PLANT DEVELOPMENT

How does your garden grow?

Anyone who has ever taken a plant cutting and put it in some water to grow knows that plants have the ability to regenerate. But what are the molecular mechanisms behind this phenomenon? Ben Scheres and co-workers, reporting in *Science*, investigate regeneration in *Arabidopsis thaliana* roots, and reveal the interaction network that re-establishes a new root tip.

The *A. thaliana* root has a simple structure that consists of concentric cylinders of cells. Within a growing root, this radial pattern emanates from a small group of stem cells that surround a quiescent centre (QC) — a region of mitotically inactive cells that maintains the stem-cell status of adjacent cells — which itself is found at the heart of the root apical meristem. Some of the new cells that originate at the meristem are root-cap cells, which cover the distal tip of the roots and protect the QC and stem-cell niche as the root grows.

Xu *et al.* used a laser to wound the QC to disrupt the flow of the plant hormone auxin, which regulates diverse aspects of plant growth and development. This resulted in the rapid upregulation of the auxin response, followed by cell-fate changes, which indicates that the disruption of auxin flow stimulates regeneration. Additionally, the authors investigated whether auxin disruption influences the localization of the transmembrane PIN proteins, which are putative auxin-efflux transporters. By monitoring functional PIN-GFP fusions after QC ablation, they showed that new PIN-protein expression and localiza-

tion is dependent on renewed cell specification. It is only after renewed cell specification, therefore, that PIN proteins can become correctly polarized in response to changes in auxin distribution.

So, what role might the key patterning genes have in the induced regeneration process? The GRAS-family transcription factors SHORTROOT (SHR) and SCARECROW (SCR) are required for QC-cell specification, and the genes that encode PLETHORA 1 (PLT1) and PLT2 can be induced by auxin and, when expressed ectopically, convey root identity. Examination of *plt1-4 plt2-2* mutants showed defects in QC specification, as expected, as well as in nuclear SHR targeting — both events are associated with root regeneration. The role of SCR in QC specification, which was investigated by examining the *scr4* null allele, was also shown to be

crucial during regeneration.

Xu and colleagues have proposed a model for root regeneration in which the cell-fate changes that are induced by auxin are dependent on new expression patterns and the activity of PLT, SCR and SHR transcription factors. Although classical canalization hypotheses, which were proposed to explain vascular pattern formation, are based on the assumption of positive-feedback regulation between auxin flow and transport, the authors have shown here that, surprisingly, cell-fate changes in the root are first induced by auxin redistribution and, only consequently, changes in the polarity of auxin flow are induced.

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ORIGINAL RESEARCH PAPER Xu, J. *et al.*
A molecular framework for plant regeneration.
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