# HOMI BHABHA KILLED A CROW

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In a March 1944 letter the Indian physicist Homi Bhabha wrote to the Tata Trust asking for support for setting up a "School of Physics." Bhabha, and his letter, have been credited with responsibility for creating the nuclear power programme and thus the nuclear weapons programme in India. But, neither Bhabha, his letter, nor the programme he created, were free from the ironies and contingencies within which individuals make history.

## Bhabha's Passage to India

Homi Bhabha was born in Bombay on 30 October 1909, into a famous, very westernised, Parsi family.[1] He went to Catholic school and in 1927 he went to study in Cambridge, where he became a brilliant physicist. The Second World War started in 1939, while Homi Bhabha was visiting India on holiday from Cambridge. Stuck there for the duration of the war, he was "persuaded" by the Nobel Prize Winner C.V. Raman to join him at the Indian Institute for Science in Bangalore, first as Reader, then as Professor.[2]

It is clear that Bhabha saw his time in India as a temporary period before his return to Cambridge. In his paper in the *1939 Proceedings of the Indian Academy of Sciences* he gives his affiliation as Gonville and Caius College, Cambridge. By 1940, he was prepared to make some concession to being in India; he submitted work to the British science journal *Nature* in March 1940 giving as his affiliation "At present at the Indian Institute of Science, Bangalore." But it was a small concession. A year later, in the 1940 *Proceedings of the Indian Academy of Sciences*, he still listed himself as "At present at the Department of Physics, Indian Institute of Science, Bangalore." Even in 1941, Bhabha was writing to the English physicist P.M.S. Blackett, "I look forward eagerly to being able to return to England."[3] This was not surprising. Recognition for his work in Cambridge had just started to appear. In 1941, he was made a Fellow of the Royal Society, and in 1942 he received the Adams Prize – becoming the first Indian to do so.

Not surprisingly, in Bangalore Bhabha seems to have longed for England. According to one account, he "dressed for dinner and listened longingly to Western classical music records on the gramophone in the Mysore State guest house."[4] What solace there was seems to have come from Raman. Bhabha was "attracted by Raman's love of nature and his quest for aesthetics...for an 'exile' like himself there was nothing so refreshing as someone taking a keen and genuine interest in the progress of his work. Thus it was 'love

at first sight.' While they differed in many respects, they also had much to share and enjoy besides science."[5]

It seems however that during this time Bhabha started to think about staying in India. And in fact decided to stay. This change of heart has led to speculation. There are those who have claimed that in Bangalore Bhabha became a nationalist, "deeply conscious of the cultural heritage and traditions of India, of which he was proud… [Bhabha] began to be conscious of the possibility of economic prosperity and social change, based on science and technology."[6] Another suggestion is that Bhabha acted not out of "a grim sense of duty" but because "he had suddenly found a sense of purpose for himself … [perhaps] Bhabha found within himself an aptitude for institution building, for administration on a grand scale, that could never have flourished in such a country as England, whose scientific institutions were already in place, but which were free to flower in the relative vacuum of India."[7]

Instead of Bhabha discovering either a sense of nationalism or a sense of purpose, it has been suggested that Bhabha stayed because he was rejected by the British for not being British, and for being an Indian[8]. In particular, attention is drawn to Bhabha's having been rejected for a position at the University of Liverpool, along with a German physicist who had been his collaborator, just before he left England; the inference drawn being that for the University a "colonial" professor, like a German (i.e., "enemy") professor, may "have been a source of confusion and anxiety for Liverpool physics students." It is also pointed out that Bhabha was not allowed to participate in the Allied war.[9] Taken together, for Bhabha, "this rejection by the British colonial authorities clearly focussed on his racial origins rather than his scientific abilities. Even as he offered himself to the body of science ... his national, colonial origins emerged unerringly and denied him he access that he felt he had in every other way; intellectually, culturally, and experientially."

Bhabha's only explanation for his change of mind is given in a letter he wrote in 1944. He recalled that "I had the idea that after the war I would accept a job in a good university in Europe or America … But in the last two years I have come more and more to the view that provided proper appreciation and financial support are forthcoming, it is one's duty to stay in one's own country."[10] This would seem to support the idea that Bhabha felt he needed "proper appreciation." But with his scientific honours pouring in, there can have been no shortage of appreciation. Especially since within the space of a year or so of his Adams Prize he was made a Professor at Bangalore, a Fellow of the Indian Academy of Sciences and President of the Physics section of the Indian Sciences Congress.[11]

**Bhabha Reborn**

It is at this time that Bhabha wrote his now famous letter to the Tata Trust. To understand how this letter has subsequently become a touchstone to register Bhabha's uniqueness it is worth looking first at how the letter justified the need for the school and the causes it ascribed for the prevailing conditions that the school was meant to change. According to Bhabha, the aim was to produce an "embryo from which I hope to build up, in the course of time, a School of Physics comparable to the best anywhere."[12] The reason was because "it is absolutely in the interest of India to have a vigorous school of research in fundamental physics, for such a school forms the spearhead of research, not only in the less advanced branches of physics but also in problems of immediate practical application to industry." That Bhabha would appeal in these terms to a Trust associated with an industrial house is not surprising. What is more interesting is his diagnosis for why such an intervention was needed.

Bhabha, in his letter, argued that "if much of the applied research done in India today is disappointing and of very inferior quality, it is entirely due to the absence of a sufficient number of outstanding pure research workers who could set the standards of good research and act on the directing boards in an advisory capacity."[13] The question that this begs is why did Bhabha not continue to work with an existing school and develop new areas of research within it, but instead choose to set up on his own?

Bhabha in his letter to Tata is not so much diagnosing the ills of Indian science but actually bemoaning the absence of a community where he felt he could belong. The community, however, may not have been purely an academic community. Bhabha may have been missing more than his Cambridge college. Even before the outbreak of World War II, a number of his friends and colleagues at Cambridge "were swept up in war work… [in] a variety of posts according to seniority, with the government."[14] This included his PhD advisor, R.H. Fowler, who was posted to Canada and the US as the scientific representative of the British government, and John Cockroft, who may have been the source of Bhabha's knowledge of and enthusiasm for atomic energy. There was also James Chadwick, whose Department at Liverpool Bhabha had tried to join. Chadwick in early 1940 had raised the possibility of an atomic bomb, and started investigating whether such a thing was possible, and how large it would be.[15]

In effect, Bhabha saw there was a new community of scientists as advisors to governments, men who were as he had put it in his letter to Tata "outstanding pure research workers" and able to "act on the directing boards in an advisory capacity." They were individually shaping the future like none of them had believed possible before.

It is intriguing that the one example Bhabha gives of such a scientific advisory body relying on pure research workers is the Department of Scientific and Industrial Research in Britain.[16] It was to this body that the Science Advisory Committee of the War Cabinet had turned in late 1941 to manage Britain's atom bomb project.[17] Both Chadwick and Cockroft were involved. In fact, since Bhabha was familiar with the work of Chadwick, Fermi, and Bohr which contributed directly to the development of nuclear weapons, he may have understood the significance of the sudden halt in 1940 of the publication of scientific papers by these and other key scientists in the field of nuclear physics. He may have sensed that, following the advice of scientists, governments had initiated secret efforts to build the atom bomb. It was this that he was missing.

Confronted with this, Bhabha may have succumbed to the "Prometheus complex," which is a condition described as "all those tendencies which impel us to know as much as our fathers, more than our fathers, as much as our teachers, more than our teachers." Unlike the legendary Prometheus who wrested the knowledge of fire from the gods, the knowledge to be wrested by Bhabha was the knowledge of the atom. And the way he did it was much the same as when "the child wishes to do what his father does, but far away from his father's presence, and so like a little Prometheus he steals some matches. He then heads for the field where, in the hollow of a little valley, he and his companions build a secret fireplace."[18]

The "secret fireplace" that Bhabha created for himself was the Tata Institute for Fundamental Research. It was set up in June 1945, with Bhabha as Founder-Director, a post he kept till his death in 1966. Its first home was in Bangalore, where Bhabha was at that time. Within six months it moved to Bombay. The selection of Bombay as a site for his centre, and the particular location within Bombay shed a fascinating light on Bhabha. First of all, as Sharma observed, Bombay was "the home town of his ancestors."[19] What he does not mention is that TIFR moved into 6000 square feet of the bungalow where Bhabha had been born.[20] Even more amazing is that Bhabha took as his office the room in which he had been born.[21] It is perhaps not surprising that, reflecting on the Institute in 1962, Bhabha declared "this Institute was the cradle of our atomic energy programme."[22] Despite the use of the language of offspring, Bhabha never married and had no children. His only progeny were India's atomic scientists.

The significance of the location of Bhabha's activities increases with the realisation that when TIFR outgrew Bhabha's home, he moved in to the Royal Bombay Yacht Club. It is described as a "fine old Victorian pile on the waterfront complete with turrets, porches, and gardens."[23] What is significant is not just that it was obviously a transplanted piece of

England, but that “in the days of British rule, no Indian had been allowed inside the building in other than a menial capacity.”[24] Mirroring his move from his childhood home at the age of 17 to study at Cambridge, Bhabha again left his childhood home and moved in to what the British had vacated.

It is by seeing how Bhabha first took his father's place and then that of the British that Bhabha’s attitudes towards the scientists at TIFR, and their attitude towards him, can be understood. The Indian physicist S. Chandrasekhar narrates that “Chaim Pekeris, a famous geophysicist who visited India, told me another story. Apparently there was a public lecture; Bhabha came in along with Pekeris. Every seat in the auditorium was occupied. But when Bhabha came in and saw that there was no vacant seat, he just waved his hand at the front row and everyone in the front row got up and just disappeared.”[25]

It was not just in public that Bhabha exercised this kind of power. A memo he sent to the staff states “each member of the staff should have a sense of personal pride in these buildings, which have been given for his use … 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.”[26]

TIFR was not enough for Bhabha to be able to create the knowledge of fire he desired. In 1948, “largely at Dr. Bhabha's insistence,”[27] the Indian Atomic Energy Commission was set up. It was inevitable. In what have become the most quoted lines from his 1944 letter to the Tata Trust, Bhabha had already indicated his ambitions for an Indian nuclear power programme, claiming “when nuclear energy 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 at home.”[28]

What was equally inevitable was that the atomic programme, proposed by Bhabha as a justification for his “school,” was to be secret. This was announced and explained by Nehru, no doubt guided by Bhabha, in Parliament in 1948 with great circumspection. Nehru gave two reasons: “the advantage of our research would go to others before we even reaped it, and secondly it would become impossible for us to cooperate with any country which is prepared to cooperate with us in this matter, because it will not be prepared for the results of researches to become public.”[29]

In the same speech however, a much more credible reason emerges for the secrecy. Nehru argued that by not having developed steam power and having thus missed out on the industrial revolution, India “became a backward country.” And what was the expression of that backwardness? In a clear reference to colonialism, he said “it became a slave

country because of that." The connection to atomic power thus became obvious. Nehru argued "the point I should like the house to consider is this, that if we are to remain abreast in the world as a nation which keeps ahead of things, we must develop this atomic energy." He seemed to qualify this in completing the sentence "we must develop this atomic energy quite apart from war."

An obvious question is does this "apart" imply that atomic energy must not be developed for war, or that it should be developed "apart" in the sense of separately but in addition to war? The latter reading is borne out by two sentences later in the 1948 speech setting up the Department of Atomic Energy. Nehru talked of the relationship between the "purposes" of the proposed nuclear programme. One the one hand he said "I think we must develop it for peaceful purposes." But he went on "Of course, if we are compelled as a nation to use it for other purposes, possibly no pious sentiments of any of us will stop the nation from using it that way." In the aftermath of Hiroshima and Nagasaki, the other purpose is clear.

There is a strange parallel here between Bhabha's choices of the places for his institutions, the secrecy that he built around them, and the choice of Los Alamos in New Mexico as the site for the US Manhattan Project to build the first atomic bombs. The New Mexico site was selected by its first Director, Robert Oppenheimer, and it is claimed "its choice had much to do with Robert Oppenheimer's knowledge of the area through camping trips in the wilderness as a boy - that is with the secrets of childhood."[30]

The relationship between childhood and secrecy is strong since "no one is more enthralled by the idea of the secret" than the child.[31] This is due to at one level the child's sense of its own existence, and ignorance about its origins; "the secret begins with what adults presumably know and the child does not - the mystery of life's origin...and end ... From within the framework of those ultimate mysteries emerge early sexual secrets (what adults – parents - do in the bedroom). No wonder the young child is so drawn to having secrets of his own. For *any* secret becomes associated with forbidden knowledge of ultimate mysteries and therefore transcendent life-power… The child's evolving sexual secrets ...are likely to become associated with "bad" secret wishes … or bad behaviour. The secret, then, takes on a trinity of forbidden knowledge, special power, and hidden badness (guilt and shame)."

In Oppenheimer's case, and in that of Bhabha, the secret was built around the "forbidden knowledge" that all nuclear programmes are nuclear weapons programmes. The special power is the power to build them. The guilt and shame is in doing this and knowing that one is party already to mass destruction by having created the means to carry it out.

An integral part of keeping things secret however is that “the secret is always held (by the child especially but by the adult also) under active psychic tension; to hold on to it means struggling against one's impulse to reveal it. That impulse may be related to guilt, or to the wish to please or merge with those who want to know the secret, or to conditions causing a diminution of power or reward derived from holding it. ... To hold on to it is to hold on to life itself; to reveal it is to risk attack, annihilation, loss of life - until the appropriate moment, should there be one, at which time revealing it enhances life.”[32]

Tragically, for Bhabha, that life enhancing moment hinted at by Nehru, when the secret history of the Indian nuclear programme would emerge, irrespective of the “pious sentiments” of anyone, never came. He died without his bomb. That moment has arrived now however, for those who grew up on Bhabha’s island. Two of them in particular, R. Chidambaram[33] and Raja Ramanna[34], who have both held Bhabha’s position as head of the Department of Atomic Energy have admitted that what India tested in May 1974 was no “peaceful nuclear device” but rather an atomic bomb. After two and a half decades of keeping a secret the need to enhance their lives seems to have arrived.

The secret that has now come out first started to take shape in TIFR, where much of the early work of the Atomic Energy Commission was done[35]. It was only after the Department of Atomic Energy was set up in 1954, with Bhabha as the Secretary, that the decision was taken to set up a separate facility, the Atomic Energy Establishment Trombay, which was inaugurated in January 1957. Following Bhabha’s death in 1966, this was renamed the Bhabha Atomic Research Centre.

The location for Trombay, like the early homes of TIFR, is suggestive and has been pointed out: “Jawaharlal Nehru noticed the remarkable juxtaposition of the Bhabha Research Center at Trombay and the Elephanta cave on an island across the water: the old and the new facing one another in ageless harmony. In time, the juxtaposition will be noticed between the atomic power station at Kalpakkam in Madras, and adjacent to it, the famous temples of Mahabalipuram – each looking out into the Bay of Bengal. Those who know Homi will not be surprised.”[36]

It is hard however to accept simply that this was a result of Bhabha's attempt to “grow science indigenously, as a way of life in the midst of all that was good and great from the past, a science that would bear the imprint of the traditions, the culture and natural gifts of the Indian people.”[37] The choice of architecture for one would not seem to support this. One visitor observes Bhabha “had adopted so resolutely Western a tone and avoided the slightest reference to any Indian architectural motifs.”[38]

It was not just the buildings of the Trombay Atomic Energy Establishment, now named the Bhabha Atomic Research Centre, the plans for the gardens seemed to have particularly engaged Bhabha. While these were being planned a visitor to Bhabha's apartment describes how "near his desk stood an enormous drawing board with huge printed plans pinned to it. He spent many hours at night poring over these plans."[39] His inspirations were also on display, "by the side of the drawing board were five illustrated volumes of the gardens of Versailles; the English gardens of the eighteenth century; and Italian, Japanese, and Persian gardens." The visitor's account offers a final insight into Bhabha's mind "he could visualise the final shape of 'his' city only its complete harmonious integration into the surrounding landscape."

It is possible to speculate that this "remarkable juxtaposition" of sites of nuclear technology with religious sites was rather meant as a continuous reminder of the "clear disjunction between India's past and its present,", a concrete and spatial reflection of the attitude associated with new authority over old, the temples like the civilisation they represented were "the bygone past, now it was dead and museumised."[40]

**The Island of Dr Bhabha**

Bhabha in his letter had claimed that in a few decades nuclear energy would be used to produce power, and that given his "School" India would not have to look for experts from abroad but would have created its own. This statement has acquired oracular status. To take just a few examples, one author describes Bhabha "wrote with such prescience his now famous letter."[41] Another quotes these lines from Bhabha and declares: "This prophecy of the father of the Indian atomic energy programme came true 25 years later."[42] Others go further. For them, the story begins with, as they call it, "Genesis" and Bhabha's letter to Tata, in which he "supported his proposal with what has now become a remarkable prophecy."[43]

Bhabha, however, had realised within twenty years, unlike his followers, that his "remarkable prophecy" had failed to come to pass. In 1963, for example, as Chairman of the Atomic Energy Commission, Bhabha was responsible for agreeing to build India's first nuclear power station as a turnkey project, where the design and construction was to be undertaken by General Electric of the US. With this Bhabha "had implicitly acknowledged that his prophecy had remained a mere dream."[44]

But what Bhabha had dreamt and wrought is a nightmare for many. Homi Sethna, one of Bhabha's successors as the head of the Department of Atomic Energy, has lamented that

“for some people” the atomic programme was the “exclusive province of elitist order which is insulated from the rest of our society and is an expensive and even vulgar showpiece of an island in a sea of hunger, poverty and illiteracy.”[45]

It is not altogether surprising that “some people” should hold such an opinion. The attitude of the prophet to the people was clear early on. In 1959, speaking to a conference on population and planned parenthood, Bhabha proposed a solution to India's population problem: a research programme “aimed at developing a substance that, when mixed with rice, would have the effect of reducing fertility by 30%.”[46]

From such beginnings it is not far to go to reach the situation in recent times where “the Department of Atomic Energy use the illiterate villagers as guinea pigs, give them relatively high wages, put them into the critical areas, expose them to high radiation for one or two weeks, and then dismiss them with a bonus. They are easily replaced with yet more villagers. And when these people eventually die of radiation exposure, there are no medical records, no studies made, and the DAE has no responsibility. The villagers die praying to the gods, while their families believe that the death is fate, destiny.”[47]

It is not just “illiterate villagers” who seem to respond in terms of dread and fatalism. It affects the nuclear scientists and engineers. There is “an electrified idol (murti) of Lord Ganesh, the elephant-headed god Hindu god, the Vighnavighataka, the destroyer of misfortune and protector who broods parent like over the fortunes of his devotees, presides over the high office of the Chief Superintendent of the Tarapur Atomic Power Station.”[48] While at “the nuclear power plant at Kota, the Chief Superintendent was wearing a big ring, studded with 9 diamonds. When I asked him the significance of the ring, he explained that he was involved with invisible dangers and so needed the ring to ward them off. For that reason the ring had been specially blessed by the High Priest at the famous South Indian temple of Madurai.”[49]

The absence of trust that this behaviour implies can be understood in terms of the nature of knowledge in modernity. Trust, it is argued, “is related to absence in space and time. There would be no need to trust anyone whose activities were continually visible and whose thought processes were transparent, or to trust any system whose workings were wholly known and understood...the prime condition of requirements for trust is not lack of power but lack of full information.”[50] The second part of trust is “reliability in the face of contingent outcomes, whether these concern the actions of individuals or the operations of systems.”[51]

It is not just that Bhabha dreamed and planned in secret. It is in the nature of nuclear systems that these conditions for trust cannot be met. A major study of the safety factors associated with nuclear reactors observes that "the high complexity and the large number of vulnerable components make all reactor types...sensitive...to errors in design, maintenance and operation."[52] In particular, "the influence of human error ... is the single most important factor which can lead to severe accidents." This is because "reactor operators have to work under conditions which demand near perfection, whereas it is human to make errors and to be allowed to make errors." To incorporate such concerns, "technical systems must be benign in reacting to human errors; nuclear reactor systems certainly are not."

The study continues that even for the people who build and operate nuclear power facilities "knowledge about their hazards is incomplete; not only because of the impossibilities to quantify the human factor, but also because generally it is impossible to anticipate all event chains which can lead to large releases (of radiation); and it is often impossible to test safety systems under realistic conditions."

It concludes, "the safety problems of nuclear reactors are exacerbated by the fact that, world-wide, regulatory authorities, reactor vendors, and electrical utilities ...all have very optimistic attitudes towards nuclear safety, and are trapped by their history: they have made investments of prestige and resources in the present generation of reactors. They cannot deeply question the priorities and standards which have led to this generation [of reactors], for fear of having to write off these investments."

That this entire critique applies in India is supported by statements from within the nuclear programme. The uncertainty among the operators about the system extends to basic characteristics of nuclear reactors. Senior scientists of the Department of Atomic Energy admit "today, we do not even have adequate ways of measuring the rate of reaction and neutron flux or the flows in the primary and secondary coolant circuits. These are major deficiencies, but we could not overcome them."[53] New reactors are built on such ignorance. The only source of wisdom is identified as the rules laid down by the US designers of Tarapur and the Canadian designers of the Rajasthan Atomic Power Plant, their "operators' manuals and techspecs (technical specifications) have become our bible."[54]

The attendant dangers follow. At Tarapur, "probably the most dangerously radiation-polluted power station in the world,"[55] there are areas "so radioactive that it is impossible for maintenance jobs to be performed without the maintenance personnel exceeding the fortnightly dose of 400 millirem in a matter of minutes." This ends up with a "common

phenomena" of "maintenance workers...holding a spanner in one hand and a pencil dosimeter in the other, turning a nut two, three rotations and rushing out of the work area." To make the violation of the possibility of trust complete, at Tarapur "most of the workers do not have adequate knowledge or understanding of radiation hazards."[56]

It is also not just Tarapur. At RAPP 1, "the world's second most contaminated nuclear station ... very few operators are made to wear protective clothing in highly contaminated areas."[57] At Narora, a nuclear power station was built in an earthquake zone, and "several DAE scientists and engineers consider this site unsafe and undesirable."[58]

The whole nuclear cycle suffers from this inability to handle "contingency" with "reliability." At the Nuclear Fuel Complex in Hyderbad, there have been many accidents. In March 1981, "a woman and three children were killed and several others, including a few employees of NFC were injured while disposing of the waste" produced from manufacturing the fuel for nuclear reactors.[59].This was followed a year later by an explosion that killed two children because the "the waste yard is not segregated and there is no fence or indication to show that the area is prohibited or a danger zone" and "there are residential huts in the vicinity."

This inability to manage a fundamentally unmanageable technology is not something that has improved slowly over time. Learning does not take place. If anything the evidence points to a worsening of the situation, with radiation doses to workers at Tarapur having increased thirty-five fold between 1969 and 1982.[60] This has led to the conclusion that "The Indian nuclear programme has been a gross failure in respect of safety. Most facilities in the department are marked by recurrent but routine breaches of safety norms, circumvention of standards, poor health monitoring of employees, frequent resort to questionable operating practices and incomplete disclosures about the risks suffered by the public."[61]

The Department of Atomic Energy's response to this is summed up in its Annual Report, which says, "DAE's commitment to safety is total." And, recognising the absence of trust in such a claim, it claims "this is monitored by the Atomic Energy Regulatory Board, which is an independent body."[62] A year later the head of the Regulatory Board, A. Gopalakrishnan, was forced to resign, leading him to declare "India's nuclear regulatory process is a total farce … the DAE wants the country to believe all is well with our nuclear power projects. This is not so."[63]

The same inability to know what can happen extends to nuclear weapons. A key participant and witness to the only nuclear explosion to have taken place so far in South

Asia, Raja Ramanna, admitted this unknowingly in a speech by saying “I saw the weary looking health physicist telling, “No activity, don't know what has happened. The crater is there, but no activity.”[64] So far, the only direct victim of this failure to understand what one is dealing with is “the crow that flew in and sat just above the site of the explosion as the zero hour neared.”[65] The crow was killed by the shock that created the nuclear crater.

The death of a crow may seem a small matter given the tragic consequences that nuclear power and nuclear weapons may have in store for South Asia. It is not however without its own significance. Given the role that fire plays in Parsi beliefs and that Parsis are referred to as crow-eaters, there are multiple ironies in Homi Bhabha the Parsi physicist lighting a nuclear fire that after his death consumed a crow. There is also a significance in that birds have their own place in nuclear history. Scientists evaluating the first US hydrogen bomb test found “the blast had incinerated birds in flight for miles around,” while one Soviet scientist has reported that “I have been told that thousands of birds are destroyed in every test; they take wing at the flash, but then fall to earth, burned and blinded.”[66] In the absence of people to kill, nuclear bombs make do with birds.

## Notes

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