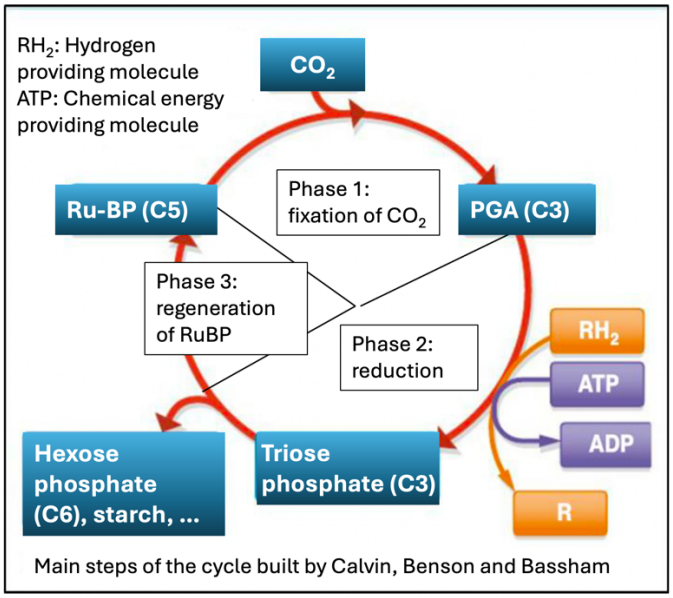
What happens during the “chemical phase”?

Photosynthesis takes place in the chloroplasts. It requires light, water, CO_2 and chlorophyll pigments found in the thylakoïds. These pigments absorb the light wavelengths needed for photosynthetic activity and the production of organic matter. The photochemical phase in the thylakoids of chloroplasts produces ATP and RH_2, and releases O_2. Light enables the photolysis of water, oxidation coupled with the reduction of an “R^+ molecule” to RH_2.
During this first phase, no starch (remember activity 1b) was produced. This must therefore take place in the following chemical reactions:



Main steps of the cycle built by Calvin, Benson and Bassham

Show how this diagram is coherent with the historical experiments presented in the documents below.

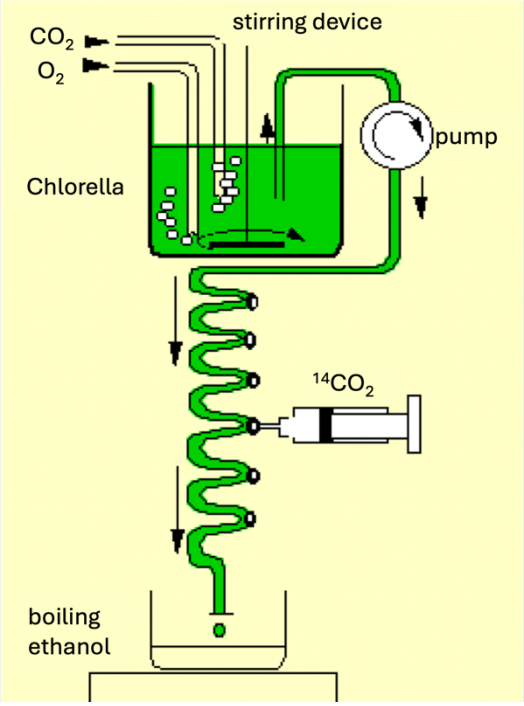
DOCUMENT 1: CALVIN, BENSON and BASSHAM

Between 1950 and 1960, Calvin, Benson and Bassham performed a series of experiments allowing them to find out the chemical steps from CO_2 to the first organic molecules produced in the chloroplasts.

Chlorella algae are kept suspended in light, in a container bubbled with carbon dioxide. These are pumped into a flexible, transparent tube, which they pass through in a given time using a pump with a known flow rate.

At a variable point in the tubing, $^{14}CO_2$ is injected: the time during which the algae can incorporate it varies according to the point of injection.

The cells are then immersed in boiling ethanol, which instantly blocks all chemical reactions:



- The carbonaceous molecules produced are radioactively labelled, and the closer the injection of labelled C to the end of the tubing, the less time the chlorella will have spent in contact with ^{14}C

Note: Depending on the pump flow rate, we are able to calculate very precisely the time during which the chlorella in the coil were in contact with the radioactive CO2 before being fixed by the boiling alcohol.

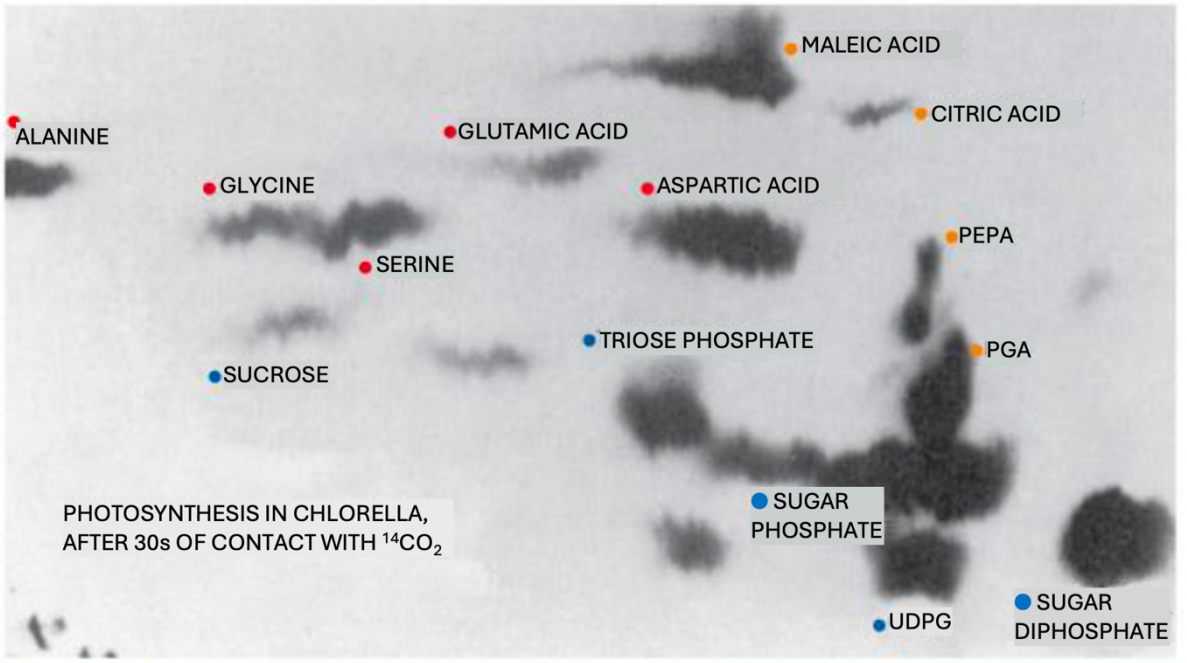
- A CHRONOLOGY of molecule formation can thus be established.

Using two-dimensional chromatography, Calvin and Benson determined the number of molecules formed as a function of time.

Notes: colors = specific revelators for recognizing molecules.

Identification of the molecules produced:

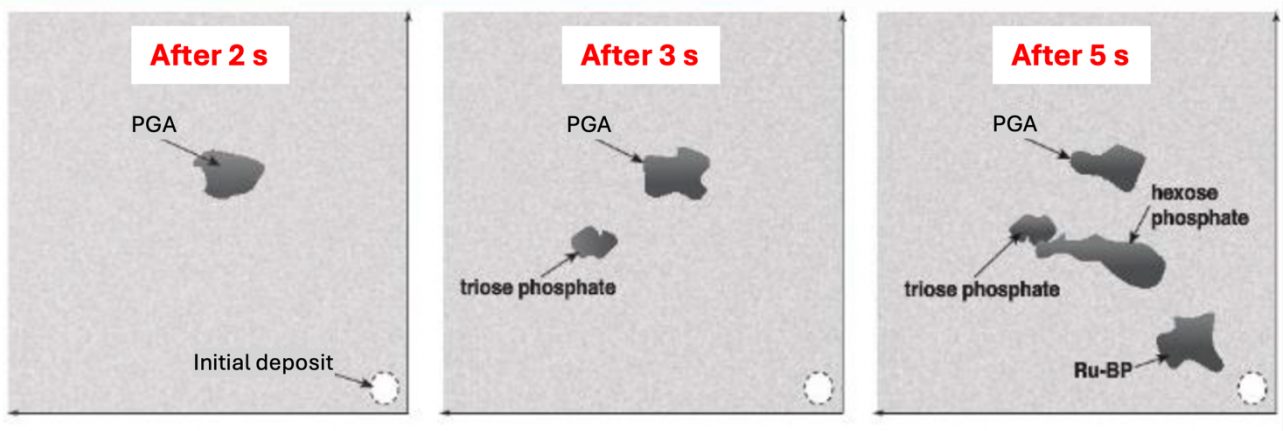
After having put algae in contact with $^{14}CO_2$ for 30 seconds, a chromatography of the sample is performed. Autoradiography reveals on photographic paper all molecules containing radioactive ^{14}C, i.e. formed from $^{14}CO_2$.



The position of the different molecules on the chromatogram allows their identification. Several molecules can be observed above:

- Carbohydrates (*)
- Amino acids (*)
- Organic acids (*)

The experiment is repeated in a short succession: It is then possible to identify the chronology of the first products formed from CO_2 during photosynthesis.



Note: PGA: phosphoglyceric acid (3C)
Triose: 3C carbohydrate
Hexose: 6C carbohydrate (e.g. glucose)
Ru-BP: Ribulose biphosphate (5C carbohydrate)

DOCUMENT 2: BASSHAM and CALVIN

Method:

- Chlorella are grown in a medium containing air enriched with radioactive CO2.
- AGP and RU-BP concentrations are measured over time.
  Note: Concentrations are deduced from measured radioactivity
- After 30 minutes:
  - half of the chlorella are put in the dark, still being provided with CO_2
  - half of the chlorella are maintained in bright light, but are not provided with CO_2 anymore.

Results: