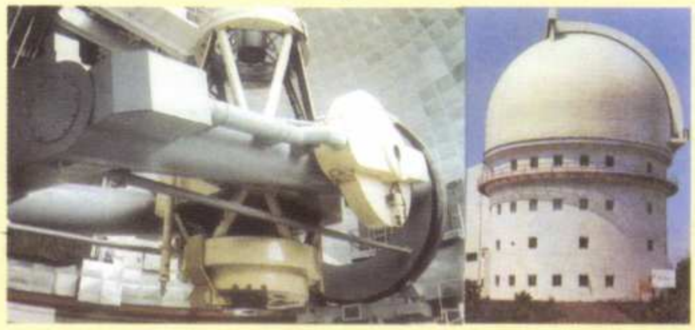
At Harvard, Bappu got the opportunity to work with new instruments and better facilities. Within a few months, after his arrival at Harvard, Bappu and his two colleagues discovered a new comet, which was named as 'Bappu-Bok-Newkirk Comet'. In 1952, Bappu got the opportunity to work with the Palomar 200-inch telescope, the largest in the world at that time. During that period Bappu and Prof. Olin Wilson jointly discovered what came to be called "Wilson-Bappu Effect". This is one of the fundamental relations often used in determining a star's luminosity.

Madras Observatory (1792)

Bappu returned to India in early 1953 and got an offer to build an observatory in Uttar Pradesh. With the help of Dr. Sampurnanand, then Chief Minister of UP, Bappu established a new observatory at Manora Park in Nainital. He installed modern instruments in this new observatory and developed there a team of young astronomers under his guidance. In April 1960 Bappu left Nainital and came to Kodaikanal to take charge of the Observatory, then biggest in the country.

The most important recommendation of the Saha Committee was to establish in the country a big observatory which could match any other in the world. Bappu diverted all his vigour and attention to achieve this objective. His first decision was to locate the new observatory somewhere in south India. From such a location the southern sky would be within the reach of the observatory's instruments. In southern India Bappu searched several hills for a suitable location. At last, he selected the sandal-wood forested Javadi hills (North Arcot district, Tamil Nadu) for the site of his dream-observatory. The observatory was named after a small village nearby -- Kavalur. At Kavalur the first observations with an indigenously built 38 cm telescope were made in late 1967.

In Kavalur the one-metre Zeiss telescope was installed in 1972, and the very next month, during an occultation event, scientists



The 2.3 metre telescope at the Vainu Bappu Observatory, Kavalur (left). The Kavalur dome where the Vainu Bappu telescope is installed.

Giant Metre-wave Radio Telescope at Khodad near Pune

discovered a trace of atmosphere on Gynymede, the largest satellite of Jupiter. Five years later the same telescope discovered the rings of Uranus.

Vainu Bappu also planned and worked hard for the erection of an indigenously built 93-inch (2.3 metre) telescope at Kavalur. But he did not live to see the realisation of his dream. This telescope, the largest in Asia, was set up in a big dome at Kavalur in 1985. In 1986, the Kavalur Observatory and the 2.3 metre telescope, both were named after the founder, Vainu Bappu. The International Astronomical Union, during its Assembly in India in 1985, unanimously decided to name a newly discovered asteroid as Vainu Bappu.

The first observatory after independence was set up in 1954 at Varanasi and this was shifted to Nainital in 1961. In 1972 it acquired a 1-metre reflector, which later was named as the Sampurnanand Telescope. The Gurushikhar Infrared Observatory, Mount Abu, houses a 1.2 metre reflector along with stellar and infrared photometers. The Udaipur Solar Observatory was set up in 1975 on a small island in the Fatehsagar lake in Udaipur. It has three telescopes for solar studies : helioseismology and chromospheric observations. Both the Mount Abu and Udaipur observatories are attached to the Physical Research Laboratory, Ahmedabad.

Before independence there was not a single radio telescopes in India. Now radio astronomical facilities exist at Ooty, Bangalore, Gaurubidanur, Ahmedabad and at Khodad near Pune. India's first major radio astronomical facility, the Ooty Radio Telescope, was set up in 1970 at Udhagamandalam in the Nilgiri Hills. It consists of 24 parabolic cylinders 530 metres long and 30 metres wide. The telescope has been used for studying distant radio sources, pulsars and supernova remnants. In the early eighties, at a distance of 4 kms, one more radio telescope was set up at Ooty.

The Giant Metre-wave Radio Telescope (GMRT) erected near Khodad, about 80 km north of Pune, has become operational in 1995. It is the world's largest aperture synthesis radio telescope at metre wavelengths. It consists of 30 fully steerable parabolic dishes of 45 metre diameter each. The main objective of this radio telescope is to search for the highly red-shifted lines of neutral hydrogen emanating from proto-galaxies and proto-clusters, with the aim of determining their time of formation.

Cosmic gamma rays are the most powerful electromagnetic radiation produced by nature. As these rays cannot reach the surface of the earth, they are studied by detectors aboard satellites. But they can also be detected on ground as high energy gamma ray photons, which are a component of the secondary cosmic rays. For Gamma-ray astronomy there are two facilities in our country : The High Altitude Research Laboratory at Gulmarg under Bhabha Atomic Research Centre (BARC) and the High Energy Gamma-Ray Observatory at Pachmarhi under Tata Institute of Fundamental Research (TIFR).

India has done very well in cosmic ray studies. Dr. Homi Bhabha (1909-1966) was a pioneer in this field. In the last few years, work has also been done in the area of X-ray astronomy, infrared astronomy and atmospheric science. There are facilities for astronomical and astrophysical studies in about a dozen Indian universities. To help the universities, the Inter-University Centre for Astronomy and Astrophysics was established at Pune in 1988. The first planetarium was set up in 1954 at New English School, Pune. Now there are about 30 planetariums in the country.

It was at the time of Sawai Jaya Singh that India came in contact with modern European astronomy. As noted by Harlow Shapley, in 1947 India had no facilities for astronomical observations worth the name. But now we have several first class facilities. The Vainu Bappu Observatory at Kavalur is one of the best in the eastern hemisphere. Also, the metre-wave radio telescope near Pune is among the most powerful in the world. Now, our astronomers' contribution is also receiving international recognition.

❑ **Gunakar Muley**

(Contd. from Page 23)

HAVE SCIENCE POPULARISATION.....

has been attracting attention nationally and internationally; starting in 1997, in response to a request from the Indian Science Congress Association, selected NCSC projects from each State have been exhibited at the Annual Science Congress Sessions and these have been a big draw with the delegates as well as visitors.

In the above, one has not mentioned the numerous micro-level gains that have accrued and are accruing as a result of the science popularisation programmes. At a macro level, however, the "difference" made by these programmes has also been manifesting itself in many ways and on different occasions. Some examples to elaborate on this would be in order; (i) the successful campaigns by women against brewing and use of liquour in rural areas of several states have had to do with the combined effect of literacy and science popularisation programmes. (Andhra Pradesh was in the news for this for a long time). (ii) Training programmes involving demonstration-cum-scientific explanations of the so-called 'miracles' performed by self-styled godmen have yielded fruit in many parts of the country. (iii) Science coverage in newspapers, radio and television has definitely improved both quantitatively as well as qualitatively over the years, as a result of specific efforts in this direction under the science popularisation programme. (iv) There are now more science writers, science programme producers for radio and television in all different Indian languages than ever before, as a result of specific efforts in this direction. (v) Also, as a result of efforts under this programme, science communication materials (software) in the form of books, publications, popular magazines, kits, charts, slide-sets, audio and video cassettes etc are available in almost all Indian languages in larger numbers than ever before — even though a lot more effort is still required for the purpose before the absolute numbers could be termed as adequate.

Considering the expenditure incurred over a period of nearly two deacades, the gains from the science popularisation programme can only be termed as spectacular. Yet, in relation to our overall size, we need a real scaling up of efforts, before we are able to reach further and make a "difference" for the entire population.

❑ **NKS**

THE STORY OF WOOL

With the advent of winter in our country the demand for woollen clothes jumps up. In colder regions, this demand remains high throughout the year. Wool provides the best available protection from cold. In pre-historic ages, man used pelts (skins of fur-bearing animals stripped from the carcass) for covering his body. As time passed he eventually learned to make yarn and fabric from the fibre-covering of animal skins, particularly sheep-skin. In the beginning, sheep had long hair. However, with the improvement in quality, their hair became soft, short and warm. Excavations have revealed the presence of wool in the graves of Babylon (Ancient city on the Euphrates River, the capital of Babylonia, an ancient empire in South West Asia) and Nineveh (capital of ancient Assyria on the Tigris River) and in the huts of natives of Britain and Peru. There is proof that the Britishers used woollen clothes prior to the Roman invasion.

With the establishment of Winchestor factory in England, different uses of wool were developed. Henry II (1133-89), the King of England, encouraged this industry and constituted byelaws, started a wool-garment market and also a union of weavers. However, in the 18th century, the popularity of cotton-clothes over-powered the wool-industry. In 1788 in Hartford (USA), a hydro-electric based factory was established for manufacturing wool. Besides USA and Britain some of the other wool-producing countries are: Russia, New Zealand, Argentina, Australia, China, India and South Africa. It may be noted that the wool of Asian sheep and mountain breeds is long and coarse; being very strong, it is used chiefly for carpets.

Bharat Merino
A cross breed of sheep

In India, people have been using wool since prehistoric times. There is a prayer in *Rigveda* for the deity of shepherds, called 'Pashma', entreating the deity to make wool white and help in its knitting. In *Mahabharata*, it has been mentioned that when Pandavas performed *'Rajsuya Yagna'*, Yuddhisthir was presented woollen clothes having golden embroidery by *Kambojs* (people of Badakhan and Pameer).

During pre-independence period Merino sheep were crossed with Indian sheep and the new breed thus developed was known as 'Kashmiri Merino' in Kashmir and 'Southern Merino' in Pune. Merino is a breed of sheep originating from Spain and noted for its long thick high-quality white fleece. Merinos are well adapted to hot arid climates and have been exported to many parts of the world, especially Australia where a Merino has been developed with superior fleece. 'Pashmina', which is considered to be the highest quality of wool, is obtained from the goats of Kashmir and Tibet. The per animal produce (yield) of wool varies due to diversity in breed, natural conditions, rainfall and grasslands. Hence, we find change in quality of wool in different parts of our country. The frequency of wool shearing in India is twice a year, but in some areas it is thrice a year.

Wool is mainly obtained by shearing fleece from living animals. The wool-grease is removed from it. Wool fibre, a bad conductor of heat, is mainly composed of animal protein, 'Keratin'. The observation of wool-fibre under a microscopic reveals that its surface is uneven and is made of cells connected over each other. The shape and form of these cells vary from sheep to sheep. In thin wool, the edges of cells are nearer to each other than in the case of thicker wool. These fibers mix with each other, when heated and cooled. The inner-layer (medulla) of the wool fibre can be seen in thick-wool. The medulla also consists of the pigment which gives colour to wool.

CENTRAL SHEEP AND WOOL RESEARCH INSTITUTE

The Central Sheep & Wool Research Institute (CSWRI) was established in 1962 at Malpura, 85 Km away from Jaipur in Rajasthan. The campus is now known as Avikanagar. The purpose of the Institute has been to conduct research for various uses of wool and improvement in wool production from sheep for carpets and garments and to increase meat production. The Institute also imparts training in sheep and wool-science education and undertakes extension activities. The main aims of the Institute are: (1) To undertake basic and applied research in all disciplines relating to sheep and rabbit production. (2) To develop, update and standardize meat, fibre and pelt technology. (3) To impart training in sheep and rabbit production as well as utilization of wool and other animal fibres. (4) To transfer technologies on sheep and rabbit production as well as animal fibre technology to farmers, rural artisans and wool industry. (5) To provide referral and consultancy services on production technology of sheep and rabbits.

The Institute has undertaken experiments to improve various indigenous breeds of sheep for production of apparel wool, carpet wool, mutton and pelts. As a result of these experiments, the Institute has developed a number of breeds of sheep:

Avikalin Sheep: A cross breed of Rambouillet and Malpura, Avikalin Sheep are suitable for both wool production as well as meat production. The annual production from one sheep is 1.66 kg of greasy fleece. The diameter of the greasy wool fibre is 27 microns, medullation 25% and staple length 4.75 cms.

Marwari Sheep: The annual production of greasy- wool from this breed of sheep is 1.5 kg having a diameter of around 45 microns and medullation around 50%.

Magra Sheep: Magra sheep has been introduced at Bikaner for multiplication and distribution of elite rams to the farmers for breeding purposes. The annual production of shiny wool from this sheep is 1.5 kgs. the diameter of the fibre is 38 micron with 63% medullation.

Angora Rabbit
A breed developed by CSWRI

Bharat Merino Sheep: Bharat Merino Sheep developed by cross breeding indigenous Chokla and Nali sheep with Rambouillet and Merino rams. This breed has proved to be good for cross-bred wool of high quality. The annual production of greasy wool is 2.5 kgs with diameter of fibre 19-20 microns, medullation less than one percent and staple length 7-8 cms.

Malpura breed is being improved for mutton production. It is also crossed with **Awassi** sheep to improve its mothering ability. **Awassi** Cross Malpura sheep wool was found to be of better quality with 36 microns diameter and 45% medullation. The crossbred wool is also lustrous and it has proved to be useful as carpet-wool. Farmers around Avikanagar are happy to accept cross-breeding of Malpura with Awassi. The newly evolved mutton type sheep attains 25% body weight at five months of age under intensive feeding conditions. Lamb weaned at 60 days' age and fed with 50% concentrate and 50% roughage feedlot attained 25% live weight at 135 days of age.

Commercial production of broiler rabbit is being studied at Avikanagar, Garsa and Mannavanur. In the general colony, 1.6 to 1.7 kg of body weight is obtained at 12 weeks of age whereas on feeding individually with diets containing various energy and protein sources, it was found that at 12 weeks the body weight of 2.0 to 2.3 kg could be obtained. At Mannavanur, the technology is being developed for backyard rabbitry which is becoming popular. It was found that the rabbits could be maintained on kitchen waste, vegetable waste etc. and they attained a weight of 1.2 to 1.3 kg at 12 weeks after individual feeding from 6th week. The technology on broiler rabbits has the potential of meeting the requirement of an alternate protein source parallel to poultry. However, it requires improvement in marketing.

At Garsa Centre of the Institute, Angora Rabbit breed has been developed. These rabbits produce about 1 kg of wool per annum with 2%

The shape of wool is also affected by climate, soil and food. Wool fibre has been classified into five types:

Thin-wool is obtained from Merino sheep. The famous Merino sheep varieties are : American, Australian, French, Spanish, South African and South American.

Merino-wool is famous in the world because of its softness, strength and resilience, best for knitting and for making carpet type 'Namda'. Flannel, high quality knitted wool garments, suits and fine dresses are made from Merino-wool.

Medium-wool is dense and dry. Its fibres are lighter than those of Merino-wool. It is used for making tweed, serge, flannel, overcoats and blankets.

Long-wool is obtained from the taller varieties of sheep. These types of sheep are found in areas which receive heavy rainfall. The long wool does not shrink due to absence of fat in it. This wool is thick and also has shine. It is used mainly for manufacturing plain woollen clothes, tweed, serge and coats.

Cross-bred wool is obtained from Merino-Rambouillet sheep crossed with long-haired sheep. (Rambouillet is a breed of large sheep, originally bred in France from Merinosheep imported from Spain). Cross-bred wool has both softness and thinness of Merino sheep wool and the length of long-wool. It is used for making socks and baniyan and other such garments. Carpet wool is obtained mostly from the sheep of Asian countries. This wool is generally used for carpet and thick blankets (rugs).

The wool fibre is curly in shape instead of being straight like a rod. This curlyness is called 'crimp'. The wool fibre which is thin has more crimps than any other wool variety. The quality of wool is judged by the number of crimps it has. The resilient fibre can return to its original length after limited stretching or compression. This quality of wool is called 'resilience'. This is because of its crimps and shape and form of its cells. The length of wool fibre can be stretched to 30% of its original length without breaking it. The wool fibre keeps its shape because of resilience and smoothness.

There are three types of shine in wool — silvery, glossy and silky. The silver shine is found in Merino-wool. Glossy shine is in straight and smooth fibre and silky shine is in long hair wool. The natural colours of wool are white, black and grey. The colour of domestic sheep wool is mostly white and of old-generation sheep it is black or grey and is used mostly for making carpets.

Wool is a bad conductor of electricity and if it is rubbed it produces momentary charges (of static electricity). The characteristic of wool which preserves the heat is its crimps, which create small airbags. Wool has also the characteristic of absorbing water-vapour. When wool absorbs water-vapour, it releases heat, which in turn is sufficient for keeping the air warm. The woollen clothes, because of the crimps in wool, do not stick with the cotton garments which cover our body, rather they create a thin layer of air which functions as a good insulation.

Chemically, wool consists of carbon, hydrogen, oxygen, nitrogen and sulphur in the form of a protein known as Keratin. This has both acidic and alkaline properties. Hence wool is an amphoteric-fibre and can be dyed in any colour.

In India, fifty percent of the total wool production is used for manufacturing blankets, thirty percent is used by the mills and ten percent by carpet-making units. The rest (ten percent) is used by other industries (such as those for making shawls, sweaters etc.). Wool cottage industries are spread all over the country as per the needs of the areas. Carpet industry is mainly in U.P. i.e Bhadohi, Mirzapur, Gopiganj, Madhosingh, Agra, Jaunpur etc. Indian carpets have good market in foreign countries. Woollen garments made in India also command good markets abroad.

❑ **Hari Krishna Devsare**

Administrative building of CSWRI

guard hair. The wool is of good quality and shawls could be produced locally by blending with Gaddi synthetic wool. The wool yield in German Angora was 498 gms. in 4 clips, where as the Russian, British and three other cross breeds yielded 349 to 399 gms in three clips. The staple length of fibre was 5 to 6 cms. Fibre diameter varied from 12.4 to 12.7 microns with guard hair of 2 to 3%.

The Centre has conducted research in feed resource development and nutrition. Cenchrus and Sewan grass species have been identified to be most suitable for semi-arid and arid pastures. Dry matter production from grass pasture alone varied from 2 to 4 quintals per hectare depending upon rainfall.

Mixed with Babool leaves, Anjan grass has proved to be good food for increasing weight of the sheep. Complete feeds have been developed for feedlot lambs containing cowpea fodder or tree leaves. For better production of wool, Marwari sheep require ten percent raw protein. The annual wool production from these sheep through half yearly clippings has been 750 gms.

Technology for embryo transplantation in sheep is also being developed in the Institute. So far, with the development of embryo preservation method, obtaining embryo through surgery and embryo transplantation - the Institute has succeeded in developing lambs of desired breeds by crossing local sheep through Merino and Rambouillet sheep.

The Institute has also experimented in treatment of diseases and their control. This has resulted in lowering of the mortality rate in sheep and rabbits, sheep-pox, viral pneumonia, pasteurelosis, clostridosis, contagious abortions, helminithic gastroenteritis, blue tongue, viral abortions and theileriasis are the emerging diseases recorded during recent years. Epidemiology of blue tongue is being investigated. Blue tongue virus in some farms and villages in Rajasthan has already been isolated. Emphasis also has been given to the economic effects of diseases, the cost of their control and the impact of diseases on productivity.

Different types of wool available in the country and of new strains being evolved have been evaluated in the Institute with respect to their physical attributes, mechano-chemical properties and end use suitability. Wool from different breeds and breed crosses are evaluated for spinnability, fabric and knitting performance. The fabrics produced by halfbred wool was much better than the native in terms of breaking strength, colourfastness, relaxation shrinkage, abrasion resistance etc. The halfbred wools met the norms stipulated for knitted fabrics. Various types of blends of wool with vegetable fibres and other animal fibres have been prepared. The woolenized jute could be successfully blended with carpet wool to an extent of 30% without any serious effect on yarn characteristics. Carpets of jute wool blends can be chemically washed to provide good lustre.

The Institute also tries to transfer technology to rural areas under its extension programme. The programme is aimed at transfer of technologies for improving sheep production through breeding, nutrition, pasture development, wool utilisation etc. The Institute also provides training on sheep and rabbit production and product utilization.

❑ **H.K.D**