THEORY OF BIOMOLECULAR MATTER

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Our group uses the tools of statistical mechanics to study molecular structures and processes in the living cell. Whenever feasible we use analytical theory to develop minimal models that provide basic insight and subsequently perform computer simulations adding relevant biological detail and complexity, whenever required. Most of the work is performed in collaborations with experimental partners. In the past few years our main focus was on understanding the dynamics of populations of the cytoskeletal filamentous polymers actin and microtubules, and the mechanism of entropy-driven chromosome segregation and its implementation in the context of a synthetic cell.

Highlights

- A simple conceptual explanation supported by extensive computer simulations how depletion induced confinement sets the size of the bacterial nucleoid [1].
- A microtubule-based mechanism explaining the choice of cell division planes in the early plant embryo, shedding light on a long-standing problem in developmental biology [2].
- An in-depth study of how the subtle mechanisms by which the microtubule severing complex katanin modulates the structure of the plant cortical array [3].

Plans

Although the group leader is formally retiring in 2023, the scientific activities of the group are continued. The work on DNA segregation will be wrapped up, and the focus of the cytoskeletal work will shift in the direction of neuronal systems. In addition, several new research lines are being developed ranging from the impact of the spatial distribution of importer channels on the uptake of nutrients by non-spherical organs/organisms, the design of multi-component colloidal using bespoke interactions mediated by engineered DNA strands, and the fundamental question of the relation between the shape of non-spherical colloidal particles and the lyotropic liquid phases they can form.

Key research items

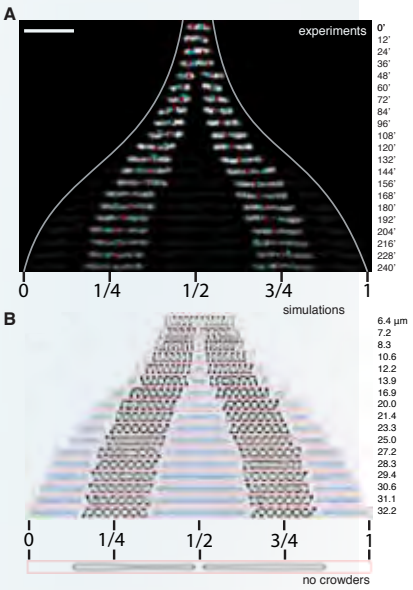
1. E.E. Deinum, B.M. Mulder, Y. Benitez-Alfonso, *From plasmodesma geometry to effective symplasmic permeability through biophysical modelling*, Elife 8, e49000 (2019)

2. F. Wu, P. Swain, L. Kuijpers, X.Zheng, K. Felter, M. Guurink, J. Solari, S. Jun, T. S. Shimizu, D. Chaudhuri, B.M. Mulder, C. Dekker, *Cell boundary confinement sets the size and position of the E. coli chromosome*, Current Biol., 29(13): 2131-2144 (2019) [1]

3. M. Nakamura, J.J. Lindeboom, M. Saltini, B.M. Mulder, D.W. Ehrhardt, *SPR2 protects minus ends to promote severing and reorientation of plant cortical microtubule arrays*, J. Cell Biol., 217 (3), 915-927 (2018)

4. B. Chakrabortty, V. Willemsen, T. de Zeeuw, C.-Y. Liao, D. Weijers, B.M. Mulder, B. Scheres, *A Plausible Microtubule-Based Mechanism for Cell Division Orientation in Plant Embryogenesis*, Current Biol., 28(19):3031-3043 (2018) [2]

5. E.E. Deinum, S.H. Tindemans, J.J. Lindeboom, B.M. Mulder, *How selective severing by katanin promotes order in the plant cortical microtubule array*, PNAS, 114 (27), 6942-6947 (2017) [3]



A simple mechanical model of a spring loaded double piston in contact with two ideal gas reservoirs elucidates the dynamics of the depletion-mediated compaction of the bacterial chromosome in elongating cells.