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Transition to Diversification by Limitation and Competition for Multiple Resources in Catalytic Reaction Networks

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All life, including cells and artificial protocells, must integrate diverse molecules into a single unit in order to reproduce. Despite expected pressure to evolve a simple system with the fastest replication speed, the mechanism by which the use of a great variety of components, and the co-existence of diverse cell-types with different compositions are achieved is as yet unknown.

Here, we show that coexistence of such diverse compositions and cell-types is the result of limitation and competition for a variety of resources, by theoretically studying a cell system with catalytic reaction dynamics that grows by uptake of environmental resources. We find that a transition to diversity occurs both in chemical components and in protocell types, as the resource supply is decreased, when the maximum inflow and consumption of resources are balanced[1]. In addition, we find negative scaling relationship between molecular diversity and resource abundances to achieve the maximum growth speed of the cell[2]. The maximum growth is determined by a trade-off between the utility of diverse resources and the concentration onto fewer components to increase the reaction rate.

Our results indicate that a simple physical principle of competition for a variety of limiting resources can be a strong driving force to diversify intracellular dynamics of a catalytic reaction network and to develop diverse protocell types in a primitive stage of life.

References:

[1] Kamimura A and Kaneko K (2015) *Journal of Systems Chemistry* 6:5. [2] Kamimura A and Kaneko K (2016) *Physical Review E* 93:062419.

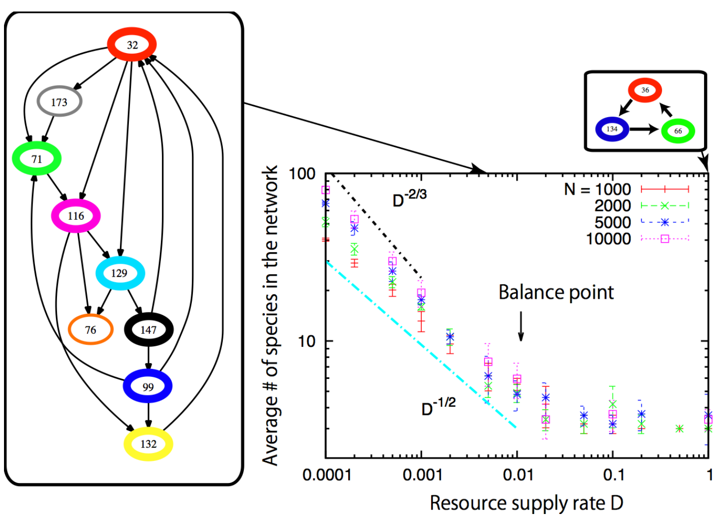

Figure 1 – The average number of species in each cell as a function of resource supply rate D. The diversity, i.e., the number of species in each cell, transits to increase as D is decreased below the balance point. Examples of the catalytic networks formed by molecular species are shown for the values of D indicated by the arrows.