Some pioneers of photosynthesis

1. Plants need water

Figure 1. Portrait of J.B. van Helmont, Aufgang...1683. Source: Portrait of J.B. van Helmont, Aufgang...1683. [Source: Wellcome Collection. Attribution 4.0 International (CC BY 4.0)]

Jean-Baptiste **Van Helmont** (1579-1644), an alchemist, chemist, physiologist and physician from the Netherlands (Figure 1), measured the amount of water absorbed by a willow tree under controlled growing conditions and showed that water contributes to plant growth. It should also be noted that Van Helmont also scientifically demonstrated the existence of "gases", around 1610, and gave them this name [1].

2. Plants produce oxygen

Figure 2. A, Carl Wilhelm Scheele Okänd (1742-1786) - 1700-tal [Public domain]; B, Joseph Priestley by Ozias Humphrey (1742-1810) [Public domain]; C, Antoine de Lavoisier explaining to his wife the result of his experiments, [Source: Okänd - 1700-tal / Public domain / Ozias Humphrey (1742-1810) / Public domain / CC BY 4.0)]

Joseph **Priestley** (1732-1804), a British chemist and theologian (Figure 2), showed that plants restore a property in the air that is necessary for animal life, but destroyed by it (*i.e.* respiration). This was actually oxygen, a gas which he co-discovered (1774) with Carl Wilhelm **Scheele** (1742-1786), a Swedish chemist (Figure 2). At the time of Priestley, it was not yet a question of oxygen, but of the theory of phlogistics [2].

A few years later, in 1777, Antoine Laurent de **Lavoisier** (1743-1794), French chemist, philosopher and economist (Figure 2), replaced the theory of phlogistics with the "general théorie of combustion ". It gives the name of oxygen to the gas involved.

3. Plants, oxygen and light

Figure 3. Left, Jan Ingen-housz, Unknown author [Public Domain]; Right, Prof. Th. W. Engelmann, date and authors unknown, published in Munich by J.F. Lehmann in 1909 [Public Domain]

In 1779, Jan **Ingen-Housz** (1730-1799), Dutch physician and botanist (Figure 3), extended Priestley's observations and demonstrated the role of light in the production of oxygen by plants. Having placed plants in the water in light and dark, he finds that :

(1) Light is necessary for the plant to restore air (photosynthesis);

(2) only the green parts of the plant are involved in this restoration;

(3) all living parts of the plant "damage" the air, but the extent of air restoration by a green plant far exceeds its harmful effect.

A century later, Theodor Wilhelm **Engelmann** (1843-1909), a German physiologist (Figure 3), demonstrated the role of the colour of light in an experiment with filamentous algae (spirogynous type) illuminated with coloured spots, then with a prism, in which aerobic bacteria* serve as an indicator of oxygen production. Bacteria density was highest in the areas illuminated by the blue and red lights.

4. Plants use carbon dioxide

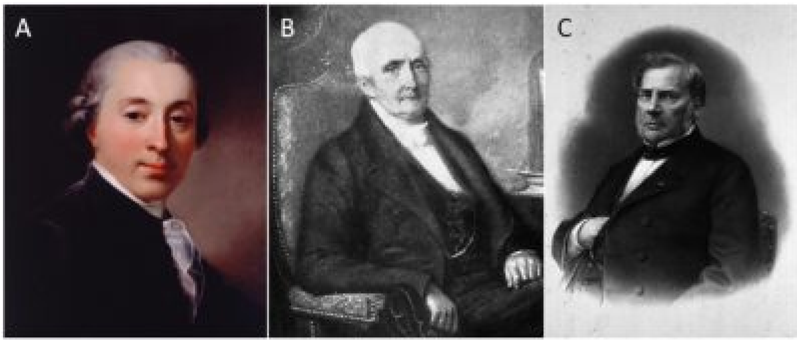

Figure 4. A, Jean Senebier [Public Domain]; B, Nicolas-Théodore de Saussure [Public Domain]; C, Jean-Baptiste Boussingault (Schultz etching from a photo by Pierre Petit [Public Domain])

In the 17th century, Van Helmont had identified the "gas sylvestre" as a product of charcoal combustion: it was in fact carbon dioxide. A century later, Lavoisier demonstrated that the carbon dioxide released by animal respiration, or by burning a candle, is made up of carbon and oxygen.

Jean **Senebier** (1742-1809), a Swiss naturalist, meteorologist and pastor (Figure 4), studied gas exchanges between plants and the atmosphere. He showed that plants absorb carbon dioxide and produce oxygen in the presence of light and published a book in 1783 entitled "*Research on the influence of sunlight in transforming fixed air into clean air by vegetation"*. These observations are reinforced by those of Nicolas-Théodore **de Saussure** (1767-1845), a Swiss chemist, biochemist and botanist (Figure 5): de Saussure shows that plants need carbon dioxide, but also water, nitrogen compounds and mineral salts to ensure their nutrition and growth.

Jean-Baptiste Joseph Dieudonné **Boussingault** (1802-1887), French chemist, botanist and agronomist, is considered the founder of modern agricultural chemistry (Figure 4). After developing air analysis techniques, he demonstrated - around 1860 - that the volume of gaseous oxygen released and the volume of CO_2 absorbed are almost identical.

5. Chlorophyll and chloroplasts

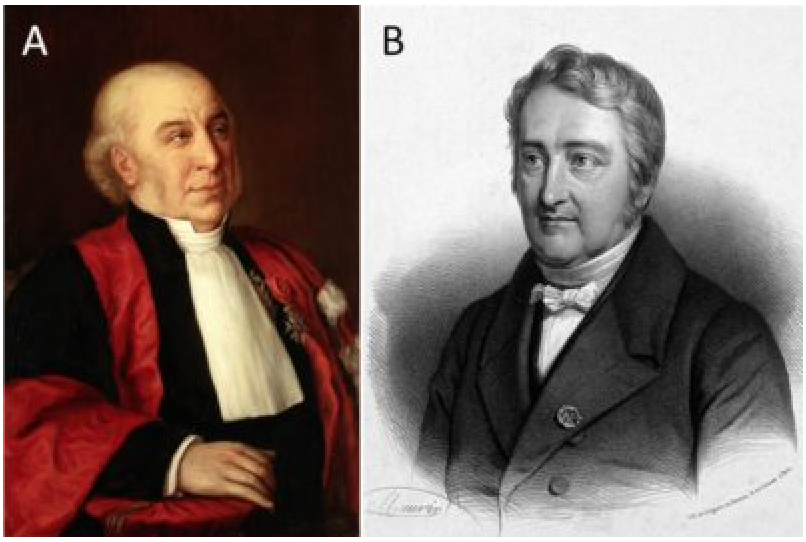

Figure 5. A, Joseph Bienaimé Caventou [Source : by Catherine Buisson, 1930, after Elisa Desrivières, 1870 / CC BY 4.0]; B, Pierre Joseph Pelletier [Lithograph by N. E. Maurin / Public domain]

Chlorophyll was isolated in 1816 by the French chemists and pharmacists Joseph **Pelletier** (1788-1842) and Joseph **Caventou**

(1795-1877) who gave it its name in reference to the green (chloro) colour of the leaves (phyllum); (Figure 5).

Hugo **von Mohl** (1805-1872), a German botanist (Figure 6), gave the first detailed description of "Chlorophyllkörnern" (chlorophyll granules) in green leaves in 1837.

Arthur **Meyer** (1850-1922), a German botanist, cell biologist and pharmacognosist (Figure 6), was the first to name and describe chlorophyll-containing structures in chloroplasts (which Meyer called "autoplasts") known as grana.

Figure 6. A, Hugo von Moh [Public domain]; B, Arthur Meyer (CC BY-NC 4.0); C, Andreas Schimper [Source : The original uploader was Paul venter at English Wikipedia / Public domain].

Andreas Franz Wilhelm **Schimper** (1856-1901) was a French then German botanist (Figure 6). In 1880, he established that starch is both a source of stored energy for plants and a product of photosynthesis. In 1881, he showed that starch grains are formed in certain bodies of plant cells; in 1883, he named these bodies "chloroplasts". In the same year, it shows that the chloroplasts originate from the division of pre-existing chloroplasts.

6. Plants transform light energy: photosynthesis

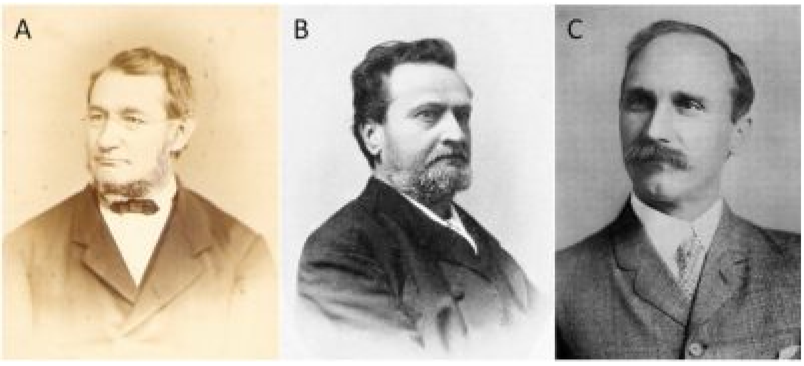

Figure 7. Julius Robert Mayer [engraving by Friedrich Berrer (1839) / Public domain]; B, Julius von Sachs [CC BY-SA 3.0]; C, Charles Barnes. [portrait from the Botanical Gazette, John M. Coulter editor. Unknown hotographer / Public domain]*

Julius Robert **Mayer** (1814-1878), German physician and physicist (Figure 7), had formulated in 1845 - after Joule in 1842, and Nicolas Léonard Sadi Carnot (1796-1832) in 1831 - the first principle of thermodynamics: energy can neither be created nor destroyed. He proposed that plants convert light energy into chemical energy.

Julius **von Sachs** (1832-1897), a German botanist (Figure 7), participated very actively in the development of plant physiology. In particular, it demonstrates that starch grains present in chloroplasts are formed under the influence of light.

Figure 8. C.B. van Niel. [Source: © 2017 Stanford University & Hopkins Marine Station, https://seaside.stanford.edu/topresent]

In 1893, **Charles Barnes** (1858-1910) proposed that the biological process of "synthesis of carbonaceous molecules from carbonic acid, in the presence of chlorophyll, under the influence of light" be referred to as "photosyntax" or "photosynthesis". He has a preference for the first term, which he considers more appropriate, but it is ultimately the term "photosynthesis" that will be remembered by posterity. [3]

It was finally in 1930 that Cornelis Bernardus **van Niel** (1897-1985), a Dutch-American microbiologist (Figure 8), demonstrated that photosynthesis is a light-dependent redox reaction, in which the hydrogen of an oxidizable compound (H_2A) reduces carbon dioxide to cellular material $(CH_2O)x$. This reaction is expressed according to the equation:

$CO_2 + H_2A + \text{light} \rightarrow (CH_2O)x + A_2 + H_2O$

Notes and References

Cover image. Joseph Priestley [Source: Ozias Humphrey (1742-1810) / Public domain]

[1] Lavoisier, very interested in Van Helmont's work, points out that the word gas comes from the Dutch word ghoast which means spirit. He adds that the English "express the same idea by the word ghost and the Germans by the word geist".

[2] Phlogistic theory is a chemical theory that explained combustion by postulating the existence of a "flame element" present within combustible bodies.

[3] Gest H. (2002) History of the word photosynthesis and evolution of its definition. *Photosynth Res* 73(1-3):7-10.

More

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- Website "Photosynthesis education". https://photosynthesiseducation.com/discovery-of-photosynthesis/