New findings on photosynthesis: Helping plants make better use of sunlight

July 5 2023

Prof. Franz Hagn (on the right) and Dr. Umut Günsel in front of a structural model of the transport protein. Credit: Astrid Eckert / TUM

Plants use photosynthesis to produce oxygen, nutrients and bioenergy. But this complex biochemical process is inefficient, with only a fraction

of the sun's energy actually being utilized in photosynthesis. Researchers want to change this in order to help increase the yield of cultivated crops. A research team in Munich has now discovered that the outer envelope membrane of chloroplasts could play a key role in this process.

Plants absorb carbon dioxide and use the sun and water to turn it into biomass and oxygen. Without photosynthesis, life as we know it would be impossible. However, the photosynthesis process is inefficient, since plants utilize only a small portion of the solar energy involved. Researchers around the world are trying to decode the process in order to optimize it—and to be able to produce more biomass in a shorter period of time.

Logistics as a limiting factor

A research team led by Franz Hagn, Professor for Structural Membrane Biochemistry at TUM and research group leader at Helmholtz Munich, has investigated a new approach to optimizing photosynthesis. The researchers didn't focus on the chemical photosynthesis process, instead they looked at what could be called the logistics. The study is published in the journal *Nature Structural & Molecular Biology*.

"Increasing the yield of simple sugars and other metabolites in the chloroplasts is the subject of intensive research," says Hagn. "But just improving the process itself won't help. The products must also be transported out of the chloroplasts across the inner and outer envelope membrane so that the plant can use them to grow."

A large number of transport proteins of the inner envelope membrane and their functionalities have already been investigated in detail. However, the role the outer envelope membrane plays in this process is by far less clear. "Among other things there was a theory that the outer envelope membrane functions as a kind of sieve which allows for almost

unrestricted passage of these metabolites."

Additional transport mechanisms have to be investigated

The researchers have now shown that this is not the case. Investigating the molecular structure of a transport protein in the outer envelope membrane, they were able to determine the mechanism by which certain molecules reach the outside. The team was thus able to demonstrate that a controlled transport takes place which selects metabolites according to charge and size.

"The outer envelope membrane of the chloroplasts has long been ruled out as a barrier for metabolites from photosynthesis. Now we've succeeded in showing that the membrane is probably an important limiting and regulated factor," says Hagn.

Next the scientists want to investigate the structural and functional details of further transport proteins of the outer envelope membrane. In the long term the findings could be used for example to integrate more and larger transport proteins in the outer envelope membrane so that the metabolites could make their way to the outside faster and thus boost the growth of the plant. Hagn says, "Increasing the yield of for example energy plants becomes more and more important in the context of climate change, extreme weather and energy shortages."

More information: Umut Günsel et al, Structural basis of metabolite transport by the chloroplast outer envelope channel OEP21, *Nature Structural & Molecular Biology* (2023). DOI: 10.1038/s41594-023-00984-y

Provided by Technical University Munich