



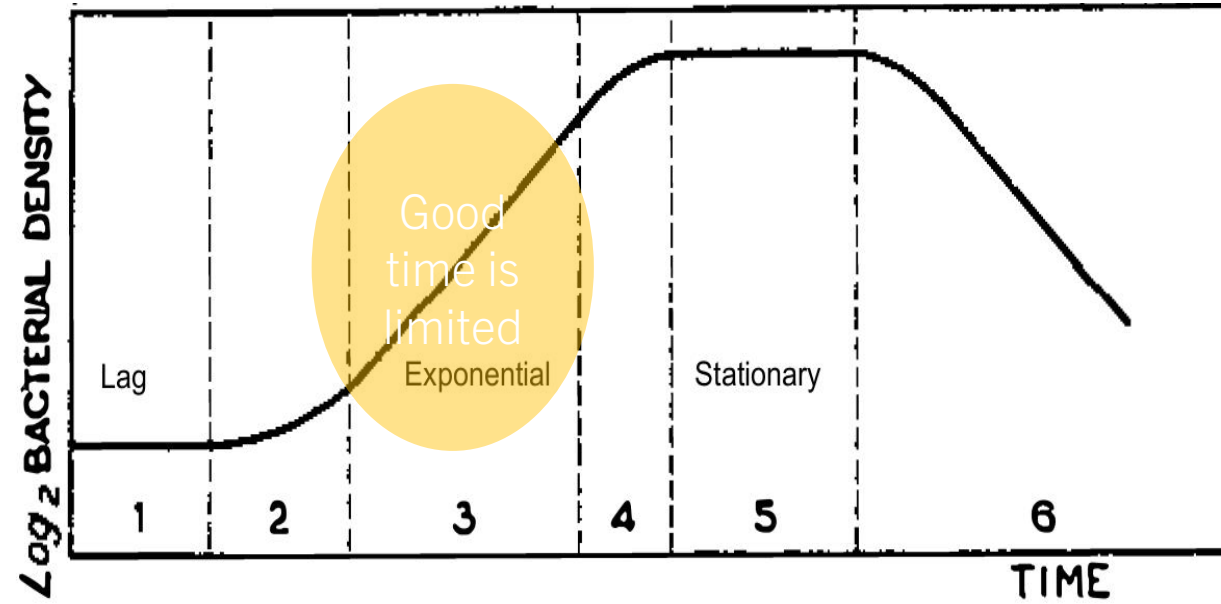
THE UNSEEN MAJORITY: BACTERIA AND PHAGE

Namiko Mitarai, NBI

**10³⁰ BACTERIA
CELLS ON EARTH**

Circular	Rod-shaped	Curved forms	Other shapes
 Diplo- (in pairs)	 Coccobacilli (oval)	 Vibrio (curved rod)	 Helicobacter (helical)
 Strepto- (in chains)	 Streptobacilli	 Spirilla (coil)	 Corynebacter (club)
			

J. MONOD (1949)

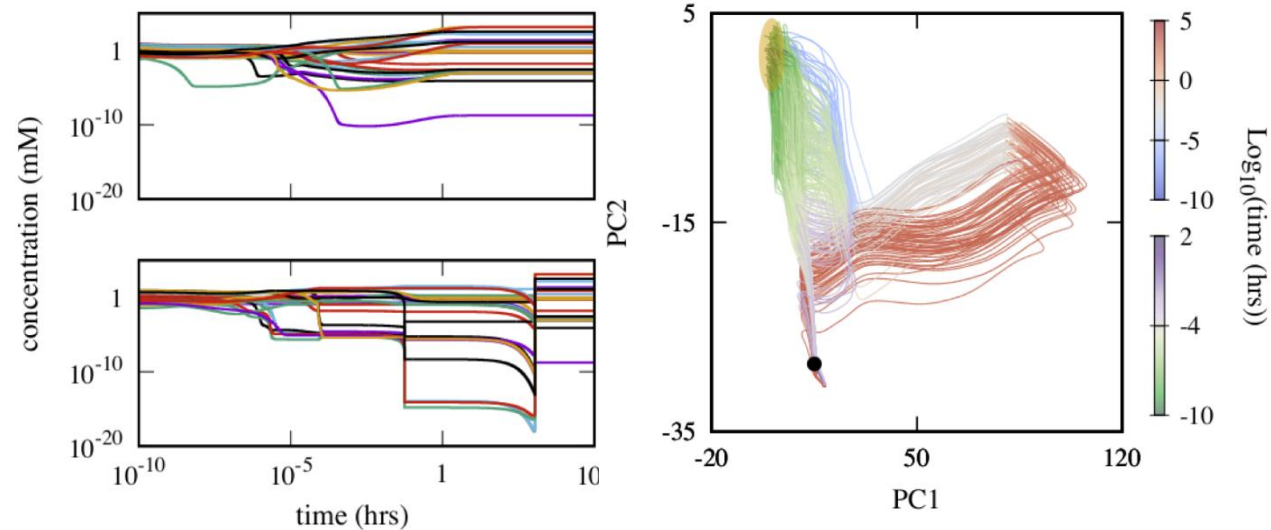
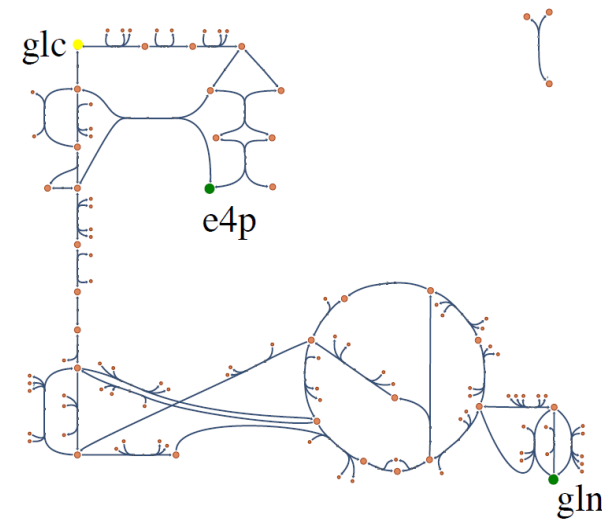


STRESSED TIME AND INDIVIDUALITY



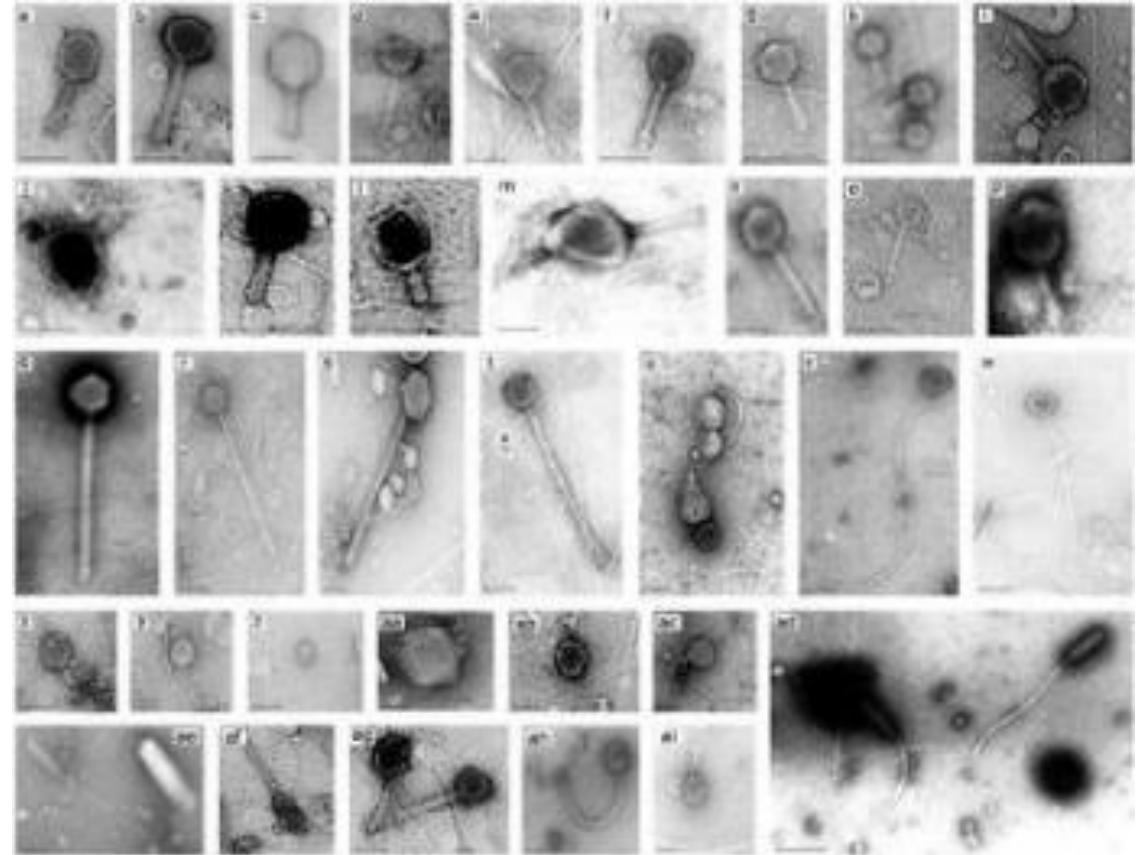
Svenningsen, Mikkel Skjoldan, et al. "Birth and resuscitation of (p) ppGpp induced antibiotic tolerant persister cells." *Scientific reports* 9.1 (2019): 1-13.

EMERGENCE OF SLOW DYNAMICS?



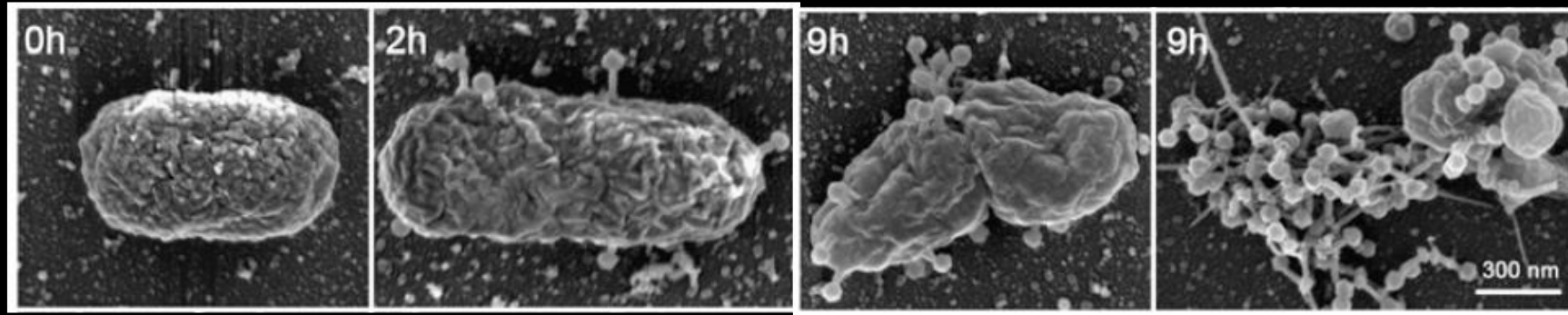
Himeoka, Yusuke, and Namiko Mitarai. "Emergence of growth and dormancy from a kinetic model of the Escherichia coli central carbon metabolism." *bioRxiv* (2021).

**10³¹ PHAGE
PARTICLES ON
EARTH**



From Sulcius et al. *Oceanologia* (2011)

BACTERIAL NEMESIS: (VIRULENT) PHAGE



From: Sabehi et al PNAS 109, 2037-2042 (2012)

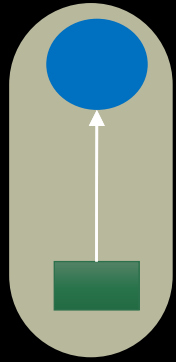
PHAGE DRIVES DIVERSITY BY COMPETITION

NO PHAGE
 $\# \text{ OF B-TYPES} \sim \# \text{ OF RESOURCES}$

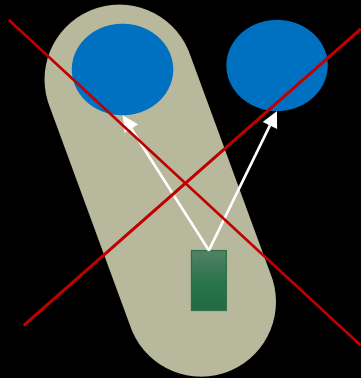
WITH PHAGE –
 $\# \text{ OF B-TYPES} \sim \# \text{ OF RESOURCE} + \# \text{ OF P-TYPES}$

- Competitive exclusion

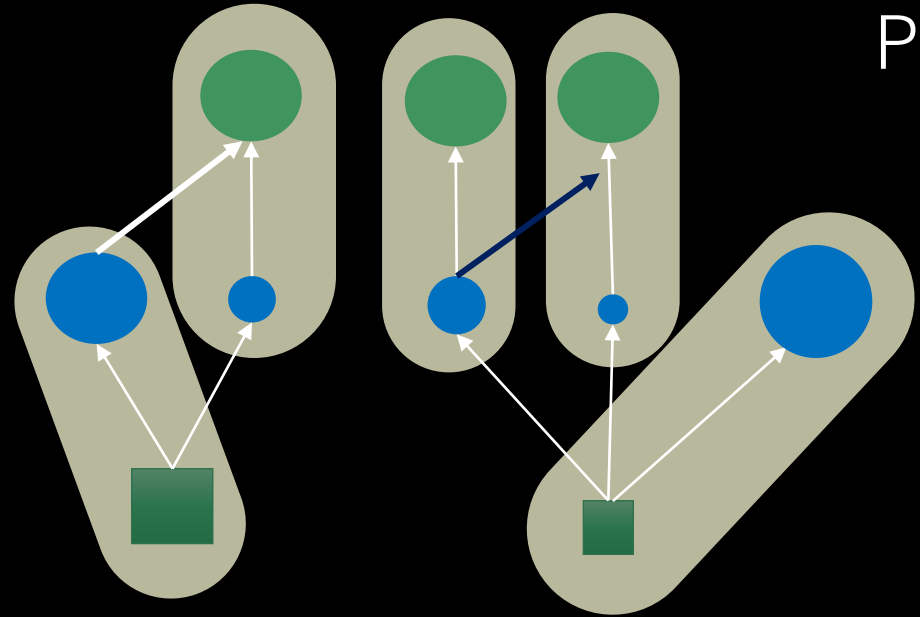
Bacteria
 N
 Resource
 S



YES



NO



YES

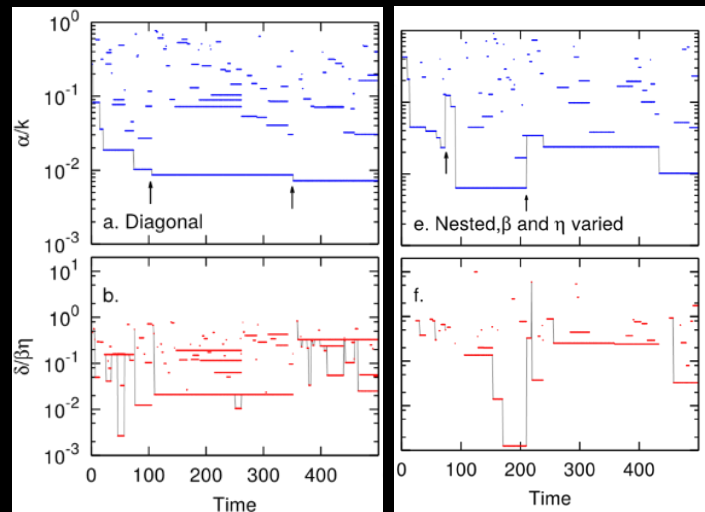
YES

Phage
 M

PHAGE DRIVES DIVERSITY BY ARMS RACE

TYPICAL RESISTANT MUTANT

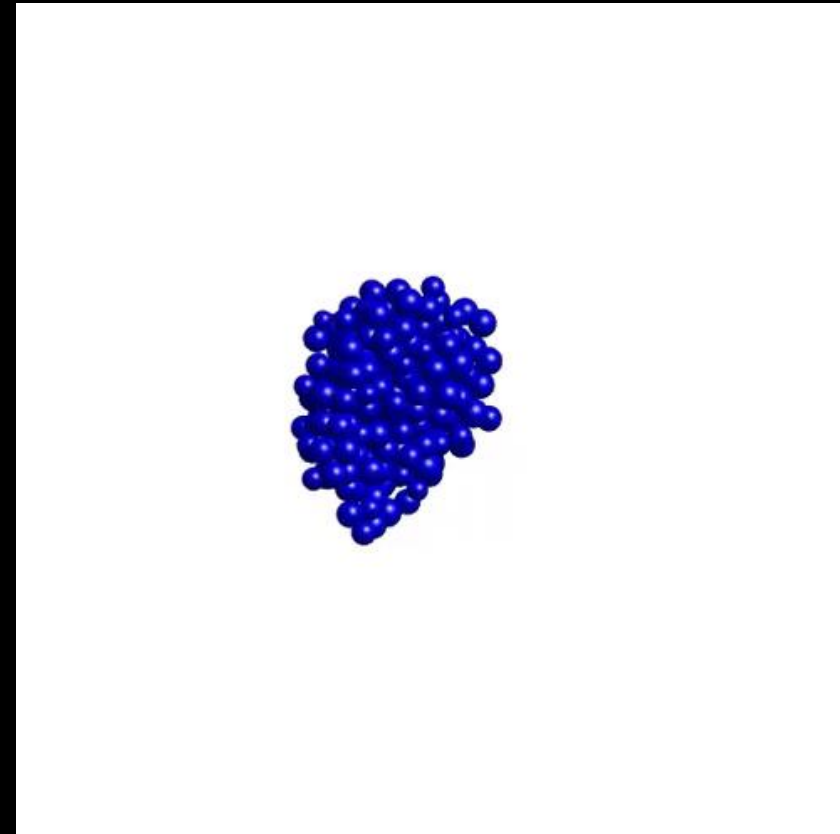
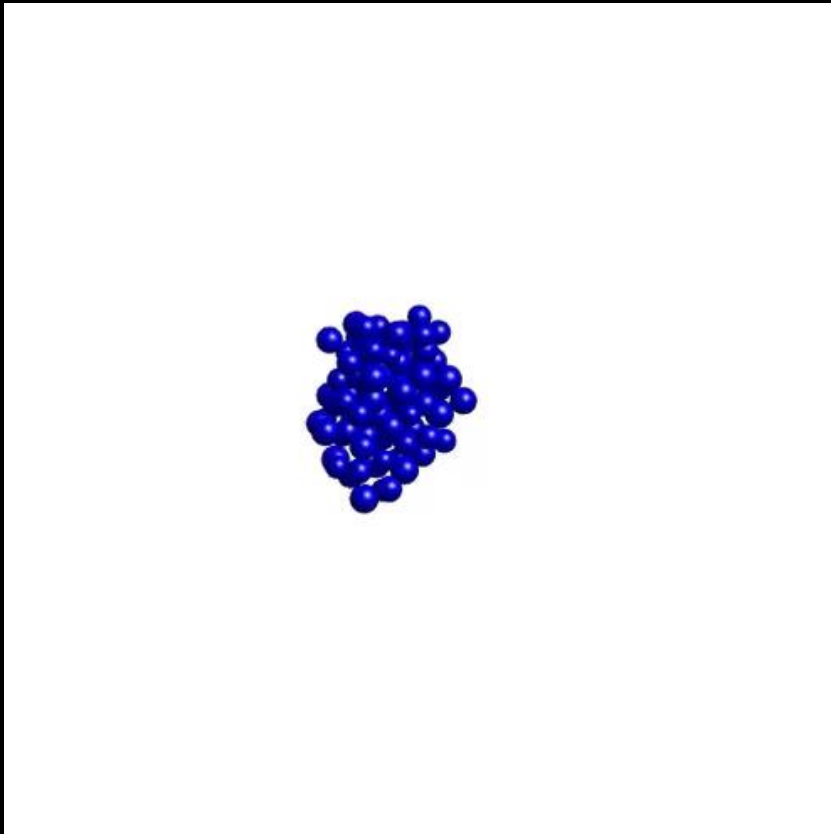
- The loss of phage receptor – phage cannot infect any more
- Typically costs the growth rate



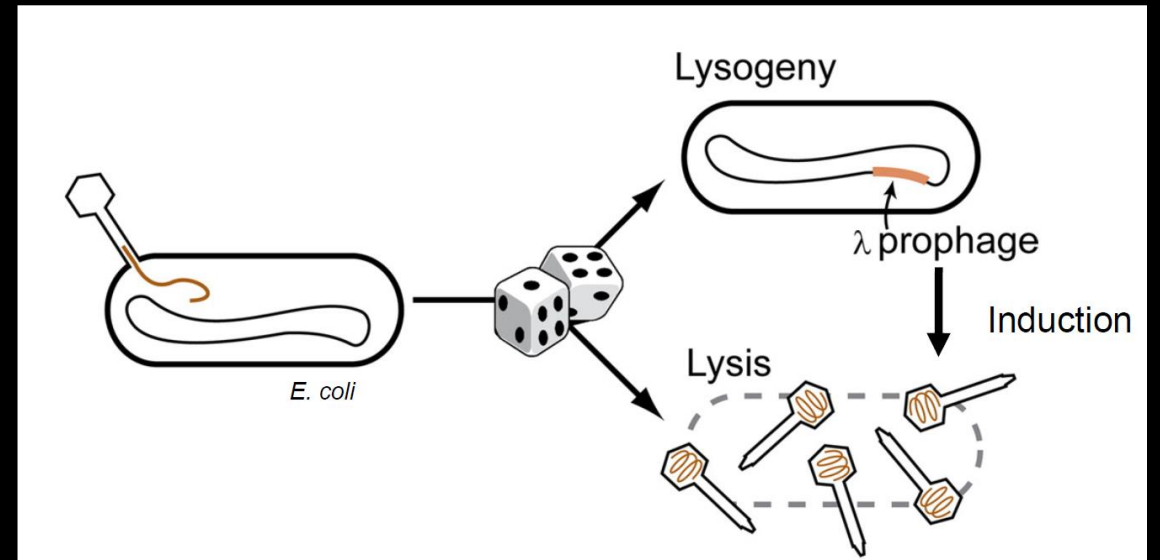
PHAGE DEFENSE MECHANISMS

- Extracellular matrix trap phages
- Restriction-Modification System
- Abortive infection, TA systems
- CRISPR immune system

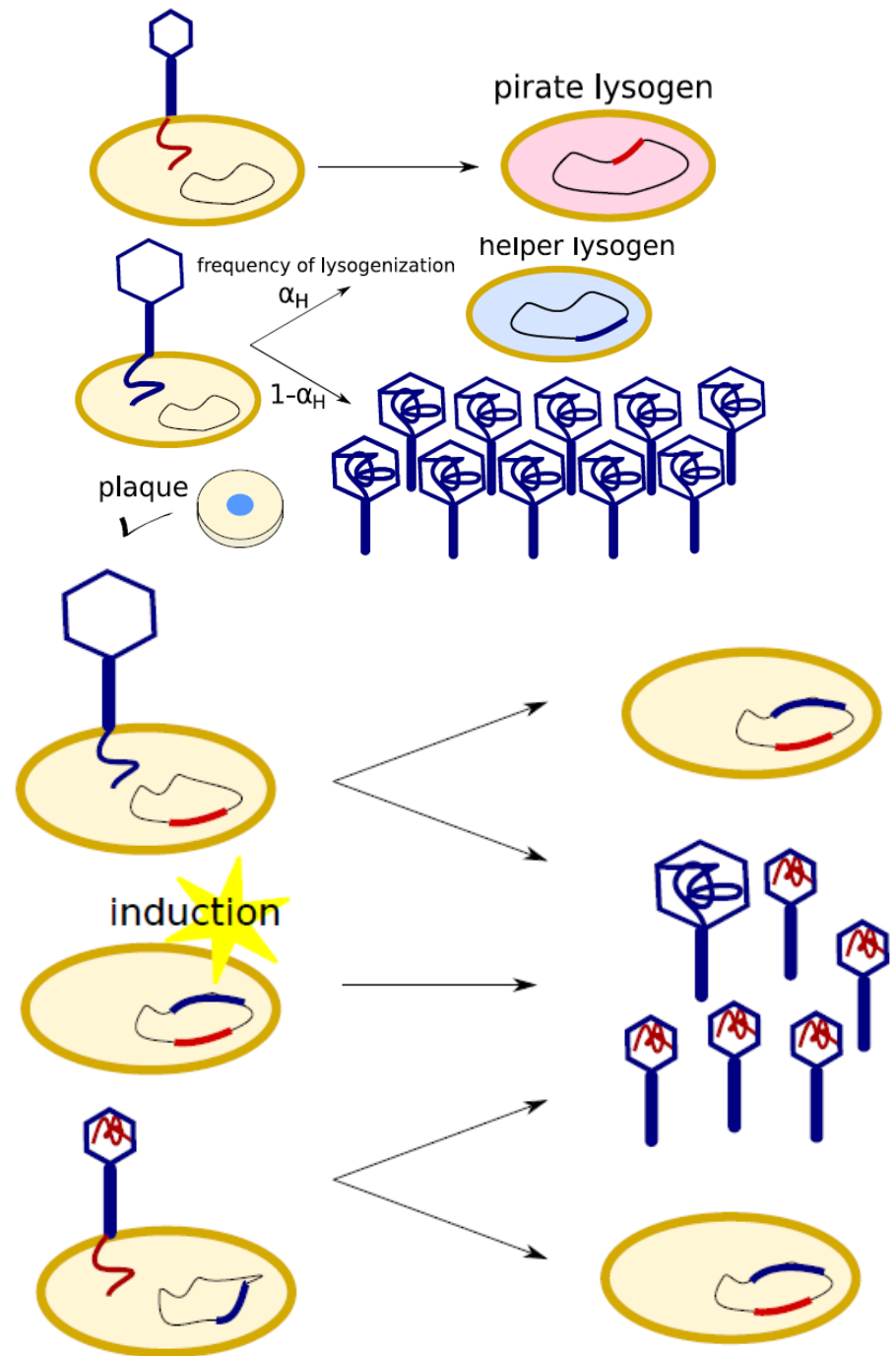
PHAGE MAY DRIVES SPATIAL STRUCTURE



PHAGES ARE ALSO
DIVERS:
TEMPERATE PHAGE



PIRATE PHAGE
(PART OF MOBILE
GENETIC
ELEMENTS)



**SURPRISING
ROBUSTNESS
AND DIVERSITY
IN UNSEEN
MAJORITY**

- good time and bad time: surviving bad time is relevant for survival
- parasites (phage) drive/accelerate microbiome diversification/evolution
- Eager to learn and think more about what they can do in different environment and to the planet