IN BRIEF

Tracking Pavement Cells through Space and Time: Microtubules Define Positions of Lobe Formation

Pavement cells in the leaf epidermis start out as simple polygons and develop into puzzle-shaped units with interlocking lobes. This complex geometry offers biomechanical advantages; interlocking increases resistance to tension and maintains the structural integrity of the leaf surface (Malinowski, 2013). Biologists have long since wondered how epidermal cells attain their wavy contours. In 1942, Watson proposed that waviness is determined by the cell’s outer cuticle, with cell expansion being limited at regions of the cell wall that have a hardened cuticle, but not at regions where the cuticle is still hardening (Watson, 1942). Panteris et al. (1993) later showed that bundles of microtubules line the anticlinal cell walls of cowpea (Vigna sinensis) pavement cells at intervals and fan out across the external periclinal wall at the junction between anticlinal and external periclinal walls and that cellulose microfibrils are deposited in an identical pattern within the walls. Given that these arrays are alternately distributed between neighboring pavement cells, the authors hypothesized that bulging is prevented at cell wall regions reinforced with microfibrils, but allowed in the intervening regions, such that indentations in one pavement cell correspond with protrusions in the adjacent cell (Panteris et al., 1993; reviewed in Panteris and Galatis, 2005).

Now, Armour et al. (2015) have developed an innovative method to analyze wall expansion during lobe formation in the pavement cells of Arabidopsis thaliana cotyledons. They speckled the surface of cotyledons with fluorescent orange paint, labeled the cell outlines with fluorescein-conjugated dextran, and then tracked fortuitously positioned paint landmarks over a 3-d period using thin-plate spline analysis (see figure). They found that anticlinal wall expansion was greatest at the sites of lobe formation and that the outer periclinal cell wall grew faster at the concave side of lobes than at the convex side. Maximal growth occurred in the day or two after the cotyledons opened. Furthermore, the concave side of the outer periclinal wall underwent isotropic growth, whereas growth of the convex side was most rapid parallel to the tangent of the curve of the anticlinal wall.

The authors then assessed the role of the cytoskeleton in lobe formation using transgenic Arabidopsis plants expressing fluorescent markers of microtubules or actin microfilaments. In agreement with previous work (Panteris et al., 1993), they found that alternating regions of microtubule-rich and microtubule-free zones occurred at the periclinal walls of neighboring pavement cells. Thin-plate spline analysis showed that periclinal cell wall growth was greater at the microtubule-depleted concave sides of lobes than at the microtubule-rich convex sides and that microtubules predict the sites of future lobe formation. Although the pattern of actin distribution did not provide any clues as to its function in lobe formation, drug studies showed that both actin microfilaments and microtubules are essential for lobe formation in pavement cells.

This work supports the long-standing hypothesis that lobe formation in pavement cells depends on differential reinforcement of the cell wall and bolsters our understanding of how pavement cells get their shape.

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REFERENCES


