BACTERIAL PHYSIOLOGY

Treadmilling runs bacterial division

“the rate of cytokinesis was found to be dependent on the rate of treadmilling”

In most bacteria, cytokinesis is initiated by the Z ring, which is a cytoskeletal structure that assembles through the polymerization of the tubulin-related GTPase FtsZ and the actin homologue FtsA at the cytoplasmic leaflet of the bacterial membrane. The Z ring recruits an ensemble of proteins to the site of cell division, including peptidoglycan synthases that drive septal cell wall synthesis, constriction and division. However, the organization and dynamics of the Z ring filaments, and how these filaments control peptidoglycan synthases to drive cytokinesis, have been unclear. Now, two studies show that the dynamics of FtsZ filament assembly and disassembly are coupled to GTP hydrolysis and control the location and activity of

the cell wall synthesis machinery to drive bacterial cell division.

Bisson-Filho, Hsu, Squyres, Kuru and colleagues investigated

the dynamics of septal peptidoglycan synthesis in *Bacillus subtilis* and found that it occurs at discrete sites that move circumferentially around the division plane. The authors then observed that a peptidoglycan synthase and FtsZ filaments move around the division plane at similar velocities, which suggests that the motion of these proteins is coordinated. Antibiotic inactivation of peptidoglycan synthases had no effect on FtsZ motion, which indicates that FtsZ movement is not dependent on cell wall synthesis. This led the authors to hypothesize that FtsZ filament treadmilling (when polymerization at one end occurs at the same rate as depolymerization at the other) drives motion and cell division. In agreement with this, the overexpression of GTPase-deficient FtsZ mutants that stabilize FtsZ decreased the directional motion of FtsZ filaments and septal peptidoglycan synthases. Moreover, the amount and area covered by septal peptidoglycan synthesis was found to be coupled to the rate of treadmilling. Finally, the rate of cytokinesis was found to be dependent on the rate of treadmilling.

In a second study, Yang and colleagues observed that FtsZ filaments in the Z ring in *Escherichia coli* undergo periodic assembly and disassembly with similar rates. Inhibiting peptidoglycan synthesis did not affect the dynamics of

assembly and disassembly, whereas reducing the intrinsic GTPase activity of FtsZ did. Furthermore, using high-resolution time-lapse imaging, the authors found that FtsZ filaments move directionally along the septum by treadmilling and that the rate of treadmilling is proportional to its GTPase activity. Owing to the observation that FtsZ GTPase mutants have altered septum morphologies during division, the authors hypothesized that FtsZ uses treadmilling to evenly distribute proteins that are required for peptidoglycan synthesis at the septum to form a smooth, symmetrical septum during division. Indeed, treadmilling of FtsZ filaments was found to guide the directional movement of one such essential protein, thus determining the direction of cell wall synthesis. However, the speed of treadmilling does not affect the rate of peptidoglycan synthesis, which contrasts with the findings in *B. subtilis*.

Together, these two studies provide strong experimental support for the role of FtsZ treadmilling in driving and organizing cell wall synthesis to enable the separation of parent and daughter cells.

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ORIGINAL ARTICLES Bisson-Filho, A. W., Hsu, Y. P., Squyres, G. R., Kuru, E. et al. Treadmilling by FtsZ filaments drives peptidoglycan synthesis and bacterial cell division. *Science* **355**, 739–743 (2017) | Yang, X. et al. GTPase activity-coupled treadmilling of the bacterial tubulin FtsZ organizes septal cell wall synthesis. *Science* **355**, 744–747 (2017)