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# THE LEGACY OF

SCIENCE/R M LALA

Dr Homi Bhabha was a person who had the rare gift of looking far into the future. It was only natural that he laid the firm foundations for India becoming self-reliant in nuclear technology. And capable of exploring advanced scientific options.

This chapter excerpted from R M Lala's forthcoming book, *The Heartbeat of a Trust*, describes the genius of Dr Bhabha. And the pioneering role he played in establishing the Tata Institute of Fundamental Research. The institute which provided the early infrastructure of the country's nuclear programme.



YOUSSEF LAIBISH

Human progress has always depended on the achievement of a few individuals of outstanding ability and creativeness. Homi Bhabha was one of them.

—Sir John Cockcroft

On August 8, 1928, a young Indian of 18 was writing from Cambridge to his father in Bombay: 'I seriously say to you that business or a job as an engineer is not the thing for me. It is totally foreign to my nature and radically opposed to my temperament and opinions. Physics is my line. I know I shall do great things here'.

Homi Jehangir Bhabha was pleading with his father to allow him to switch from an engineering to a mathematics tripos. Father and son struck a bargain. If Homi got a first class in engineering, he could do two years more of mathematics at Cambridge. In June 1930, Homi obtained a first class in the mechanical sciences tripos and thereafter went to work as a research student in theoretical physics and passed out first class with a tripos in mathematics.

The first years of his research work coincided with a remarkable period at the Cavendish Laboratory,

Cambridge. In 1932, Chadwick demonstrated the existence of the neutron; Walton and Cockcroft achieved the transmutation of light elements by bombardment with high-speed protons; and Blackett and Occhialini demonstrated by beautiful cloud chamber photographs the production of electron pairs and showers by gamma radiation. It was a period of great interest and excitement in the world of theoretical physics. Homi was selected to an Isaac Newton Studentship in 1934 and travelled to the principal European centres of theoretical physics. He studied at the Niels Bohr's Institute of Theoretical Physics in Copenhagen, the Mecca of theoretical physics; with W Pauli in Zurich and with Enrico Fermi in Rome.

From the age of 17 to 29, Homi Bhabha studied and worked in the West and nowhere in the world could he have found a finer atmosphere for his study than in Cambridge in the 1930s. With two exceptions, Bhabha's papers at Cambridge were written by him alone. A mathematical physicist, he lectured at Cambridge from 1935 to 1939. For him it was a fruitful period. In a paper he published in 1937, Bhabha and Heitler enunciated the celebrated Cascade Theory of Cosmic Ray Showers.

Cosmic rays are particulate matter, such as atomic nuclei and electrons which move with great energies in the spaces between the stars of our galaxy. These radiations from outer space strike the earth and their study is of great relevance to nuclear science.

In 1939, Homi Bhabha published two important papers. One reported the existence of a hitherto unknown fundamental particle in the penetrating component of cosmic radiation. The second gave the quantum theory of this particle which has since been called the Meson. The first paper explained the production

of 'showers' by the penetrating component through the agency of 'collision electrons'. The process was named after Bhabha. All these 'great things' he achieved before he was 30. He also found at Cambridge the time to design and paint sets for plays and operas as well as to paint and draw for his own pleasure. He was fond of track-running and tennis.

At the age of 30, Bhabha came on a holiday to India. While he was here, World War II broke out and he was unable to return to Cambridge. In 1940, through a grant from the Sir Dorab Tata Trust, he was appointed Reader at the Indian Institute of Science at Bangalore, and two years later he became Professor of Cosmic Ray Research. The five years he spent in Bangalore were important years in his life in many ways. Prof M G K Menon, who succeeded Homi Bhabha as director of the Tata Institute of Fundamental Research (TIFR) said: "I believe this was the period when he found his mission in life; he became aware of the role he could play in the development of India."

As Bhabha contemplated at Bangalore on issues concerning the development of the country, the inadequacy of scientific facilities in India came sharply into focus. On August 19, 1943, he wrote in a letter to J R D Tata that 'lack of proper conditions and intelligent financial support hamper the development of science in India at the pace which the talent in the country would warrant.' He mentioned that he himself had had an idea of accepting at the end of the War, a job at Cambridge or Princeton but had come to the view that, provided proper facilities are available, 'it is one's duty to stay in one's own country' and build up schools comparable with those in other lands.' Tata replied: 'If you and/or some of your colleagues in the scientific world will put up concrete proposals backed by a sound case, I

think there is a very good chance that the Sir Dorab Tata Trust... will respond. After all, the advancement of science is one of the fundamental objectives with which most of the Tata Trusts were founded, and they have already rendered useful service in that field. If they are shown that they can give still more valuable help in a new way, I am quite sure that they will give it their most serious consideration.'

The Dorab Tata Trust had not only provided the money for the establishment of the Cosmic Ray Research Unit at the Institute of Science, it had also provided, at the request of Jawaharlal Nehru to J R D Tata, a cyclotron (an apparatus used to accelerate subatomic particles) for Prof M N Saha, the well-known scientist at the Calcutta University.

It became clear to Dr Bhabha that fundamental research in physics and mathematics, including nuclear physics and cosmic rays, was too big a subject to be dealt with in a small department of a university or in a general purpose research institute. It needed an institution devoted primarily, if not solely, to this end. With this conviction, reinforced by the encouragement of Tata, Dr Bhabha wrote, on March 12, 1944, a formal letter to Sir Sorab Saklatvala, chairman of the Sir Dorab Tata Trust. In this letter, which he wrote at one sitting, he described his vision for the India of the future.



# HOMI BHABHA

...when nuclear energy,' he wrote, has been successfully applied for power production, in say a couple of decades from now, India will not have to look abroad for its experts but will find them ready at hand.' Closing the letter he said: 'The scheme I am now submitting to you is but an embryo from which I hope to build up in the course of time a school of physics comparable with the best anywhere. If Tatas would decide to sponsor an institute such as I propose through their Trusts, I am sure that they would be taking the initiative in a move which will be supported soon from many directions and be of lasting benefit to India.'

When Bhabha spoke of nuclear energy at that time, he was not aware that work on the atomic bomb was already far advanced and that 18 months later the world would awaken to the first atomic blast at Hiroshima. All that he knew was that nuclear fission (the splitting of the atomic nucleus) had been achieved and his mind was already engaged in working out means for its use not for destruction but for the generation of electric power.

Nearly two decades later, in a report to Jawaharlal Nehru, the prime minister, Dr Bhabha was to observe: 'My proposal was consi-

dered by the trustees of the Dorab Tata Trust in the light of two covering notes on Trust policy written by the director, Prof R D Choksi. The first note entitled, 'Note on Trust Policy,' which I saw for the first time a few days ago, gives an admirable and clear statement of the objectives of a big Trust.' Prof Choksi's second note dealt specifically with Bhabha's proposal: 'A further reason for advocating full support to Dr Bhabha's scheme lies in the pioneer character of the undertaking. The Trust has always stood for pioneer work. It undertook a project in the field of social sciences in 1936, it completed and established a much later project in the medical sphere in 1940, and in 1944 it may well enter upon a modest project in the field of pure science. It is important that the Trust should maintain its character for pioneer work.'

While the trustees were debating this issue on April 14, 1945, Dr Bhabha was waiting in the ante-room. Though elsewhere there may have been discussion on whether a poor country like India could afford the luxury of 'pure' research when there were such pressing economic problems before it, the Trust accepted J R D Tata's view that fundamental research was necessary and the point to decide was whether the Trust could take on such a commitment stretching over a period of years—which involved

launching another major institution.

The minutes of the Trust record. After discussion of the financial implications of Dr Bhabha's proposal as embodied in his letter, the trustees decided to undertake the responsibility. They were of the opinion that this responsibility should be shared from the outset with the Bombay University and the Bombay Government—both in respect of finance and administration. It was remitted to Prof Choksi under the general direction of the chairman to explore the possibilities of such cooperation with the university and the government. Dr Bhabha was present at this stage of the meeting and entered into the discussion. He readily accepted the trustees' views regarding the sharing of responsibility.

Within 32 days of receipt of Bhabha's request, the Trust had taken on the responsibility both in terms of long-term finance and administration. J R D Tata tried to interest also a senior industrialist friend in supporting the project:

'...Although nuclear physics is today still in the realm of pure science, physicists already believe that within a relatively short period of time this branch of physics will make available to man a new, immense, and inexhaustible source of motive power. Thanks to the work done in this field by Bhabha and some other Indian scientists, India has already contributed her full share to the present day knowledge of the subject. More than ever before, the future of modern civilisation will depend on scientific progress, and that progress itself will continue to depend on pure research. Because the realisation of this is becoming universal all the important countries of the world have enormously increased the extent and scope of their activities in pure research, and India should not be allowed to lag behind in this vital quest for knowledge. She has men of world renown, like Homi Bhabha, Chandrashekhar and others, and if given proper facilities she is more than capable of holding her own.'

Circumstances prevented the industrialist from associating with Tatas and the Government of Bombay in this great project, but, fortunately for the new institute the initial Tata grant of Rs 45,000/- per year (the equivalent of about Rs 5 lakhs in 1983) plus the Rs 25,000/- of the Government of Bombay was augmented by a grant, from the Government of India of Rs 10,000/-, a combined total of Rs 8 lakhs of today. The University of Bombay

did not join in but the interest of the union government at an early stage was an encouraging sign. The union government's block grant the next year was as large as the combined contribution of Tata and the Government of Bombay. From then on, the Government of India bore considerable financial responsibility as it valued the work of the Institute. The credit for this goes primarily to Dr S S Bhatnagar who, in 1947, became director-general of the Council of Scientific and Industrial Research and was at the same time secretary to the Ministry of Natural Resources and Scientific Research.

Dr Bhabha believed that while the government should support scientific institutions financially, they should not be placed under government control. Under its constitution, the TIFR is run by a governing council on which the Dorab Tata Trust, the Government of India, the Government of Maharashtra and, later, the Atomic Energy Commission are represented. The Atomic Energy Commission now provides the funds for running the Institute.

When the Dorab Tata Trust had sanctioned the proposal, Sir Sorab Saklatvala, chairman of the Trust, became the first chairman of the TIFR with a provisional committee consisting of Dr John Matthai; S N Moos, Director of Public Instruction, Bombay Presidency; and Dr Homi Bhabha. On June 1, 1945, the Institute began functioning in Bangalore as Dr Bhabha and his facilities were based there. However, Dr Bhabha always felt that the Institute should be located in Bombay and by December 1945 it had already shifted to an old bungalow, 'Kenilworth', on Peddar Road (now Dr Deshmukh Marg) owned by his aunt, Cooverbai Panday. Half of that old house, about 6,000 sq ft was obtained on a rent of Rs 200/- for Dr Bhabha to install his little laboratory and staff. Inaugurating this first home of the TIFR on December 19, 1945, Sir John Colville, Governor of Bombay, said: "We are embarking on an enterprise of importance to the country's development, in which great wealth, wisely husbanded and applied, individual initiative and government support are all blended. I do not think there could be a better combination for progress."

Prof Kosambi, the well-known mathematician was one of the first to be invited to join. N R Puthran, a young accountant, joined the Institute when it had a staff of six. He recalls that Peddar Road in those days had

Examining a nuclear reactor assembly during a visit to the US



ROBERT LAWS

mostly gracious bungalows with hardly a couple of buildings more than two storeys high. Homi's aunt was very fond of her nephew and Homi was always served tea in the finest chinaware of the house. The nearest teashop was at Cowalia Tank, half a mile away, and for the convenience of the then small TIFR family, Panday allowed the use of her staff and kitchen to serve their refreshment needs. On Parsi new year's day, the TIFR family feasted on traditional Parsi delicacies. Panday's warmth and kindness pervaded the Institute and made them all feel that they were really part of a family.

The Institute soon outgrew these small premises and one day the building had to be vacated for demolition. Puthran recalls that, on their last day there, Homi's mother, Meherbai came to 'Kenilworth' and nostalgically recalled that the room on the first floor, where her son had worked as director, was the very room in which he was born. Puthran, who worked with Bhabha for the next 20 years, recalls that in all those years, he cannot recall his ever losing his temper or raising his voice. He gave so much of himself that all those who worked with him felt they had to do the same.

Dr Bhabha enjoyed the good-will and unquestioned confidence of the trustees as he was later to enjoy that of Prime Minister Nehru. Sir Sorab Saklatvala told the accountant: "Cheques and other routine papers should be put up to me for signature so that Homi can spend his time on scientific affairs." Dr John Matthai, one of India's most distinguished administrators, assisted Bhabha in the formulation of administrative norms.

In September 1949, the Institute moved into the picturesque 35,000 sq ft premises adjoining the Gateway of India previously occupied by the Royal Bombay Yacht Club. In 1962, as described later in this chapter, they moved to their present premises at the southern tip of Bombay overlooking the Arabian Sea.

In its early years, the Institute concentrated on mathematics and theoretical physics. The experimental work was in cosmic rays and high energy particles.

Bhabha, the theorist, had earlier started experimental cosmic ray studies in Bangalore, flying his instruments high in planes of the US Air Force. He was inspired by the studies R A Millikan had earlier carried out in India. It was clear to him that research in modern experimental areas was of the utmost importance, for its own sake and also to provide the right balance for theoretical studies. Experimental work generated confidence in the design, fabrication and use of equipment.

In 1948, the Atomic Energy Commission was formed with Bhabha as chairman and in 1954, the Atomic

Energy Department of the union government with Bhabha as secretary. These offices he held concurrently with the directorship of the Tata Institute which he was busy developing. However, he clearly demarcated the respective roles of the Atomic Energy Establishment (AEE) which was coming up at Trombay (Bombay) and the TIFR. The functions of the AEE (later the Bhabha Atomic Research Centre—BARC) was to undertake research of a technical or semi-technical nature, aimed at solving problems arising in the design and construction of atomic reactors. The TIFR was to undertake research in all aspects of atomic science without reference to immediate utility. As Bhabha said: "The TIFR can carry out its large-scale projects of fundamental research. Fundamental research thrives best in an atmosphere that is free, permitting an unrestricted exchange of ideas. An institution for fundamental research should be open to all scientists of eminence, whatever the country to which they belong, and should be unfettered by the secrecy regulations required in commercial or strategic establishments. Had the Institute (TIFR) not existed, the Indian Atomic Energy Commission would have been compelled in time to create such an institution where fundamental research in atomic science could be carried out in a free academic atmosphere on a scale larger than is convenient in a university laboratory."

Over the years, Dr Bhabha trained a hard core of scientific personnel at the Tata Institute. When the Atomic Energy Establishment started, he transferred 46 of them from the TIFR to the AEE, including Dr Raja Ramanna, head of the TIFR Nuclear Physics Group and A S Rao, head of the Electronics Group. There was a time when the entire staff of the fledgling Atomic Energy Establishment at Trombay was looked after by the Institute and its administration carried on from the TIFR, which had the necessary infrastructure. It was at this time that the control system of *Apsara*, the first atomic reactor in Asia, was built under the auspices of the Institute in a wartime hutment, many parts of the reactor being fabricated at the TIFR workshops. When the Atomic Energy Training School (now the BARC Training School) was started in 1957, to train the manpower required for the growing atomic energy programme, a major part of the teaching load in the initial years was carried by the TIFR scientists.

Dr Bhabha was planning the expansion of the TIFR at the same time as he was working on the blueprints of the Atomic Energy Establishment at Trombay which included designing the landscaping of its gardens.

The Yacht Club could not serve as a permanent home for the growing



Dr Bhabha discussing the design of the first Indian nuclear reactor.

Institute. Unbuilt areas large enough to accommodate the structure the Institute required were being examined. The only land Dr Bhabha found spacious and suitable enough was in the extreme south of Bombay in an area belonging to the Ministry of Defence. He applied for it. The Ministry of Defence, initially turned down the request. Dr Bhabha went up to the prime minister and through Mr Nehru's intervention had the land released, and started constructing on it a magnificent structure of 2,50,000 sq ft. He was intensely involved in the architecture, design and structure of the building. The architect, Helmuth Bartsch, was to say later: "In the past I have always worked for my clients. This is the only time I have worked with a client." Dr Bhabha converted what was once a site for coastal batteries into a large expanse of green lawns and a small casuarina forest.

For Homi Bhabha, the Tata Institute was to be a 'centre of excellence' for the country. What put it in a class by itself was his close personal attention to every detail, be it the buildings, the gardens, the art collection, or most important, the scientific programmes and its high standards—they all bore the unmistakable imprint of Homi Bhabha's personality and genius.

Dr Bhabha was a lover of art and a patron of artists. He bought scores of paintings in the 1950s and early 1960s of artists who were later to become famous—Husain, Chavda, Raza, Gaitonde and many others. He

had a sculpture of the head of Einstein fashioned by Jacob Epstein, a Rajasthan temple pillar of the 10th century AD; fragments of sculptures of the Chola period from South India (AD 10th century) which included a large Vishnu; and several wood carvings. He personally supervised the hanging of paintings and the placing of the other works of art. He was proud of the new building. Some months before it was completed, on February 20, 1961, he issued the following statement:

"These buildings are as fine as any corresponding building to be found anywhere in the world and no more have been spared in providing the members of the Institute with the good conditions of work and facilities for their comfort and well-being as are to be found anywhere today. The buildings have been paid for by grants from the Government of India and above all from voluntary grants made by the people of India. These buildings, therefore, have been made available to the Institute by the people of India through the taxes they have paid."

"Each member of the staff should have a sense of personal responsibility for these buildings, which have been given for his use, and it is his duty to take personal interest in their proper maintenance and to see that he himself uses them in such a way as to maintain their quality and cleanliness and so as not to cause inconvenience to others. Certain personal and elementary good treatment with regard to the use of the buildings and the fixtures and furniture in



them must be observed. A member, who sees another not using the buildings properly should draw his attention to the proper conduct in such matters. If any person continues to misbehave, the matter should be reported to his superior.

"The strictest norms of cleanliness should be maintained throughout the buildings, more especially in the lavatories. Feet should be wiped on a mat before entering the building, and marks from dirty hands should not be left on the walls. Lavatories should be used properly and kept spotlessly clean."

Four years later, March 26, 1965 he issued another standing order to say that the facilities he had referred to were not being used by members of the staff as they should be and "those who continue to behave in an unhygienic and unsocial manner will have to leave the Institute."

Bhabha wanted to create in India something much more than a scientific institute. He wanted to establish a centre for excellence that would radiate to the rest of the country, standards as high as any to be encountered anywhere. What is heartening is that these standards are still maintained. Twenty years later the building is as good as new—it has not even been repainted.

Within six days of the approval of the institute project by the Trust in April 1944, Bhabha was inviting the renowned astrophysicist, Dr S Chandrasekhar, who was working in the USA, to join it. He told him that it was his endeavour "to build up in time an intellectual atmosphere approaching what we knew in

places like Cambridge and Paris." He envisaged a day when the Institute would move beyond the immediate requirements of pure science and come closer to the humanities.

At the opening of the Institute he wrote to Prime Minister Nehru: 'I have also had the idea that some day the Institute might render useful service to this country by carrying out research in the history of Indian science. If the contributions of India and the East to the progress of science in the past ages and their relations to world science are to be systematically investigated and appreciated in their proper historical perspective, it is necessary that a great deal of work on the history of Indian science should be done with the proper modern scientific and critical outlook. This is a subject which the Institute might possibly take up at some later stage, if the proper people to do the work can be found.'

A beginning was made in 1957 with the TIFR publication of a facsimile edition of the notebooks of Srinivasa Ramanujan, the renowned Indian mathematician, who was elected a Fellow of the Royal Society in 1918.

Homi Bhabha's mind ranged over a wide spectrum of human endeavour—the arts, music, science and industry. Way back in 1952, he was thinking in terms of using solar energy for air-conditioning in Bombay. He was very keen that the finest foreign scientists should visit India and lecture at the TIFR and among those who came at his invitation were several Nobel Prize winners in physics, including Professors Niels Bohr, W Pauli, P A M Dirac, P M S Blackett and Sir John Cockcroft.

The whole of Sunday, January 23, 1966, Dr Bhabha worked at the TIFR and his close group of scientists and administrators worked with him. He spoke to them about his ideas for the rapid development in India of science, technology and industry. He was to leave that night for Europe and, as was their practice, they were all present at the airport before he left in case he had last-minute instructions to give. He took off for Geneva. Early next morning, as his Air India plane, the *Kanchenjunga*, was flying over Mont Blanc, it crashed into the frozen heights of the Alps.

The following day *The Guardian*, London, wrote: 'India has lost a prophet and a guide in Dr Bhabha who single-handedly at the start, set the nation's sights on the highest peaks of technology.' The *New York Times* recalled that only a few days earlier the Indian atomic scientist had said that India was only 18 months away from nuclear capability. The paper called the TIFR 'the biggest Indian research laboratory'.

At the age of 24, writing to one of his trusted friends, Jessie Maver, Dr Bhabha had said: 'I know quite

clearly what I want out of life. Life and my emotions are the only things I am conscious of. I love consciousness of life and I want as much of it as I can get. But the span of one's life is limited. What comes after death no one knows. Nor do I care. Since, therefore, I cannot increase the content of life by increasing its duration, I will increase it by increasing its intensity. Art, music, poetry and everything else that I do have this one purpose—increasing the intensity of my consciousness and life.'

The personality of Dr Bhabha was summed up by Lord Redcliffe-Maud: "Affectionate and sensitive, elegant and humorous, dynamic, one of the very few people who enhance life whatever the content of their living.... Whatever he set himself to do, he did as a professional—but one who worked for love; restlessly creative, enhancing life because he loved all forms of it."

One of the men that Dr Bhabha left behind to continue the atomic programme was Dr Homi Sethna. Sethna called his guru: "...a man of outstanding dimensions, a giant among men. He was an engineer *par excellence* and a scientist, an intellectual of rare calibre, a savant of art and culture, a sensitive artist himself, and an inspiring leader and an architect of modern India. Above all he was a visionary who looked far into the future and tried to shape it.... He laid firm foundations for self-reliance in nuclear technology."

That 'firm foundation' was laid at the TIFR. During his lifetime Bhabha created the infrastructure that gave India the support for its leap into the atomic age.

**W**hat Homi Bhabha achieved for India would not have been possible without the sustained support he received first from J R D Tata and later from Jawaharlal Nehru.

It was J R D Tata who ensured that Bhabha's genius would flourish in India rather than flower in Cambridge or Princeton. Barely overcoming his characteristic modesty, Tata was to say about this in later years: "Of all the activities in the creation of which I have played some role, in this case a very minor one, there is none of which I am prouder today than the Tata Institute of Fundamental Research." It is perhaps a small but significant fact that for three successive Sundays the chairman of Tata Sons who also ran Air-India came to the TIFR with Dr Bhabha for discussing the model, design and details of an auditorium for the TIFR. This was completed only after Bhabha's death and is named after him.

Jawaharlal Nehru gave Homi Bhabha his utmost trust, support and confidence. In her speech at the inauguration, on November 9, 1968,

of the Homi Bhabha Auditorium, Prime Minister Indira Gandhi disclosed that it was on board a ship in 1937 that Homi Bhabha, then only 27, met her father Jawaharlal Nehru. Said Mrs Gandhi: "The life of a politician lacks many of those warm moments of sensitivity that other people take for granted in their everyday life .... I know that Homi Bhabha opened one such 'window' for my father, and he always found it no matter how tired my father was, no matter how late it was in the night, he always found time for Dr Bhabha, not only because the problems which Dr Bhabha brought were important and he wanted to give them urgent attention, but because he found at the same time it was relaxing and it was an entirely new world."

"The stature of a man can be judged by the width of his mental horizon. Homi Bhabha was a man who bridged the generations—he bridged the old and the new, the West and the East. He was equally at home in the world of science and in the world of the arts. For, he was a creator and a doer—a man of thought as well as a man of action.... India owes him a very great deal. Amongst his many activities he founded this Institute of which we are all so proud, the Tata Institute of Fundamental Research."

Bhabha left a personal collection of distinguished works of art, including a Picasso, paintings of some of the finest Indian artists of whom he was a prime patron, as also an impressive array of his own paintings and drawings. The TIFR and the Bhabha Atomic Research Centre are also his legacies. Perhaps his richest legacy is in the large number of trained scientists who, alongside him, embraced the vision of a new India, confident in her ability to stand before the world.

Prof M G K Menon, who succeeded Bhabha at the TIFR and later became secretary of the Union Ministry of Science and Technology, says: "Homi Bhabha sought to create the right environment and right conditions for work. He succeeded in enthusing those who worked around him with the same spirit of dedication in national endeavour which motivated him, enthused them to maintain the highest standards of scientific integrity, and to set standards of quality in all that they did. This viable, self-generating group of trained personnel, the scarcest commodity in a developing nation, products of Homi Bhabha's inspiring and warm leadership, are his richest legacy to India."

Much was to flow from this legacy in the years to unfold. W

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