

Insights into the inner side: new facets of endocytosis

Only few are aware of the fact that the largest sensory organ in humans is the skin – around two square meters filled with sensory organs for touch, cold, heat, pain, and additional, often highly specialized sensations. When it comes down to the level of individual cells, it is the plasma membrane that does this job. Here is the site where a cell is confronted with its environment and here cluster numerous receptors, channels, carriers, but also nonproteinaceous molecules that are involved in signaling. One would presume that such a complex structure is strictly preserved once it has been established. One of the surprises from live cell imaging is the insight into a shockingly high turnover of membranes in most cells. We understand now that the plasma membrane represents a very dynamic equilibrium, where lipids, proteins, and sugars are continuously inserted and where, on the other hand, these components of the plasma membrane have to be recycled into the cell in order to maintain a balance between volume and surface. The regulatory circuits of membrane dynamics have emerged as central topic of current cell biology with enormous impact on our understanding of differentiation and development. Several articles in this issue highlight cell biological and evolutionary facets of this fascinating field.

Incomplete phagocytosis of endosymbionts

Already at the turn of the last century, Mereshkovsky put forward the idea that the larger organelles, such as mitochondria and plastids, derive from incomplete endocytosis, and it was mainly the merit of Lynn Margulis that this idea became substantiated and shaped the current view of early evolution. Model systems, in which the early steps of endosymbiosis can be studied, contribute to this central mechanism of evolution. Using endosymbiont-free strains of *Paramecium bursaria*, a ciliate that hosts endosymbiotically the unicellular green algae *Chlorella* spp., Y. Kodama and M. Fujishima (pp. 55–63) investigate factors that decide about the fate of the endosymbiont. They can exclude genetic diversity, cell cycle stage, and location of the endosymbiont within the vacuole as determinants. In addition, they demonstrate that endosymbiotic resistance

against digestion requires neither protein synthesis nor the presence of a perialgal membrane within the vacuole. This suggests that endosymbiosis is actively triggered by the host at the time of membrane invagination rather than by a predisposition of the endosymbiont.

Membrane flow in Amoeba proteus

Amoeba proteus derives its name from Proteus, the Greek god of change, and has attracted great interest as very original representative of eukaryotic evolution and as a model for cell motility. Its morphogenetic flexibility is accompanied by an extraordinary dynamics of membrane flow, which is addressed by two articles in this issue. When life advanced into freshwater habitats, the contractile vacuole evolved as efficient mechanisms of osmoregulation balancing the continuous influx of water from the hypotonic environment. Despite the central role of the contractile vacuole in freshwater protists, knowledge about the membrane dynamics of this organelle is still surprisingly poor. Using the styryl dye FM 4-64, E. Nishihara et al. (pp. 25–30) analyze membrane flow in the contractile vacuole of *Amoeba proteus*. They show that the membrane of the contractile vacuole is stained directly when the pore opens during contraction. The fluorescently labeled membrane of the contractile vacuole is subsequently maintained as an entity and does not merge into the plasma membrane during the cycles of contraction and re-formation. This leads to the conclusion that the contractile vacuole has to be understood as a specialized membrane structure that is physically maintained despite continuous events of membrane fusion and separation. The work by P. Pomorski et al. (pp. 31–41) addresses the role of the Arp2/3 complex for pinocytosis. By immunolabeling and live imaging of actin, they show that actin assembly driven by the Arp2/3 complex is involved in the formation of the branching network of the contractile layer, adhesive structures, and perinuclear cytoskeleton without altering overall filamentous-actin concentration. They attribute the strongly condensed state of the microfilament system to isometric contraction of the cortical layer accompanied by its retraction from distal cell regions.

Endocytosis and toxicity

In contrast to the highly mobile animal cells, plants have solved the problem of osmoregulation by a rigid cell wall that prevents protoplast swelling leading to a considerable turgor pressure. In contrast to this seemingly static setup, plant cells are endowed by considerable membrane dynamics as well, and this membrane flux is intimately linked to cellular response to stresses and signals. M. H. Wierzbicka et al. (pp. 99–111) investigate the role of membrane flux for the resistance to highly toxic heavy metals

such as cadmium or lead in onion epidermal cells. By electron microscopy, they can show that lead is encapsulated into small vesicles in the cytoplasm, accompanied by fragmentation of the endoplasmic reticulum. The sequestering of lead in vesicles, a process not observed for cadmium, is correlated to a substantially better resistance to lead as compared to cadmium. Thus, plant cells seem to employ endocytotic membrane flow to efficiently detoxify heavy metals by sequestration.

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