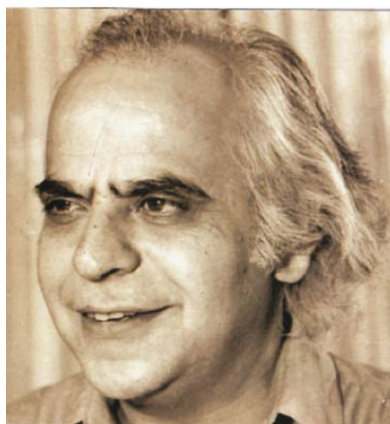


## Yash Pal (1926–2017)

In the evening hours of Monday, 24 July 2017 Professor Yash Pal the educator and scientist passed away. Nirmal, who has known him for 75 years, and was his constant companion and wife for 64 years, and their two sons, Anil and Rahul are deeply saddened by this loss and my heart goes out to them. Millions of persons, scientists, administrators, people in the villages of India, students, children and indeed the widest spectrum of people we can think of are touched by his demise. Such was the life of Yash Pal, and such was his personality that everyone individually felt a personal bond with him. He was a man of fine aesthetic sensibilities and egalitarian principles. Words cannot assuage the sorrows of this loss; only time will work its alchemy to convert our pathos into fond memories, and a celebration of his wonderful and extraordinary life. 'He is gone, but his values and wisdom will remain to guide us,' said Shyam Narayan Tandon, his student and long-standing associate<sup>1</sup>.

During his many splendored career Yash Pal made pioneering contributions to particle physics, to observational and theoretical study of astrophysics and cosmic rays, to cosmology, to building of scientific and educational institutions, to the national space programme, including to the application of space technology to remote sensing and to reaching out to every nook and corner of India to spread general education on subjects like health and hygiene, animal husbandry and agriculture, to the popularization of science, to bring about inter-departmental cooperation, and to infuse a self-confidence into one and all of us that we can solve our problems, technological, societal or political by our own efforts<sup>2-5</sup>. He contributed, in no small way, to bind us together as a nation, poor or rich, villagers or city dwellers, educated or otherwise. Accordingly, talking about Yash Pal's SITE experiment that 'blossomed into a full scale television facility connecting millions of villages of India', N. R. Narayana Murthy of Infosys Technologies says that SITE together with CDOT pioneered by Sam Pitroda have transformed the lives of Indians like never before, and have given us vibrant TV media, and efficient communication systems on par with the best in the world<sup>6</sup>.

Yash was born in the small town of Jhang, on the eastern banks of the Chenab River in Punjab on 26 November 1926, to a prosperous family with highly ethical and cultural values. His father Ram Pyare Lal Bhutani was a Gazetted Officer in the Central Government under the British rule, a well-respected position, and his mother Lakshmi Devi was a highly intelligent and generous lady. Yash was the eldest of five siblings, with a sister Swarn, and three brothers, Om Prakash, Rajinder Kumar and Sunil, who



were all well educated, and have served the country admirably in various capacities. His primary education was in the city of Quetta in Balochistan where his father had been posted. Fortunately he and his family survived the terrible 1935 earthquake, which claimed more than 60,000 lives. This disrupted his studies for almost a year during which the city was rebuilt, allowing him to return to Quetta to complete his primary and secondary school education. His father was transferred to Jabalpur on the banks of the River Narmada, in the Central Provinces, and his education continued there. A silverlining in all this interrupted education was that he came under the influence of a great teacher, Pawar, who adopted the Socratic method in his teaching instead of conventional lectures, and introduced Yash Pal to self-study of various subjects. He matriculated with a Secondary School Certificate in 1942. Fearing further such disruptions, the family decided to send Yash away to his aunt's house and continue his education in Lyallpur, better known today as Faisalabad. And this was where he met his closest friend Mohindra Chadha, and

perhaps even more importantly, Nirmal Sharma who was a fellow student. Nirmal was a courageous and brilliant young girl, with a sparkling good humour that lights up her face even today. Yash was captivated; they became good friends. The year was 1943.

At that time World War II was raging in Europe and Africa in the West, and in Burma and Rangoon in the East, and the civil disobedience movement demanding independence for India from British rule was gathering strength. Amidst all this, Yash completed the Intermediate stage (F.Sc.), and imbibed the patriotic spirit, and assimilated ideas of egalitarianism and *ahimsa* advocated by leaders like Mahatma Gandhi and Pandit Jawaharlal Nehru. He read Nehru's autobiography *Towards Freedom* (written in the Almora prison), Tolstoy and Thoreau. From Lyallpur, Yash moved to Punjab University, Lahore to enroll in B Sc (Physics honors), and in the few years' time he took to graduate and then enroll in the master's programme, the divisive feelings of hatred among different communities, and the feverish demands for a division of India on religious lines had vitiated the atmosphere. In June 1947, for his summer vacation Yash went to New Delhi where his father had been transferred from Jabalpur. At midnight, as the fifteenth day in August commenced Nehru proclaimed the independence of India from the ramparts of the Red-fort: '...at the midnight hour – when the whole world is asleep, India is awake...' There were celebrations all over India, but India had been partitioned into two countries, India with a wide distribution of ethnicity and religions, and Pakistan with predominantly Muslims. Riots had broken out and refugees of minority population were pouring into India, which was not prepared and had to scramble to house them and feed them. Yash was in the thick of it as a volunteer. There was no question of his going back to Lahore to complete his studies for the Master's degree; that was impossible. During this period he befriended many artists, students and intellectuals, and his friendship with Nirmal continued through those troubled times. With enterprise and help from great educators like D. S. Kothari, Yash and his friends continued their studies in makeshift classrooms. It

is from such a crucible that Yash Pal emerged with sterling character and dedicated to a life in science and service to his fellowmen.

In order to fulfill the requirement for the Master's degree he had to conduct independent research, and write a dissertation. Fortunately, he was able to secure a position as a research assistant at the already famous Tata Institute of Fundamental Research, Bombay, founded by Homi Bhabha in 1945. When Yash Pal joined the institute in 1949, he became close friends with another precocious student, Devendra Lal, who was bubbling with energy and impish humour. The visit of Bernard Peters on a visit to the institute in 1950, gave a fillip to their research: They floated a stack of photographic emulsion pellicles to altitudes of ~30,000 feet suspended from latex balloons filled with hydrogen gas, to record cosmic ray particles and their interactions. By that time such methods of research were well established by Cecil F. Powell of Bristol University, who had discovered the ' $\pi$  meson', the Yukawa particle responsible for the binding force among protons and neutrons inside an atomic nucleus. The effort of D. Lal, Yash Pal and B. Peters<sup>7</sup> was highly successful. They discovered several events of ' $K^+$  and  $K^-$ -mesons' decaying into either two or three pions, that indicate violation of the symmetry called 'parity' and commonly referred to as the  $\tau - \theta$  puzzle. Such events triggered intense theoretical studies culminating in the Nobel Prize winning work by T. D. Lee and C. N. Yang on parity non-conservation in  $\beta$ -decay and other processes involving 'weak interactions'. They also discovered events in the stack representing the short and long-lived decay of neutral mesons,  $K_S^0$  and  $K_L^0$ . The other members of the 'nuclear emulsion' group at TIFR like S. Biswas, R. R. Daniel and Rama Thor provided much support in the technical aspects of the experiment and in the measurement of the events. Soon after the publication of their joint paper in 1953, with the M Sc Degree (Punjab University) thus earned, Yash Pal became a regular member of TIFR, and married Nirmal in a simple and elegant ceremony. In 1954, a year after the publication of these results, Homi Bhabha deputed Yash to Massachusetts Institute of Technology, for graduate work under the guidance of his friend and distinguished scientist Bruno Rossi.

Yash and Nirmal arrived at Rossi's lab where they were warmly welcomed by fellow research workers, Hale Bradt, Elihu Boldt, David Caldwell, George Clark, Gaurang Yodh and Stanislaw Olbert, besides Bruno Rossi and Herb Bridge. Yash Pal continued his research studying the properties and decay characteristics of neutral and charged  $K$ -mesons, and of heavier particles called hyperons, which are produced in association with  $K$ -mesons, now using energetic particles generated in manmade particle accelerators. Nirmal took up a technical position at MIT. The title and a brief summary of Yash Pal's doctoral thesis<sup>8</sup> submitted to MIT is given in Box 1. This effort carried out with several members of Rossi's group led to the publication of several important papers<sup>9-14</sup>. It may not be out of place here to note that in 1959, Segre and Chamberlain were awarded the Nobel Prize for the discovery of the anti-proton, and in 1964, Christenson, Cronin, Fitch and Turlay in their continued study of the decay neutral  $K$ -mesons made the Nobel prize-winning discovery of the violation of the combined symmetry of parity and charge conjugation. Yash Pal returned to TIFR in 1958, accompanied by Nirmal and their newly born son, Anil.

Students flocked to him upon his arrival in TIFR – A. K. Ray, T. N. Rengarajan, P. Babu, R. Cowsik, S. N. Tandon and R. P. Verma; he also collaborated extensively with postdoctoral research workers such as S. M. Chitre and other professors at TIFR. His international collaborations were mainly with Bernard Peters and Gaurang Yodh. The research was on several fronts<sup>15-32</sup> spanning high-energy physics, neutrino physics, cosmic rays, astrophysics and cosmology. It is impossible to present here a full account of all their research findings, and only a selection of results are included: The detailed calculation of the fluxes of neutrinos/antineutrinos of the electron and

muon flavors generated by the decay of secondary cosmic-ray pions and kaons, followed by a prescription of how to detect them in deep underground experiments<sup>21</sup> are as relevant for the ongoing experiments even today, as they were for the TIFR effort in the mines of Kolar by B. V. Sreekantan, M. G. K. Menon and others in the 1960s. A major effort for the studies of cosmic-ray neutrinos subsequently launched by the Japanese group, led to the discovery of neutrino oscillations, and the award of the Nobel Prize for M. Koshiba. Such instances indicate that he focused his research efforts always on important questions, especially on those whose solutions were not only possible but also imminent. The study of the cut-off in the cosmic ray spectrum induced by their interactions with a hypothetical neutrino background in the universe<sup>20</sup> foreshadowed the cut-off in the cosmic-ray spectrum predicted by Greisen, Zatsepin and Kuzmin owing to their interactions with the 2.7 K universal microwave background. Once the discovery of the background became known in India, his group calculated the effects of Compton scattering of the microwave photons on the cosmic-ray electrons and estimated their lifetime in the Galaxy<sup>23</sup>. The comparison of the U–Pb and the K–Ar dating of the same meteoritic samples yielded a strict upper bound of less than 0.5% variation of the fine-structure constant  $\alpha$  over the age of the universe<sup>25</sup>. The analysis of the air shower data yielded evidence for the increase of the  $p$ - $p$  cross-sections with energy<sup>31,32</sup>, a result later confirmed by the experiments at the 'collider' at CERN.

We have described Yash Pal's growth from birth into a brilliant scientist to show how the events that he experienced on the way tempered and conditioned him to take up even more challenging tasks in the public domain, and accomplish so much on so many different fronts. Thus when he was invited in 1973

**Box 1.** Decay and interaction of neutral strange particles produced at cosmotron energies

For his Ph D Yash studied cloud chamber tracks of kaons and hyperons produced by the interaction of 1.6 GeV  $\pi$ -mesons produced at the Cosmotron, a manmade accelerator facility. He measured the lifetimes of both short and long-lived neutral  $K$ -mesons,  $\theta_1^0$  and  $\theta_2^0$ , and also estimated roughly their mass difference using the quantum mechanical particle mixture theory. He also observed the decay mode  $\Lambda^0 \rightarrow n + \pi^0$  and measured the lifetime of the  $\Lambda^0$  particle.

to direct the Space Application Centre in Ahmedabad, whose objective was to bring the benefits of space technology to the common man, Yash Pal did not hesitate to give up his pursuit of science, and dedicate his efforts and talent to the service of the country. The first task was the SITE experiment to establish direct reception of television signals to about 2500 villages, where TV sets were to be installed to which programmes could be broadcast using NASA's ATS-6 geostationary satellite positioned over India. Yash Pal's vision was much more ambitious, and of greater relevance for India: He infused confidence in our engineers and scientists that no task was impossible, and energized them to develop indigenously all the needed hardware with a quality suitable for space applications. Furthermore he transformed SITE into a countrywide classroom for the education of isolated population in new agricultural methods, animal husbandry, health and hygiene, to give voice to their cultural values and concerns, and to provide special programmes for children. For this purpose, he collaborated widely to develop the programmes in several languages, with the villagers coaxed to playact, speaking their own dialects. He had to also build TV studios and audiovisual centres at universities to develop content and record them for broadcast under the acronym EDUCAST. This effort has been hailed, nationally and internationally, as the most meaningful and challenging communication effort ever undertaken and completed with unparalleled success. He was awarded the international Marconi Prize for communication<sup>33</sup>. SITE was also responsible for the wider development of TV media in India, and for bonding together the multilingual and multi-ethnic nation. His second major achievement was to fully develop indigenously the multi-spectral remote sensing programme initiated by P. R. Pisharoty, which today is one of the best in the world, providing meteorological and ecological data, as well as mapping out earth resources.

These innovative use of space technologies for the benefit of the people projected him onto the international arena, and he was appointed in 1982 as Secretary General of UNISPCE-II that focused on 'raising awareness of the vast potential of space benefits for all mankind and addressed the concerns of how to maintain outer space for peaceful pur-

poses and prevent an arms race in outer space as essential conditions for peaceful exploration and use of outer space'<sup>34</sup> and as it invariably happens when Yash Pal takes the chair, the members of the committee see the purity of his purpose, set aside their narrow differences, and devote their efforts for the betterment of all humanity. Thus in the span of two years he was able to forge an agreement amongst the nations to preserve the outer space for use by all, not exclusively by technically advanced nations.

By now it was clear that he had a transformative influence on every office he held, and so it was when he returned to the national scene in 1984 as the Secretary, Department of Science and Technology, and concurrently served as the Advisor to the Planning Commission of the Government of India. Of special interest here is to note that he supported the Bharat Jan Vigyan Jatha movement, established NCSTC wing of DST to communicate widely the advances in science and technology, stewarded *Bharat Ki Chhap*, a series of films on the history of science in India by Chandita Mukherjee<sup>35</sup>, and in general tried to ensure that the benefits of our investments in science flowed across to all sections of our society, and helped to improve the quality of education not only at the university level but also from kindergarten upwards.

His life and contributions moved from crescendo to crescendo, and he was appointed in 1986 as the Chairman of University Grants Commission, a role very dear to his heart, as it would allow him to revitalize our Universities by providing them opportunities to carry out research in advance facilities that were earlier available only to research institutes. In order to achieve this, he set up and fostered Inter University Centres, for nuclear physics in New Delhi, for laser physics and studies with energetic UV beams generated by the electron synchrotron at Indore, and for astronomy and astrophysics at Pune, and these have had a transformational effect on our education system. In this context the Information and Library Network (INFLIBNET) and the Centre for Educational Communication (CEC) he established are also playing important roles. He had by now served in almost all branches and departments of the government, DAE, Space, DST, Planning Commission, and Human Resources. This allowed him to work toward interdepartmental coopera-

tion, for example, among ISRO, DST and DAE in the expansion of the Institute for Plasma Research, founded by Predhiman Krishan Kaw for development of fusion technologies for power generation.

As his tenure as the Chairman of UGC was coming to a close, the indefatigable Yash Pal started playing an important role in the TV series *Turning Point*, a science programme broadcast by Doordarshan, India. The script and direction were jointly by Neelabh Kaul and Indraneel Kaul, and popular film and media personalities like Girish Karnad, Mahesh Bhatt and Mrinalini Sarabhai would periodically interview Yash Pal and let him explain in his inimitable manner current issues related to science, and answer questions the public had sent on science-related matters that they encountered in their daily lives. The series ran a phenomenal 150 episodes, and made Yash Pal one of the most recognized human beings in India. Even after the end of the series, the thirst for knowledge, especially for the children, never ceased, and Yash Pal continued to engage them in correspondence through post and email, with the participation of his son Rahul. During such an illustrious career, he has been the recipient of numerous awards, including the Marconi Prize mentioned earlier, UNESCO's Kalinga Prize for the popularization of science and *Padma Vibhushan* – the Presidential Medal, and I dare say that the prestige of each of these awards went up after he became a recipient. Amidst all this accomplishment in the vast national and international arena, he had a special place in his heart for his students from the past: he helped Ramanath Cowsik establish one of the highest astronomical observatories in the world at Hanle in Ladakh, and Shyam Narayan Tandon to build the Ultra Violet Imaging Telescope, the best ever built, which is now orbiting the earth, as a part of ASTROSAT, in both cases acting as Chairman of the project management board.

His life was full of joy, and the challenges he faced only made him stronger and of purer metal. His life was dedicated to science and he toiled to infuse 'the adventurous and yet the critical temper of science'<sup>36</sup> into our lives and in the service of humanity. Let us celebrate the wondrous, loving and many-faceted life of Yash Pal.

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## Pushpa Mittra Bhargava (1928–2017)

### *Bhargava and his Camelot for Cellular and Molecular Biologists*

Pushpa Mittra Bhargava's vision for the Centre for Cellular and Molecular Biology (CCMB), founded by him in Hyderabad in 1977, is now the stuff of legend. He had already set his sights on institution building before he hit 30, at a time when most researchers are thinking about establishing their own careers and identities. CCMB was the idyll where about 20 of the finest minds led small-to medium-sized groups of scientists to study major unsolved questions in biology. The groups admitted only the most exceptional doctoral students, selected for that ineffable spark, following a rigorous written test, in two arduous rounds of interviews. 'Describe something interesting you saw on the trip from the train station'. 'Why do phulkas puff up when cooked on an open flame?' 'What is the role of the ball in a ball-pen?' They

worked day or/and night in centrally air-conditioned laboratories, and exchanged ideas in meticulously designed offices, coffee rooms, a lecture hall, or a leafy



P. M. Bhargava (Photograph courtesy: Chandana Chakrabarti).

arbor with its own blackboard, chalk and duster (aptly named Shantiniketan). They had abundant storage spaces, common equipment rooms, walk-in cold rooms, emergency power supply, distilled water on tap, extensive supply of fine chemicals and enzymes, a 24-hour centralized monitoring system, lifts equipped with emergency telephones, and closed circuit TVs. One entered the campus through electrically powered gates, and incongruously for Hyderabad, there even was an octagonal 'Stop' traffic sign on a campus intersection. Receptionists manning the lobby were knowledgeable and helpful. Anyone could engage the emergency vehicle anytime and, thoughtfully, the emergency drivers were provided a lounge to rest in. The monthly pocket writing pad had easily-detached pages and listed useful telephone numbers.