https://doi.org/10.1093/plcell/koad039

THE PLANT CELL

THE PLANT CELL 2023: 35: 1302–1303

In Brief

Against the grain: Certain microtubules arrange perpendicularly to the division site to guide cell division in maize

Michael Busche [1,2,*]

1 Assistant Features Editor, The Plant Cell, American Society of Plant Biologists, USA
2 Laboratory of Genetics, University of Wisconsin, Madison, WI 53706, USA

*Author for correspondence: busche2@wisc.edu

Cell division is a highly dynamic and tightly regulated process. The initiation and maintenance of the spatial aspects of cell division, including the establishment of cell polarity and placement of the new cell wall, are particularly important to this process. Furthermore, plant cells are immobile, and use directional cell divisions to maintain boundaries and establish tissue and organ polarity, meaning that missteps in spatial regulation of cell division can sometimes have serious developmental consequences.

The final stages of cell division in plants include the formation of a vesicle-rich structure known as the phragmoplast. The phragmoplast is a scaffold-like network of actin filaments and microtubules that forms during telophase and helps create the cell plate and, ultimately, the new cell wall. The phragmoplast initiates between the 2 nuclei of the future daughter cells and then begins to expand toward a specific band on the cortex known as the division site (Smertenko et al. 2017). How this expansion is guided precisely to the division site is unknown. The location of the division site, however, is predictable and established well before phragmoplast expansion, as a cast of proteins and structural molecules assemble there before mitosis even initiates. This, in part, has led researchers to believe division-site- and phragmoplast-localized proteins work together to actively guide the phragmoplast, and the ensuing cell plate, to the division site.

Recent work by **Marschal Bellinger, Aimee Uyehara, and their colleagues** (Bellinger et al. 2023) reveals more about how the phragmoplast is precisely positioned during cell division in maize. Using live-cell imaging of actively dividing maize epidermal cells, they observed a distinct group of microtubules accumulating during telophase near the cell cortex rather than from or within the phragmoplast. These cortical-telophase microtubule arrays began to extend along the cortex toward the division site where most of them were captured, likely leading to the overall reorientation of the microtubule array perpendicular to the division site itself. As the phragmoplast continued to expand and made contact with the cortical-telophase microtubule arrays, most of the microtubules were incorporated into the microtubule arrays of growing phragmoplast, sometimes severing from the cortical-telophase array entirely (Fig. 1).

To observe the interaction between the cortical-telophase microtubules and the division site more closely, researchers examined wild-type epidermal cells expressing a YFP-tagged copy of the TANGLED1 (TAN1) protein. TAN1 is a microtubule-binding protein that localizes to the division site in maize and contributes to proper phragmoplast guidance during its expansion (Martinez et al. 2017). This experiment showed that extending cortical-telophase microtubules pause at the division site near TAN1 puncta specifically rather than elsewhere along its length. Furthermore, cortical-telophase microtubules were absent or less abundant in many *tan1* mutant cells. When present, the arrays were often asymmetrically distributed or misoriented, suggesting the TAN1 promotes cortical-telophase microtubule stability and organization. While these experiments do not provide evidence for direct interaction between TAN1 and cortical-telophase microtubules, they do suggest that TAN1 or other division-site-localized proteins interact

Received February 06, 2023. Accepted February 08, 2023. Advance access publication February 15, 2023

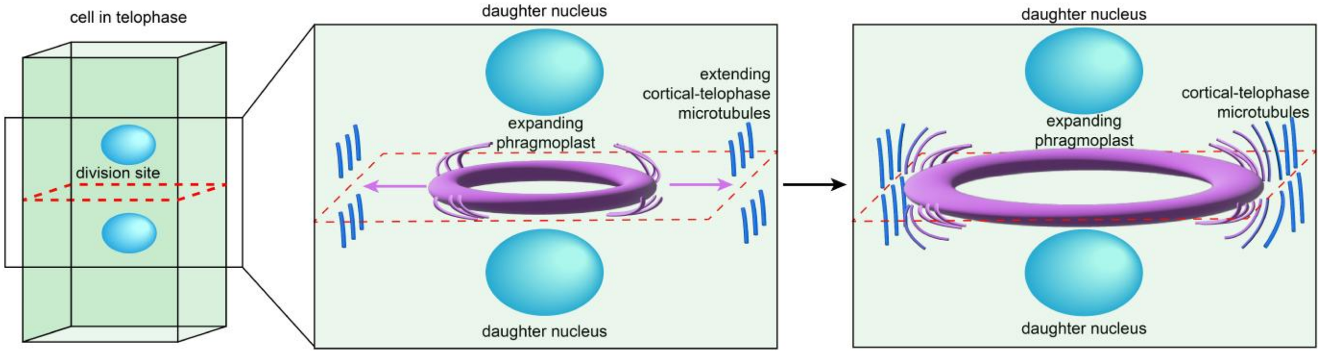

Figure 1. Cortical-telophase microtubules aid in guiding the phragmoplast in maize. Bellinger et al. (2023) describe a unique population of cortical microtubules that appears during telophase in maize epidermal cells. These extend from the cortex toward the division plane (dashed box) where they often pause and reorient to be perpendicular to the plane. As the phragmoplast expands toward the division site, the cortical-telophase microtubules are often incorporated into the phragmoplast's microtubules arrays where they aid in guiding the direction of phragmoplast expansion toward the division site. Figure created by M. Busche with Adobe Illustrator.

with and stabilize the extending microtubules, causing them to pause and adjust their orientation.

Finally, the group explored the effects of asymmetrically distributed cortical-telophase microtubules on the direction of phragmoplast expansion. They found that sustained asymmetric distribution of cortical-telophase microtubules (i.e. more arrays above or below the plane of the phragmoplast) correlated with biased phragmoplast expansion toward the side with more microtubule arrays. This was observed in both wild-type and *tan1* cells. These data suggest that cortical-telophase microtubules actively contribute to the direction of phragmoplast expansion and shed new light on the complex and dynamic mechanism of division plane positioning.

References

Bellinger MA, Uyehara AN, Allsman L, Martinez P, McCarthy MC, Rasmussen CG. Cortical microtubules contribute to division plane positioning during telophase in maize. Plant Cell. 2023:**35**(5):1496–1512. https://doi.org/10.1093/plcell/koad033

Martinez P, Luo A, Sylvester A, Rasmussen CG. Proper division plane orientation and mitotic progression together allow normal growth of maize. Proc Natl Acad Sci USA. 2017:**114**(10):2759–2764. https://doi.org/10.1073/pnas.1619252114

Smertenko A, Assaad F, Baluška F, Bezanilla M, Buschmann H, Drakakaki G, Hauser M-T, Janson M, Mineyuki Y, Moore I, et al. Plant cytokinesis: terminology for structures and processes. Trends Cell Biol. 2017:**27**(12):885–894. https://doi.org/10.1016/j.tcb.2017.08.008