Comparison of ecological and evolutionary strategies to address bacterial genome reduction

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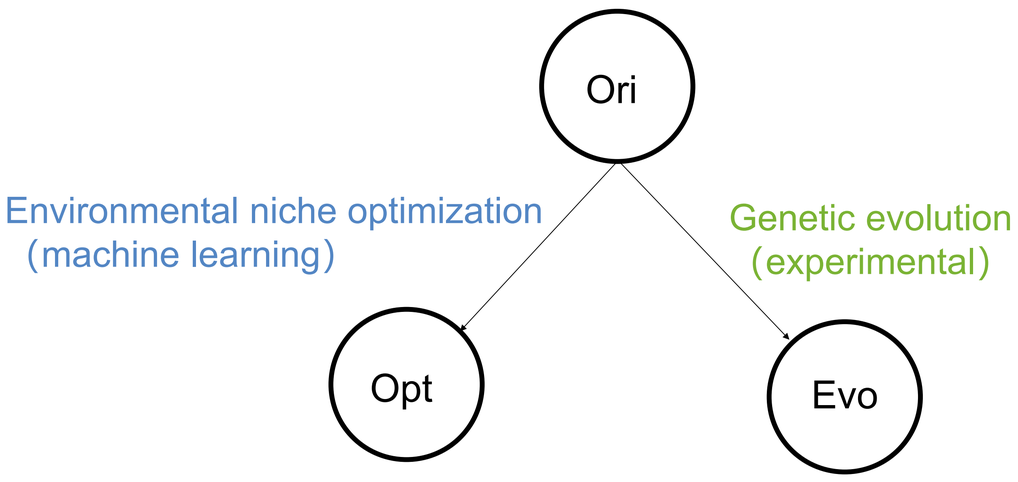
1.Background

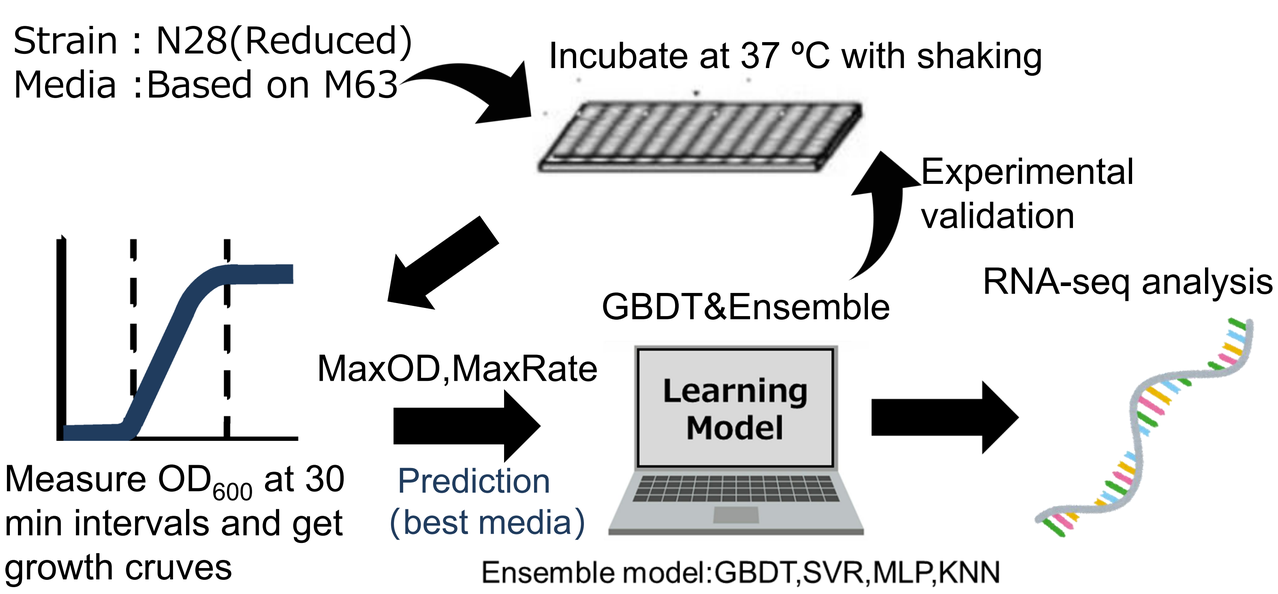
Biological adaptation is driven by both genetic evolution and ecological niche reconstruction. However, whether these two distinct pathways lead to comparable levels of fitness increase remains unclear. Minimal genome organisms often exhibit significant fitness costs. Identifying how they regain adaptiveness is crucial for understanding biological resilience. We established a comparative framework using genome-simplified E. coli to contrast experimental evolution and machine learning-driven niche optimization in order to assess their respective roles in adaptive recovery.

2.Objective

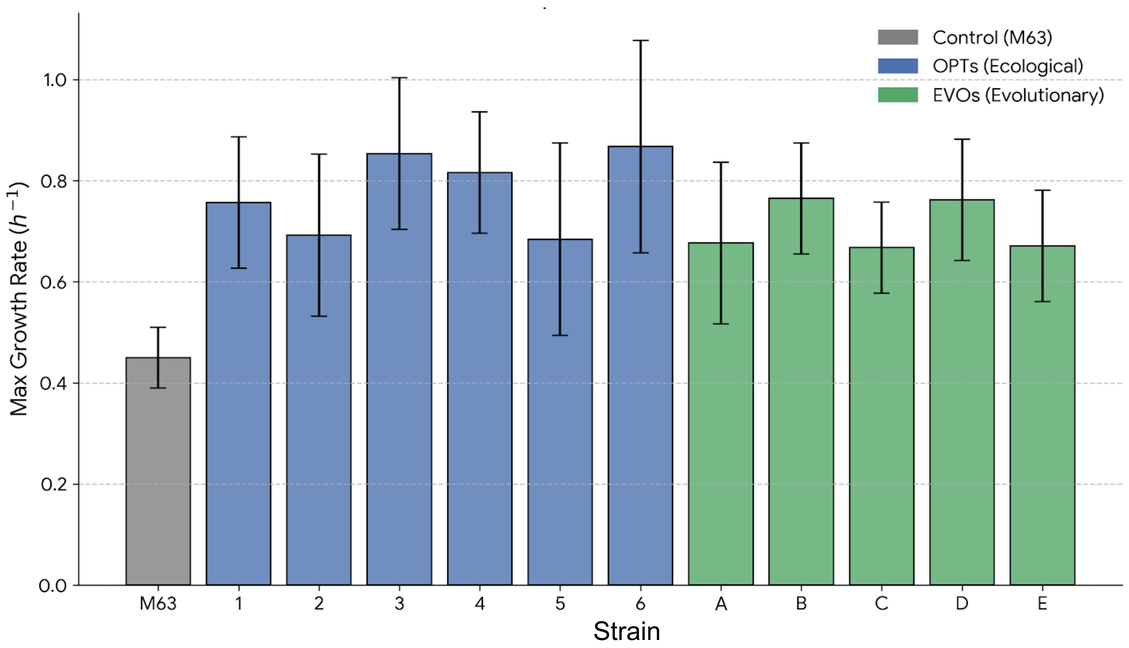
- To determine if **environmental niche optimization** can achieve comparable biological adaptiveness and fitness increase to **genetic evolution** in genome-reduced bacteria.



3.Methods・Materials

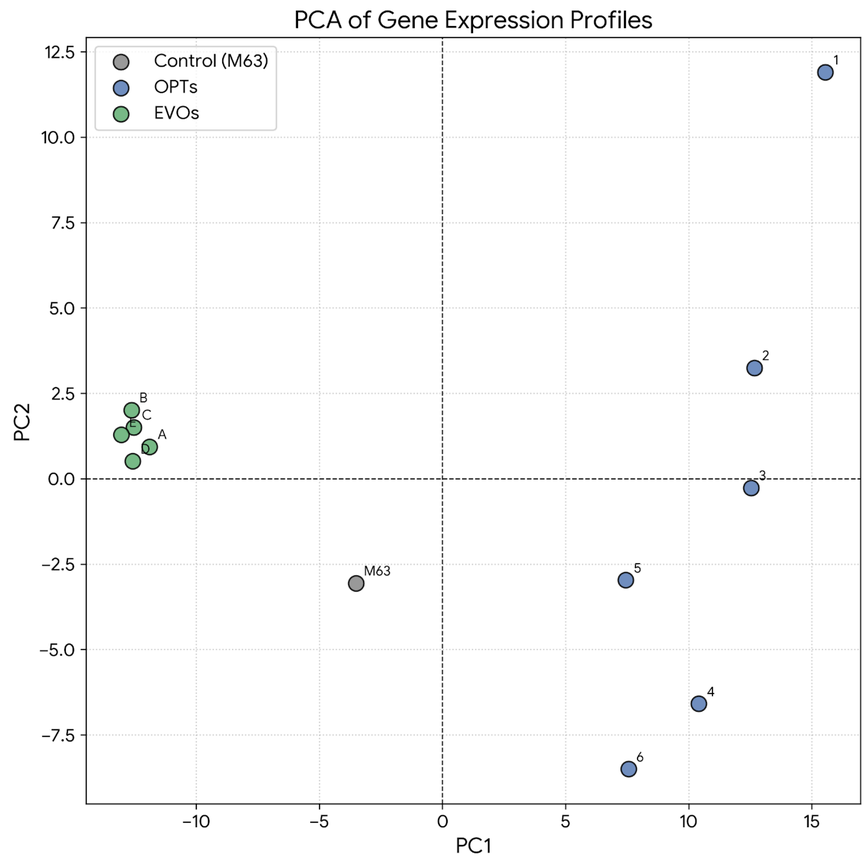


4. Comparable fitness recovery via parallel strategies



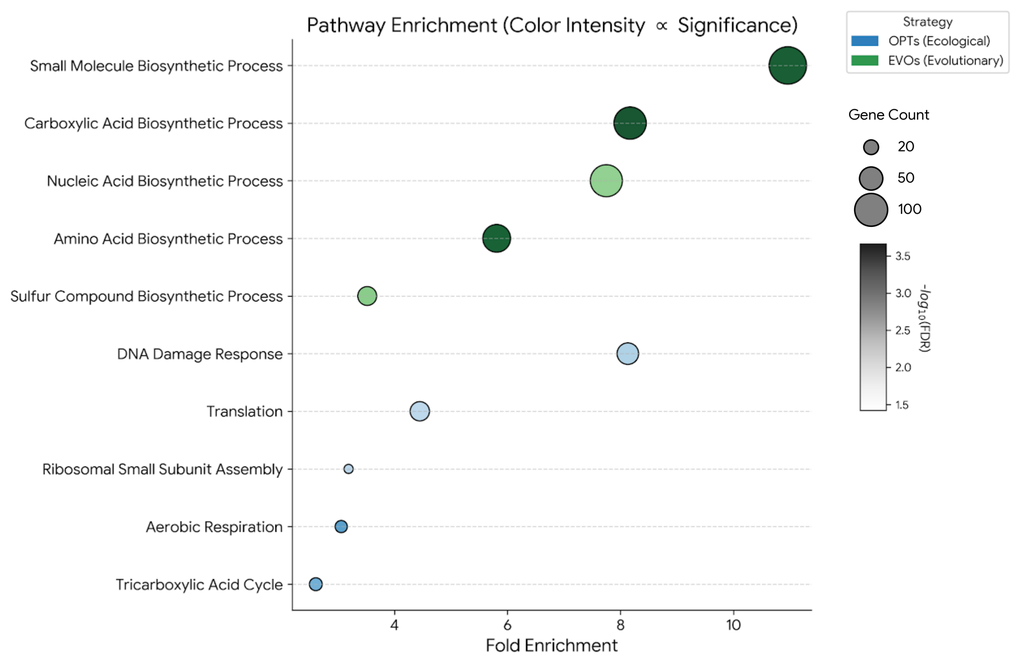
Both environmental optimization (OPT) and experimental evolution (EVO) significantly restored the growth fitness of genome-reduced E. coli.

5. **Distinct transcriptomic landscapes**



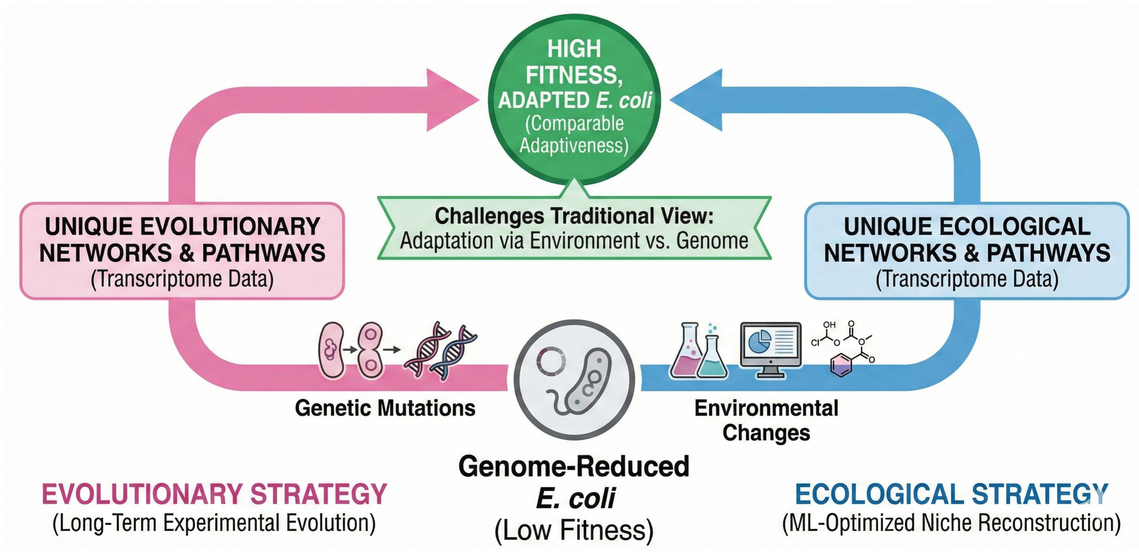
Although the adaptation results are converging, OPT and EVO occupy completely different transcriptomic spaces.

6. Biological Mechanisms



Pathway enrichment analysis shows a clear divergence in mechanism.

7. A framework for biological adaptation



This study challenges the gene-centric view of evolution.