Introduction.
The stability of replicator systems is confronted by two problems:
(i) a large mutation rate—error-threshold;
(ii) junk templates parasitizing the catalytic-parasites.

We previously studied (i) the error-threshold from two levels:
(1) below replicator (structure of molecules)—genotype-phenotype map;
(2) above replicator (population structures)—group selection.

We now combine two approaches to examine (ii) the problem of parasites in catalytic networks, and investigate the evolutionary interplay between the process above and below replicators.

(1) Below replicators.
Q: Does the error-threshold disappear by mutational neutrality?

Basic equations: \( \frac{dx}{dt} = \alpha(x + \sigma(1 - \lambda)(1 - Q)(x - D) - x) \)

\( \frac{dy}{dt} = \lambda(y - \sigma(1 - \lambda)(1 - Q)(y - D) - y) \)

Additive assumption:
\[ q_e = \sum_{d = 0}^{\infty} \binom{N}{d} q^{N-d}(1-q)^d x^d = (q + (1-q)\lambda)^N \]

\[ q_{\text{min}} = (\sigma - 1/N - \lambda)/(1 - \lambda) \]

Results:
Phenotypic error-threshold

A: An increase of the error threshold by mutational neutrality is limited.
(Ref. Takeuchi N. et al., BMC evol. Biol., 2005 89)

(2) Above replicators.
Q: Does group selection circumvent the error-threshold despite stochasticity?

Models: Replicator: Cellular Automata, Vesicles: Cellular Pots Model.

Neutral model: the master seq. and mutants contribute equally to the growth of vesicles.

Differential-division model: only the master seq. contribute to the growth of vesicles.

Colors: white=master seq.; red=mutants; black=vesicle wall.

Results of neutral model:
Ratio of master seq.

Results of differential-division model:

Error-threshold

Parameter search

A: Error-threshold becomes even more severe in neutral model.
Group selection does not work for free: Stochastic effect is strong.

(1+2=3) Below & Above replicators.

Q: By taking both processes below and above replicators into consideration, can a system be stable against parasites?

Model: Above replicators: catalytic reaction networks.
Below replicators: RNA folding genotype-phenotype map.

Above replicators
Reactions of molecules:
1. template based polymerization;
2. degradation;
3/4. binding/unbinding btw. 3-end & 5-end. (1-e^{-0.5}m / e^{0.2}m)
Diffusion of molecules.

Below replicators
Polymerase: 3 stems connected by m-loop.
Parasites: other 2ndary structures.

Results:
Low mutation intensity
High mutation rate

(1) Population dynamics.

(2) Below replicators: the structures of RNA.

(3) Phylogenies.

(4) Above replicators: reaction networks.

(a) Parasites increase diversity
(population dynamics)

(b) Hypercycle (Altruism)

(5) Very large mutation rate

Conclusions:
(1) The system actually becomes more stable with a larger mutation rate.
(2) The system chooses different molecular structures and network topologies depending on the mutation rate: generalist vs specialist; symmetric vs asymmetric catalyst.
(3) The processes below and above the molecules influence each other, and self-organize into a viable system.