

Annotated bibliography

Primary sources`

Secondary sources

Briney, Amanda. "Overview of the Haber-Bosch Process." ThoughtCo, Dec. 6, 2021, [thoughtco.com/overview-of-the-haber-bosch-process-1434563](https://www.thoughtco.com/overview-of-the-haber-bosch-process-1434563).

I used this to find out an amazing quote, "approximately half of the protein in today's humans originated with nitrogen fixed through the Haber-Bosch process" (Rae-Dupree, 2011).

"Carl Bosch." *Britannica Academic*, Encyclopædia Britannica, 4 May. 1999.

academic-eb-com.content.elibrarymn.org/levels/collegiate/article/Carl-Bosch/80796..

Accessed 7 Nov. 2023. I used this article to find out the industrial way to create high amounts of ammonia through the Haber-Bosch process. You would put a nitrogen/hydrogen mixture in a pressurized tube with a catalyst (Primarily made of iron), and then heat it to lower temperatures than normal, only about 650 degrees celsius. I also used this article to find out that, as Haber created the process, Bosch made it an industrial work. I used this article to find out where Carl Bosch went to school, and when he graduated. His date of passing and birth date. He was born on August 27th, 1874, in Cologne, Germany. Died on April 26th, 1940, in Heidelberg. I used this book to find the number of experiments that were enacted to try to decipher the ammonia secrets. This number was 20,000.

Charles, Daniel, *Master Mind: the Rise and Fall of Fritz Haber, the Nobel Laureate who Launched the Age of Chemical Warfare, 1st ed., HarperColling Publishing inc*, 2005. I used this book to find out how the Haber-Bosch process first created ammonia. It was a sheet of osmium, put into a tube with a nitrogen-hydrogen mixture, then pressurized with the force of a hundred atmospheres, and superheated to 1,000 degrees celsius. This generated about **one** cubic centimeter of ammonia.

Cochran, Malcolm. "Heroes of Progress, Pt. 2: Fritz Haber and Carl Bosch." *Human Progress*, 12 Apr. 2023, humanprogress.org/heroes-of-progress-pt-2-fritz-haber-and-carl-bosch/. Accessed 19 Nov. 2023. I Used this article to find out how many years of failed experiments it took to get the process. (15)

Croddy, Eric. *Chemical and Biological Warfare*. Scarecrow Press, 1997.

This book furthered my understanding of why the Haber-Bosch process was needed, but from a military standpoint, the Haber-Bosch system makes fertilizer, which can be turned into explosives. Explosives were needed because Germany severely lacked them, and there was a war going on.

Evans, Robert, Host, "Fritz Haber: The Man Who Invented Chemical Warfare." Behind The Bastards, season one, 81, 8/29/19 5:00 AM CDT, Accessed 11/12/23, 5:08-22:50 13:01-13:02

I used this podcast to find out about Haber's early life, including his parents, his father's absence, and his starting out failure. This could be used to add a backstory to Haber using a small paragraph. I used this also to find out where and when he graduated.

"Fritz Haber." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 25 Oct. 2023, www.britannica.com/biography/Fritz-Haber. Accessed 14 Nov. 2023. I used this article to find out how he died. I could use this in a short paragraph describing Haber's life. This could be helpful in a website, when I have more words to say.

"From Fertiliser to Zyklon B: 100 Years of the Scientific Discovery That Brought Life and Death." *The Guardian*, Guardian News and Media, 3 Nov. 2013, www.theguardian.com/science/2013/nov/03/fritz-haber-fertiliser-ammonia-centenary. Accessed 20 Nov. 2023. I used this website to find out how long historians estimate Germany stayed in the war because of Haber-Bosch. (One year.)

Gorran, Morris. *The Story of Fritz Haber*. University of Oklahoma, 1967.

I used this book to find why fixed nitrogen was needed. Europe had been running on South American Chilean nitrate for so long, it was about to run out. They needed to find another source of fixed nitrogen.

"Home." *Famous Scientists*, www.famousScientists.org/carl-bosch/. Accessed 20 Nov. 2023.

I used this to find out what Bosch majored in. (Biological Chemistry)

Hager, Thomas. *The Alchemy of Air*. 1st ed., Crown, 2009.

I used this book to find the reason why the Haber-Bosch process was needed, it was needed because of a fixed nitrogen shortage, fixed nitrogen is used in fertilizers, which were needed at the time due to a impending food crisis

Jack Hough, Host, "Almost Fresh Fertilizer Episode" Barron's Streetwise, season one, episode 186, 8/25/23, 7:00 AM CDT, 10:29-10:31 I used this podcast to find out what the three key elements for plant growth are. (Nitrogen, Phosphorus, and Potassium).

Lisaj. "FROM the VAULT: Boom! Part 1." *Museum*, 25 Aug. 2023, mypolice.qld.gov.au/museum/2023/09/12/from-the-vault-boom-part-1/. Accessed 20 Nov. 2023. I used this article to find out what ammonium nitrate looks like. It's a white crystalline powder.

NIHF Inductee Carl Bosch and the Production of Ammonia, www.invent.org/inductees/carl-bosch. Accessed 19 Nov. 2023. I used this source to find out what else Bosch did that got him fame.

Published by Statista Research Department, and Sep 20. "U.S. Fertilizer Consumption by Nutrient." *Statista*, 20 Sep. 2023, [www.statista.com/statistics/1330021/fertilizer-consumption-by-nutrient-us/#:~:text=The%200 consumption%20of%20 agricultural%20 fertilizers,some%2011.17%20 million%20metric%20 tons](https://www.statista.com/statistics/1330021/fertilizer-consumption-by-nutrient-us/#:~:text=The%200%20consumption%20of%20agricultural%20fertilizers,some%2011.17%20million%20metric%20tons). Accessed 14 Nov. 2023. I used this website to find out how much chemical fertilizer is used per year in the U.S. since 2010-2021. It's... a lot, about 11.17 million metric tons.

"The Nobel Prize in Chemistry 1931." *NobelPrize.Org*, www.nobelprize.org/prizes/chemistry/1931/bosch/biographical/. Accessed 20 Nov. 2023. I used this article to find out what Bosch really did in the Haber-Bosch process. He turned it mass industrial.

[www.epa.gov/nutrientpollution/issue#:~:text=Too%20much%20nitrogen%20and%20phosphorus%20 in%20the%20water%20causes%20algae,aquatic%20life%20need%20to%20survive](http://www.epa.gov/nutrientpollution/issue#:~:text=Too%20much%20nitrogen%20and%20phosphorus%20in%20the%20water%20causes%20algae,aquatic%20life%20need%20to%20survive). Accessed 14 Nov. 2023. I used this webpage to find out the effects of overdose of chemical fertilizer to the water. It's a colossal bloom in algae due to the overdose of phosphorus and nitrogen. It also decreases the water quality.

Images

"Carl Bosch." *Britannica Academic*, Encyclopædia Britannica, 4 May. 1999.
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www.nobelprize.org/prizes/chemistry/1918/haber/biographical/. Accessed 30 Nov. 2023.

Laura Buckler Dec 07, 2017. "The Hidden Dangers of Chemical Fertilizers." *Environmental Protection*,
eponline.com/articles/2017/12/07/the-hidden-dangers-of-chemical-fertilizers.aspx. Accessed 30
Nov. 2023.

Ziemke, Tobias. "The Haber Process." *ChemTalk*, 24 Mar. 2023, chemistrytalk.org/haber-process/.
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"As the World Warms, Harmful Algal Blooms Are on the Rise." *NBCNews.Com*, NBCUniversal News
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www.leybold-shop.com/vc5-1-1-2.html. Accessed 30 Nov. 2023.

"Ammonia." *American Chemical Society*,
www.acs.org/molecule-of-the-week/archive/a/ammonia.html. Accessed 30 Nov. 2023.

Gaiimo, Cara. "When The Western World Ran on Guano." *Atlas Obscura*, 9 June 2021,
www.atlasobscura.com/articles/when-the-western-world-ran-on-guano. Accessed 13 Dec. 2023.

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www.indiamart.com/proddetail/sodium-nitrate-white-crystal-12170119791.html. Accessed 13 Dec.
2023.

"Star of David." *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 28 Nov. 2023,
www.britannica.com/topic/Star-of-David. Accessed 21 Dec. 2023.