The Scientist as Expert: Fritz Haber and German Chemical Warfare During the First World War and Beyond

Margit Szöllösi-Janze

Abstract In the course of the First World War, scientists who would in peacetime generate new knowledge assumed the role of experts, i.e., professionals who made extant knowledge accessible to non-scientist clients. The deepest conviction of Fritz Haber, the 1918 Chemistry Nobel laureate, was that problems faced by mankind could be solved by means of science and technology. Herein, Haber is interpreted as a personification of an early German expert culture. Acting as both mediator and organizer, Haber coaxed politicians, generals, industrial leaders, and scientists to join forces in developing new processes for the mass-production of war-relevant chemicals and in establishing large-scale industries for their manufacture. Among the chemicals produced were poison gases—the first weapons of mass extermination. Haber's leadership resulted in a conglomerate of enterprises similar to what we now call "big science". In close contact with "big industry", traditional science was transformed into a new type of applied research. With borderlines between the military and civilian use blurred, Fritz Haber's activities also represent an early example of what we now call "dual use". He initiated modern pest control by toxic substances, whereby he made use of a military product for civilian purposes, but went also the other way around: During the Weimar era, he used pest control as a disguise for illegal military research. Having emerged under the stress of war, scientific expertise would remain ambivalent—a permanent legacy of the First World War.

The first major poison gas attack, at Ypres, on April 22, 1915 is irrevocably linked with Fritz Haber, the 1918 Nobel laureate in chemistry. The developments that connect the place, time, and person, are paradigmatic. They had their origins in the late nineteenth century and came to full fruition in the Great War. They shaped new trends that would leave a deep imprint on the twentieth century. Rather than

M. Szöllösi-Janze (✉)
Ludwigs-Maximilians-Universität, Munich, Germany
e-mail: Margit.Szoelloesi-Janze@lrz.uni-muenchen.de

B. Friedrich et al. (eds.), *One Hundred Years of Chemical Warfare: Research, Deployment, Consequences*, DOI 10.1007/978-3-319-51664-6_2

describing at length Haber's life,[1] this contribution will focus on the impact of those trends on the ways in which the German physical chemist influenced future developments. More than any other person, Haber embodies the ambivalence of the modern scientist who has been praised as a benefactor of mankind and, at the same time, accused of being a war criminal. His scientific work transformed both food production and warfare. He was not just an eminent intellectual, but also belonged to the select group of experts who shaped in fundamental ways the functioning of modern societies in war.

With the outbreak of the First World War in 1914, the impact of Haber's research on warfare became increasingly apparent. We can differentiate two important strands of his activities, the first concerning the production of explosives. Cut off from its major supply of natural nitrates by the British blockade, Germany suffered a serious munitions crisis after only a few months of trench warfare. The Haber-Bosch process, for which Haber laid the scientific foundation, provided a large-scale supply of synthetic ammonia and thereby of nitric acid, its oxidation product. Haber was actively involved (technically, but also politically) in the development of the production facilities such as the huge chemical factory in Merseburg/Leuna (Szöllösi-Janze 2000a).

In the following, I will focus on the second strand of Haber's activities: as a physical chemist, Haber's main research focus was on the reactions of gases. This expertise had placed him at the centre of Germany's preparations for introducing an entirely new weapon—poison gas. I will condense my considerations into some major points.

1. The declarations of war in 1914 provided new spaces of warfare. Those spaces came about as a result of a massive use of science and technology which, in turn, were profoundly transformed by the war experience.

The battlefields of the First World War constitute a space extended into all three dimensions (Trischler 1996). Trench warfare created a new geometry of the battlefield that included new zones: no-man's-land in the crossfire of the artilleries, the widely branching system of trenches, wire fences, supply lines, the hinterland used for the necessary logistics. Extending warfare into the air and below the surface of the seas added the hitherto unknown experience of three-dimensional warfare, which developed its own dynamics. The experience of war was total: it took possession of all spatial dimensions.

Science and technology had a significant impact on these developments. In the three decades preceding the war's outbreak, railway systems had increased troop mobility. Telephone, telegraph, and radio improved communications. The military use of aircraft—not just balloons, but also the newly developed zeppelins and aeroplanes—as well as submarines added a new physical dimension to warfare.

[1]Some recent biographies on Haber are available in German and/or English: see Stoltzenberg (1994, 2004). Daniel Charles' more popular biography (Charles 2005) was published under different titles in the US and the UK with the same content. In what follows I will mainly refer to my own book (Szöllösi-Janze 1998, reprinted 2015).

None of these new weapons or technologies decided the course of the war. But they marked a turning point on the way to modern warfare. Not only did changes already underway speed up considerably but also completely new developments emerged because the total war forced the belligerents to find novel solutions to completely new challenges.

2. The integration of new spaces into warfare led to a formerly unknown convergence of the state, the military, the economy, and of science. In all belligerent nations, these developments were anything but visible at the beginning of the military confrontation.

As Jeffrey Allen Johnson underscored, in pre-war Germany, "the academic-industrial symbiosis still primarily consisted of its classical core", meaning personal ties between industrial chemists and their colleagues in academe, mutual research support and the "educational link", meaning the supply of trained manpower from the universities to a growing, science-based industry (Johnson 2000, 17–18). Johnson and MacLeod came to a similar assessment concerning the development of military technology. Areas such as munitions testing, military education, military medicine, and the technical disciplines within the military sector had long been established. However, as both authors also noted, "in no European country was there provision for the mobilization of scientific expertise, nor did anyone anticipate such mobilization to be necessary for a war that was expected to be short and fought with conventional military technologies" (Johnson and MacLeod 2002, 170).

Stagnation on the Western front meant that within a few months Germany faced multiple deepening crises, notably in areas such as access to raw materials and resources, munitions production, famine at the so-called "home front", and, last but not least, politics. Under the pressure of having to win this war, no matter what the circumstances and no matter what the cost, economy turned into wartime economy based on regulation, rationing, and technology. "War is a technological forcing house"—that's how Lutz Haber, an economic historian and Fritz Haber's son, called his chapter on the history of the chemical industry in the First World War (Haber 1971, 184, 208). The progressive integration of external technical and scientific expertise into decision-making transformed the style and methods of government. Advisory committees, personal councils and consolidated advisory task forces proliferated in a very short time. Such processes affected all belligerents, if at different times and in different ways. The national "styles of scientific thought" (Harwood 1993), which reflected the characteristics of each country's scientific cultures, went obviously hand in hand with national styles of scientific expertise.

3. In the course of the First World War, scientists and other academics adopted new roles as producers and re-producers of knowledge relevant to warfare.

Experts, and in particular their status, legitimacy, and control, have been the subject of heated sociological debates for decades (see Etzemüller 2009; Kohlrausch et al. 2010). Herein, I argue that the First World War contributed significantly to the emergence of the experts as a social stratum of intermediaries between the rulers and the ruled. In view of the rapidly evolving demands of modern warfare, only scientifically trained experts were able to maintain an overview over the extant knowledge in their fields. They were in a position to assess how science could contribute to the war effort by having the insights needed in industrial product design and manufacture. Through their advice, they placed themselves at the intersection between the military, the administration, and the industry. In this way, scientific experts started playing a highly significant intermediary role in society. They were anything but passive, but on the contrary actively helped to define possible solutions to all war-related military and social problems. Expert cultures mediating but also actively influencing government decision-making arose in all warring parties. This was particularly true for Germany. During the war, the traditional system of scientific research underwent rapid institutional change and functional differentiation. With state support, a whole system of highly centralized, closely linked research institutes, university seminars, and industrial laboratories had emerged.

4. Fritz Haber was among the first and most important scientists who offered their expert services to civil and military decision-makers.

Haber was by far not the only one to do so. Many scientists offered their help, and among those who did so, chemists played a prominent role. This demonstrates that the catchphrase about the reportedly "mandarin tradition" of autonomously researching German professors (Ringer 1969), originally coined in the humanities, is not appropriate for the sciences. Rather, it should make way for a more differentiated view of the transformation of the German academic community into a new type of scholarly self-understanding, which accelerated especially after 1914 (Johnson and MacLeod 2002, 176–177).

In hindsight, Haber's importance grew from his networking mind-set, which affected the ways in which he thought, communicated and acted. In support of modern warfare, he first had to establish the basic cooperation between the state, the military, the economy, and the scientific establishment. In April 1918, Haber quite consciously reflected on his role:

> Before the war, this relationship was incomplete. The general would live on the *bel étage* and would politely greet the scholar who lived in the same building, but there was no internal connection. For mediation, he would use the services of the industrialist who lived in that house as well (Haber 1918, 197).

Establishing this "internal connection" between the scholar, the general, and the industrialist was Haber's central aim during the war years.

5. Fritz Haber as a scientific expert had to simultaneously fulfil the triple role of mediator, organizer, and innovator.

The relative weight of the roles could vary depending on the task at hand (Szöllösi-Janze 2000b), but in the case of Haber's involvement in poison gas warfare, they played out as follows:

First, mediation[2]: Haber's research activities in physical chemistry led to the development of large-scale industrial solutions. From this long-term cooperation with BASF, he knew the different viewpoints and spoke the different jargons of both the industrialists and the scientists. During his time at the Kaiser-Wilhelm-Institute in Berlin, he also learned how to deal with political decision-makers. In wartime, Haber became something of a communications interface. He broke down communication barriers, translated the needs and aims of one party into the jargon of another, devised possible solutions drawn from his own scientific discipline, and applied these to large-scale crash programs. No institutions initially possessed such mediating abilities, which underscored the importance of individual experts.

Secondly, organization: as an organizer, the scientific expert goes beyond his role of just establishing communication. He aims to make communication and cooperation permanent, by establishing institutions and finding practical applications. In Germany, sharp borders between different academic fields existed. Haber succeeded in making the borders permeable: he would embody the interconnection among pure science, applied science, technical development, and a practical application. Although initially driven by wartime demands, such institutional cooperation was clearly intended to persist beyond the war's end.

Thirdly, innovation: this term describes Haber's contribution to the emergence of a modern type of scientific research. Later known as big science, it refers to a different way of organizing the research process. It grew out of the long-term cooperation among the state, the military, the economy, and the scientific establishment. However, politically networked, large-scale research had an immediate bearing on both the substance and the way of doing research.

6. The first use of poison gas at Ypres in April 1915 reflected Haber's early success as a mediator, organizer, and innovator.

As a simple volunteer advisor to the war ministry, Haber quickly understood the impact of the new spaces and dimensions of warfare. The layered system of trenches, dug outs, and command posts protected soldiers relatively well from conventional weapons. Chlorine gas, being heavier than air, would not just poison the surface of the battlefield but also sink into the structures built underground. Trenches and underground facilities would not be safe any longer. Haber also understood how to utilize the technological and scientific potential of large-scale chemical industry for military purposes and how to establish the necessary contacts. Of course he was aware that the German chemical industry produced and consumed toxic compounds for manufacturing intermediaries or for civilian goods. The chemical plants required only little adaptation to produce warfare agents: the carrier systems were common oxygen cylinders, distribution was well established, and budgeting was assured. The formerly export-oriented dye companies transformed themselves into producers of nitrates, explosives, and chemical weapons (see

[2]See Emil Fischer for another outstanding mediator among German chemists (Moy 1989).

Johnson 2000, 23). Haber was furthermore aware of the number of highly qualified German chemists. Their problem-solving skills easily translated from improving dyes to developing explosives or poison gas. An estimated 1,000 scientists supported Germany's poison gas efforts towards the end of the war, 150 of whom worked at Haber's own institute. The industrial laboratories employed most of them: Bayer alone had 200 chemists on its payrolls (Martinetz 1996, 30; MacLeod 1993).

Finally, Haber knew how to sell the potential contribution of science to warfare even to the mostly hesitant or dismissive military leaders. In doing so, he helped to permanently integrate science into warfare—even though its impact never reached the amplitude or acquired the strategic importance he had been hoping for. With warfare becoming more industrialized and technological, the officer corps underwent professionalization that resulted in growing numbers of officers with a technical education or scientific interest. Science and technology turned the German military, as Michael Geyer put it, into "a complex corporation for the highly efficient production of violence" (Geyer 1984, 99). Moreover, specialized military units began to emerge. Haber easily persuaded his military interlocutors that well-trained, specialized troops were needed to handle poison gas safely and reduce risk of its employment to their own troops. They were to become the so-called "Gas Pioneers". To this end, he enlisted physicists, chemists, biologists, engineers, and meteorologists who readily exchanged the boredom of the trenches for the excitement of becoming experts in a novel mode of warfare. They included future Nobel laureates and eminent scientists such as Otto Hahn, James Franck, Gustav Hertz, Hans Geiger, Wilhelm Westphal, and Erwin Madelung. Only future Nobel Prize winner Max Born refused all offers to take part in chemical warfare, instead preferring the less brilliant field of developing radio equipment for air planes (Born 1975, 235, 261).

7. The ways in which Fritz Haber organized his activities led him to adopt novel approaches to research: big science.

To use chemistry as a metaphor: Haber played the role of a catalyst in forcing the existing, at first rather reluctant elements—state authorities, military, industry, and science—to blend in a fierce chemical reaction that unleashed its own dynamics. This dynamics had an impact on research itself. Haber developed a complex, goal-oriented style of research that aimed for politically relevant results. Many well-resourced teams of scientists and technicians from different fields worked systematically and on long-term basis on a given project. Interdisciplinary research removed the formerly impermeable borders between different scientific fields in ways similar to how the erstwhile sacrosanct boundaries between pure science, applied science, technical development, and industrial mass production would disappear (see as an example Trischler 2001, 80–83). But we can put on our record that Haber's approach was in many respects a nucleus of modern big science. Its immediate impact was to lay to rest the idea of the Humboldtian German professor conducting autonomous research in utter freedom and splendid isolation. Whether this idea ever reflected a reality (see Paletschek 2001) does not matter here. In any case, the First World War pretty much buried the Humboldtian concept.

The poison gas project employed several interdisciplinary teams of scientists, engineers, lab technicians, and auxiliary employees. Each team bore responsibility for its specific sub-projects and, interestingly, enjoyed relative freedom of research within the overall program. In 1916, Haber's Kaiser-Wilhelm-Institute came under military command (for the following, see: Szöllösi-Janze 1998, 333, 438–439). By September 1917, its budget had increased 50-fold over peacetime levels. It comprised nine departments, six of which were researching offensive chemical warfare, including the projection of new warfare agents, the analysis of enemy agents, research in toxicology and pharmacology, and the generation of aerosols. Several teams specialized in the control of the risky large-scale production of warfare agents, gas munitions and gas mine launchers. The remaining three departments worked on gas defense and protection. Besides chemists, the teams included physicists, biochemists, pharmacologists, physicians, veterinarians, zoologists, botanists, and meteorologists, and were supported by engineers, explosives experts, medical officers, and technicians. Together with the auxiliary and temporary staff, the Kaiser-Wilhelm-Institute employed some 2,000 people.

The big science type structures of research in Haber's institute faced their share of criticism among colleagues: "I hope the lion does not lay its hand on our modest department", complained Lise Meitner who worked next door to Haber at the Kaiser-Wilhelm-Institute for Chemistry, "the Haber people treat us of course like conquered territory; they take whatever they want, not what they need" (in Charles 2005, 169).

8. Fritz Haber's commitment to the German war effort always implied plans to apply his wartime experiences to the future.

Haber always tried to transfer the results from poison gas research to future civilian uses. In a programmatic talk to officers of the War Ministry on November 11, 1918, he explicitly coined the phrase that his motivation was "to turn the means of extermination into sources of new prosperity". But he also realized that to apply his capacity for networked solutions to large-scale problems over a longer time, he had to maintain the all-important interaction between the state, military, economic and scientific communities (Haber 1924, 28–29). I will mention just one example.

Still during the war, Haber found immediate peacetime application of his poison-gas research in chemical pest control (for the following, see Szöllösi-Janze 2001). The German population suffered from famine as a consequence of the Allied blockade. Pests in countless mills and granaries aggravated the food situation further. With the help of his military personnel experienced in handling poisonous gases, Haber developed new methods for rooting out harmful pests. His teams organized systematic regional "gassing cycles" of mills and granaries and developed suitable operational techniques and systems to implement them all over the country. However, it was a typical ploy to consciously exploit the dual-use nature of the science and technology underlying gas warfare.

Already in the final phase of the war, Haber pursued the idea to continue military poison gas research under the pretence of civilian pest control. He was quite aware that the victorious Entente would prohibit any further military research, and he wanted to avoid anything that could be used as a pretext to close down his Institute as a whole. He pulled off an ingenious coup when he succeeded in transferring his institute's pharmacological department to the unsuspected Biological Reich Institute for Agriculture and Forestry (Biologische Reichsanstalt für Land- und Forstwirtschaft). There, it could hide under the cover of the laboratory for physiological zoology. Haber was able to raise generous anonymous funds to finance additional scientific and technical staff, new buildings, laboratory animals, and testing equipment. A deeper look into the sources reveals that he carried out a top-secret transfer of considerable funds from the German military, the Reichswehr, to the Biological Reichsanstalt. These funds covered the running costs of its physiological laboratory, which developed and tested poison gases not only for pest control, but also for military purposes. The long-term deal was initiated and arranged by Haber, whose role as mediator and organizer can hardly be overestimated (Szöllösi-Janze 1998, 452–467; 2001).

The dual use of poisonous gases for pest control, however, implied also an application which was absolutely beyond Haber's imagination. For it was within this far-reaching network of institutions, engaged covertly or overtly in research on toxic gases, that scientists developed processes to handle cyanides for pest control without the risk of harm to the technical staff. Among the substances they developed, there were Cyclon A and later the infamous Cyclon B, whose potential for dual use shows the tragic ambivalence of Haber's commitment. Cyclon B was a result of the conversion of military into civil poison gas research. Only some twenty years later, it was used against human beings as a means of mass extermination in the extermination camps. Haber was convinced that he could keep the interconversion of poison gas research under control, but in the Age of Extremes (Eric Hobsbawm), this was not possible.

9. "I was one of the mightiest men of Germany"—the technological imperative.

Many commentators have explained Haber's extensive involvement in the German war effort by pointing to his burning patriotism. He was indeed convinced that Germany had been pulled into the war against its will and was waging it for a just cause. Almost all other German scientists shared this view; they were, however, less intensely involved. It cannot have been mere patriotism, then, even though Haber also appeared to have felt a very "Prussian", state-oriented sense of duty and had a keen interest in the military. He also volunteered the services of his institute in support of the German cause, just like many other scientists. He showed initiative when approaching military leaders to offer his assistance. In line with his classical education, he saw a role model in Archimedes, who was said to have served "the progress of mankind in peace, but his home in wartime" (Haber 1920, 352).

In my view, his sense of power played a larger role for Haber than his patriotism. He was well aware of the power that the expert-scientist wielded as an intermediary between the ruling and the ruled. Especially during the first half of the war, the role of experts was informal—they connected with individuals rather than with institutions and stood outside formal bureaucratic structures. It was precisely this informality that they were able to use to their advantage. Scientific experts were flexible enough to take on tasks that cut across fields, including the early stages of policy advice (see Fisch and Rudloff 2004). Haber typified this transformation. As director of the Kaiser-Wilhelm-Institute for Physical Chemistry and Electrochemistry, he presented himself as a war volunteer who described his function simply as "adviser to the war ministry". He thus offered his scientific expertise and network of connections in an act of patriotic self-mobilization for the German war effort. Only later during the war, he became gradually integrated into the military-governmental apparatus. At the same time, he was perfectly aware of the fact that he was not only influential but also in control of a sector relevant to modern technological warfare. In hindsight, in August 1933, he reflected on his earlier power:

> I was one of the mightiest men in Germany. I was more than a great army commander, more than a captain of industry. I was the founder of industries; my work was essential for the economic and military expansion of Germany. All doors were open to me (Weizmann 1950, 437).

Haber's exercise of power went hand in hand with a technocratic mind-set— and a technocratic rhetoric. He was convinced that there was a scientific and technological solution to all societal problems. As a technocrat through and through, the demands of modern warfare challenged him intellectually. He was fascinated by the opportunities offered by modern science and technology to solve political, military, and economic problems. His notable ability for networking and strategic thinking served his remarkable creativity in addressing desperate situations. Typically, in one of his few remarks about his personal involvement in chemical warfare, Haber transpires as a gambler who had been provoked, with an almost physical sensation of risk, to play and win big in the game of high-tech warfare. In a letter to Carl Duisberg from February 1919, he wrote that he felt challenged to apply his own "scientific imagination" to future problems of warfare and find possible solutions at the forefront of scientific and technological progress. He portrayed conventional warfare dominated by artillery as a simple game of checkers that "turned into chess by poison gas warfare and the defence against it".[3]

So, is the scientific expert ultimately a mere technocrat fascinated by gambling at the large board of modern mass warfare?

10. As a key player in the high-tech combat of chemical warfare, Haber was aware of the underlying "human factor".

[3]Haber to Carl Duisberg, 26 February 1919. Abt. V, Rep. 13 (Haber Collection), no. 860, Archives of the Max Planck Society, Berlin.

It is no coincidence that the First World War accelerated the development towards the "scientification", the *Verwissenschaftlichung* that brought along with it the idea that the "human factor" is measurable. As a result, military leaders from all belligerent countries discovered the utility of the new discipline of psychology for their ways and means, such as intelligence tests in the US and the "psycho-technical" surveys of aircraft pilots in Germany (Raphael 1996, 174–176; Geuter 1984). Fritz Haber was highly conscious of the strong psychological dimension of chemical warfare. Like others, he used a specific gas warfare discourse. He rejected the suggestion that poison gas use was "unchivalrous" as initially argued by traditionally minded officers. On the contrary, he underlined that chemical weapons were more "humane" than conventional weapon technology, since their wide-spread use would shorten the war. This is, of course, a first-strike rhetoric. History did not bear out this argument, because weapon innovation set in motion an endless dynamics of increasingly lethal weapon technologies. It is well known that less than twenty-four hours after the German chlorine cloud attack at Ypres, the British commander in France and Belgium, Sir John French, sent a telegram to London:

> Urge that immediate steps be taken to supply similar means of most effective kind for use by our troops. Also essential that our troops should be immediately provided with means of counteracting effect of enemy gases which should be suitable for use when on the move (In Charles 2005, 164; Schmidt 2015, 26–28).

Haber's insight into the psychological dimension of chemical warfare went deeper yet. It was common knowledge—also among the Allied Forces—that poison gas war could unsettle the morale of the troops as well as on the home front (Schmidt 2015, 23). But Haber reflected on the impact of gas on the frontline soldier in a specific way. To him, the toxicity of chemical warfare agents was less relevant than the fact that the chemicals forced troops to wear respirators and use other protective devices. This demanded, as he wrote to Carl Duisberg, "better leadership and higher military ability".[4] The conviction that chemical warfare demanded a higher mind-set led to a curious expression of social Darwinism in Haber as well as in many other proponents of chemical warfare—just to mention Colonel Max Bauer, Haber's military protector, who used to ruminate on the "selection of the fittest" through poison gas warfare.[5] In this sense, Haber viewed chemical warfare primarily as a quest for psychological superiority. In modern scientific war, he wrote, the "psychological imponderables" are decisive.

> A strict selection divides the men capable of withstanding pressures thanks to this gas discipline and fulfilling their military duties from the inferior mass of soldiers who break up and leave their battle position (Haber 1924, 36, 39).

[4]Haber to Carl Duisberg, 26 February 1919. Abt. V, Rep. 13 (Haber Collection), no. 860, Archives of the Max Planck Society, Berlin.

[5]See Max Bauer's Memorandum (1918) in Brauch and Müller (1985, 81).

"Gas discipline" as a means to select the fitter soldiers from inferior ones—this is twentieth-century social Darwinism at its best.[6]

Fritz Haber, however, was also the product of the nineteenth century. His personal duty was to remain loyal to the state and to commit himself unconditionally to the German cause. Even if his personal conviction had been different, Haber would not have questioned the German agenda, including chemical warfare. Just like millions of others, he never asked himself who exactly had set that agenda. For his personal morality, he relied on the presumed morality of the state, which he never doubted. His son, Lutz Haber, later described his father as "a Prussian, with an uncritical acceptance of the State's wisdom, as interpreted by bureaucrats" (Haber 1986, 2). The British physical chemist J. E. Coates discerned one of Haber's most important characteristics in his wish "to be a great soldier, to obey and be obeyed […] autocratic and ruthless in his will to victory" (Coates 1951, 146).

So Daniel Charles is quite right when he deems that Haber wasn't much preoccupied with the morality of his innovation because it arose from "a kind of technological imperative", which he viewed as "simply inevitable". Charles also correctly points out that Haber's vision was strictly limited to the battlefield. He never anticipated the possibility that future warlords would use poison gas or other weapons of mass destruction against civilian populations. "In this respect", Charles concludes, "Fritz Haber's imagination remained trapped in the nineteenth century" (Charles 2005, 174).

References

Born, Max. 1975. *Mein Leben. Die Erinnerungen des Nobelpreisträgers*. Munich: Nymphenburger Verlagsanstalt.

Brauch, Hans Günter, and Rolf-Dieter Müller (eds.). 1985. *Chemische Kriegführung—Chemische Abrüstung. Dokumente und Kommentare*. Berlin: Verlag Arno Spitz.

Charles, Daniel. 2005. *Master mind: The rise and fall of Fritz Haber, the Nobel laureate who launched the age of chemical warfare.* New York: Harper Collins; *Between genius and genocide: The tragedy of Fritz Haber, father of chemical warfare*. London: Jonathan Cape.

Coates, J. E. 1951. The Haber Memorial Lecture. Delivered before the Chemical Society on April 29th, 1937. In *Memorial Lectures Delivered before the Chemical Society 1933–1942,* vol. IV, ed. F. G. Donnan, 127–157. London: The Chemical Society.

Etzemüller, Thomas, ed. 2009. *Die Ordnung der Moderne. Social Engineering im 20. Jahrhundert.* Bielefeld: Transcript.

Fisch, Stefan, and Wilfried Rudloff (eds.). 2004. *Experten und Politik: Wissenschaftliche Politikberatung in geschichtlicher Perspektive*. Berlin: Duncker & Humblot.

Geuter, Ulfried. 1984. *Die Professionalisierung der deutschen Psychologie im Nationalsozialismus*. Frankfurt: Suhrkamp.

Geyer, Michael. 1984. *Deutsche Rüstungspolitik 1860–1980*. Frankfurt: Suhrkamp.

[6]However, the phrase of gas warfare as "a higher form of killing," which has been repeatedly attributed to Haber since Harris and Paxman's study of 1982, cannot be found in the sources (see in detail Schmidt 2015, 484–485).

Haber, Fritz. 1918. Das Verhältnis zwischen Heereswesen und exakten Naturwissenschaften. *Chemiker-Zeitung* 42/no. 49 (24 April): 197.

Haber, Fritz. 1920. Die chemische Industrie und der Krieg. *Die chemische Industrie* 43: 350–352.

Haber, Fritz. 1924. Die Chemie im Kriege (November 11, 1918). In *Fünf Vorträge aus den Jahren 1920–1923*, ed. Fritz Haber, 25–41. Berlin: Julius Springer.

Haber, Ludwig F. 1971. *The chemical industry 1900–1930: International growth and technological change*. Oxford: Clarendon Press.

Haber, Ludwig F. 1986. *The poisonous cloud. Chemical Warfare in the First World War*. Oxford: Oxford University Press.

Harwood, Jonathan. 1993. *Styles of scientific thought. The German genetics community 1900–1933*. Chicago, IL: University of Chicago Press.

Johnson, Jeffrey A. 2000. The academic-industrial symbiosis in German chemical research, 1905–1939. In *The German chemical industry in the twentieth century*, ed. John E. Lesch, 15–56. Dordrecht/Boston/London: Kluwer Academic Publisher.

Johnson, Jeffrey A., and Roy MacLeod. 2002. War work and scientific self-image. Pursuing comparative perspectives on German and allied scientists in the Great War. In *Wissenschaften und Wissenschaftspolitik. Bestandsaufnahmen zu Formationen, Brüchen und Kontinuitäten im Deutschland des 20. Jahrhunderts*, ed. Rüdiger vom Bruch and Brigitte Kaderas, 169–179. Stuttgart: Franz Steiner Verlag.

Kohlrausch, Martin, Katrin Steffen, and Stefan Wiederkehr, eds. 2010. *Expert cultures in Central Eastern Europe. The internationalization of knowledge and the transformation of Nation States since World War I.* Osnabrück: Fibre.

MacLeod, Roy. 1993. The chemists go to war: The mobilization of civilian chemists and the British war effort, 1914–1918. *Annals of Science* 50: 455–481.

Martinetz, Dieter. 1996. *Der Gaskrieg 1914/18. Entwicklung, Herstellung und Einsatz chemischer Kampfstoffe. Das Zusammenwirken von militärischer Führung, Wissenschaft und Industrie.* Bonn: Bernhard & Graefe.

Moy, Timothy. 1989. Emil Fischer as 'Chemical Mediator'. Science, industry, and government in World War One. *Ambix* 36: 109–120.

Paletschek, Sylvia. 2001. The invention of Humboldt and the impact of National Socialism: The German university idea in the first half of the twentieth century. In *Science in the Third Reich*, ed. Margit Szöllösi-Janze, 37–58. Oxford and New York: Berg Publishers.

Raphael, Lutz. 1996. Die Verwissenschaftlichung des Sozialen als methodische und konzeptionelle Herausforderung für eine Sozialgeschichte des 20. Jahrhunderts. *Geschichte und Gesellschaft* 22: 165–193.

Ringer, Fritz K. 1969. *Decline of the German mandarins: The German academic community, 1890–1933*. Cambridge, MA: Harvard University Press.

Schmidt, Ulf. 2015. *Secret science. A century of poison warfare and human experiments.* Oxford: Oxford University Press.

Stoltzenberg, Dietrich. 1994. *Fritz Haber: Chemiker, Nobelpreisträger, Deutscher, Jude*. Weinheim: VCH.

Stoltzenberg, Dietrich. 2004. *Fritz Haber: Chemist, Nobel Laureate, German, Jew.* Trans. Jenny Kein, Theodor Benfey, and Frances Kohler. Philadelphia, PA: Chemical Heritage Foundation.

Szöllösi-Janze, Margit. 1998 (reprint 2015). *Fritz Haber 1868–1934. Eine Biographie.* Munich: C. H. Beck.

Szöllösi-Janze, Margit. 2000a. Losing the war, but gaining ground: The German chemical industry during World War I. In *The German chemical industry in the twentieth century*, ed. John E. Lesch, 91–121. Dordrecht/Boston/London: Kluwer Academic Publisher.

Szöllösi-Janze, Margit. 2000b. Der Wissenschaftler als Experte. Kooperationsverhältnisse von Staat, Militär, Wirtschaft und Wissenschaft, 1914–1933. In *Geschichte der Kaiser-Wilhelm-Gesellschaft im Nationalsozialismus. Bestandsaufnahme und Perspektiven der Forschung*, vol. 1, ed. Doris Kaufmann, 146–64. Göttingen: Wallstein.

Szöllösi-Janze, Margit. 2001. Pesticides and war: The case of Fritz Haber. *European Review* 9 (1): 97–108.

Trischler, Helmuth. 1996. Die neue Räumlichkeit des Krieges: Wissenschaft und Technik im Ersten Weltkrieg. *Berichte zur Wissenschaftsgeschichte* 19 (2–3): 95–103.

Trischler, Helmuth. 2001. Aeronautical research under National Socialism: Big Science or small science? In *Science in the Third Reich*, ed. Margit Szöllösi-Janze, 79–110. Oxford and New York: Berg Publishers.

Weizmann, Chaim. 1950. *Trial and error. The autobiography of Chaim Weizmann*, 4th ed. London: Hamilton.

Springer

http://www.springer.com/978-3-319-51663-9

One Hundred Years of Chemical Warfare: Research, Deployment, Consequences
Friedrich, B.; Hoffmann, D.; Renn, J.; Schmaltz, F.; Wolf, M. (Eds.)
2017, XI, 408 p. 43 illus., 11 illus. in color., Hardcover
ISBN: 978-3-319-51663-9