Non-specific centering of large objects in Prophase I and Meiosis I oocytes

Alexandra Colin[1], Gaëlle Letort[2], Nitzan Razin[3], Maria Almonacid[2], Wylie Ahmed[4], Timo Betz[5], Marie-Emilie Terret[2], Nir S Gov[3], Raphaël Voituriez[6], Zoher Gueroui[1], Marie-Hélène Verlhac[2,]

[1]Ecole Normale Supérieure, PSL Research University-CNRS-ENS-UPMC, Paris, France. [2]Center for Interdisciplinary Research in Biology, Collège de France, CNRS, INSERM, PSL Research University, Paris, France. [3]Department of Chemical and Biological Physics, Weizmann Institute of Science, Rehovot, Israel.[4]Department of Physics, California State University, Fullerton, USA. [5]Institute of Cell Biology, ZMBE, Münster, Germany. [6]UMR 8237 and UMR7600-CNRS/Sorbonne Université, Paris, France.

Previous theoretical considerations suggest that a gradient of motile activity of small particles can generate a pressure gradient that will center large objects [1]. Such phenomenon could explain the robust centering observed for the mouse oocyte nucleus [2], possibly due to a gradient of activity of actin-positive vesicles. We tested the plausibility of this model by implementing 3D center-based numerical simulations tuned to the properties of Prophase I oocytes. Simulations demonstrated how a gradient of persistence of the actin-positive vesicles would indeed center the nucleus, but also other passive objects above a threshold size. By microinjecting oil droplets and fluorescent beads into Prophase I oocytes, we verified experimentally the non-specificity and size-dependency of the centering. Strikingly, we also observed this non-specific centering during Meiosis I, concomitant with meiotic spindle off-centering towards the cortex, a process partially depending on the same myosin activity. Our experimental and numerical observations suggested that this centering gradient was still present but less efficient due to a decrease in the recruitement of actin-positive vesicles.

[1] N. Razin et al., Phys. Rev. E. (2017)
[2] M. Almonacid et al., Nat. Cell. Biol. (2015)