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Actin filaments control the shape of the cell structure that divides plant cells

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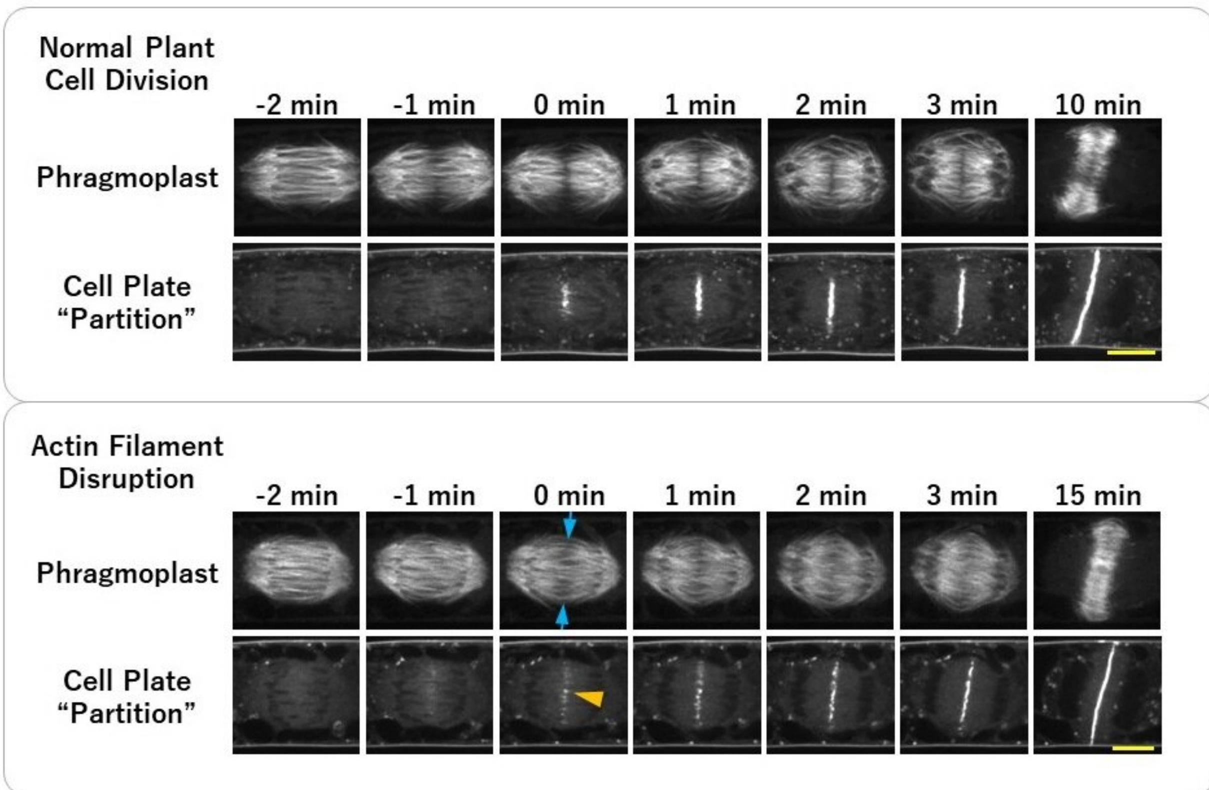


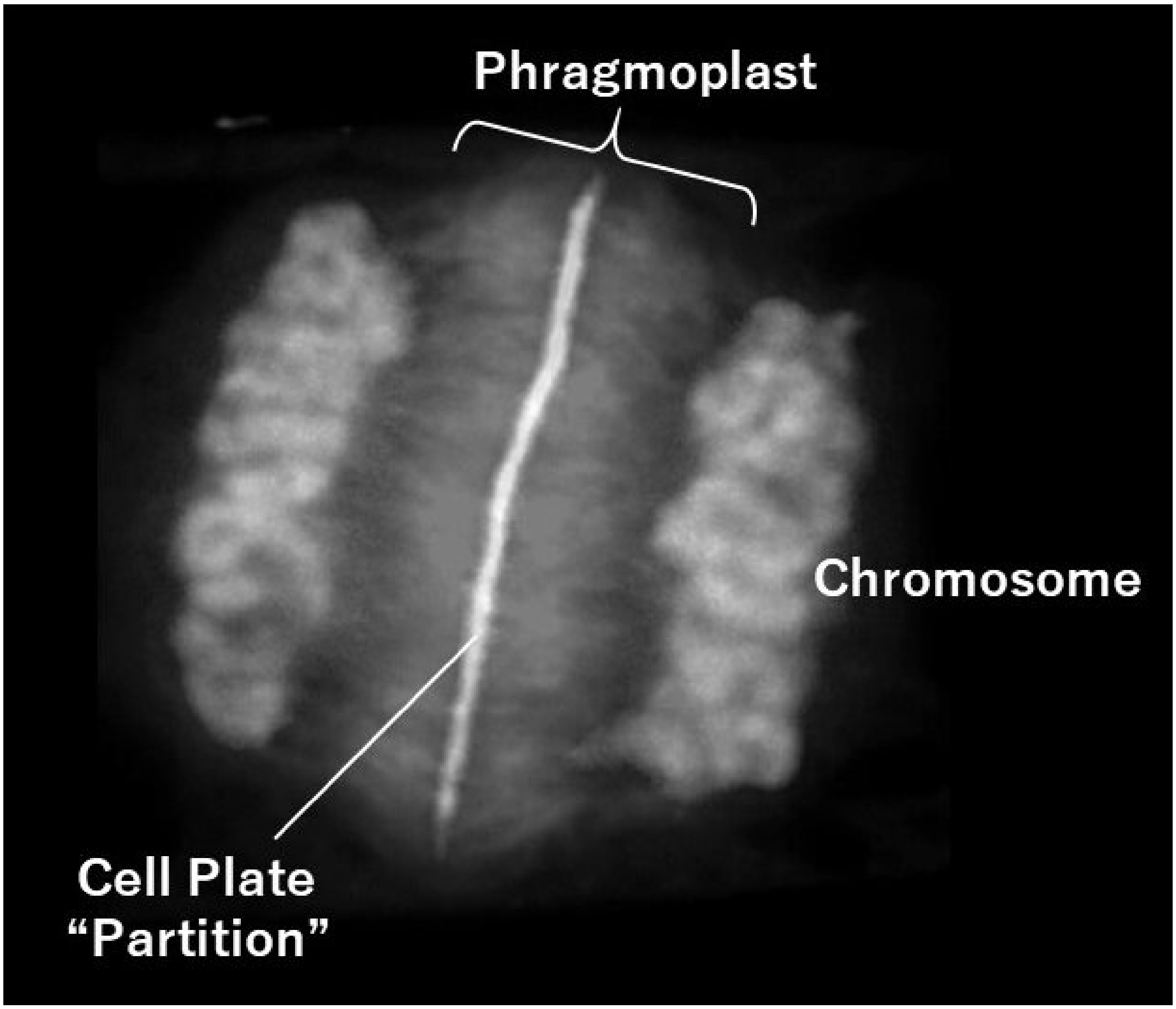
The phragmoplast, which is normally constricted toward the center of the cell, becomes abnormally widened (blue arrows), and the shape of the cell plate is changed (orange arrowhead) when actin filaments are disrupted. Normally, the cell plate spreads from the center to the edge, but without actin filaments the dotted shapes gradually connect and form into the cell plate. The final time differs between the top and bottom frames because cell plate expansion gradually slows down when actin filaments are disrupted. Credit: Associate Professor Takumi Higaki

Using microscopic video analysis, a research group from Kumamoto University, Japan has provided deeper insight into the mechanics of plant cell division. The video reveals that the shape of phragmoplasts—cell structures that create the partition between two dividing plant cells—is controlled by actin filaments.

The discovery was made while the researchers were analyzing phragmoplast behavior during cytokinesis: the point in cell division where daughter cells physically separate. They noticed a change in the phragmoplast shape that could only be seen for about 30 seconds in the video. Even though plant cell division mechanisms have been thoroughly studied, the role that actin filaments play in the process appears to have been previously overlooked.

During plant cell division, a partition called a cell plate appears between two chromosomes and expands to divide the cell into two. This cell plate is created by the phragmoplast, which appears only during cell division and contains microtubules and actin filaments. Microtubules were known to play a major role in the formation of the phragmoplast, as destroying them with chemicals results in non-formation of the cell plate. On the other hand, the role of actin filaments was not well understood, since their destruction does not cause any noticeable change in phragmoplasts or cell plates.

Using microscopic video analysis to examine the changes that occur in the phragmoplast and cell plate when actin filaments are disrupted, Dr. Takumi Higaki and graduate student Mr. Keisho Maeda noticed that the phragmoplast became abnormally wide immediately after it was created. (Normal phragmoplasts are constricted toward the center of the cell.) Interestingly, this change was observed for as little as 30 seconds immediately its creation, after which the effects of the disrupted actin filaments became less apparent. Furthermore, the shape of the cell plate changed only when the shape of the phragmoplast changed. These findings indicate that actin filaments are involved in the formation of cell plates through control of new phragmoplast development.



The cell plate emerging within the phragmoplast. Credit: Associate Professor Takumi Higaki

Additionally, the researchers examined the behavior of several proteins thought to be carried by phragmoplasts to cell plates and are responsible for phragmoplast expansion. Some proteins were found to accelerate the timing of transport to the cell plate when actin filaments are disrupted. It is thought that the phragmoplast has two stages, a "childhood" and an "adolescence." Actin filaments are necessary for shaping its childhood, but are not necessary during adolescence. Apparently, cells will eventually divide normally without actin filaments, but it remains to be determined whether the absence of actin filaments does not have an effect on cells after their "adolescence."

"This discovery has shed some light on the role of actin filaments during plant cytokinesis. Actin filaments were found to be present in phragmoplasts about 35 years ago, and a lot of research has been done since then, but there appears to be no report on this phenomenon," said Dr. Higaki. "This is probably because recent time-lapse image analysis technology has improved and is now able to capture subtle differences in a short time; these were very difficult to notice with conventional observation methods. We advocate 'imaging biology' that utilizes image analysis technology in biology, and we hope to keep finding new phenomena with a similar research approach."

More information: Keisho Maeda et al, Actin Filament Disruption Alters Phragmoplast Microtubule Dynamics during the Initial Phase of Plant Cytokinesis, *Plant and Cell Physiology* (2020). DOI: 10.1093/pcp/pcaa003

Provided by Kumamoto University

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