Press Release

Drought resistance explained

Structural study at EMBL reveals how plants respond to water shortages

Grenoble, 8 November 2009 - Much as adrenaline coursing through our veins drives our body's reactions to stress, the plant hormone abscisic acid (ABA) is behind plants' responses to stressful situations such as drought, but how it does so has been a mystery for years. Scientists at the European Molecular Biology Laboratory (EMBL) in Grenoble, France, and the Consejo Superior de Investigaciones Cientificas (CSIC) in Valencia, Spain discovered that the key lies in the structure of a protein called PYR1 and how it interacts with the hormone. Their study, published online today in Nature, could open up new approaches to increasing crops' resistance to water shortage.

Under normal conditions, proteins called PP2Cs inhibit the ABA pathway, but when a plant is subjected to drought, the concentration of ABA in its cells increases. This removes the brake from the pathway, allowing the signal for drought response to be carried through the plant's cells. This turns specific genes on or off, triggering mechanisms for increasing water uptake and storage, and decreasing water loss. But ABA does not interact directly with PP2Cs, so how does it cause them to be inhibited? Recent studies had indicated that the members of a family of 14 proteins might each act as middle-men, but how those proteins detected ABA and inhibited PP2Cs remained a mystery – until now.

A group of scientists headed by José Antonio Márquez from EMBL Grenoble and Pedro Luis Rodriguez from CSIC looked at one member of this family, a protein called PYR1. When they used X-ray crystallography to determine its 3-dimensional structure, the scientists found that the protein looks like a hand. In the absence of ABA, the hand remains open, but when ABA is present it nestles in the palm of the PYR1 hand, which closes over the hormone as if holding a ball, thereby enabling a PP2C molecule to sit on top of the folded fingers. As these features seem to be conserved across most members of this protein family, these findings confirm the family as the main ABA receptors. Moreover, they elucidate how the whole process of stress response starts: by binding to PYR1, ABA causes it to hijack PP2C molecules, which are therefore not available to block the stress response.

"If you treat plants with ABA before a drought occurs, they take all their water-saving measures before the drought actually hits, so they are more prepared, and more likely to survive that water shortage – they become more tolerant to drought", Rodriguez explains. "The problem so far", Márquez adds, "has been that ABA is very difficult – and expensive – to produce. But thanks to this structural biology approach, we now know what ABA interacts with and how, and this can help to find other molecules with the same effect but which can be feasibly produced and applied."

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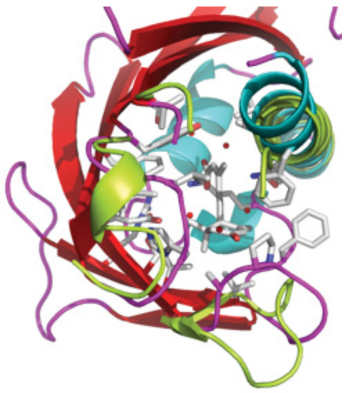
After being subjected to drought for 15 days, an Arabidopsis thaliana plant will normally be withered and dry (far left), but plants from the same species that were genetically engineered to enhance their response to ABA (centre left, centre right and right) were more resistant to drought.



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This image shows the structure of PYR1 (coloured ribbons) in its open, unbound state (light green loops) and how it folds around ABA (white rods) when it binds to this hormone (turquoise and purple loops).

To determine the structure of PYR1, the scientists made use of the infrastructure of the Partnership for Structural Biology, including EMBL Grenoble's high-throughput crystallisation facilities and the beamlines at the European Synchrotron Radiation Facility, located in the same campus as EMBL Grenoble.

Source Article

Santiago, J., Dupeux, F., Round, A., Antoni, R., Park, S.Y., Jamin, M., Cutler, S.R., Rodriguez, P.R. & Márquez, J. A. The abscisic acid receptor PYR1 in complex with abscisic acid. *Nature* advance online publication, 8 November 2009.

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About EMBL

The European Molecular Biology Laboratory is a basic research institute funded by public research monies from 20 member states (Austria, Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom) and associate member state Australia. Research at EMBL is conducted by approximately 80 independent groups covering the spectrum of molecular biology. The Laboratory has five units: the main Laboratory in Heidelberg, and Outstations in Hinxton (the European Bioinformatics Institute), Grenoble, Hamburg, and Monterotondo near Rome. The cornerstones of EMBL's mission are: to perform basic research in molecular biology; to train scientists, students and visitors at all levels; to offer vital services to scientists in the member states; to develop new instruments and methods in the life sciences and to actively engage in technology transfer activities. EMBL's International PhD Programme has a student body of about 170. The Laboratory also sponsors an active Science and Society programme. Visitors from the press and public are welcome.

About EMBL Grenoble

The EMBL Outstation in Grenoble, France, is located in very close proximity to two unique European facilities for research in structural biology: the nuclear reactor of the Institut Laue-Langevin (ILL), which provides high flux neutron beams, and the European Synchrotron Radiation Facility (ESRF),which produces Europe's most intense X-ray beams. EMBL Grenoble collaborates very closely with both of these facilities in building and operating beamlines for macro-molecular crystallography, in developing the associated instrumentation and techniques, and in providing biochemical laboratory facilities and expertise to external visitors, as well as supporting an active in-house research programme in structural biology.