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Interdisciplinary research reveals astonishing adaptation mechanisms of microscopic algae

Researchers from the University of Jena and the Leibniz Institutes in Jena have published new findings on the adaptability of the microalgae Chlamydomonas reinhardtii. The interdisciplinary study, largely carried out by researchers from the Cluster of Excellence 'Balance of the Microverse', shows how the tiny green alga can adapt its shape and metabolism under natural conditions without changing its genome.

The research was published today in the scientific journal 'New Phytologist'. The research team investigated how the green microalga Chlamydomonas reinhardtii, a model organism in biology, undergoes a kind of 'metamorphosis' in an acetate-rich, spatially structured environment modelled on natural rice paddy soils. In its natural environment, the alga is often found in wet soils, such as rice paddies, which are acetate-rich and where it coexists with other microorganisms. The cells of the alga are normally about 10 micrometres in size, carry two flagella and have a primitive eye, the so-called 'eyespot', which is responsible for light-controlled movements.

The researchers found that the tiny alga adapts significantly under the simulated conditions: The cell size is further reduced, the flagella become shorter, the eyespot volume increases, and the cell wall is strengthened. These changes facilitate survival in the complex, partly anaerobic environment characterized by microorganisms. In addition, the algae regulate the amount of its light-sensitive receptors and produce more carbohydrates in the form of starch. Simulating the natural conditions of rice fields makes it better to understand the interactions between algae and their environment. Adaptation to these environments is necessary as the algae compete with other microorganisms and are often exposed to stress conditions that occur in these soils.

'Our study shows how important it is to investigate microorganisms not only under laboratory conditions but also in environments that resemble their natural habitat,' emphasizes Maria Mittag, Professor of General Botany and corresponding author of the article. 'Only under such conditions do profound adaptation mechanisms reveal themselves that are not observed in the laboratory.' Together with the working group of Prof Pierre Stallforth, Professor of Bioorganic Chemistry and Palaeobiotechnology, researchers from both professorships have created a spatially structured 3D environment for the algae.

The research work demonstrates the interdisciplinary collaboration in the Cluster of Excellence 'Balance of the Microverse' in Jena. Expertise from microbiology, botany, photonics, and bioinformatics was combined to investigate the adaptations of Chlamydomonas reinhardtii. Dr Patrick Then and Dr Martin Westermann captured the algae's altered shape in images. The expertise of the working groups of Prof. Maria Mittag in the field of algae biology and Prof. Jürgen Popp in Raman spectroscopic analysis made it possible to visualize changes in starch metabolism at the subcellular level.

'The combination of innovative optical technologies and interdisciplinary approaches has enabled us to gain a comprehensive insight into the biological adaptations of Chlamydomonas reinhardtii,' says Prof Jürgen Popp, explaining

the need for interdisciplinary collaboration.

It came as a surprise to the authors that simply changing the cultivation conditions led to the up- or down-regulation of certain genes or proteins and ultimately metabolic pathways, without the need to change the genome. The findings could have long-term applications in biotechnology, for example in the production of sustainable biofuels.

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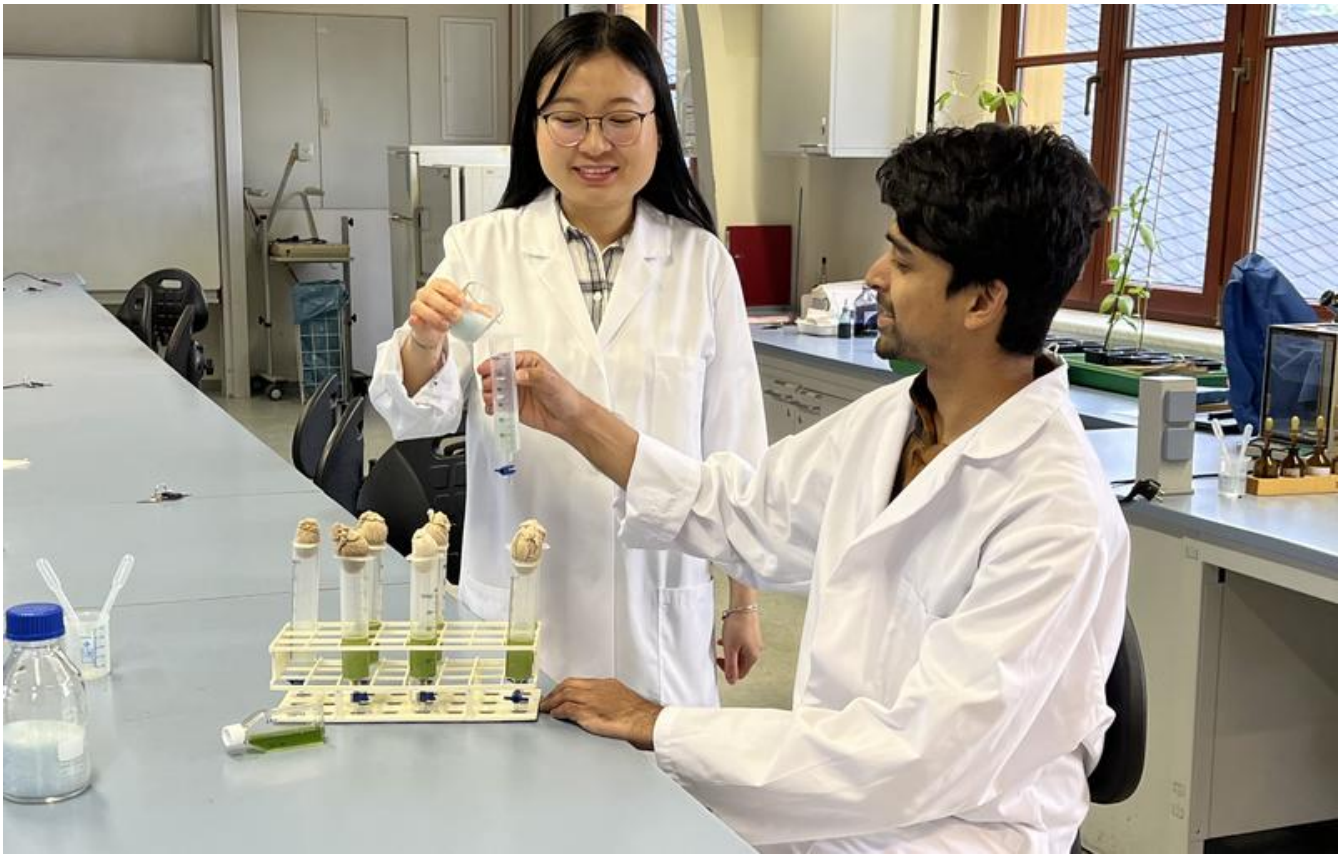

Dr Trang Vuong (l.) and Dr Prateek Shetty from the University of Jena show the growth of the green alga in the spatially structured 3D environment in comparison to conventional cultivation conditions in the laboratory.
Photo: Maria Mittag