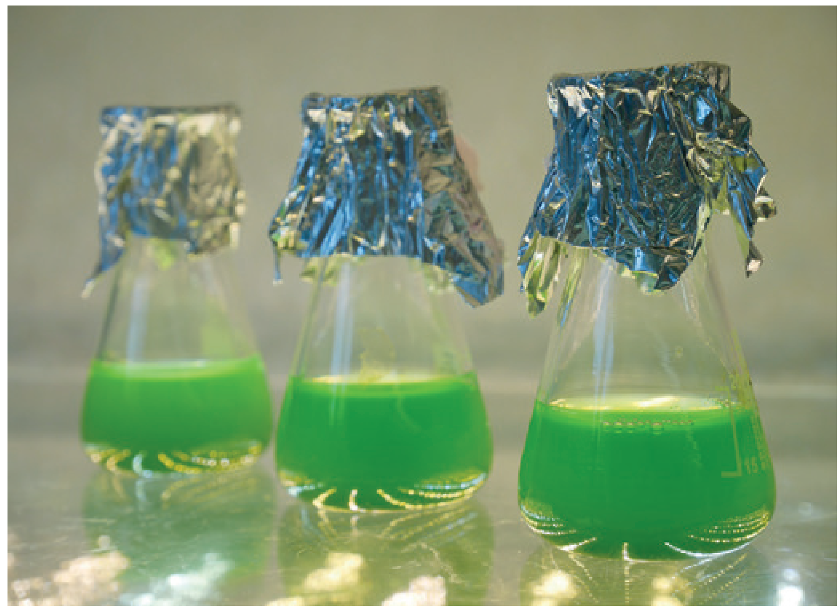
PROFESSOR TOBIAS ERB: BOOSTING CO_2 REDUCTION WITH SYNTHETIC BIOLOGY

TURBOCHARGING PHOTOSYNTHESIS

Is it possible to improve upon a biological system that has existed for billions of years? Professor Tobias Erb from the Max Planck Institute for Terrestrial Microbiology in Marburg conducts research into photosynthesis and believes this is possible.

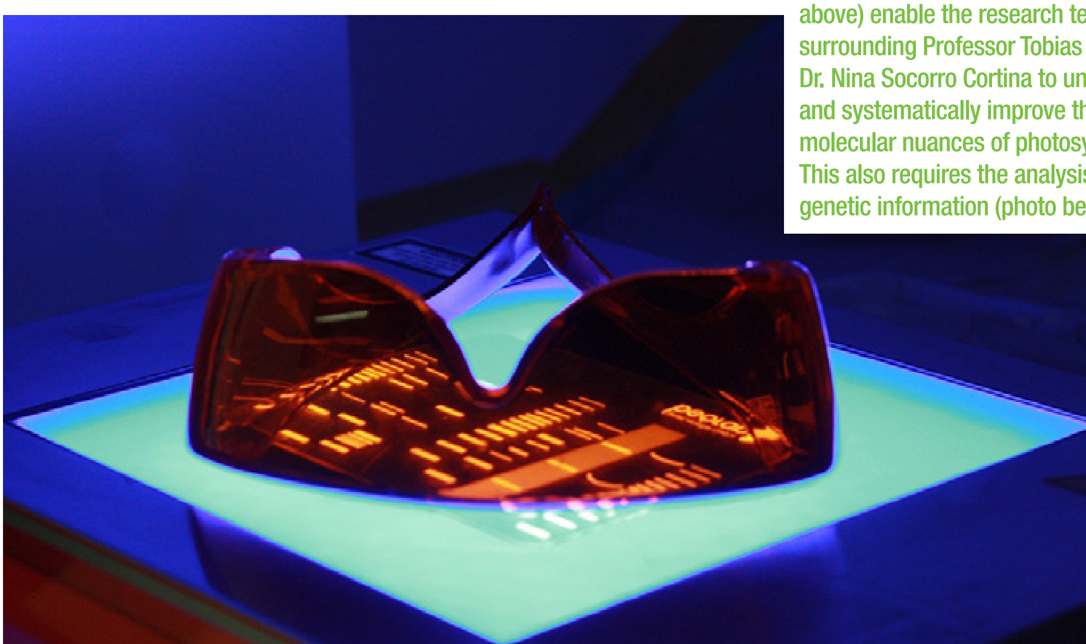
According to International Energy Agency estimates, energy production accounted for 32.5 metric gigatons of global CO_2 emissions in 2017. Carbon dioxide is vital to plants' survival, which have always converted this otherwise harmful greenhouse gas into the oxygen that is essential for many organisms, albeit not to the extent that causes the offsetting of additional anthropogenic emissions. Not yet. At a Max Planck Institute, Professor Tobias Erb is working on improving photosynthesis.



Researchers also work with cyanobacteria and algae, which is aimed at boosting photosynthesis.

Thanks to synthetic biology, it is possible to technically optimize three billion years of evolution in just three years of intensive work in the laboratory. Together with his team, Professor Tobias Erb, Director and Group Leader at the Max Planck Institute (MPI) for Terrestrial Microbiology in Marburg, has managed to create an artificial cycle that absorbs carbon dioxide (CO_2) and is more effective than plants' natural photosynthesis reaction. "Plant leaves are full of the enzyme RuBisCO, which absorbs CO_2 and converts it into oxygen. However, the enzyme works quite slowly and is also prone to error. For example, instead of carbon dioxide, it sometimes takes oxygen molecules and produces a product that is toxic to the plant," explains Erb. Ultimately, the detoxification process robs the plant of valuable energy.

This natural phenomenon inspired Professor Erb and his team to find a more efficient solution for reducing CO_2. In doing so, they are addressing a global issue that is of concern to many environmental and climate protection activists – how do microorganisms absorb and convert the greenhouse gas CO_2 – and how can people benefit from this mechanism?



High-precision measuring instruments such as a mass spectrometer (photo above) enable the research team surrounding Professor Tobias Erb and Dr. Nina Socorro Cortina to understand and systematically improve the molecular nuances of photosynthesis. This also requires the analysis of genetic information (photo below).

The research group's strategy is to imitate natural processes, while improving their design. "We need the right building blocks to construct a functioning artificial metabolism," says Erb, who searches for them everywhere. After all, these desired properties can be found in deep-sea organisms, in plants, in heat-resistant bacteria or in those capable of surviving the lowest temperatures. Publicly accessible databases assist Erb in his quest. More than 100 million sequenced genes and over 50,000 characterized enzymes could potentially serve as biocatalysts. "Determining which biomolecule to use for artificial biological processes is like trying to find the best young striker for a soccer team," explains Erb.

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>
> **Dr. Tobias Erb**

From theoretical design to biological reality

The solution to optimize CO_2 absorption seemed very simple on paper, which was underlined by the fact that the theoretical design was in place after just two weeks. Then the research really began – Erb and his team, including biochemists, geneticists and analysts, worked for three years on the realization of the CETCH cycle (crotonyl-CoA)/ethylmalonyl-CoA/hydroxybutyryl-CoA cycle), as they call artificial photosynthesis. The team's motto is: "First come up with the findings, then make use of them." What this specifically means in the laboratory is that if you understand how an enzyme envelops a substrate, then you can teach it to absorb other molecules instead. "In the end, the enzyme has to do what we want it to." Achieving this involves a process that entails looking, understanding and systematically modifying.

Crystallographers initially determine the three-dimensional structure of the suitable enzyme. This is followed by experimentation. All building blocks must be able to be combined in a way that enables them to work together efficiently. "If this isn't the case, we replace the building blocks or have to systematically modify them – we call this enzyme engineering," notes Erb. "For example, we use genetic engineering methods to replace small parts of the amino acids located in the middle of the enzyme." The researchers then test whether the new varieties catalyze new reactions. They have already reached this milestone in a small test tube – by adding chemical energy, the researchers can absorb CO_2 using a combination of enzymesmore efficiently than natural photosynthesis. Can this fix climate problems?

"We've already found real potential solutions and achieved the first breakthrough. However, the artificial metabolism is currently still isolated outside a cell," explains Dr. Erb. "The next step is to deploy it in living cells." His goal is not to replace, but rather to "boost" photosynthesis. Erb says an alternative is to find a technical solution – for example, to create an artificial cell. "We don't have to reproduce nature exactly," he stresses. "Humans observed birds flying and ultimately developed something new – airplanes."

Biology, environment & genetic engineering – researcher by conviction

Erb has always been committed to environmental protection. Although his focus was not on synthetic biology while attending school, now he is proud that his ongoing commitment has contributed to the development of solutions for the environment. "I remained true to myself and realized that these new methods are extremely promising." While Professor Erb does acknowledge the importance of societal skepticism, he also notes that it can pose an obstacle to innovation. "We need the opportunity to try things out."

Erb cautions that it is presumptuous to claim that people are superior to nature: "Nature works according to the principle of contingency, meaning while it's good at cobbling together processes – it's not an engineer. Furthermore, it adapts biological processes over a long period of time, but rarely creates anything fundamentally new." Erb envisions the conversion of CO_2 not into biomass, but rather directly into a valuable product – such as biofuel or antibiotics and continues to work together with his ambitious team to further develop concrete solutions in cooperation with partners from the industry.

Erb's guiding principle: at least one new question per day

Erb never really intended to become a professor, but was rather searching for answers to biological and chemical questions. He considers working at the MPI to be a privilege: "Each day I ask myself at least one new question – and each answer raises ten new questions. That motivates me to press on with my research," Erb says. He even dedicates his free time to plants, by enjoying walks through the woods – be it with his family, or on his mountain bike or cross-country skis – where he is surrounded by photosynthesis. ////