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Perspective

Photosynthesis occurs during leaf development

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PERSPECTIVE

The coordinated morphogenesis process by which a leaf is formed and grows to become a mature photosynthetic organ is referred to as leaf development. It begins with the formation of a primordium in the shoot meristem and culminates in the fully structured leaf, which is made up of trichomes, guard cells, epidermal and mesophyll layers, and vascular cells.

The leaf's photosynthetic capacity is the foundation for the entire plant's growth. It is critical to get a mechanistic understanding of leaf growth and development, as well as the effect of genetic and environmental factors on the process, in order to optimise crops for increased productivity and resistance in future climate scenarios. The basic building blocks of the leaf are cells, and the regulatory units that integrate genetic and environmental information into the developmental programme are cells.

To fully comprehend leaf formation, one must be able to rebuild the developmental course of individual cells (and their children) from the stem cell niche to the mature leaf's final position. We evaluate existing information on the spatial and temporal control mechanisms working on cells that contribute to the creation of a leaf to lay the groundwork for such an understanding.

Intercellular signaling molecules such as plant hormones, sugars, peptides, proteins, and microRNAs regulate molecular networks that control exit from stem cell fate, leaf initiation, polarity, cytoplasmic growth, cell division, endoreduplication, transition between division and expansion, expansion and differentiation, and their regulation by intercellular signaling molecules such as plant hormones, sugars, peptides, proteins, and microRNAs. We address whether the knowledge available in the literature can be used in systems biology approaches to model the process of leaf growth, starting with the model species, in order to better understand and predict leaf growth.

Understanding how plants and their constituent parts are regulated is an important goal in biology. It is the foundation for agricultural productivity, ecosystem turnover, and the plant's ability to adapt to changing environmental conditions and experimental treatments. The formation of leaves in dicotyledonous plant species is a fascinating process that involves a complex interplay of regulatory circuits. On the one hand, it is so tightly controlled that the resulting leaf morphology is a trustworthy taxonomic feature. However, the process is so malleable that external influences can alter the size of mature leaves by an order of magnitude.

Surprisingly, despite genetic variances in thousands of genes, leaf form is frequently highly retained between related species, yet a single mutation can occasionally cause morphological differences equivalent to those that distinguish species and even families. Many elements of leaf growth have been widely explored due to these unique traits and the relevance of leaves for plant performance and function.

Through molecular/genetic techniques, significant progress has been made in understanding the regulation of leaf development in recent decades. Furthermore, as high-throughput technologies become more widely used, new biological data is continually being generated at various organizational levels. Systems biology provides a way to incorporate accumulating knowledge into holistic mechanistic models to gain a thorough understanding of biological processes in this environment. These models are frequently built using computer simulations of normal and/or experimentally perturbed systems to see how closely they mirror the real situation and to learn more about its mechanistic foundation.

An integrated perspective of the regulatory networks that control developmental decisions and activities of cells as they move in space and time from the Shoot Apical Meristem (SAM) to their final position in the leaf is required for a mechanistic understanding of leaf formation. As a result, we look at the later-acting developmental networks that direct individual cells from the SAM to a differentiated state somewhere in a fully differentiated leaf. Based on this description, we can determine how well we understand how changes in cell regulation affect the overall form and size of the leaf, as well as the implications for incorporating this knowledge into full-fledged simulation models.

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