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Genetic comparisons provide insight into the evolution of a crucial filament protein in animals, plants and bacteria

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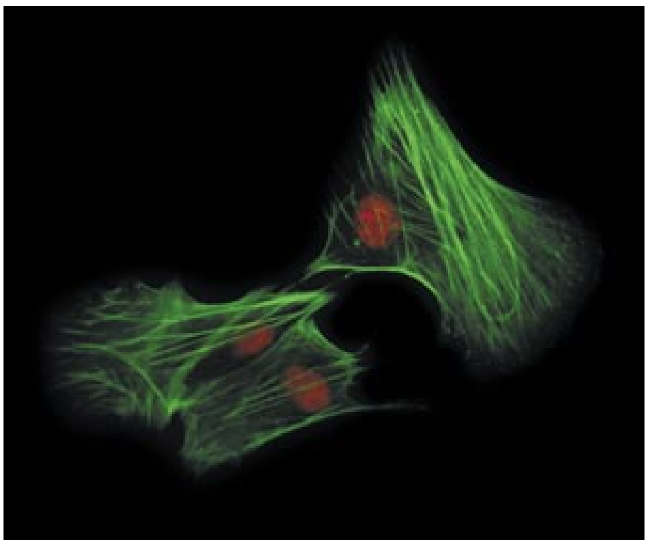

Elongating actin filaments (green) drive cell shape changes and movement. Credit: Beano5/E+/Getty

Divergent evolutionary pathways in different domains of life have resulted in distinct filament systems that underlie cellular structure and polymerizing-protein motors, according to A*STAR researchers. The work focuses on the protein actin, and proposes how divergent systems in animals, plants and bacteria arose.

Actin forms filaments that make up the cellular skeleton, provide a scaffold on which proteins can be locally assembled, and drive the movement of cells. While the structure of actin and its filaments is similar in all animals and plants, the structure of actin-like proteins in bacteria is markedly different. Robert Robinson, from the A*STAR Institute of Molecular and Cell Biology, and colleagues analyzed the genetic relationships between actin-like proteins in various organisms to understand these differences.

"By comparing the genomes from organisms that have diverged at different time points in evolution, we can chart the paths of how protein machines became more sophisticated," says Robinson. "We show that the filamentous force-generating machines from bacteria, plants and animals have followed different evolutionary paths."

The researchers determined that bacteria have a 'one-filament-one function' design, in which diverse actin-like proteins carry out distinct cellular functions. By contrast, plants and animals have developed a 'universal-pool-of-actin' system, in which a single type of actin is involved in many cellular processes.

Robinson and colleagues propose that the functional requirements of bacterial cells led to actin-like proteins evolving at different rates. For example, filaments required to ensure accurate bacterial cell division need to form at different times and locations to filaments involved in making the bacterial cell wall. Differences in function led to divergence in structure, resulting in distinct forms of the protein.

The team suggests that the involvement of actin in various cellular processes in the common ancestor of animals and plants meant that any changes to the protein would compromise these functions, thereby restricting its evolutionary pathway. A big surprise though, says Robinson, is that a later drive toward extending filament variety within this restrictive framework led to different mechanisms for achieving filament diversity between plants and animals.

"We hope that the concepts we have defined will influence thinking in relation to filament systems," explains Robinson. However, he notes that little is known about actin filaments in the third domain of life: single-celled organisms called archaea. "We would like to see more archaea genomes sequenced to better understand the state of actin filaments at the time of their evolutionary split," he concludes.

More information: P. W. Gunning et al. The evolution of compositionally and functionally distinct actin filaments, *Journal of Cell Science* (2015). DOI: 10.1242/jcs.165563

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