Published in part in *Angewandte Chemie* (*International Edition*) **44**, 3957 (2005) and **45**, 4053 (2006).

Fritz Haber (1868-1934)

Bretislav Friedrich

Fritz-Haber-Institut der Max-Planck-Gesellschaft

Faradayweg 4-6, D-14195 Berlin, Germany

bretislav.friedrich@fhi-berlin.mpg.de

On January 29, 1935, a "purely internal and strictly private" memorial service was to be held in Harnack House, the faculty club and conference center of the Kaiser Wilhelm Society, in Berlin-Dahlem. Max Planck, the Society's president, picked up Otto Hahn, the designated orator, at his office at the Kaiser Wilhelm Institute for Chemistry. The directive prohibiting all members of the Kaiser Wilhelm Society to enter Harnack House that morning was posted on the notice board. As Hahn recollected [1]:

> Planck was, however, excited and pleased that the ceremony will take place in spite of all the odds, unless perhaps on our short walk [to Harnack House] a group [of thugs] sent by the [Nazi] Party will try to prevent us from entering by force. But nothing happened … The lovely large reception hall of Harnack House … was full. … Most of those present were women, the wives of Berlin professors [or] of members of the Kaiser Wilhelm Society … They came as representatives of their husbands who had been prevented by a brutal prohibition from bidding their final farewell to an important person and scientist.

The "important person and scientist" Hahn referred to was Fritz Haber. Effectively banished from Germany for "opposing the National Socialist State," Haber had died a year earlier to the day in exile.

> Privy councilor Planck gave the introductory address, pointing out that had Haber not made his magnificent [ammonia synthesis] discovery, Germany would have collapsed, economically and militarily, in the first three months of World

> War I. … The two main speeches, by myself and [Karl Friedrich] Bonhoeffer, dealt with Haber's personal side, the significance of his famous institute [the Kaiser Wilhelm Institute for Physical Chemistry and Electrochemistry], as well as his scientific work. As … Bonhoeffer was not able to be present – had been forbidden to come – I read Bonhoeffer's manuscript in his name.

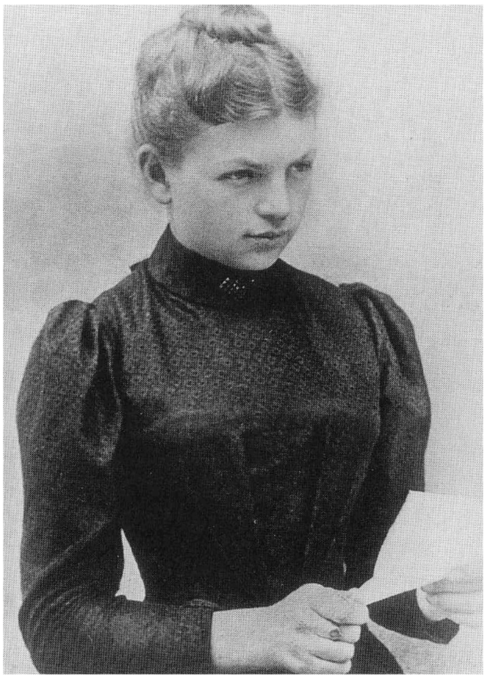
However telling Hahn's and Bonhoeffer's long-lost orations may have been, it remained a recalcitrant problem for Haber's colleagues, historians, and lay public alike to come to grips with Haber's complex and contradictory legacy. In an obituary, published in *Naturwissenschaften* in 1934 [2], Max von Laue predicted that Haber would be primarily remembered as the inventor of the synthesis of ammonia from its elements, a process that revolutionized chemical industry and, through its use in the production of fertilizers, provided nourishment for billions of people. Apart from yielding "bread from air" (as von Laue called it), the ammonia synthesis also afforded the production of "gunpowder from air," its primary employment at the time, which drove the implementation, on an industrial scale, of what's known as the Haber-Bosch process (the Leuna Werke of the Badische Anilin- und Sodafabrik, BASF, became fully operational as late as 1916 [3]). However, what has interfered with von Laue's prediction most destructively was Haber's promotion of the first weapons of mass destruction. Driven by his patriotic zeal and acting under the credo "In peace for mankind, in war for the fatherland!" Haber devoted himself and his Kaiser Wilhelm Institute to the development of "poison instead of air" – to chemical warfare.

The work of the historian in sorting out the triumphs, failures and paradoxes of Haber's life has been greatly facilitated by the endeavor of one of Haber's former coworkers, Johannes Jaenicke, who headed the unsuccessful "gold from seawater" project. Jaenicke assembled a total of 2290 items related to Haber's life and bequeathed them to the Archive of the Max Planck Society. Jaenicke's collection is a historian's goldmine. So far it has been tapped only by the chemist/historian Dietrich Stoltzenberg [3] and the historian Margit Szöllösi-Janze [4]. Their complementary, award-winning accounts provide a high-resolution image of Haber's life and times.

Fritz Haber was born in Breslau, Prussia (today Polish Wroclaw) on December 9, 1868, to a family whose forbears can be traced back to the beginning of the 1800s. His father was a wealthy merchant dealing in dyes and pharmaceuticals, with far-reaching family and business connections. His mother died in childbirth. The female element in Fritz's childhood was mainly represented by his three stepsisters, from his father's second marriage. Fritz's strongest early influence was his uncle Hermann, a liberal who ran a local newspaper to which Fritz had later contributed. Uncle Hermann also provided space, in his apartment, for Fritz's early chemical experiments. Fritz's interest in chemistry may have been ignited by his father, who possessed some chemical expertise. At that time, Fritz was attending a humanistic high-school (gymnasium), closely affiliated with the largest protestant church in Breslau, St. Elisabeth's. Half of its pupils were Jewish, as was Fritz. Instead of an apprenticeship that would prepare him for taking over the family business, Fritz, with some help from uncle Hermann, was able to prevail upon his father and go to college. Aged 18, he entered Berlin's Friedrich-Wilhelms-Universität (now the Humboldt University) to study chemistry and physics, drawn to both fields by the towering figures of August von Hofmann and Hermann von Helmholtz. The next year, he spent at Robert Bunsen's Institute in Heidelberg, only to return to Berlin to study organic chemistry under Carl Liebermann at the Technische Hochschule Charlottenburg (now the Technical University Berlin). Haber also developed a bent for philosophy, especially Kantian, under Wilhelm Dilthey. He graduated *cum laude* in 1891 from the Friedrich-Wilhelms-Universität with a PhD thesis on piperonal (an indigo derivative) under Hofmann. Upon his return to Breslau, he was uncertain about what to do next. On his father's urging, he took several "apprentice jobs" in chemical industry.

Fritz Haber, shortly after his graduation in 1891

This was a watershed for Haber, as he discovered some pressing deficiencies in his education, particularly in chemical technology. Thus he went to the ETH Zurich, in 1892, to work under Georg Lunge, a family friend, and to Jena, where he became research assistant to Ludwig Knorr. From Jena, Haber applied for a research assistantship with the physical chemist Wilhelm Ostwald, whose field was then regarded as the basis of both chemistry and chemical technology. Despite several attempts, he never got the job, just a single disappointing interview. Ostwald never warmed up towards Haber. During his time in Jena, Haber, at age 25, converted to Christianity, likely fired up by Theodor Mommsen's essay (written in reaction to Heinrich von Treitschke's antisemitic article) to foster the newly fledged German unity: Germans were to abandon "those loyalties and affiliations that divided them." In the Spring of 1894, he moved to the Technische Hochschule Karlsruhe, where he was to stay for the next seventeen years. He started as assistant to the professor of chemical technology, Hans Bunte, habilitated as Privatdozent in 1896, became *extraordinarius* in 1898, and was finally named full professor, of physical chemistry, in 1906. Haber never attended a single lecture on physical chemistry (apart from his own), as he later admitted with glee [5].



Clara Haber, nee Immerwahr,
whom Haber married in 1901

In Karlsruhe, during the "first heyday period" of his career, Haber developed a remarkably diverse research program. As Stoltzenberg emphasizes and exemplifies [3], this ranged from chemical technology, to electrochemistry, to gas-phase chemistry.

Haber's crowning achievement was the synthesis of ammonia from its elements. The need to find new ways of replenishing agricultural soil with nitrogen in a form that can be metabolized by plants was articulated, in 1898, by William Crookes (who also coined the term "fixation," as in fixing a date between nitrogen and hydrogen), and was widely perceived as a challenge. A number of people before Haber could have laid a claim to coming up with the idea for a direct "fixation" of nitrogen, such as William

Ramsey, Le Chatelier – or Ostwald, who actually did. Ostwald wrote about it in his 1920 autobiography [6]:

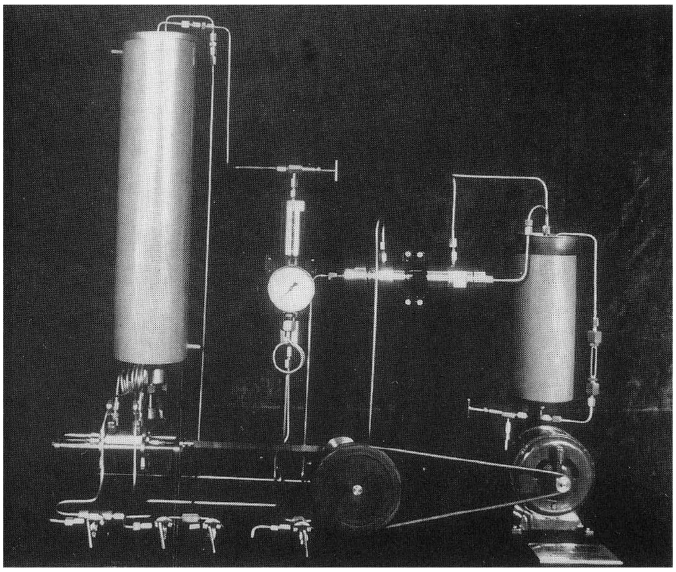
> As the expert immediately recognizes, the basic ideas for the synthesis of ammonia … had been clearly and unambiguously stated [in March 1900; the ideas comprised elevated temperature and pressure, a copper or iron catalyst, and recirculation of the nitrogen and hydrogen gases]. Thus I am justified in calling myself the intellectual father of [the ammonia] industry. I have certainly not become its real father, for all the difficult … work needed to create a technologically and economically viable industry from the right ideas was carried out by those who took on the abandoned infant.

Haber had first studied the ammonia equilibrium in 1903, in response to a query from the Österreichische Chemische Werke. The equilibrium constant that Haber found at normal pressure and a temperature of about 1000ºC was way too low (corresponding to a 0.0044% yield of ammonia) for a direct synthesis from the elements to be of any commercial use. Haber later commented [7]:

> If one wished to obtain practical results with a catalyst at normal pressure, then the temperature must not be allowed to rise much above 300ºC. … The discovery of catalysts which would provide a rapid adjustment of the point of equilibrium in the vicinity of 300ºC and at normal pressure seemed to me quite unlikely.

And indeed, no such catalysts were ever found. Although the effects of elevated temperature and elevated pressure on the yield of the reaction had been well established by that time (in 1905), Haber put the ammonia research on the back burner, due to its anticipated technical difficulty.

But then two events in 1908 compelled Haber to turn the heat on the ammonia problem again [7]: First, he caught a glimpse of an industrial procedure that was making use of a gaseous reaction under heat and elevated pressure; second, Haber was sharply attacked by Walther Nernst, who claimed in talks and in writing that Haber's equilibrium constant was "far from the truth." Nernst reached this conclusion based on his measurements of the heat capacities of the reagents and products, which, aided by Nernst's heat theorem, he then related to the equilibrium constant. Haber's reaction to Nernst's onslaught was shrewd: he remeasured the heat capacities himself – and found them in agreement with his value of the equilibrium constant. Furthermore, along with Robert Le Rossignol, who came from Ramsey's lab, he explored the so far neglected high-pressure range. Le Rossignol and Haber found that at a pressure of about 200 atmospheres and a temperature of 600°C, a yield of about 18% could be obtained, with the aid of an osmium catalyst. Haber lived through his *eureka* moment, when synthetic ammonia had begun to drip, with the words "There's ammonia!"



Haber-Le Rossignol ammonia synthesis apparatus

In the industrial-scale Haber-Bosch process, developed by Carl Bosch and his coworkers at BASF, an iron catalyst was used instead of osmium. This added an entirely unexpected twist. Haber commented on it, in 1910 [8]:

> [It] is remarkable how … new special features always come to light. Here iron, with which Ostwald had first worked and which we later tested a hundred times in its pure state, is now found to function when impure.

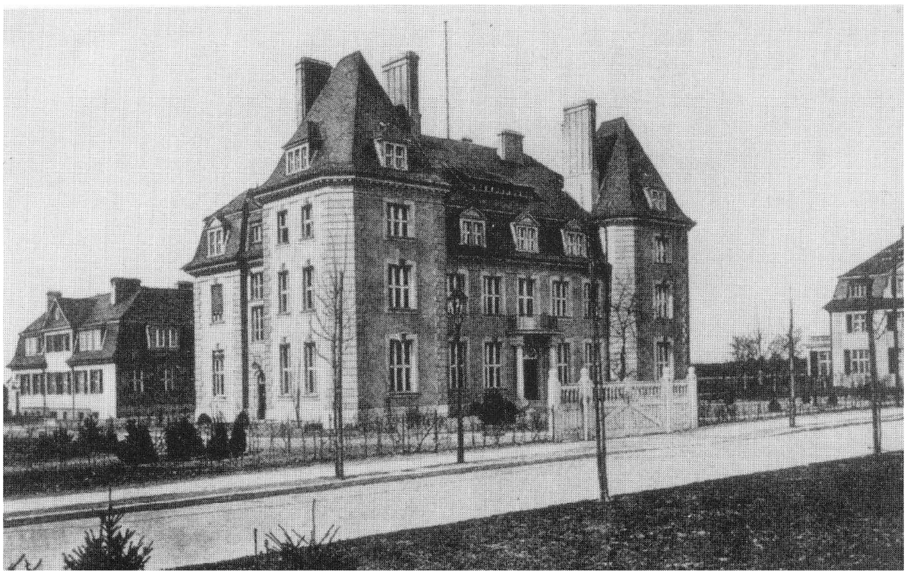
Bosch had made use of water-gas hydrogen which introduced the beneficial impurities … Later, Nernst's unexpected favorable testimony became instrumental for awarding the ammonia patent to BASF and to Haber [3]. In turn, the agreement between the predictions of Nernst's theorem and Haber's data played a role in recognizing the theorem's value and helped secure, in 1920, a Nobel prize for Nernst [9].

Haber's Department at the Technische Hochschule Karlsruhe (1908)

Meanwhile, in Berlin, a group of prominent chemists, including Nernst, Ostwald, and Emil Fischer, pondered on creating an elite institution dedicated to research in chemistry. Aided by their contacts with the Prussian official Friedrich Schmidt-Ott and the Kaiser's personal friend, the distinguished theologian Adolf von Harnack, they developed the idea for what was to become the Kaiser Wilhelm Society (now the Max Planck Society) for the promotion of all sciences. The society came into being in 1911, and its first two institutes were inaugurated by Wilhelm II in 1912 in Berlin-Dahlem. One of them was the Kaiser Wilhelm Institute for Physical Chemistry and Electrochemistry, funded from an endowment donated by the banker and entrepreneur Leopold Koppel. On the recommendation of Svante Arrhenius and under pressure from Koppel, Fritz Haber was invited to become its first director. It was an offer that Haber couldn't resist: Haber was guaranteed a generous operating budget, the status of a state official, professorship at the Berlin university, and membership in the Prussian

Academy. The Institute was designed to Haber's image by the chief imperial architect, Ernst von Ihne, and included a director's mansion that served as Haber's residence. As Stoltzenberg put it [3]:

> [Haber's] influence depended as much on his scientific success as it did on the perfect fit between his own career and the spirit of the times.



Kaiser-Wilhelm-Institut für Physikalische Chemie und Elektrochemie (cca 1912). Haber's mansion is on the right.

In late 1913, Berlin's academic luster got even brighter as Albert Einstein arrived on the scene, to direct the Kaiser Wilhelm Institute for Physics. Haber and Einstein quickly developed a rather close relationship. Einstein's personal circumstances – his increasingly dysfunctional marriage with Mileva – may have fostered the closeness with Haber who, at times, even acted as an intermediary between Einstein and his wife. This and much more has been recently rendered by Thomas Levenson [10]. There was also a scientific interaction between the two. According to a Berlin legend, Haber called upon Einstein "to do for chemistry what he [Einstein] did for physics." After all, Einstein's first paper and his thesis dealt with molecules …

The era of peace and prosperity that Prussia had enjoyed for 43 years came to an end with the outbreak of the Great War. Its first salvos were echoed by verbal exchanges between the academics of the warring parties. This "war of the spirits" [11] took a lethal form once the scientific communities became ensnarled in promoting and developing new weapons systems, in breach of the ethos of the *Republique des Lettres* – and, eventually, of international law. Haber's initiative to develop chemical weapons and his involvement in their deployment remain among the best examples of the breach of both. Brought to glistening prominence by Germany's need to produce "gunpowder from air," Haber, backed by the profiteering chemical industry, was able to persuade his country's military leadership to stage a battlefield test of a chemical weapon. Fischer, who foresaw the proliferation of chemical weapons as a necessary consequence of their first use "wished for [Haber's] failure from the bottom of [his] patriotic heart" [3].

Haber on the front during WWI

On April 22, 1915, a 6 km stretch of the front at Ypres, Belgium, was exposed to 167 tons of chlorine released from 5,700 gas cylinders, and carried towards the British and French trenches by a long-awaited wind. The chlorine cloud, which passed through the front within a few minutes, left behind at least 5,000 casualties. Among the 1,000 dead were also Germans, hit by the inherently inaccurate weapon. The attack was repeated two days later under more favorable conditions, causing another 10,000 casualties and 4,000 dead. The New York Times reported on April 26, 1915:

> Some [soldiers] got away in time, but many, alas, not understanding the new danger were not so fortunate and were overcome by the fumes and died poisoned. Among those who escaped, nearly all cough and spit blood, the chlorine attacking the mucous membrane. The dead were turned black at once … [The Germans] made no prisoners. Whenever they saw a soldier whom the fumes had not quite killed they snatched away his rifle … and advised him to lie down 'to die better'.

The lethality of the chlorine attack at Ypres lured the German military into adopting chemical warfare. Haber was promoted, by an imperial decree, to the rank of captain.

Among those who had not shared the military's and Haber's exaltation was Haber's wife Clara, whose life was traced by Gerit von Leitner [12]. Trained as a physical chemist (PhD in 1900, presumably the first awarded to a woman), Clara grew increasingly frustrated with her designated role of a housewife. When she discovered her husband's involvement in chemical warfare – which she regarded as "an abomination of science and a sign of barbarism" – her marriage took the appearance of a pointless sacrifice. The night that Haber sported his self-designed chemical uniform and celebrated the first use of a weapon of mass destruction, Clara committed suicide. She shot herself, with Haber's army pistol, in the garden of their mansion. According to von Leitner, Haber, under his daily allowance of sleeping pills, didn't hear the shots. Clara was found dying by their 13 year old son Hermann. Haber, unable to secure a permission to stay, left the next day for the Eastern front, to join what was to become his "Pionierregiment," a unit charged with the deployment of chemical weapons.

Haber advertised the first use of a chemical weapon as an important milestone in the "art of war" – and saw its psychological effect as key [13]:

> All modern weapons, although seemingly aimed at causing the death of the adversary, in reality owe their success to the vigor with which they temporarily shatter the adversary's psychological strength.

Apart from developing additional chemical agents at his Kaiser Wilhelm Institute (such as phosgene and the contact poison LoSt, named for Haber's coworkers Lommel and Steinkopf), Haber introduced the procedure of "Bunteschiessen" (variegated shelling), which consisted of first deploying "Maskenbrecher" – irritants based on organic arsenides that penetrated all available filters and forced those under attack to remove their gas masks – and subsquently of shelling with poisons such as phosgene or LoSt (better known as mustard gas or yperite).

Otto Dix: German gas attack (1924)

Haber argued that chemical warfare was more "humane" than the conventional one, as it would shorten the war. However, it was Fischer who got things right: the Entente retaliated with its own chemical arsenal within a few months. At the end of WWI, about 25% of all artillery shells were filled with chemical agents. Chemical warfare thus became a complete failure militarily, providing no advantage to either party. It only increased the already unspeakable suffering of the troops (mainly draftees) on both sides of the front (according to Quincy Wright's count [14], a total of 92,000 soldiers were killed and 1.3 million injured with chemical weapons). What put finally an end to the war was the economic collapse of Germany. The photograph of a circus elephant hauling an empty hay-cart through snow-covered Berlin reminds us of the level of Germany's exhaustion. Einstein's pacifist view contrasted sharply with Haber's: "Warfare cannot be humanized. It can only be abolished."

Berlin, cca 1917

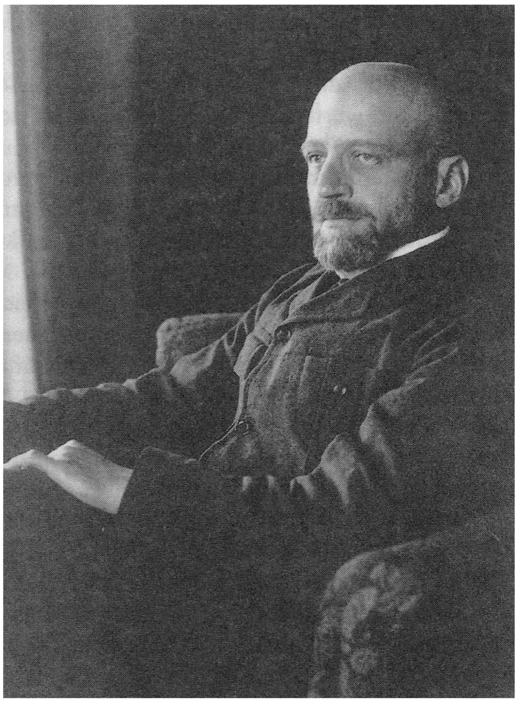
According to Szöllösi-Janze [4], after the armistice, the victorious powers published a list of about 900 alleged war criminals, with Haber's name among them. In response, Haber put aside his "chemical" uniform, grew a beard, and fled to Switzerland, where, in the hope of securing immunity from prosecution, he acquired the citizenship of St. Moritz. Unexpectedly, the Allies dropped the charges soon thereafter (presumably because of the complicity of their own academic establishments in the illegal war effort), and so Haber returned to Berlin and to his Institute.

In 1920, the Swedish Royal Academy dropped a bombshell: it announced the 1914-1919 Nobel Prizes, five of which were awarded to elated Germans: to Max von Laue, Richard Willstätter, Max Planck, Johannes Stark – and Fritz Haber, who received the 1918 Chemistry Prize, "for the synthesis of ammonia from its elements." The indignation of the French and British was boundless …

As Stoltzenberg put it [3]:

> … the laudatory address [by the president of the Swedish Royal Academy] is remarkable for its omissions: although he described in detail the significance of the ammonia synthesis for agriculture, he made no mention of its significance for the explosives industry …

One may add that Haber happily followed suit in his Nobel lecture – and left out the issue of "gunpowder from air" as well. There was no mention, by anybody, of Haber's involvement in chemical warfare.



Fritz Haber, cca 1919/1920

But Haber was involved in chemical warfare even as he spoke at the Nobel ceremony [3, 4]: in 1919 Germany launched a secret program to continue the development and production of chemical weapons, under

Haber's tutelage. In order to avoid inspections instituted by the Versaille treaty, the program had been moved to third countries, one of them being the Soviet Union. Stoltzenberg's father, Hugo, was in charge as Haber's proxy. Haber's involvement came to an end only in 1933, when he fell out of grace. The chemical weapons production lines in Germany were converted, in part, to accommodate the manufacture of fumigants, legal under Versaille. The necessary research & development was provided by Haber and his Institute. Among the agents then developed was probably also "Zyklon B," later used in the Nazi extermination camps to poison millions of people, mainly Jews, among them several members of Haber's family.

Between 1920-1926, Haber toiled on the patriotic "gold from seawater" project. The hyperinflation that beset Germany in 1923 must have contributed to Haber's drive. But the concentration of gold in seawater (averaging roughly 10 ppt) turned out to be about a thousand times smaller than what would have been needed for making its extraction profitable, so the project had to be scrapped. In 1927, Haber broke up with his second wife, Charlotte, whom he had married in 1917. Charlotte described aspects of her life with Haber in an autobiography [15]. They had two children, Eva and Ludwig. Ludwig (Lutz) became a historian of chemistry, and produced a volume on chemical warfare [16].

The period 1926-1933 was largely dedicated to pioneering basic research – and, as Stoltzenberg put it [3], "can be described as the second heyday of Haber's life." Haber hired a great number of young first-class researchers and gave free rein to their pursuits. Here's how Paul Harteck, the co-discoverer, with Bonhoeffer, of para-hydrogen, characterized Haber's leadership during "the second heyday" period [17]:

> Haber, by his personality, set the tone at the institute. He was wise enough to know that one had to give the group leaders and also the keen young members of the

> institute a far-reaching scientific freedom [in order] to create an atmosphere of free scientific thinking and enterprise.

At the same time, Haber was able to secure adequate funding, mainly through his contacts with industry; BASF was among the principal sponsors. Funding was also provided by the Notgemeinschaft der Deutschen Wissenschaft (later Deutsche Forschungs-gemeinschaft), which Haber co-founded, together with Schmidt-Ott, in 1920.

The diversity and quality of the work done at Haber's Institute is astounding. Although physical chemistry remained the principle subject, the themes pursued ranged from fundamental physics to physiology. The embryonic quantum mechanics, on the minds of physicists and physical chemists from the 1910s on, "ushered in the new structural era (and spawned chemical physics)," as Dudley Herschbach described it in his 1986 Nobel lecture [18]. Haber's Institute was instrumental in pushing the departure from thermochemistry, by then complete, towards the study of structure.

In 1916, Haber hired Herbert Freundlich, well known for his work on gas absorption; Freundlich did later pace-setting work in colloid chemistry. Two years later, James Franck joined the institute, to further unfold his research on electron scattering, launched earlier in collaboration with Gustav Hertz; among Franck's coworkers were Walter Grotrian, Paul Knipping and Hertha Sponer, who all reached prominence later on. Rudolf Ladenburg laid the foundations of the quantum theory of dispersion, and related it to atomic structure. Michael Polanyi pioneered gas-kinetic studies and, with collaborators such as Eugene Wigner and Henry Eyring, developed basic theoretical devices of reaction dynamics, in anticipation of the dynamics era that succeeded the structural era in the late 1950s. Wigner (Polanyi's PhD student and an "apprentice" of the mathematician Karl Weissenberg), deployed group theory and symmetry arguments in general across quantum mechanics. Hartmut Kallmann studied ionization of molecules by slow electrons, outlined the basic principles of a heavy-ion linear accelerator, and, together with Fritz London, provided a quantum-mechanical description of energy transfer between atomic systems. Bonhoeffer, Harteck, and Ladislaus Farkas (the last of whom later founded the first school of physical chemistry in Israel) tackled the kinetics of free radicals and undertook studies of flames and of autoxidation. Farkas and Bonhoeffer established a connection between the diffuse bands in the electronic spectra of ammonia with predissocciation and interpreted the bands' widths in terms of the energy-time uncertainty relation. Hans Kopfermann and Ladenburg demonstrated negative dispersion in a neon gas discharge tube as evidence of stimulated light emission. The last pet-theme of Haber's was the decomposition of hydrogen peroxide catalyzed by iron salts … This much for a sampling of key results obtained during the "second heyday."

The Institute was also famous for its bi-weekly colloquia, moderated by Haber, often with Einstein, Hahn, von Laue, Otto Warburg, and Leonor Michaelis (to name just a few) in the front row. The colloquia were highly interdisciplinary, covering subjects "from the helium atom to the flea."

Stoltzenberg characterizes Haber's attitude towards his work – and what he considered his duties – as follows [3]:

> The outmost exertion, often to the limits of his physical strength, was a constant habit throughout his life. He could never totally relax, and he found idleness unbearable. His mind had to be constantly in use.

Haber made several social commentaries that were as apt in his time as they are today. In particular, he believed that Germany had to vigorously foster science if the German-style welfare state were to remain in place.

The happy period ended in 1933. With the Nazis at the helm, Germany "was done with the Jew Haber" – in the words of Bernhardt Rust, the *Reichserziehungsminister*. One is reminded of Einstein's jibes aimed at his good friend Haber, such as "that pathetic creature, the baptized Jewish

Geheimrat [privy councilor]" [10]. As an institute director, Haber found himself under the obligation to implement Hitler's "Law for the Restoration of the Professional Civil Service" of April 7, 1933, and fire all twelve of his coworkers of Jewish descent (according to Stoltzenberg's count). Among these were Farkas, Freundlich, Kallmann, and Polanyi. Haber had soon recognized that what remained for him to do was to help find jobs abroad for his dismissed coworkers - and to quit. He handed in his resignation letter on April 30, 1933, in which he firmly stated that racial considerations were inconsistent with his approach to academic appointments. Haber's resignation fired up Max Planck who made an attempt at saving Haber's institute from dissolving, first by pleading with Rust, and subsequently by asking Hitler, in person, to intercede with the Minister. As Planck later vividly recollected [19], Hitler didn't budge, and embellished his refusal with a satanic tantrum worthy of a furious Führer.

As Stoltzenberg recounts [3], the nets that Haber had spread on his own behalf brought him job offers from Japan, Palestine, France, and Britain. Haber decided for the last – and accepted the invitation of Sir William Pope to join him at Cambridge University. During his two-month stay there, he may have lived through his last happy moment in science: a reunion with some of his Dahlem coworkers. As Kallmann recollected "a scientific discussion [unfolded] more wonderful than you can imagine" [20].

Haber also had a standing invitation from Chaim Weizmann to come to Palestine and take a position at the nascent Daniel Sieff Institute (later the Weizmann Institute), in Rehovot. Weizmann, preoccupied with establishing Jewish academic institutions in Palestine, visited Haber in Dahlem in 1932 – and was impressed by Haber's Institute to the point that he modeled the Sieff Institute on Haber's. Moving to Palestine became a serious temptation for Haber in the last months of his life, although his correspondence from that period suggests that he wasn't ready yet to give up on his German identity and homeland and move far away from either [3]. Rita Crakauer, Haber's secretary and "the soul of the Institute," later became Weizmann's secretary.

Haber's English sojourn was also a reunion of sorts with his estranged European colleagues, many of whom had held a grudge against him or even had boycotted him for his involvement in chemical warfare, most prominent among them Ernest Rutherford.

The harsh English winter that year took a toll on Haber's fragile health; he let himself be persuaded to set out on a south-bound journey, but not as far as Palestine, since a long trip could have further aggravated his condition. On his departure from Cambridge, Haber left behind a letter in which he spoke of the "chivalry from King Arthur's time still [living] among [English] scientists" [3].

Farewell gathering of Haber's institute (1933)

In this time of humility and contrition, before leaving Cambridge, Haber drafted his testament. In it, he expressed his wish to be buried alongside his first wife Clara – in Dahlem if possible, or elsewhere "if impossible or disagreeable," and to have the following words inscribed on his grave "He served his country in war and peace as long as was granted him." Haber's son Hermann, the will's executor, later admitted that he "never found out how [Haber really] meant it" [21].

Haber died on January 29, 1934 in Basel, Switzerland, on a journey "south," without a clear destination, in the presence of his personal physician, Dr. Rudolf Stern, of a heart attack [22]. He was buried there. In accordance with his will, Clara's ashes were reburied beside his. There's no credo inscribed on the couple's gravestone.

The gravestone of Fritz and Clara Haber in Hörnli, Basel, Switzerland

Einstein's words read like an epitaph to Haber [23]:

> At the end, he was forced to experience all the bitterness of being abandoned by the people of his circle, a circle that mattered very much to him, even though he recognized its dubious acts of violence. … It was the tragedy of the German Jew: the tragedy of unrequited love.

We may amend what Einstein had said: despite the ambiguity grounded in Fritz Haber's work, his love is no longer unrequited in Germany: on Max von Laue's suggestion, Haber's institute in Berlin was named, in 1952, for its founding director. Haber is also remembered in Israel: the library of the

Sieff (Weizmann) Institute in Rehovot holds the Haber Collection, acquired through a private book donation from Haber. And the Hebrew University in Jerusalem cherishes its Fritz Haber Center for Molecular Dynamics, created in 1981 and named so to honor Haber's legacy.

Those who wish to meet Fritz Haber may find him almost alive in Stoltzenberg's and Szöllösi-Janze's fine biographies.

Acknowledgments: I'm grateful for comments and suggestions kindly provided to me by Gerhard Ertl (Berlin), Peter Gölitz (Weinheim), Eckart Henning (Berlin), Dudley Herschbach (Cambridge, Massachusetts), Karsten Horn (Berlin), Friederike Jentoft (Berlin), Emily Kröger (Warwick), Gerard Meijer (Berlin), and Wieland Schöllkopf (Berlin).

References:

1. Otto Hahn: *Zur Erinnerung an die Haber-Gedächtnisfeier vor 25 Jahren* (Mitteilungen der Max-Planck-Gesellschaft **1**, 3 (1960).
2. Max von Laue: Naturwissenschaften **22**, 97 (1934).
3. Dietrich Stoltzenber: *Fritz Haber. Chemiker, Nobelpreisträger, Deutscher, Jude* (Wiley-VCH, Weinheim, 1994); also *Fritz Haber: Chemist, Nobel Laureate, German, Jew* (Chemical Heritage Press, Philadelphia, 2004.)
4. Margit Szöllösi-Janze: *Fritz Haber: 1868-1934* (C.H. Beck, München, 1998); the book also lists Haber's scientific papers.
5. Johannes Jaenicke: *Fritz Haber (1868-1934)* (Fridericiana, Heft 35, Universität Karlsruhe).
6. Wilhelm Ostwald: *Lebenslinien: Eine Sebstbiographie* (Berlin: Klasing, 1920).
7. http://nobelprize.org/chemistry/laureates/1918/haber-lecture.html
8. Haber to BASF, 14 January, 1910 (Archiv zur Geschichte der Max-Planck-Gesellschaft, Dept. Va, Rep. 5, 664).
9. Diana Kormos Barkan: *Walther Nernst and the Transition to Modern Physical Science* (Cambridge University Press, 1999).
10. Thomas Levenson: *Einstein in Berlin* (Bantam Books, New York, 2003).
11. Stefan L. Wolff: Physiker in 'Krieg der Geister' (Münchner Zentrum für Wissenschafts- und Technikgeschichte, 2001).
12. Gerit von Leitner: *Der Fall Clara Immerwahr* (C.H. Beck, München, 1993).

13. Fritz Haber: *Fünf Vorträge aus den Jahren 1920-1923* (Berlin: Springer, 1924).

14. Quincy Wright: *A Study of War* (Chicago: The University of Chicago Press, 1964).

15. Charlotte Haber: *Mein Leben mit Fritz Haber: Spiegelungen der Vergangenheit* (Econ, Düsseldorf, 1970).

16. Lutz Haber: *The Poisonous Cloud: Chemical Warfare in the First World War* (Oxford University Press: Oxford, 1986).

17. Paul Harteck: Journal of Chemical Education **37**, 462 (1960).

18. http://nobelprize.org/chemistry/laureates/1986/herschbach-lecture.html

19. Max Planck: Physikalische Blätter **3**, 143 (1947).

20. Hartmut Kallmann: *Fritz Haber, in memoriam* (Archiv zur Geschichte der Max-Planck-Gesellschaft, Dept. Va, Rep. 5, 1285).

21. Herrman Haber to J.A. Coates, 11 April 1933 (Archiv zur Geschichte der Max-Planck-Gesellschaft, Dept. Va, Rep. 5, 664).

22. R. Stern: Fritz Haber: Personal Recollections," in Yearbook of the Leo Baeck Institute 1963 (Leo Baeck Institute, New York, 1963).

23. A. Einstein to Hermann and Marga Haber, as quoted by D. Charles, in Master Mind (HarperCollins, New York, 2005), p. 239.