How Does the Early Frog Embryo Coordinate Cell Division in Space and Time?

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The early Xenopus laevis frog embryo rapidly divides twelve times to reduce its size from a single large cell of about 1 mm to somatic cell size of about 10 micrometer. Recent experiments and modeling have shown that cell division is coordinated in space and time via traveling waves of biochemical activity sweeping through the embryo [1, 2, 3]. Such traveling waves arise from the interaction of bistability and spatial diffusive coupling within the large frog egg.

During my postdoc in the Ferrell lab at Stanford University, we used *in vitro* frog egg extracts to experimentally characterize the dynamics of such traveling waves in heterogeneous media. We found that one spatial wave tends to dominate all others on biological distance scales, which allows for well-defined regulation of mitosis within each cell. We also determined the requirements for self-organization of such spatial mitotic trigger waves using simulations. Next, we carefully characterized cell division timings in the multi-cellular early embryo and found that multiple cells also divide in a similar spatial wave pattern. By studying the response of the embryo to transient temperature perturbations, we found that all dividing cells function as uncoupled cell cycle oscillators, simply responding to their own local clock with a stable period. This lack of spatial coupling implies that the intercellular division waves are not a traveling wave phenomenon, in contrast to the cell cycle coordination within each cell. Instead, we found that the observed division waves are the result of spatially structured period differences.

Recently I started my own research lab at the University of Leuven (www.gelenslab.org), where we aim to combine theory of nonlinear dynamics and complex systems with biological experiments in order to gain new insights into the origin of these different wave patterns and their role in coordinating cell division. More generally, we are interested in understanding how the incredibly complex network of genes and proteins interacts and regulates various cell cycle processes in space and time.

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[1] Chang, J. and Ferrell, J.E. (2013). Nature **500**, 603.

[2] Gelens L., Anderson G., and Ferrell J.E. (2014). Mol Biol Cell **25**, 3486.

[3] Gelens L., Huang K. C., and Ferrell J.E. (2015). Cell Rep. **12**, 1.