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Equipping crop plants for climate change

May 3 2021

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Biologists at Ludwig-Maximilians-Universitaet (LMU in Munich) have significantly enhanced the tolerance of blue-green algae to high light levels—with the aid of artificial evolution in the laboratory.

Sunlight, air and water are all that cyanobacteria (more commonly known as blue-green algae), true algae and plants need for the production of organic (i.e. carbon-based) compounds and molecular oxygen by means of photosynthesis. Photosynthesis is the major source of building blocks for organisms on Earth. However, too much sunlight reduces the efficiency of photosynthesis because it damages the 'solar panels', i.e. the photosynthetic machineries of cyanobacteria, algae and plants. A team of researchers led by LMU biologist Dario Leister has now used "artificial laboratory evolution" to identify mutations that enable unicellular cyanobacteria to tolerate high levels of light. The long-term aim of the project is to find ways of endowing crop plants with the ability to cope with the effects of climate change.

The cyanobacteria used in the study were derived from a strain of cells that were used to grow at low levels of light. "To enable them to emerge from the shadows, so to speak, we exposed these cells to successively higher light intensities," says Leister. In an evolutionary process based on mutation and selection, the cells adapted to the progressive alteration in lighting conditions—and because each cell divides every few hours, the adaptation process proceeded at a far higher rate than would have been possible with green plants. To help the process along, the researchers increased the natural mutation rate by treating cells with mutagenic chemicals and irradiating them with UV light. By the end of the experiment, the surviving blue-green algae were capable of tolerating light intensities that were higher than the maximal levels that can occur on Earth under natural conditions.

To the team's surprise, most of the over 100 mutations that could be linked to increased tolerance to bright light resulted in localized changes in the structures of single proteins. "In other words, the mutations involved primarily affect the properties of specific proteins rather than altering the regulatory mechanisms that determine how much of any given protein is produced," Leister explains. As a control, the team then introduced the genes for two of the altered proteins, which affect photosynthesis in different ways, into non-adapted strains. And in each case, they found that the change indeed enabled the altered cells to tolerate higher light intensities than the progenitor strain.

Enhancing the tolerance of crop plants to higher or fluctuating light intensities potentially provides a means of increasing productivity, and is of particular interest against the background of ongoing global climate change. "Application of genetic engineering techniques to plant breeding has so far concentrated on quantitative change—on making more or less of a specific protein," says Leister. "Our strategy makes qualitative change possible, allowing us to identify new protein variants with novel functions. Insofar as these variants retain their function in multicellular organisms, it should be possible to introduce them into plants."

Provided by Ludwig Maximilian University of Munich

Citation: Equipping crop plants for climate change (2021, May 3) retrieved 19 September 2024 from https://phys.org/news/2021-05-equipping-crop-climate.html