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BIOGRAPHICAL MEMOIRS

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R. A. Hinde and J. L. Finney

Biogr. Mems Fell. R. Soc. 2007 **53**, 309-326, published 1 December 2007

Supplementary data "Data Supplement"
http://rsbm.royalsocietypublishing.org/content/suppl/2009/05/01/53.0.309.DC1

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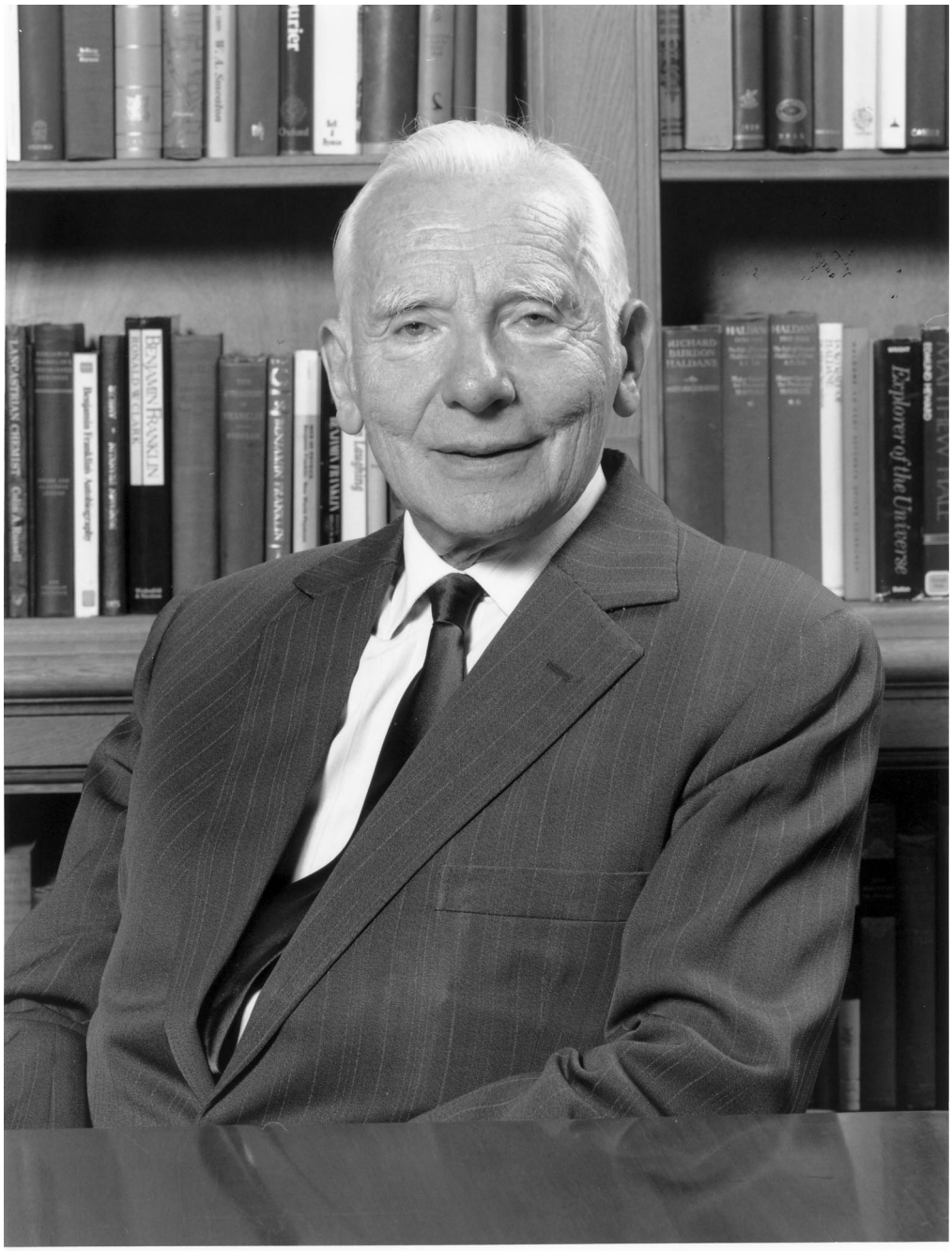

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SIR JOSEPH (JÓZEF) ROTBLAT

4 November 1908 — 31 August 2005

Elected FRS 1995

BY R. A. HINDE[1] CBE (HON.) FBA FRS AND J. L. FINNEY[2]

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Joseph Rotblat, having suffered considerable hardships in his youth in Warsaw, graduated in physics from the Free University of Warsaw. On a fellowship to work with James (later Sir James) Chadwick FRS in Liverpool, he joined the Manhattan Project early in 1944. Resigning as a matter of conscience when he learned that the bomb was not needed as a deterrent against Hitler's Germany, he subsequently devoted the rest of his life to radiation physics and radiobiology and to the abolition of nuclear weapons and of war itself. He was one of the founders and the moving spirit of the Pugwash Conferences on Science and World Affairs, with whom he shared the Nobel Peace Prize in 1995.

EARLY LIFE

Joseph Rotblat was born on 4 November 1908 in Warsaw, the fifth of the seven children of a Jewish family, although the two eldest died in infancy. His father had a nationwide horse-drawn paper transport business and bred horses in the countryside: Joseph described his early childhood as idyllic. However, circumstances changed dramatically 'almost overnight' in World War I. His father's horses were requisitioned for the army, and the business collapsed. A wave of anti-Semitism did not help. Thrust into penury, the family was forced to move into a wretched flat with no bath and an outside toilet. All the childhood diseases were rife, food was scarce, and he was never afterwards able to eat potatoes because of his memories of the taste of potatoes that had been frozen. The hardship, illness and intolerance that he experienced at that time, generated by the war, did much to determine his later dedication to promoting world peace.

His education was severely disrupted: he could not regularly attend school and at the age of $12\frac{1}{2}$ years started training as an electrical technician. As a result he did not obtain the

doi:10.1098/rsbm.2007.0023

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matura secondary-school certificate necessary for admission to the University of Warsaw. However, while working as a domestic electrician, in 1929 he began studying in the evenings at the Free University of Warsaw and read everything he could in English and Russian as well as Polish. His parents had wanted him to be a rabbi, but with his mathematical and experimental abilities he obtained a master's degree from the Free University in 1932. From 1933 to 1939 he was a Research Fellow at the Radiological Institute of the Scientific Society of Warsaw under Professor Ludwik Wertenstein (who had been an assistant of Maria Sklodowska Curie and had also worked with Lord (Ernest) Rutherford FRS in Cambridge). He sat for and passed the *matura* as an external student and qualified as Doctor of Physics at the University of Warsaw in 1938. Rotblat described Wertenstein's humanitarian approach to science as having had a deep effect on his life, and he came to see himself as Wertenstein's heir. From 1937 to 1939 Rotblat was Assistant Director of the Atomic Physics Institute of the Free University.

Early work on nuclear physics

The year in which Rotblat began his research life was that in which James Chadwick had published his discovery of the neutron. Two years later, in 1934, artificial radioactivity was discovered by the Joliot-Curies. Artificial radioactivity work had already started in the Warsaw laboratory, using α-particle bombardment. Rotblat began to explore the field by using neutron bombardment.

The main source of neutrons that could be exploited at the time was radium. His early experiments used 30 milligrams of radium in solution as a source of neutrons: every few days the accumulated radon was pumped into a tube filled with beryllium powder; the α-particle bombardment of the beryllium produced the neutrons. This source was very limited, as were other experimental facilities, causing Rotblat to comment years later, 'we had to compensate for the lack of facilities with ingenuity'. The Warsaw experiments included the discovery of several radionuclides and, more importantly, evidence for the inelastic scattering of neutrons, the subject of Rotblat's doctoral thesis and of his first nuclear physics paper. This first experimental demonstration of what was previously only a hypothesis of Niels Bohr's added an important building block to the growing young edifice of nuclear physics. During his five years or so in the Warsaw laboratory, Rotblat produced 15 papers on different aspects of this newly developing field. He discovered induced radioactivity in nickel and cobalt, phenomena that the much better resourced team under Enrico Fermi (ForMemRS 1950) had failed to find. His work on the production of artificial radioactivity by fast neutrons led him to devise an ingenious yet simple way of enhancing weak signals, and a method was found for measuring the ranges in air of particles emitted in nuclear disintegration.

At first he used gold in his detector system, but in 1938 he was beginning to experiment with uranium. When he heard of the fission of uranium by Frisch & Meitner (1939) he realized that the reaction would result not only in energy but also in the emission of some additional neutrons, and demonstrated this experimentally. It thus became clear to him, at the same time as to scientists in other countries, that a divergent chain reaction, leading to an enormously powerful bomb, was a theoretical possibility. Horrified by this thought, and distracted by his move to England and the necessity of learning English, he put the possibility to the back of his mind. But the thought that the Nazis would make the bomb persisted: if they were to,

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he was sure that they would use it. He came to think that the only way to prevent the Germans from using an atomic bomb would be to make one first, so that the Allies could deter the Nazis from using it by threatening immediate retaliation.

Leaving Poland

After he obtained his PhD, Rotblat received two offers, one from the Joliot-Curies in Paris and the other from James Chadwick at Liverpool University. He chose the latter, reasoning that participating in the development of the cyclotron facilities being created there would enable him to bring back related expertise to Warsaw to help establish a world-class nuclear physics facility in Poland. He went to work with Professor Chadwick in March 1939. Initially Chadwick could offer him only a very small salary (£120 p.a.), barely enough for one person to live on, so he had to leave his wife, Tola Gryn, whom he had married in 1937, in Warsaw. At first he found the language barrier very difficult. His wife persuaded him to persist and not to move to Paris and thus, he said, saved his life.

During his first few months in Liverpool, he developed a time-discriminating electronic detector system that enabled the study of radionuclides with sub-second lifetimes. In addition to opening up an experimental window on artificial isotopes with lifetimes down to about 10^{-5} seconds, this development was also particularly useful in determining absolute source intensities (particularly of weak ones) and in measuring the efficiency of Geiger counters. It was on the basis of this imaginative work that, in August 1939, Chadwick offered him the Oliver Lodge Fellowship, doubling his salary and raising hopes that he could fetch his wife.

His attempt to do so was tragically frustrated because she had developed acute appendicitis with complications and was unable to travel. Rotblat had to come back to England alone, and two days later the German army entered Poland. During the coming months he made several attempts to arrange for her to leave Poland. The first, with the aid of Niels Bohr ForMemRS, was to be through Denmark, but Denmark was invaded by the Germans before the plan could come to fruition. A similar plan for her to leave with the help of cousins in Belgium was frustrated when that country, too, fell to the invaders. Then she tried through Italy, but while she was actually on her way to the border, Italy entered the war as a German ally and she was turned back. Tola returned to live with her parents in Lublin, and Rotblat had only one more letter from her, in December 1940; unknown to him, she and her widowed mother died in Majdanek concentration camp. That his wife had died was known to British Intelligence in 1941 but was not communicated to him until 1945. His brother survived as a partisan, while his mother and five other family members had the enormous good fortune to survive hidden in a Gentile family's house in Otwock, near Warsaw.

Nuclear fission

In his brief visit to Warsaw, Rotblat discussed his scruples about the terrible possibilities of atomic weapons with Professor Wertenstein, who was convinced by Rotblat's calculations but refused to advise him on the moral issue.

Back in Liverpool, where he taught an honours course in nuclear physics and also lectured on radio, his lectures were received with great enthusiasm by the students, one of whom

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referred to a 'friendly tension' between students and Rotblat. Using his skill as an electrician, he also replaced the aged direct-current wiring of the laboratories and installed alternating current, which they needed for radar research. When the Blitz came to Liverpool, he took his full share of fire-watching duties. In November 1939 he discussed with Chadwick his plan for research on the feasibility of the atom bomb, and wrote later that the reply was 'typically Chadwickian': Chadwick grunted without letting on whether he had already had the same idea. A few days later Chadwick told him to go ahead and gave him two young assistants, one of whom was a Quaker and a conscientious objector; Rotblat had qualms of conscience about using him without revealing the real purpose of the research.

Rotblat realized that the chain reaction would have to be propagated by fast neutrons; otherwise the nuclear explosion would not differ much from a chemical explosion. It was therefore important to measure the fission cross-section for fast neutrons, their energy distribution, their inelastic scattering, and the proportion of those captured without producing fission. It was also necessary to find the probability of spontaneous fission of uranium, to ensure that stray neutrons would not cause a premature reaction. These problems were tackled with the Liverpool cyclotron, causing other pioneering work that had been started with this new facility, for example a study that Rotblat had initiated on radioactive bromine, to be abandoned for what Rotblat later called 'more urgent duties'.

Meanwhile the Frisch–Peierls memorandum (Frisch & Peierls 1940) was effectively a blueprint for an atomic bomb. Otto Frisch (FRS 1948) and Rudolf (later Sir Rudolf) Peierls (FRS 1945) consulted with Rotblat and Chadwick, and Frisch came to Liverpool and measured the fast-neutron fission cross-section for uranium-235. It was thus established by Chadwick's team that a nuclear explosive based on fission was feasible. However, its manufacture was beyond the resources of wartime Britain.

The Manhattan Project

In 1943 Churchill and Roosevelt signed the Quebec agreement for UK–USA collaboration on the development of the atom bomb. It was decided that Chadwick, Frisch and Rotblat should go to work on the Manhattan Project at Los Alamos. In late 1943 Rotblat was visited by a policeman who took down a few superficial particulars and, on enquiry, told him that he was to become a British citizen in a week's time: apparently the agreement had been that scientists taking part in the Manhattan Project had to be US or UK citizens. Rotblat, who later remarked that this 'instant citizenship' procedure later allowed Klaus Fuchs to slip through the net, was deeply torn. He had shared nightly bombing with the Liverpudlians and had come to love Britain dearly, but on the other hand he felt a deep loyalty to his native Poland, devastated by the war. He refused citizenship, and the UK group sailed in December 1943 without him. However, two weeks later he was told that General Groves, head of the Manhattan Project, had uniquely waived the citizenship requirement in his case. Upon arrival at Los Alamos he immediately questioned whether wartime Germany could mount a scientific project on the scale needed to make an atomic weapon. The only available record of his work at Los Alamos concerned four detectors to analyse fast neutron pulses.

All the workers at Los Alamos were subject to strict security and censorship. Jean Thomson, a friend whom Rotblat had known in England, had asked him to get in touch with a young woman, Elspeth Grant, who was living in Santa Fe and gradually becoming deaf,

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lonely and depressed. The scientists were allowed to take a bus into Santa Fe, but meetings with outside people required security clearance. Rotblat decided that this would involve Elspeth in being interrogated, and with Chadwick's permission visited her once. Her brother was killed on D-Day, and he saw her again briefly. Later he went to Santa Fe with colleagues to learn to fly, and so could see her more regularly. His visits not only provided her with company but were also relaxation for him, with his increasing disillusion with his work.

General Groves, in charge of the Manhattan Project, was a frequent dinner guest at the Chadwicks'. On the evening of 4 March 1944 Rotblat was present when Groves said that the real purpose of making the bomb was to subdue the Soviets. (Groves corroborated his 1944 remarks 10 years later when giving evidence at the Oppenheimer hearings. He is recorded as saying that, from soon after he took charge he had no illusion but that Russia was the enemy and that the project was conducted on that basis.) Rotblat was deeply shocked: the USSR was an ally against the common Nazi enemy and was suffering heavy losses on the eastern front. His dismay was exacerbated by conversations with Niels Bohr, who even then worried about the consequences of an arms race between East and West. Towards the end of 1944 Chadwick told him that intelligence reports indicated that the Germans had abandoned their bomb project. Rotblat felt that his presence at Los Alamos, helping to make an horrendous weapon, was no longer justifiable and asked permission to leave. Disillusioned with the project, he also worried about the fate of his family in Poland.

Rotblat was probably the only project scientist to resign for moral reasons. The majority had insufficient moral scruples. As Professor Hoodbhoy of Islamabad put it, 'Joseph Rotblat did exactly what was right. And moral. No equivocation, no this-or-that. He simply quit.' In Rotblat's view those who took no action were motivated by their continuing scientific curiosity, a belief that using the bomb would save many American lives, or a fear that their careers would be jeopardized.

Informed of his decision, Chadwick was not pleased that a member of the British team should be the first to leave. He informed the intelligence chief at Los Alamos and was shown a dossier with evidence apparently incriminating Rotblat as a spy: his conversations with Elspeth had been reported, and his flying lessons were interpreted as part of a plan to be parachuted into Soviet-occupied Poland, to hand over the secrets of the atom bomb. Rotblat came to believe that he had been subject to extra surveillance because he lacked US or UK citizenship. Fortunately the dossier contained details of conversations and dates that could easily be disproved, and he was allowed to leave, ostensibly for personal reasons, provided he did not discuss his real reasons with his former colleagues. But he had been branded as a traitor and a turncoat for listening to his own conscience. He was allowed to say goodbye to Elspeth only in an open place, not telling her why he was leaving. She visited London as a married woman in 1950, and Rotblat enjoyed playing with her three children. Later, when she returned to the USA, she was interrogated several times by CIA agents, who told her that Rotblat was a Communist agent.

On his return journey a box containing all his personal possessions, reprints, notebooks, personal correspondence and photographs mysteriously disappeared from the train to New York. He sailed from New York and resumed his post as lecturer (later senior lecturer and director of research into nuclear physics) at Liverpool University. Contact was established with the surviving members of his family in Poland, and his sister had the terrible task of telling him over the telephone that his wife had died at the hands of the Nazis. Rotblat obtained visas for his family and found them accommodation in Liverpool. He never remarried, saying

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that he never knew anything definite about his wife, although many believe that his dedication to science and to peace was also an issue. His brother and family came to live with him, and later he brought his brother's widow to live close to him in London. Partly because his family circumstances had changed, and partly because he did not want to live under a totalitarian regime, he took British citizenship in 1946.

Postwar work on nuclear physics and medical applications

After his return to Liverpool, Rotblat was effectively in charge of the laboratory's research direction in the periodic absences of Chadwick, and fully in charge from the time of Chadwick's move to Cambridge in 1948 until his successor took over in 1950. At a conference on nuclear physics held at Harwell in September 1947 to celebrate 'both the start up of the first British pile, and the restarting of nuclear physics research in Britain after the war', he reported on the extensive range of work at Liverpool, largely based on the (then recently improved) cyclotron, which included elastic and inelastic collisions of protons, deuterons and neutrons with a range of nuclei. The whole field was growing rapidly, and Rotblat was in the thick of it.

Outside Liverpool, in the immediate postwar years Rotblat played a key role in the wider development of nuclear physics in the UK. Recognizing the potential of atomic energy, the UK government set up an Advisory Committee on Atomic Energy. Rotblat took the leading role in two areas of its work: the development of more powerful particle accelerators and of improved photographic emulsions for the detection of elementary particles.

His own research was instrumental in improving the photographic technique as an efficient energy-sensitive detector of elementary particles. Earlier work with photographic emulsions for particle detection, including their use in the critical experiments on uranium in 1940–41, had indicated that improvements were needed to improve their efficiency and reliability, and much of Rotblat's work at the time was directed at overcoming the problems involved. Under his chairmanship, the work of the emulsions panel of the Advisory Committee realized major improvements, with Ilford and Kodak, working to the panel's programme, producing several different kinds of 'nuclear research emulsion' to meet the different requirements of the experimental nuclear physicists. Offering a range of sensitivities and grain sizes to meet these different demands, the photographic detection method became a standard experimental technique. The new emulsions made the detection of rare events much easier and facilitated the discovery of the pi meson by Cecil Powell (FRS 1949) and colleagues. The camera that Rotblat devised in Liverpool to use these photographic plates, which was later improved for work on the Birmingham cyclotron, provided the workhorse for a range of important nuclear physics experiments through the 1950s. Energies of detected particles could be measured reliably, cross-sections of nuclear processes could be determined and, given certain model assumptions, information on spins and parities of different nuclear states could be obtained.

One of the inherent limitations of the cyclotron was that particle energies were limited to about 25 MeV. The increasing scientific need to produce particles with higher energies than this led to proposals for building synchrocyclotrons, particle accelerators in which this limitation could be overcome. Obtaining a large grant to build one in Liverpool, Rotblat took on much of the responsibility for the design and planning of this new-generation machine. While this planning work was underway, Powell's discovery of the pi meson in cosmic ray studies

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showed the need for even higher energies than the 250 MeV that the Liverpool machine was designed to achieve. Working within the severe material and production constraints of the postwar period, Rotblat's practical and engineering expertise, allied to direct discussions with the steel manufacturers, pushed the design of the machine to one capable of producing 400 MeV protons. Out of loyalty to that project, he turned down the offer of a professorship in Warsaw.

He was determined that in future he himself would decide how his work should be applied. Accordingly he changed gradually to a topic that would certainly benefit humanity: the medical aspects of radiation. Deciding against qualifying as a doctor, he preferred to work with doctors on the medical effects of radiation. Although Chadwick did not approve of the change, he put Rotblat in touch with Henry Cohen, Professor of Medicine in Liverpool, who in turn gave him further contacts. An immediate result was a study of the use of radioactive iodine as a diagnostic aid for intrathoracic goitre. For this he developed a primitive scanner using a well-collimated Geiger counter mounted on a mobile X-ray stand that allowed the scanner full movement. Published in 1948, this may have been the first medical application of a scanning detector. It also used the first specimen of ^{131}I produced in the UK's first nuclear reactor at Harwell. He also studied the possible application of radioactive copper, iodine and phosphorus in the treatment of melanomata and the application of radioactive phosphorus in skin cancer research.

In 1949 he was elected to succeed F. L. Hopwood as Professor of Medical Physics at St Bartholomew's Hospital, London, a chair that he held from 1950 until he retired in 1976. Chadwick tried to stop him from taking up the post, saying he would never be an FRS if he worked in radiation medicine, but Rotblat was never easily deterred. Some of the medical staff at Bart's objected so strongly to his appointment that he was forced to delay leaving Liverpool for some months. Initially, as a physicist he was treated as an outsider by the medical staff, and his only friend was the Australian endocrinologist A. J. Marshall; neither of them took kindly to the blimpishness of the establishment. Much later some of the doctors, notably Sir Geoffrey Keynes, came round, but even in those days Rotblat was a very forceful figure: this often had positive constructive consequences, but sometimes destructive ones.

At Bart's he became active as an administrator and was instrumental in setting up several research and development groups. He led a team developing the therapeutic uses of particle accelerators; parallel work was going on elsewhere. In partnership with Professor Patricia Lindop he did extensive work on the effects of radiation on living organisms, studying especially ageing and fertility effects. He was particularly interested in the effects of strontium-90, which affects bone, and became a world authority on the effects of radiation on humans. He was largely responsible for two major World Health Organization studies (1, 2)*. He also set up a Medical Engineering Group under Bernard (later Professor) Watson. As a research worker, he always strove for accuracy and never exaggerated the effects of exposure to radiation. As editor-in-chief (1960–72), he built up *Physics in Medicine and Biology*.

Although the focus of his work at Bart's was on medical applications, he continued his involvement in fundamental nuclear physics. One of the earliest publications he produced from Bart's was very much a nuclear physics paper but one with strong medical implications: the use of nuclear emulsions to locate a radioactive atom by tracing the origin of the tracks emanating from it. Much of his fundamental nuclear physics research from this time onwards

* Numbers in this form refer to the bibliography at the end of the text.

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was in collaboration with others, using the Birmingham cyclotron. The continued development of particle sources and detectors, and the arrival of computers, enabled more complex problems to be addressed, and permitted sophisticated theoretical models of nuclear structure and processes to be tested by more precise experiments. Nuclear probes with low charge (for example protons, deuterons, ^{3}He and ^{4}He) were used to sample the potential due to nuclear forces. A series of fundamental nuclear physics papers that he co-authored between 1951 and 1964 relied extensively both on the emulsion techniques he had been instrumental in developing and on further improvements to his plate camera. Although this work was not central to his primary nuclear medicine interests, he did consider these studies of energy levels and other nuclear properties with the use of high-energy beams of light particles to be among his major scientific achievements. His citation on election to the Fellowship of the Royal Society quotes specifically his work on determining the angular distribution of protons from the (d,p) reaction, research that led to an important tool for measuring the spin and parity of nuclear levels.

He was an inspiring teacher, even at the relatively elementary first MB level. One student describes how 'the physics lecture theatre became the source of increasing wonder' and that Rotblat was 'clearly someone different, a committed soul, a man who loved knowledge and communicating knowledge'.

Against the bomb

Rotblat described hearing that the nuclear bomb had been used on civilians at Hiroshima as one of the worst moments of his life. He had hoped that the bomb would not work, and felt strongly that it should not have been used against civilian centres. Once it had been used, he felt himself to be released from the pledge of secrecy imposed when he left Los Alamos.

At first he wondered if a moratorium on further development would be possible, but left-leaning colleagues, such as Patrick (later Lord) Blackett FRS and Cecil Powell, were against it, because it would leave the USA as sole possessor of the bomb. The Association of Scientific Workers offered help, but Rotblat felt it was too left-wing. Accordingly, in late 1945 and early 1946 he was co-founder of the Atomic Scientists' Association (ASA, or BASA) in the UK, and served as executive vice-president from 1952 to 1959. This consisted largely of Liverpool and Oxford scientists who had worked on the Manhattan Project or its British predecessor, code-named 'Tube Alloys'. Its vice-presidents included many prominent UK scientists, including Blackett and Lord Cherwell FRS, and its members included Harrie (later Sir Harrie) Massey FRS, Peierls, Nevill (later Sir Nevill) Mott FRS and G. P. (later Sir George) Thomson FRS. The ASA was smaller than its US counterpart, the Federation of Atomic Scientists, but did much to stimulate public debate. A statement on UK policy, proposing controls on nuclear weapons, was put forward. Within the framework of the ASA, Rotblat was the principal organizer of a travelling exhibition, which he called the 'Atom Train', explaining the good and evil aspects of nuclear energy. For this he obtained a loan from the Ministry of Supply. Although the loan was repaid, the sale of 56 000 booklets, which he wrote to explain the exhibition, funded the ASA for years. He also became editor of the *Atomic Scientists' Journal*, and was in frequent touch with his colleagues in America, especially Eugene Rabinowitch. The Americans managed to influence their government to the extent of making nuclear policy a civilian rather than a military matter. In 1951, although at first refused a visa, Rotblat attended a conference in Chicago that enabled him to discuss plans for collaboration with Leo Szilard

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and Eugene Rabinowitch: he said later that plans for international cooperation could be discussed meaningfully only after Stalin's death.

In 1954 the Americans tested the first hydrogen bomb at Bikini Atoll. A Japanese fishing boat was showered with radioactive dust: one of the crew died and the rest required treatment. By analysing data on the fallout, provided by a Japanese scientist, Rotblat showed that it was a three-stage hydrogen bomb of devastating power, and published his results. Largely because of this he became more widely known, and an increasing number of people became worried about nuclear weapons. His disclosures brought him into disfavour with the government. Nevertheless the British Association for the Advancement of Science helped with the running of the ASA, and a committee was set up to study the radiation hazards from nuclear testing. He later determined the LD_{50} of radiation for humans (that is, the dose that would be lethal for 50% of those affected) from data on mortality at Hiroshima.

The vice-presidents of the ASA, some of whom were inclined to be right-wing, forbade future public statements, and that led to the demise of the association, or rather its transformation into the British Pugwash Group. This was at first refused charitable status, probably because it was seen as too political. Later, however, a charitable trust was created.

Soon after the first hydrogen-bomb test, Rotblat met Lord (Bertrand) Russell FRS on a BBC *Panorama* programme. Russell, himself agitated about the developments in nuclear weapons, started to come to Rotblat for information, and gave a BBC lecture in December 1954 entitled 'Man's peril' on the dangers of the bomb. Russell decided to persuade several eminent scientists from around the world to join him in issuing a statement outlining the dangers of thermonuclear war and calling on the scientific community to convene a conference on averting the danger. Albert Einstein responded enthusiastically to Russell's request, and signed what became known as the 'Russell–Einstein Manifesto' (Russell & Einstein 1955) shortly before he died. This was an eloquent and stark statement of the dangers of nuclear weapons. Rotblat was the youngest of the 11 signatories, and chaired its launch by Russell in London on 9 July 1955.

It contained the injunction:

> Remember your humanity and forget the rest. If you can do so, the way lies open for a new Paradise; if you cannot, there lies before you the risk of universal death.

Pugwash

The manifesto drew considerable attention; it called for a conference of scientists to discuss the abolition of nuclear weapons and of war itself. Rotblat started to organize such a meeting of scientists of different ideological and geopolitical backgrounds. A plan to meet in New Delhi in 1956/57 was aborted because of the political situation and because of the difficulty of raising travel funds. However, a Canadian-born businessman, Cyrus Eaton, had offered Lord Russell his house in Pugwash, Nova Scotia, covering all expenses. Twenty-two scientists from 10 countries attended: these included 16 physicists, two chemists, one biologist, two physicians and a lawyer. Three 'scientific staff' who attended the meetings included Ruth Adams, then assistant editor of the *Bulletin of the Atomic Scientists*. For the first time in the nuclear age, scientists from East and West met to discuss the implications of the new weapons. Rotblat was one of two co-organizers; he wrote the section of the report that dealt with the consequences of the use of nuclear weapons and the development of nuclear power. In his own paper he stressed that it was important that scientists should not attempt to gain public attention by exaggerating the effects of nuclear weapons, and that scientific issues should be

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separated from political and ethical ones. He then reviewed the current state of knowledge about the biological hazards and discussed the predictions to which it led. The conclusions of the conference were sent to leaders in the USA, Canada, the USSR and the UK and to the Soviet Academy of Sciences. Only Britain's Prime Minister, Harold Macmillan, did not reply.

This was the start of the Pugwash Conferences on Science and World Affairs to which Rotblat dedicated the major part of the rest of his life. There has been at least one major Pugwash conference every year, and Rotblat attended every one up to and including 2004. Conference participants, mainly scientists but also government observers, military men, and others, come from over 60 different countries and attend as individuals whose remarks are non-attributable as representatives of their countries or of any other organizations (occasionally official representatives from international organizations, mainly the United Nations, are invited as observers). This was of special importance during the Cold War, for scientists from both sides of the Iron Curtain could speak freely and then report back to their governments. Pugwash challenged the view that scientists should stick to science and spoke directly to politicians. Its high scientific standards and its objectivity ensured that the politicians listened. Inevitably some, especially in the American administration, saw him as naively serving the Soviet Union.

In the early days of the Cold War, Pugwash was an important, and in some ways unique, channel of communication between East and West. (The Edinburgh Conversations, organized by Professor John Erickson, were another.) Never abandoning its long-term aim of disarmament, it focused on arms control. Operating mainly behind the scenes, Pugwash carried out sustained work over decades on nuclear arms control. It was influential in laying the important groundwork for several international treaties, including the Partial Test Ban Treaty (1963), the Biological Weapons Convention (1972), the Chemical Weapons Convention (1993) and the Anti-Ballistic Missile Treaty (1972), as well as laying the foundations of the Nuclear Non-Proliferation Treaty (1968, strengthened in 2000). It also contributed groundwork for some of the strategic nuclear arms treaties (for example the Strategic Arms Limitation Talks and the Strategic Arms Reduction Treaties) as well as some European confidence-building measures. In addition, because of its stature as a respected international scientific organization, Pugwash could act as an 'honest broker' between parties in conflict. It established contact between the USA and the North Vietnamese in the late 1960s and sought to keep the channels open in the Cuban missile crisis. It has been concerned in attempts to resolve the Arab–Israeli dispute and the Greek–Turkish disputes over Cyprus, the tensions on the Korean peninsula and those between India and Pakistan in Kashmir. U Thant spoke of the attention paid to Pugwash statements in the United Nations. Rotblat and Jack Boag participated in a 1987 meeting of scientists in the USSR and helped raise with President Gorbachev the results of a Pugwash study on non-offensive defence. Further correspondence between Pugwash and Gorbachev led to Gorbachev's decision to remove 10 000 tanks from eastern Europe, paving the way for the 1990 Conventional Forces in Europe Treaty.

In addition to the annual meetings, Pugwash runs 10–12 workshops each year on such matters as the control of nuclear, chemical and biological weapons, the Middle East, scientific ethics, energy, environment, food security, security in southern Africa, economic inequities, and international cooperation in science; Rotblat attended a high proportion of these (figure 1). A statement issued in 2002 states that Pugwash's mission is

> to bring scientific insights and reason to bear on threats to human security arising from science and technology in general, and above all from the catastrophic threat posed to humanity by nuclear and other weapons of mass destruction … .

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Figure 1. Rotblat lecturing at the First Pugwash Workshop on East Asian Security in Seoul, South Korea, in April 2001. (Photograph copyright © Pugwash Conferences; reproduced with permission.)

From the first meeting in 1957, Rotblat was the guiding spirit of the Pugwash movement. He was Secretary-General from 1957 to 1973 (with Patricia Lindop as Assistant Secretary-General from 1964 to 1970), and President (later Emeritus) from 1988 to 1997. He was Chair of British Pugwash from 1978 to 1988. His extraordinary commitment to disarmament and peace, his great organizational skill, and his exceptional human qualities have undoubtedly been the main engine of Pugwash's success. He donated his Nobel Peace Prize money and other awards to support Pugwash activities.

Government attitudes

Not surprisingly, Rotblat, ASA and the Pugwash organization were regarded as probable Communist sympathizers by both the US and UK governments. In the UK, Prime Minister Clement Attlee had refused to visit the Atom Train in 1948. Two reports, full of anti-Communist language, by the Subcommittee on Internal Security of the US Senate's

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Committee on the Judiciary ostensibly explored 'The extensive use to which the Communist propaganda has made use of the Pugwash Conferences' (US Congress, Senate Committee on the Judiciary 1961, 1964).

After Pugwash was formed, the UK government tried to inculcate an attitude of scepticism towards it. But when Rotblat asked Sir John Cockcroft FRS to suggest who might attend the 1958 conference, the government decided that it would be politic to go with the flow and sent a senior member; however, it continued to be suspicious, seeing Pugwash meetings as little better than 'Communist-front gatherings'. Nevertheless, UK government policy gradually shifted, and Cockcroft attended the 1960 Moscow conference. Indeed, the government sought to take over the Pugwash movement by suggesting its own representatives, but Rotblat then dug his feet in. By 1962 the government was describing Pugwash as 'now a very respectable organisation', and after the 1963 Partial Test Ban Treaty Rotblat was awarded the CBE.

Science for peace

Rotblat's efforts were not limited to the ASA and Pugwash. He was a founder of the Campaign for Nuclear Disarmament (1958) and an initiator (later governing-body member, 1966–71) of the Stockholm International Peace Research Institute. He was expert adviser for the United Nations for the 1986 Year of Peace and helped establish the chair of Peace Studies at Bradford University. Rotblat was a member of the Management Group of the World Health Organization (1984–90). The Nobel Peace Prize for 1995 was awarded jointly to Rotblat and the Pugwash Conferences: congratulations from John Major, then the UK's Prime Minister, were conspicuous by their absence.

Rotblat lamented that about one-fifth of the world's scientists and engineers work on military projects. Furthermore, they are usually better paid and have better facilities than scientists in other fields. He was convinced that present nuclear policies, particularly—but not only—those of the USA, are perpetuating nuclear weapons and putting the whole world at risk. Initially concerned with nuclear weapons, he was also aware of the dangers of chemical and biological weapons. However, he also worried that the continuing unchecked advance of science and technology would produce weapons even more devastating than nuclear weapons.

His concern with the role of ethics extended to science in general, not only nuclear matters. He advocated that ethical principles should be taught in all science courses, and that graduating scientists should undertake not to be involved in projects harmful to humankind. He regretted the role of financial gain in the motivation of scientists or their employers, and the secrecy imposed by commercialization and also by scientists themselves in seeking the prestige of being 'first past the post'.

His ethical concern went far beyond these issues. His philosophy was based on respect for the majesty of nature: we master the forces of nature to our benefit, but also to our great peril. Hussain Al-Shahristani, who met him after spending 11 years behind bars for refusing to work on Saddam Hussein's nuclear weapons programme, said he symbolized humanity's reach for peace and respect for life. Rotblat was deeply concerned with abolishing the death penalty world-wide, and campaigned actively for whistleblowers, especially Mordechai Vanunu, who served a long prison sentence for revealing Israel's manufacture of atomic weapons.

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The younger generation

His elder niece described Jo Rotblat as 'someone who knew how to find his way to a child's heart'. He loved to preside at his two nieces' birthday parties, which he made more interesting and lively than anyone else's. His great-nieces loved to play with the elaborate system he installed in his bedroom to control the lights, the TV, the record-player and even the curtains from a console by his bed.

Whether or not that was related either to the adulation he received for his university lectures or to his stress on the importance of recruiting young people into Pugwash, he certainly recognized the importance of ensuring that the pursuit of peace should be continued well into the future. He reached out to the Student/Young Pugwash movement, recognizing the importance of engaging the next generation if the goals laid out in the Russell–Einstein Manifesto were to be achieved. He had a special way of reaching students, energizing the room with the force of his arguments and gentle humour, and making them feel he was a bridge across generations.

Promoting public awareness

Pugwash has mostly operated behind the scenes, trying to influence politicians directly rather than the general public. However, Rotblat had been a founder member of the Campaign for Nuclear Disarmament and was active in many related enterprises. He recently created a 'Weapons of Mass Destruction Awareness Programme' to increase the general public's consciousness of nuclear weapons issues. This programme, which involves cooperation between several organizations concerned with promoting peace, was launched in London in 2004 by Rotblat and former President Mikhail Gorbachev (figure 2). It organizes a range of awareness-raising events, often involving international figures, with recent examples including Robert McNamara, Richard Garwin, Sir David Attenborough FRS, Senator Douglas Roche and Lord Rees FRS. Consonant with Rotblat's emphasis on involving the young, the programme has produced educational materials for use in citizenship modules in schools. It also maintains an informational website.

Always courtly and polite, Rotblat had enormous charm. However, when serving on a committee with him one soon learned that he had great determination. His energy was unlimited: he travelled extensively (economy class until he was well past 90 years old) and lectured all over the world. He wrote over 300 books and papers on nuclear physics, medical physics and radiation biology; radiation hazards and the consequences of nuclear war; nuclear power; arms control; and the Pugwash Movement and the responsibility of scientists. He continued to write and to lecture until shortly before his death.

On hearing of Rotblat's death, John Holdren, director of the Program on Science, Technology and Policy at the John F. Kennedy School of Government at Harvard University and a Pugwash stalwart, said, 'we have lost a towering figure in the struggle for peace. Joseph Rotblat was one of a kind: brilliant, eloquent, tireless, demanding, impatient, completely committed to the pursuit of a saner, safer world for all of its inhabitants.'

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Figure 2. Rotblat with President Gorbachev during the 2nd Pugwash workshop on the Status and Future of the Nuclear Weapons Complexes of Russia and the USA, Moscow, in February 1995, on a visit to the Gorbachev Foundation. (Photograph from the Russian Pugwash archives; reproduced with permission.)

Degrees

1932 MA, Free University of Poland
1938 Doctor of Physics, University of Warsaw
1950 PhD, University of Liverpool
1953 DSc, University of London

Honours

1965 Commander of the Order of the British Empire
1966 Foreign Member of the Polish Academy of Science.
1972 Hon. Foreign Member, American Academy of Arts and Sciences.
1973 Hon. DSc, University of Bradford
1983 Bertrand Russell Society Award
1985 Hon. Fellow, University of Manchester Institute of Science and Technology
1987 Commander of the Polish Order of Merit.
1988 Foreign Member and Gold Medal, Czechoslovak Academy of Sciences
Order of Cyril and Methodius (1 Cl.), Bulgaria
Dr *honoris causa*, University of Moscow

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1989 Hon. DSc, University of Liverpool
Knight Commander's Cross, Order of Merit, Germany
Distinguished Citizen Award, International Physicians for the Prevention of Nuclear War
1990 Hon. Member, British Institute of Radiology
1992 Albert Einstein Peace Prize (with Hans Bethe)
1993 Hon. Professor, University of Blagoevgrad
1994 Foreign Member, Ukranian Academy of Sciences
1995 Fellow of the Royal Society
Nobel Peace Prize (with the Pugwash Conferences on Science and World Affairs)
1996 Hon. Freeman of the Borough of Camden
Copernicus Medal, Polish Academy of Sciences
Hon. Fellow, Queen Mary and Westfield College, University of London
Hon. DSc, City University
Hon. DSc, Slovak Academy of Science
Member of the Canberra Commission
1997 Lifetime Achievement Award, Nuclear Age Peace Foundation
Hon. Fellow, Institute of Physical Sciences in Medicine.
1998 Hon. Fellow, Royal Society of Edinburgh
Knight Commander of Saint Michael and Saint George
Knight Commander's Cross and Star of the Order of Polonia Restituta
Hon. Fellow of the Royal College of Radiologists
Hon. DSc, Acadia University, Wolfville, Nova Scotia
Hon. Dr of International Relations, University of Richmond
1999 Jamnalal Bajaj Peace Award
2000 Toda Peace Prize
Hon. Fellow, Academy of Medical Sciences
2001 Hon. Fellow, Institute of Physics
DSc (Medicine), University College London
2002 Linus Pauling Centennial Award

Acknowledgements

We are indebted to many relatives and friends of Joseph Rotblat who helped with this memoir. Two books (Rowlands & Attwood 2006; Braun *et al*. 2007), published not long after his death, contain reminiscences from those who knew him, as well as more detailed accounts of both his peace and scientific work.

The frontispiece photograph was taken in 1995 by Prudence Cuming Associates. Copyright © The Royal Society.

References to other authors

Braun, R., Hinde, R., Krieger, D., Kroto, H. & Milne, S. (eds) 2007 *Joseph Rotblat: visionary for peace.* Berlin: Wiley-VCH.

Frisch, O. R. & Meitner, L. 1939 Disintegration of uranium by neutrons: a new type of nuclear reaction. *Nature* **143**, 239–240.

Downloaded from http://rsbm.royalsocietypublishing.org/ on November 20, 2018

Frisch, O. R. & Peierls, R. 1940 Memorandum on the properties of a radioactive 'super-bomb'. http://www.atomicarchive.com/Docs/Begin/FrischPeierls.shtml

Rowlands, P. & Attwood, V. (eds) 2006 *War and peace: the life and work of Sir Joseph Rotblat.* University of Liverpool.

Russell, B. & Einstein, A. 1955 Russell–Einstein manifesto. (Republished in 2001 by Pugwash Conferences on Science and World Affairs (http://www.pugwash.org/about/manifesto.htm).)

US Congress, Senate Committee on the Judiciary 1961 *The Pugwash Conferences. Subcommittee to Investigate the Administration of the Internal Security Act and Other Internal Security Laws. The Pugwash Conferences. A staff analysis. 87th Congress.* Washington DC: US Government Printing Office.

US Congress, Senate Committee on the Judiciary 1964 *The Pugwash Conferences revisited: the Pugwash Movement viewed as of October 1964. 88th Congress.* Washington DC: US Government Printing Office.

Bibliography

The following publications are those referred to directly in the text. A full bibliography is available as electronic supplementary material at http://dx.doi.org/10.1098/rsbm.2007.0023 or via http://www.journals.royalsoc.ac.uk.

(1) 1984 Physical effects of nuclear weapons. In *Effects of nuclear war on health and health services* (International Committee of Experts in Medical Sciences and Public Health to Implement Resolution WHO34.38), pp. 26–48. Geneva: World Health Organization.

(2) 1987 Physical effects of nuclear war. In *Effects of nuclear war on health and health services* (2nd edn) (International Committee of Experts in Medical Sciences and Public Health to Implement Resolution WHO34.38), pp. 45–64. Geneva: World Health Organization.