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Effects of central dogma processes on the compaction and segregation of bacterial nucleoids

The bacterial cytoplasm is characterized by a distinctive membrane-less organelle, the nucleoid, which harbors chromosomal DNA. We investigate the effects of dynamic processes associated with transcription and translation on the structure of this organelle, using coarse-grained molecular dynamics (MD) simulations implemented through the LAMMPS package and its recently developed REACTER module. Our model captures the scale of the entire cell and incorporates a reaction-diffusion system for ribosomes and polyribosomes, integrating their dynamics with DNA through excluded volume interactions and out-of-equilibrium processes. Our findings demonstrate that out-of-equilibrium processes generate distinct local microscopic structures within the nucleoid while reducing overall DNA compaction. Furthermore, we find these processes are essential for complete sister chromosomes separation and the establishment of the quarter positioning pattern of each nucleoid, which has been observed experimentally.

Topical Area

Biology and life sciences

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