ALBA news

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Scientists unveil a molecular mechanism that controls plant growth and development

BL13 - XALOC

Researchers from the Institute for Research in Biomedicine (IRB), the Molecular Biology Institute of Barcelona (IBMB-CSIC) and the University of Wageningen (The Netherlands) have discovered how auxin hormone-regulated proteins activate development genes in plants. Some of the measurements of this study- published in Cell- were performed at XALOC beamline.

Auxins are plant hormones that control growth and development, that is to say, they determine the size and structure of the plant. Among their many activities, auxins favor cell growth, root initiation, flowering, fruit setting and delay ripening.

At the molecular level, the hormone serves to unblock a transcription factor, a DNA-binding protein, which in turn activates or suppresses a specific group of genes. Some plants have more than 20 distinct auxin-regulated transcription factors. They are called ARFs (Auxin Response Factors) and control the expression of numerous plant genes in function of the task to be undertaken, that is to say, cell growth, flowering, root initiation, leaf growth etc.

This joint study, headed by Miquel Coll at the IRB and the IBMB-CSIC, has analyzed in detail the DNA binding mode used by various ARFs using X-ray diffraction techniques at the ALBA Synchrotron and at the European Synchrotron Radiation Facility (Grenoble, France). Researchers solved the 3D structures revealing why a given transcription factor is capable of activating a single set of genes, while other ARFs that are very similar with only slight differences trigger a distinct set.

Reference: "Structural basis for DNA binding specificity by the auxin-dependent ARF transcription factors" D. Roeland Boer, Alejandra Freire-Rios, Willy van den Berg, Terrens Saaki, Iain W. Manfield, Stefan Kepinski, Irene López-Vidrieo, Jose Manuel Franco, Sacco C. de Vries, Roberto Solano, Dolf Weijers, and Miquel Coll. Cell (2014) 156:577-589

IRB link

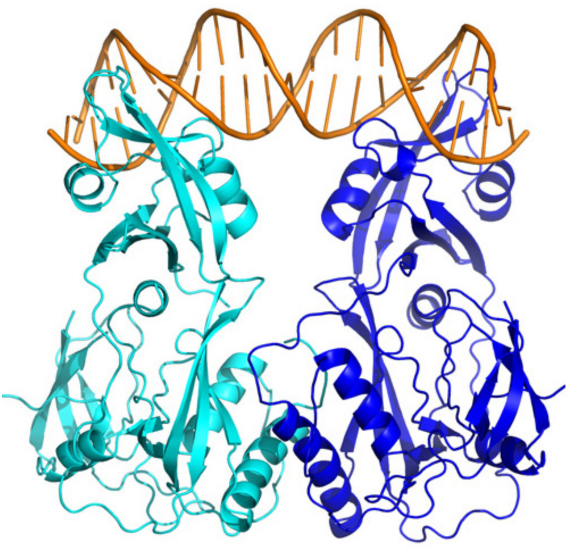

Figura 6: Atomic structure of an ARF/DNA complex. Auxins control the growth and development of plants through ARF (Author: R. Boer, IRB/CSIC)

Check the article written by John Helliwell about this experiment on page 10.

Photo taken by John R Helliwell in his garden.

The inner life of plants and their responses

Have you ever wondered why plants in an identical pot and under obviously identical weather conditions respond differently? This photo (above) from my own garden in mid-February shows one part of a plant pot that has given up and one part that is still green and obviously alive. Have you ever read the Day of the Triffids by John Wyndham with the giant plants that take over the world? Or have you considered these ideas about life on Mars and beyond in potentially different atmospheres and soils than our own Earth?

● Plant response factors are the biochemical details to address such questions. Recent research published in Cell involves the auxin response. Auxin was originally discovered in research started by Charles Darwin and his son Francis looking at how plant growth responds to the direction of the light illumination (http://en.wikipedia.org/wiki/Auxin#Discovery_of_auxin).

Indole-3-acetic acid is the most abundant and basic auxin in plants. Auxin acts via regulation of genes in the plant. In the study by Boer et al published in Cell [1] they made a truly comprehensive study involving biophysical and biochemical characterisation techniques, including X-ray crystallography data quite recently measured at ALBA on the Xaloc beamline, as well as earlier data measured at ESRF in Grenoble before ALBA came online. From the 3D protein and nucleic acid structures the critical amino acids involved in the gene regulation could be identified. Modern genetics allows specific amino acids to be changed. The modified protein can be isolated and crystallised for further X-ray crystal structure analysis. The mutant G245A (glycine changed to alanine at position 245 in the particular protein polypeptide chain studied) was the one studied at ALBA. Earlier studies involved mutations at several other key places of the protein. These changes were deliberately introduced to disrupt or distort the protein nucleic acid interaction.

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With these site specific molecular changes in the genes the 'genetically modified plant' of the Arabidopsis (a small flowering plant related to cabbage and mustard) could be grown. These showed a variety of poor or compact (ie bushy) growing features.

How might this fundamental science make its way to impacting on society at large? Of course, as it did with this writer, it fuelled the imagination from arousing my renewed curiosity of what is happening in my own garden and on to my wilder imagination as to its implications in 'astrobiology'. Genetically modified (GM) crops are the more 'bread and butter' aspects. These are welcomed in some countries e.g. where hunger and famine are common place and controversial in others, notably where the citizens are well fed. How might this research help both community factions? For the hungry in the world such fundamental research will surely assist a more penetrating set of ideas and discoveries as to how to work with plant growers and agriculturalists as well as ultimately farmers. For the GM sceptics such research shows explicitly and clearly how plants respond to their environment via their genes and their biochemical response molecules, in this case auxin. Thus the wish by the sceptics of GM for a greater clarity on the effect of a given genetic mutation within the plant is achieved.

For myself I think the impact of this work is several fold. The team involved in the publication is clearly broad and each team is at the forefront of such modern day research; I am full of admiration. Secondly, as Chairman of the ALBA Beamtime Panel and of the Science Advisory Committee, for me to be able to see over a 4 years period of time the ALBA facility in general and Xaloc in particular move from build to commissioning to regular use is a marvellous thing. The Spanish community in all its range of science and technology skills can be rightly proud of this achievement with ALBA. Thirdly I have learnt a lot more than I did about plant molecular biology. Fourthly, maybe it is time for me to start that novel as a modern successor to the 'Day of the Triffids'!

[1] Boer et al Cell Volume 156, Issue 3, 577-589, 30 January 2014.

If you want to know more about this experiment, go to page 15.