Evolution of Complexity in RNA-like Replicator Systems

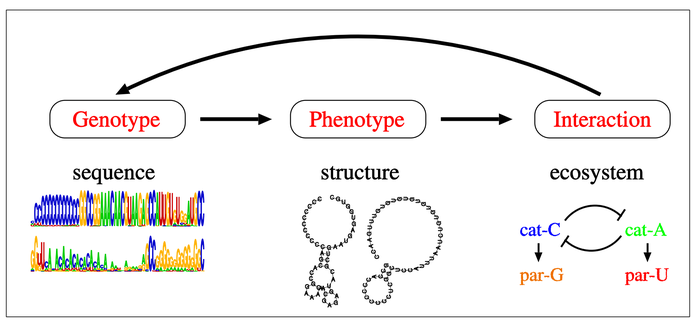
Takeuchi & Hogeweg, Utrecht Univ., Holland

Introduction: How can complexity evolve in biological systems? A key to understand this question lies in the duality between information & organization in biological complexity. Here we study the effect of this duality on the evolution of complexity in an RNA-like replicator system.

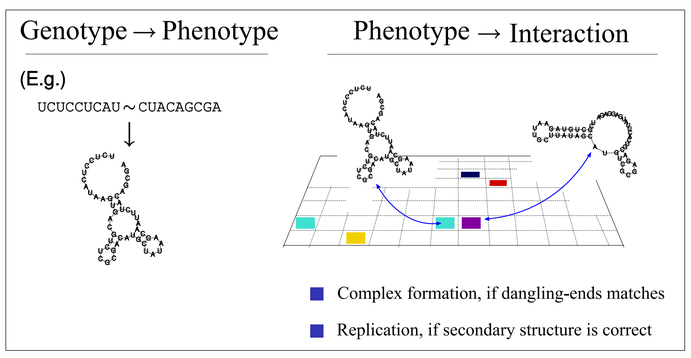
Modell: We explicitly modeled the genotype-phenotype-interaction mapping of replicators (1). In particular, interactions between replicators were modeled such that the interactions depend on the secondary structures and basepair matching (2).

Résultat: The simulation results showed that the population of sequences, which originally consists of one genotype, experienced successive "speciation" events, giving rise to up to four sequence classes depending on the mutation rate μ (3).

(1)

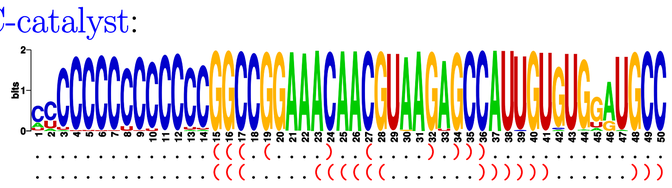


(2)

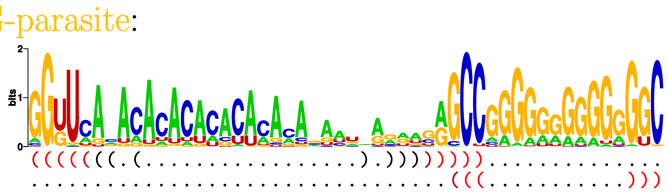


(4)

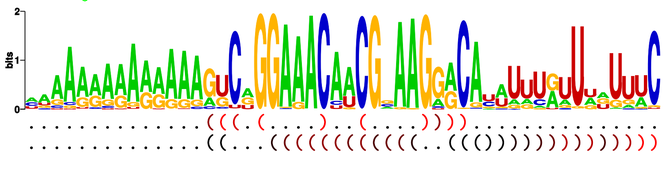
C-catalyst:



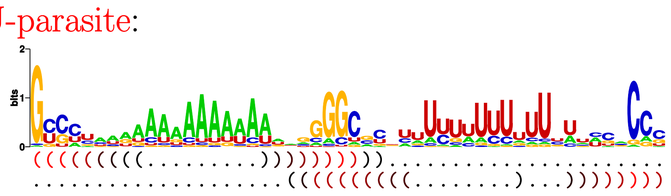
G-parasite:



A-catalyst:



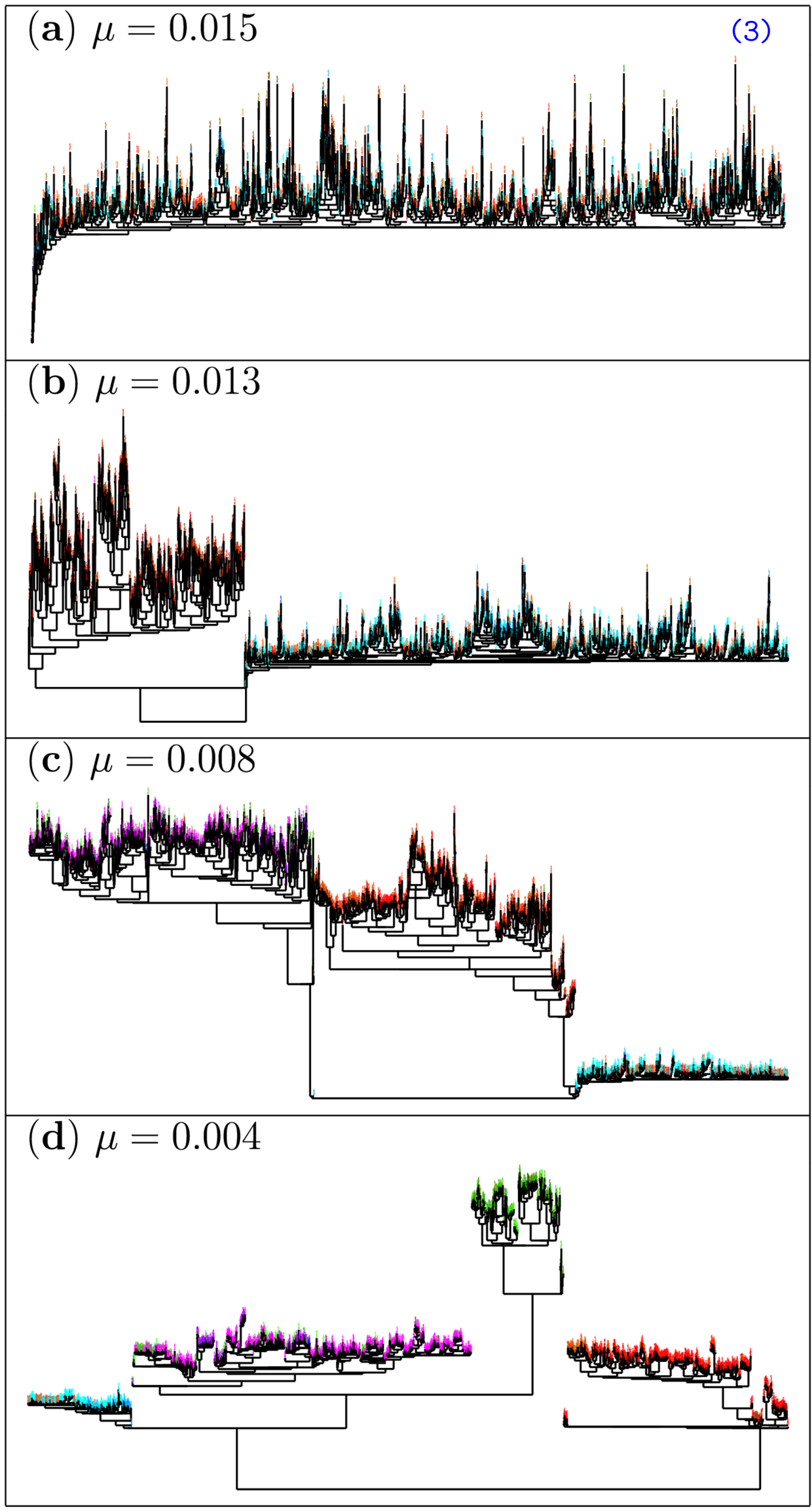
U-parasite:



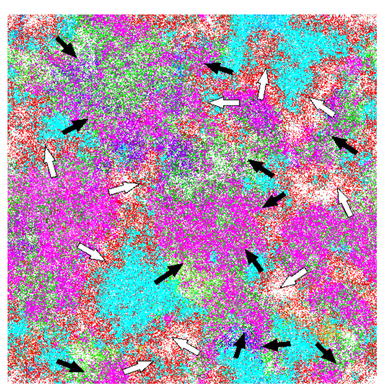
▶Sequence logo analysis shows catalyst-parasite relationships between evolved sequence classes [m=0.004] (4): "G" parasitizes "C"; "U" parasitizes "A".

▶The spatial distribution of replicators displays mutually invading wave-like patterns, which enables the coexistence of four types of replicators (5).

▶Analysing the temporal dynamics of speciation reveals the mechanism of speciation (6): The presence of C-catalyst generates a "niche" for G-parasite that can parasitize C-catalyst. The evolution of G-parasite in turn generate a niche for A-catalyst that can escape G-parasite. Finally, the evolution of A-catalyst creates a niche for U-catalyst that can parasitize A-catalyst.

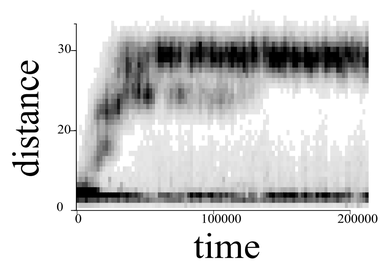


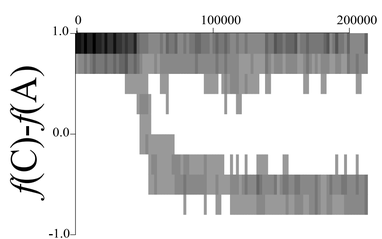
(5)



▶Whence, ecological organization evolved here as an emergent property of the system through a chain reaction of niche generation & speciation.

(6)





Discusión: Evolution generated patterns in sequence & structures of replicators, and these patterns had a function (information) in their ecological organization, which itself was generated by evolution too. Hence, evolution generated information from within the system.

Conclusione: Emergent ecological organization supplies a context in whicn novel information can evolve. The evolution of novel information in turn generates more complex ecological organization: Evolutionary feedback between information & organization.