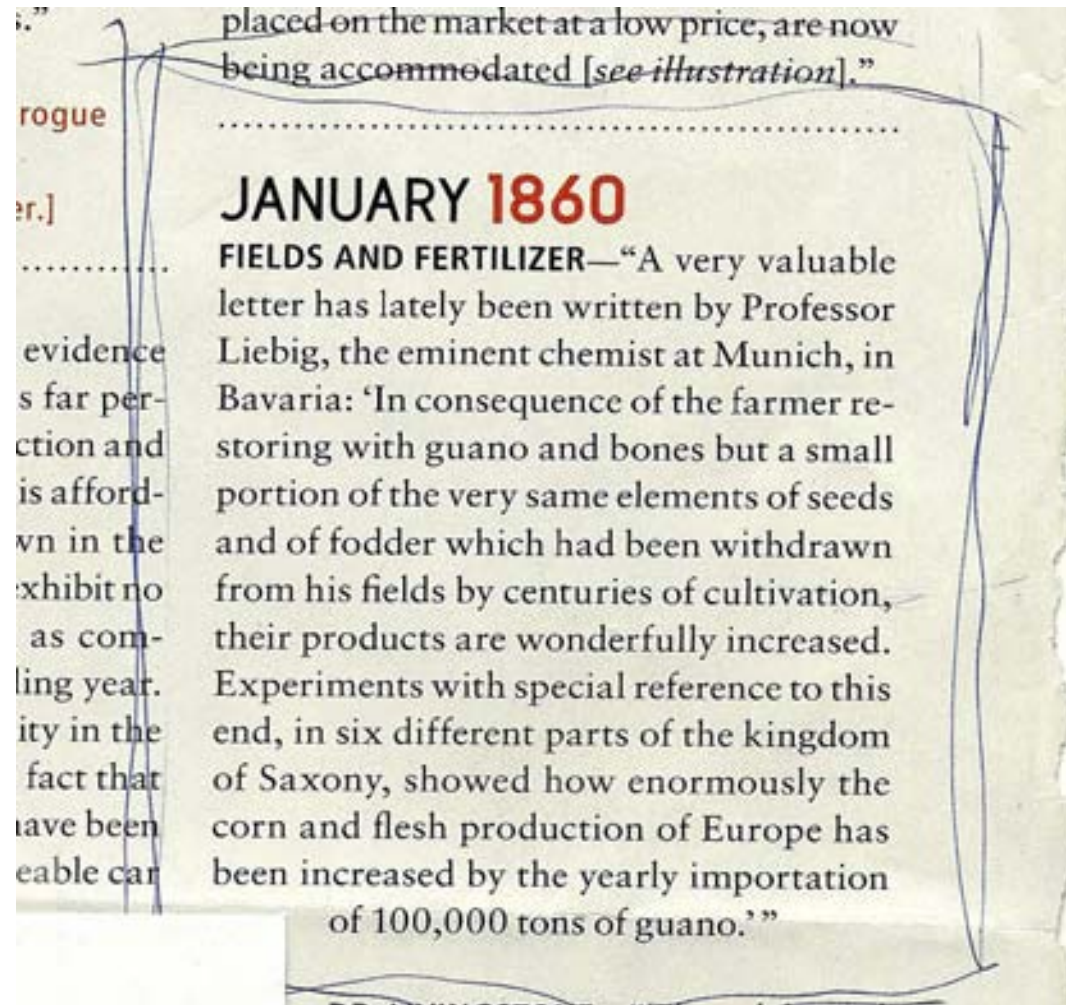
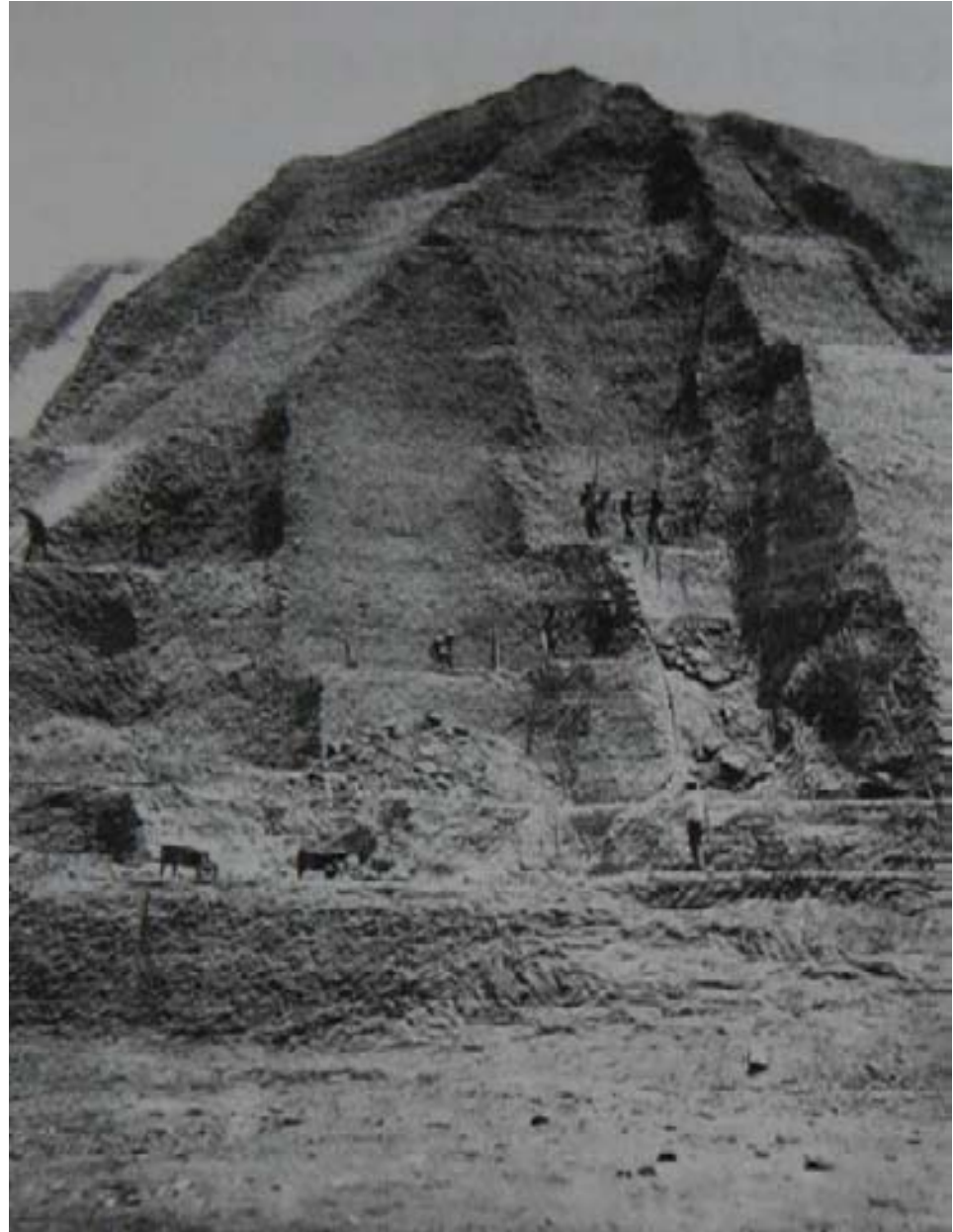


Haber-Bosch Process

Cutting from Scientific American



Guano deposit in Chile

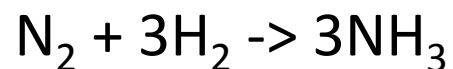


3 Main sources of “Natural” Fixed Nitrogen

- High temperature combustion: eg forest fires, internal combustion engines, power plants, lightening strikes, $N_2 + O_2 \rightarrow NO_x$
- Soil bacteria, principally located in the root nodules of legumes.
- Recycling of animal and human waste

Ammonia Production from Nitrogen

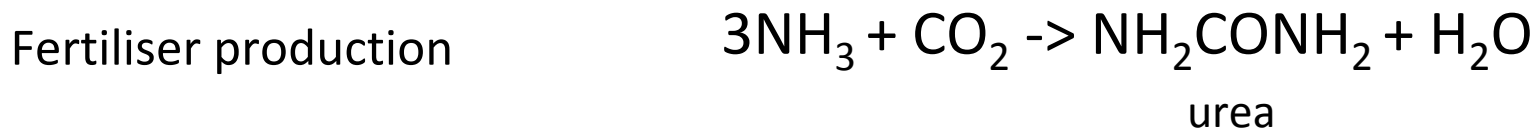
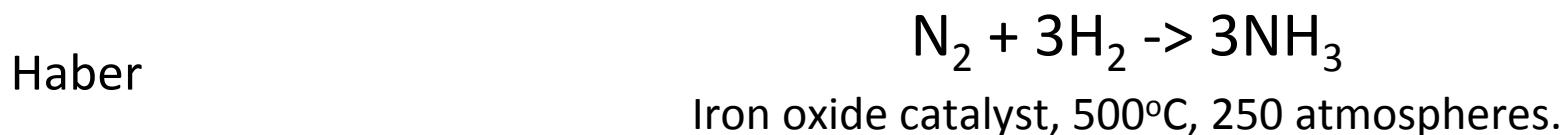
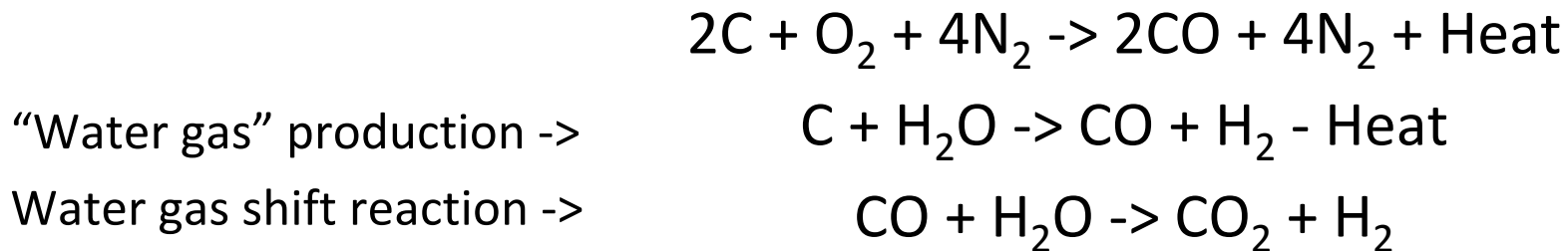
Fritz Haber 1909



Iron oxide catalyst, 500°C, 250 atmospheres.

- Obtained hydrogen from electrolysis of water, nitrogen from air.
- Lab demonstration apparatus produced about ½ cup per hour.

Chemical Reactions in Ammonia Production



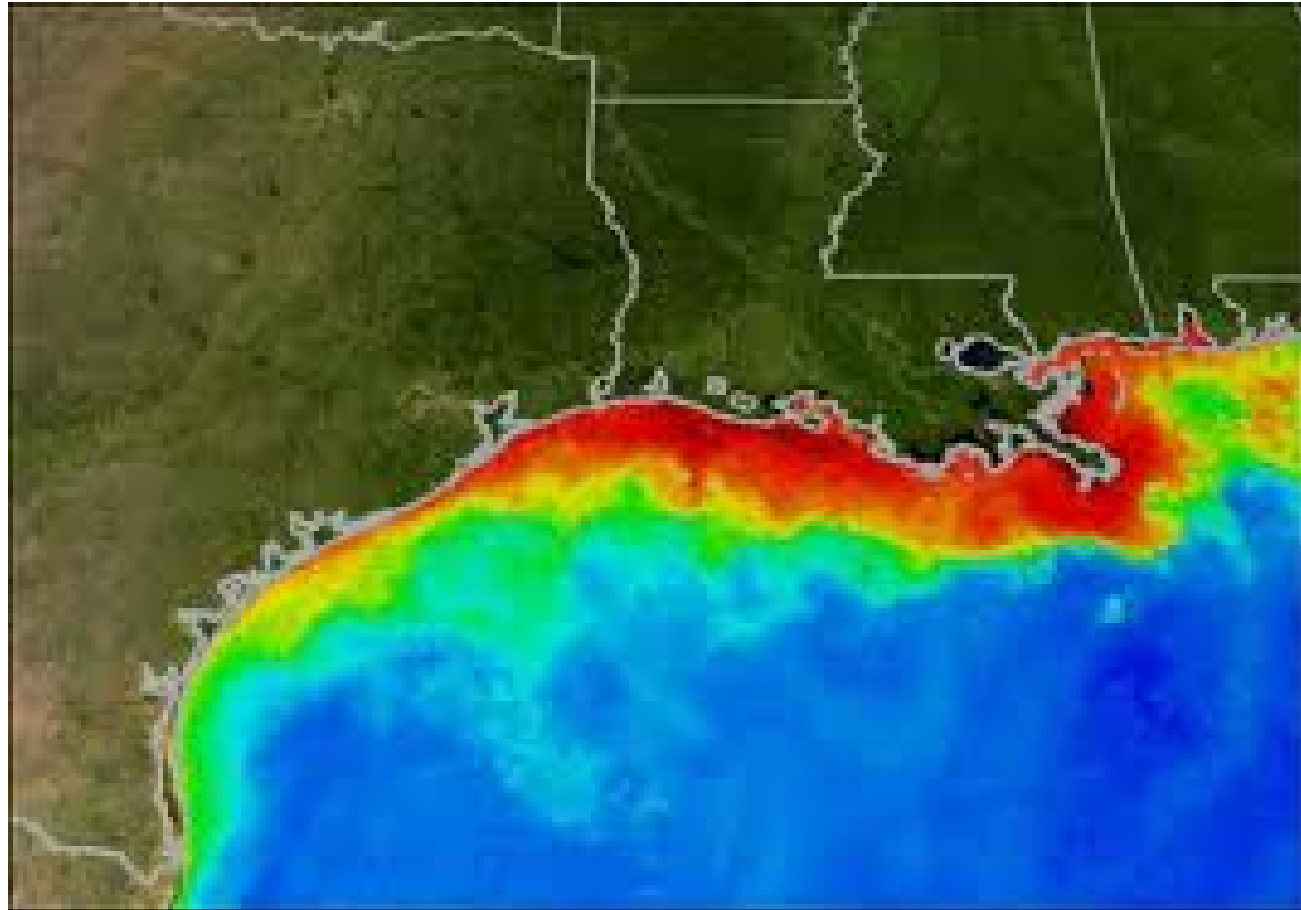
Analogous set of reactions beginning from natural gas

- Ammonia was first manufactured using the Haber process on an industrial scale in 1913 in BASF's Oppau plant in Germany.
- Haber was awarded the Nobel Prize in 1918, Bosch in 1931.
- The availability of cheap N fertiliser was the principal contributor to the post WWII “Green revolution” which allowed the world population to grow by ~ 2 billion people.
- Production now ~100 million tons of nitrogen fertiliser per year.
- 3–5% of world natural gas production is consumed in the Haber process.
- That fertilizer is responsible for sustaining one-third of the Earth's population.

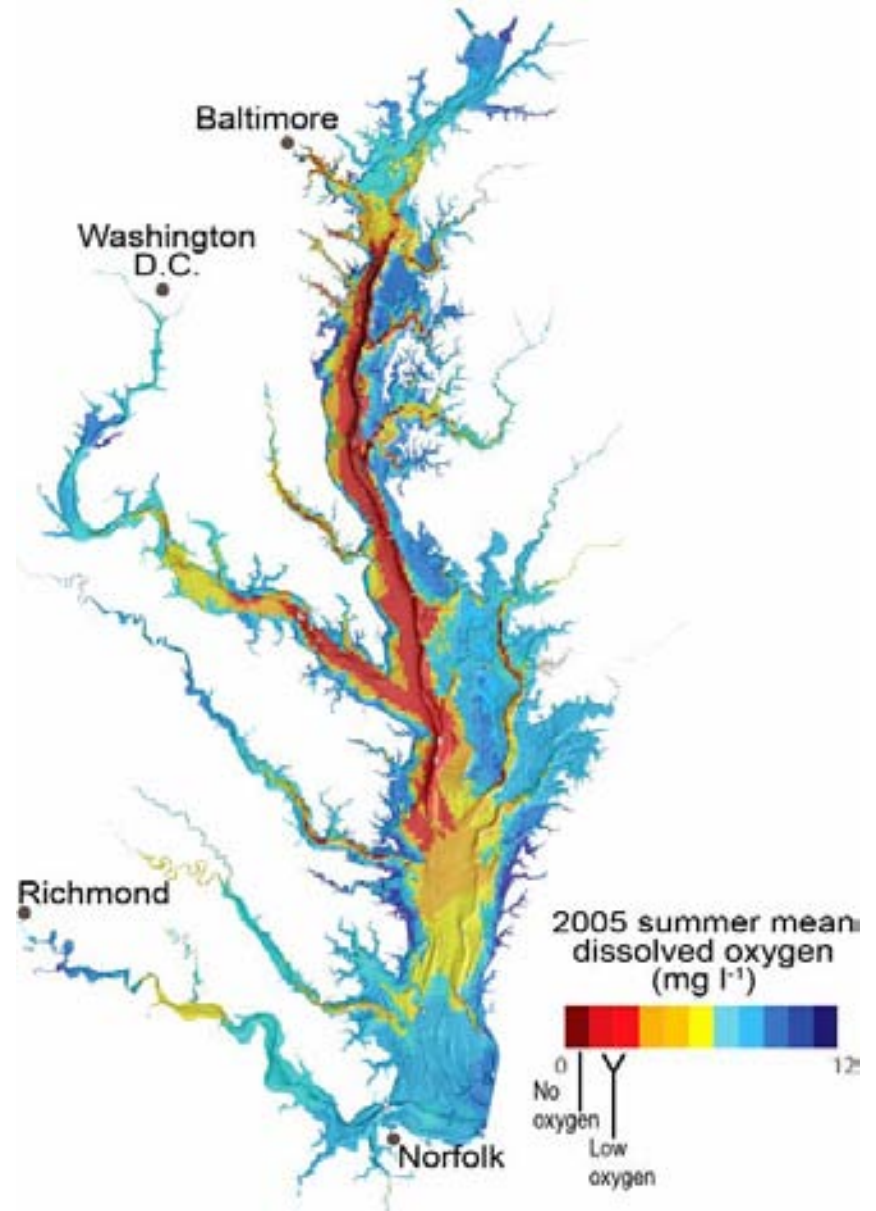
Downside

- Low cost and availability has lead to excessive use
- Other sources of nitrogen into the environment have increased: power plants, automotive engines, jet engines, human and animal waste.
- Excess N leaches into rivers and the sea causing algae blooms and “dead” anaerobic regions. There are over 400 of these world-wide.

Gulf of Mexico – Dissolved Oxygen

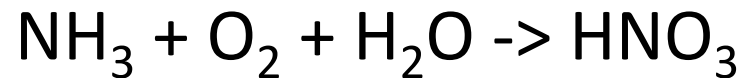


Chesapeake Bay



Also, about 1900

Discovery of the oxidation of ammonia to nitric acid:



Nitric acid plus:

- ammonia -> ammonium nitrate – (fertiliser and explosive)
- toluene -> TNT -> Dynamite (explosive)
- glycerine -> nitroglycerine (explosive)
- cellulose -> nitrocellulose or gun cotton (propellant)

“It has been suggested that without this process, Germany would not have fought in the war (WW1), or would have had to surrender years earlier.’

Few people had a greater impact on the 20th century than Fritz Haber and Carl Bosch.

Bibliography.

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- The Disappearing Spoon, Sam Kean.