

Pictures in cell biology

Actin-driven polar growth of plant cells

One of the major discoveries in cell biology from the past decade was the finding that forces associated with actin polymerization are strong enough to propel bacteria such as *Listeria* and *Shigella* within eukaryotic host cells and even to drive animal/mammalian cell motility by pushing the plasma membrane at their advancing fronts. This actin polymerization-driven 'pushing of the cellular envelope' is tightly coupled to both signal-perception and signal transduction at the plasma membrane. The coupling of signaling at the plasma membrane to actin dynamics is valid also for plant cells [1,2]. However, until recently, plant cells did not seem to fit into the emerging scheme in which the dynamic machinery associated with the process of actin polymerization is implicated in signaling-mediated navigation required for cell polarity and motility. Obviously, this might have something to do with the unique features of plant cells – which are all enclosed by rigid cell walls. The latter feature precludes cellular motility, and a long-standing dogma holds that the ultimate force behind cellular growth in plant cells is the high internal turgor pressure generated within plant cells.



Fig. 1. Actin visualized in root hairs using a monoclonal antibody against actin and chemically fixed plant material. Note actin-enriched tips of growing root hairs (arrows). For further details, see Ref. [6]. Bar, 20 μm .

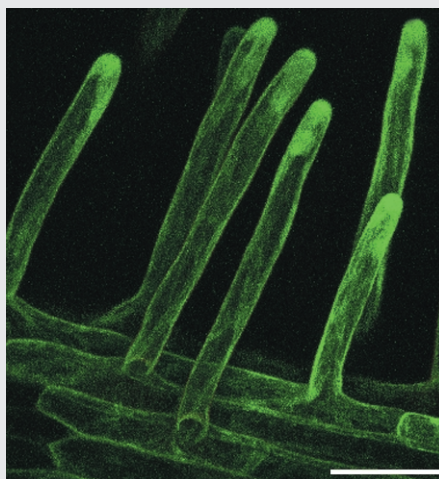


Fig. 2. Actin visualized in living root hairs of *Arabidopsis* seedlings transformed with the actin-binding domain of talin linked to green-fluorescent protein (GFP). Note actin-enriched tips of growing root hairs. For further details, see Ref. [6]. Bar, 90 μm .

But recent studies reveal that this long-lasting belief might be incorrect for apices of tip-growing plant cells, such as root hairs and pollen tubes, and partially incorrect even for rapidly elongating plant cells. A breakthrough in our understanding of processes driving the growth of plant cells came with the use of highly efficient inhibitors of actin polymerization known as latrunculins. Latrunculin B at low-nanomolar concentrations perturbs the organization of actin filaments in the tip of growing pollen tubes, and this rapidly inhibits their tip growth [3]. Moreover, at the level of the whole plant, long-term depolymerization of F-actin allows cell division and development to continue but prevents rapid cell elongation, resulting in dramatic seedling dwarfism [4]. Importantly, extremely low levels (<10 nM) of latrunculin B stop the tip growth of pollen tubes without affecting intracellular motilities and cytoplasmic streaming [3]. These intriguing results were confirmed in a more extensive study documenting that actin polymerization is the rate-limiting process for growth of the pollen tube tip [5]. In accordance with this, actin polymerization has been shown to be essential also for the tip growth of

root hairs [6]. Moreover, dense meshworks of dynamic F-actin, supported by abundant profilin [6] and actin-depolymerizing factor (ADF) [7] molecules, are closely associated with tips of rapidly growing root hairs (Figs 1,2).

Now, another unexpected finding on tip-growing pollen tubes has just been published. cAMP is identified as a hot candidate for a second messenger in pollen tube tip growth and navigation [8]. As cAMP signaling is closely related to signal-mediated dynamics of the actin cytoskeleton in non-plant cells [9], it might turn out that elements of cAMP signaling impinge directly on the machinery driving actin polymerization in plant cells too.

References

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František Baluška

Dieter Volkmann

Rheinische Friedrich-Wilhelms-University of Bonn, Institute of Botany, Kirschallee 1, D-53115 Bonn, Germany.

e-mail: baluska@uni-bonn.de