Nature Reviews Molecular Cell Biology | AOP, published online 27 March 2013; doi:10.1038/nrm3559

Journal club

ROOTS OF BEAUTY

The arrangement of flowers around the stem and the patterns of veins in a leaf are examples of the many attractive spatial patterns that plants can create. Many of these patterns are generated during development by polar transport of the phytohormone auxin. Auxin gradients, which result from the self-organization of auxin transport, are as important in plant development as morphogen gradients are to animal development. The concept of a self-organizing auxin transport system can be traced to a paper published by Tsvi Sachs in the late 1960s.

It was already known at the time that auxin is transported through plant tissues, usually in the shoot-to-root direction. Sachs wanted to understand how auxin could induce new vascular tissue organized in sharply defined strands. He removed the vasculature from sections of pea roots and saw that localized auxin application was sufficient to induce differentiation of new vascular strands that were oriented towards the pre-existing vasculature further down the root. Performing repeated auxin applications, he showed that pre-existing vascular strands were sufficient to orient new strands. By applying auxin simultaneously to the site of strand initiation and to a pre-existing vascular strand, Sachs also showed that the orientation of new vascular strands depended on the difference in auxin levels between the two sites, rather than on the absolute levels of auxin in the tissues.

> “Sachs … influenced our understanding of plant development with simple experiments using peas, auxin-laced lanolin, steady hands and a rigorous mind.”

To explain his results, Sachs proposed the auxin canalization hypothesis: as auxin flows through the tissues, cells respond by becoming better auxin transporters and compete to establish a preferred path of auxin flow. This flow drains auxin from the surrounding tissues and the cells along the preferred path differentiate as vasculature. This autocatalytic process explains both vascular continuity and the sharp boundaries of vascular differentiation within the tissues.

Subsequent work revealed the central role of self-organizing auxin transport not only in vascular development but also in establishing the arrangement of new leaves around the stem (phyllotaxis), in setting embryo polarity and in positioning plant stem cell niches, to mention just a few processes. The molecular and cellular mechanisms underlying polar auxin transport continue to be a highly active research area and are central to current computational modelling of plant development.

Sachs laid the roots of a concept that has profoundly influenced our understanding of plant development with simple experiments using peas, auxin-laced lanolin, steady hands and a rigorous mind.

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The author declares no competing financial interests.

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