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Justus Liebig (1803-1873)
(For image see https://www.flickr.com/photos/tekniskamuseet-telehistoriska/)

For thousands of years, humans knew that the addition of excrements or ash on fields leads to improved crop yields. However, only in the mid 19th century, the German chemist Justus von Liebig performed systematic scientific studies of the substances that plants require for growth. He identified phosphorus and nitrogen as the two most

important chemical elements for growth. He also realised that plants are not normally able to extract nitrogen from the atmosphere, where it constitutes close to 80% of the total volume, but that rather water-soluble chemical compounds of nitrogen are required. This insight led to a great mining boom in those countries that had natural deposits of such compounds, such as Chile. These deposits, guano and saltpetre, were mainly based on the weathered excrements of thousands of generations of seabirds – clearly a finite and practically non-renewable ressource! Already towards the end of the 19th century, it was becoming clear that the world would run out of this precious stuff within the next few decades and that therefore, the industrialised nations, having become very dependent on this natural fertilizer, were facing a crisis. The only viable alternative that was proposed was the transformation of nitrogen from the air into a water soluble form, a perspective advertised as “bread from air” (“Brot aus Luft”). The fundamental challenge that this project was facing consisted in the highly inert nature of nitrogen towards chemical reactions of any kind. Nitrogen gas is a molecule which consists of two atoms of the element that are held together by an exceptionally strong chemical bond. This bond has to be broken first if nitrogen is to form a compound with any other type of atom. Very high temperatures of many hundreds of degrees Celsius lead to the required breakage of the these bonds, but under such extreme conditions, the desired compounds would break down even more rapidly, resulting in negligible yields of the useful nitrogen compounds, such as ammonia. The solution of this problem was found by two German chemists, Fritz Haber and Carl Bosch, towards the end of the first decade of the 20th century. The strong involvement of German chemists is no coincidence, as chemical research was dominated by German Scientists in the second half of the 19th and first half of the 20th century. This dominance was probably due to the well-organised teaching and research in Chemistry at the many German universities which had been established there earlier than in most other countries. Fritz Haber had the idea to let nitrogen react at high pressures and moderately high temperatures (where the reaction yield is acceptable, but the reaction is slow) in the presence of a catalyst, a substance that accelerates a chemical reaction without changing its outcome. Carl Bosch, working for the chemical industry, then subsequently managed to develop this method into an industrial scale process. Both scientists were awarded Nobel prizes for their work (Haber 1919 and Bosch 1931).

The so-called Haber-Bosch process continues today to be by far the major industrial process by which nitrogen containing compounds for the production of fertilizer are made, and it is estimated that half of the nitrogen atoms in your body, dear reader, have undergone the Haber-Bosch reactions in a chemical plant.