

# Conflict and Cooperation in Microorganisms

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16-18 March 2010

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# Simpson's paradox in *Escherichia coli*

## Golden rule of the evolution of cooperation:

Cooperators have to be privileged recipients of the common good.

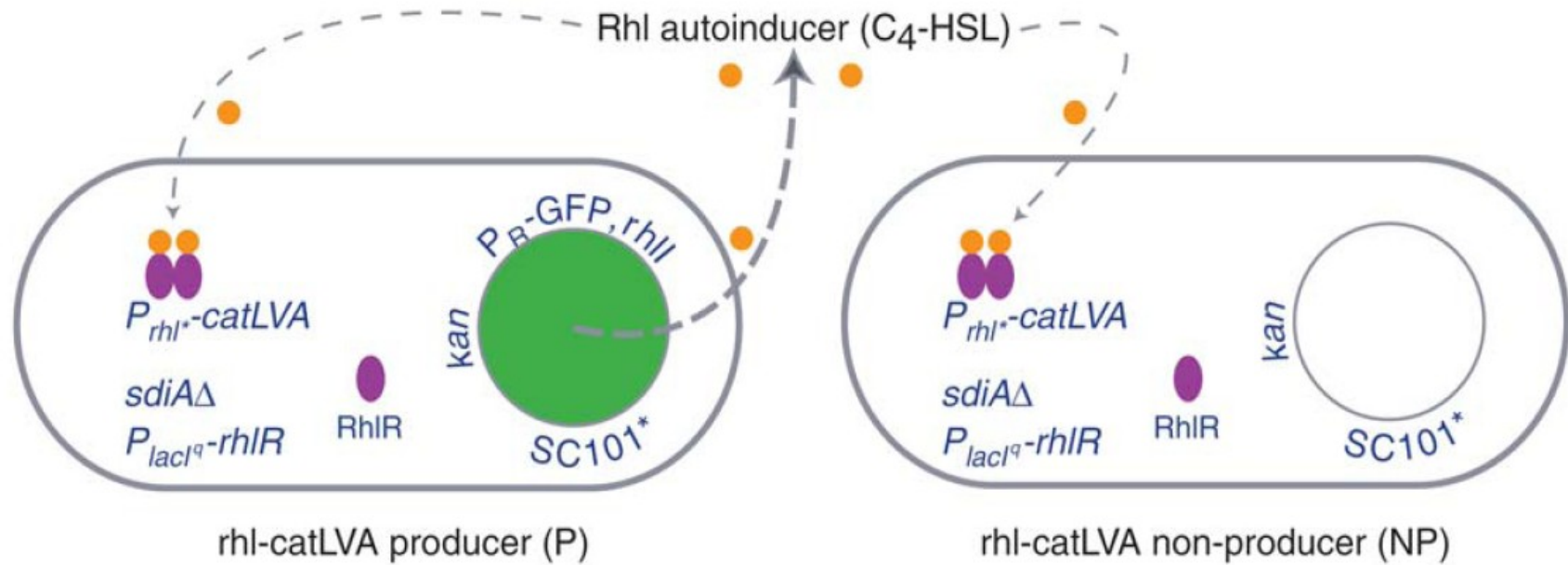
- A new mechanism: multi-level selection.
- Cooperators and cheaters distributed heterogeneously into subpopulations

## **THE PARADOX**

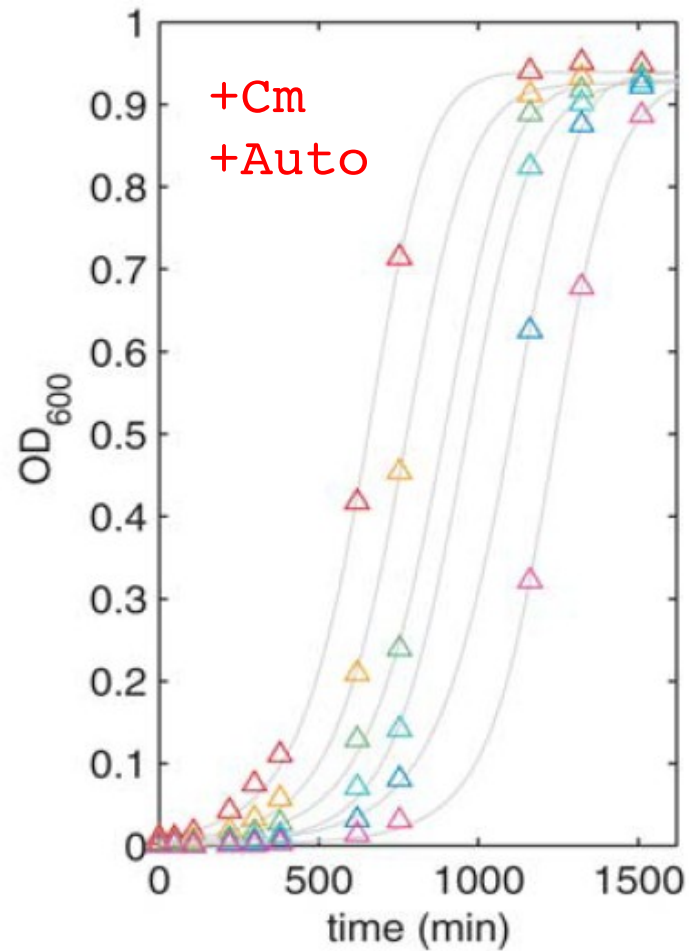
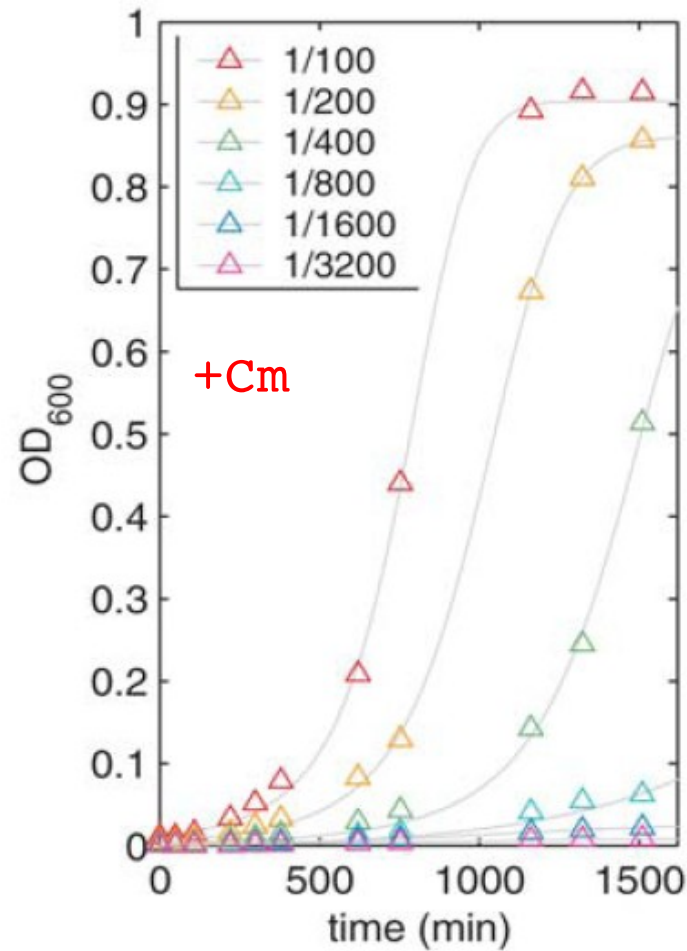
It could be that cooperators decrease in each subpopulation and yet its overall fraction increases

# Synthetic design in *Escherichia coli*

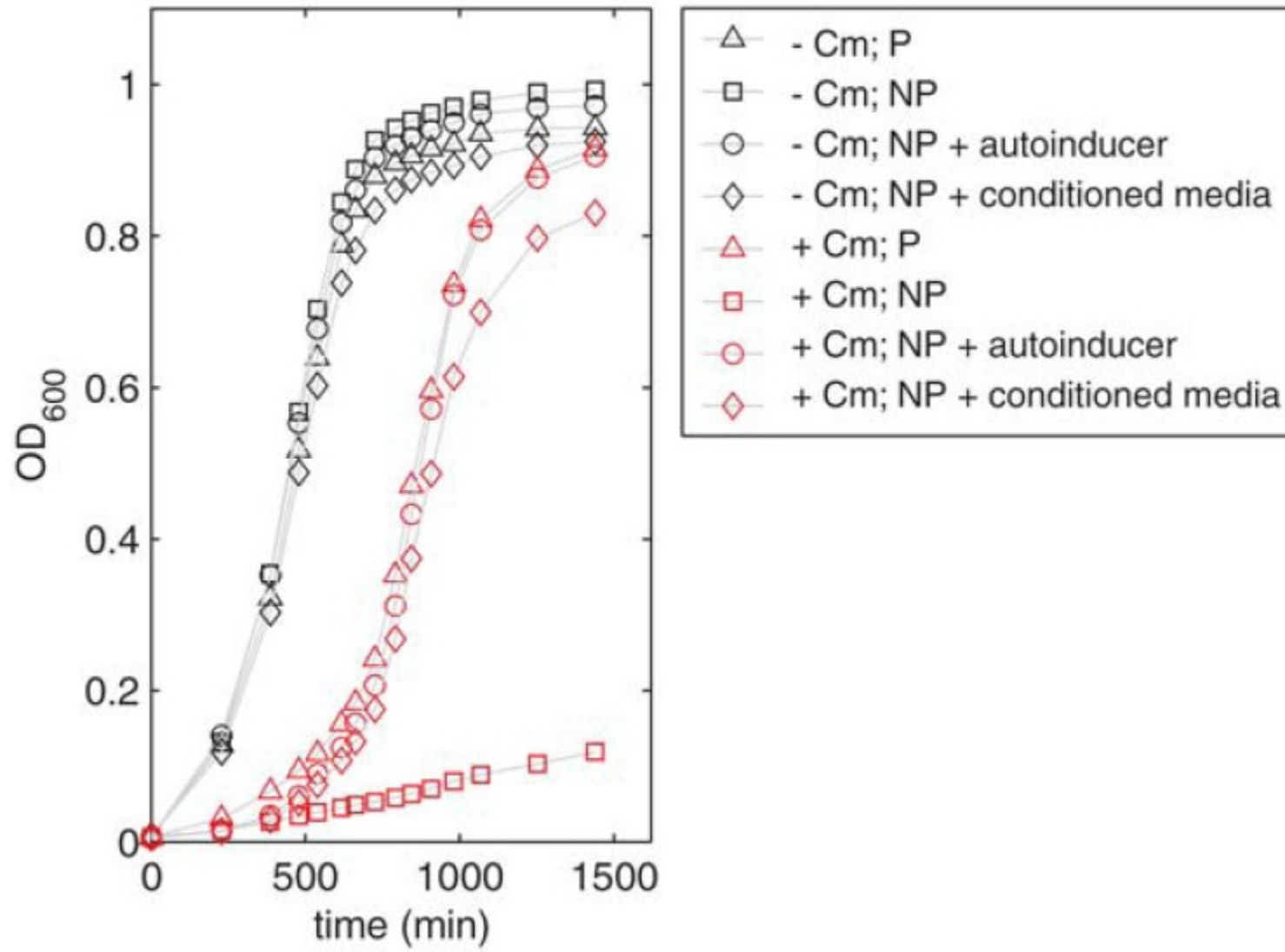
JS Chuang *et al*  
Science **323**,272(2009)



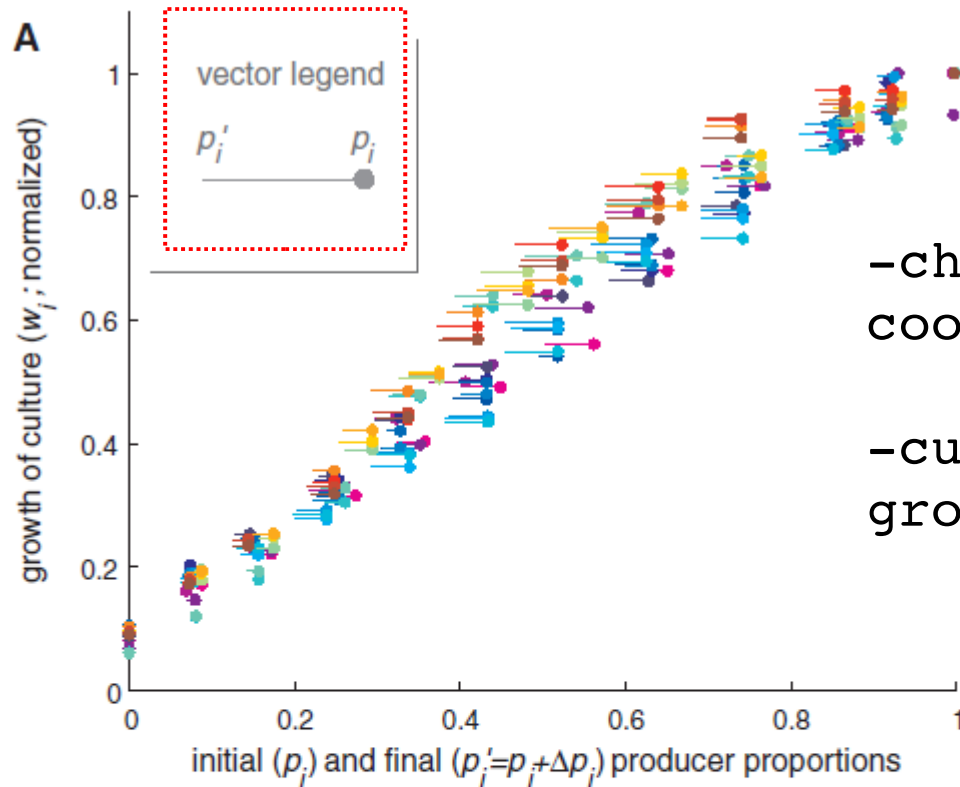
In Cm media, cooperators growth is density dependent



# Pure cultures of cooperators grow faster

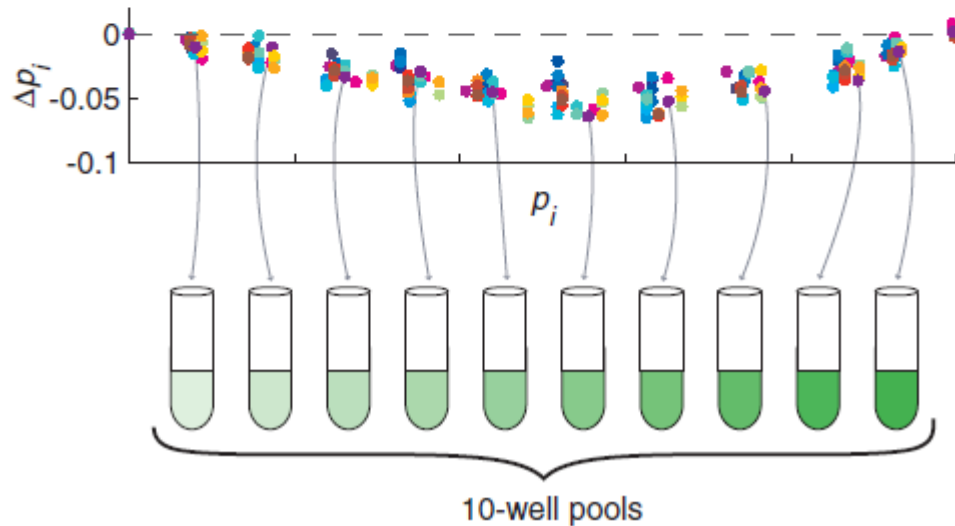


# Mixed cultures

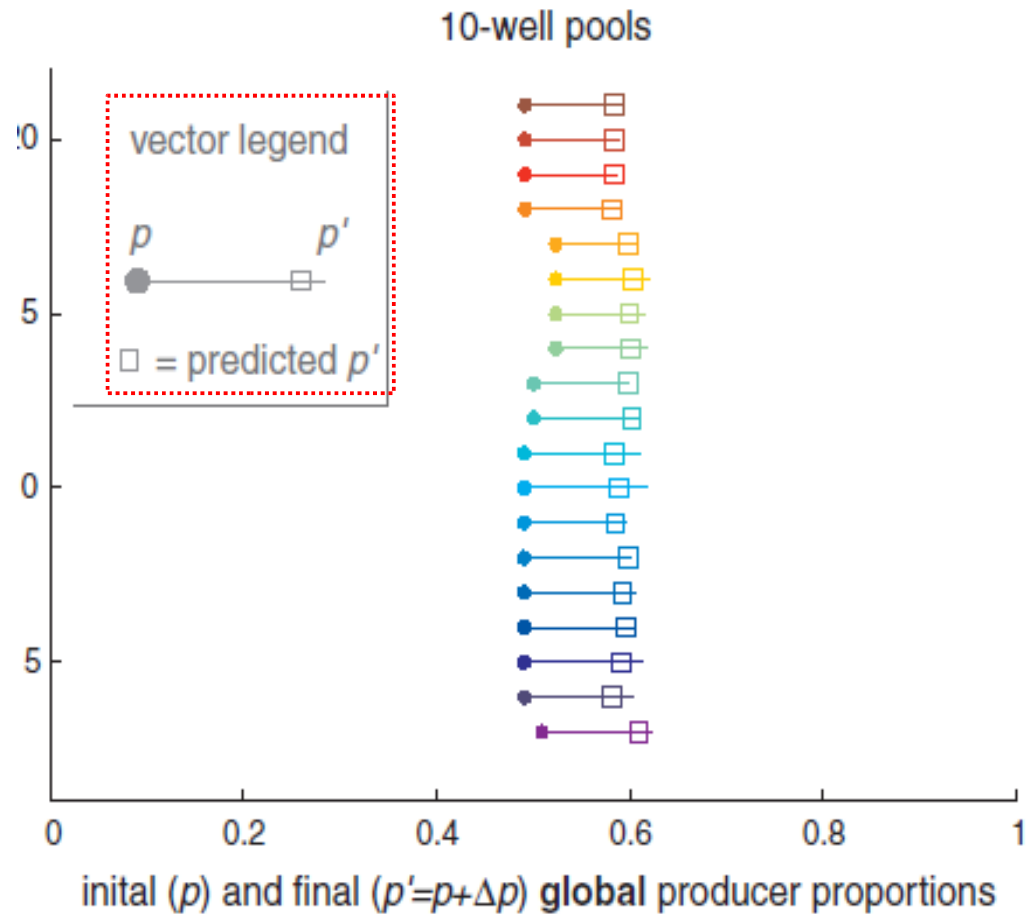


-cheaters grow faster than cooperators within each culture

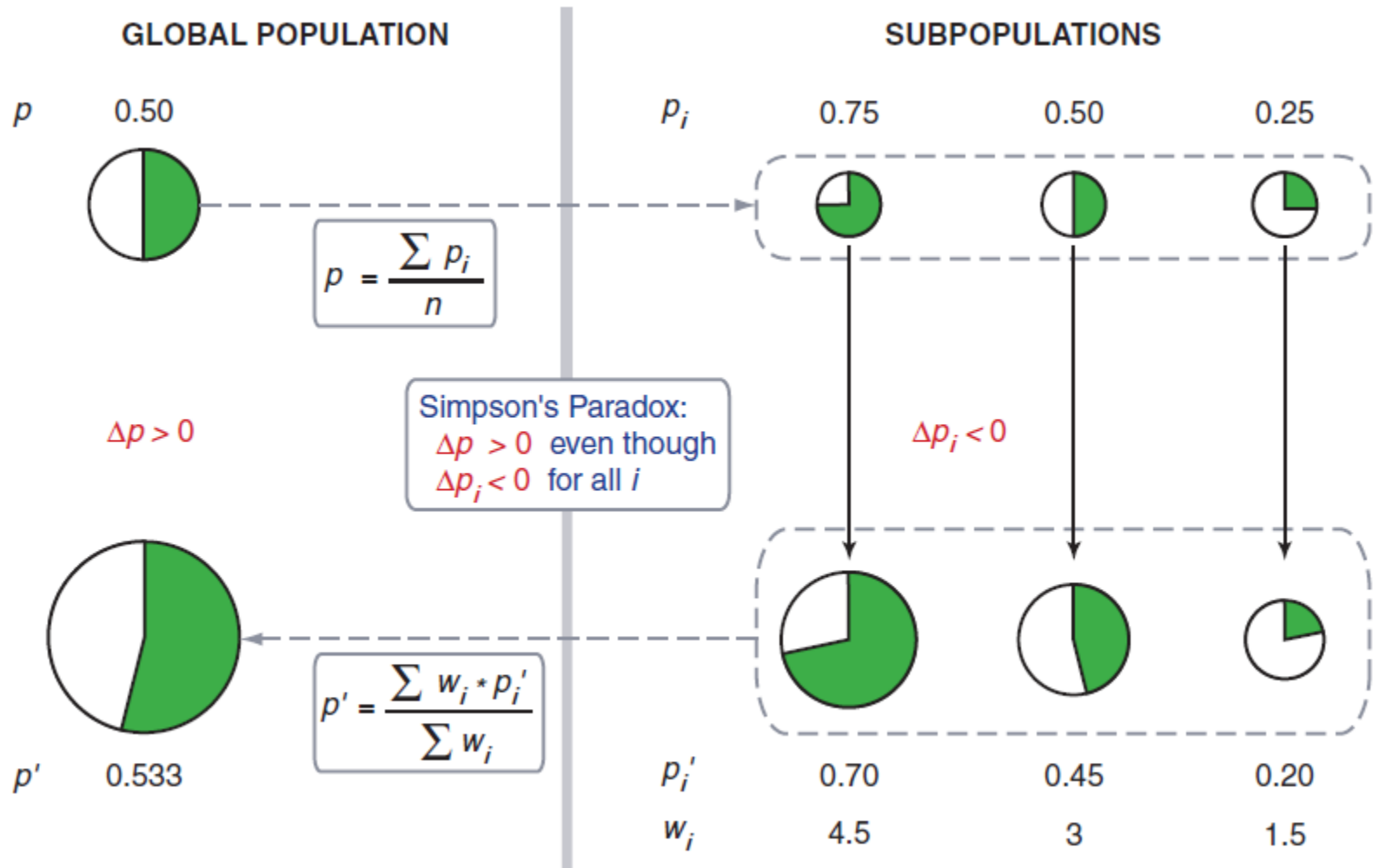
-cultures with more cooperators grow to larger densities



# Mixed cultures

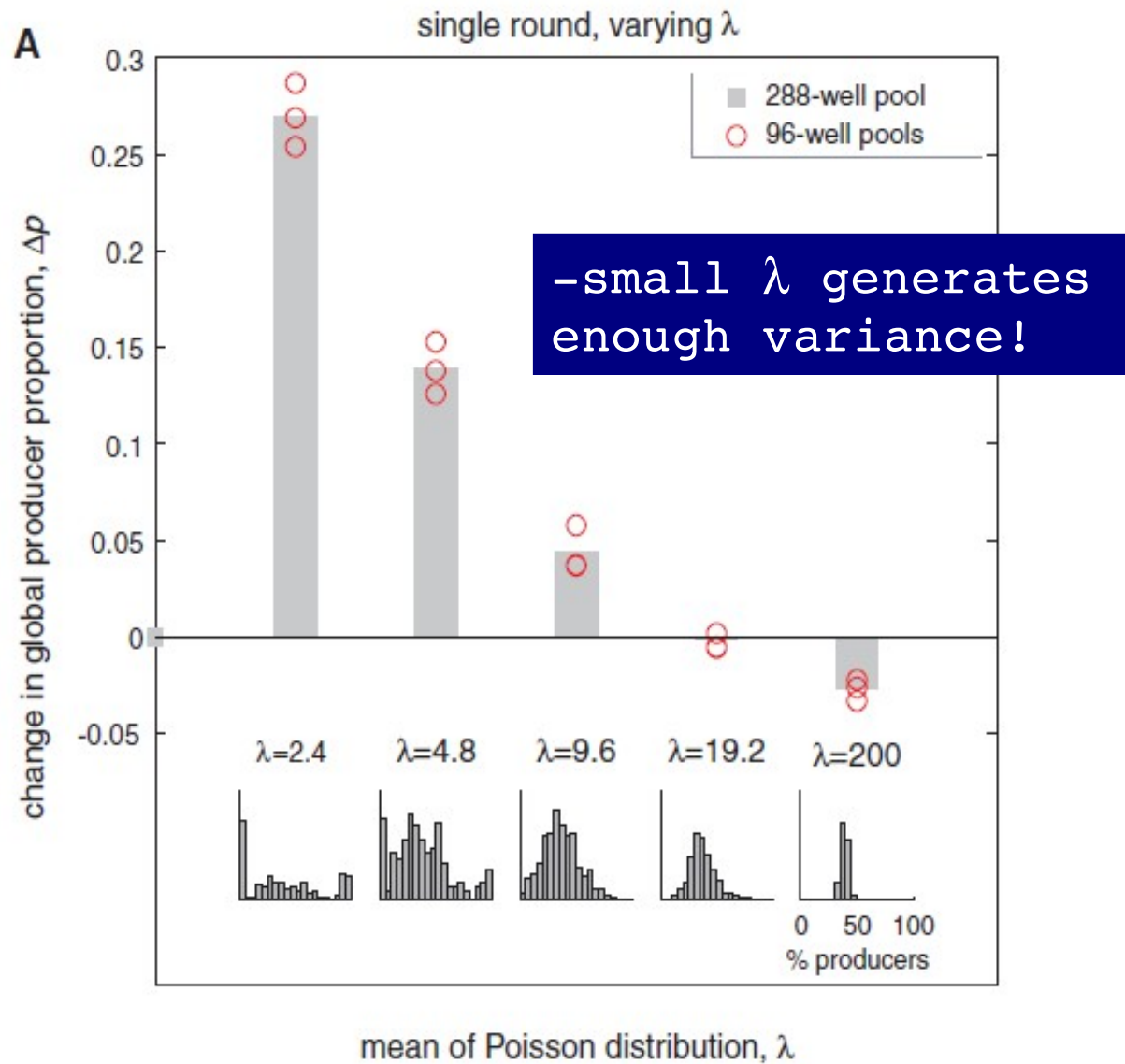


# Simpson's paradox in *Escherichia coli*

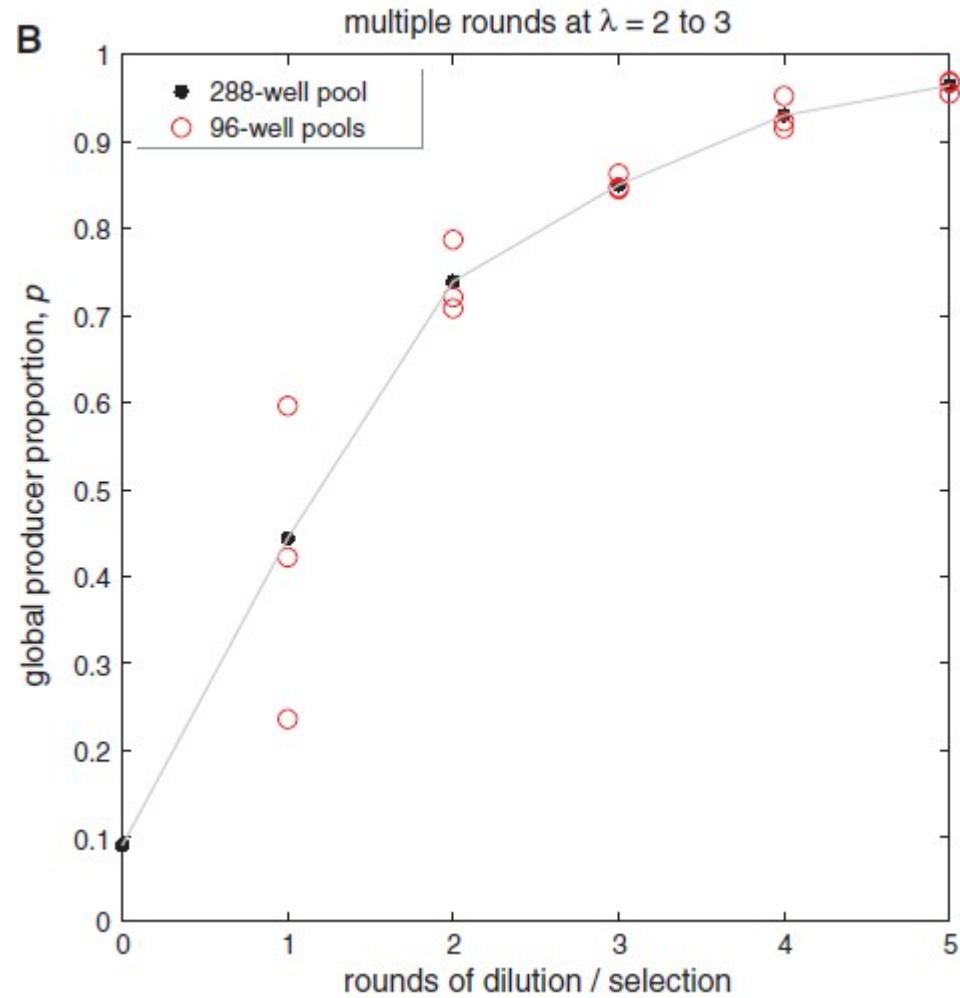




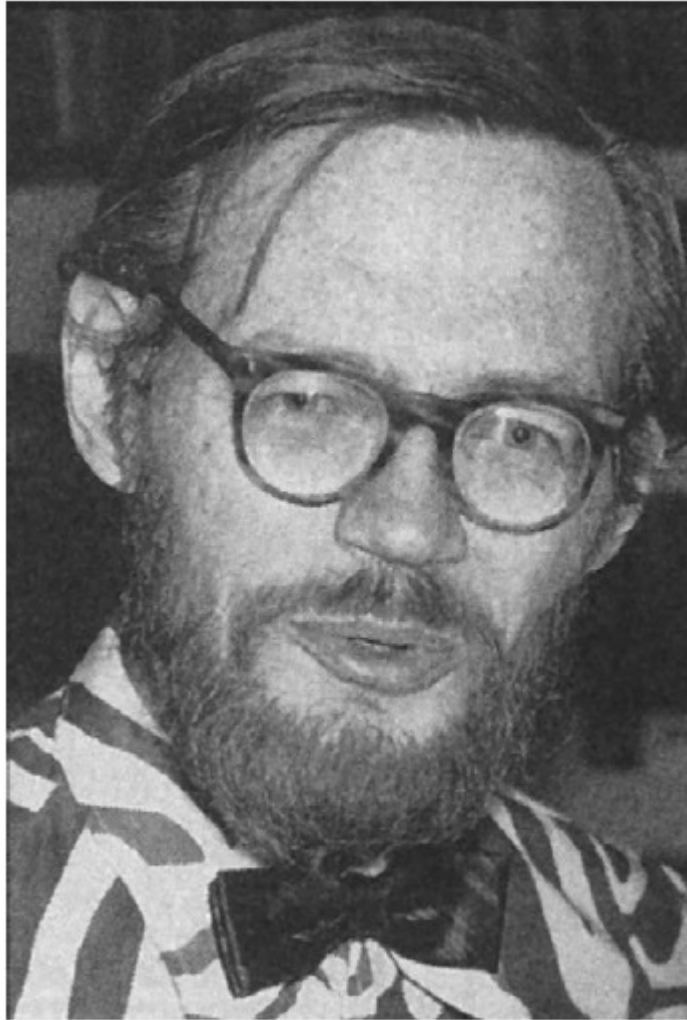
Important: generate large subgroup variance



# Iterations of Poisson Dilutions



## Price's theorem



$$\overline{\omega \Delta \Phi} = \text{cov}(\omega, \Phi) + E(\omega, \overline{\delta})$$