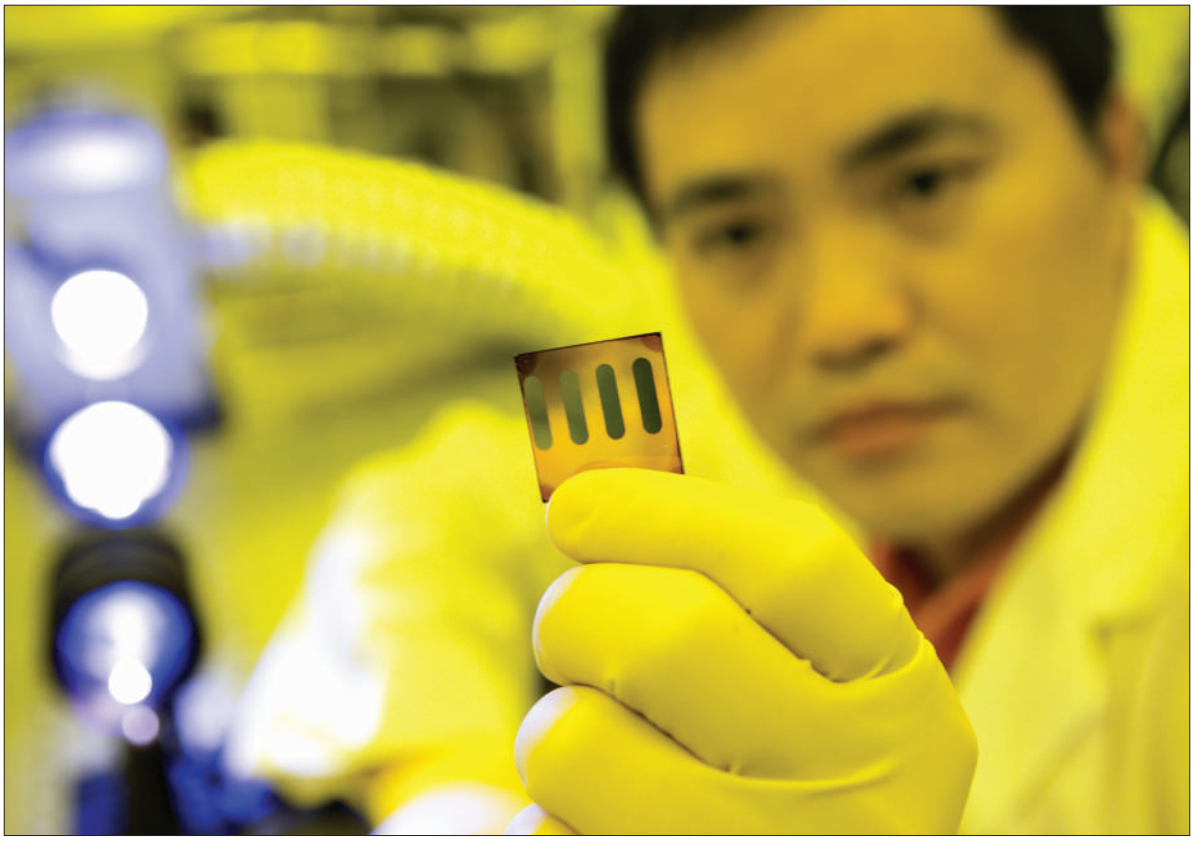

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How Plants Counteract Against the Shade of Larger Neighbours

Plants that "lose the battle" during competitiveness for light because they are shaded by larger neighbours, counteract. They adapt by rapid shoot elongation and stretch their leaves towards the sun. The molecular basis of this so-called shade avoidance syndrome had been unclarified to date. Research scientists from the Utrecht University in the Netherlands and the Ruhr University in Bochum have now been able to unravel a regulation pathway.

A specific transport protein (PIN3) enables the accumulation of the plant hormone auxin, which plays an important role during this adaptation process, in the outer cell layers of the plants, thus enhancing the growth process. The international group of researchers, which includes the plant hormone specialist Prof. Stephan Pollmann from the RUB, has published its observations in the current edition of the Proceedings of the National Academy of Science PNAS.

Suddenly in the shade: plants counteract

Plants often grow in very complex ecosystems, implying that they are in danger of being overgrown and thus shaded by adjacent larger neighbours. Plants have a number of adjustment mechanisms enabling them to register competing neighbours and enhance their competitive reaction. This ensures flexible reaction. Permanent perception of the light intensity and quality is imperative for this process. Prof. Pollmann explained that chlorophyll, the photosynthetic pigment in the leaves, absorbs almost all shades of blue and far red, only allowing dark red light to pass through the leaves. There is a significant change in the red to far-red ratio if a plant is shaded by foliage. If the light receptors in the plants register this change, they initiate a number of adjustment mechanisms in their growth and development program. Taken together these constitute the so-called shadow avoidance syndrome. They enhance the growth of shoots and the upward movement of the leaves (i.e. the hyponastic response).

Auxins play a significant role

Vascular plants produce an entire series of different small signalling molecules, so-called phytohormones, which regulate growth and differentiation processes. Auxins, one of the best-known plant growth factors, have an extremely wide spectrum of activity, and are particularly important. They play a decisive role in almost all plant growth processes, including the shade avoidance reaction. To date, the underlying mechanism was however not fully comprehended. Prof. Pollmann stated that it had been known that the effect of auxin is based on an interaction of auxin formation, transportation and signal transduction. These processes are all influenced by a low red to far-red ratio, but the exact mechanisms were not understood.

Protein distribution ensures directional the flow of hormones

A group of research scientists working under the auspices of the ecophysiologist Dr. Ronald Pierik at the Utrecht University (NL) has now managed to shed light on the matter and further clarify the growth processes in the shoots during the shade avoidance syndrome. They made an interesting observation, namely that shoot growth during a low red to far-red ratio is subject to an intact auxin perception mechanism and is dependent on the accumulation of auxin in the shoot. The auxin transport protein PIN-FORMED 3 (PIN3) is primarily responsible for this accumulation. The formation of PIN3 is enhanced when the ratio between red to far red is low. It primarily accumulates in the lateral endodermal cell walls. This distribution of PIN3 leads to an auxin flow towards the epidermal cell layers, which are responsible for the elongation growth of the shoot.

Comparison between plants in light and shade

This working hypothesis could be experimentally verified by collaboration with Prof. Stephan Pollmann, an expert for phytohormones at the Ruhr University in Bochum. Using state-of-the art mass spectrometry, he succeeded in quantifying and comparing the auxin content in wild-type and genetically created pin3 mutants, which are not capable of producing the transport protein. The shade avoidance syndrome was not present in the genetically altered plants without PIN3. Prof. Pollmann summarized that it is thus possible to deduce the important role of PIN3 controlled auxin accumulation during the shade avoidance reaction.

Journal Reference: D. H. Keuskamp, S. Pollmann, L. A. C. J. Voesenek, A. J. M. Peeters, R. Pierik. Auxin transport through PIN-FORMED 3 (PIN3) controls shade avoidance and fitness during competition. Proceedings of the National Academy of Sciences, 2010; DOI: 10.1073/pnas.1013457108