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Researchers develop an artificial chloroplast

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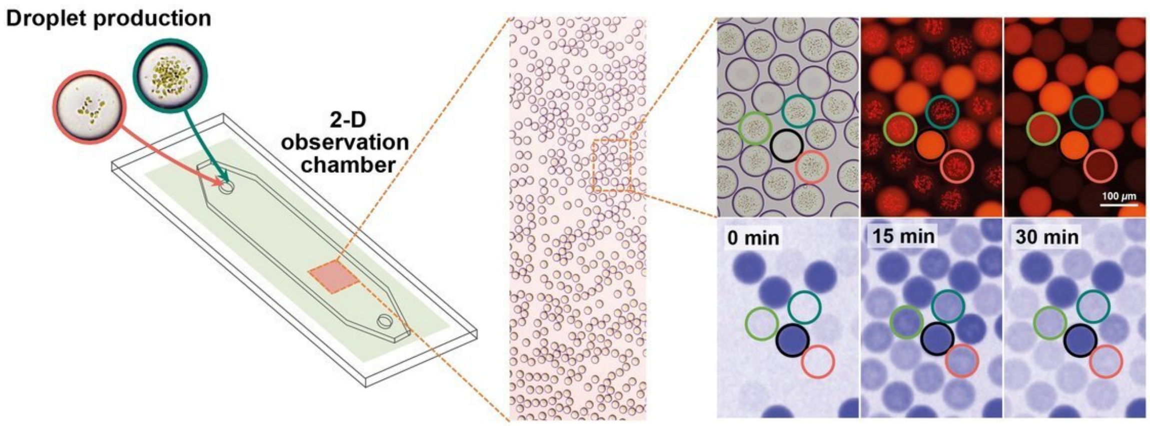

Micro-droplet production and real-time observation on a microfluidic platform. Micro-droplets are collected in a chamber where their activity can be microscopically monitored in real time, including quantifying the enzymatic activity by measuring NADPH fluorescence. Using the bright field the droplets are located and the photosynthetically active membranes can be seen. These membranes are fluorescent when excited. The droplet populations are distinguished using a coding dye, which is observable when the droplets are excited by a specific wavelength (550 nm). The NADPH production of the droplets is observed using NADPH fluorescence (using, 365 nm). Credit: Planck Institute for terrestrial Microbiology/Erb

The photosynthesis apparatus isolated from the spinach plant proved to be robust enough that it could be used to drive single reactions and more complex reaction networks with light. For the dark reaction, the researchers used their own artificial metabolic module, the CETCH cycle. It consists of 18 biocatalysts that convert carbon dioxide more efficiently than the carbon metabolism naturally occurring in plants. After several optimization rounds, the team succeeded in light-controlled fixation of the greenhouse gas CO_2 in vitro.

The second challenge was the assembly of the system within a defined compartment on a micro scale. With a view to future applications, it should also be easy to automate production. In cooperation with Jean-Christophe Baret's laboratory at the Centre de Recherché Paul Pascal (CRPP) in France, researchers developed a platform for encapsulating the semi-synthetic membranes in cell-like droplets.

More efficient that Nature`s photosynthesis

The resulting microfluidic platform is capable of producing thousands of standardized droplets that can be individually equipped according to the desired metabolic capabilities. "We can produce thousands of identically equipped droplets or we can give specific properties to individual droplets," said Tarryn Miller, lead author of the study. "These can be controlled in time and space by light."

In contrast to traditional genetic engineering on living organisms, the bottom-up approach offers decisive advantages: It focuses on minimal design, and it is not necessarily bound to the limits of natural biology. "The platform allows us to realize novel solutions that nature has not explored during evolution," explains Tobias Erb. In his opinion, the results hold great potential for the future. In their publication in the journal *Science*, the authors were able to show that equipping the "artificial chloroplast" with the novel enzymes and reactions resulted in a binding rate for carbon dioxide that is 100 times faster than previous synthetic-biological approaches. "In the long term, life like systems could be applied to practically all technological areas, including material science, biotechnology and medicine—we are only at the beginning of this exciting development." Furthermore, the results are another step towards overcoming one of the greatest challenges of the future: the ever-increasing concentrations of atmospheric carbon dioxide.

More information: Tarryn E. Miller et al. Light-powered CO_2 fixation in a chloroplast mimic with natural and synthetic parts, *Science* (2020). DOI: 10.1126/science.aaz6802

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