



מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

High Self-Catalysis Reduces Evolvability

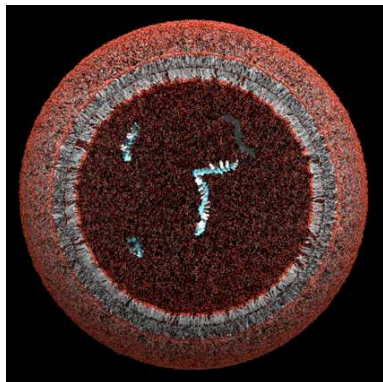
Omer Markovitch

Ph.D. advisor: Doron Lancet



ILASOL 24th meeting, December 2010, Israel.

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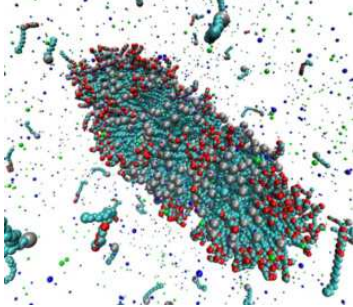


**How could the first biotic cell
come to be?
How could life have emerged?**

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Lipid-assembly as a possible origin

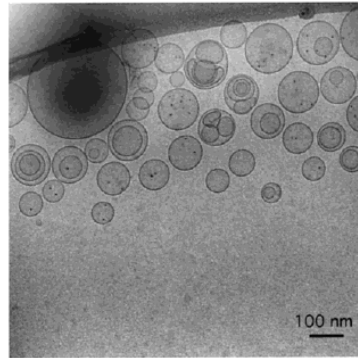
Spontaneous self-assembly



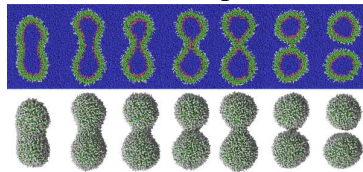
Cell-Cycle

Template effects

Assembly; Matrix effect.



Vesicle split

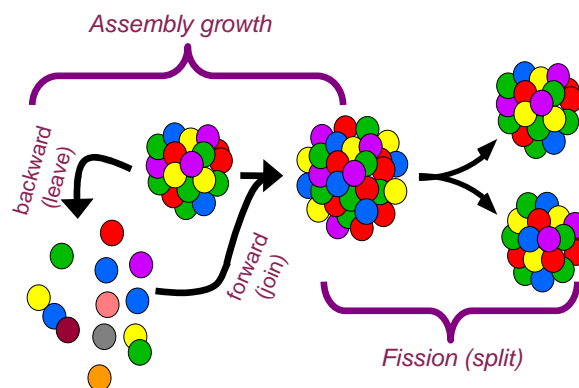


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GARD model (graded autocatalytic replication domain)

Lipid world: Compositional information.

Rich molecular repertoire ($N_G \sim 100$ lipids).



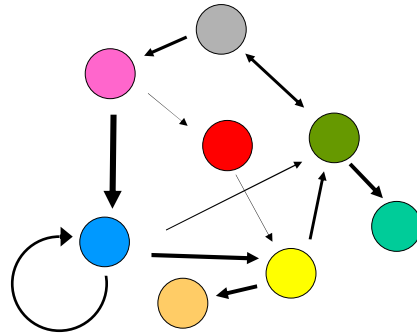
Segre, Lancet, Kedem & Pilpel, OLEB 28 (1998)
Segre, Ben-Eli & Lancet, PNAS 97 (2000)

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GARD model

β matrix \rightarrow main driving force behind GARD.

Each matrix is randomly picked from a lognormal distribution.



i, from the environment

	1	2	3					
		3						
				1				
				2				
			2					
			2					
	3				1			
	2				4			

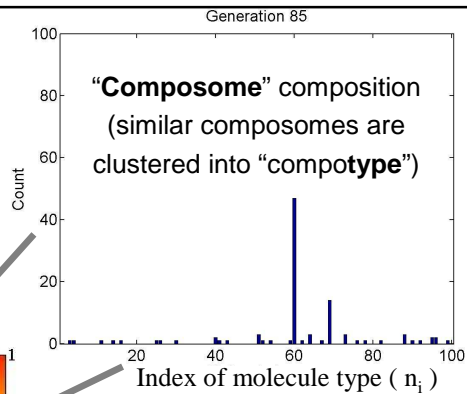
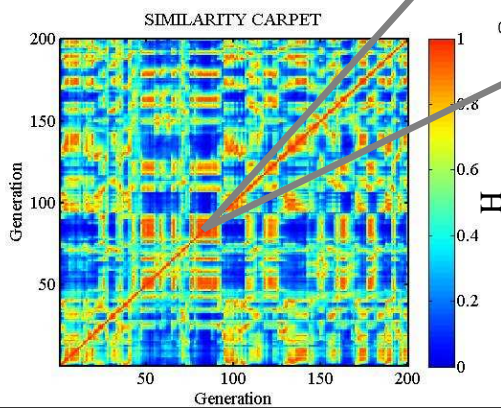
j, within the assembly

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GARD simulation

$$v = \{n_1, n_2, \dots, n_{N_G}\}$$

Composition vector



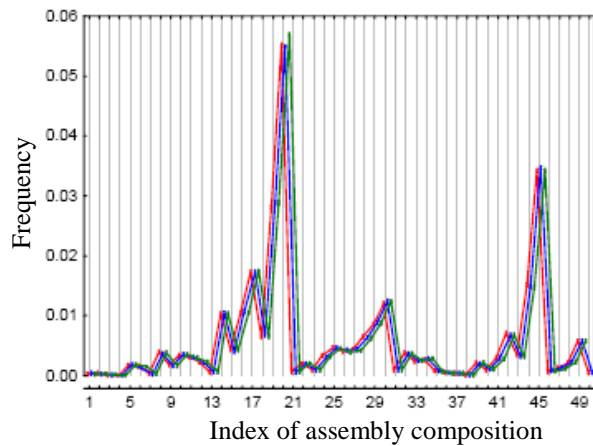
$$H(\chi, \delta) = \frac{v^\chi \cdot v^\delta}{|v^\chi| \cdot |v^\delta|}$$

Similarity

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Lack of selectivity in GARD?

Vasas, Szathmary & Santos, PNAS 107, 1470-1475 (2010): Imposing Darwinian selection in GARD has, at most, negligible effect...



Their weak points:

- (1) Target is not a composome.
- (2) Arbitrary fitness threshold.
- (3) Only a single simulation performed.

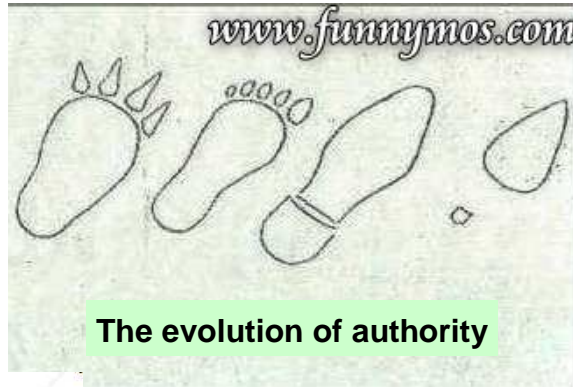
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Lack of selectivity in GARD? NO!

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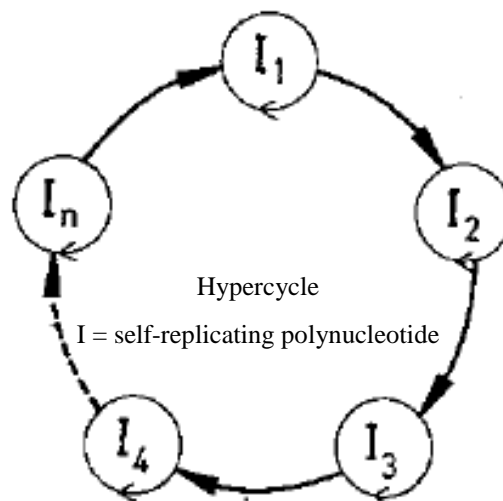
Done with the intro., now to the main course.



Self-catalysis (SC)

SC is in the heart of origin-of-life field, and a prerequisite of Darwinian evolution and life, yet is taken for granted.

Self-replication: a process by which a "thing" copies itself (with or without errors).

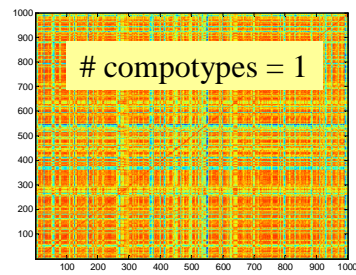
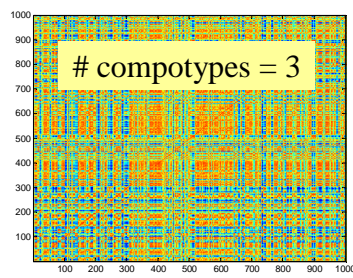


Eigen and Schuster, Naturwissenschaften 64 (1977)

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Identifying different simulations

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Evolvability score (ES) in GARD

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Self-catalysis (SC)

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Summary

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Mutual catalysis is the heart of good evolution.

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Acknowledgments

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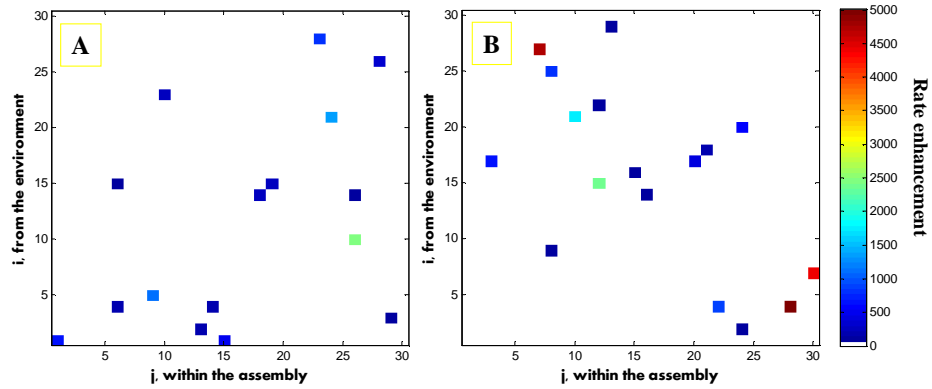
Aron Inger.

OOL team and Lancet group members.

\$\$\$ E.U. FP7 "MATCHIT" (MATrix for Chemical Information Technology).

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β matrices



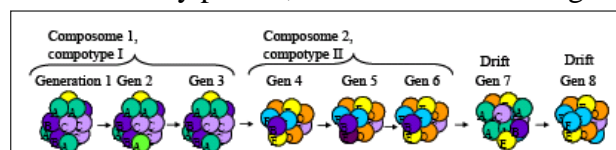
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GARD simulation

- ❖ The general Chemistry and Physics of the 'universe' are 'determined' by: $k_f; k_b; \rho; N_G; N_{\max}; \mu; \sigma$
- ❖ The specific 'GARD environment' is determined by the actual β_{ij} values, which are different for different randomization.

Simulation:

- 1) Generate β_{ij} values.
- 2) Start with initial, random, assembly (ν).
- 3) Assembly is grown according to the GARD equations.
- 4) A random split occurs at N_{\max} .
- 5) One child is randomly picked, and the other is disregarded.



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Real GARD

Raphael Zidovetzki from University of California, Riverside.

Real lipids.

Actual physical properties (charge, length, unsaturation).

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