Autocatalytic Sets
A Cooperative Origin of Life

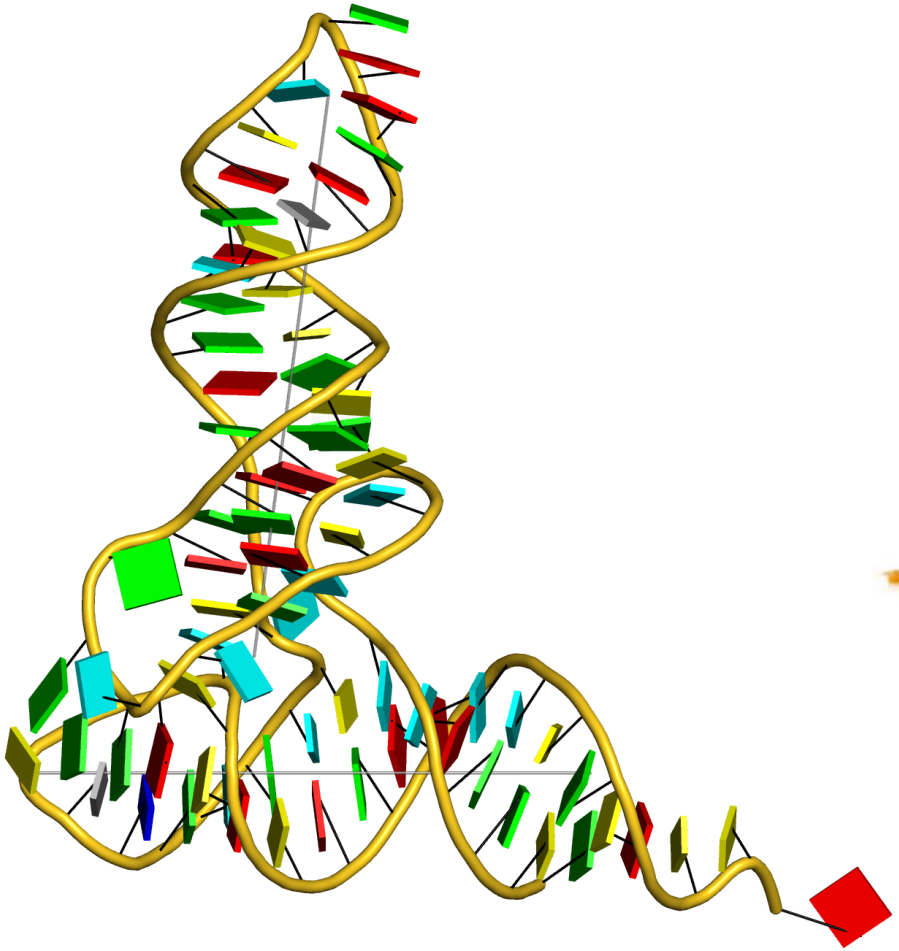
Wim Hordijk

The RNA World

A tRNA molecule

(x3dna.org)

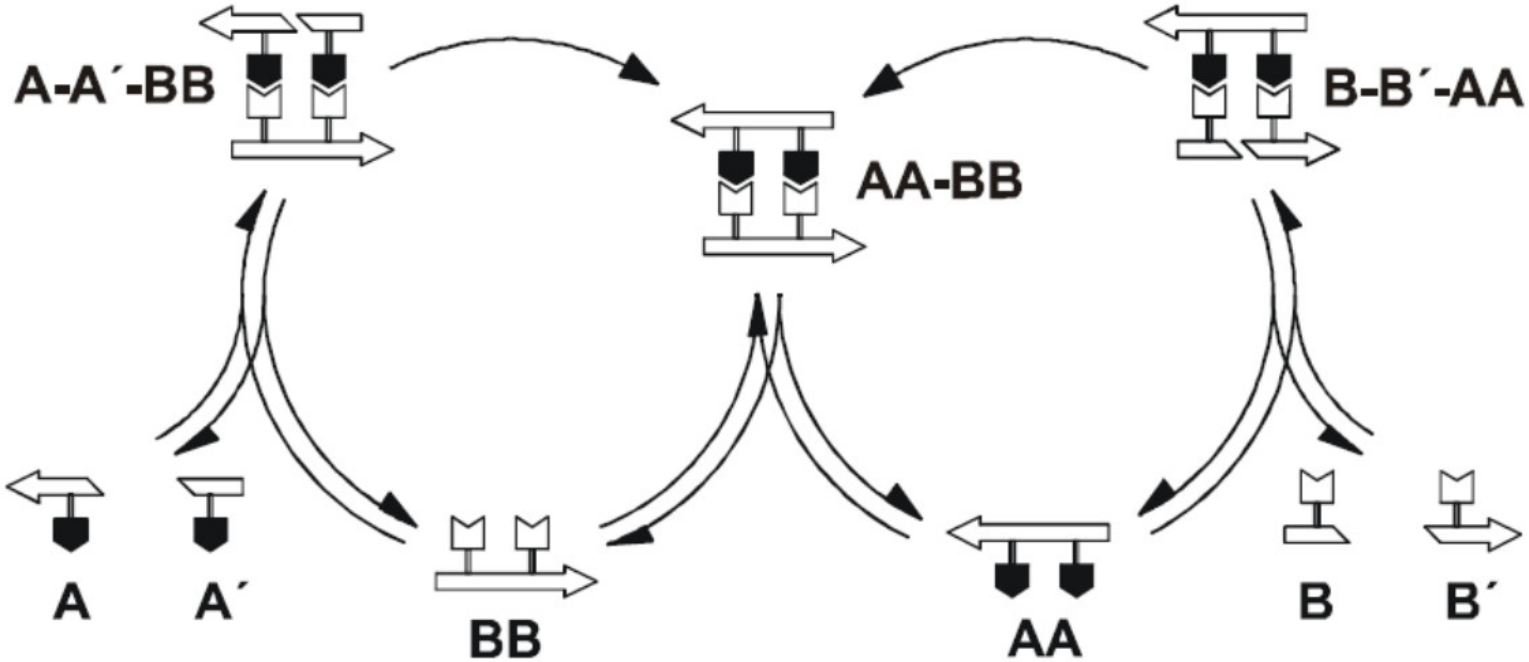
The RNA World



A tRNA molecule
(x3dna.org)

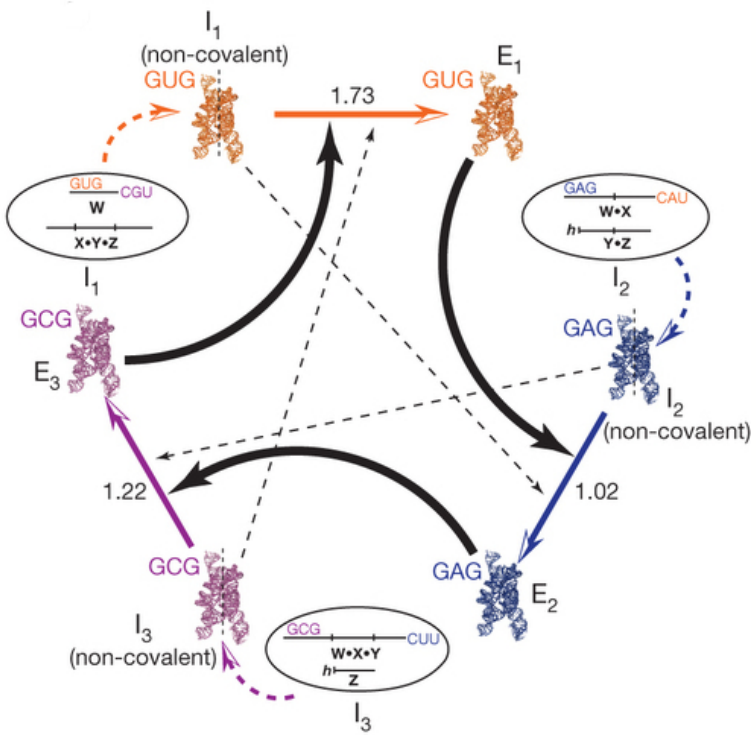
Mutual Catalysis

Mutual Catalysis



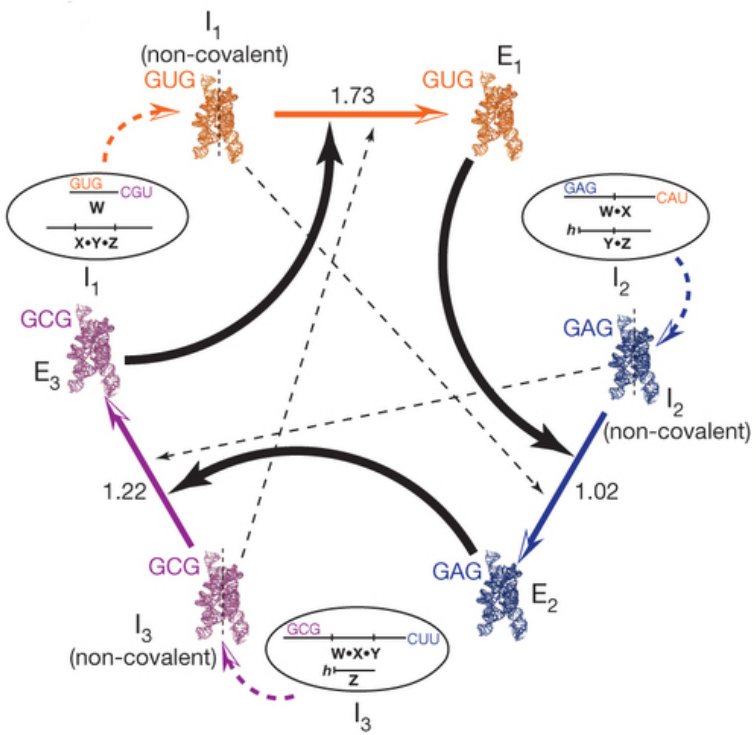
(Patzke & von Kiedrowski, *Arkivoc*, 2007)

Mutual Catalysis

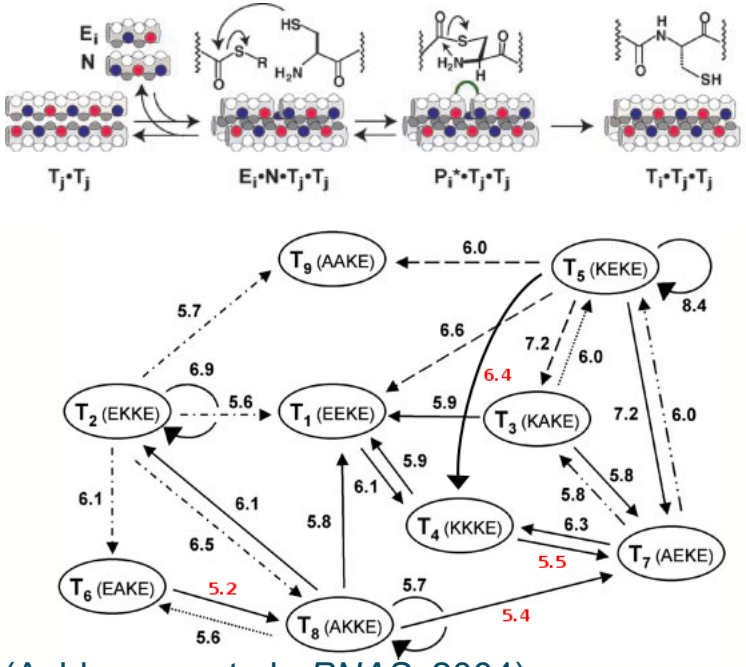


(Vaidya et al., *Nature*, 2012)

Mutual Catalysis



(Vaidya et al., *Nature*, 2012)



(Ashkenasy et al., *PNAS*, 2004)

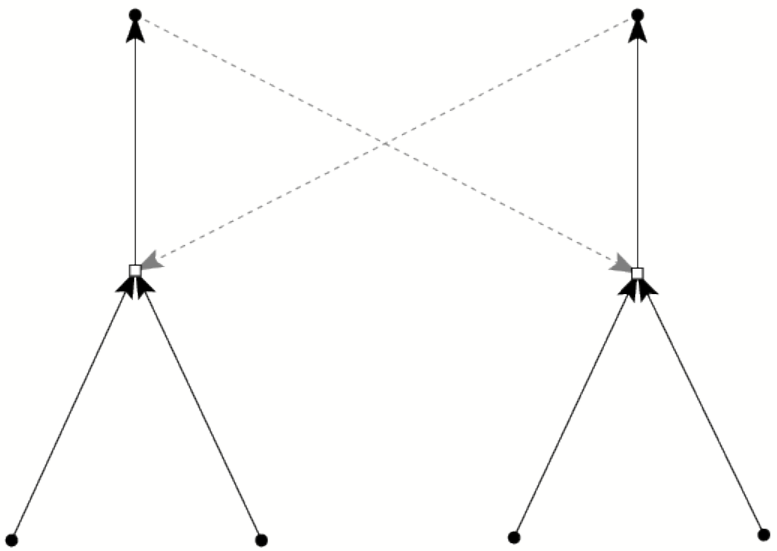
Autocatalytic Set

Chemical reaction network with:

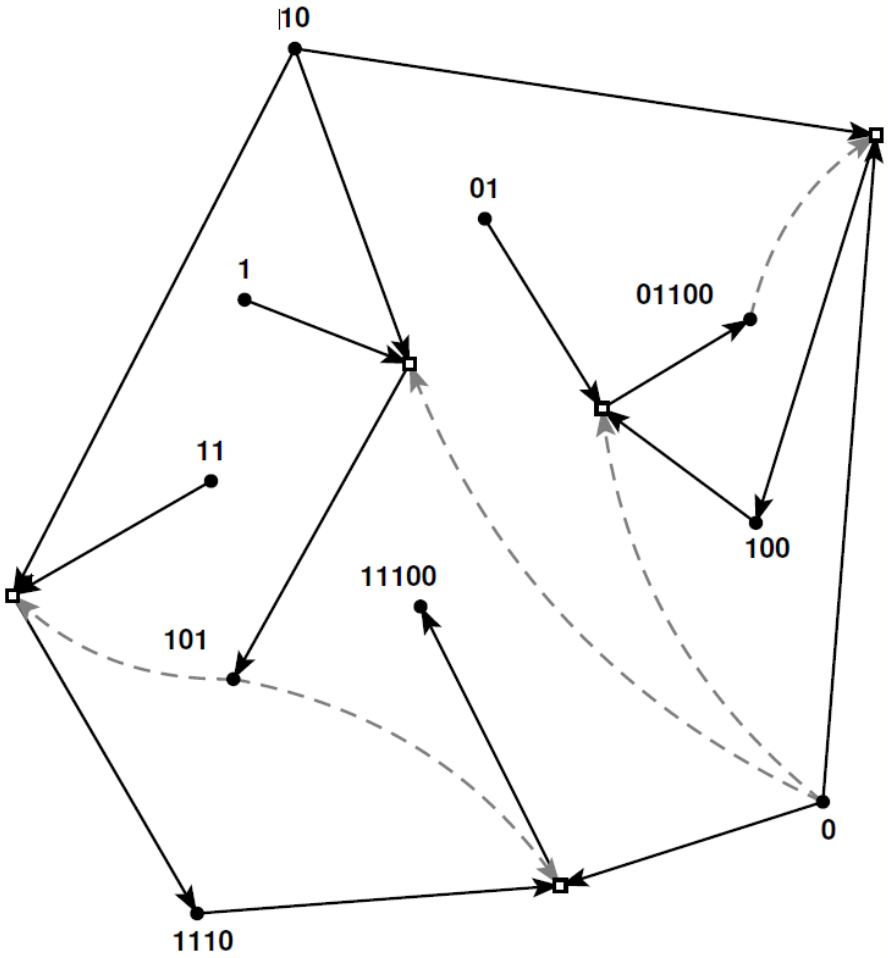
1. Each reaction catalyzed by at least one molecule from the set.

2. Each molecule produced from the food set through reactions from the set.

1. Food = environment

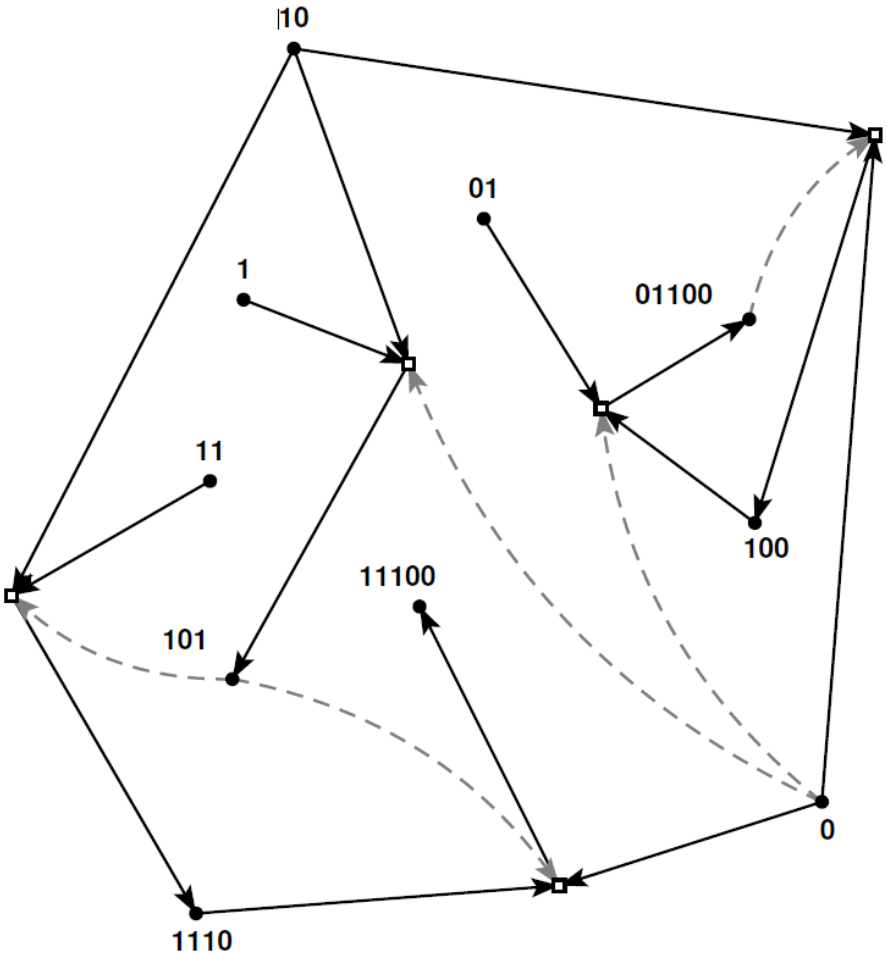


Autocatalytic Set

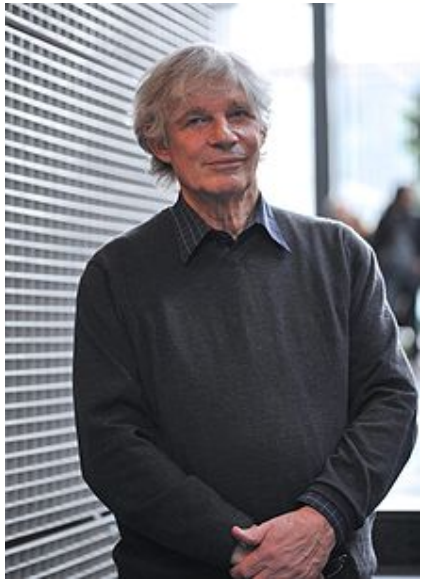


(Hordijk, Steel & Kauffman,
Acta Biotheoretica, 2012)

Autocatalytic Set



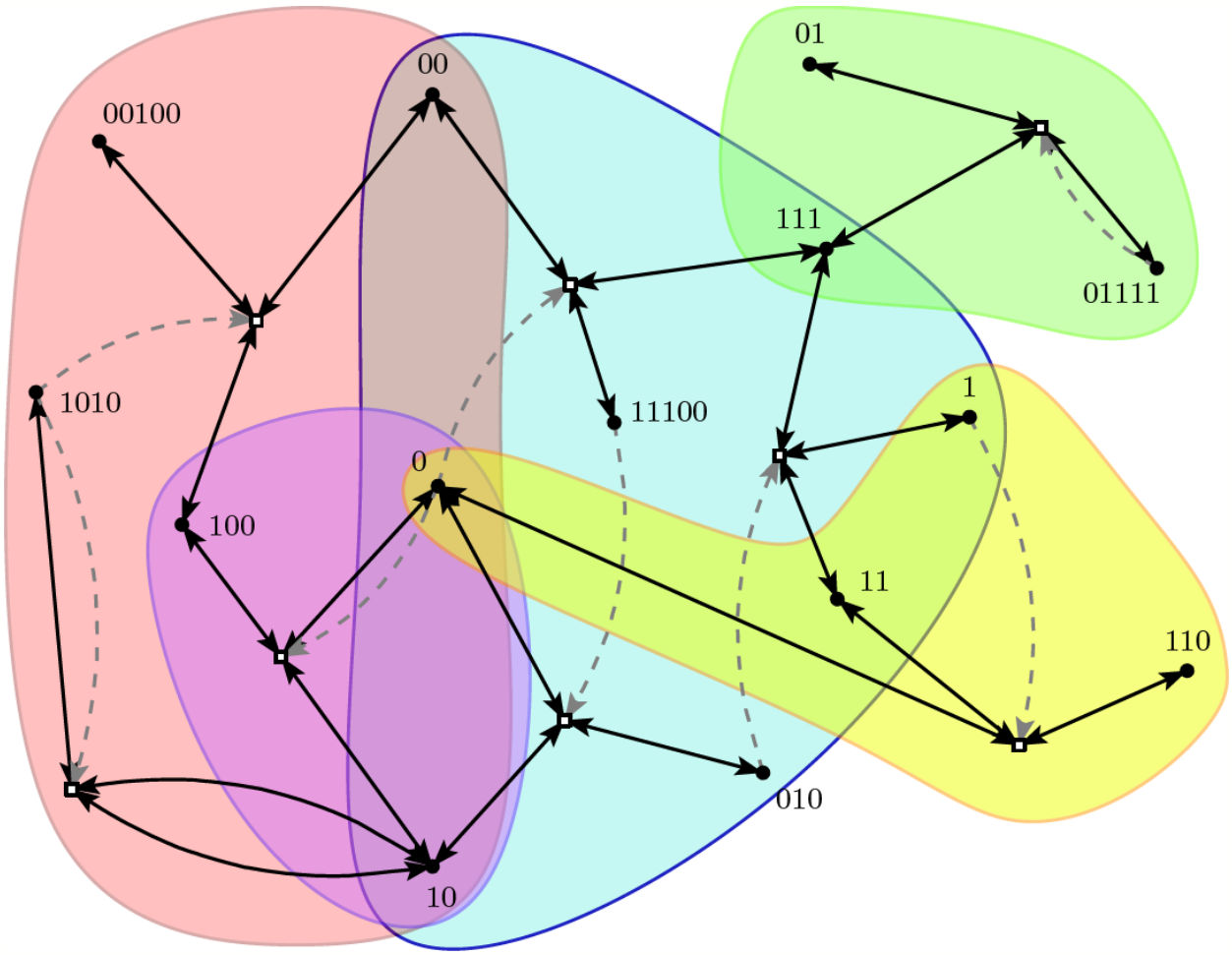
(Hordijk, Steel & Kauffman, *Acta Biotheretica*, 2012)



Stuart Kauffman

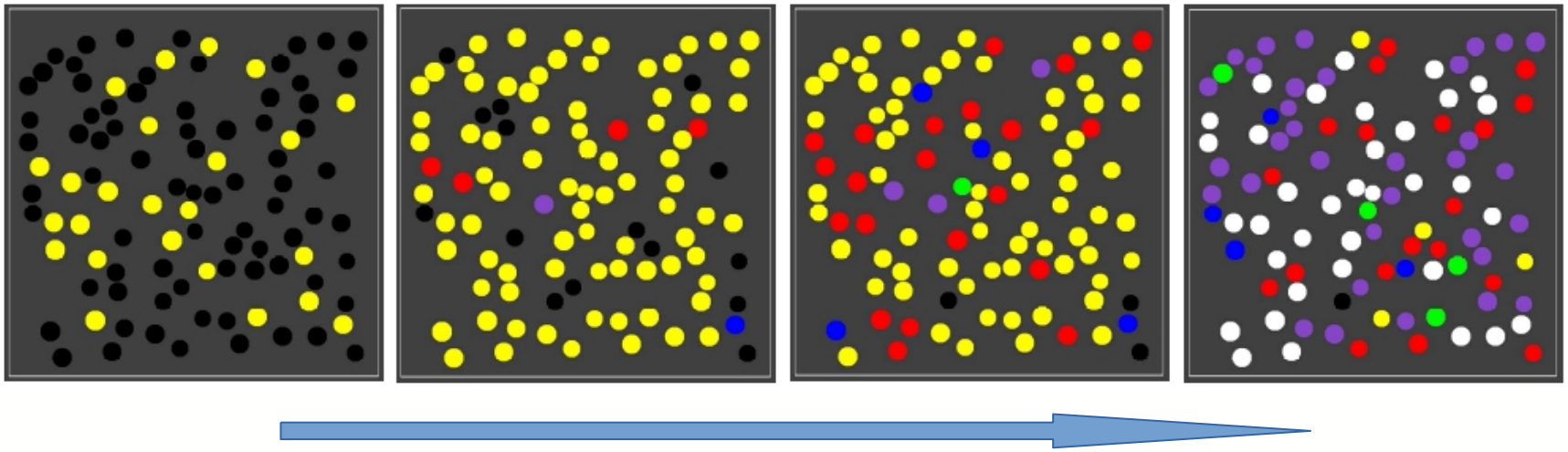
Mike Steel

Autocatalytic Subsets



(Hordijk & Steel, *BioSystems*, 2017)

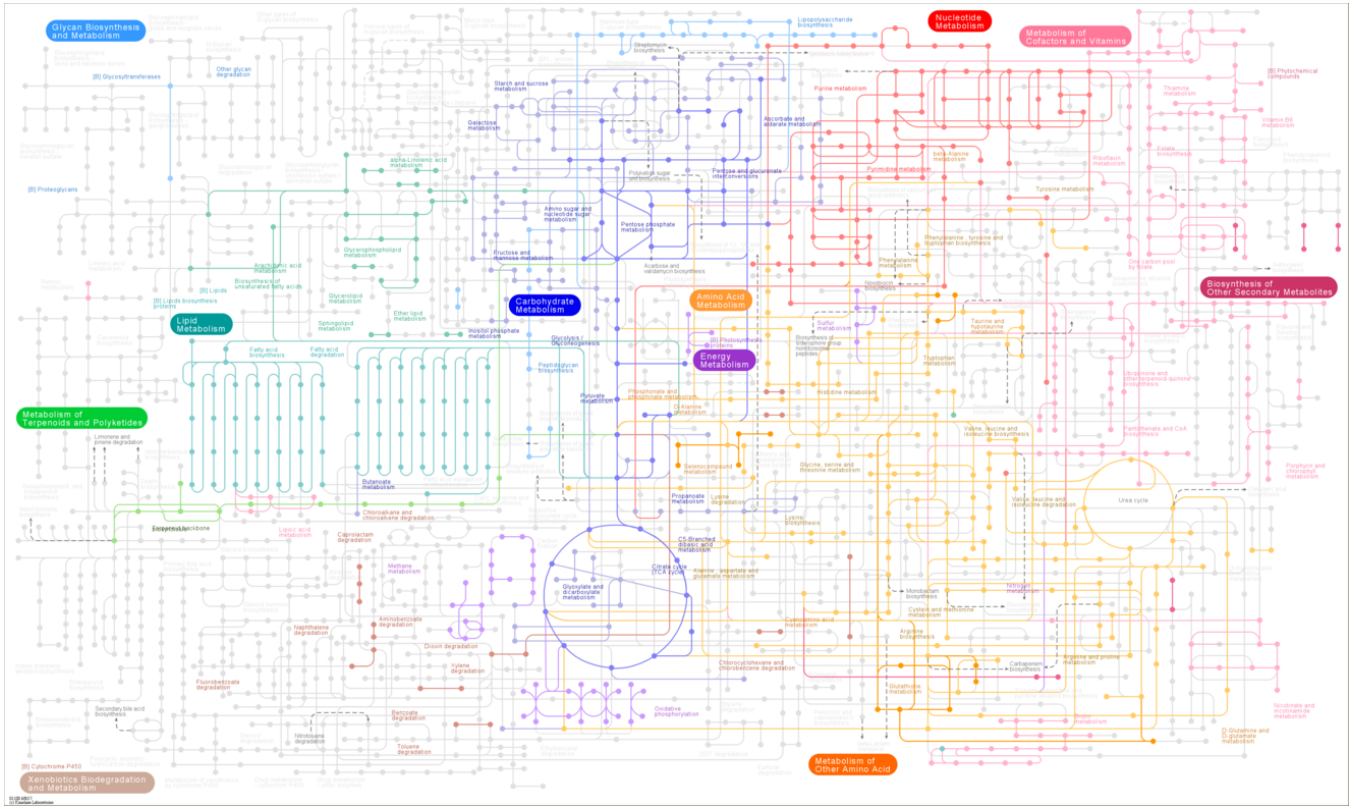
Evolvable “Protocells”



Time

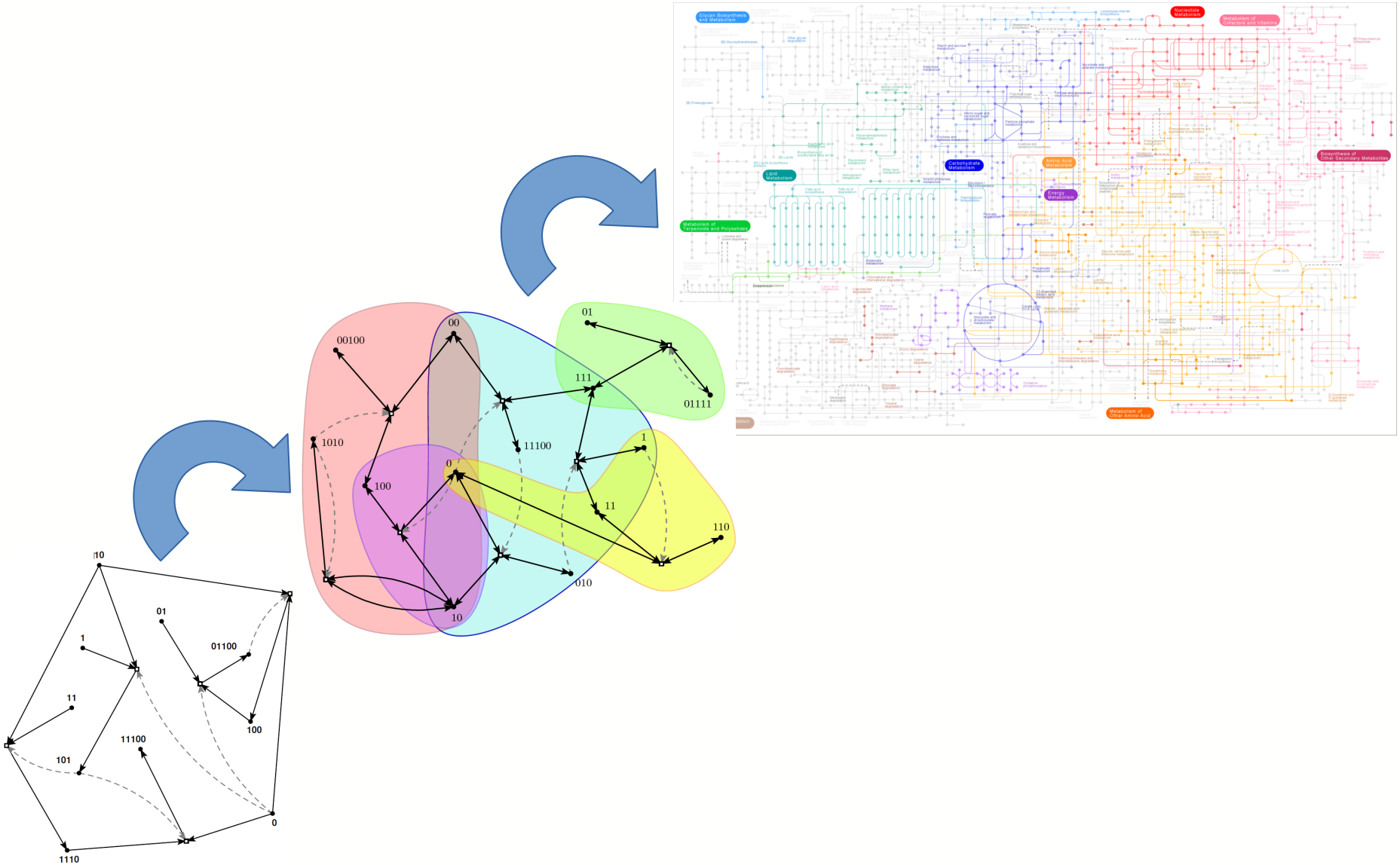
(Hordijk et al., *Life*, 2018)

Autocatalytic Set in *E. coli*



(Sousa et al., *Journal of Systems Chemistry*, 2015.
Network image: KEGG)

A Cooperative Origin of Life



Further Reading

W. Hordijk. The origin of life: A selfish act or a cooperative effort? *This View of Life*, September 2017.

W. Hordijk & M. Steel. Chasing the tail: The emergence of autocatalytic networks. *BioSystems* 152:1-10, 2017.

www.WorldWideWanderings.net

References

x3dna.org

V. Patzke & G. von Kiedrowski. Self replicating systems. *Arkivoc* 2007:293-310, 2007.

N. Vaidya, M. L. Manapat, I. A. Chen, R. Xulvi-Brunet, E. J. Hayden & N. Lehman. Spontaneous network formation among cooperative RNA replicators. *Nature* 491:72-77, 2012.

G. Ashkenasy, R. Jegasia, M. Yadav & M.R. Ghadiri. Design of a directed molecular network. *PNAS* 101:10872-10877, 2004.

W. Hordijk, M. Steel & S. Kauffman. The structure of autocatalytic sets: Evolvability, enablement, and emergence. *Acta Biotheoretica* 60:379-392, 2012.

W. Hordijk & M. Steel. Chasing the tail: The emergence of autocatalytic networks. *BioSystems* 152:1-10, 2017.

W. Hordijk, J. Naylor, N. Krasnogor & H. Fellermann. Population dynamics of autocatalytic sets in a compartmentalized spatial world. *Life* 8:33, 2018.

F. L. Sousa, W. Hordijk, M. Steel & W. F. Martin. Autocatalytic sets in *E. coli* metabolism. *Journal of Systems Chemistry* 6:4, 2015.

www.genome.jp/kegg