

**Bottlenecks create higher-level organization in multicellularity and protocells.** N. Guttenberg<sup>1</sup> and M. Lanouvelle<sup>1</sup> and C. Smith<sup>2</sup> and R. Puzio<sup>2</sup>, <sup>1</sup>Earth Life Science Institute (ELSI), Tokyo Institute of Technology, Tokyo, Japan, <sup>2</sup>Albert Einstein College of Medicine, New York, USA.

**Introduction:** Many of the major transitions in evolution share a common motif of the emergence of higher level 'individuals' - the transition to multicellularity happens when the level of individual changes from cell to arrangement of cells. Similarly, in models of early life[1] and in protocell experiments[2], there must at some point be a transition from cells simply acting as containers for populations of independently replicating short genes to cells themselves as the replicative object.

In both of these cases, an information bottleneck plays a prominent role in the system. Multicellular organisms are comprised of many cells, yet replicate through a single germ cell. Protocells may contain many genes, but new protocells produced by budding may only sample a random subset.

We will present a model of replication through a bottleneck of variable size and show that the bottleneck acts as a repair mechanism to maintain higher-level population structures against drift, as well acting to improve the transfer of macro-scale selection pressures down to micro-scale degrees of freedom. As a result, the presence of a stringent bottleneck self-stabilizes and also allows for the emergence of individuals at the larger scale.

**References:** Use the brief numbered style common in many abstracts, e.g., [1], [2], etc. References should then appear in numerical order in the reference list, and should use the following abbreviated style:

[1] E. Zintzaras and M. Santos and E. Szathmary. (2002) *J. Theo. Biol.*, 217, 167–81. [2] N. Ichihashi and T. Yomo (2014). *Current opinion in chemical biology*, 22, 12–17.