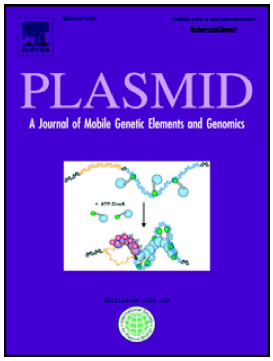

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Brownian ratchet mechanisms of ParA-mediated partitioning

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The faithful segregation of DNA, coordinated with cell division, assures genetic inheritance for all organisms. Bacteria are single-celled organisms that lack nuclei. Bacterial genomic DNA is condensed along with associated proteins into a nucleoid structure. Many bacterial strains also carry plasmids, which are autonomously replicating and segregating DNA entities. Chromosome segregation *via* a mitotic spindle apparatus has been established in eukaryotes. In prokaryotes, however, the mechanisms governing the partition of genetic material remain under debate. For high-copy-number small plasmids, random diffusion is sufficient to ensure both daughter cells inherit at least one plasmid copy following cell division. However, for most low-copy-number large plasmids and bacterial chromosomes, active partitioning is required. Active partitioning is predominantly carried out by a conserved tripartite partition system comprising a ParA-type ATPase, its stimulator protein ParB, and a centromere-like site, *parS*, on the plasmid or the chromosome, to which ParB specifically binds. Many key aspects of the biochemistry of ParA-type systems have been experimentally defined (1), but the underlying operational principle for this important DNA segregation machinery remains largely unknown. Defining the inner workings of ParA-mediated partition will not only shed light on the general mechanism of chromosome segregation, but also bridge the gap in our understanding of how evolution shapes these key processes throughout all kingdoms of life.

Recent progress in *in vitro* reconstitution experiments (2-4), in parallel with super-resolution microscopy approaches (5, 6), have provided new mechanistic insights into the inner workings of ParA-mediated partitioning that challenge established filament-based models. Collectively, these experiments show that, in contrast to eukaryotic mitosis, ParA-type partition machinery drives the directed movement of DNA without the formation of filamentous structures. These studies have converged upon a new proposal in which ParA-type partitioning is driven by a Brownian ratchet-driven motility even though the precise mechanistic underpinnings of these ratchet models remains under debate. In this short essay, we provide an overview of