

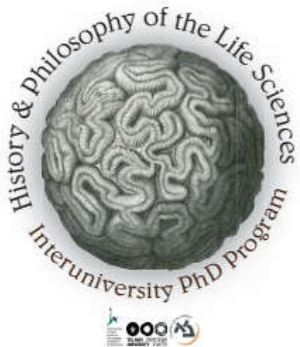
# Holobionts: An Evo-Devo Perspective

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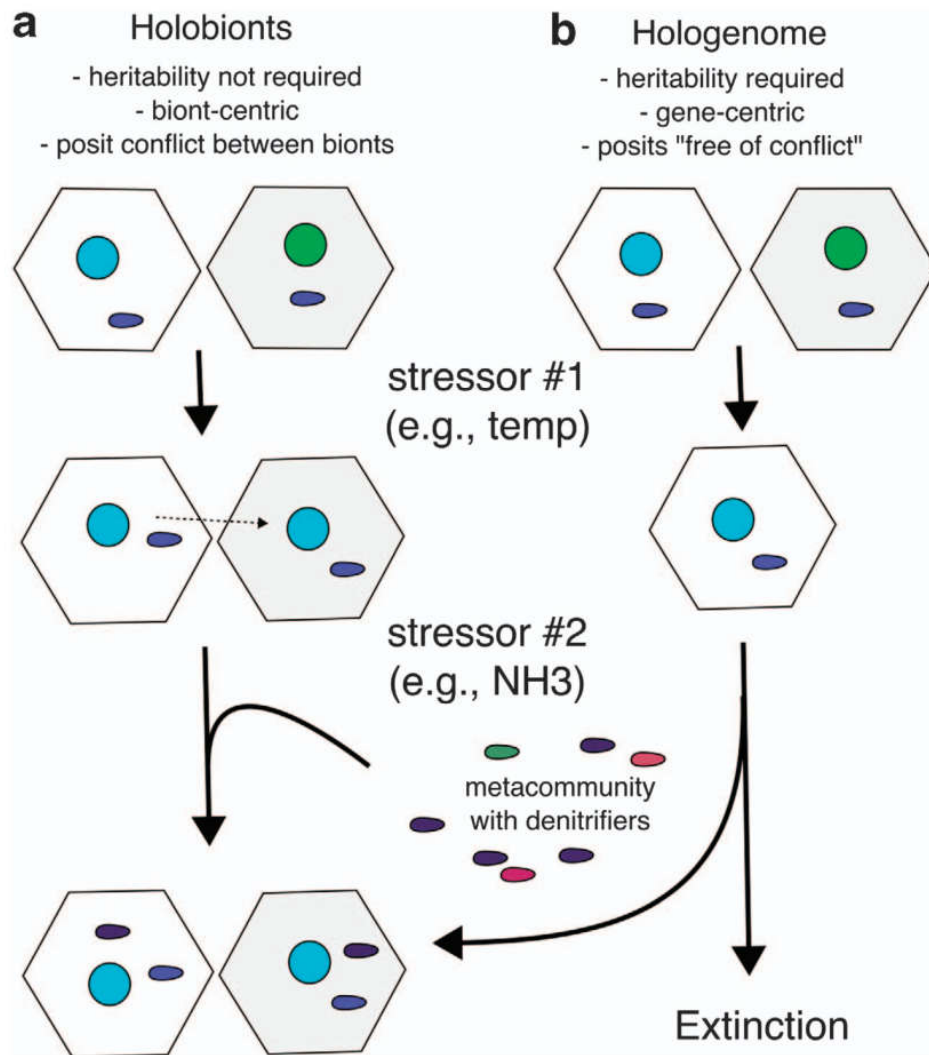
# The challenge to individuality



Lamm, E., *Big Dreams for Small Creatures: Ilana and Eugene Rosenberg's path to the Hologenome Theory* (2018-forthcoming in **Dreamers, Visionaries, and Revolutionaries in the Life Sciences**, Harman & Dietrich eds. Chicago University Press) [on philsci-archive]

# Outline

- The holobiont generalization and hologenome idealization
- Overlapping individuals
- Peradaptations and goal-directed mechanisms
- How to conceptualize holobiont evolution



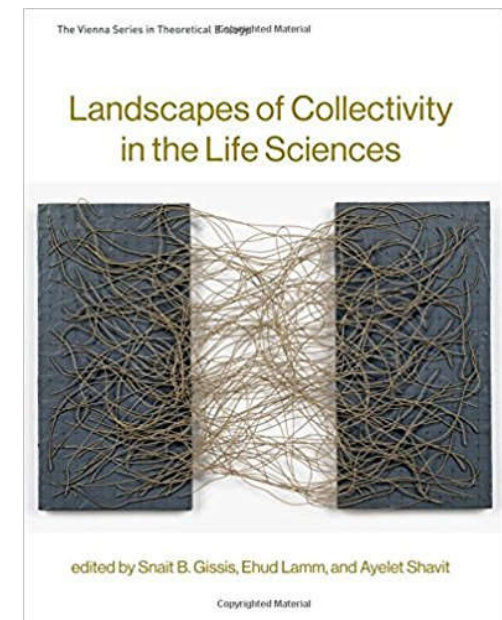
- Evolutionary individuals (u.o.s)?
- Organisms (coevolution)?

Hester et al. (2015)


# Holobiont structure of evolution

- A structure of evolution is a "constellations of evolutionary relevant factors, which include selection, but also other factors, such as properties of heredity."

Lamm, E. 2018. "Cultural Group Selection and Holobiont Evolution – a Comparison of Structures of Evolution."  
In *Landscapes of Collectivity in the Life Sciences*.



# Holobiont structure of evolution (generalization)

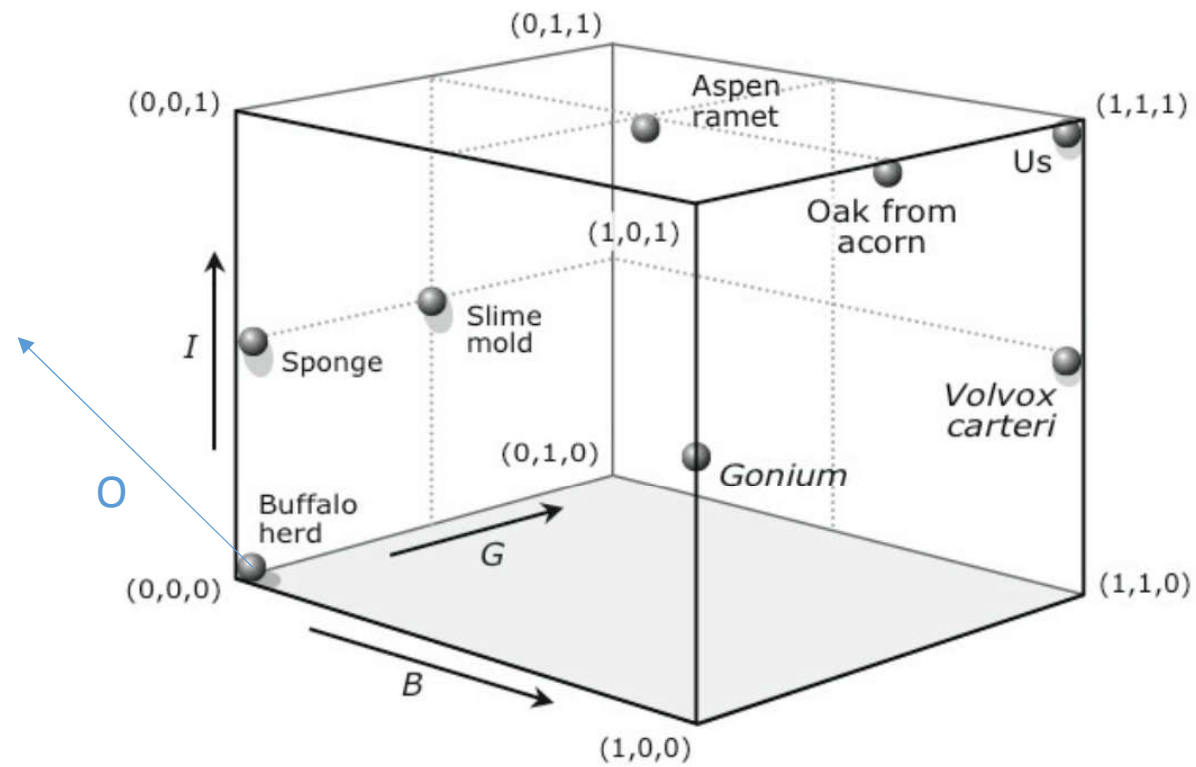
1. A host.
2. Microorganismic partners. 
3. Genomes, of both the partners and the host.
4. Vertical transmission of partners in holobiont reproduction.

# The Hologenome (idealization)

$$\text{Hologenome} = \{H, m_1, m_2, \dots, m_n\}$$

Where  $H$  is the genome of the host and  $m_i$  are microbial genomes.

"...the term hologenome is used to reflect the sum of all genomes comprising the holobiont, creating equivalence between 'host' genes and symbionts within the individual" (Hurst, 2017, p. 2).



*O*: Overlap  
(lack of)

*B*: Bottleneck  
*G*: Reproductive specialization (germ/soma)  
*I*: Overall integration

Forms of Collective Reproduction  
 (Godfrey-Smith, 2009)



# Hare-ball?

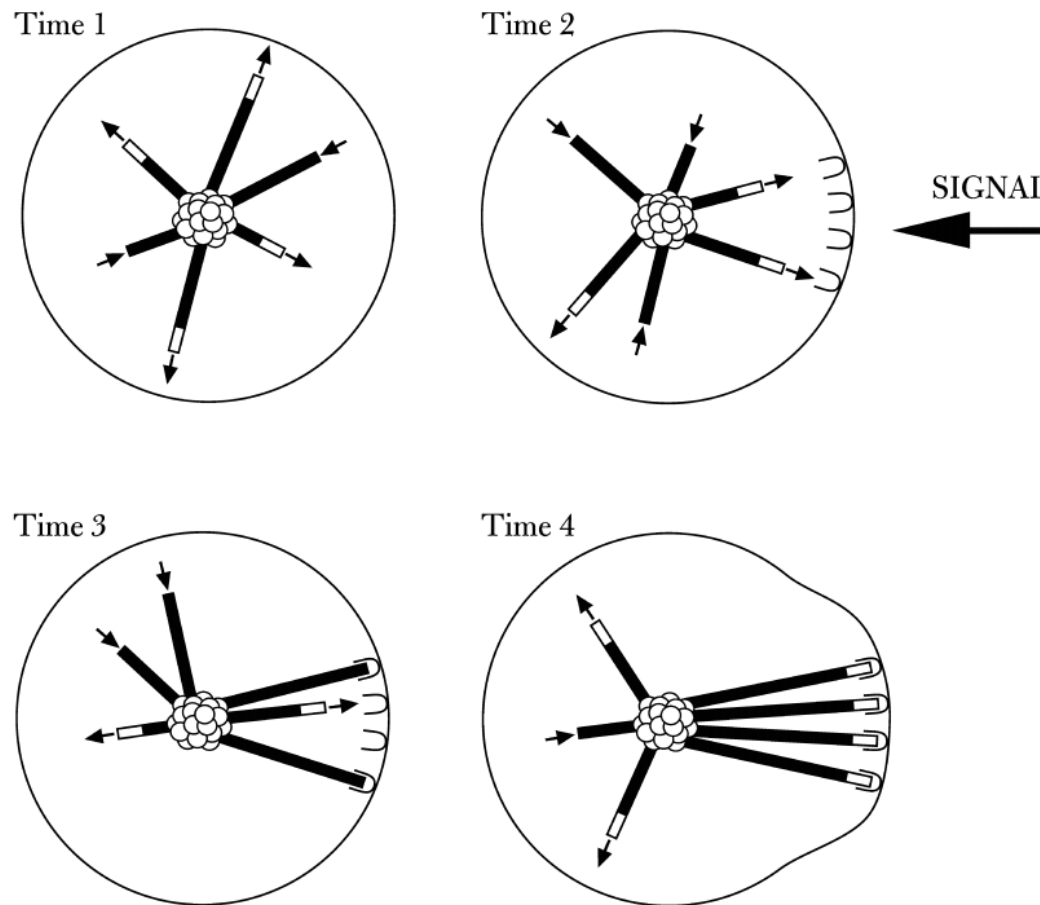
- Distinct from VT
- Distinct from HGT



# Mechanisms

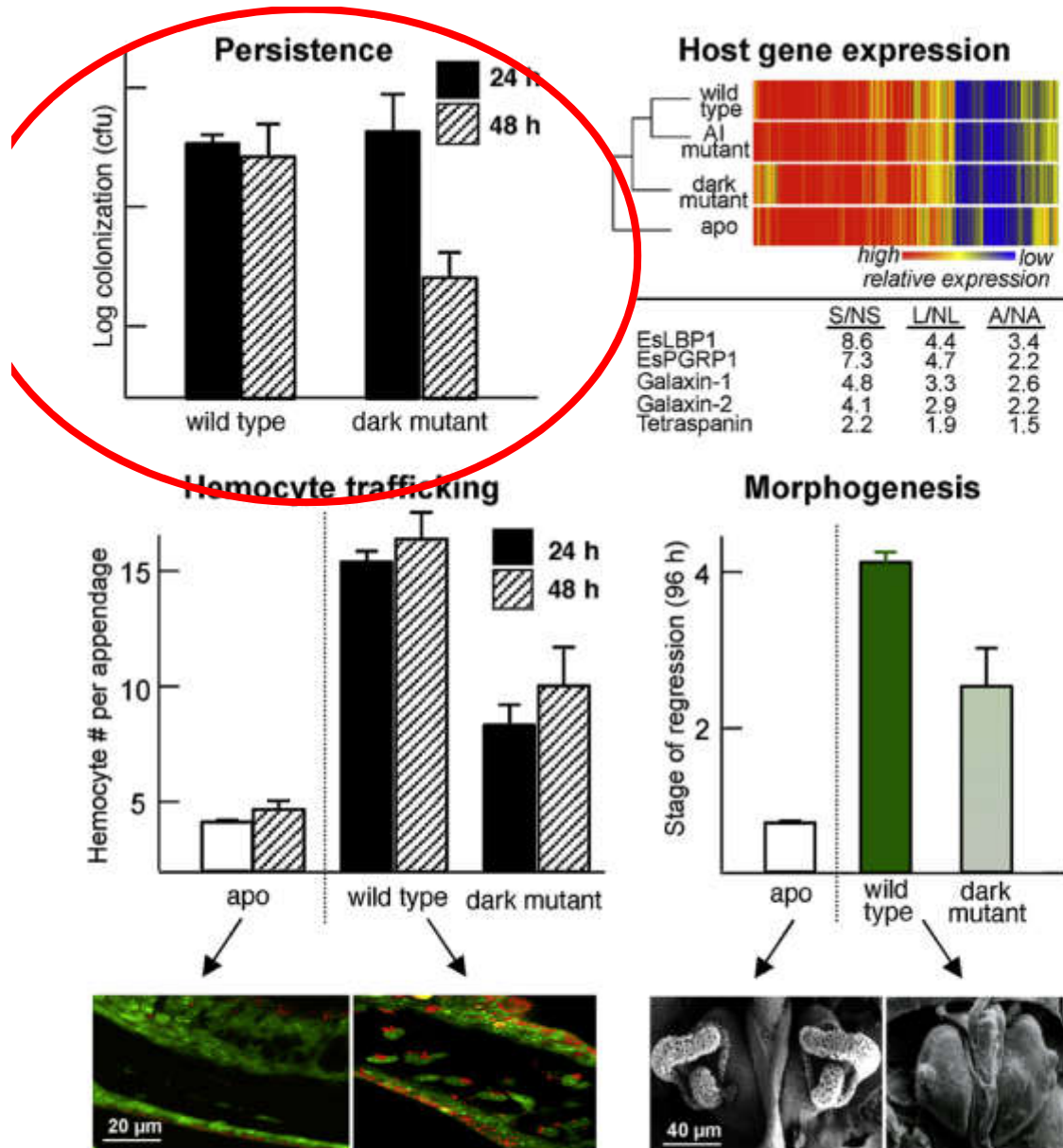
- ***Specific acquisition/expulsion mechanisms:*** mechanisms that evolved for the particular species of symbionts and hosts
- ***General purpose mechanisms:*** mechanisms that may be involved in relations with microorganisms in general, or for other functions of the host (including immunity).
- ***Goal-directed mechanisms:*** mechanisms involved in acquisition, expulsion, and maintenance of the microbiome that are sensitive to functional contribution.

# Selective stabilization



Kirschner & Gerhardt, *The Plausibility of Life* (2005)

McFall-Ngai et al. (2012)



light production to normal symbiosis. Upper left, mutants defective in light production ( $\Delta lux$ , 'dark mutant') fail to persist in the host organ. No colonization, as these mutants colonize to wild-type levels at 24 h, but by 48 h, the population has diminished several fold and the colonization of these mutants is reduced within days. Upper right, dark mutants are defective in inducing normal symbiosis-induced changes in the expression of several genes. A heat map at the absence of symbiont luminescence dramatically affects the overall patterns of the transcriptome. Most notable is the defect in changes in the expression of the MAMP-interacting proteins, EsLBP1 and EsPGRP1. Lower left, dark mutants are defective in inducing normal activities of host cells, including the blood sinus. Lower right, dark mutants are also defective in normal development, i.e., in the symbiosis-induced loss of the ciliated field.

# Views on Holobiont Evolution

- Holobiont as unit of selection
- Vanilla coevolution
  - Ignores the host, group level, genome
  - Ignores goal directed mechanisms (evo-devo)
  - Bacteria quickly evolve, exchange functional capabilities
  - Hierarchy of times scales, and hence fitness
- Songs, not singers
  - Hierarchy of times scales, and hence fitness

Holobiont host singers coevolving with bacterial songs

# Predictions

- Vanilla coevolution suggests that after long periods of time we should expect the partners to become coadapted, typically through the evolution of specific mechanisms (in the sense defined above).
- The "holobiont singers coevolving with bacterial songs" model predicts holobiont mechanisms that are based on preadaptations for coexistence and on goal directed mechanisms, as found in the squid.

Holobiont host singers...

with general purpose, developmentally flexible,  
selective stabilization mechanisms...

coevolving with bacterial songs



# Thanks!



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Philosophy, Tel Aviv University

