Phys. perspect. 7 (2005) 204–252
1422-6944/05/020204–49
DOI 10.1007/s00016-004-0236-9

Physics in Perspective

Ever Ready to Go: The Multiple Exiles of Leo Szilard

Tibor Frank*

I argue that to understand the life and work of Leo Szilard (1898–1964) we have to understand, first, that he was driven by events to numerous departures, escapes, and exiles, changing his religion, his language, his country of residence, and his scientific disciplines; second, that he was a man haunted by major moral dilemmas throughout his life, burdened by a sincere and grave sense of responsibility for the fate of the world; and third, that he experienced a terrible sense of *déjà vu*: his excessive sensitivity and constant alertness were products of his experiences as a young student in Budapest in 1919. The mature Szilard in Berlin of 1933, and forever after, was always ready to move. I proceed as follows: After a brief introduction to his family background, youth, and education in Budapest, I discuss the impact of his army service in the Great War and of the tumultous events in Hungary in 1918–1919 on his life and psyche, forcing him to leave Budapest for Berlin in late 1919. He completed his doctoral degree under Max von Laue (1879–1960) at the University of Berlin in 1922 and his *Habilitationsschrift* in 1925. During the 1920s and early 1930s, he filed a number of patents, several of them jointly with Albert Einstein (1879–1955). He left Berlin in March 1933 for London where he played a leading role in the rescue operations for refugee scientists and scholars from Nazi Germany. He also carried out notable research in nuclear physics in London and Oxford before immigrating to the United States at the end of 1938. He drafted Einstein's famous letter of August 2, 1939, to President Franklin D. Roosevelt, worked in the Manhattan Project during World War II, initiated a petition to President Harry S. Truman not to use the bomb on Japan, and immediately after the war was a leader in the scientists' movement that resulted in civilian control of nuclear energy. In 1946 he turned to biology, in which his most significant contribution was to formulate a theory of aging. In 1956 von Laue led an effort to invite him to head a new institute for nuclear physics in West Berlin, which he ultimately declined at the end of 1959. He remained in the United States, becoming a highly visible public figure, speaking, writing, and traveling extensively, and even corresponding with Soviet Premier Nikita S. Khrushchev and President John F. Kennedy to promote the international control of nuclear weapons. In retrospect, although Szilard was a man of many missions, his life story could be read as that of a man of conscience with but a single mission, to save mankind.

Key words: Leo Szilard; William Beveridge; Arthur H. Compton; Lord Cherwell; Albert Einstein; Enrico Fermi; Leslie R. Groves; John F. Kennedy; Max von Laue; John von

* Tibor Frank is Professor of History at Eötvös Loránd University in Budapest, Hungary. His paper originated in 1988–1990 when he carried out substantial archival research as a Fulbright Visiting Professor at the University of California, Santa Barbara, and at the University of California at Los Angeles, and is based largely on the Leo Szilard Papers in the Mandeville Special Collections Library of the Geisel Library at the University of California, San Diego, in La Jolla. He completed his archival research during 2003–2004 as a Humboldt Research Award Winner at the Max Planck Institute for the History of Science in Berlin.

Neumann; Friedrich A. Paneth; Max Planck; Michael Polanyi; Erwin Schrödinger; Edward Teller; Harold C. Urey; Eugene Wigner; Budapest; Hungary; Berlin; Great War; Nazi Germany; Szilard-Chalmers reaction; World War II; Manhattan Project; Metallurgical Laboratory; Franck Report; Atomic Bomb; Cold War; Atomic Stalemate; patents; psychology; émigré scientists; nuclear physics; nuclear fission; nuclear-chain reaction; scientists' movement; biophysics; theory of aging.

Introduction

Leo Szilard (figure 1) seemed to be continually in search of himself throughout his life, to travel where his mind led him, to chase the world. He was a man of frequent changes: He converted to another religion, he migrated from country to country, and he moved freely among different disciplines and fields of knowledge. Szilard's life was one of continual change, intellectual unrest, a quest for role, influence, and identity.

Szilard was a member of the distinguished group of Hungarian émigré scientists whose work became most closely associated with the atomic bomb.[1] A student of Max von Laue and close associate of Albert Einstein in Berlin, Szilard probably was the most imaginative and original member of this outstanding group of scientists whose pervasive characteristics were imagination and originality.

Szilard's colleagues saw him as a genius. Eugene Rabinowitch remembered him as a "brilliant, paradoxical, arrogant, lonely man of ideas and sudden action"; Eugene Wigner asserted that he had met "no one with more imagination and originality, with more independence of thought and opinion...."[2] Szilard was a problem solver *par excellence*, one who identified, posed, and solved problems of very different types, in a variety of fields. He seems to have faced the world with a certain playful readiness to attack an unending sequence of problems that he considered himself to be called upon to solve. He felt a strong sense of urgency to find causes that he could identify himself with and apply his strong missionary zeal. He cannot be located in any narrow intellectual field within the confines of some academic discipline; his field was the universe.

Budapest

Leo Szilard (1898–1964) was born in Budapest into a middle-class family with some upper-class aspirations and a great deal of common sense.[3] His father, a construction engineer, changed his original German-Jewish name Spitz to Szilárd in 1900 when his son was barely two years old. His parents were freemasons for whom their Jewish faith was probably more a tradition than a doctrine. They helped their children study languages and all of European culture. In their beautiful home on Városligeti fasor in the then most fashionable district of Pest, their son Leo experimented in physics and at age 10 read Imre Madách's *The Tragedy of Man* (*Az ember tragédiája*), a dramatic 19th-century vision of human existence in poetic form, the greatest source of his intellectual inspiration in his childhood.[4] It had such a profound and lasting influence on him that after the atomic bomb was dropped he spoke of it at length to *New York Post* interviewer Oliver Pilat. Szilard saw Madách's *Tragedy* as applicable to the atomic era, and described the story's relevance to the post-Hiroshima world.

Fig. 1. Leo Szilard (1898–1964). *Credit*: Mandeville Special Collections Library of the Geisel Library, University of California, San Diego.

> In that book the Devil shows Adam the history of mankind with the sun dying down. Only Eskimos are left and they worry chiefly because there are too many Eskimos and too few seals. The thought is that there remains a rather narrow margin of hope after you have made your prophecy and it is pessimistic. That is exactly the situation in regard to the atomic bomb. We must concentrate on that narrow margin of hope.[5]

Szilard was particularly successful in mathematics in high school (*Főreáliskola*) in Budapest's VIth District, studying under Ignácz Rados (1859–1944),[6] one of the best mathematics teachers of the period whose younger brother was the great mathematician Gusztáv Rados (1862–1942). Szilard finished high school in 1916 by winning second prize in the prestigious national competition for physics students administered by the Hungarian Association for Mathematics and Physics.[7] He went on to study engineering at the Technical University of Budapest.[8]

Along with so many of his young Budapest contemporaries who shared the same social background,[9] Szilard joined the Galileo Circle (*Galilei Kör*), where he was influenced by radical currents in philosophy and politics.[10] He and his younger brother Béla (1900–1993) founded the Hungarian Association of Socialist Students, a small group to distribute a pamphlet that he had written on tax and monetary reform, inflation, and related matters, but otherwise he never got involved in student politics. He joined the army in the Great War but never saw action. After the war he was initially enthusiastic about the Commune, but there is no evidence that he joined the Red Army or played any other active political role.[11]

In an otherwise well-documented life, Szilard hardly ever mentioned his experiences during the tumultuous year 1919. Yet, that was a year of monumental importance in his life: Within a few months he left his native Hungary, his religion, his field of study, and to an ever-increasing extent, his language, starting to use German, and later English, instead of his mother tongue. Together these changes represented the first major turning point in his life, and perhaps the single most important one.

Military Service and Personal Identity

Leo Szilard's social situation and identity crisis after his military service in the Austro-Hungarian Imperial and Royal (*kaiserlich und königlich*, *k.u.k.*) Army resembled that of the officers portrayed in Austrian playwright Franz Theodor Csokor's *3. November 1918*. A group of wounded officers begin to talk about their national origins after they hear about the end of the war. Some are happy to still embrace their specific national identities just as the supranational *k.u.k.* identity of the Austro-Hungarian Army is about to be dissolved. But the highest ranking officer still identifies himself with the supranational Austro-Hungarian Army, while the Jewish reservist identifies himself with – supranational Austria.[12] Szilard, after a year in the *k.u.k*. Army, must have felt like the Jewish reservist. He became a volunteer in a reservist officer school in Budapest on September 27, 1917, and then an officer cadet (*Kadetaspirant*) in the Tyrol. His military career ended in a Budapest military hospital; he was discharged on November 17, 1918.[13]

Memories of the Great War cropped up much later in Szilard's mind. In a "Letter to Stalin" in 1947, he recalled his Hungarian past to make a point about the growing threat of a new war and his deep concern about the steady deterioration of Soviet-American relations.

> Situations of this general type are not without precedent in history; they occur also on occasion in the lives of individuals, and the story of one such occurrence made a very deep impression on me. In 1930, twelve years after the end of the First World War, I met a classmate of mine and we talked of what had happened to us since we had separated. He had been a lieutenant in the Austrian [Austro-Hungarian] Army, and in the last days of the war in the Carpathian Mountains he was in charge of a patrol. One morning they heard by way of rumor that an armistice had been concluded, but being cut off from communications they were unable to obtain confirmation. They rode out on patrol duty as usual, and as they emerged from the forest,

> they found themselves standing face to face with a Russian patrol in charge of an officer. The two officers grabbed their guns and, frozen in this position, the two patrols remained for uncounted seconds. Suddenly the Russian officer smiled and his hand went to his cap in salute. My friend returned the salute, and both patrols turned back their horses. "To this day," my friend said to me, "I regret that it was not I who saluted first."[14]

After his discharge from the army, Szilard continued his studies in engineering at the Technical University of Budapest and took his first major comprehensive examination on July 16, 1919.[15] The atmosphere at the university was heavily charged with social conflict, bitter animosity, and political infighting. The Galileo Circle had ceased to exist in the fall of 1918, leaving him without a support group of like-minded intellectuals. That he still was able to pursue his engineering studies, apparently successfully, during the academic year 1918–1919, with its turmoil, increasing racial hatred, and political battles, speaks highly for his intellectual discipline.

That Szilard never dwelled on his experiences in 1919 is all the more conspicuous because it was a time of momentous changes in his life: It was the year when he completed his studies for an engineering degree at the Technical University of Budapest; it was his last year in Hungary; and on July 24, 1919, he converted from Judaism and was baptized into the Calvinist faith.[16] He was baptized in the Calvinist church on the street (*Fasor*) where he lived with his family, probably because he knew its minister or because some of his schoolmates attended it. The date of his baptism, however, reveals a sense of urgency: The Hungarian Council Republic would exist for just one more week, and the signs of an anti-Semitic wave of revenge for what was generally viewed as a Jewish takeover of the government were evident.

The Roots of Anxiety

During the clouded months of late 1919, Szilard felt increasingly insecure as the White Terror reigned and threatened his future. In September he and his brother Béla suffered a humiliating attack at the Technical University for being Jewish students, and his recently acquired baptismal certificate, which he naïvely presented in self-defense, seemed to further inflame the anti-Semitic hatred of their attackers. Béla remembered that Leo was unable to obtain a visa after the establishment of the Commune but ultimately secured an official document, within 24 hours, from the Budapest police on December 11, 1919, testifying to his "political reliability,"[17] because his name "had not been entered into the books of the political police" – a testimony to his lack of political involvement at the time. He also acquired a written statement from the mathematician Lipót Fejér (1880–1959) on December 14 testifying that he had won second prize in the student competition in physics under the auspices of the Mathematical and Physical Society. These documents allowed him to leave Budapest for Berlin within a few days at the end of 1919.

Just as the year 1919 was one of national identity crisis for Hungary, it also was one of personal identity crisis for Szilard and the root of major fears. The long and agonizing fall of 1919 left a lasting impression on his young mind and imprinted on

it an acute awareness of history's dangerous turns. His various psychological complexes, such as his impulse to always live in hotels or rented rooms instead of setting up his own residence,* and his constant state of alert, allowing him to move quickly whenever necessary, probably have their roots in the terrible anguish he experienced in 1919. It is telling that he kept his most important belongings, particularly his papers, in two suitcases in his hotel room ready to be carried away at a moment's notice – as he did in Berlin at the beginning of March 1933, right after the Reichstag fire.[18] Like so many of his Hungarian contemporaries who were then living in Germany, he experienced a terrible sense of *déjà vu* of the Budapest of 1919, a disagreeable sense of familiarity with a threat that warranted steady vigilance and urgent response. It is perhaps not far off the mark to speak here of an "anxiety neurosis" (*Angstneurose*) in Sigmund Freud's sense, the symptoms of which Szilard experienced throughout his life.[19] The sudden outburst of anti-Semitism, the violence of a right-wing takeover, and the threatening atmosphere of vengeance were all well known to Szilard and his Hungarian contemporaries from their experiences in Budapest well over a decade before the Nazi takeover in Germany, and would remain in their minds for the rest of their lives. Szilard's excessive sensitivity and constant alertness were products of his experiences as a young student in Budapest in 1919; the mature Szilard in the Berlin of 1933, and forever after, was always ready to move.

German social historian Joachim Radkau's diagnosis of the age of nervousness (*Nervosität*) in Germany from Bismarck to Hitler also fits Hungary after the Great War.[20] In a roundabout way, the rise of a distinct Hungarian school of psychology, with internationally recognized achievements in psychoanalysis, fate analysis, and stress, point to the psychological consequences of a society in turmoil.** Émigrés of Jewish origin like Szilard had additional reasons to be nervous.[21] One may venture to think that his psychological impulses motivated his pioneering efforts to build the bomb against the threat of Hitler. His Hungarian-Jewish background, his upbringing, and his long and permanent exile contributed to a troubled and difficult psyche. It is also true, however, that his psychological makeup equipped him with skills to survive and to help everyone who needed his support, often in the face of adversity. After the Great War and the Hungarian revolutions of 1918–1919, Szilard's life reveals a continuous interplay of politics and science, a drama in which he seems to have been too political for a scientist and too scientific for a politician.

---

* His hotels included the Imperial Hotel in London, the International House and King's Crown Hotel in New York City (opposite Columbia University), the Quadrangle Club in Chicago, the Webster Hotel and Dupont Plaza in Washington, D.C.; even the small cottage in which the Szilards lived during the last few months of his life in early 1964 in La Jolla, California, was connected to a motel; see Lanouette, *Genius* (ref. 3), pp. 136, 149, 163, 173, 230–231, 274–275, 321, 329, 383, 398, 430–432, 466–467.

** Franz Alexander (1891–1964), Michael Bálint (1896–1970), Sándor Ferenczi (1873–1933), Imre Hermann (1889–1984), Ferenc Mérei (1909–1986), Hans Selye (1907–1982), and Leopold Szondi (1893–1986) were among the most widely known Hungarians in the history of 20th-century psychology; see Lívia Nemes und Gábor Berényi, ed., *Die Budapester Schule der Psychoanalyse* (Budapest: Akadémiai Kiadó, 1999).

Berlin, 1920–1933

By January 3, 1920, at the latest, Szilard was in Berlin-Charlottenburg, where he presented his documents and continued his studies in engineering at the Technical University (*Technische Hochschule*) for two semesters and then turned to science at the University of Berlin for an additional four semesters. He defended his doctoral dissertation in the summer of 1922.[22]

The University of Berlin offered great prospects for Szilard, now in his early twenties. In physics he could work with Max von Laue (1879–1960), Max Planck (1858–1947), and Albert Einstein (1879–1955), not to mention lesser figures.[23] Berlin physicists favored theory, yet also were deeply interested in experiment – an ideal combination for a man who was theoretically gifted but who also was challenged by the exciting potential of modern technology. He showed a remarkable talent, in fact, for putting his theoretical knowledge to use in the form of patents, products, and practical ideas.[24]

In his doctoral dissertation of 1922 Szilard showed that statistical fluctuations, which hitherto had been taken as proof of the reality of atoms, can be included within the framework of phenomenological thermodynamics without making any reference to atoms. He arrived at his results in a highly characteristic way. He remembered much later that he had spent several agonizing months working hard on a problem in thermodynamics and had come to believe that he had no chance in solving it. He then took a vacation for a month, determined just to loaf, but while relaxing an unrelated idea in statistical mechanics occurred to him, and he solved the problem before the end of his vacation. Einstein, much of whose past work had been based upon the analysis of statistical fluctuations, did not believe Szilard's solution until Szilard showed him how he arrived at it. Von Laue also was skeptical about Szilard's solution when Szilard handed him his manuscript, but the next day von Laue telephoned the young man, saying that his work had been accepted as a doctoral thesis.[25] Von Laue praised Szilard's dissertation as an "independent" and "major achievement," primarily for his pioneering use of Einstein's analysis of energy fluctuations, and judged it to be outstanding (*Eximium*). His dissertation was published three years later.[26]

After receiving his degree, Szilard first carried out experimental work in the Kaiser Wilhelm Institute for Fiber Chemistry (*Faserstoff-Chemie*) and then, in 1924, received a stipend from the Kaiser Wilhelm Institute for Physics. At the end of that year he became an assistant in the Institute for Theoretical Physics at the University of Berlin,[27] working under von Laue, investigating the relationship between entropy and information, soon conceiving ideas that would form part of modern information theory. He completed his second thesis (*Habilitationsschrift*) in 1925 although it was not published until 1929.[28] Von Laue (figure 2) praised it lavishly as "an essential clarification of an old and important question" and stated that it "satisfies more than completely the demands that the faculty expects from a *Habilitationsschrift*."[29] Planck agreed completely, adding that:

> Dr. Szilard has been working for several years in Berlin and often had the opportunity to prove his scientific talent and industry. Also his *Habilitationsschrift* distin-

Fig. 2. Max von Laue (1879–1960). *Credit*: Collection of Dieter Hoffmann, Berlin.

> guishes itself through the originality of thinking and clarity of presentation. I do not doubt that he would continue to work successfully as a *Dozent*. In time, he hopefully will be able to overcome a certain one-sidedness in the direction of his work.[30]

All of the members of Szilard's *Habilitation* Committee (Ernst Bodenstein, Fritz Haber, Wolfgang Köhler, Richard von Mises, Walther Nernst, Wilhelm Schlenk, and Arthur Wehnelt) agreed with von Laue and Planck. Szilard thus became a *Privatdozent*, gaining the right to lecture (*venia legendi*) at the University of Berlin.[31] In 1928 he offered courses, mostly in theoretical physics, some jointly with John von Neumann (1903–1957), Hartmut Kallmann (1896–1976), and Fritz London (1900–1954). Beginning in the winter term of 1930–1931 he taught as a member of a group headed by Erwin Schrödinger (1887–1961), and in 1931–1932 he offered a joint seminar with Lise Meitner (1878–1968) on "questions of atomic physics and chemistry."[32]

Szilard's work was firmly rooted in the practicalities of technical developments in the 1920s and early 1930s. He was obsessed with practical applications, which took him out of his laboratory and ever more frequently close to the production line. He devised

Fig. 3. Albert Einstein (1879–1955). *Credit*: Archive of the Max-Planck-Gesellschaft, Berlin-Dahlem.

a method of pumping liquid metal through tubes, which the German General Electric Company (*Allgemeine Elektrizitäts Gesellschaft*, AEG) wanted to use to develop a pump, and which ultimately found its practical application in nuclear reactors in the United States after the Second World War. Szilard worked as a consultant to the AEG for three years and patented several of his inventions in Great Britain and the United States.

In the late 1920s, Szilard worked with Einstein (figure 3) on a number of innovative approaches to cooling, making good use and taking some advantage of his celebrated coworker by patenting his inventions under both of their names. These included a refrigerator and an apparatus for transporting liquid metal, especially for concentrating gases and vapors in refrigerators in 1927, an electromagnetic apparatus for producing an oscillatory motion in 1928, a compressor in 1929, and a pump, chiefly for refrigerators in 1930.[33] For some reason, Szilard also patented basically the same inventions a little later under his own name alone, including the refrigerator both in 1929 and 1931, the apparatus for transporting liquid metal in 1929, and the compressor as well as a stator for refrigerators in 1931.[34] The new principle that Szilard and Einstein conceived promised to lead to a new type of refrigerator that was more efficient and less dangerous to operate than existing ones. One of their main ideas was to produce cooling by causing alcohol to be absorbed by water, but this idea did not prove to be of lasting industrial influence.[35] More important was their invention, which became known as the Einstein-Szilard electromagnetic pump, in which "a traveling electromagnetic field

causes a liquid metal to move." The prestigious AEG developed a prototype of their pump for refrigeration purposes.[36]

Although Szilard and Einstein patented their refrigerator in Great Britain, the United States, and Hungary, and although Szilard later tried to promote interest in it in the United States,[37] it was never marketed, mainly because of the devastating economic effects of the Great Depression. Einstein also declined to lend his name to advertisements for it. A schoolfriend asked Szilard about this refrigerator shortly before his death. Szilard replied: "Oh that?… That went into the atomic bomb."[38]

Rescue Operations

Two weeks after the Nazi Party's success in the Reichstag elections of September 14, 1930, Szilard assessed its significance in a letter to Einstein:

> From week to week I detect new symptoms, if my nose doesn't deceive me, that peaceful [political] development in Europe in the next ten years is not to be counted on.… Indeed, I don't know if it will be possible to build our refrigerator in Europe.[39]

Szilard left Berlin for Vienna at the beginning of March 1933.

The international community of scientists and scholars showed a great deal of compassion for their colleagues who were forced to emigrate from Germany after the promulgation of the Law for the Restoration of the Career Civil Service (*Gesetz zur Wiederherstellung des Berufsbeamtentums*) of April 7, 1933. They established parallel organizational frameworks and provided material assistance, which eventually allowed some 6000 professionals, mostly Jewish, to leave Germany.[40] The Emergency Society of German Scholars Abroad (*Notgemeinschaft Deutscher Wissenschaftler im Ausland*), headquartered in Zürich, Switzerland, was founded largely through the efforts of a Hungarian-born scientist. As Lord Beveridge wrote:

> Professor Philip Schwartz, Hungarian by birth but holding a Chair of General Pathology and Pathological Anatomy at Frankfurt-am-Main in Germany, was an immediate victim of Hitler's racial persecution and went in March 1933 to Zürich in Switzerland. There he founded at once the *Notgemeinschaft* and directed it for six months.…
>
> [For] money it had to depend almost wholly on contributions from displaced scholars whom it had helped to re-establish. But by its personal knowledge of the scholars themselves and by using its contacts with universities everywhere, it rendered invaluable service.…[41]

The Emergency Society provided a list of nearly 1500 dismissed academics, which was published in 1936 with the assistance of the Rockefeller Foundation.[42] For German scientists in trouble, the idea of a *Notgemeinschaft* was not new: The Emergency Society of German Science (*Notgemeinschaft der Deutschen Wissenschaft*) was founded immediately after the Great War to heal the wounds to German science at a time of total military, economic, and psychological collapse. Thoroughly nazified after 1933, this Emer-

gency Society, of course, had nothing to do with the newly established one to aid émigré scientists.[43] The first major success of the latter Emergency Society was to secure a promise from the Turkish government to place 33 German professors at the University of Istanbul. Its staff then discussed possible similar arrangements with Australian, Indian, South African, Soviet, and American authorities, as well as with the Committee for Intellectual Cooperation of the League of Nations.

In May 1933, scientists in Great Britain established the Academic Assistance Council (AAC, first conceived as the International Board of Scientists and Scholars) with Nobel Laureate Lord Rutherford (1871–1937) as President and Sir William (later Lord) Beveridge (1879–1963) and Professor Charles S. Gibson (1883–1950) as Secretaries.[44] A few weeks later, the Emergency Committee in Aid of Displaced German (later Foreign) Scholars was established as the American counterpart of the AAC to provide grants or fellowships to refugee scientists and scholars. The main financial contributions to the Emergency Committee came from Jewish foundations and individuals.[45] Another support committee, the International Committee for the Placement of Refugee Intellectuals (*Comité International pour la Placement des Intellectuels Réfugiés*) was formed in Geneva, Switzerland, offering positions to refugee professors from Austria, Germany, and Italy.[46]

Jewish groups in Europe considered raising funds to establish a new university somewhere in Europe to be staffed by refugee faculty (a *Flüchtlingsuniversität*), an idea conceived by Einstein,[47] but his long-time colleague and friend Szilard was able to convince him "that this would not be an easy task," and that instead he should "concentrate on one promising effort."[48] Einstein took Szilard's advice and lent his support to the Academic Assistance Council. Szilard also suggested that money should be raised for the Palestine University, but owing to the economic hardships of the Great Depression these projects never materialized. Instead, some forms of relief were provided by several other agencies, such as the Jewish Relief Committee in Amsterdam.

The academic community in America was horrified to learn of the events in Germany. The German-American anthropologist Franz Boas (1858–1942) was one of the first to receive a first-hand report from the American physicist and inventor Benjamin Liebowitz (1890–1977), who traveled throughout Europe collecting information and helping to plan relief efforts. "It is impossible to describe the utter despair of all classes of Jews in Germany," he wrote to Boas in early May 1933.

> The thoroughness with which they are being hunted out and stopped short in their careers is appalling. Unless help comes from the outside, there is no outlook for thousands, perhaps hundreds of thousands, except starvation or the sleeping pill. It is a gigantic "cold" pogrom. And it is not only against Jews; Communists, of course, are included, but are not singled out racially; social democrats and liberals generally are coming under the ban, especially if they protest in the least against the Nazi movement. Please note that I am not speaking from hearsay: I *know* people, friends in many classes – scientists, scholars, doctors, lawyers, business men, economists, etc.[49]

Ultimately, some 6000 displaced scientists and scholars applied for aid to the Emergency Committee in New York, of which 335 were granted assistance.* Among the Hungarians who received grants or fellowships either after they left Germany in 1933-1934 (*Group I*), or after they left Hungary following the introduction of anti-Semitic legislation there in 1938–1939 (*Group II*), were as follows:

Group I

Melchior (Menyhért) Pályi (1892–1970), economist
Otto Szász (1884–1952), mathematician
Gabriel (Gábor) Szegő (1895–1985), mathematician
Leo Szilárd (1898–1964), physicist
Edward (Ede) Teller (1908–2003), physicist

Group II

George Pólya (1887–1985), mathematician
Dezső Rapaport (1911–1960), psychologist
Ladislas (László) Tisza (b. 1907), physicist
Charles de Tolnay (1899–1981), art historian
Rusztem Vámbéry (1892–1948), lawyer, diplomat
Egon Wellesz (1885–1974), musicologist, composer

The following Hungarians were among those who applied for but did not receive aid from the Emergency Committee:

Group I

Friedrich (Frigyes) Antal (1887–1954), art historian
Willy (Vilmos, William John) Fellner (1905–1983), economist

Group II

Elemér Balogh (1881–1955), comparative law
Béla Bartók (1881–1945), composer, musicologist, pianist
René Fueloep [Fülöp]-Miller (1891–1963), author
Nicholas (Miklós) Halász (1895–1985), journalist, author, novelist
Péter Havas (1916–2004), physicist
Hugo Ignotus (1969–1949), critic, editor
Aurél Thomas Kolnai (1900–1973), author, philosopher
Francis (Ferenc) de Kőrösy (1906–1997), chemist
Eugene (Jenő) Lukács (1906–1987), mathematician, statistician

* There are 195 boxes of correspondence and papers in the files of the Emergency Committee in Aid of Displaced Foreign Scholars, New York Public Library, Manuscripts and Archives Division, New York, New York; my lists are based on these documents. Robin E. Rider also compiled a list of mathematicians and physicists who emigrated to the United States or Britain; her list includes a few more Hungarians such as physicists Gusztáv Kürti (1903–?), Cornelius Lánczos (1893–1974), and Elisabeth (Erzsébet) Róna (1890–1891) and mathematicians Paul Erdős (1913–1998), Tibor Radó (1895–1965), and Stefan (Steven, István) Vajda (1901–?); see Rider, "Alarm" (ref. 44), pp. 172–176. She did not distinguish between Germans and Hungarians, however, and did not discuss the contributions of Leo Szilard or other Hungarians to the establishment of the Academic Assistance Council or the Emergency Committee. I am grateful to Gábor Palló for additional information based upon his own research in the files of the Emergency Committee. See also Fermi, *Illustrious Immigrants* (ref. 40), pp. 76–78.

Altogether some 65 Hungarians appear on the lists of the Emergency Committee. Almost all were Hungarian Jews who immigrated, either directly or indirectly, to the United States, for the most part after the introduction of the Hungarian anti-Semitic legislation in 1938–1939, although a sizable group of them had been in Germany by 1933 and then had immigrated. All were especially sensitive to the upheaval in Germany because they had a strong sense of *déjà vu*: The rise of anti-Semitism and xenophobia in Germany and the threats they created were strongly reminiscent of the Hungarian ordeal in 1919–1920. That sensitivity impelled some of them to become highly active leaders in the rescue operations, which saved the lives and careers of thousands of scientists and scholars.

Leo Szilard voluntarily took on the enormous task of contributing to these rescue operations throughout 1933 and beyond. He was generally recognized as a man of extraordinary abilities and completely unselfish motives, who no doubt was deeply grateful for the help he himself had received from German professors, colleagues, and friends throughout the 1920s and early 1930s. Paul Ehrenfest (1880–1933) of the University of Leiden captured Szilard's personality and talents in a letter to Frederick G. Donnan (1870–1956) on August 22, 1933:

> Szilard is a *very rare* example of a man because of his combination of great *purely scientific* acumen, his ability to immerse himself in and solve technical problems, his fascination and fantasy for organizing, and his great sensitivity and compassion for people in need.… What I find so particularly enviable in him, is that he reacts to any difficulty which may arise with immediate action rather than depression or resignation. For even though this procedure is not always successful, an energetic reaction is still vastly more fruitful than a passive attitude. I feel deeply ashamed when I see how wonderfully energetically he immediately set about doing everything in his power to work for the Jewish-German scholars.… [He] simply felt that, confronted with this great, wild catastrophe, his first duty was to use his special talents in organizing aid for a specific subgroup of scientists.[50]

Among his fellow Hungarians in Germany, Szilard was well known as a man who was always ready to help. Philosopher Karl Mannheim (1893–1947), who worked with Szilard in establishing the Academic Assistance Council in 1933, remembered him as someone who "belongs to that rare group of people who never demand something for themselves."[51] Another friend and colleague, physicist Eugene Wigner (1902–1995), also had nothing but lavish praise for Szilard's unselfishness.[52] Szilard was hailed for his "rare social abilities" and "unusual social competence," which served him well not only when helping people but also later when mobilizing scientists and politicians in the United States to investigate the nuclear-chain reaction and its consequences.[53]

Perhaps more than anyone else, Szilard was the prime mover behind the founding of the Academic Assistance Council when fleeing Berlin rapidly after the burning of the Reichstag on February 27, 1933. Soon thereafter, he accidentally met Sir William (later Lord) Beveridge in Vienna and persuaded him to form a committee to aid refugee scientists and scholars.[54] "Things in England develop very well," Szilard wrote to the distinguished Austrian chemist Friedrich A. Paneth (1887–1958) from Brussels in mid-May 1933.

> Sir William Beveridge, whom I met in Vienna and who has been very active since he came back in London succeeded in getting a very prominent group to make an appeal for raising funds in England. The first contribution will probably be made through voluntary cuts of salaries of University teachers (this is very confidential).[55]

Szilard functioned like an entire team of people. He had followed Beveridge back to London, where he wrote to Max Delbrück (1906–1981) on May 7, 1933: "What I am concerned with at the present is to co-ordinate the foreign groups which are already in existence, and to stimulate the formation of groups in countries where there are no suitable groups as yet."[56] He then traveled for a month on the Continent. In Belgium he met the Rectors of all four of the Belgian universities, the physicist Jacques Errera and the philosopher and politician Hendrik de Man of the University of Brussels, who assisted him in mobilizing Belgian colleagues to aid refugee scientists and scholars. In Switzerland he talked to Gustave Gerard Kullman of the Committee for Intellectual Cooperation of the League of Nations and Walter Kotschnig of the International Student Service.[57]

In London Szilard (figure 4) met with university leaders and prominent scientists such as Beveridge, Director of the London School of Economics and Political Science, Frederick G. Donnan of University College, London, Gilbert Murray of Oxford, Chairman of the League of Nations Committee for Intellectual Cooperation, Sir John Russell, G.H. Hardy of Cambridge, Nobel Laureate Niels Bohr of Copenhagen, Nobel Laureate Archibald V. Hill of the Royal Society and University College, London, Henry Mond, the Second Lord Melchett, Chairman of the Jewish Agency, and Jewish leaders such as Neville Laski, Claude Joseph Goldsmid Montefiore, Sir Philip Hartog, Chairman of the Committee of the Jewish Board of Deputies and the Anglo-Jewish Association, and Chaim Weizmann, the future President of Israel. Living as always in a hotel, and working from his office at the Academic Assistance Council headquartered at the Royal Society, Szilard apparently contacted all of the agencies in London that were formed to help European Jewish scientists in trouble, including the Central Jewish Consultative Committee at 1 Finsbury Square and the Jews' Temporary Shelter at 63 Mansell Street.[58] He put Friedrich Paneth in touch with the Jewish Refugees Committee's Hospitality Committee at Woburn House in June 1933; soon thereafter Paneth was appointed as a consultant for the Imperial Chemical Industries (ICI) and later taught at Imperial College, London, and the University of Durham from 1939 to 1953.[59] Szilard also considered mobilizing Nobel Laureates to aid refugee scientists and scholars, but this plan failed to receive general approval and was soon dropped.[60]

The Academic Assistance Council helped several Hungarian scholars, including the economic historian Karl Polanyi (1886–1964), get to England; his younger brother Michael Polanyi (1891–1976), securely on his way to England, also tried to help some of his gifted students remaining in Germany to obtain scholarships in Great Britain.[61] Other Hungarian scientists as well, many of whom have been hitherto unidentified, were rescued by a job in Great Britain, often as a stepping stone to one in the United States. A case in point was the nutrition expert Paul György (1893–1976), who was dismissed from his position at the University of Heidelberg in 1934 after thirteen years

Fig. 4. Leo Szilard (1898–1964). *Credit*: *Bulletin of the Atomic Scientists*; courtesy of the American Institute of Physics Emilio Segrè Visual Archives.

there: He was offered a research fellowship at the University of Cambridge during 1934–1935, then was appointed to a professorship at Western Reserve University in Cleveland (1935–1944) before becoming Professor of Clinical Pediatrics and of Nutrition in Pediatrics at the University of Pennsylvania in Philadelphia.[62]

Szilard realized that an AAC fellowship often would not lead to a permanent position in Great Britain. Thus, as he wrote to Charles S. Gibson in June 1933:

> It is therefore important to take up every case as soon as possible with America and other countries in order to get a more uniform distribution as far as permanent appointments are concerned. A certain number of American scientists and scholars should in view of this problem be asked to act as correspondent members of the Academic Assistance Council.…[63]

The relief efforts met with a great deal of support in the United States, where the academic community was "terribly concerned about the situation in Germany." "I have a letter this morning from an old friend," wrote Abraham Flexner (1866–1959), Director of the Institute for Advanced Study in Princeton on March 30, 1933, to John von Neu-

mann who was traveling in Europe, "telling me unspeakable things about the way in which Hitler is ruining the German Educational Ministry and other cultural activities. The whole thing seems to me the act of mad men. I cannot believe that it will endure."[64] Five weeks later he added:

> The whole American nation is a unit as respects the crazy performances of the German Government. Göttingen has been absolutely ruined and the University students must all be mad. Nothing crazier has happened in human history since the days of the French Terror.[65]

Acting through Benjamin Liebowitz, Szilard was instrumental in securing contributions from Franz Boas of Columbia University, who played a leading role in marshaling support for the refugee cause.[66] Boas invited philosopher John Dewey, economist Frank William Taussig, zoologist Raymond Pearl, physiologist Walter Cannon, and others (including poet Ezra Pound) to serve on a board to coordinate the efforts of the AAC with those of American universities and scientists.[67] Other Hungarians besides Szilard, including von Neumann and Theodore von Kármán (1881–1963), played active roles in the relief efforts. Oswald Veblen (1880–1960), Professor of Mathematics in the Institute for Advanced Study, wrote to his colleague von Neumann, who again was traveling in Europe in May 1933, that "It would be a good idea to write me whatever you know in detail about the mathematicians and physicists who are in difficulties."[68] Veblen reported that "there are a number of attempts being made to raise money to provide relief in this country for the Jews and Liberals who are being dispossessed in Germany." Von Neumann supplied both money and information for the relief efforts to the Emergency Society of German (later Foreign) Scientists Abroad.[69] The Emergency Committee in Aid of Displaced Foreign Physicians in New York City also assisted medical doctors who were trying to escape the Nazi threat. The physician Frederick P. Reynolds of the New York Academy of Medicine, however, warned applicants in the fall of 1933 of "the crowding in the medical profession in this country," adding that, "Apparently these conditions are growing worse each year."[70]

Szilard, despite all of the relief work he did for others, was himself in trouble, writing to his friend Eugene Wigner in June 1933: "Last, not least, someone must take care of myself, as I naturally can't do this myself and it would be incompatible with my current activities anyway."[71] Curiously, it seems that at this time Szilard's fellow Hungarian scientists rated him rather poorly as a physicist. As Wigner wrote to Michael Polanyi, he had

> complete appreciation for his [Szilard's] directness and trustworthiness. His unselfishness is almost unparalleled among my acquaintances. He has an imagination that would be of extraordinary use to him and to any institution for which he works. I don't know if a purely scientific job would be the best for him, although this should be also considered.[72]

Wigner mentioned two possible jobs for Szilard, neither of which was in academia. Similarly, von Kármán, when asked for his comments on Szilard as a prospective visiting professor in America in 1934, said that he did "not think that the case of Szilard is a very strong one."[73]

Nuclear Physics

Szilard turned his attention to nuclear physics already in Berlin in 1932 but then moved to England following the Nazi takeover.[74] As a newcomer to this field, it is not surprising that he was not invited to attend the seventh Solvay Conference in Brussels in October 1933, which was devoted to nuclear physics.[75] Within a few years, however, he rose to prominence in this field.

Szilard began experimental work in nuclear physics in the Radium Department of St. Bartholomew's Hospital in London in the summer of 1934 where, he wrote to Friedrich Paneth in late August 1934, "I spend most of my time."[76] Earlier that year he had patented his invention of what became known as a cyclotron and had recognized the possibility of a chain reaction,[77] achievements that he later cited with pride although he was careful to not take away "credit from others to whom credit is due."[78]

At St. Bartholomew's Hospital Szilard and T.A. Chalmers systematically investigated key features of radioactivity. They devised a technique for separating radioactive nuclei produced by neutron bombardment from their normal isotopic environment (the "Szilard-Chalmers reaction"); they recognized the first case of isomerism among artificially radioactive elements; and they discovered and made pioneering investigations on the photoemission of slow neutrons from beryllium, which ultimately led to a means of distinguishing the emission of slow from fast neutrons in nuclear fission, a critically important problem in a chain reaction.[79] These and other experiments brought Szilard the award of an ICI grant and an invitation to the Clarendon Laboratory in Oxford.[80] There, beginning in 1935, he joined J.H.E. Griffiths in studying the emission of gamma rays when slow neutrons are absorbed by elements of odd atomic number.[81] He also was able to supply Paneth with enough radon and other substances from the Clarendon Laboratory for his own experiments.[82] In 1941 Wigner commented as follows about Szilard's work during this period:

> I first heard the possibility of nuclear power seriously discussed in the Spring of 1934, when I saw Szilard during a visit to London. The efficiency of collisions between neutrons and nuclei was realized by Szilard simultaneously with and independently from Fermi. He visualized the possibility of chain reactions involving neutrons even at this time.… Szilard showed me copies of some of the patent applications which he made in 1934 and 1935.… One of his applications contains the following passage:
>
> "(a) Pure neutron chains, in which the links of the chain are formed by neutrons of the mass number 1 alone. Such chains are only possible in the presence of a metastable element. A metastable element is an element the mass of which (packing fraction) is sufficiently high to allow its disintegration into parts under liberation of energy. Elements like uranium and thorium are such metastable elements; these two elements reveal their metastable nature by emitting alpha particles. Other elements may be metastable without revealing their nature in this way."[83]

Wigner added that, "These were certainly almost prophetic words in 1934 or 1935." By 1941 Wigner clearly had reevaluated his earlier unenthusiastic view of Szilard as a physicist.

In the spring of 1934 Szilard filed a British patent that included the concept of a chain reaction that was accepted in 1935, but he then assigned that part under seal to the British Admiralty.[84] Thus, in his own way, he began to wage war against Hitler, attempting to translate his theoretical concepts into practical results, becoming increasingly convinced of the vast potential of theoretical physics for industrial applications. As he wrote to Sir Hugo (later Lord) Hirst (1863–1943), founder of the British General Electric Company, in February 1934:

> I do not yet know for certain if we have got immediate important application for fast electrons, but I do believe that a Company like the General Electric Company would be justified in keeping in close touch with the probably very quick development in this new field.[85]

The following month he commented to Sir Hugo on H.G. Wells's book of 1914, *The World Set Free*, adopting Rutherford's term "moonshine" but speculating that his pessimism may be off the mark:

> Of course, all this is moonshine. But I have reason to believe that in so far as the industrial applications of the present discoveries in physics are concerned, the forecast of the writers may prove to be more accurate than the forecast of the scientists. The physicists have conclusive arguments as to why we cannot create at present new sources of energy for industrial purposes; I am not so sure whether they do not miss the point."[86]

Szilard filed one patent application after another in a wide variety of fields, including ones on a new means of reproducing books (which essentially was the forerunner of microfilm and microfiche),[87] the production of fast protons (including by means of an accelerator), and the production of radioactive elements by bombarding nuclei with fast protons, alpha particles, and neutrons, the last one being "based on a process which recently has been discovered by Fermi."[88]

Szilard also sought financial support to carry out experiments that promised "a good chance of highly significant industrial applications,"[89] including, as he wrote to Enrico Fermi on March 13, 1936, those involving "the practical application of modern nuclear physics, though I am by no means certain that such practical applications of importance at present really exist."[90] He did not wish to "consider these patents as my private property and that if they are of any importance, they should be controlled with a view of public policy." Any income derived from them should not be used for private purposes, but for further research or, if the income was large, for other constructive purposes. He was optimistic that "certain applications of very great importance might materialise in a not too distant future," so he suggested to Fermi that the income should be used to create a fund for paying the salaries of young physicists, for acquiring radium, for further experiments, and for travel expenses to facilitate visits of physicists to different laboratories.

In 1938, around the time of the Munich crisis, Szilard foresaw a general war within two years. In 1960 he recalled that he had told British authorities "that if he could work on war work, he would stay in England. If not, he would emigrate to the U.S." He continued:

> The British wouldn't let any foreigner work on war work, but since uranium was not useful and since non-useful things were not secret, refugees could work on uranium studies. He [I] emphasized that there could not have been a bomb if it hadn't been for British contributions. A memorandum on a subject of a bomb from uranium originating from German refugees in England was brought to the U.S. as part of the British contribution to the Ally [*sic*] scientific efforts. This is mentioned in the *Smyth Report*. The U.S. has not given due credit to those responsible for this British contribution in its official histories.[91]

When Szilard's fellowship at Oxford ended in 1938, he emigrated to the United States, working without salary at Columbia University in New York beginning in March 1939, "developing certain inventions which are at present considered to be important for national defense."[92]

Politics *versus* Science: The Moral Dilemmas of War

Szilard's relationship with Einstein went back to 1920, his first year in Berlin, or soon thereafter. Einstein had a high opinion of the young Hungarian, whom he considered to be a "fine and clever man who is ordinarily not given to illusions. Like many people of that type, he may be inclined to exaggerate the significance of reason in human affairs."[93] In 1931 Szilard asked Einstein for a letter in support of his application for a U.S. visa, drafting a few sentences for Einstein's signature. Einstein changed Szilard's modest wording from "he has been well known to me [*persönlich gut bekannt*] from many years of joint work" to "he is closely associated [*eng verbunden*] with me…," adding that he had "a direct interest" in Szilard's journey to America.[94] In October 1931 Einstein also supported the granting of a nonquota immigrant visa to Szilard.[95]

Szilard thus was in a unique position in 1939 to call on Einstein, the most famous Nobel Laureate in the world, to alert President Franklin D. Roosevelt to recent developments in nuclear physics. The first, undated draft of Einstein's famous letter to Roosevelt of August 2, 1939, pointing out the need for funds to carry out research on the nuclear-chain reaction, which could lead to the construction of extremely powerful bombs, mentioned Wigner as the prime mover behind it, but from Szilard's correspondence with Einstein through October 1939 we know that Szilard worked closely with Wigner in this effort.[96] Moreover, since Edward Teller drove Szilard to Einstein's vacation cottage on Long Island, New York, to secure his signature, this was indeed a Hungarian initiative. These Hungarian refugees, in fact, proved to be more effective than the recent Italian Nobel Laureate Enrico Fermi, who tried to approach the U.S. Navy Department in March 1939 for funds but was dismissed as a "crazy wop."[97] The Hungarians thus may have learned from Fermi's failure and saw that Einstein was the only possible scientist who was likely to gain the ear of the president. Even so, it took two and a half months before the economist Alexander Sachs, who was known to have close ties to Roosevelt, felt free to deliver Einstein's letter by hand to him,[98] a telling example of the status and image of scientists in America at this time. Refugees from Hitler's Germany, however, knew full well that the Nazis would use every means at their disposal to further their war aims, and these three Hungarian refugee scientists in partic-

ular, with their experiences during the Great War, during the Hungarian revolution and counterrevolution of 1919–1920, and during the Weimar period in Germany, had ample reasons for concern. They also were politically astute, finding and exploiting effective channels of power in the United States.

Two weeks after Einstein signed the letter to Roosevelt, Szilard wrote to the famous American aviator Charles Lindbergh, attaching a letter of support from Einstein,[99] trying to enlist Lindbergh's aid in securing governmental funds for purchasing the tons – not pounds – of uranium needed to sustain a nuclear-chain reaction. In yet another month, in the middle of September 1939, Szilard was feverishly working on plans for experiments "on an almost industrial scale.…"[100] He also used the cyclotron at the University of Rochester to continue earlier studies on indium, which led to his and his colleagues' discovery of radioactivity induced by nuclear excitation.[101] Then, working with Walter Zinn at Columbia University, he joined the increasing number of scientists studying the emission of neutrons in nuclear fission to determine if "a chain reaction can in fact be sustained in a system containing uranium."[102] In July 1939 he had concluded that it probably would be self-sustaining in a graphite-uranium system, a conclusion that he reported in a paper to the *Physical Review* on February 14, 1940.[103] Since, however, this was vital information that could be used by physicists in Nazi Germany, he "spent six months of hard work getting the Government to ask him to withhold his paper which … he wanted to withhold." Publication, in fact, was deferred indefinitely "at the request of the U.S. Government."[104]

In late 1940 Szilard worked with the National Defense Research Committee at Columbia University, and in February 1942 Arthur H. Compton (1892–1962), who was in charge of work on the chain reaction at the University of Chicago and organized the Metallurgical Laboratory (Met Lab) there, placed Szilard in charge of the supply of materials as a member of Fermi's group.[105] Just as Szilard was convinced that he should not publish his research on the chain reaction, he was deeply reluctant to make money from patents related to a new weapon of mass destruction to be used against Germany and Japan. His reluctance vanished only after he concluded at the end of 1942, during the course of the battle of Stalingrad, "that we may win the war by ordinary methods within a couple of years." The new weapon probably would not be ready before the end of the war, mainly "due to the diffusion of responsibility [for its development] … and perhaps to a lesser extent, also to the general attitude [of the military] towards the creative scientist."[106] In early 1943, therefore, he decided to file patent applications on his basic inventions.

The resulting negotiations with the government compelled him to not file patent applications on the inventions he had made prior to November 1940, when he was first employed at Columbia University. Ultimately, in August 1943, he was given the choice of either losing his job at Chicago or of assigning to the government "any and all inventions, discoveries, methods and ideas relating to nuclear fission, which are not covered by issued patents or abandoned patent applications."[107] He chose to retain his job and to sign an agreement conferring to the U.S. Government the rights to all of his inventions in the field of nuclear fission. That was a decision of conscience because, as he explained to General Leslie R. Groves on December 3, 1943, and eight days later reported to Compton, he was, "rightly or wrongly, convinced that the Germans have

caught up with us in this work, and that in this situation I do not wish to leave the project."[108] On December 19, 1944, Szilard and Fermi then filed a patent on the chain reaction in uranium, which had first been achieved at Chicago on December 2, 1942; they assigned it to the U.S. Atomic Energy Commission in 1955.[109]

Admiral Harold G. Bowen, Director of the Naval Research Laboratory in Washington, D.C., suggested during a meeting at the U.S. National Bureau of Standards on April 27, 1940, that scientists should withhold information on uranium fission voluntarily but that the government would do nothing to force them to do so.[110] The German invasion of the Netherlands, Belgium, and Luxemburg two weeks later, on May 10, 1940, however, brought about "a noticeable change in attitude" on this issue, as was manifest in letters that Szilard received from colleagues. He himself was committed to finding "a satisfactory substitute in the form of some private publication,"[111] but at the same time he also was committed to the intellectual openness characteristic of "the great democracies."

Nonetheless, right from the outset Szilard had played an important role in persuading his colleagues and the U.S. Government of the importance of maintaining secrecy about work on the chain reaction. Thus, as early as March 1939, he had tried unsuccessfully to persuade Fermi to withhold publication of their observations on the number of neutrons emitted in the fissioning of uranium, and he tried to convince Frédéric Joliot-Curie (1900–1958) at the Collège de France in Paris to do the same. Victor Weisskopf (1908–2002) made a similar plea to Patrick Blackett (1897–1974) in Manchester, and Wigner wrote to Paul Dirac (1902–1984) in Cambridge urging him to support Blackett in not publishing work on fission. The British reaction was positive, but Joliot-Curie refused to cooperate and in April 1939 published his and his team's results on the number of neutrons emitted in the fissioning of uranium. After the German invasion of Poland on September 1, 1939, however, Joliot-Curie became convinced of the necessity of withholding publications and in late October deposited a sealed envelope with the *Académie des Sciences* containing an explanation of the principle of nuclear reactors. In the United States, after further efforts by Szilard and others, Gregory Breit (1899–1981) of the University of Wisconsin played a leading role in June 1940 in formulating a general policy on self-censorship of publications about nuclear fission.

Szilard's plea for secrecy backfired: He became a victim of his own initiatives and in the eyes of General Groves a liability to the Manhattan Project because he, like many other scientists, opposed Groves's policy of "compartmentalization of information." Szilard recalled a telling example of the negative effects of that policy following a conversation with his Hungarian friend Edward Teller (1908–2003) in the summer of 1942:

> Upon Teller's return from the summer conference in Berkeley, I went to see him and asked him whether this point had been considered and whether, in view of this fact, it would not be wise to put more emphasis in autocatalytic methods of explosion which I had discussed with him in the past. Teller replied that he personally is placing considerable emphasis on the autocatalytic method, but that the group did not consider it as important. Teller, as you know, is an old friend of mine and I found him occasionally embarrassed when I tried to discuss with him things which he did not feel free to discuss with me. For this reason I interpreted his reply as meaning that

> the situation was well in hand, and that there was no need for us to discuss it. Consequently, I changed the subject of our conversation and did nothing further in the matter. Teller, on the other hand, as it now turns out, interpreted my changing of the subject as meaning that I was going to look into this question, and that it was not necessary for him to do anything about it.[112]

Szilard felt that compartmentalization had, "in fact, crippled this work from its very beginning," declaring that:

> we have compartmentalization of information, like in secret societies, but unlike as in secret societies, we do not have a group in the center who knows everything, but rather a group who knows very little. Consequently, we have no sound mechanism for reaching decisions and decisions are taken which most of us know to be wrong and which frequently lead to a loss of from four to eight months.[113]

Even "Professor [Harold C.] Urey [1893–1980] is pushed around by General Groves' office," which ironically and nonsensically cut him off from reports relating to his own discovery of heavy water, and which Szilard saw as "part of the general [military] attitude towards the creative scientists." He voiced his concern repeatedly and emphatically to Vannevar Bush (1890–1974), Director of the Office of Scientific Research and Development,[114] arguing that compartmentalization generated mistrust and impeded progress in producing the bomb. Like other leading scientists who worked on the Manhattan Project, Szilard erred in thinking that he, and scientists in general, could control the military and political uses of their work.

Another of Szilard's concerns was that intelligence should be gathered on nuclear research being carried out in Germany. Having lived in Germany for over a decade, he believed that he knew German psychology sufficiently well to predict that after the German defeat at Stalingrad in the winter of 1942–1943, they might try to win the war by other means. In a characteristic blend of science and politics and confidence in his ability to influence events, he sent a letter, with the permission of the U.S. Government, on August 18, 1944, to Lord Cherwell (Frederick A. Lindemann), Prime Minister Winston S. Churchill's Scientific Advisor, whom he knew from his Oxford days, suggesting that German industrial installations that could be used to produce a nuclear bomb should be identified and destroyed.[115] Fully aware of Cherwell's long-standing, close association with Churchill, Szilard drew Cherwell's attention to private communications he had received from Switzerland in 1942 indicating that the Germans knew how to produce a chain reaction, concluding that "they must have gone *full scale* into this work soon after Stalingrad at the latest." He argued that British Military Intelligence should augment the routine methods of its agents for gathering information by equipping them with questions devised by physicists "with great care and circumspection." For this purpose, a small group of physicists should be organized under Churchill or Cherwell who would liaise with British Military Intelligence. Through Cherwell Szilard also alerted the British War Cabinet to the potential detonation of "a small atomic bomb" on a German city should nuclear materials be found to be manufactured there. With chilling precision, he went into detail in estimating the radii of destruction of atomic bombs, depending on their sizes and efficiencies, and urging that some first-class

British theoretical physicist should be consulted on these questions. "My writing to you may be a breach of etiquette from the official point of view," Szilard concluded, "but as I see it, something more important than etiquette is at present involved." Though well-informed as usual, Szilard could not know that he had overestimated the progress of German nuclear research at this time.[116]

Science *versus* Politics: The Moral Dilemmas of Peace

By the spring of 1945 Szilard had convinced himself that the bomb should not be used. He knew that the defeat of Germany was imminent, which obviated the original motivation for creating the Manhattan Project, and that the use of the bomb on Japan would harm the peace process. Ever eager for a cause, he thus decided to alert President Roosevelt to the dangers of a nuclear-arms race in a memorandum and again asked Einstein for a letter of support for it, which Einstein promptly provided, writing to Roosevelt on March 25, 1945, that Szilard (figure 5) was "greatly concerned about the lack of adequate contact between scientists who are doing this work and those members of your Cabinet who are responsible for formulating policy."[117] In his memorandum Szilard called for the establishment of an international system of controls to avoid an arms race. He apparently gained an appointment with Roosevelt for April 12, the very day on which Roosevelt died. Szilard then modified his memorandum and sent it along with Einstein's letter to President Harry S. Truman on May 25, 1945, who in turn passed it on to his future Secretary of State James F. Byrnes. Together with Urey, Szilard visited Byrnes at his home in South Carolina on May 28, 1945.

Szilard and Urey tried to persuade Byrnes that an arms race between the United States and the Soviet Union could only be averted if postwar control of atomic energy was not maintained as a U.S. monopoly but rather vested in an international organization. In his memorandum, Szilard warned prophetically that the "competition between the United States and Russia … would lead to a rapid accumulation of vast quantities of atomic bombs in both countries," and he noted "the possibility of the outbreak of *a preventive war* … [that] might be the outcome of the fear that the other country might strike first and no amount of good will on the part of both nations might be sufficient to prevent.…"[118] Szilard thus suggested the establishment of "a tight control on the atomic power development by a reciprocal agreement with Great Britain and Russia and extended to all territories of the world.…"

Byrnes rejected Szilard's arguments completely. He believed that the Soviet Union had no uranium deposits and hence would require many years to make a bomb, enough time for the United States to create its own world order. To Byrnes and the Truman Administration, American military power, rather than American diplomacy, would keep the Soviets in check.[119] Szilard's failure to convince Byrnes of his arguments was to him both a tremendous disappointment and a cause for alarm. He sensed, for the first time, that control of the bomb was slipping away from the scientists who had created it. Geochemist Harrison S. Brown (1917–1986) commented gravely: "If he [Szilard] had been taken as seriously by Mr. Byrnes as he had been taken seriously by Mr. Roosevelt more than five years previously, the whole course of history might have been altered."[120]

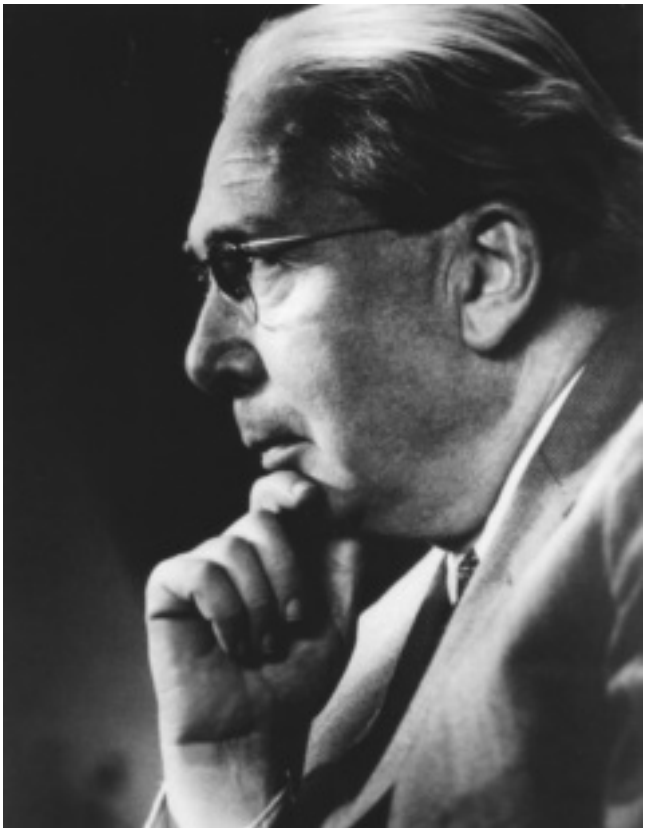

Fig. 5. Leo Szilard (1898–1964). *Credit*: Mandeville Special Collections Library of the Geisel Library, University of California, San Diego.

In June 1945 Szilard became one of only seven signers of the Franck Report,[121] and in July he circulated a draft of a petition to President Truman that urged:

> that before this weapon be used, without restriction in the present conflict, its powers should be adequately described and demonstrated, and the Japanese nation should be given the opportunity to consider the further refusal to surrender. We feel that this course of action will heighten the effectiveness of the weapon in this war and will be a tremendous effect in the prevention of future wars.[122]

Szilard garnered the signatures of 67 scientists residing in Chicago in support of his petition and on July 19 transmitted it to Arthur H. Compton, asking him to forward it to Truman through the War Department, which Compton did on July 24.[123] In his covering letter to Compton, Szilard had commented that:

> Some of those who signed the petition undoubtedly fear that the use of atomic bombs at this time would precipitate an armament race with Russia.… Others are

> more inclined to think that if we withhold such a demonstration we will cause distrust on the part of other nations and are, therefore, in favor of an early demonstration.[124]

Compton, in turn, in his letter of transmittal said that Szilard had modified his position and now approved of the "use of the weapons after giving suitable warning and opportunity for surrender under known conditions." Compton also noted that he had asked chemist Farrington Daniels (1889–1972), Director of the Met Lab, to conduct an opinion poll on Szilard's petition, which Daniels had done on July 12 and had received replies from 150 members of the Met Lab who were asked to choose among the following five options:

(1) Use the weapons in the manner that is from the military point of view most effective in bringing about prompt Japanese surrender at minimum human cost to our armed forces.
(2) Give a military demonstration in Japan, to be followed by a renewed opportunity for surrender before full use of the weapons is employed.
(3) Give an experimental demonstration in this country, with representatives of Japan present; followed by a new opportunity for surrender before full use of the weapons is employed.
(4) Withhold military use of the weapons, but make public experimental demonstration of their effectiveness.
(5) Maintain as secret as possible all developments of our new weapons, and refrain from using them in this war.[125]

The result was that 46% of the respondents chose the second option. By then, however, the Scientific Panel of the Secretary of War's Interim Advisory Committee already had expressed its opinion "that military use of such weapons should be made in the Japanese War."[126]

Szilard's action became so well known in the United States that he appeared under the pseudonym "Szigny" in Nobel Laureate Pearl S. Buck's novel of 1959, *Command the Morning*, as the scientist who organized the protest against dropping the bomb and embodied the moral dilemma of the scientist who had irretrievably released the genie from its bottle.[127] "Szigny" – pursuing a lost cause – thought that Japan was "already on her knees" and that "we need not to use the bomb."

Farrington Daniels reported at the end of January 1946 that Szilard stated that his "mind is so occupied with the social and political implications of the bomb and with the affairs in Washington that he has found it difficult to give his proper attention to the scientific work of the Metallurgical Laboratory."[128] By then Szilard was confronted fully with the burden of conflict between his success as a scientist and his failure as a world citizen. As a scientist, he had worked for years on a project that had caused devastation on an unprecedented scale; as a citizen, he had done everything in his power to prevent this tragedy. He now had to live with the greatest problem in his life: to seek redemption and battle the weapon he had helped to create. He spent the rest of his life doing so.

Immediately after the war Szilard thus became a leader in the scientists' movement to wrest control of nuclear energy from the military and place it into the hands of a

civilian authority.[129] This, and his earlier opposition to the use of the bomb, incurred the wrath of General Groves, who reportedly said:

> You know he wouldn't be allowed to serve in the project if the pending legislation [the May-Johnson Bill] goes through. In the last war he served in the German Army – or rather in the Austrian Army. Anyway after the war he studied – didn't teach, or so to speak ever earn his way. Just a kind of … "research assistant." Went to Germany. Did some more studying there – always with people, kind of an assistant you know. He left Germany in 1933. I don't think because he was Jewish, they hadn't really done anything against the Jews yet. In this country he was at Columbia, here and there, never teaching, never did anything really you might say but learn. Everywhere he went from what I hear he was hard to work with. The kind of man that any employer would have fired as a troublemaker – in the days before the Wagner Act [the National Labor Relations Act of 1935].[130]

Groves even criticized Szilard's role in convincing Einstein to sign his famous letter to Roosevelt in 1939: "Only a man with his brass would have pushed through to the President. Take Wigner or Fermi – they're not Jewish – they are quiet, shy, modest, just interested in learning."[131] Then, concerned that he might appear anti-Semitic, Groves added: "I don't like certain Jews and I don't like certain well-known characteristics but I'm not prejudiced."*

Still, Groves evidently hated Szilard, who to him was an uncontrollable civilian who exhibited a repulsive intellectual superiority, even though he acknowledged his resourcefulness in a backhanded way by admitting,

> of course, most of his ideas are bad, but he has so many.… You know no firm wants him for a consultant. Why he's the kind of guy that advises a company one way and they're half way through that, says, "No, let's try this way." Of course, he isn't paying the bills![132]

Leonard Lyons reported in *The New York Post* on May 7, 1946, that:

> Maj. Gen. Groves, head of the Atomic Bomb project, in his private discussions of the Army-sponsored bill and of the opposition to it by the scientists, makes no secret of his dislike for Dr. Szilard, who first alerted Roosevelt to the potential impact of the bomb. If the Army bill passes, Szilard – because he was born in Hungary, and served in the German Army in the first World War – wouldn't be allowed to work on the project.…"[133]

Groves's dislike of Szilard was largely responsible for Szilard's inability to continue as an atomic scientist after 1945. Thus, Farrington Daniels reported to Szilard that the U.S. Army Corps of Engineers had asked Daniels "not to offer you a position in the new Laboratory." Daniels, however, clearly did not share Groves's low opinion of Szilard, since he went on to praise him for his "very valuable contributions to its suc-

* The prejudiced nature of Groves's attitude towards Szilard by presenting Wigner as a non-Jew is pointed out in Palló, "A kívülálló: Leó Szilárd" (ref. 3), p. 338.

cess." Daniels continued, in words that almost seem like a citation for a national award:

> Your foresight and initiative were largely responsible for obtaining support for the original atomic energy program, and your work on piles and your vision for new types of piles have been important in the development of the research program of the Laboratory. You have made important contributions to the patent structure of the Manhattan District, and you have been vigorous in pointing out the political and social implications of the atomic bomb.[135]

Daniels's subsequent correspondence with Szilard makes clear that he dismissed Szilard from the Met Lab in mid–1946 with uneasiness and a bad conscience.

Szilard had jeopardized his position at the Met Lab by attempting to secure the declassification of his petition with its 67 signatories a few weeks after Hiroshima.[136] Groves had opposed Szilard's attempt, asserting that declassification without the approval of the Manhattan District would violate the contract that Szilard had signed on his employment. Szilard thus publicized his opposition to the bomb by other means after his dismissal from the Met Lab. In 1947 he called for a crusade in the *Bulletin of the Atomic Scientists* to support "a bold and constructive solution" to the threat of nuclear weapons.[137] That fall he realized that such a solution would require the cooperation of the Soviet Union, so he drafted a "Letter to Stalin" in which he expressed deep concern about "the steady deterioration of Russian-American relations," and on October 25, 1947, in accordance with the Logan Act of 1799,* requested the permission of the U.S. Government through the Attorney General to send it. He soon lost hope of receiving a favorable reply, however, so instead of sending his letter to Stalin, he submitted it to the *Bulletin* on November 10 for publication.[138]

Characteristically, Szilard began his letter by identifying the problem to be solved – the lack of an international agreement on nuclear weapons and the concomitant threat of a new and devastating war. Harking back to his own experiences during the Great War, he compared the potential confrontation of the two emerging superpowers to the confrontation of two enemy patrols, and he suggested that to avoid it Stalin should speak directly to the American people every month, just as the American president should address the Soviet people directly every month. He invited Stalin to discuss "the framework of a post-war reconstruction of the world," and to convince the American people that "private enterprise and the Russian economic system and also mixed forms of economic organization can flourish side by side; that Russia and the United States can be part of the same world; that 'one world' need not necessarily be a uniform world." He was convinced that unless the American people and the Soviet people understood this clearly the world was headed toward war. He tried to convince Stalin

* The Logan Act forbid American citizens to communicate with foreign governments without the permission of the U.S. Government "with an intent to influence the measures or conduct of any foreign government or of any officer or agent thereof, in relation to any disputes or controversies with the United States…." See Criminal Code, Section 5, amended, R.S. §5335 from Act January 30, 1799, c. 1, 1 Stat. 613.

that by overcoming the difficulties of communications a people's diplomacy might be initiated, and he offered to form a group of American citizens who could freely discuss "the issues which face the world today."[139]

Szilard's naïve initiative was inevitably doomed to failure, but that did not discourage him. He continued to believe that conditions could be created under which the Soviet Union could be provided with strong incentives to cooperate with the United States to alleviate the nuclear threat in Western Europe. Thus, in April 1948 he proposed that an international body should be established to monitor Soviet-American relations, and he suggested that the American government could make "many concessions to Russia along the lines of general disarmament, which would alleviate Russia's fears of being attacked.…"[140] In that election year of 1948, he went on to criticize the Truman Administration, which

> instead of showing concern for the welfare of Russia, approached Russia as a potential enemy. If the new Administration were to approach Russia in a different spirit, if it were to approach her as a potential friend … showing willingness to create a situation in which Russia would have an important stake in the economic reconstruction of Europe, indicating the determination to build up an organized world community of which Russia would be an important part, then the new approach might have some chance meeting with a favorable Russian response, and of leading to a stable peace.[141]

Throughout the rest of his life Szilard continued to advocate that the best way to prevent another world war was through direct communication with the Russians. On September 23, 1949, Truman announced that the Russians had detonated an atomic bomb (figure 6), and Szilard warned that "we should stop underestimating the Russians."

Toward an Atomic Stalemate

Throughout the 1950s and early 1960s Szilard became involved in an impressive number of political organizations at the national and international levels. His efforts to achieve civilian control of atomic energy grew into a more general commitment to abolish war by creating a lasting peace. He played an active role in a wide variety of movements, such as the Scientists for Survival, the Emergency Committee of Atomic Scientists, the Council of Inquiry into the Conditions of Peace, the Movement for Abolishing War, the Campaign for World Government, and the Alliance for Progress.

These numerous activities revealed Szilard at his best. To him the problem of world security was the major problem he felt compelled to tackle in the postwar era and, as always, he appealed to his friend Einstein for letters of support, which Einstein provided to the end of his life.[143] Szilard continued to try to bridge the gap between the United States and the Soviet Union as a self-appointed ambassador-at-large, tirelessly attending meetings to discuss the international political implications of the bomb. He attended, for instance, almost all of the Pugwash Conferences (figure 7),[144] which were sponsored by the Cleveland industrialist Cyrus Eaton (1883–1979) and took their inspiration from a speech that Lord Bertrand Russell (1872–1970) delivered in the House of Lords on November 28, 1945, less than two months after Hiroshima and Nagasaki.

Fig. 6. Leo Szilard (1898–1964) reading about President Harry S. Truman's announcement on September 23, 1949, that the Russians had detonated an atomic bomb. *Credit*: Argonne National Laboratory; courtesy of the American Institute of Physics Emilio Segrè Visual Archives.

During the second Pugwash Conference at Lac Beauport, Quebec, Canada, from March 31 to April 11, 1958,[145] the American participants raised the problem of international security posed by the bomb and drafted a memorandum that was sent to Alexander Vasilevich Topchiev (1907–1962), Vice President (as of 1958) of the Soviet Academy of Sciences, urging that Soviet scientists should discuss it with American scientists

> who are familiar with the technology of modern weapons and who, by virtue of their relationship to the United States government, are in a position to communicate their own thinking to the government, but who are not, themselves, officials of the United States government.[147]

This obviously described Szilard's position precisely and the role he hoped to play in it.

Fig. 7. Leo Szilard (1898–1964) at a Pugwash Conference in the early 1960s. *Left to right*: Bernard T. Feld, Morton Grodzins, Szilard, Harrison Brown, John D. Cockcroft. *Credit*: *Bulletin of the Atomic Scientists*; courtesy of the American Institute of Physics Emilio Segrè Visual Archives.

By that time Szilard had come to believe that the major problem that the two superpowers faced was not nuclear disarmament but rather the maintenance of a stalemate between their strategic bombing forces; it seemed impossible to him that a disarmament agreement could be reached in the foreseeable future that would eliminate atomic bombs, bombers, and long-range rockets. "Once we have an Atomic Stalemate," he wrote to Congressman Chester Bowles (Democrat-Connecticut) in 1955,

> a full scale atomic war, no matter who gets in the first blow, would end with the devastation of both Russia and the United States to the point where the continued existence of either of them as a nation would be in serious jeopardy.… As the Atomic Stalemate draws nearer it becomes much more important to avoid a full scale atomic war. The real issue is, of course, how to get a political settlement that will eliminate the danger of war, make disarmament possible and permit us to eliminate the strategic airforces and their bombs.…[147]

To alert both the U.S. Government and the general public that America was "headed for an all-out war," Szilard launched a new crusade by founding the Council to Abolish War (later the Council for a Livable World), reinforcing his message through numerous talks, articles, and personal contacts. He was one of the first to urge publicly, in the mid-1950s, the ending of the Cold War, and some of his letters, such as the

one he published in *The New York Times* in 1955,[148] were highly appreciated in liberal circles.

Szilard, probably through Bowles, also gained the ear of Senator John F. Kennedy in early 1960, who acknowledged "the great responsibility and imagination you have brought to the problem of securing peace."[149] That fall Szilard briefed Kennedy on "the mood and substance" of private conversations he had had with the Soviet Premier Nikita S. Khrushchev on October 5, 1960, in New York City.[150] Szilard had begun writing to Khrushchev already a year earlier on the controversial issues involved in an atomic stalemate – that Szilard initiated this correspondence is all the more surprising because of the shock he must have experienced when the Soviet army brutally suppressed the Hungarian Revolution of 1956. Yet, distressed as he was by the subsequent execution of Prime Minister Imre Nagy and his associates in 1958, Szilard nonetheless was ready to fly to Moscow soon thereafter, and he also corresponded amicably with the Chinese Embassy in London in regard to a pending visit to China. Khrushchev encouraged Szilard's idea of holding informal meetings between scientists from both countries.[151]

Szilard kept the incoming Kennedy Administration informed about his scientific diplomacy,[152] making clear that nuclear disarmament could be accomplished faster if, he told Bowles, "we are able to communicate with the Russians," which "seems to me that we are not doing … at present."[153] He continued to act in his self-appointed role as confidential negotiator between Kennedy and Khrushchev, even going into such technical details as those associated with the presence of American troops in West Berlin. In general, Szilard refused to remain silent about his concerns on any subject, expressing his strong views on the Cuban Missile Crisis in a letter to Kennedy in June 1961, blaming the Kennedy Administration for what he perceived to be the neglect of U.S. obligations under the U.N. Charter.[154] In his last letter to Kennedy, just before Kennedy's assassination, Szilard half-ironically revealed that he considered himself to be a one-man Shadow State Department.[155] He saw himself as acting as an uninvited adviser on disarmament and proposed to organize a group of Americans and Russians to conduct a nongovernmental study of disarmament measures that their respective governments could undertake.[156]

From Physicist to Biologist

Though forced to leave nuclear research in 1946, Szilard nevertheless discussed his turn to biology as arising from his early interest in that field after he left Germany for England in 1933. The transition that his fellow Hungarian Michael Polanyi made shows remarkable similarities in terms of field, time, place of residence, and language. Emigration is a complex process. As I pointed out earlier, Polanyi made a

> "Copernican turn," changing not only his country of residence but also his language and ultimately his field of research. In this sense, Polanyi chose a very special, complex form of emigration: first he left medicine, then Hungary and the Hungarian language, then he left Germany for Britain, as well as science for philosophy, and chose English rather than German as an exclusive language of publication.[157]

Scientists react sensitively to their social, political, and scientific environments, together forming an intricate, interrelated complex. Erwin Schrödinger (1887–1961), in a pioneering lecture in Berlin on February 18, 1932, was probably the first scientist to discuss how science depends upon the cultural milieu (*Kulturmilieu*).[158] He was remarkably prescient in broaching this issue on the eve of the Nazi takeover, which forced so many scientists in Germany into exile, drastically changing their cultural landscapes and the German scientific landscape as well. Evidently applying the literary theory of Hippolyte Adolphe Taine (1828–1893) to the sciences, Schrödinger asked

> whether statements in the natural sciences are invariants in relation to the cultural milieu or whether they depend upon it as a "system of reference" and though not actually becoming inaccurate in detail, they essentially alter their actual meaning and interest in case of a strong change of the cultural milieu.[159]

Historian Arne Schirrmacher's term "emigration physics" (*Emigrationsphysik*) came to include several areas of physics that immigrants in Britain and the United States particularly influenced, such as nonlinear field theory.[160]

Still, one is tempted to believe that Szilard's turn to biology resulted from his forced departure from nuclear science in 1946 and his belief that he could begin an entirely new career in the young science of biology. "I was probably the first physicist with notable achievements in physics who made this jump," Szilard remembered in 1962.[161] But he was not alone: Among others who made a similar turn to the life sciences were James Franck (1882–1964), who addressed problems in photosynthesis, and Max Delbrück (1906–1981), who became one of the founders of molecular biology.[162] Szilard was 48 years old at this time, a somewhat advanced age for a scientist, but liked to think of himself as "young in biology," feeling that "we are brighter when we are younger; and also we aren't prejudiced when we first come into contact with a problem." He was optimistic about his ability to solve problems in biology that had eluded others: "Once a man has missed the solution to a problem when he passes by, it is less likely he will find it the next time." As a physicist, he had acquired the

> conviction, which few biologists had at the time, that mysteries can be solved. If secrets exist, they must be explainable. You see, this is something which modern biologists brought into biology, something which the classical biologists did not have. They often were astonished, but they never felt it was their duty to explain. They lacked the faith that things are explainable – and it is this faith, you know, which leads to major advances in biology.[163]

Szilard's faith that the mysteries of the world are comprehensible was a legacy of the Enlightenment and was shared by many scientists, including his generation of great Hungarian scientists.

Szilard chose the young physical chemist Aaron Novick at Argonne National Laboratory as his young colleague and began to work in the Institute of Radiobiology and Biophysics at the University of Chicago and, after this institute was discontinued, as a professor of biophysics in the Enrico Fermi Institute for Nuclear Studies at Chicago. He knew that biophysics was a young discipline and was generally pessimistic about pursuing its study in research institutes. To him such precedents as the Kaiser Wilhelm

Institutes in Berlin and the Rockefeller Institute for Medical Research in New York City were

> only moderately encouraging. These institutes have no connections with any university, their members do no teaching, nor do they give their attention to the practical application of science. I believe that by and large, it is not good for a scientist to be in a position where he has to justify his existence by putting out a never-ending stream of insights or discoveries. Few men are happy if placed in a position where it becomes moral necessity for them – as Mr. Einstein put it – "to lay golden eggs."[164]

For the past half century physics had been "the king of the natural sciences," but Szilard felt that "this happy state of affairs" was now over and that able students were hesitant to become physicists. He compared the state of biology to that of physics in a memorandum of 1952 on the future of biological research institutes, warning that

> biology has not reached the stage which physics has reached, where enough knowledge has accumulated to permit the scientist to sit in the bath tub, review in his mind well established facts, and emerge with a significant insight or a new theory. In biology, this type of activity is stopped short by the realization that experiments of one kind or another must be done before further thinking becomes profitable.
>
> In physics, enough is known to make it possible to appraise the significance of any new fact unearthed by experiments. In physics, few experiments result in discovery, but it is easy to assign to the result of the experiment its proper place in an already well established structure. In biology, on the other hand, it is easy to make a discovery, but difficult to appraise its significance.[165]

As always, Szilard was productive in his new field at different levels. His practical vein surfaced in constructing new scientific instruments, such as the chemostat, which allowed scientists to control the rate of growth of microorganisms by adjusting the rate of dilution of the medium in which they are cultured.[166] This was a novel idea and even surprised specialists in the field. As zoologist Jack Myers of the University of Texas commented in 1951, "I feel pretty silly, in not having thought of your arrangement before as an outgrowth of our own device."[167]

Szilard won special praise for his ability to stimulate biologists in their own researches, and in the 1950s he increasingly became a roving scientist, a visitor even to his own institution. As Rollin D. Hotchkiss of the Rockefeller Institute for Medical Research rightly observed in a letter of support for him for a National Science Foundation grant, "Association with him is at its most stimulating and rewarding level when not continuous, but shared with a number of institutions and colleagues, as projected."[168]

Interlude: West Berlin, 1956–1959

As his reputation as a biologist was growing, Szilard, surprisingly, was approached to become a candidate for a major position as a physicist in postwar West Berlin. In 1956–1957, on the suggestion of his former mentor Max von Laue, Szilard suddenly became a candidate for the directorship of the newly founded Hahn-Meitner Institute and also perhaps to succeed von Laue as director of the Fritz Haber Institute of the

Max Planck Society (*Max-Planck-Gesellschaft*).[169] Szilard's commitment to biology, however, proved to be stronger than his desire to put his name forward for these positions. He immediately suggested to von Laue that a new institute for biophysics and molecular biology should be founded in Berlin and questioned that "the role which I could play in the development of physics in Germany could come anywhere near to what I could do for the development of biophysics."[170] In any case, both the West Berlin Atomic Commission (*Atomkommission*) and the Faculty of Mathematics and Science of the Free University of Berlin declined to support von Laue's nomination of Szilard for the above positions, referring to Szilard's recent lack of achievements in nuclear physics and his probable inability to develop new methods of research in this field. Von Laue, however, regarded his former student as "a high-powered motor" and did not give up; he secured the support of West Berlin Education Senator Professor Joachim Tiburtius. The West Berlin Atomic Commission ultimately endorsed the offer on April 2, 1957. Szilard (figure 8) therefore was invited to Berlin that fall to discuss plans for creating a section for nuclear physics in a new institute and to deliver a lecture at the annual meeting of the Society of German Chemists (*Gesellschaft Deutscher Chemiker*) on October 7, 1957.[171]

In Berlin Szilard met with leading German physicists and then summarized his vision for the new institute in a letter to Tiburtius from Heidelberg on January 13, 1958,[172] sending copies to Max von Laue, Dean Alexander Dinghas of the Free University, nuclear physicists Werner Heisenberg, Hans Kopfermann, and Carl Friedrich von Weizsäcker, nuclear chemist Karl-Erik Zimen, and the Mayor of West Berlin Willy Brandt. Szilard was primarily concerned about the potential parochialism of the new institute and thus set its establishment against the larger background of the flourishing scientific life in West Germany. He argued that a new institute in nuclear physics was not really necessary, since there were enough of them already in West Germany, with more than enough qualified physicists to staff them. Soon, he warned, only the "rest" would stay in Berlin; the more qualified ones would be attracted by good jobs elsewhere in West Germany. Thus, to retain leading physicists in a new institute for nuclear physics in West Berlin they should be offered salaries equal to those of full professors in West Germany. Szilard also suggested that a scientific board composed of such leading German physicists as Willibald Jentschke, Otto Haxel, Hans Kopfermann, Wilhelm Walcher, and Carl Friedrich von Weizsäcker should be created to oversee the ever-changing circumstances in West Berlin. The new institute then could and should play an important role in the scientific life of West Berlin and would be linked not only to the Free University of Berlin but also to the larger network of universities in West Germany. A young physicist then could view his job in Berlin as a stepping stone in an academic career in West Germany. For this to happen, however, it was essential that the new institute should be conceived from the outset with the goal in mind of enhancing scientific productivity. On the whole, if careful consideration of the personnel that would be necessary to staff a new institute for nuclear physics in West Berlin were not taken into account, then Szilard was skeptical about its prospects for success.

Senator Tiburtius joined forces with Szilard and forwarded Szilard's memorandum approvingly to Mayor Willy Brandt.[173] A protracted period of intercontinental planning and brainstorming ensued, with Szilard continually demanding new conditions,

Fig. 8. Leo Szilard (1898–1964). *Credit*: Mandeville Special Collections Library of the Geisel Library, University of California, San Diego.

new positions, new personnel.[174] By May 1958 it seemed that Szilard would receive a call to a chair of nuclear physics at the Free University of Berlin, which he would occupy after the new institute was constructed.[175] Then, in November he received an emphatic renewal of his call from Gerhard Schenck, Rector of the Free University, who urged Szilard in no uncertain (and somewhat unorthodox) terms to come to Berlin, and to come very soon indeed.[176] Nevertheless, shortly before Christmas Szilard expressed his willingness to Hans Kopfermann to "write a letter to enable the University to appoint Boehm to the Professorship which is now reserved for me."[177]

The anguish over Szilard's invitation to Berlin ended only a year later, in late 1959. Kopfermann, who was one of the first to learn of Szilard's final withdrawal, commented sarcastically in a letter of December 10, 1959:

> I find it very fair of Mr. Szillard [*sic*] that he hands back his call [*Ruf*] and I hope that Mr. v. Laue will be clever enough not to advise him yet to come. One could not expect of Szillard [*sic*] in Berlin much else apart from witty talk, certainly no nuclear physics. He is currently interested only in politics in the realm of physics.[178]

By then, however, Szilard had serious reasons to decline the Berlin invitation: He had received a major grant from the National Institutes of Health in November, and he realized that he was gravely ill with what turned out to be bladder cancer.[179] He tendered his formal resignation from the Berlin position – which he had never held – on December 26, 1959.[180]

A Theory of Aging

Szilard's major contribution as a biophysicist was his theory of aging, which he published in early 1959,[181] and which postulated that "different individuals age at different rates, and the rate of aging of an individual is determined by the number of 'faults' inherited."[182] These "faults" are mutants of what he dubbed "vegetative" genes that are inherited through the chromosomes containing them and whose number increase with age and cause some people to be relatively old even before they are born. He derived mathematical formulae for aging based upon his hypothesis of "aging hits" on the human cell, from which he interpreted the shape of the mortality curve of the U.S. population and predicted the decrease in life expectancy of children who are exposed to ionizing radiation. He concluded that the inherited faults increase the death rate "in conjunction with the hits of time, and they increase it appreciably only above 40 [years of age]"; "thus, in its crudest form, the theory postulates that the age at death is uniquely determined by the genetic makeup of the individual."[183] Further, he concluded that his theory of aging would illuminate scientific issues involved in the practice of birth control and in determining the period of optimal fertility of the female population.

Szilard's theory was received warmly in England. John Lear suggested in *The New Scientist* that it was "inevitable that this latest of the Hungarian-born theorist's long line of brilliances will in time be recognized as a major contribution to human thought."[184] Further studies that he undertook on the process of enzyme induction in bacteria and on antibody formation moved him into the realm of modern molecular biology, which he hoped to study at the Salk Institute for Biological Sciences in La Jolla, California. Still, not all of his ideas were well received by biologists, who severely criticized, for example, his paper on memory and recall,[185] one of his last contributions before his death.[186] Szilard himself had a cheerful capacity for self-criticism, commenting on one of his last papers:

> While writing the paper, I remember having once read the minutes of a meeting of the German Physical Society, which recorded that in the discussion of the paper … "Dr. Muller presented two explanations, but expressed doubt as to the existence of the phenomenon."[187]

That was vintage Szilard (figure 9): He knew who he was and acknowledged defeat as well as victory.

A Man of Missions

Indeed, when Szilard reviewed his postwar achievements there was very little that he could point to with pride. For almost two decades he had posed problems instead of

Fig. 9. Leo Szilard (1898–1964). *Credit*: Mandeville Special Collections Library of the Geisel Library, University of California, San Diego.

solving them; he had identified dozens of major scientific and human problems, but did not contribute seriously to solving them. His attention had turned more and more away from experimental research and more and more toward politics and issues confronting the survival of humanity. Most of what he produced scientifically after 1945 proved to be merely an idea, a thesis, a theory, a model leading to a research proposal, a sparkling summary of what should be done, but hardly ever a meticulous struggle with theoretical details and experimental tests. But he did not view experiments as his job; he thought their adequacy should be justified on the basis of some overarching theory that he constantly sought.[188] Scientists found his papers to be stimulating, but were bothered by many of his basic assumptions.[189] He was a reductionist who tried to create general guiding principles first and then use them as frameworks to understand observable phenomena. He was essentially a nineteenth-century thinker who in an age of increasing specialization continued to think in terms of grand and fundamental princi-

Fig. 10. Leo Szilard (1898–1964). *Credit*: Mandeville Special Collections Library of the Geisel Library, University of California, San Diego.

ples in the best tradition of the Enlightenment. He continued to view science and indeed the world as a whole, attempting with missionary zeal to change what he saw as wrong.

In retrospect it seems that the central problem that Szilard (figure 10) took upon himself to solve was to save mankind, a single mission that merely assumed different forms. His devotion to the rescue operation of refugee scientists in 1933, his courage to help initiate the nuclear program in the United States by turning to Roosevelt in 1939, his determination to implore Truman to stop the use of the bomb in 1945, his efforts to control and contain the damage of the Cold War by turning to Stalin in 1947 and to Khrushchev in 1960 – all were manifestations of his overarching commitment to do what he could to save humanity. His intimate mixture of science and politics can be seen as underlying his major exercise in problem solving, not unlike the efforts that his fellow Hungarians Michael Polanyi and Edward Teller, however different, made to

preserve the balance of world power as they saw it. All had experienced the tribulations that Hungary had undergone immediately after the First World War, and all now felt that it fell to them to cope with the issues of war and peace after the Second World War.

It would not be an overstatement to suggest that Leo Szilard felt that his calling was to change history. He was a man of many missions. Still, his biography could easily be read as the life story of a zealot who met with successes and failures while pursuing a single mission, to save the world. He was admirably suited to play this role: Among scientists, he was a politician; among politicians, a scientist. As a result of the many years he had spent in different countries, he became supranational, acquired formidable language skills (coming close to shunning his mother tongue), and embraced a universal and holistic vision of humanity. Although he spoke all languages with a heavy Hungarian accent, he was a cosmopolitan with little if any national consciousness. He was not only able to identify major issues, he had a gift for dramatizing and marshalling broad support for them. His diverse personal experiences and international perspective made him sensitive, sometimes overly sensitive, to the great questions of his time, which he addressed with enormous energy. His strong personality, forced emigration, cultural assimilation, and scientific twists and turns heightened his sensibility to the great moral dilemmas of his century. In an age of unprecedented disasters and threats, Leo Szilard played the essential role of a man of conscience.

Acknowledgments

I thank Dieter Hoffmann for his critical comments, expert advice, and friendly support during the completion of my paper. I am gratetul to the Alexander von Humboldt Foundation and the Max Planck Institute for History of Science in Berlin for my stay in Germany. I also thank Roger H. Stuewer for his extremely helpful and meticulous editorial work on my paper.

References

1 Stefan L. Wolff, "Das ungarische Phänomen – ein Fallbeispiel zur Emigrationsforschung," *Deutsches Museum Wissenschaftliches Jahrbuch 1991* (München: Deutsches Museum, 1992), pp. 228–245.
2 Eugene Rabinowitch, "James Franck 1882–1964," Leo Szilard 1898–1964, *Bulletin of the Atomic Scientists* **20** (October 1964), 16–20; quote on 20; Eugene P. Wigner, "Leo Szilard 1898–1964," *Biographical Memoirs of the National Academy of Sciences* **40** (1969), 337–347; quote on 337.
3 William Lanouette with Bela Szilard, *Genius in the Shadows: A Biography of Leo Szilard* (New York: Charles Scribner's Sons, 1992), pp. 3–29; reviewed by Dick Teresi, Book Review Section, *The New York Times* (January 24, 1993). Gábor Palló, "William Lanouette on his Leo Szilárd Biography. Conversation with William Lanouette," *The New Hungarian Quarterly* **29**, No. 111 (Autumn 1988), pp. 160–170; Gábor Palló, "A kívülálló: Szilárd Leó," *Fizikai Szemle*, No. **8** (1993), 335–341; Wigner, Szilard (ref. 2).
4 Lanouette, *Genius* (ref. 3), pp. 23–24.
5 "Leo Szilard," *Current Biography* (1947), 622; based upon *New York Post* (November 24, 1945), 7.
6 Leó Szilárd, "Reáliskolai Érettségi Bizonyítvány [High School Final Certificate]," Budapest, June 27, 1916; Leo Szilard Papers, Mandeville Special Collections Library, University of California, San Diego, Geisel Library, La Jolla, California, Box 1, Folder 9, MSS 32. Ignácz Rados, one of the

school's most notable teachers, taught there from 1894–1920; see *Magyar Életrajzi Lexikon*, Vol. II (Budapest: Akadémiai Kiadó, 1969), p. 466.

7 Leopold (Lipót) Fejér, "Erklärung," Budapest, December 14, 1919; "Beglaubigte Abschrift," Berlin-Charlottenburg, January 3, 1920, Szilard Papers (ref. 6), Box 1, Folder 12.

8 Ferenc Szabadváry, "Leo Szilard's Studies at the Palatine Joseph Technical University of Budapest," *Periodica Politechnica* (1987), 187–190.

9 Tibor Frank, "Der Kult des Allwissens im Budapest des Fin-de-Siècle," in Frank Baron, David N. Smith, and Charles Reitz, ed., *Authority, Culture, and Communication: The Sociology of Ernest Manheim* (München: Synchron Verlag, 2005), pp. 89–116; Tibor Frank, "George Pólya and the Heuristic Tradition," *Polanyiana* **6**, No. 2 (1997), 22–37; reprinted in *Revista Brasileira de História da Matemática* **4**, No. 7 (Abril–Setembro 2004), 19–36.

10 Márta Tömöry, *Uj vizeken járok. A Galilei Kör története* [*Sailing Unchartered Waters. The History of the Galilei Circle*] (Budapest: Gondolat, 1960); Zsigmond Kende, *A Galilei Kör megalakulása* [*The Founding of the Galileo Circle*] (Budapest: Akadémiai Kiadó, 1974). See also György Litván, "Jászi Oszkár, a magyar progresszió és a nemzet [Oscar Jaszi, Hungarian Progressivism, and the Nation], in Endre Kiss and Kristóf János Nyíri, ed., *A magyar filozófiai gondolkodás a századelőn* [*Hungarian Philosophical Thought in the Early 20th Century*] (Budapest: Kossuth, 1977), p. 107.

11 Lanouette, Genius (ref. 3), pp. 45–50; Palló, "Lanouette" (ref. 3), pp. 164–165; Palló, "A kívülálló: Szilárd Leó" (ref. 3), p. 336; Wigner, "Szilard" (ref. 2), pp. 337–338.

12 István Deák, *Beyond Nationalism: A Social and Political History of the Habsburg Officer Corps, 1848–1918* (New York and Oxford: Oxford University Press, 1990), p. 184.

13 Leo Szilard, "Biographical Table," Szilard Papers (ref. 6), Box 2, Folder 9.

14 Leo Szilard, "A Letter to Stalin," MS, November 10, 1947, Szilard Papers (ref. 6), pp. 2–3; *Bull. Atom. Sci.* **3** (December 1947), 347–350, 353, 376; reprinted in Helen S. Hawkins, G. Allen Greb, and Gertrud Weiss Szilard, ed., *Toward a Livable World: Leo Szilard and the Crusade for Nuclear Arms Control* (Cambridge, Mass. and London: The MIT Press, 1987), pp. 26–34; quote on p. 27.

15 Szilard, "Biographical Table" (ref. 13).

16 "Kivonat a budapesti VI–VII. ker. Fasori református egyház keresztelési anyakönyvéből [Extract from the Baptismal Registry of the Calvinist Church in the Fasor, Budapest, VI–VIIth District]," Vol. II (Budapest: July 24, 1919), p. 14; Szilard Papers (ref. 6), Box 1, Folder 11. See also Lanouette, *Genius* (ref. 3), pp. 30–51.

17 Leo Szilard, "Petition to the Budapest Police, December 11, 1919," Szilard Papers (ref. 6), Box 1, Folder 11; Palló, "Lanouette" (ref. 3), pp. 164–165.

18 Wolff, "Das ungarische Phänomen" (ref. 1), p. 236; Lanouette, *Genius* (ref. 3), pp. 110, 115. The internationally celebrated Jewish-Hungarian playwright Menyhért (Melchior) Lengyel (1880–1974) showed remarkable similarities in his long exile that he spent mostly in hotels carefully guarding his manuscripts in two suitcases, always ready to go; see József Vinkó, "Előszó" [Preface], in: Menyhért Lengyelt, *Életem Kőnyve* [The Book of my Life] (Budapest: Gondolat, 1987), p. 12.

19 Sigm[und] Freud, "Über die Berechtigung, von der Neurasthenie einen bestimmten Symptomencomplex als 'Angstneurose' abzutrennen," *Neurologisches Centralblatt*, Band 14, Heft 2 (Leipzig: Verlag von Veit & Comp., 1895), pp. 50–66; reprinted in Sigmund Freud, *Gesammelte Werke*, Sixth Edition, Vol. I (Frankfurt a. M.: S. Fischer Verlag, 1991), pp. 315–342; translated in *The Standard Edition of the Complete Psychological Works of Sigmund Freud*, Vol. III (London: The Hogarth Press, 1999), pp. 90–115; on the translation of "Angst," see pp. 116–117.

20 Joachim Radkau, *Das Zeitalter der Nervosität: Deutschland zwischen Bismarck und Hitler* (München: Propyläen Taschenbuch, Econ Ullstein List, 2000), pp. 201, 534, 598, where Radkau rightly quotes Budapest hypnotist Ferenc Völgyesi's book, *Botschaft an die nervöse Welt! Nervosität, Hypnose, Selbstbeherrschung* (Zürich: Orell-Füssli, 1936); translated as *A Message to the Neurotic World* (London: Hutchinson, 1935), as a contribution to his own thesis on *Nervosität*. The international popularity of Völgyesi's book (it was published in at least four languages) demonstrated the timeliness and importance of this problem. Vögyesi was one of the most popular psychiatrists in Budapest for forty years; he had altogether around 40,000 private patients; Mrs. Ferenc Völgyesi (who served as his assistant), personal communication, February 3, 1992.

21 Radkau, *Zeitalter* (ref. 20), pp. 357–362; Lanouette, *Genius* (ref. 3), p. 466. Jonas Salk recalled after Szilard's death: "There was something driving Leo"; *ibid*., p. 476.
22 Leo Szilard, "Lebenslauf," *Habilitationsschrift*, University of Berlin, March 15, 1926; Universitätsarchiv, Philosophische Fakultät, Humboldt-Universität zu Berlin, Nr. 1242, Blatt 120, Fiche 3/16.
23 Hubert Laitko, "Zentrum, Magistrale und Fluchtpunkt. Der Wissenschaftsstandort Berlin im 20. Jahrhundert," in Rüdiger vom Bruch und Eckart Henning, ed., *Wissenschaftsfördernde Institutionen im Deutschland des 20. Jahrhunderts* [Dahlemer Archivgespräche 5] (Berlin: Archiv zur Geschichte der Max-Planck-Gesellschaft, 1999), pp. 11–39. See also Tibor Frank, "Station Berlin: Ungarische Wissenschaftler und Künstler in Deutschland 1919–1933," *IMIS Beiträge*, Institut für Migrationsforschung und Interkulturelle Studien, Universität Osnabrück, 10/1999, pp. 7–38.
24 Wolff, "Das ungarische Phänomen" (ref. 1), p. 238.
25 Szilard mentions this in a letter to Richard Gehman, April 8, 1952, Szilard Papers (ref. 6), Box 8, Folder 27; see also Friedrich Herneck, *Max von Laue* (Leipzig: Teubner, 1979), p. 47.
26 Leo Szilard, "Über die Ausdehnung der phänomenologischen Thermodynamik auf die Schwankungserscheinungen," *Zeitschrift für Physik* **32** (1925), 753–788; reprinted in Bernard T. Feld and Gertrud Weiss Szilard, ed. *The Collected Works of Leo Szilard: Scientific Papers* (Cambridge, Mass. and London: The MIT Press, 1972), pp. 34–69.
27 "Lebenslauf" (ref. 22), p. 120; Max von Laue to Leo Szilard, November 27, 1957, Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin-Dahlem, III. Abt., Rep. 50, Nr. 1971, quoted in Wolff, "Das ungarische Phänomen" (ref. 1), p. 234.
28 L. Szilard, "Über die Entropieverminderung in einem thermodynamischen System bei Eingriffen intelligenter Wesen," *Zeit. f. Phys.* **53** (1929), 840–856; reprinted in *Collected Works* (ref. 26), pp. 103–119.
29 Max von Laue in Szilard, *Habilitation* papers (ref. 22), pp. 128–129.
30 Max Planck in Szilard, *Habilitation* papers (ref. 22), p. 129.
31 Szilard, Biographical Data and List of Publications 1922–1946, Szilard Papers (ref. 6), Box 2, Folder 8.
32 Wolff, "Das ungarische Phänomen" (ref. 1), p. 235. The courses offered every semester at the University of Berlin (and other universities) were published in the *Physikalische Zeitschrift*.
33 Reichspatentamt, Patentschrift Nr. 563,403, 561,904, 554,959, 556,535, 562,040, 565,614; Archiv zur Geschichte der Max-Planck-Archiv, Berlin-Dahlem, Va. Abt., Rep. 2, Albert Einstein. Further research is required to determine Einstein's and Szilard's respective contributions to these patents.
34 Reichspatentamt, Patentschrift Nr. 556,536, 564,680 and 548,136, 543,214 and 555,141, 531,581, 581,780, 568,680; Archiv zur Geschichte der Max-Planck-Archiv, Berlin-Dahlem, IX. Abt., Rep. 1, Leo Szilard.
35 Rudolf Plank and Johann Kuprianoff, *Haushalt-Kältemaschinen und kleingewerbliche Kühlanlagen*, second edition (Berlin: Springer, 1934); *Die Kleinkältemaschine*, second edition (Berlin, Göttingen, Heidelberg: Springer, 1960); Rudolf Plank, *Amerikanische Kältetechnik* (Düsseldorf: Deutscher Ingenieur-Verlag, 1950).
36 Gene Dannen, "The Einstein-Szilard Refrigerators," *Scientific American* **276** (January 1997), 90–95; "Die Einstein-Szilard-Kühlschränke," *Spektrum der Wissenschaft* (June 1997), 94–100. This article also appeared in Arabic, Chinese, French, Japanese, Polish, and Spanish.
37 Szilard's many patents (some with Einstein) in Britain and the United States are given in Szilard, *Collected Works* (ref. 26), p. 543ff. For Hungary, see Magyar Királyi Szabadalmi Bíróság, Szabadalmi leírás, 102079. Szám, XVIII/c osztály, published March 2, 1931. For interest in the Einstein-Szilard Refrigerators in the United States, see Szilard to Gano Dunn, September 13, 1939, Szilard Papers (ref. 6), Box 7, Folder 21.
38 Quoted in George Halasz, "Dr. Einstein's Icebox," in Martin Levin, ed., *The Bedside Phoenix Nest* (New York: Yves Washburn, 1965), pp. 317–318.
39 Szilard to Einstein, September 27, 1930; quoted in Michael Grüning, *Ein Haus für Albert Einstein: Erinnerungen, Briefe, Dokumente* (Berlin: Verlag der Nation, 1990), pp. 335–337, and Dannen, "Einstein-Szilard Refrigerators" (ref. 36), p. 78.
40 Laura Fermi, *Illustrious Immigrants: The Intellectual Migration from Europe 1930–41* (Chicago: University of Chicago Press, 1968), pp. 60–92; Herbert A. Strauss and Werner Röder, ed., *Interna-*

tional Biographical Dictionary of Central European Emigrés 1933–1945, 3 Vols. (München: Saur, 1980–1983).

41 Lord Beveridge, *A Defence of Free Learning* (London, New York, Toronto: Oxford University Press, 1959), pp. 128–129; See also Charles Weiner, "A New Site for the Seminar: The Refugees and American Physics in the Thirties," in Donald Fleming and Bernard Bailyn, ed., *The Intellectual Migration: Europe and America, 1930–1960* (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1969), p. 212.

42 Fermi, *Illustrious Immigrants* (ref. 40), p. 62; *The Rockefeller Foundation: A Review for 1920–28, 1936–40, 1942–51* (New York: The Rockefeller Foundation, 1921–1952); Raymond Blaine Fosdick, *The Story of the Rockefeller Foundation* (New York: Harper, 1952); reprinted with a new introduction by Steven C. Wheatley (New Brunswick, N.J.: Transaction Publications, 1989); The Rockefeller Foundation, *Directory of Fellowships and Scholarships, 1917–1971* (New York: Rockefeller Foundation, 1972).

43 Notker Hammerstein, "Die Geschichte der Deutschen Forschungsgemeinschaft im Nationalsozialismus," in Doris Kaufmann, ed., *Geschichte der Kaiser-Wilhelm-Gesellschaft im Nationalsozialismus*, Vol. 2 (Göttingen: Wallstein Verlag, 2000), pp. 600–609; Lothar Mertens, *"Nur politisch Würdige": Die DFG-Forschungsförderung im Dritten Reich 1933–1937* (Berlin: Akademie Verlag, 2004).

44 Beveridge, *Defence* (ref. 41), p. 2; Szilard (London) to Jacques Errera, June 4, 1933 (in German); Szilard Papers (ref. 6), Box 7, Folder 22; Benjamin Liebowitz (London) to Ernst P. Boas (London), May 4, 1933; *ibid*., Box 12, Folder 4. The Council remained in existence until 1966 as the Society for the Protection of Science and Learning; see also Leo Szilard to unknown, May 14, 1933; *ibid*., Box 12, Folder 21, and Robin E. Rider, "Alarm and Opportunity: Emigration of Mathematicians and Physicists to Britain and the United States, 1933–1945," *Historical Studies in the Physical Sciences* **15** (1984), 116.

45 Beveridge, *Defence* (ref. 41), pp. 15, 126–127; Karl Brandt Circular, New York, February 1, 1934 (in German), John von Neumann Papers, "1933: Some very interesting letters to J. v. N.," Box 7, Library of Congress, Washington, D.C. See also Rider, "Alarm" (ref. 44), pp. 116, 139, 144.

46 Fermi, *Illustrious Immigrants* (ref. 40), pp. 62–63.

47 Einstein (Le Coq-sur-Mer) to Szilard, April 25 and May 1, 1933; Szilard (London) to Einstein, May 4 and 9, 1933 (in German), Szilard Papers (ref. 6), Box 7, Folder 27.

48 Szilard (Brussels) to Beveridge, May 14, 1933, Szilard Papers (ref. 6), Box 11, Folder 18; Szilard (London) to Beveridge, May 4, 1933, *ibid*., Box 4, Folder 30.

49 Benjamin Liebowitz (London) to Ernst P. Boas, May 4, 1933, Szilard Papers (ref. 6), Box 12, Folder 4.

50 Paul Ehrenfest (Leiden) to Frederick George Donnan, August 22, 1933, Szilard Papers (ref. 6), Box 7, Folder 22.

51 Karl Mannheim (London) to Max Horkheimer, March 30, 1937, Szilard Papers (ref. 6), Box 12, Folder 14; see also Szilard (Brussels) to unknown, May 14, 1933, *ibid*., Box 12, Folder 21; Szilard to Neville Laski, May 1933, *ibid*., Box 11, Folder 18.

52 Wigner (Budapest) to Michael Polanyi, n.d. [July 1933?], Michael Polanyi Papers, Department of Special Collections, University of Chicago Library, Chicago, Box. 2, Folder 12.

53 Klaus Fischer, *Changing Landscapes of Nuclear Physics: A Scientometric Study on the Social and Cognitive Position of German-Speaking Emigrants Within the Nuclear Physics Community 1921–1947* (Berlin: Springer Verlag, 1993), p. 203; Wolff, "Das ungarische Phänomen," (ref. 1), p. 238.

54 Norman Bentwich, *The Rescue and Achievement of Refugee Scholars: The Story of Displaced Scholars and Scientists 1933–1952* (The Hague: Martinus Nijhoff, 1953), p. 11; Fermi, *Illustrious Immigrants* (ref. 41), pp. 63–64; Edward Shils, "Leo Szilard: A Memoir," *Encounter* **23** (December 1964), 38–39; Weiner, "New Site" (ref. 40), p. 211; Stefan Wolff, "Frederick Lindemanns Rolle bei der Emigration der aus Deutschland vertriebenen Physiker," in Anthony Grenville, ed., *German-speaking Exiles in Great Britain. The Yearbook of the Research Centre for German and Austrian Exile Studies*, Vol. 2 (Amsterdam and Atlanta: Rodopi, 2000), p. 28.

55 Szilard (Brussels) to Friedrich A. Paneth, May 14, 1933; Nachlass F. A. Paneth, Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin-Dahlem, Jewish Refugees Committee, 1933, III. Abt. Rep. 45.
56 Szilard (London) to Max Delbrück, May 7, 1933, Szilard Papers (ref. 6), Box 7, Folder 9.
57 Jacques Errera (Bruxelles) to Szilard, June 5, 1933 (in French), Szilard Papers (ref. 6), Box 7, Folder 2; Szilard (Brussels) to unknown, May 14, 1933, *ibid*., Box 12, Folder 21; [Leo Szilard], "Report," May 23, 1933, *ibid*., Box 4, Folder 30.
58 Szilard (London) to Delbrück, May 7, 1933, Szilard Papers (ref. 6), Box 7, Folder 9; Szilard (Strand Palace Hotel, London) to Friedrich A. Paneth, November 26, 1934, and Szilard (Brussels) to Friedrich A. Paneth, May 14, 1933 (handwritten notes), Nachlass F. A. Paneth, Jewish Refugees Committee, 1933 (ref. 55), III. Abt. Rep. 45; Szilard (London) to Wigner, August 17, 1933, Michael Polanyi Papers (ref. 52), Box 2, Folder 12.
59 I. Zinn, Secretary of the Jewish Refugee Committee, to F. A. Paneth, June 7, 1933, Nachlass F. A. Paneth, Jewish Refugees Committee, 1933 (ref. 55), III. Abt. Rep. 45; R[alph] E. Oesper, "Fritz A. Paneth (1887–), *Journal of Chemical Education* **16** (July 1939), 301; J. Mattauch, "Friedrich A. Paneth," *Verbandsausgabe der Physikalischen Verhandlungen*, 8. Lieferung (1958), 165–169.
60 Szilard (London) to Maxwell Garnett, May 9, 1934, Szilard Papers (ref. 6), Box 8, Folder 23; Julian Huxley (London) to Szilard, May 3, 1934, *ibid*., Box 9, Folder 12.
61 Karl Polanyi (London) to Michael Polanyi, October 31, 1934 (in Hungarian), Michael Polanyi Papers (ref. 52), Box 17, Folder 5; [Lawrence] Bragg (Manchester) to Michael Polanyi, July 10, 1933, *ibid*., Box 2, Folder 12.
62 Paul György, Biographies, Paul György Papers, American Philosophical Society Library, Philadelphia, Penn.; Fritz Zilliken, "Paul György 7.4.1893–1.3.1976," *MPI Berichte und Mitteilungen, Sonderheft* (1977), 15–17; Paul György Papers, Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin-Dahlem, IX. Abt. Rep. 1. György received an honorary doctorate from the Ruprecht-Karl-University of Heidelberg in 1960 and the U.S. National Medal of Science from President Gerald R. Ford in 1976.
63 Szilard (London) to C. S. Gibson, June 13, 1933, Szilard Papers (ref. 6), Box 8. Folder 23.
64 Abraham Flexner (New York) to John von Neumann, March 30, 1933, John von Neumann Papers (ref. 45), Box 7.
65 Abraham Flexner (New York) to John von Neumann, May 6, 1933, John von Neumann Papers (ref. 45), Box 7.
66 Benjamin Liebowitz (London) to Ernst P. Boas, May 4, 1933, Szilard Papers (ref. 6), Box 12, Folder 4.
67 Szilard (London) to Gibson, June 13, 1933 (ref. 63).
68 Oswald Veblen (New York) to John von Neumann, May 22, 1933, John von Neumann Papers (ref. 45), Box 7.
69 K. Brandt (New York) to John von Neumann, March 19, 1934, John von Neumann Papers (ref. 45).
70 George Baehr, M.D., Secretary of the Emergency Committee in Aid of Displaced Foreign Physicians, to Erich Marx, March 14, 1934; Memorandum of The New York Academy of Medicine, September 15, 1933. Haber-Sammlung von Joh. Jaenicke, Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin-Dahlem, Va Abt., Rep. 5, 1176–1177.
71 Szilard, quoted in Wigner (Budapest) to Michael Polanyi, n.d. [July 1933?], Michael Polanyi Papers (ref. 52), Box 2, Folder 12.
72 Wigner (Budapest) to Michael Polanyi, *ibid*.
73 Theodore von Kármán (Pasadena) to Robert Oppenheimer, March 12, 1934, Theodore von Kármán Papers, California Institute of Technology Archives, Pasadena, File 22.10.
74 Szilard, "Biographical Data" (ref. 31).
75 Roger H. Stuewer, "The Seventh Solvay Conference: Nuclear Physics at the Crossroads," in A.J. Kox and Daniel M. Siegel, ed., *No Truth Except in the Details: Essays in Honor of Martin J. Klein* (Dordrecht: Kluwer, 1995), pp. 333–362.
76 Szilard (Brussels) to Friedrich A. Paneth, August 28, 1934, Nachlass F. A. Paneth, Jewish Refugees Committee, 1933 (ref. 55), III. Abt. Rep. 45.

77 Leo Szilard, "Asynchronous and Synchronous Transformers for Particles," British Application 5730/34, filed February 21, 1934; "Transmutation of chemical elements," British Application 7840/34; filed March 12, 1934; issued as Patent No. 440,023; reproduced in Szilard, *Collected Works* (ref. 26), pp. 564–604; 605–622.

78 Szilard to Richard Gehman, April 8, 1952, Szilard Papers (ref. 6), Box 8, Folder 27; see also Szilard-Samuel Glasstone correspondence, 1956–57, *ibid*., Box 8, Folder 23; Memorandum by E. P. Wigner, April 16. 1941, *ibid*., Box 3, Folder 23.

79 Leo Szilard and T.A. Chalmers, "Chemical Separation of the Radioactive Element from its Bombarded Isotope in the Fermi Effect," *Nature* **134** (1934), 462–463; "Detection of Neutrons Liberated from Beryllium by Gamma Rays: A New Technique for Inducing Radioactivity," *ibid*., 494–495; "Radioactivity Induced by Neutrons," *ibid*., **135** (1935), 98; reprinted in Szilard, *Collected Works* (ref. 26), pp. 143–144; 145–146; 149. See also Leo Szilard, "Biographical Notes," n.d. (completed after Szilard's death), Szilard Papers (ref. 6), Box 2, Folder 9.

80 The Earl of Birkenhead, *The Professor and the Prime Minister: The Official Life of Professor F.A. Lindemann, Viscount Cherwell* (Cambridge: Riverside Press and Boston: Houghton Mifflin, 1962), p. 108; Wolff, "Frederick Lindemanns Rolle" (ref. 54), p. 42.

81 J.H.E. Griffiths and Leo Szilard, "Gamma Rays excited by Capture of Neutrons," *Nature* **139** (1937), 323–324; reprinted in Szilard, *Collected Works* (ref. 26), p. 153.

82 Friedrich A. Paneth to Leo Szilard, July 26, 1935, Nachlass F.A. Paneth, Jewish Refugees Committee, 1933 (ref. 55), III. Abt. Rep. 45.

83 Eugene P. Wigner, "Memorandum," April 16, 1941, Szilard Papers (ref. 6), Box 3, Folder 23. The quotation is from Szilard, "Transmutation of chemical elements" (ref. 77), p. 615.

84 Szilard, "Transmutation of chemical elements" (ref. 77); Samuel Glasstone to Szilard, November 28, 1956, Szilard to Glasstone, January 15, 1957; Glasstone to Szilard, January 17, 1957; Szilard Papers (ref. 6), Box 8, Folder 23.

85 Szilard (London) to Sir Hugo Hirst, February 21, 1934, Szilard Papers (ref. 6), Box 9, Folder 34.

86 Szilard (London) to Sir Hugo Hirst, March 17, 1934, Szilard Papers (ref. 6), Box 9, Folder 34; published in Spencer R. Weart and Gertrud Weiss Szilard, ed., *Leo Szilard: His Version of the Facts. Selected Recollections and Correspondence* (Cambridge, Mass. and London: The MIT Press, 1978), p. 38; see also Robert C. Williams and Philip L. Cantelon, ed., *The American Atom. A Documentary History of Nuclear Policies from the Discovery of Fission to the Present 1939–1984* (Philadelphia: University of Pennsylvania Press, 1984), p. 7; H.G. Wells, *The World Set Free* (New York: Dutton, 1914).

87 Szilard to Electric & Musical Industries Limited, 1934–1935, Szilard Papers (ref. 6), Box 7, Folder 30.

88 Szilard (Oxford) to Enrico Fermi, March 13, 1936, Szilard Papers (ref. 6), Box 8, Folder 6.

89 Leo Szilard, "Memorandum of Possible Industrial Applications Arising out of a New Branch of Physics," in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 39–40; quote on p. 40; see also Williams and Cantelon, *American Atom* (ref. 86), pp. 8–9.

90 Szilard (Oxford) to Enrico Fermi, March 13, 1936, Szilard Papers (ref. 6), Box 8, Folder 6.

91 Leo Szilard, "Biographical Information," February 22, 1960, p. 5; University of Chicago, Office of Public Relations.

92 Statement Attached to Selective Service Questionnaire of Leo Szilard Order No. 10322, Local Board No. 36, New York, New York, Szilard Papers (ref. 6), Box 1, Folder 27.

93 Einstein to H.M. Brailsford, April 24, 1930, Szilard Papers (ref. 6), Box 7, Folder 27; translated in Otto Nathan and Heinz Norden, ed., *Einstein on Peace* (New York: Simon and Schuster, 1960), pp. 103–104.

94 Szilard (Berlin) to Einstein, June 30, 1931, Szilard Papers (ref. 6), Box 7, Folder 27.

95 Einstein (Caputh bei Potsdam) to U.S. Consulate General in Berlin, October 24, 1931, Szilard Papers (ref. 6), Box 27, Folder 5.

96 Einstein (Peconic, Long Island) to F.D. Roosevelt, n.d. [1939], Szilard Papers (ref. 6), Box 7, Folder 27; Einstein (Peconic, Long Island) to F.D. Roosevelt, August 2, 1939, Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin-Dahlem, Va Abt., Rep. 2; published for instance in Morton

Grodzins and Eugene Rabinowitch, ed., *The Atomic Age: Scientists in National and World Affairs* (New York and London: Basic Books, 1963), pp. 11–12; Nathan and Norden, *Einstein on Peace* (ref. 93), pp. 294–296; Daniel J. Boorstin, ed., *An American Primer* (New York: Mentor Books, 1968), pp. 882–887; Williams and Cantelon, *American Atom* (ref. 86), pp. 12–14. Szilard is quoted on his drafting of the letter and his trip with Wigner to Einstein on Long Island in Weart and Weiss, *Szilard: His Version* (ref. 86), pp. 82–84; Teller mentions only Szilard as his passenger; see Edward Teller, with Judith L. Shoolery, *Memoirs: A Twentieth-Century Journey in Science and Politics* (Cambridge, Mass.: Perseus Publishing, 2001), pp. 145–147.

97 Quoted in Donald Fleming, "Albert Einstein's Letter to Franklin D. Roosevelt, 1939," in Boorstin, *American Primer* (ref. 96), p. 884.

98 Szilard reports this in a letter to Einstein, October 17, 1939, Szilard Papers (ref. 6), Box 7, Folder 27; published and translated in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 107–109.

99 Szilard to Charles Lindbergh, August 16, 1939, Szilard Papers (ref. 6), Box 12, Folder 5; published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 99–100; Einstein's letter is not published here.

100 Szilard to Gano Dunn, September 13, 1939, Szilard Papers (ref. 6), Box 7, Folder 21.

101 M. Goldhaber, R.D. Hill, and Leo Szilard, "Radioactivity Induced by Nuclear Excitation. I. Excitation by Neutrons," *Physical Review* **55** (1939), 47–49; reprinted in *Collected Works* (ref. 26), pp. 155–157.

102 Szilard "Biographical Data" (ref. 31), p. 6.

103 Leo Szilard, "Divergent Chain Reactions in Systems Composed of Uranium and Carbon"; reprinted in *Collected Works* (ref. 26), pp. 216–256.

104 Szilard to John T. Tate, February 6 and 14, 1940; John T. Tate to Leo Szilard, February 14, 1940; Madeline M. Mitchell to Leo Szilard, February 14, 1940, Szilard Papers (ref. 6), Box 7, Folder 21.

105 Leo Szilard, "Biographical Information" (ref. 91); see also Richard G. Hewlett and Oscar E. Anderson, Jr., *A History of the United States Atomic Energy Commission*. Vol. I. *The New World, 1939/1946* (University Park: Pennsylvania State University Press, 1962), p. 56.

106 Szilard to A.H. Compton, December 3, 1942, Szilard Papers (ref. 6), Box 6, Folder 29.

107 Szilard to A.H. Compton, August 9, 1943; see also December 29, 1942, January 13, 1943, April 20, 1943, May 7, 1943, July 20, 1943, August 4, 5, 6, 7, 19, 1943; November 19, 20, 1943, December 11, 15, 1943, n.d. [1943]; Compton to Szilard, August 4, 1943, March 26, 1943, Szilard Papers (ref. 6), Box 6, Folders 29–30.

108 Szilard to A.H. Compton, December 11, 1943, Szilard Papers (ref. 6), Box 6, Folder 29.

109 Enrico Fermi and Leo Szilard, "Neutronic Reactor," U.S. Patent 2,708,656; published in Szilard, *Collected Works* (ref. 26), pp. 691–696. See also Szilard, "Biographical Data" (ref. 31), pp. 6–7, and Henry DeWolf Smyth, *Atomic Energy for Military Purposes* (Princeton: Princeton University Press, 1945), p. 34.

110 Spencer R. Weart, "Scientists with a secret," *Physics Today* **29** (February 1976), 29; Szilard (New York) to Admiral Bowen, May 30, 1940, Szilard Papers (ref. 6), Box 4, Folder 20.

111 Szilard (New York) to Gregory Breit, July 3, 1940, Szilard Papers (ref. 6), Box 5, Folder 6; Leo Szilard, "Attempts at Secrecy from March 1939 to June 1940," November 4, 1942, Szilard Papers (ref. 6), Box 6, Folder 30. For a full account, see Weart, "Scientists" (ref. 110), pp. 23–30.

112 Szilard to A. H. Compton, November 25, 1942, Szilard Papers (ref. 6), Box 6, Folder 30; published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 160–161.

113 Szilard to Vannevar Bush, n.d.; Szilard to Vannevar Bush, August 11, 1943, Szilard Papers (ref. 6), Box 5, Folder 21.

114 Szilard to Vannevar Bush, January 10, 1943, n.d., August 11, 1943, December 13, 1943, January 14, 1944, Szilard Papers (ref. 6), Box 5, Folder 21; last letter published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 161–163. See also L. Szilard, "Rough Draft of Proposed Conversation with Dr Bush," February 28, 1944, Szilard Papers (ref. 6), Box 5, Folder 21; published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 164–179.

115 Szilard (Chicago) to Lord Cherwell, August 18, 1944, Szilard Papers (ref. 6), Box 5, Folder 22; published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 192–196.

116 On German nuclear research, see, for example, Mark Walker, *German National Socialism and the quest for nuclear power 1939–1949* (Cambridge: Cambridge University Press, 1989); *Nazi Science: Myth, Truth, and the German Atomic Bomb* (New York and London: Plenum Press, 1995); Geoffrey Brooks, *Hitler's Nuclear Weapons: The Development and Attempted Deployment of Radiological Armaments by Nazi Germany* (London: Leo Cooper,1992); and Thomas Powers, *Heisenberg's War* (New York: Alfred Knopf, 1993); Dieter Hoffmann, ed., *Operation Epsilon: Die Farm-Hall-Protokolle oder die Angst der Allierten vor der deutschen Atombombe* (Berlin: Rowohlt, 1993).

117 Einstein (Princeton) to Roosevelt, March 25, 1945; Leo Szilard, "Enclosure to Mr. Albert Einstein's Letter of March 25, 1945 to the President of the United States," Szilard Papers (ref. 6), Box 7, Folder 27; published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 205–207. See also Szilard to Truman, May 25, 1945, published in *ibid*., p. 208.

118 Szilard, "Atomic Bombs and the Post-War Position of the United States in the World," Szilard Papers (ref. 6), Box 10, Folder 9.

119 Nicholas and Robert Halász, "The Reluctant Father of the Atom Bomb," *New Hung. Quart.* **15** (1974), 167–168.

120 Quoted in Robert Jungk, *Brighter than a Thousand Suns. A Personal History of the Atomic Scientists* (San Diego, New York, London: Harcourt Brace Jovanovich, 1958), p. 180.

121 James Franck, Donald J. Hughes, J.J. Nickson, Eugene Rabinowitch, Glenn T. Seaborg, Joyce C. Stearns, and Leo Szilard, "A Report to the Secretary of War," in Grodzins and Rabinowitch, *Atomic Age* (ref. 96), pp. 19–27.

122 Szilard, "To the President of the United States," n.d. [July 1945], Szilard Papers (ref. 6), Box 6, Folder 29; the final version, dated July 17, 1945, is published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 211–212.

123 Szilard to Compton, July 19, 1945; Compton to Colonel K.D. Nichols, July 24, 1945, Szilard Papers (ref. 6), Box 6, Folder 29; published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 214–215; Farrington Daniels (Chicago) to A.H. Compton, July 13, 1945, Szilard Papers (ref. 6), Box 7, Folder 5; see also Arthur Holly Compton, *Atomic Quest: A Personal Narrative* (New York: Oxford University Press, 1956), pp. 242–244.

124 Szilard to Compton, July 19, 1945, in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), p. 214.

125 Daniels to Compton July 13, 1945; see also Compton, *Atomic Quest* (ref. 123), pp. 242–244.

126 Compton to Nichols, July 24, 1945, in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), p. 215.

127 Pearl S. Buck, *Command the Morning* (New York: John Day Co., 1959), pp. 272–281; quote on p. 281.

128 Farrington Daniels to Wayne W. Johnson, January 31, 1946, Szilard Papers (ref. 6), Box 7, Folder 5.

129 Alice K. Smith, *A Peril and a Hope: The Scientist's Movement in America, 1945–1947* (Chicago: University of Chicago Press, 1968); see also Robert Gilpin, *American Scientists and Nuclear Policy* (Princeton: Princeton University Press, 1962); Barton J. Bernstein, "Four Physicists and the Bomb: The Early Years, 1945–1950," *Historical Studies in the Physical and Biological Sciences* **18** (1988), 231–263; Lawrence Badash, *Scientists and the Development of Nuclear Weapons: From Fission to the Limited Test Ban Treaty 1939–1963* (New York: Humanities Press, 1995); and Mary Jo Nye, "A Physicist in the Corridors of Power: P. M. S. Blackett's Opposition to Atomic Weapons Following the War," *Physics in Perspective* **1** (1999), 136–156.

130 Frances Henderson to Don Bermingham, March 8, 1946, Szilard Papers (ref. 6), Box 9, Folder 11. The Wagner Act, sponsored by Robert F. Wagner (Democrat-New York) and officially called the National Labor Relations Act of 1935, was enacted by Congress to forbid employers to interfere with the organization of labor unions.

131 Quoted in *ibid*. See also Lanouette, *Genius* (ref. 3), pp. 237–242, 248–249, 253–255, 262–269, 271, 273–275, 305–313. For Groves's relationship to scientists see Stanley Goldberg, "Der Endspurt: Zu den Hintergründen der Entscheidung für den Bombenabwurf auf Hiroshima und Nagasaki," *Physikalische Blätter* **51** (September 1995), 828–830.

132 Quoted in Henderson to Bermingham, March 8, 1946 (ref. 130).

133 Quoted in Szilard (Chicago) to Farrington Daniels, May 9, 1946, Szilard Papers (ref. 6), Box 7, Folder 5.

134 Farrington Daniels to Szilard, May 10, 1946, Szilard Papers (ref. 6), Box 7, Folder 5.
135 *Ibid*.; see also Farrington Daniels to Szilard, May 10 and 15, 1946; Farrington Daniels and Wayne W. Johnson to Szilard, June 1, 1946, Szilard Papers (ref. 6), Box 7, Folder 5.
136 James S. Murray to Szilard, August 27, 1945; August 28, 1945; Szilard to Robert M. Hutchins, August 30, 1945; published in Weart and Weiss Szilard, *Szilard: His Version* (ref. 86), pp. 216–222; for the original of the last letter, see Szilard Papers (ref. 6), Box 10, Folder 9.
137 Leo Szilard, "Calling for a Crusade," *Bull. Atom. Sci*. 3 (April–May 1947), 102–106, 125; reprinted in Hawkins, Greb, and Weiss Szilard, *Livable World* (ref. 14), pp. 7–20
138 Szilard to the Attorney General, October 25, 1947; Szilard, "A Letter to Stalin," Manuscript, November 10, 1947; Szilard to Robert M. Hutchins, November 11, 1947, Szilard Papers (ref. 6), Box 10, Folder 9; Szilard, "Letter" (ref. 14), pp. 26–32.
139 Szilard, "Letter" (ref. 14), pp. 29, 32.
140 Szilard to Robert M. Hutchins, April 19, 1948, Szilard Papers (ref. 6), Box 10, Folder 9.
141 *Ibid*.
142 Szilard, "Biographical Information" (ref. 91).
143 Einstein to Jawaharlal Nehru, April 6, 1955, Szilard Papers (ref. 6), Box 7, Folder 27.
144 J. Rotblat, *Pugwash – the First Ten Years: History of the Conferences of Science and World Affairs* (New York: Humanities Press, 1968); *Scientists in the Quest for Peace: A History of the Pugwash Conferences* (Cambridge, Mass. and London: The MIT Press, 1972).
145 Rotblat, *Pugwash* (ref. 144), pp. 18–20; *Scientists* (ref. 144), pp. 37–38.
146 Szilard to Warren C. Johnson, "Memorandum, Confidential," July 2, 1958; n.d.; Szilard Papers (ref. 6), Box 10, Folder 22, pp. 2–3.
147 Szilard to Chester Bowles, "Memo," May 24, 1955; see also Chester Bowles to Szilard, May 15, 1955, Szilard Papers (ref. 6), Box 4, Folder 36.
148 Leo Szilard, "Letter to the Editor," *The New York Times* (February 6, 1955); reprinted in Hawkins, Greb, and Weiss Szilard, *Livable World* (ref. 14), pp. 132–134.
149 John F. Kennedy (Washington, D.C.) to Szilard, May 27, 1960, Szilard Papers (ref. 6), Box 11, Folder 5.
150 Szilard, "Conversation with K on October 5, 1960," in Hawkins, Greb, and Weiss Szilard, *Livable World* (ref. 14), pp. 279–287.
151 Khrushchev to Szilard, August 30, 1960, in Hawkins, Greb, and Weiss Szilard, *Livable World* (ref. 14), p. 269.
152 Szilard to John F. Kennedy, October 16, November 19, 1960, May 10, June 6, 1961, Szilard Papers (ref. 6), Box 11, Folder 5; last two letters published in Hawkins, Greb, and Weiss Szilard, *Livable World* (ref. 14), pp. 341–346.
153 Szilard to Chester Bowles, March 17, 1961, Szilard Papers (ref. 6), Box 4, Folder 36.
154 Szilard to John F. Kennedy, Letter and Memorandum, June 6, 1961, Szilard Papers (ref. 6), Box 11, Folder 5; letter published in Hawkins, Greb, and Weiss Szilard, *Livable World* (ref. 14), p. 346.
155 Szilard to John F. Kennedy, November 14, 1963, Szilard Papers (ref. 6), Box 11, Folder 5.
156 Szilard to John F. Kennedy, Letter and Memorandum, n.d. [1962?], Szilard Papers (ref. 6), Box 11, Folder 5.
157 Tibor Frank, "Polányi Mihály és a tudomány demokráciája," *Polanyiana* **3**, No. 2 (1993), 6; "Cohorting, Networking, Bonding: Michael Polanyi in Exile," *ibid*. **10**, Nos. 1–2 (2001), 121; see also Mary Jo Nye, "Scientific Practice and Politics: A Preliminary Look at Blackett and Polanyi in Manchester," *ibid*. **5**, No. 2 (1996), 21–35.
158 Erwin Schrödinger, *Über Indeterminismus in der Physik; Ist die Naturwissenschaft milieubedingt? Zwei Vorträge zur Kritik der naturwissenschaftlichen Erkenntnis* (Leipzig: Barth, 1932); the latter reprinted in Karl von Meyenn, ed., *Quantenmechanik und Weimarer Republik* (Braunschweig: Vieweg, 1994), pp. 295–332; translated freely by James Murphy and W.H. Johnson as "Is Science a Fashion of the Times?" and "Physical Science and the Temper of the Age," in Erwin Schrödinger, *Science and the Human Temperament* (New York: W.W. Norton, 1935), pp. 81–132.

159 Quoted in Arne Schirrmacher, '"Emigrationsphysik'," *Physikalische Blätter* **52**, Nr. 5 (1996), 449–452; quote on 449; another translation is given in Schrödinger, *Science and the Human Temperament* (ref. 158), p. 122.
160 Schirrmacher, '"Emigrationsphysik"' (ref. 159), pp. 449–452.
161 DC/RC [Daniel I. Cooper and Robert Colborn], "Thinking ahead with Leo Szilard," *International Science and Technology* **No. 5** (May 1962), 35.
162 Donald Fleming, "Émigré Physicists and the Biological Revolution," in Fleming and Bailyn, *Intellectual Migration* (ref. 41), pp. 152–189; H.G. Kuhn, "Franck, James," in Charles Coulston Gillispie, ed., *Dictionary of Scienctific Biography*, Vol. 5 (New York: Charles Scribner's Sons, 1972), pp. 117–118; Ernst Peter Fischer and Carol Lipson, *Thinking about Science: Max Delbrück and the Origins of Molecular Biology* (New York: Norton, 1988).
163 DC/RC, "Thinking ahead" (ref. 161), pp. 35–36.
164 Szilard to Warren C. Johnson, "Memorandum on the Future of the Institute of Radiobiology and Biophysics," December 12, 1952, Szilard Papers (ref. 6), Box 10, Folder 22, pp. 4–5.
165 *Ibid*., p. 2.
166 Aaron Novick and Leo Szilard, "Description of the Chemostat," *Science* **112** (1950), 715–716; "Experiments with the Chemostat on Spontaneous Mutations of Bacteria," *Proceedings of the National Academy of Sciences* **36** (1950), 708–719; reprinted in Szilard, *Collected Works* (ref. 26), pp. 403–404, 405–416.
167 Jack Myers to Szilard, February 8, 1951, Szilard Papers (ref. 6), Box 13, Folder 27.
168 Rollin D. Hotchkiss (New York) to the National Science Foundation, September 15, 1956, Szilard Papers (ref. 6), Box 10, Folder 3.
169 M. von Laue to K.[-E.] Zimen for the Free University of Berlin and the Berlin *Atomkommission*, July 17, 1957, Hahn-Meitner Institut, Berlin, Aktenarchiv, EZ-00003, No. 272, p. 124. Von Laue evidently served as Szilard's main contact in Berlin: A pencilled note on a letter to him from Dean Alexander Dinghas of the Free University asks, "wann kommt Szilard? [When does Szilard arrive?]"; see also A. Dinghas (Berlin-Dahlem) to K.-E. Zimen, October 26, 1957, Hahn-Meitner Institut, Aktenarchiv, GF-00212, No. 503, p. 236, and Szilard to M. v. Laue, December 20, 1958, *ibid*., GF-00212, No. 503, p. 250.
170 Quoted in Burghard Weiss, *Großforschung in Berlin: Geschichte des Hahn-Meitner-Instituts* (Frankfurt/Main and New York: Campus, 1994), pp. 202–203.
171 Senatsrat Dr. Gehlhoff (Berlin) to members of the West Berlin *Atomkommission*, September 5, 1957, Hahn-Meitner Institut, Berlin, Aktenarchiv, GF-00212, No. 503, p. 223.
172 Szilard (Heidelberg) to J. Tiburtius, January 13, 1958, Hahn-Meitner Institut, Berlin, Aktenarchiv, EZ-00003, No. 272, pp. 136–140; also quoted in Weiss, *Großforschung* (ref. 170), pp. 204–205.
173 J. Tiburtius to W. Brandt, January 31, 1958, Hahn-Meitner Institut, Berlin, Aktenarchiv, GF-00212, No. 503, pp. 237–238.
174 Weiss, *Großforschung* (ref. 170), pp. 204–206.
175 Bähr (for the Senator für Volksbildung) to Ministerialrat Dr. [Alexander] Hocker, Berlin, May 16, 1958, Hahn-Meitner Institut, Berlin, Aktenarchiv, GF-00212, No. 503, pp. 240–241.
176 G. Schenck to Szilard, November 14, 1958, Hahn-Meitner Institut, Berlin, Aktenarchiv, GF-00212, No. 503, pp. [248–]249.
177 Szilard to H. Kopfermann, December 20, 1958, attached to Szilard to M. v. Laue, December 20, 1958, Hahn-Meitner Institut, Berlin, Aktenarchiv, GF-00212, No. 503, pp. 250–252.
178 H. Kopfermann (Heidelberg) to B. v. Mutius, December 10, 1959, Hahn-Meitner Institut, Berlin, Aktenarchiv, GF-00212, No. 503, p. 254–255; also quoted in Weiss, *Großforschung* (ref. 170), pp. 206–207.
179 Lanouette, *Genius* (ref. 3), p. 403. For a moving eyewitness account of Szilard's illness, see George Klein, "Szilard Plays Chess with Death," in George Klein, *The Atheist and the Holy City: Encounters and Reflections* (Cambridge, Mass. and London: The MIT Press, 1990), pp. 29–36.
180 Szilard (Chicago) to B. v. Mutius, December 26, 1959, Hahn-Meitner Institut, Berlin, Aktenarchiv, GF-00212, No. 503, p. 255.

181 Leo Szilard, "On the Nature of the Aging Process," *Proc. Nat. Acad. Sci.* **45** (1959), 30–45; "A Theory of Aging," *Nature* **184** (1959), 956–958; reprinted in *Collected Works* (ref. 26), pp. 447–462, 465–468.
182 Szilard to G. Lalor Burdick, January 5, 1959, Szilard Papers (ref. 6), Box 11, Folder 18.
183 John Lear, "A theory of how we age," *The New Scientist* **5** (February 12, 1959), 346.
184 *Ibid*.
185 Leo Szilard, "On Memory and Recall," *Proc. Nat. Acad. Sci.* **51** (1964), 1092–1099; reprinted in *Collected Works* (ref. 26), pp. 497–504.
186 Ralph W. Gerard (Irvine, Calif.) to Szilard, May 25, 1964, Szilard Papers (ref. 6), Box 8, Folder 23.
187 Szilard to George Beadle, August 8, 1963, Szilard Papers (ref. 6), Box 4, Folder 25.
188 Szilard to G. Lalor Burdick, January 5, 1959, Szilard Papers (ref. 6), Box 11, Folder 18.
189 Gerard to Szilard, May 25, 1964 (ref. 186).

Department of American Studies
Eötvös Loránd University
Ajtósi Dürer sor 19–21
H-1146 Budapest, Hungary
e-mail: tzsbe@hu.inter.net

NAIVE -

Naive you are
if you believe
life favours those
who aren't naive.

Piet Hein