The amoral scientist – Notes on the life of Fritz Haber

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As far as science is concerned, there is no doubt whatsoever in my mind that to look upon it as a means of increasing one's power is a sin.

– Karl Popper
The Moral Responsibility of the Scientist

The selection by Vaclav Smil, *Nature*, 1999, 400–415 (see also Balaram, Editorial, *Curr. Sci.*, 1999, **77**, 627) that the Haber–Bosch process for producing ammonia as the most important scientific advance of the century induces me to present this article about Fritz Haber. It is based on the biography of Haber by Dietrich Stoltzenberg and is really a condensation of the essay review on the book entitled *Friend or Foe of Mankind*? by Max Perutz in the New York review of books.

Haber was a German chemist born in 1868, famous for his being the first scientist to have synthesized ammonia from nitrogen in the air, thus opening up the way to the synthesis of nitrogen fertilizers. This has dramatically increased agricultural production throughout the world. He also became quite infamous for being the first to introduce poisonous gas during the First World War.

He was a man of intellectual brilliance, with a wide knowledge, overriding ambition and a certain lack of humanity. He was always seen as a scientist lording over his colleagues and collaborators, truly a *Geheimrat* par excellence. His father was a respected Jewish businessman trading in dyes and pharmaceuticals. He allowed his son to launch on what was then considered a badly paid academic career in chemistry. Little would he have imagined that one day Fritz Haber's guests would be dining off golden plates in his house. Chemistry had fascinated Haber as a schoolboy. He studied in a succession of universities and finally ended up in the Technical University in Karlsruhe. Knowing that academic careers were closed to non-Christians, he cleverly decided to be baptized into the Christianity faith. Fritz Haber married Clara Immerwahr, daughter of another respected Jewish family. Clara matched Fritz's ambition and became the first female Ph D in science from the Breslau University. By his hard work, Haber was determined to get to the top and he produced many scientific papers and patents. When he failed to be appointed to the coveted chair in Physical Chemistry, Wilhelm Ostwald, chemistry's elder-statesman told him 'Achievements generated at a greater than the customary rate raise instinctive opposition amongst one's colleagues'. Finally, in 1908 when Haber was 40, he was appointed Full Professor of Physical Chemistry. He was at that time described as impulsive, temperamental and quick-thinking, an excellent lecturer and could hold forth on any subject at any time.

In 1784, the French Chemist C. L. Berthelot discovered that ammonia consists of one atom of nitrogen and three atoms of hydrogen. For the next 125 years chemists tried their best to make ammonia from these two gases but failed. Haber, being an excellent theoretician, understood the laws governing chemical reaction and solved this problem. He collaborated with the English scientist Robert Le Rossignol and calculated that at 200°C and at a pressure of 200 atmospheres, nitrogen and hydrogen would react. This pressure was much more than what had been obtained in chemistry labs in those days. But the reaction was extremely slow and to hasten it a catalyst was required and a metal on whose surface hydrogen and nitrogen could combine. After much experimentation, these two scientists found that osmium accelerated the reaction spectacularly. In 1909, they produced a few drops of ammonia by this process.

At that time, saltpetre mines in Chile were the main sources of natural nitrogen fertilizer and they expected that even this resource would be exhausted by 1940. The Director of Badische Anilin und Soda Fabriken firm gave unlimited resources to engineers Carl Bosch and Alwin Mittasch, to develop Haber's method as a viable industrial process. Experimenting with thousands of catalysts and after innumerable tests, they finally selected a mixture of iron, with small amounts of oxides of aluminium, calcium and potassium as the ideal catalyst. In September 1913, the first industrial unit was set up by Bosch and Mittasch and it started producing 3 to 5 tons of ammonia daily. The current world produce of ammonia for fertilizer is about a hundred thousand times greater and it still uses Mittasch's original iron catalyst, whose efficiency and durability has never been surpassed. Haber was rewarded with generous royalties and the Nobel Prize for Chemistry in 1918; Carl Bosch received the Nobel Prize in 1931 for the development of the new technology for the production of ammonia under high pressure. Unjustifiably Mittasch's name was left out. In 1921, in one of the factories, there was an awful explosion which killed 561 people and rendered 7000 homeless.

Haber did very little personal science since then but he got embroiled in many controversies over his discovery. In 1910, the German Emperor founded the Kaiser Wilhem Gesellschaft zur Forderung der Wissenschaft, a semi-independent body for the support of research which was to prove of immense benefit to German science and learning. Haber was made the Director of this Foundation. Simultaneously, the Institute of Physical Chemistry in Berlin was also set up under Fritz Haber's direction. Along with Max Planck and Walter Nernst, Berlin's leading physicists, Haber persuaded Albert Einstein to leave Zurich and move to Berlin, and he also attracted many excellent young scientists to his new Institute. Germany's greatest chemist, Emil Fischer, who received the Nobel Prize in 1902 for the work on the structure and synthesis of sugars, also belonged to this Foundation.

Nitrates form an essential part of explosives. When war broke out in 1914, the British blockade cut Germany off from Chilean supplies of saltpetre, the traditional source of nitrates. The Ger-

mans captured 20,000 tons of saltpetre in Antwerp harbour after their invasion of Belgium, but had it not been for Haber's synthesis of ammonia, German nitrate supplies would have been exhausted and the Germans would have had to sue for peace.

Haber was appointed the Chief of the chemistry section in the War Department for Raw Materials. In December 1914, he happened to attend a test of artillery shells filled with tear gas, but he found the gas was too widely dispersed to have any effect. Haber then suggested using chlorine instead of teargas. The 'advantage' was that chlorine immediately produces violent coughing; corrodes the eyes, nose, mouth, throat and lungs; and finally asphyxiates the person who inhales it. Haber proposed that if blown in the wind toward the enemy lines, being heavier than air, it would sink into the trenches and drive the soldiers out into the open, where they could easily be killed! The idea appealed to the Chief of the German General Staff. Unfortunately, there was the awkward matter of the Hague Conventions of 1899 and 1907, which Germany had signed and ratified. According to this convention: 'The Contracting Powers agree to abstain from all projectiles whose sole object is the diffusion of asphyxiating or deleterious gases'. The Germans made a fine distinction between projectiles filled with noxious gases and gases being blown by the wind from cylinders on the ground, which the Conventions had not foreseen. Haber was promoted and put in charge of a project to make such cylinders. Haber's son Ludwig later wrote: 'In Haber the (High Command) found a brilliant mind and an extremely energetic organizer, determined, and also quite unscrupulous'. Stoltzenberg confirms that Haber was without any doubt the initiator of chemical warfare. Haber then worked himself to exhaustion organizing the manufacture of hundreds of tons of chlorine gas and thousands of gas cylinders. He trained special troops to test them; and oversaw their installation in the trenches at the front – regardless of danger to his own person. Otto Hahn, known for his discovery of uranium fission, first objected that what he was doing was contrary to International law. But his objections were overruled and Haber seems to have determined to win the war singlehanded. He planned to have chlorine gas blown toward the Allied lines on a front of fifteen miles, which would either have killed the enemy soldiers or put them to flight. There were many army Chiefs who refused to use this chemical warfare technique. Haber's special troops dug into the German trenches about 6,000 cylinders capable of releasing 150 tons of chlorine gas along a four-mile-long front, which was to be blown toward the enemy when the wind came from the east. Haber was always referred as 'Geheimrat Haber' and Otto Hahn became a participating 'observer' and the future Nobel Laureates in Physics, James Franck Gustoav Hertz also joined him. But it must be recorded that Max Born, another young physicist at Haber's Institute and a future Nobel Laureate refused to take part. The simultaneous opening of 6,000 cylinders which released 150 tons of chlorine along 7,000 meters within about ten minutes was spectacular. Those who were not suffocated from spasms broke and ran, but the gas followed. The front collapsed. The gas attack caused 15,000 Allied casualties, 5,000 of them fatal. Even so, Haber's great victory failed to materialize. Chemical warfare had failed to break the stalemate on the western front, but it had succeeded on the southern front, where the Austrian and Italian armies faced each other. Austrians owed their breakthrough to an attack on the unprotected Italians with a mixture of chlorine and phosgene gas that had been prepared by Otto Hahn and other coworkers of Haber. Otto Hahn later in his autobiography regretted for having taken part in this activity. In September 1939, after attending a meeting at the German Army Ordnance Department where the possibility of exploiting his discovery of nuclear fission for an atomic bomb was discussed, Hahn declared 'If my work leads to a nuclear weapon, I will kill myself'. He sounded desperate when he heard of Hiroshima during his internment at Farm Hall in England. Fortunately, he would have found it difficult there to carry out his threat, had he still wanted to do so.

Haber's wife Clara shot herself with his pistol. There was no doubt at all that Clara's suicide was a protest against Haber's war work. It is well-known that Clara pleaded with Haber repeatedly not to work on techniques of chemical warfare and James Franck stated clearly that Haber's part in the gas warfare without doubt influenced Clara's suicide. Clara and Fritz's marriage was happy at first, but changed after their son's birth, when Clara became increasingly concerned, according to Haber, with domestic trivia, which irritated him. Clara believed that Haber's search for self-fulfillment made him build a wall around himself which became his self-imposed prison. Once Haber released the chlorine gas, the Allies soon matched the German effort and the prevailing west wind blew in their favour.

Haber's action contradicted the well held belief that knowledge makes men gentle.

Despite his complaints of his overwhelming responsibilities at the front, he found time to conceive of strategies for research on armaments when the war was over. Haber proposed that Germany establishes a Kaiser Wilhelm Institute for chemical warfare with himself as Director. The Emperor approved and founded it in 1916 with Fritz Haber, Emil Fischer, Walter Nernst, and three other chemists on the Governing Board. The main Kaiser Wilhelm Foundation however, hesitated to collaborate with this new Foundation for chemical warfare as its members objected saying that killing people was not the Gesellshaft's job. But in 1918, its directors agreed to cooperate and the War Ministry assigned six million marks for the project.

After Germany's collapse two months later, Haber and Nernst were branded as criminals by the Allies, who demanded their extradition. Haber fled to Switzerland where he was given Swiss citizenship, a privilege normally reserved for the very rich. After a few months the Allies dropped their demand that he be extradited, and he returned to Germany to help with reconstruction and to continue the secret manufacture of poison gas in violation of the Treaty of Versailles. The Spanish government sought German help in manufacturing and using chemical weapons for suppressing the revolt in Morocco. The Soviet government entered into a clandestine agreement with the Germans to manufacture weapons, including poison gas, and the German War Ministry set up a secret chemical warfare factory near

Wittenberg. Haber directed these enterprises through his wartime collaborator Hugo Stoltzenberg, the father of the writer of Haber's biography, whom Ludwig Haber describes as 'a rogue'. In Spain, Stoltzenberg set up a poison gas factory near Madrid and personally advised the Spanish dictatorial prime minister, on the best gas tactics to be employed against the Moroccan rebels. Haber was also allowed to set up some of the factories as his own private enterprises.

Emil Fischer killed himself in 1919 in despair over the loss of his son in the war and the postwar chaos following the German defeat. It seems that Haber never regretted about the use of chemical weapons and he persisted in manufacturing them. It is necessary to mention that many of the survivors were broken in both body and spirit for the rest of their lives. Haber continued until 1933 to advise Germany's government on its secret production of chemical weapons, but his main energies were devoted to the rebuilding of his institute as a leading center of fundamental research, to the revival of German science and to the restoration of contacts with scientists abroad.

Then Haber launched on a new project. Under the Treaty of Versailles which made Germany's huge reparations payable in pre-war gold marks, which crippled Germany's recovery. Haber had read that a ton of sea water contains between five and ten thousandths of a gram of gold, which meant that the oceans might contain as much as 8 million tons of it. Once again Haber set out to save Germany singlehanded. He decided to devise chemical methods to extract the gold, and to use it to pay Germany's reparations. However, a careful analysis showed a mean gold content of no more than a thousandth of the original estimates. It was a shattering blow for Haber.

In April 1933, the Nazis ordered that all Jewish civil servants be dismissed, including employees of the Kaiser Wilhelm Gesellschaft. Max Planck, its President, used his official courtesy call on the newly appointed Chancellor to plead that Jewish scientists including Haber be allowed to continue their work. Hitler retorted that he had nothing against the Jews, but that they were all Communists. When Planck remonstrated and pointed out that Germany would harm itself if it expelled all of its excellent Jewish scientists, Hitler slapped his knee, talked faster and faster, and whipped himself into such a rage that Planck had no choice but to leave the room.

At that time, Albert Einstein was visiting the United States, where he stated publicly that he would not return to Germany because it no longer recognized civil liberty, tolerance and equality of citizens before the law. The Nazi press responded with a flood of abuse and the Commissioner in charge of the Prussian Academy of Sciences demanded that disciplinary action be taken against Einstein. Planck believed that as a German, Einstein should have stood up for Germany abroad, whatever be the faults of the new regime, and decided that Einstein had made his continued membership of the Academy impossible. When Planck put this view to the assembled members, Haber concurred wholeheartedly and only the physicist and Nobel Laureate Max von Laue had the courage to object to the shameful decision, which Einstein deeply resented. When a friend asked him later if he could take greetings from him back to Germany, Einstein replied: 'Only to Laue'. 'Really no one else?' 'No, only to Laue'.

Haber himself eventually fled to Cambridge in England, where the Professor of Chemistry, William Pope, his adversary in chemical warfare, received him with honours, but the laboratory technicians who had fought in the trenches shunned him. After a short stay, he travelled to Switzerland, where he died of a heart attack after his arrival in Basel in January 1934, at the age of 65.

In 1919, when Allied inspectors of his Institute prevented further research on chemical warfare against human beings, Haber turned to chemical warfare against agricultural pests. He became National Commissioner for Pest Control and founded a new firm, the German Society for Pest Control. The firm developed a preparation combining hydrocyanic acid, which is highly toxic, with a sweet-smelling, volatile, nontoxic irritant; both were absorbed in a porous powder. The firm Tesch and Stabonov undertook to spread the powder in insect-contaminated fields and buildings. When it was spread on an open field, the acid evaporated, killing all the insect pests, and the irritant warned people to keep away. The preparation was called Zyklon B. Later, the Director of the Pest Control received a secret order from an SS officer to deliver Zyklon B without the irritant to Auschwitz and other concentration camps. He was told that it would be used to kill criminals, incurables, and mentally deficient persons, and he was threatened with the death penalty if he broke the secret. So the pesticide which began in Haber's institute ended up as an instrument of the holocaust, in which some of Haber's own relations perished. Tesch, the sole owner of the firm Tesch and Stabonov was convicted by a British Military Court of delivering Zyklon B to Auschwitz and hanged. In his essay, Max Perutz states 'By a terrible irony of fate, it was Haber's apparently most beneficent invention, the synthesis of ammonia, which also harmed the world immeasurably. Without it, Germany would have run out of explosives once its long-planned blitzkrieg against France failed'. The war would have come to an early end and millions of young men would not have been slaughtered. In these circumstances, Lenin might never have got to Russia, Hitler might not have come to power, the Holocaust might not have happened, and European civilization from Gibraltar to the Urals might have been spared.

Yes, Haber's synthesis of ammonia for fertilizer was an extremely important discovery, but, unlike relativity, it did not take a scientist of unique genius to conceive it; any number of talented chemists could, and no doubt would, have done the same work before very long.

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