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Not superficial, but on the surface

When cells grow, their surface increases with the second power of the radius, their volume only with the third power. This leads to a progressive discrepancy between the supply of resources and their consumption. This discrepancy is adjusted by cell division, and during early evolution, multicellularity initially probably evolved as a strategy to increase in size and thus to escape the fate to be divoured by predators. However, the full potential of multicellularity was exploited only when the individual cells of the newborn organism began to assign different functions to individual members of the population. This implies that specific tasks have to be upregulated on cost of other functions that are downregulated and therefore must be compensated by complementary output from adjacent cells (P. M. Lintilhac, BioScience 49: 59–68, 1999). This division of labour is based on intensive signaling between neighbouring cells and/or the environment. The underlying "chemical negotiation" takes place at the external surface – at the plasma membrane, and (in case of plants) at the plasmodesmata and the cell wall. Three contributions to the present issue highlight these three domains of the external surface.

A quantitative view of plasmodesmal transport

Plasmodesmata are central pathways for the exchange of macromolecules between neighbouring plant cells. However, the actual mechanism by which these molecules can move from one cell to the other has remained elusive. It has been suggested that many macromolecules can traffic cell to cell by passive diffusion. However, a rigorous test of this assumption has been lacking so far. Using transient expressions of GFP fusions with the potato virus X TGBp1 as reporter, G. Schönknecht et al. (pp. 143–152) investigate plasmodesmal transport on a quantitative level. From the temperature dependency of transport for the fusion protein in comparison to isolated GFP they estimate activation energies for protein transport and arrive at the conclusion that the actual movement is driven by diffusion. With progressive expansion of the leaves (resulting in a lower density of plasmodesmata), this diffusion-driven movement decreases, indicating that the targeting of the cargo to an open plasmodesma by nondirectional diffusion is limiting for the capacity of cell–cell transport.

Crucifer on the rocks – plasma membrane and cold adaptation

The plasma membrane is not only the site of intercellular signaling but is central for the sensing of environmental signals and stress factors. During recent years, the plasma membrane could be shown to be a central element of cold signaling and the adaptive response to cold. The impact of cold signaling is especially obvious in so-called cryophytes, plants that are adapted to very harsh temperatures. Using the crucifer *Chorispora bungeana*, a cryophyte living in periglacial areas and adapted to average temperatures of −5 to −7 °C, Y. Shi et al. (pp. 173–181) investigate adaptive responses of the plasma membrane in response to chilling and freezing temperatures. They can show that membrane permeability and fluidity, after an initial breakdown, can recover, which is accompanied by an increase of unsaturated fatty acids such as linolenic acid. To test the adaptation of membrane enzymes, the authors follow the activity of the plasma membrane H^+-ATPase and observe that enzyme activity is maintained at a very high level and even recovers in the course of adaptation. They conclude that cold resistance is tightly linked with the rapid and flexible regulation of membrane lipids and membrane-associated enzymes.

Sense and seize – how the cell wall responds to touch

Due to its composite structure and the high content of sugar residues, the cell wall is not the ideal target for biochemical approaches and we are therefore still far from having uncovered all its secrets. However, it becomes increasingly clear that, in addition to its role for the regulation of cell expansion, it seems to be a major platform for signal processing and the communication with neighbouring cells and the external environment. For instance, the cell wall seems to be a major player in the perception of touch and other mechanic stimuli. This is especially evident in tendrils, which have evolved as organs to sense

and seize mechanic supports. Choosing tendrils of the Virginia creeper (*Parthenocissus quinquefolia*) as example, A. Bowling and K. Vaughn (pp. 153–163) can show that in response to a touch stimulus, the epidermal cells of these tendrils become papillate and produce an adhesive. This adhesive consists of pectinaceous mucilage that contains rhamnogalacturonan I epitopes surrounding a core of callose. In addition, more mobile components, composed of arabinogalactans and mucilaginous pectins, intercalate both the support and the tendril, penetrating the tendril to the proximal ends of the papillate cells. As soon as the adherence to the support has been completed, the rhamnogalacturonan I epitopes disappear from the anticlinal walls and appear in the contact region, forming an integral part of the adhesive compound. This case study demonstrates that the cell wall responds to mechanic stimulation by synthesis of specific polysaccharides and that this synthesis is regulated in both space and time in a very complex manner. To understand this intricate regulation in response to mechanic stimulation will be an exciting challenge for future studies.

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