

Box 3.2 Fritz Haber changes the global nitrogen cycle

Until the end of the industrial revolution, plants and plant communities depended upon two natural sources of nitrogen: biologically fixed nitrogen and nitrogen fixed by lightning discharges. All of this changed in the early 1900s. The first driving factor was gunpowder, the production of which also required nitrogen. The Germans knew that in the case of war, access to the rich beds of guano in Chile would be cut off by the British navy. The second driving factor was also related to military matters. In the case of war, German supplies of fertilizer (and hence food) would also be at risk. There had to be a way to extract nitrogen directly from the atmosphere.

This process was discovered by a German chemist named Fritz Haber (Figure B3.2a) in 1909, and it is still named the Haber process in his honor (Oakes 2002). At high temperature and pressure, a metal catalyst is used in converting nitrogen to ammonia. So long as there are sufficient supplies of fuel, such as natural gas, the supplies of nitrogen are now nearly endless.

At very least, Dr Haber prolonged the cataclysmic First World War by ensuring that both gunpowder and food would be amply available for the German war machine. Sadly, Haber was unable to stop there. To prove his loyalty to Germany, he became further involved with chemical warfare, and introduced poison gas attacks, personally supervising them and refining the methods (Figure B3.2b).



Figure B3.2(a) Fritz Haber was awarded the 1918 Nobel Prize for chemistry for the synthesis of ammonia from its elements (courtesy Edgar Fahs Smith Memorial Collection, University of Pennsylvania Library).

Figure B3.2(b) A poison gas attack on the eastern front during the First World War. As the gas drifts downwind to the left, the shadows of advancing German troops can be seen on the right. Fritz Haber helped develop and refine methods of gas warfare that killed or injured more than a million soldiers (www.ga.k12.pa.us, accessed 15/2/05).

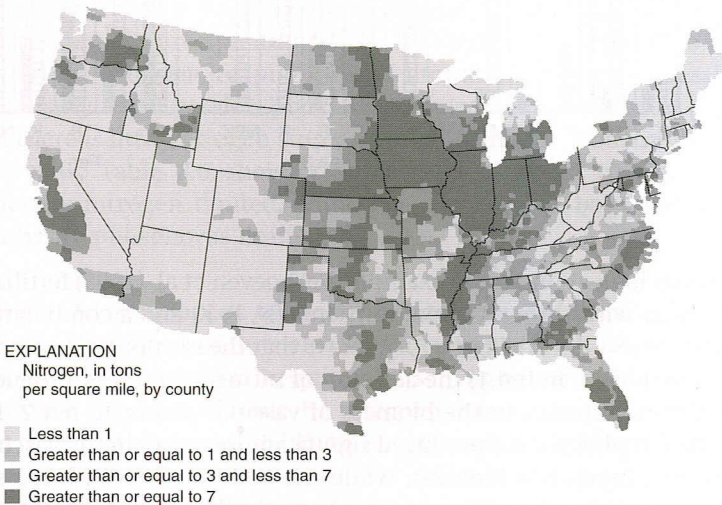
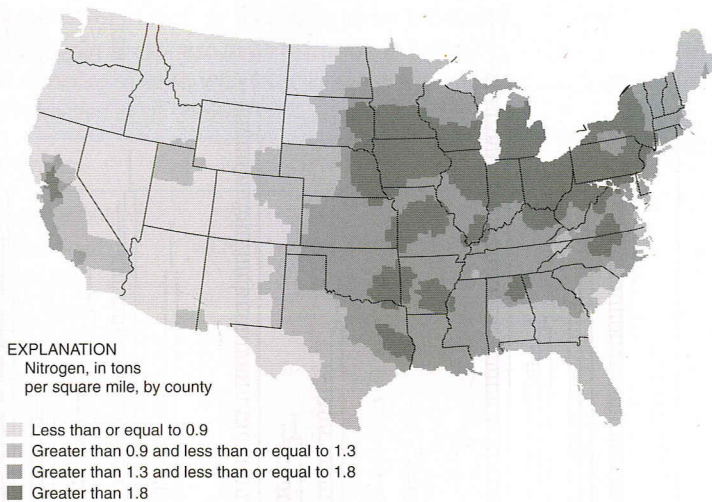


Hundreds of thousands of soldiers from Russia, France, Britain and Canada, among others, were blinded, crippled or killed (Haber 1986, Stoltzenberg 2004). Haber married in 1901, his wife Clara being the first woman in Germany to have earned a PhD in chemistry. Horrified by his involvement in chemical warfare, she shot herself in 1915. Haber continued his poison gas research, and married an apparently less squeamish woman in 1917.

The year after the end of the war, even at the time he was considered a war criminal, Haber received his Nobel Prize in chemistry (Oakes 2002). He was, however, eventually forced to leave Germany because of his Jewish ancestry, and died of a heart attack in Switzerland in 1934. The poison gas research at his institute led to the Zyklon process (Stoltzenberg 2004) which was used to produce Zyklon B, the poisonous gas used to murder Jews, political dissidents, homosexuals, gypsies and other "undesirables" in their millions in concentration camps such as Auschwitz and Birkenau.

Quite apart from the dark history of chemical warfare, his other legacy, the Haber process, continues to alter the world's nitrogen cycle. The rate of industrial fixation was 80 Tg per year in the 1990s, and continues to grow (Vitousek et al. 1997). Eutrophication by surplus nitrogen (Figure B3.2c) is now an emerging problem for the Earth's plant communities (Ellenberg 1988a, Keddy 2000).

Figure B3.2(c) The production of ammonia for agriculture by means of the Haber process has grown throughout the last century. The consequences are illustrated by these maps from the United States of America showing atmospheric deposition of nitrogen (top) and nitrogen applied in commercial fertilizer (bottom) (from Puckett 1994).



blanket bog, a valley bog with *Sphagnum* and *Erica tetralix*, and an acid mire with *Sphagnum* and *Carex echinata*. Fertilizer application to *C. echinata* grown in pots of peat from each site produced growth attributable to three main effects: nitrogen, phosphorus, and between-site differences. Nitrogen was more limiting on the wet heath peats, whereas phosphorus was more limiting on the blanket bog. There was a minor effect of potassium, suggesting that it was present in adequate supply everywhere except in the blanket bog. The use of peat in pots may have increased experimental control, but it is vulnerable to the criticism that it does not necessarily show that the same nutrients are important under more natural field conditions. Sediments collected from waterways and put into pots suggest too that nitrogen rather than phosphorus usually limits plant growth (Smart and Barko 1978, Barko and Smart 1978, 1979).