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Faust, the Physicists and the Atomic Bomb

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This paper explores the cross-fertilization between science and literature in the 1930s, at key moments in atomic physics and in the development of the atomic bomb. In 1932, the centenary of Goethe's death, physicists attending an international conference at Niels Bohr's Institute of Theoretical Physics in Copenhagen performed a parody of Goethe's *Faust*. Goethe's critique of science in the play made this a significant choice at the dawn of nuclear physics. James Chadwick's discovery of the neutron that year was highlighted in the performance. In 1933 while in Bloomsbury, London, the physicist Leo Szilard realized how to use a self-sustaining neutron chain reaction to release the energy of the atom. The previous year Szilard had read H. G. Wells's novel *The World Set Free* (1914) in which the phrase 'atomic bomb' was coined. As well as considering the Faustian themes in the novel, I explore parallels between Wells's scientist, Holsten, and Leo Szilard himself. I argue that this is a clear example of fiction influencing science, and that Goethe's notion that scientific knowledge and self-knowledge should evolve hand in hand, remains a valuable insight when considering the role of scientists in the creation of weapons of mass destruction.

As the subject of this paper might be somewhat unfamiliar territory to the English Goethe Society, I would like to begin by briefly setting it in the context of my past and present research.

My research focuses on the relation between science and literature. As a post-graduate I looked at how scientific ideas were explored in works by five German writers — Goethe, Büchner, Stifter, Musil, and Brecht.[1] For the last three years I have been working on a book called *Doomsday Men*, which explores the relationship between science and popular culture, especially fiction.[2] The subject is one where the boundaries between science and literature are blurred. It is at such moments, when

[1] P. D. Smith, *Metaphor and Materiality: German Literature and the World-View of Science 1780–1955*, Oxford, 2000.
[2] P. D. Smith, *Doomsday Men: The Real Dr Strangelove and the Dream of the Superweapon*, London, 2007.

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the divide between the so-called 'two cultures' breaks down, that it becomes apparent that the relationship between scientists and writers is not always *one* way, that is, science influencing literature. Rather, there is a mutual process of cross-fertilization, a constant flow of ideas back and forth between science and the wider culture.

The scientist Leo Szilard immediately struck me as an interesting figure to explore from this perspective. Szilard was born in Hungary in 1898, but studied physics in Berlin under such luminaries as Albert Einstein and Max Planck during the 1920s, the golden age of physics. He is chiefly remembered today by non-scientists for being a key player in the decision to build the atomic bomb. It was Szilard who went to see Einstein in 1939 to warn him about the military implications of fission, and of the danger that the Nazis could develop an atomic bomb before the Allies. Szilard helped Einstein write the letter to President Roosevelt that is often credited with initiating the Manhattan Project.

It was also Szilard who, six years earlier in 1933, had come up with the idea of a neutron chain reaction as the way to unlock the energy frozen inside matter. This was the key to atomic power, which had been the subject of feverish speculation in popular fiction since at least the turn of the century. After Hiroshima and Nagasaki had been destroyed by his brainchild — something he worked to prevent — Szilard became a passionate campaigner for arms control. He became a public figure in cold war America and one of the first politically active scientists.

Szilard had an incredibly versatile mind and his creativity did not respect disciplinary boundaries. He was once described as an intellectual bumblebee, cross-pollinating different fields, from physics to biology. A friend quipped that he was the greatest scientist never to have won a Nobel prize. He was a great character, and there are many amusing anecdotes about his life. But apart from this there are three reasons why Szilard became the central figure in my book: first, as a scientist he was influenced by fiction, particularly in 1933 when he came up with the chain reaction. As we shall see, H. G. Wells's novel *The World Set Free*, with its Faustian characters, was a key influence on him at this time. Secondly, during the cold war he himself wrote fiction and his stories were published in 1961 as *The Voice of the Dolphins*.[3] But thirdly, and most importantly for my book, in 1950 he came up with the defining symbol of the cold war and the science of destruction: the cobalt doomsday bomb.

This was a nuclear weapon (effectively a huge radioactive 'dirty' bomb) that could end all life on earth. It was an idea that would terrify America and the world — a scientifically feasible weapon that would feature in novels and films from Nevil Shute's bestseller *On the Beach* (London, 1957) to *Beneath the Planet of the Apes* (1970). And, of course, this is the source for the title of my book, in which I argue that the origins of this ultimate weapon of mass destruction, and the dream of the superweapon generally, lie in fiction, film, and popular culture, as much as in science.

Leo Szilard's life-story embodies this interplay between science and fiction that so fascinates me. He was a scientist who wrote fiction and who was influenced by fictional ideas and themes. With the cobalt bomb he also created a powerful literary motif, one that contributed significantly to an influential cold war genre: atomic

[3] Leo Szilard, *The Voice of the Dolphins*, New York, 1961; repr. Stanford, 1992.

doomsday fiction. Thus, in my book, I use Szilard as an example of the way ideas migrate between disciplines, or cultures, as C. P. Snow termed them.

Today, I will not be talking directly about the story of the cobalt bomb. In this paper, as well as giving an insight into my research on the science and literature of destruction in the twentieth century, I want to explore its relation to Goethe's *Faust*. For in 1932 physicists attending an international conference in Copenhagen performed a play in which one of their own was cast as Faust. This scientific performance of Goethe's play came at a crucial moment in the history of science and the world. Within months, Szilard — who had fled Hitler's Germany and was living in exile near where we are this evening, on Russell Square — would grasp how to release the energy of the atom, and the race for the atomic bomb would begin.

Naturally, for someone such as myself with a background in German studies, it was remarkable to find these physicists performing Goethe's great play at this key historical moment. Not only did this strike me as immensely significant in the way it opens up parallels between Goethe's science and the course of physics in the twentieth century, but it also concretely demonstrates the role literature can and does play in the history of science. Indeed, it illustrates perfectly the thesis of my book: namely that to understand our twentieth-century obsession with ever more terrible weapons of mass destruction — from Fritz Haber's poison gas in World War I to Szilard's doomsday bomb in 1950 — we have to explore not just science and its history, but the broader cultures of destruction found in literature and film.

Central to my argument is the idea that the 'dream of the superweapon' begins in popular culture, and especially fiction, at the beginning of the last century. Novels such as *His Wisdom the Defender* from 1900, by the American astronomer and popularizer of science, Simon Newcomb, suggest that a revolutionary discovery — generally to do with the new radioactive element radium — will bring about Utopia. The hero of these books is typically the Scientist, who emerges from his laboratory with a scientific superweapon that he uses to force the armies of the world to disarm. Thus the 'saviour scientist' (as I call this figure) achieves what neither politics nor religion have been able to: *world peace*, the precondition of Utopia. In Newcomb's novel, the saviour scientist is described as a 'twentieth-century Faust', a scientist striving to achieve both greater knowledge and Utopia.[4] Widely read stories such as Newcomb's show how the dream of the superweapon enthralled the twentieth century from its earliest years. This was, of course, a dream that came true at Hiroshima in August 1945. But the price scientists would pay for creating such terrible weapons was to lose their image as saviours, and to be increasingly viewed by the public as 'mad scientists'. For many people, the twentieth-century Faust would eventually become Dr Strangelove.

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If you were a physicist in the 1920s and 1930s, all roads led to Copenhagen's Blegdamsvej 15. This was where Niels Bohr's Institute of Theoretical Physics was located. The Ukrainian-born physicist George Gamow recalled that 'the Institute

[4] Simon Newcomb, *His Wisdom The Defender*, 1900; repr. New York, 1975, p. 4.

buzzed with young theoretical physicists and new ideas about atoms, atomic nuclei, and the quantum theory in general'.[5] In physics the tall, softly spoken Niels Bohr was in a league of his own. German physicist Carl Friedrich von Weizsäcker said after meeting Bohr: 'I have seen a physicist for the first time. He suffers as he thinks.'[6] Together with Ernest Rutherford, Bohr had mapped the structure of the atom, and later, in the 1920s, he helped shape the quantum revolution, despite strong resistance from its founder, the former patent officer from Bern, Albert Einstein. Einstein's debates in the late 1920s with Bohr on quantum theory were like a scientific clash of the Titans. Einstein could never accept the indeterministic quantum mechanics that grew out of his own 1905 paper on the photoelectric effect.[7]

During the late 1920s, Einstein was engaged in one of the most unlikely research projects in the history of physics: the search for a safe refrigerator, which he conducted with Leo Szilard. But Einstein was also ploughing a lonely intellectual furrow in theoretical physics. His goal was the unified field theory. He believed until his dying day that this would bring relativity and the quantum realm together in one theory, describing the movement of planets as well as subatomic particles. This quest isolated Einstein from a new generation of physicists — nuclear physicists — whose increasingly strange theories about the subatomic realm challenged the very foundations of classical physics and provided the conceptual tools to build the atomic bomb. These new, revolutionary physicists — people like Walther Bothe and James Chadwick — were Einstein's intellectual children. When he disowned them, the former footballer, Niels Bohr, became their father figure. Bohr's annual conference, to which he invited about thirty physicists, was the highlight of the physics year. From 3 to 13 April 1932, the brightest minds in physics gathered together in Copenhagen. In a few years' time, many of these same physicists would be working on the atomic bomb. But for now they still had time for a little light-hearted play acting.

Each year the conference ended with what George Gamow called a 'stunt pertaining to recent developments in physics'.[8] The year before, Gamow had rounded up proceedings with a cartoon history of quantum mechanics, starring Mickey Mouse in the lead role.[9] In 1932, as it was the centenary of Goethe's death, they decided to stage a version of the German writer's greatest play, *Faust*.

Written when the industrial revolution was transforming Germany, Goethe's *Faust* raises some key questions regarding science and technology, including: what is the purpose of knowledge, and how can we have progress without increasing human suffering? This remarkable work acknowledges the indebtedness of science to its earlier, hermetic roots in alchemy, while looking forward to the technoscientific world of the future. By chance, the final part of *Faust* was published in the year the English word 'scientist' was coined. Goethe's Faust is a proto-scientist, whose desire to know nature's deepest secrets leads him to strike a fateful bargain with Mephistopheles. In

[5] George Gamow, *Thirty Years That Shook Physics*, 1966; repr. Mineola, NY, 1985, p. 51.

[6] Cited in Richard P. Feynman, *Don't You Have Time to Think?*, London, 2005, p. xii.

[7] Albert Einstein, 'Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt', *Annalen der Physik*, XVII (1905), 132–48. See P. D. Smith, *Einstein*, London, 2003, pp. 60–63.

[8] Gamow, p. 167.

[9] John Canaday, *The Nuclear Muse: Literature, Physics and the First Atomic Bombs*, Madison, 2000, p. 268, n.

the sixteenth century, the story of Faust was used by the Church to frighten people about the dangers of non-Christian knowledge. Goethe's play reworks the classic theme for the modern age. His Faust celebrates the spirit of inquiry, while highlighting the dangers of misapplied knowledge. True scientific understanding is life-affirming and creative, not destructive and exploitative, Goethe suggests.

One key question for Goethe is what constitutes 'true' scientific knowledge. The observing subject is central to Goethe's science, which is both empirical and phenomenological. As Faust discovers, neither words, books nor instruments alone can lead to true knowledge. Faust's longing to know 'was die Welt / Im Innersten zusammenhält' (ll. 382–83) is a scientific and philosophical goal he pursues tirelessly throughout his life, regardless of the cost to himself or others around him.[10] Unlike in Newtonian science, which relied on instruments for enlightenment, Goethe believed the observer must first grasp the 'Zusammenhang' of Nature, almost intuitively, through 'Geist'. Faust is epitomized by his incessant 'Streben' for knowledge. However, according to Goethe, the true scientist's approach to Nature should be characterized by the active observation and the reflexive 'Erkennen' of natural phenomena grasped as part of a greater, interrelated whole, or 'Zusammenhang'. Most importantly for Goethe, the route to scientific knowledge and self-knowledge was a parallel process. As he wrote in 1823: 'Der Mensch kennt nur sich selbst, insofern er die Welt kennt, die er nur in sich und sich nur in ihr gewahr wird. Jeder neue Gegenstand, wohl beschaut, schließt ein neues Organ in uns auf.'[11]

These themes are, I believe, most apparent in the scene at the beginning of Part 2, where Faust observes the waterfall and rainbow. This depicts a moment of genuine insight and self-knowledge, where Faust confronts nature without the aid of texts or instruments and where he comes closest to truly grasping 'was die Welt / Im Innersten zusammenhält'. Significantly, Mephistopheles is absent from this scene. For it is Mephistopheles who subverts Goethe's ideal scientific process by offering Faust easy access to the knowledge and power he craves. Faust increasingly loses touch with both nature and himself through his 'übereiltes Streben', a tendency encouraged by Mephistopheles. This leads to fatal decisions, such as the deaths of the old couple, Baucis and Philemon, at the end of Part 2. On one level then, *Faust* is a play about how *not* to do science.

Wagner, Faust's famulus, serves as another example of a misguided approach to science. As I have argued elsewhere, Wagner's alchemistic attempt to create the Homunculus in Act 2 of Part 2 combines allusions to both Paracelsian recipes and contemporary advances in chemistry, such as Friedrich Wöhler's synthesizing of urea in 1828.[12] Wagner only succeeds because Mephistopheles is present. Otherwise, suggests Goethe, such endeavours — both the alchemy of the past and the mechanistic science of the future — can only yield misleading and potentially dangerous results.

As we shall see, there is a fascinating parallel between the physicists' *Faust* of 1932 and Goethe's scientific critique of Wagner's experiment. More generally, Goethe's notion that scientific knowledge and self-knowledge should evolve hand in hand is

[10] See P. D. Smith, 'Scientific Themes in Goethe's *Faust*', in Paul Bishop (ed.), *A Companion to Goethe's Faust*, Rochester, NY, 2001, pp. 194–220.

[11] Goethe, 'Bedeutende Fördernis durch ein einziges Geistreiches Wort' (1823); HA, XIII, 38.

[12] Smith, 'Scientific Themes in Goethe's *Faust*', pp. 198–99.

a deeply suggestive and relevant theme for twentieth-century science. What is the point of knowing nature's deepest secrets, Goethe asks, if humankind never attains self-knowledge? The Faustian physicist might control the forces of nature but he does not understand, let alone control, himself. The implications were not lost on the atomic physicists gathered at Bohr's Institute in spring 1932.

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The 1932 *Faust* was rewritten and, of course, greatly abridged — the performance lasting no longer than an hour — by the younger scientists at Bohr's conference. Their literary skills were no doubt boosted by the products of Copenhagen's other claim to fame — the Carlsberg Brewery, which also happened to be one of Danish science's most generous benefactors. Max Delbrück, who would later become a central figure in the post-war revolution in molecular biology, did most of the writing.

The play is reworked into what is essentially a humorous skit at the expense of the leading physicists of the day. Goethe's characters were replaced with contemporary physicists, their younger colleagues donning masks to play them on stage. Mephistopheles became the irascible Austrian Wolfgang Pauli, while Faust became Paul Ehrenfest, a close friend of Einstein. The role of God was reserved, appropriately enough, for their host, Niels Bohr.

The play parodied Goethe's masterpiece and allowed the next generation of physicists to make fun of their esteemed elders, who were sitting in the audience. For instance, Wolfgang Pauli's rudeness was legendary. In the play he bluntly tells the painfully polite Niels Bohr (or God) that his latest theory is 'Mist'.[13] But their gentlemanly host, Niels Bohr, is also gently mocked. His almost pathological fear of being too critical becomes the motto of the play, emblazoned on the text's cover: 'Nicht um zu kritisieren.'[14] Even Einstein does not escape unscathed. His flawed unified field theory, which had created a media storm of interest when it was published in 1929, is lampooned by his young colleagues as the son of a flea.

Faust's first speech echoes Goethe's original, although with modern additions:

Habe nun, ach, Valenzchemie,
Elekrodynamik und Gruppenpest,
Und leider auch Transformationstheorie
Durchaus studiert mit heissem Bemühn;
Da steh' ich nun, ich armer Wicht:
Nichts Gewisses weiss ich nicht![15]

Faust is depicted as a proud, even vain, figure, one who is deeply dissatisfied by what he has learnt and what physics can offer. Mephistopheles tries to tempt Faust

[13] The Blegdamsvej Faust is on microfilm 66 of the Archive for the History of Quantum Physics (American Philosophical Society). An English version, together with the illustrations, is in Gamow, *Thirty Years That Shook Physics*, pp. 165–218. Canaday also provides a detailed discussion with excerpts in German; this quotation is from *The Nuclear Muse*, p. 87.

[14] Cited in Canaday, p. 80.

[15] Ibid., p. 91.

by convincing him to accept one of quantum physics' more outlandish theories, specifically Pauli's own idea of the neutrino, a particle without mass or charge. If once he can make Faust say to such a theory, 'Verweile doch! Du bist so schön!', then he has won his wager with God.

At times the play is anarchic, even Dadaist, in its celebration of the bizarre world of quantum theory. But in the 1930s the new physics was itself full of weird and wonderful notions. Niels Bohr once greeted one of Pauli's theories with the comment: 'We are all agreed that your theory is crazy. The question, which divides us, is whether it is crazy *enough* to have a chance of being correct. My own feeling is that it is not crazy enough.'[16] The audience of the physicists' *Faust* were not surprised, therefore, when The Group Dragon and Donkey-Electrons appeared on stage in the Quantum Mechanical Walpurgis Night. Other bizarre characters to appear on stage in this display of weird and wonderful quantum theories included The Spin of the Photon and the Gauge Invariant. As British physicist Paul Dirac says in the play, 'our theories, gentlemen, have run amok'.[17]

After this scene, Mephistopheles ushers a press photographer on stage and it is this that is Faust's undoing. The physicists transform Faust's death scene at the end of Goethe's play into a moment of supreme bathos. Paul Ehrenfest utters Faust's famous dying words, just as he is about to be immortalized by the photographers:

> *Faust*: höchst entzückt, stellt sich für den Pressenphotographen in Positur:
> Zum Augenblicke möcht' ich sagen:
> Verweile doch, du bist so schön!
> Es bleibt die Spur von meinen Erdentagen
> Doch in den Zeitungen bestehn![18]

Although humour was the last thing in Goethe's mind as he penned this poignant scene, in the physicists' version of *Faust* it becomes a wonderfully witty moment, albeit with serious undertones. The physicists are making fun of their colleagues' vanity and self-importance. Indeed, by highlighting the theme of fame, they were making an important point: in the coming years nuclear physicists would enter the public eye and feature ever more frequently in the media.

As the physicists' *Faust* suggests, in 1932 a new age of science was dawning and, as actors on the world's stage, scientists would be increasingly forced to drop the mask of the saviour which popular culture had hitherto made them wear. Instead, as they were drawn ever closer to the government and the military, they began to be feared by the public and eventually viewed as 'mad scientists'. To be depicted as Dr Strangelove would be the eventual price of the physicists' Faustian bargain. Indeed, one physicist featured in the play would rival even Einstein's fame after Hiroshima and Nagasaki: Robert Oppenheimer.

Another physicist who would enter the media spotlight this year made a brief appearance at the end of the play as Faust's over-ambitious famulus, Wagner. James Chadwick is portrayed by his fellow physicists as 'die Personifikation des idealen

[16] Bohr cited in Robert Ehrlich, *Eight Preposterous Propositions*, Princeton, 2005, p. 5.

[17] Gamow, p. 207.

[18] Cited in Canaday, p. 100.

Experimentators'. He walks on stage after Faust's death scene wearing the scientist's trademark lab coat and balancing a black ball on one finger:

Neutron, es schwankt heran,
Masse, sie lastet dran,
Ladung, sie ist vertan,
Pauli, er glaubt daran![19]

This rather sinister figure at the end of the play was announcing an extraordinary discovery, one of which Faust himself would have been proud. James Chadwick had found one of the basic constituents of matter: the third elementary particle after protons and electrons, the neutron.

I think the parallels here between Wagner and Chadwick, as well as the neutron and the homunculus, are wonderfully suggestive. Goethe used the scene in Wagner's laboratory both to belittle alchemy's supposed achievements and to criticize mechanistic science. If he had lived to see the science of the next century, Goethe would no doubt have been deeply sceptical of the value of phenomena such as the neutron that relied utterly on instruments and theories for their discovery, just as he was of Newton's experiments with light. Yet the discovery of the neutron, just before the Copenhagen conference, was a seminal achievement for modern nuclear physics. Its discovery made possible Leo Szilard's idea in the following year, of a self-sustaining chain reaction. This in turn opened the door to the atomic bomb. It is a powerful reminder that the tragedy of Goethe's *Faust* was about to be played out on a world stage. Clearly, the lessons of Goethe's science had still to be learnt by the scientific community.

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'At different times', said Leo Szilard during the height of the cold war, 'different physicists have been given the dubious honor of being called the "father of the atomic bomb". But in truth, the father of the atomic bomb was no physicist — he was a dreamer and a writer.'[20] His name was H. G. Wells.

In earlier works, Wells had predicted tanks, fantastic heat rays and gas-filled missiles. In his novel *The World Set Free*, written in 1913, he imagined a weapon that would transform warfare and the history of the world — the atomic bomb. Wells coined the phrase 'atomic bomb'. He was inspired by the fascination with radioactivity in the early years of the twentieth century, out of which also came the figure of the 'saviour scientist' in popular fiction.

In his novel, Wells describes an atomic war taking place in 1956, in a decade he did not live to see, but which did indeed face the threat of atomic doomsday. Wells's atomic war ravages the earth. Over two hundred cities across the world, from Chicago to Tokyo, are reduced to radioactive wastelands. This global atomic holocaust is, as Wells says, the Last War. Wells's true purpose, however, is not to show us the end of the world, but the origins of a Utopia built on the power of the

[19] Ibid., p. 104.

[20] Szilard speaking in 1956, the year of Wells's Last War; cited in David A. Grandy, *Leo Szilard: Science as a Mode of Being*, Lanham, Md, 1996, p. 139, n. 43.

atom. The invention of the atomic bomb, predicts Wells, would make war redundant. It would 'set the world free'. The story Wells tells is about humanity being reborn in the elemental fires of the atomic bombs. It is a story that is almost alchemistic in its symbolism of a journey through fire to wisdom, through war to peace, and to Utopia.

Leo Szilard read *The World Set Free* in 1932, the year in which the atom began to reveal its secrets and the physicists performed *Faust*. This was the year that Chadwick discovered the neutron and two of his colleagues at the Cavendish Laboratory, John Cockcroft and Ernest Walton, created a machine to smash an atom. As physicist Hans Bethe has said, 1932 was the year in which atomic physics was born. When Szilard began reading *The World Set Free*, his mind was uniquely primed to receive both the scientific and the social message of Wells's novel. I would argue that this is one of the clearest examples of fiction influencing science. Wells's novel supplied one of the sparks needed to make Szilard's mind burst into creativity. And, as the fuse burnt in his mind, Europe descended into chaos; the countdown to war had begun.

When Hitler became Chancellor in spring the following year, Leo Szilard saw the writing on the wall and fled Germany. He caught a train first to Vienna and then to London, where he helped establish and run the Academic Assistance Council, which dedicated itself to helping academics who were fleeing from the Nazis. He lived in Russell Square, at the Imperial Hotel, just across from where we are this evening. For the scientist who once said, 'there is no place as good to think as a bathtub', what made the hotel irresistible were its famous Turkish baths.[21]

Ironically, while Szilard was living on the square, another 'doomsday man' arrived from Germany — Fritz Haber, the scientist who thought his chemical superweapons would turn him into Germany's saviour scientist in the First World War. Haber stayed at the rather more upmarket Hotel Russell, which is still there by Russell Square tube station. Unfortunately, the original Imperial Hotel has gone and been replaced with a modern building.

Both Szilard and Haber were talking to Professor Frederick G. Donnan at University College London about an academic position. Szilard came with the best possible references from some of the greatest physicists of the age, including Einstein, Max von Laue, and Schrödinger. Even Faust had recommended him: Paul Ehrenfest had sent Donnan a warm personal testament. Tragically, within weeks of writing the letter of recommendation, Ehrenfest committed suicide. According to the note he left, one reason for his suicide was his despair at the incomprehensible quantum realm.

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Late in the morning on Tuesday 12 September 1933, Leo Szilard was sitting in the lobby of the Imperial Hotel reading *The Times*. The paper had devoted two of its lead columns to a scientific conference at which Ernest Rutherford was speaking. His speech on transmuting the atom was reported almost word for word. Szilard never forgot how annoyed he became as he read that article. Rutherford claimed that the

[21] Spencer R. Weart and Gertrud Weiss Szilard (eds), *Leo Szilard: His Version of the Facts — Selected Recollections and Correspondence*, Cambridge, Mass., 1978, vol. 2 of Szilard's *Collected Works*, p. 19 (Hereafter cited as CW, 2).

dream of atomic energy was mere 'moonshine'. Most people would have been content to accept the word of this distinguished atomic researcher. But not Szilard. The fact that Rutherford said it was impossible made Szilard determined to prove him wrong. He took to his feet that morning to think the problem through, leaving the hotel lobby and setting off into the grey light of a September day in London.

As he walked the streets of Bloomsbury, he suddenly realized how to liberate the energy of the atom. 'I remember,' said Szilard later, 'that I stopped for a red light at the intersection of Southampton Row' (CW, 2, 17). As the traffic lights changed and the cars stopped, the physicist stepped out in front of the impatient traffic. And in that moment, Leo Szilard saw how to release the energy locked up in the heart of every atom: a self-sustaining chain reaction created by neutrons.

> As I was waiting for the light to change and as the light changed to green and I crossed the street, it suddenly occurred to me that if we could find an element which is split by neutrons and which would emit two neutrons when it absorbed *one* neutron, such an element, if assembled in sufficiently large mass, could sustain a nuclear chain reaction. I didn't see at the moment just how one would go about finding such an element, or what experiments would be needed, but the idea never left me. In certain circumstances it might become possible to set up a nuclear chain reaction, liberate energy on an industrial scale, and construct atomic bombs. The thought that this might be in fact possible became a sort of obsession with me. (CW, 2, 17)

Szilard spent the winter writing up his explosive ideas. As he did so he was also thinking about Wells's *The World Set Free*. We know this because he sent an extract from Wells's novel to an industrialist who he thought might finance his research. The pages he sent are some of the most evocative in Wells's novel. They concern a scientist, Holsten, and his discovery of how to release the energy of the atom. 'Of course, all this is moonshine,' Szilard told the industrialist, echoing Rutherford, '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*.'[22] Significantly, when it came to the future of atomic energy, Szilard sided with the novelists, rather than the physicists.

H. G. Wells's scientist in *The World Set Free*, Holsten, was born in 1895, just three years before Leo Szilard. Holsten is a Faustian scientist. He is, writes Wells, 'possessed by a savage appetite to understand'.[23] Faust wanted to know 'was die Welt / Im Innersten zusammenhält' (ll. 382–83). Holsten discovered that secret by setting up 'atomic disintegration in a minute particle of bismuth' (*The Last War*, p. 18). This explosive reaction, in which Holsten is slightly injured, produces radioactive gas and gold as a by-product. Thus the quest of the alchemists is over — gold can now be created on demand. But Holsten has also discovered something far more valuable than even gold:

> from the moment when the invisible speck of bismuth flashed into riving and rending energy, Holsten knew that he had opened a way for mankind, however narrow and dark it might still be, to worlds of limitless power. (ibid., p. 18)

[22] Szilard to Sir Hugo Hirst, from 6 Halliwick Rd, London, 17 March 1934; CW, 2, 38.

[23] H. G. Wells, *The World Set Free: A Story of Mankind*, 1914; repr. as *The Last War*, Lincoln, 2001, p. 13.

When Holsten realizes the implications of what he has found, his mind is thrown into turmoil. Like Szilard, he goes for a walk to help him think. But his knowledge now sets him apart from the people he passes on the street. It makes him feel 'inhuman', like an outsider in his own country. Wells writes:

> All the people about him looked fairly prosperous, fairly happy, fairly well adapted to the lives they had to lead, — a week of work and a Sunday of best clothes and mild promenading — and he had launched something that would disorganize the entire fabric that held their contentments and ambitions and satisfactions together. (ibid., p. 20)

In what is one of the most powerful moments in the book, Holsten then meets an old school friend who is out walking his dog. Holsten tries hard to tell his friend 'the wonder of the thing' he has discovered. But the gulf in understanding between the scientist and the ordinary man in the street is unbridgeable (ibid., p. 21).

These scenes in Wells's novel are powerfully reminiscent of the scene in Goethe's *Faust*, 'Vor dem Tor'. Before he signs his fateful pact with Mephistopheles, Faust walks with Wagner among his fellow citizens. It is a holiday and there is dancing and singing. Suddenly, Faust is struck by the poignant thought that he will never be like these ordinary people. He will always be an outsider. His intense, almost physical, desire for knowledge and understanding isolates him from the trials and joys of everyday life. 'Zwei Seelen wohnen, ach! In meiner Brust', cries the tormented Faust. 'Die eine hält, in derber Liebeslust, / Sich an die Welt mit klammernden Organen': one part of him knows the 'joyous earthy lust' of physical experience. But 'Die andre hebt gewaltsam sich vom Dust / Zu den Gefilden hoher Ahnen', a hauntingly beautiful expression of intellectual yearning — the desire for knowledge, for science. Faust, the archetypal scientist, has tasted the forbidden fruit. Now he cannot rest, but must engage in a lifelong quest for knowledge, even if the price of that be self-destruction.

Similarly, on his walk, Holsten passes the carefree Sunday strollers, a fallen man mingling with the innocent. In his head is the knowledge that will quite literally bring the world they know to an end. He sees himself as 'a loose wanderer from the flock returning with evil gifts from his sustained unnatural excursions amidst the darknesses and phosphorescences beneath the fair surfaces of life' (Wells, *The Last War*, p. 23). In the context of my research into the origins of the dream of the super-weapon, Holsten is the Doomsday Man personified, the destroyer of worlds, as Oppenheimer described himself after the Trinity atomic test in 1945. But the moral crisis Holsten experiences is also Faust's. Indeed, it is the dilemma facing all scientists in the modern age.

Leo Szilard was similarly overwhelmed by the historic nature of his *Eureka!* moment. Like Holsten, he trod the streets of Bloomsbury with the knowledge of life and death, of good and evil, seething in his brain:

> He was oppressed, he was indeed scared, by his sense of the immense consequences of his discovery. He had a vague idea that night that he ought not to publish his results, that they were premature, that some secret association of wise men should take care of his work and hand it on from generation until the world was riper for its practical application [. . .] (Wells, *The Last War*, p. 21)

These are Holsten's thoughts, but this could just as well be Szilard walking round Russell Square in 1933, twenty years after Wells was writing. Like Holsten, Szilard now faced a terrible decision: whether to make public his discovery and risk his ideas being exploited to create atomic weapons, or whether to keep his fatal knowledge secret. In the end, Holsten decides: 'I am a little instrument in the armoury of Change. If I were to burn all these papers, before a score of years had passed some other man would be doing all this [. . .]' (ibid., p. 23). This self-justification has become familiar in the modern technoscientific world. Science (so the argument goes) is not the product of one mind alone, as is art or literature. It is a Leviathan whose steady progress is the result of many minds. Suppressing the findings of one scientist is futile. It is only a matter of time before another will make that same discovery.

But Leo Szilard decided to try to stop the scientific Leviathan. Unlike Holsten, Szilard would eventually opt for secrecy, a decision that offended the beliefs of most of his fellow scientists. Rather than write up his idea in a scientific paper for publication, Leo Szilard worked out the details of critical mass and a self-sustaining chain reaction with neutrons, and then patented it. In 1935, he gave the patent to the British Admiralty on condition of absolute secrecy. He then spent six years trying to prevent Hitler's physicists from discovering his secret and making an atomic bomb. Not until 1939 would Szilard see the experimental proof of his idea, late one February evening in a Columbia University laboratory in New York. The rest — as they say — is history.

After the war, Leo Szilard left physics and retrained in biology. He spent the post-war years campaigning for arms control and for world peace. He died in 1964. Later that year, Edward Teller, the scientist chiefly responsible for the hydrogen bomb, wrote about his friend and fellow Hungarian. He compared Szilard to a famous sixteenth-century alchemist: 'I cannot but think of that legendary, restless figure, Dr Faust, who in Goethe's tragedy dies at the very moment when at last he declares he is content.'[24] For both the designer of the H-bomb and the man who contributed so much to the development of the atomic bomb, Faust's pact with the devil remains a powerful symbol of the dangers of scientific knowledge acquired without a parallel gain in self-knowledge. The physicists, it appeared, still had much to learn from both Faust and Goethe.

[24] Edward Teller, writing in *Disarmament and Arms Control* (Autumn 1964), p. 453.