Protoplasma (2009) 237:1–2
DOI 10.1007/s00709-009-0077-0

EDITORIAL

Editorial: comparing is worth the effort—lessons from mitosis

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Current biology has been dominated by studies of model organisms that offer easy access to genomic information, mutant collections, expression profiles, and numerous additional tools that help to assign gene functions and to dissect cellular mechanisms. The idea of using model organisms is to extrapolate from the model organism on a whole taxon, often even beyond a taxonomic group. This approach has been very successful to understand fundamental patterns of molecular interactions and cellular mechanisms. But each success asks a price—investigations that questioned generalization and rather focussed on the specific differences between organisms were neglected and appeared to be outdated. The recent extension of genomic information and tools to non-canonical models, for instance algae or lower land plants has alleviated this issue a bit, but still, comparative cell biology has to fight against the prejudice to be "confirmatory" and, thus, not sufficiently innovative to become interesting. It is time that this still widespread view is revised. Evolution matters, and there is no other way to understand evolution rather than comparing. Whereas metabolic differences such as secondary metabolism of plants between species had always remained in the focus of attention, because they are of tremendous biotechnological relevance, it is now progressively becoming clear that also cell biology is much more shaped by evolutionary differences as hitherto appreciated. Two contributions in the current issue dealing with mitosis illustrate that comparing is worth the effort:

Evolutionary studies determine the host-specificity of viruses, because the viral life cycle exploits host genes and pathways. The cytoskeleton as central element of motility represents a central target for this viral usurpation. In fact, many animal viruses spread through interaction with the microtubular cytoskeleton of the host. The cellular function usurped here might be motor-driven transport of messenger RNA, which has been investigated in neurons, migrating fibroblasts, but also in polarizing yeast cells and plants. In fact, tobacco mosaic virus (TMV) has been the system where viral transport has been studied most intensively. The viral RNA of TMV moves from cell to cell by virtue of a virus-encoded movement protein (TMV-MP). The interaction of the TMV-MP with microtubules is based on molecular mimicry: a conserved motif has been identified in the TMV-MP that exhibits similarity to a motif in α-tubulin motif and mediates the association of MP with microtubules during cell-to-cell movement. Thus, the movement protein acts as a microtubule-associated proteins (MAP), and ectopic expression of this protein is expected to interfere with functions mediated by microtubules. In previous work, this has been investigated for mammalian cells as hosts, and, in fact, mitosis has been observed to be inhibited. In the work by **Boutant et al.** in the present issue, this question is addressed in tobacco, i.e., the natural host species of TMV. This comparative approach leads to some observations that were to be expected, but also to several surprises. In order to minimize undesired side effects on development that would hamper functional analysis, a dexamethasone-inducible system driving the expression of MP in fusion with the green fluorescent protein, was established in tobacco BY-2 cells. Upon induction, the fusion protein decorated all microtubule arrays, including mitotic structures such as preprophase band, spindle, or phragmoplast. This was congruent with the findings from mammalian cells. However, in mammalian

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cells, where the MP induces loss of centrosomal γ-tubulin and impairs centrosomal microtubule nucleation activity, no inhibition of mitosis was observed in BY-2. This difference seems to be correlated with the fundamentally different organization of microtubule-nucleation between animal and plant cells. Whereas γ-tubulin and, thus, nucleation activity, is concentrated on the centrosome in mammalian cells, γ-tubulin is widely distributed over the cytosol in plant cells and, thus, microtubule nucleation is observed at a couple of locations leading to working models on molecular components relevant for plant microtubule nucleation. Thus, the comparative approach uncovers fundamental differences in cellular organization that are interestingly far beyond the specific topic of viral spread.

The study by **Brown and Lemmon** extends comparative approaches even down to the intrataxonomical level. Using indirect immunofluorescence and confocal microscopy, they study microtubular nucleation and organization during meiotic division in liverworts. During the post-meiotic cytokinesis of moss sporocytes, a peculiar, quadripolar shaping of the cytoplasm occurs. This so-called quadrilobing had originally been discovered in the liver-and hornworts, but was later also found, however, in less distinct manifestation, in the Musci, and, thus, represents a common cellular feature of all Bryophytes. In their detailed study of this process in two species of the Jungermanniopsida (leafy liverworts, the largest group of liverworts), they show that the initial step is initiated by characteristic girdling bands of γ-tubulin and microtubules, similar to those recently described previously for a different group, the simple thalloid liverworts. From these bands, a quadripolar spindle develops in a complex process that is described for the first time, for leafy liverworts. The pre-meiotic microtubule bands recall the preprophase band in mitosis of cormophytes that predicts axis and symmetry of the ensuing cell division. However, preprophase bands have never been described in free cells, such as those of the reproductive lineage. The discovery of the pre-meiotic bands in sporocytes of thalloid and leafy liverworts is, therefore, unexpected and allows new insights into the early evolution of land plants. Interestingly, no such predictive microtubular component of cytokinesis exists in extant charophycean green algae, the group most closely related to ancestors of land plants. However, predictive infurrowing does occur in peripheral cells of the *Coleochaete* (that, during recent years, have emerged as new model system to study the transition from algae to terrestrial plants) prior to radial mitotic divisions, but without formation of predictive microtubule bands. Thus, the comparative cell biology of liverworts does not only advance our understanding of the taxonomy of this group of lower plants, but stimulates new models for the early evolution of terrestrial plants.