Morphing time—plant chloroplasts wake up before they go go

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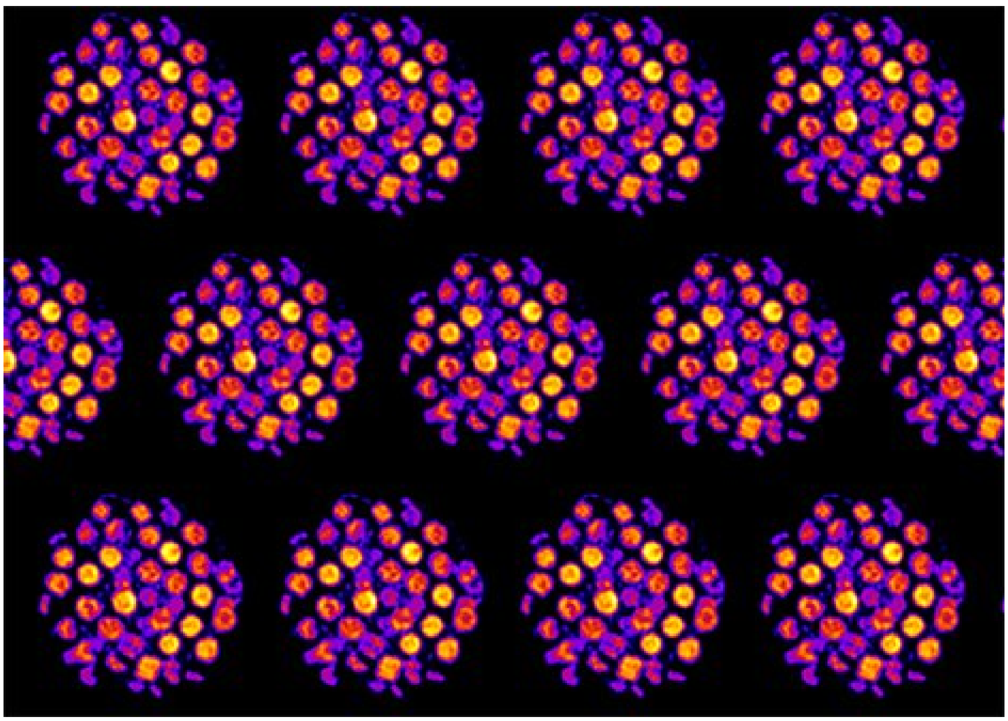

Credit: University of Sheffield

New research published this week in *Nature Plants* by University of Sheffield scientists explains how plants switch from photoprotection to photosynthesis when transitioning from darkness to daylight.

During photosynthesis plant chloroplasts convert light into chemical energy and utilise it to make sugars from CO_2. It's been known since the early part of the twentieth century that when plants first 'wake up' from darkness activation of CO_2 conversion initially lags behind the light driven production of chemical energy. The untapped excess of energy can damage the plants' delicate photosynthetic machinery and so they've evolved a way to protect "themselves" until their CO_2 metabolism kicks in. Until now it wasn't clear how plants switch from this photoprotective mode when they first 'wake up', to efficient photosynthesis thereafter.

The new research led by Dr. Matt Johnson in the Department of Molecular Biology and Biotechnology used structured illumination and atomic force microscopies to image the morphological changes in plants chloroplasts as they transition from dark to light. Using computer modelling and electron transfer measurements they could show how the dark and light structures favour photoprotection and efficient photosynthesis respectively.

Dr. Johnson explains "It was thought for many years that chloroplast structure was fairly immutable but our work shows that they are dynamic on a timescale of minutes and that these changes allow plants to control the flow of electrons between the photoprotective and photosynthetic pathways while they wake up"

"Our imaging shows that in the dark half of the photosynthetic membranes in the chloroplast stack up tightly limiting their interaction with the other half, this partition creates separate pools of one of the key electron carriers, ensuring the photoprotective pathway can be activated. However, this comes at a price since part of the system isn't operating in photosynthesis. Therefore, once conversion of CO_2 wakes up the plant transitions to a light state with reduced membrane stacking, ensuring the full electron carrier pool is efficiently devoted to photosynthesis."

"The efficiency with which plants transition between photosynthesis and photoprotection has already been shown to increase crop yields. The added understanding brought by this work could therefore provide further clues on how we can grow more food to feed a growing population and produce more biofuels from plants and algae to meet future energy need"

Professor Peter Horton FRS, the Chief Research Advisor at the University of Sheffield's Grantham Centre for Sustainable Futures praised the work "This remarkable discovery brings together several previously unlinked phenomena in photosynthesis and merges them together into a coherent model. It is particularly apt that the work should be carried out in Sheffield, since not only does it build upon some of my own research done in the 1980s but it is also based on the pioneering insights into the metabolic changes occurring in plants as they transition from dark to light made by Professor David Walker FRS here 4 decades ago."

More information: William H. J. Wood et al. Dynamic thylakoid stacking regulates the balance between linear and cyclic photosynthetic electron transfer, *Nature Plants* (2018). DOI: 10.1038/s41477-017-0092-7

Provided by University of Sheffield