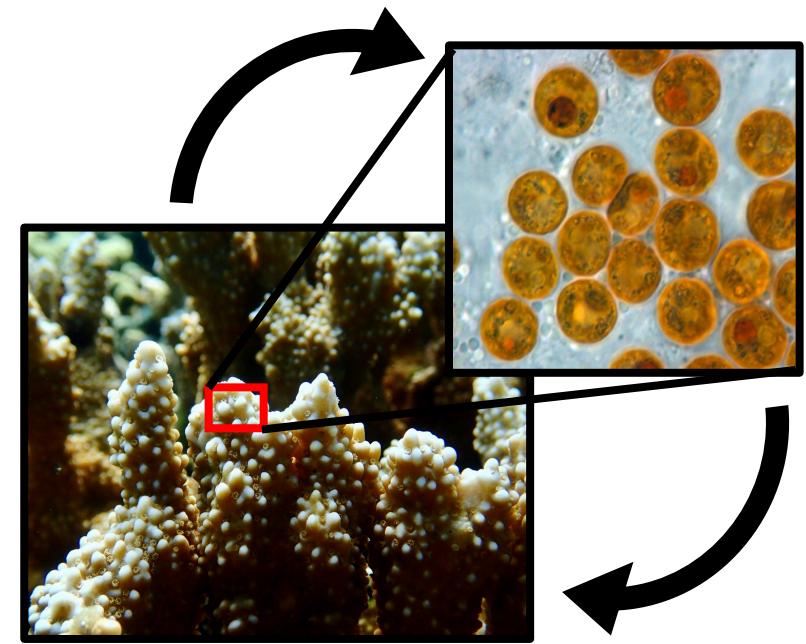
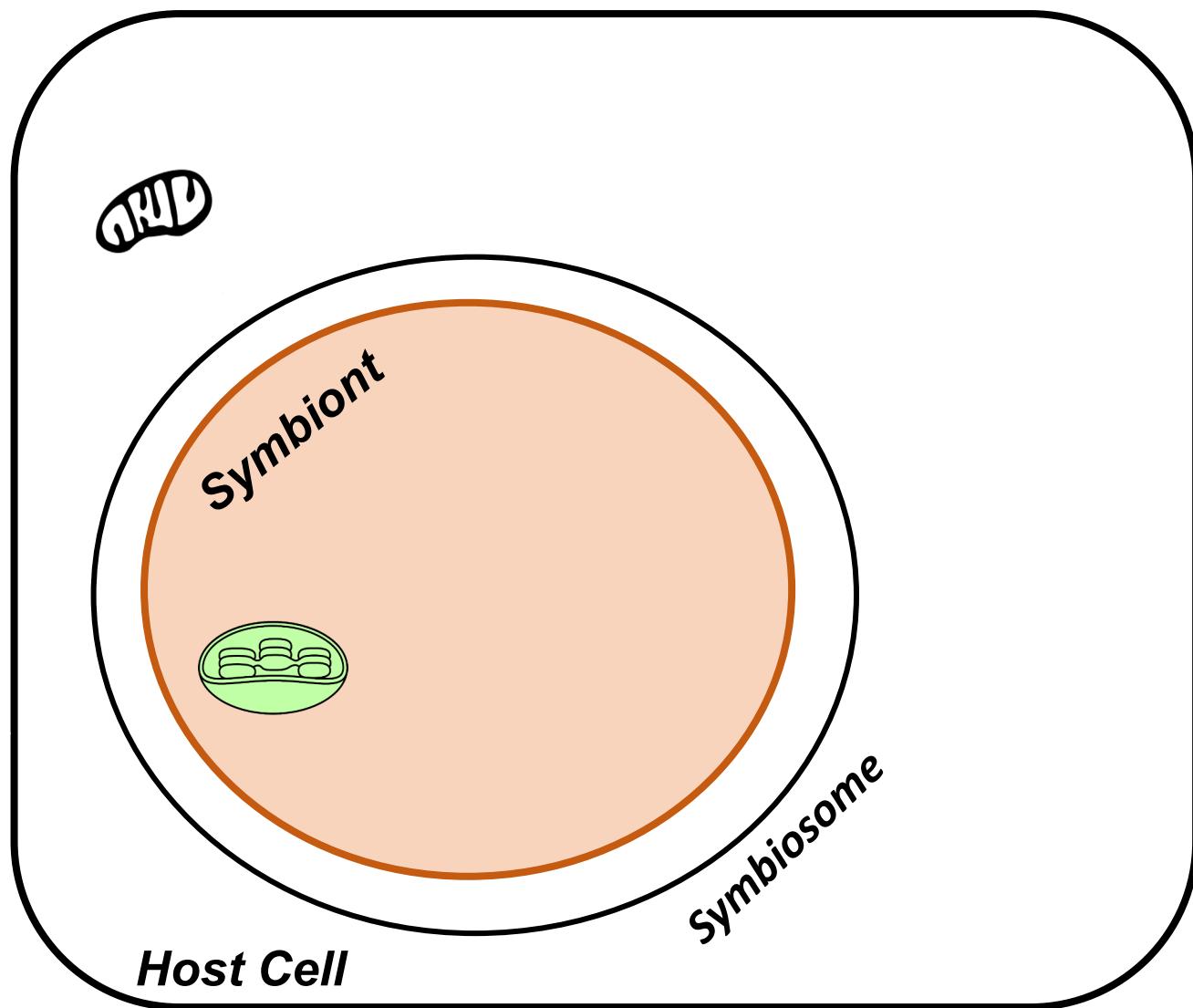
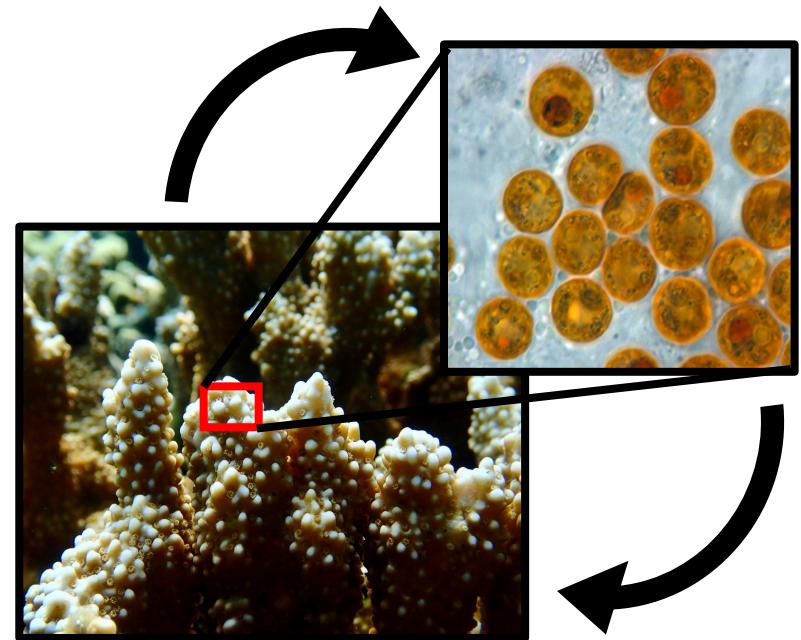
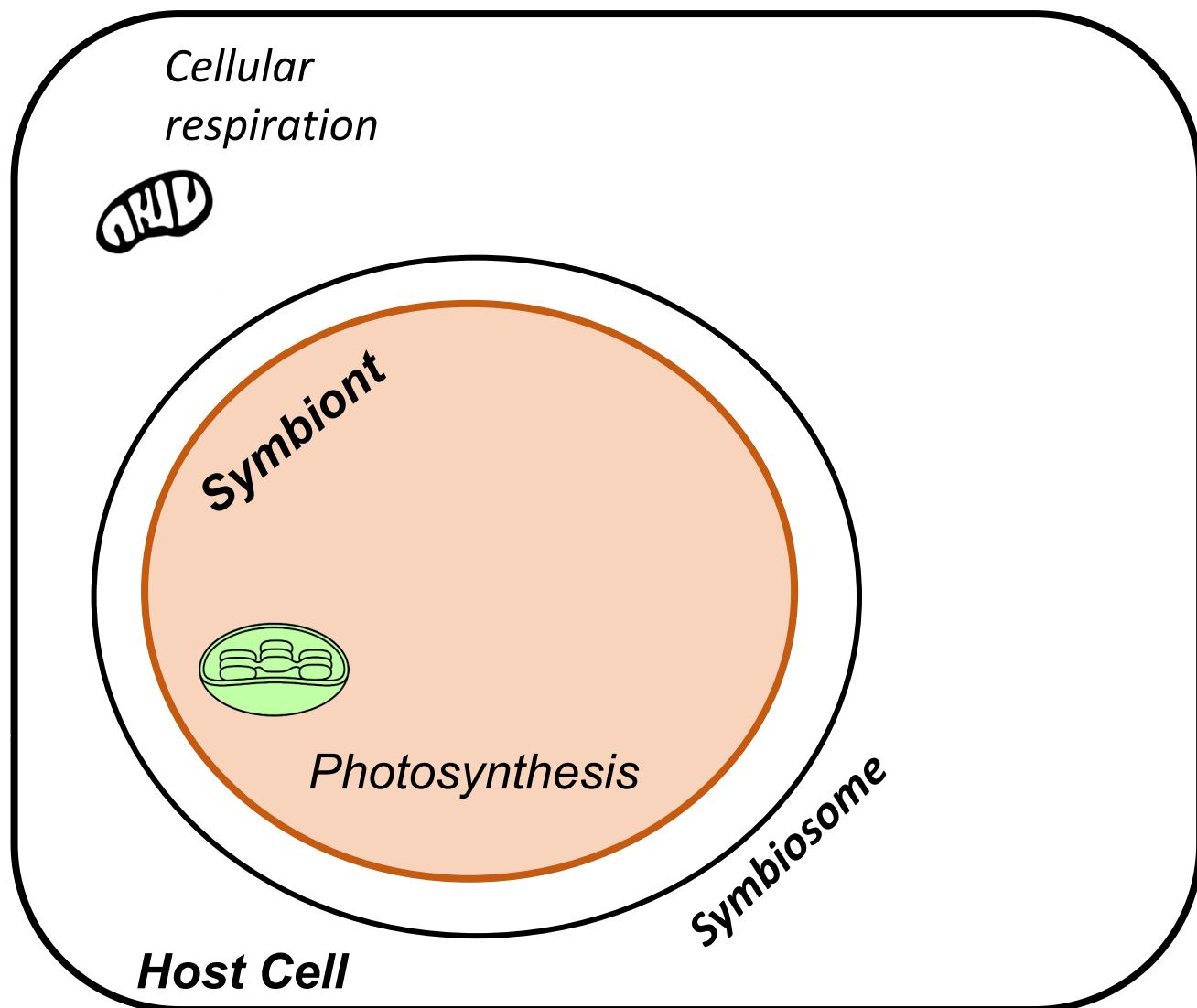


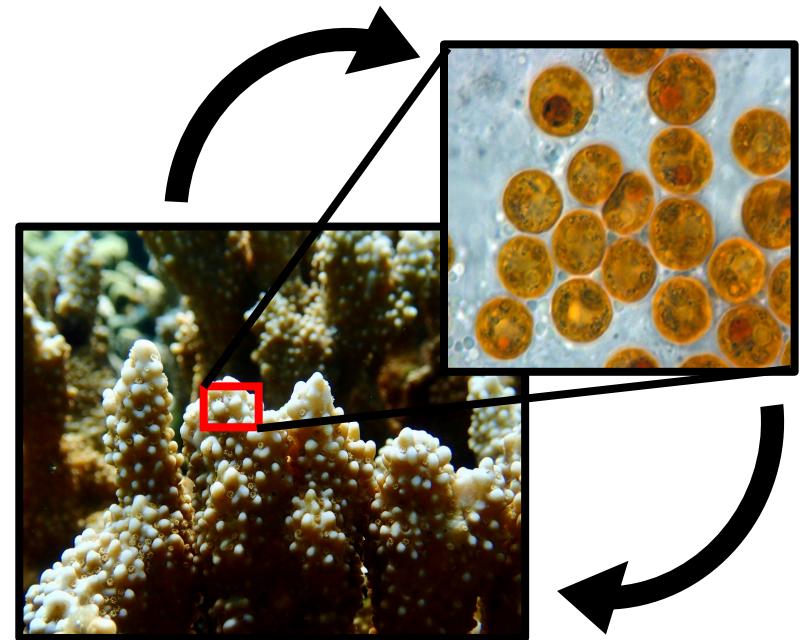
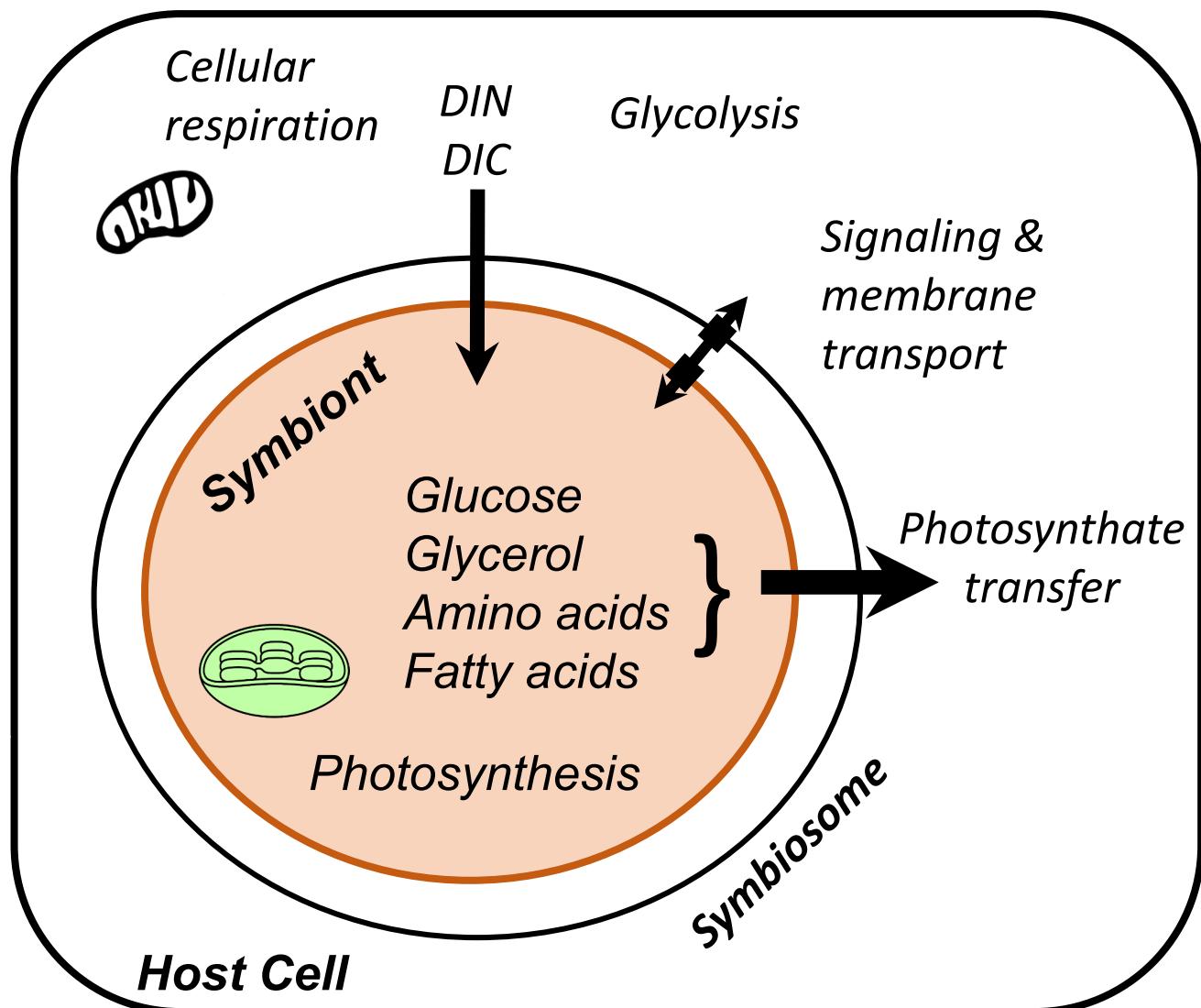
Coral-Symbiodiniaceae Nutritional Exchange



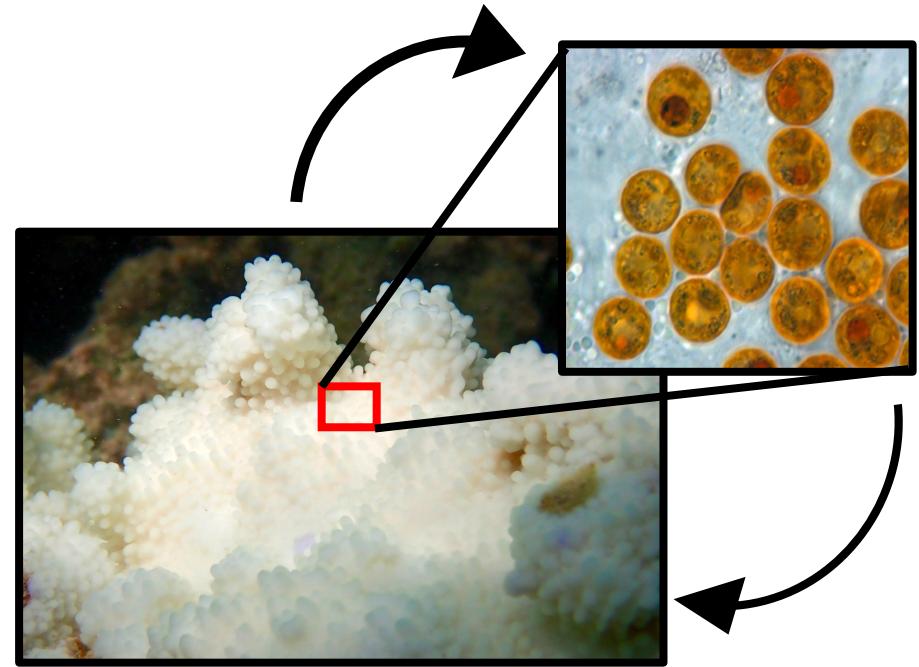
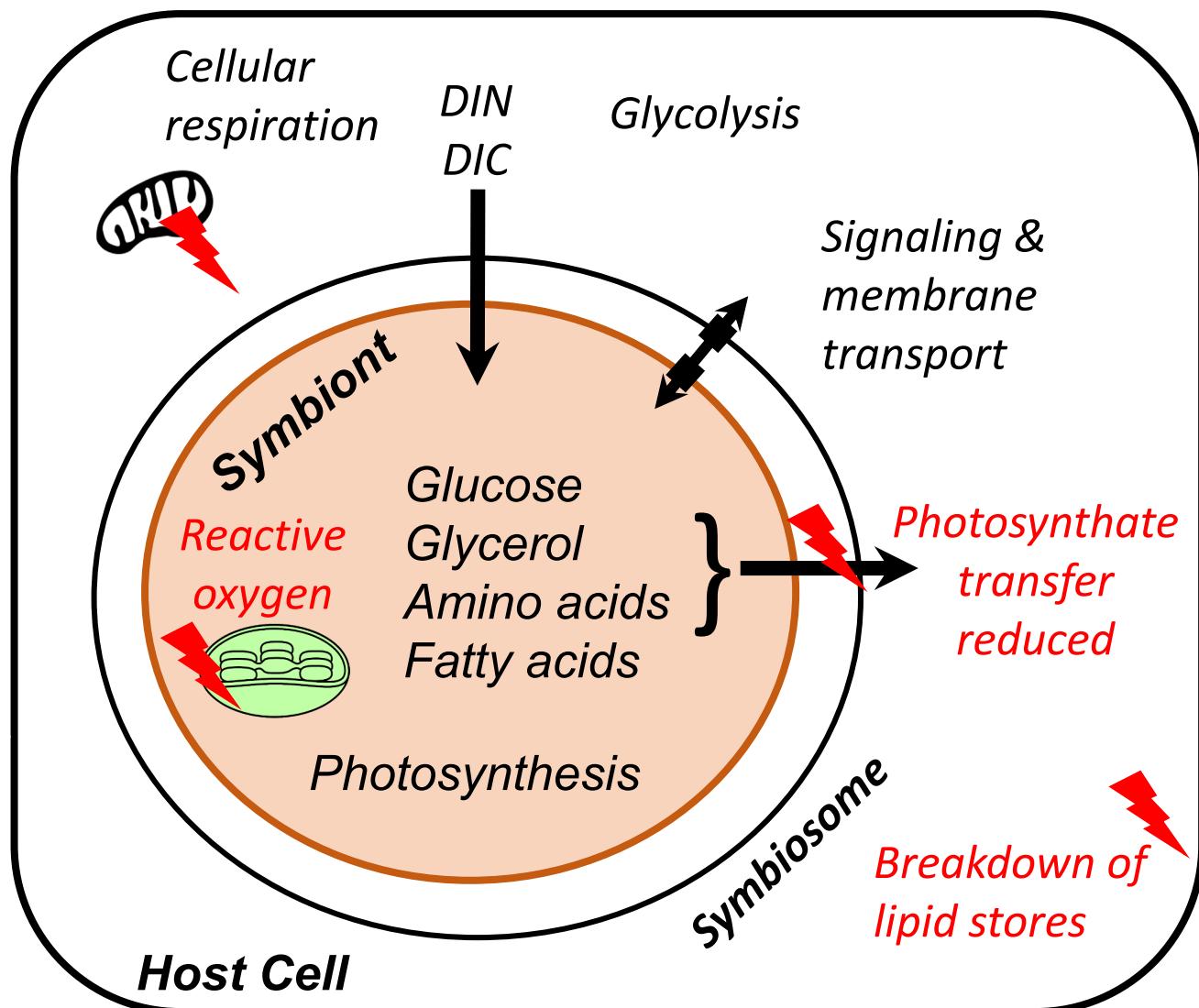
Coral-Symbiodiniaceae Nutritional Exchange



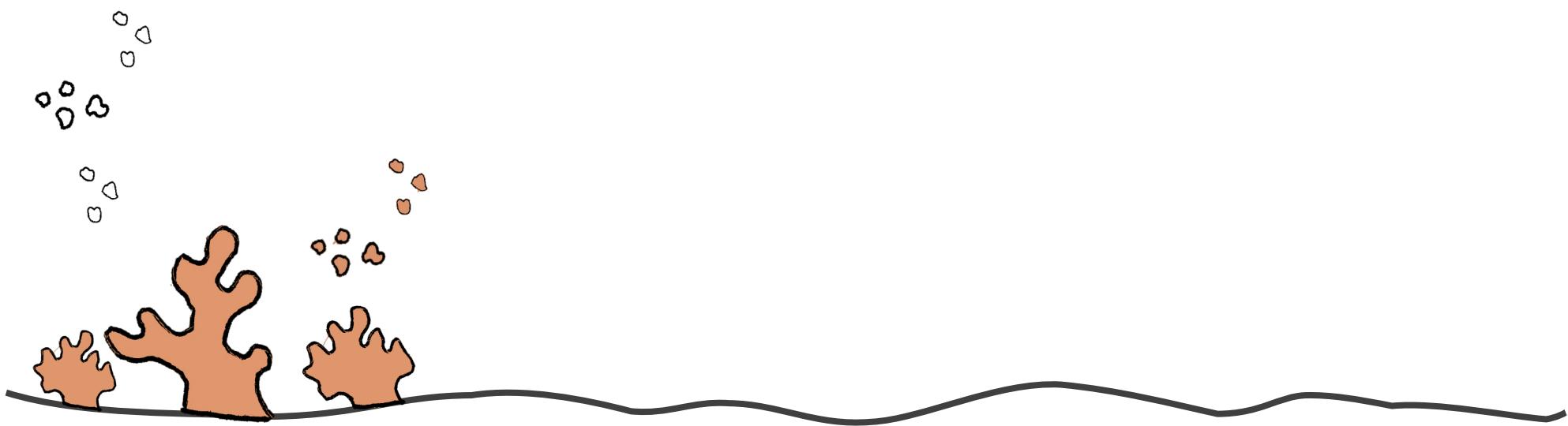
Coral-Symbiodiniaceae Nutritional Exchange

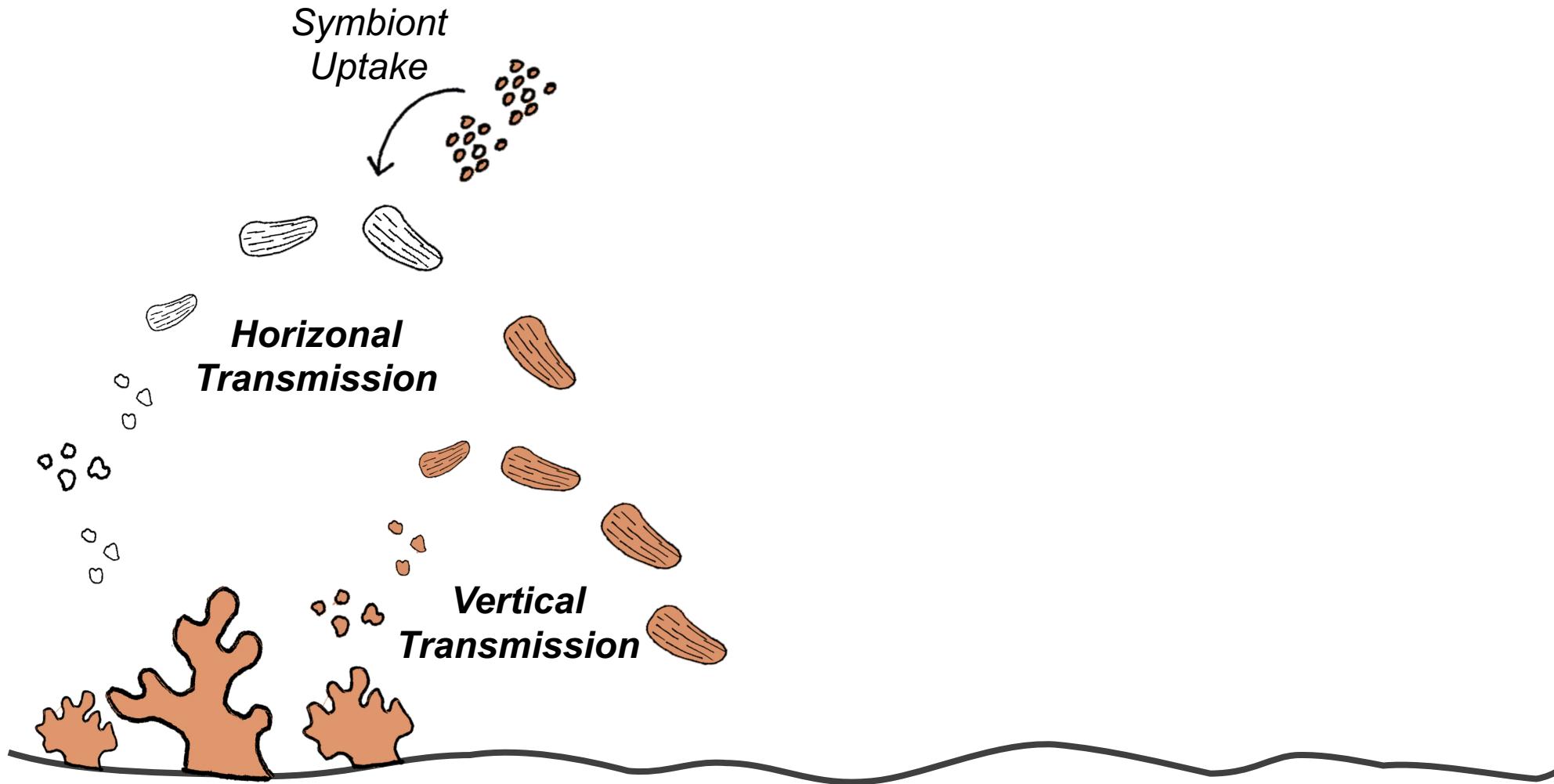


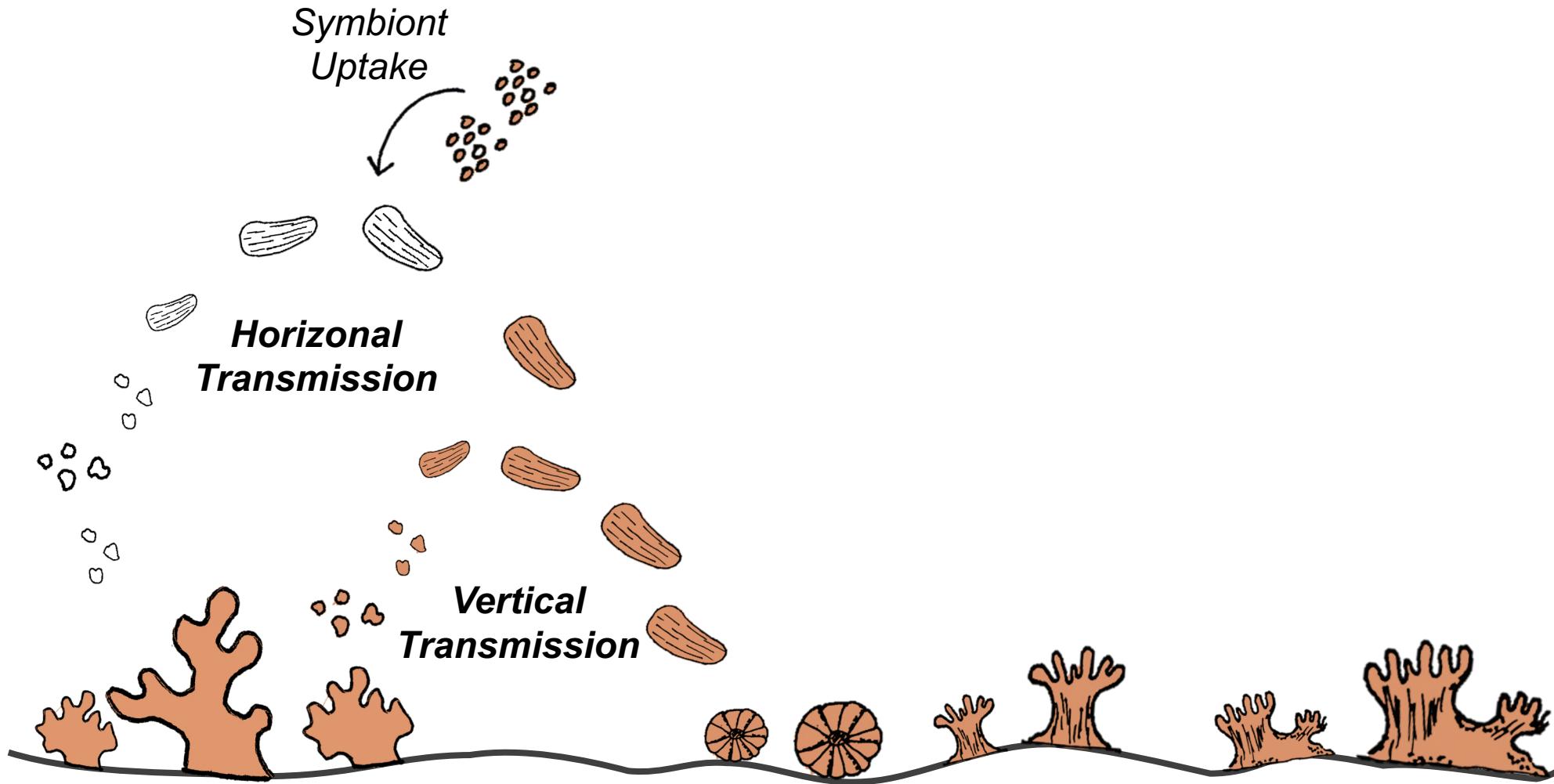
Coral-Symbiodiniaceae Nutritional Exchange



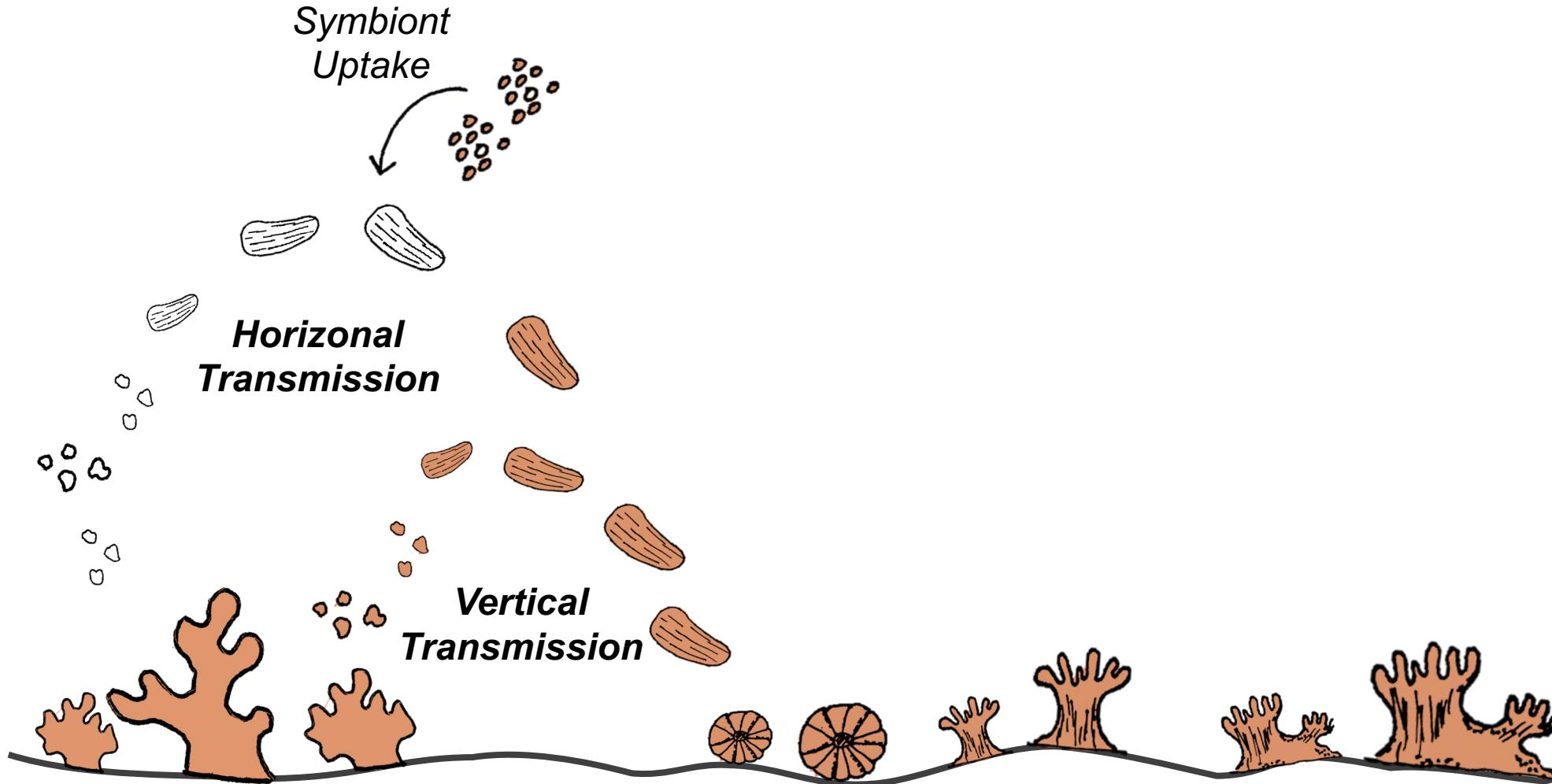
**Symbiotic breakdown
can lead to mass coral
mortality during
bleaching events**







How do early life history experiences influence thermal tolerance of coral recruits?

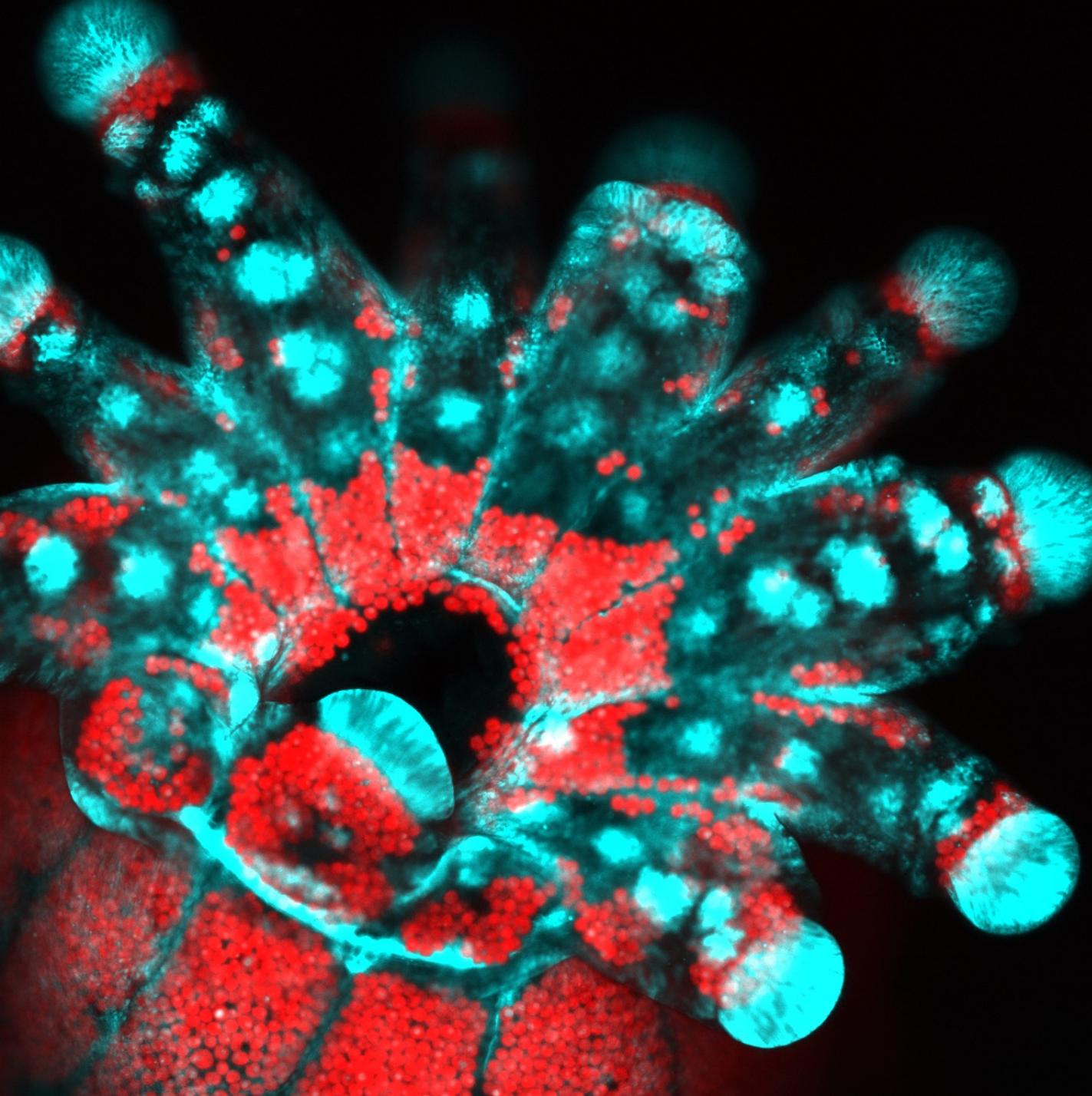


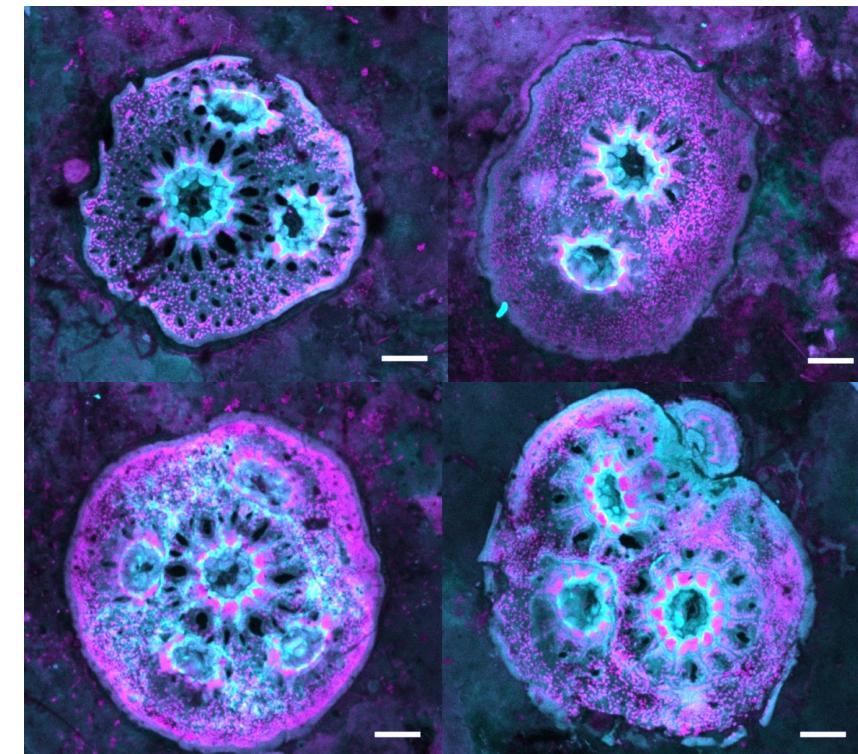
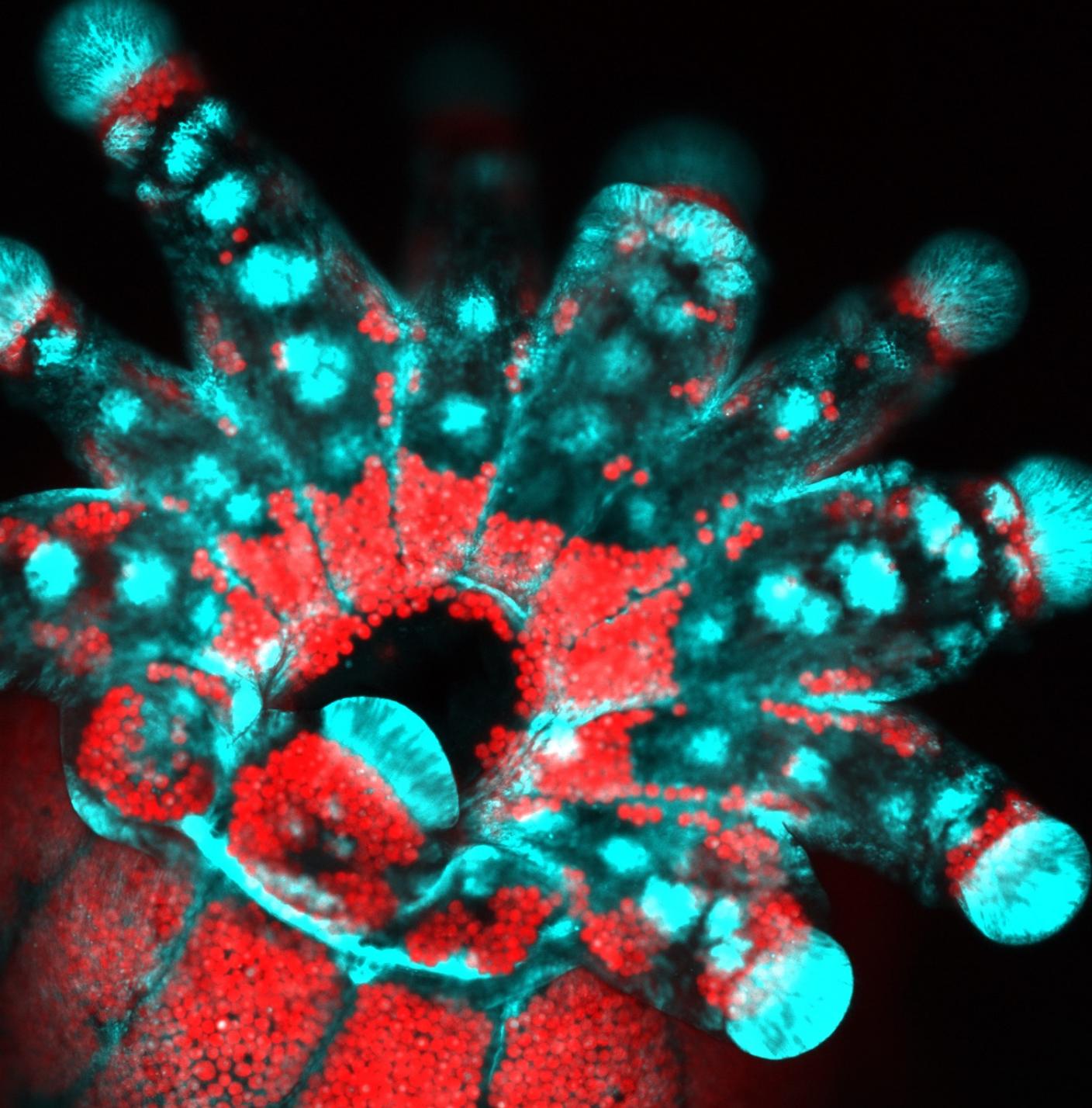


UNIVERSITY of HAWAII[®]

MĀNOA







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METHODS & TECHNIQUES

Evaluation of laser scanning confocal microscopy as a method for characterizing reef-building coral tissue thickness and Symbiodiniaceae fluorescence

A. S. Huffmyer^{1,*}, S. B. Matsuda¹, A. R. Eggers², J. D. Lemus¹ and R. D. Gates¹

Heterotrophy is necessary for juvenile *P. acuta* growth and stress tolerance.



ROYAL SOCIETY
OPEN SCIENCE

royalsocietypublishing.org/journal/rsos

Research



Feeding and thermal conditioning enhance coral temperature tolerance in juvenile *Pocillopora acuta*

Ariana S. Huffmyer^{1,2}, Colton J. Johnson^{1,3}, Ashleigh M. Epps^{1,4}, Judith D. Lemus^{1,†} and Ruth D. Gates^{1,†}

¹Hawai'i Institute of Marine Biology, University of Hawai'i at Manoa, Kane'ohe, HI 96744, USA

²Department of Biological Sciences, University of Rhode Island, Kingston, RI 02881, USA

³Department of Biology, San Diego State University, San Diego, CA 92182, USA

⁴Department of Life Sciences, Texas A&M University-Corpus Christi, Corpus Christi, TX 78412, USA

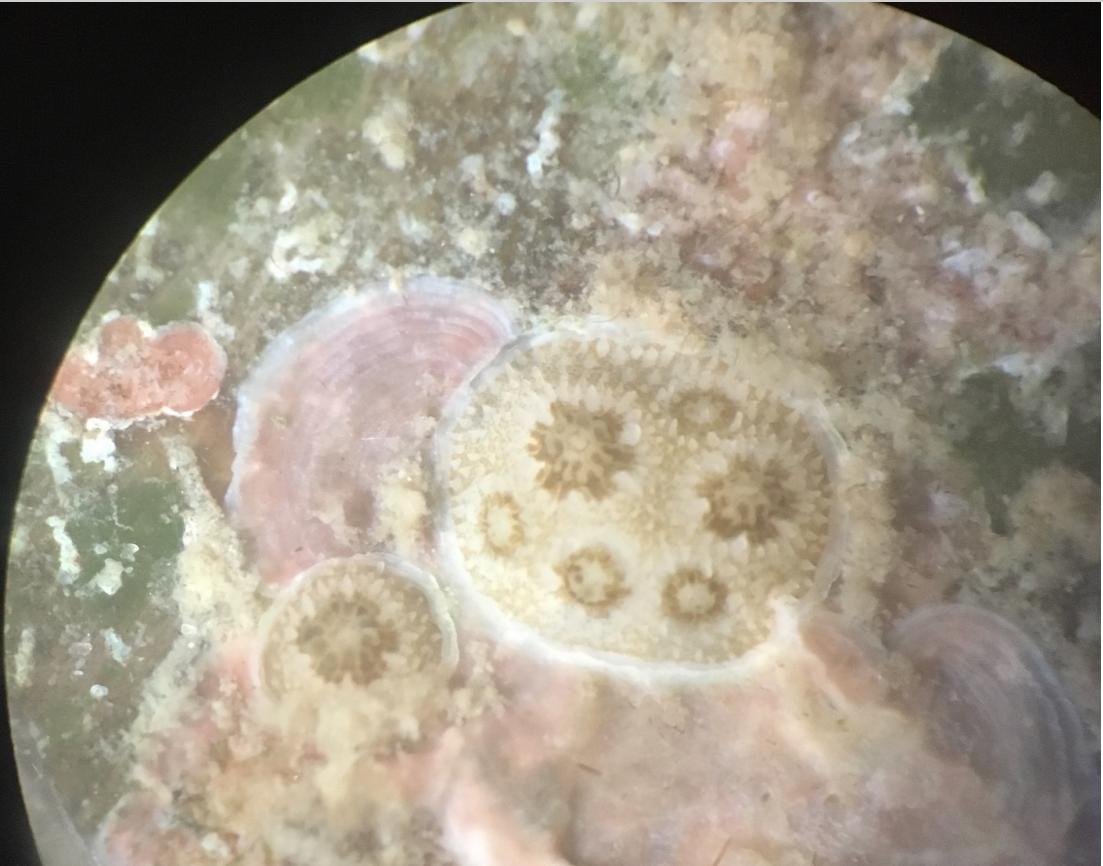
ASH, 0000-0002-9170-0971; CJJ, 0000-0001-8895-6813;

AME, 0000-0003-1873-0004; JDL, 0000-0001-6056-1262

Fusion enhances *P. acuta* recruit thermal tolerance, especially in diverse groups.



Fusion enhances *P. acuta* recruit thermal tolerance, especially in diverse groups.



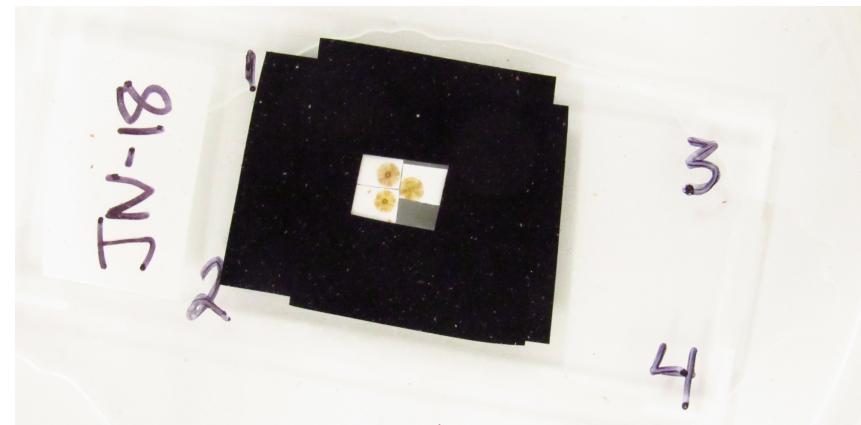
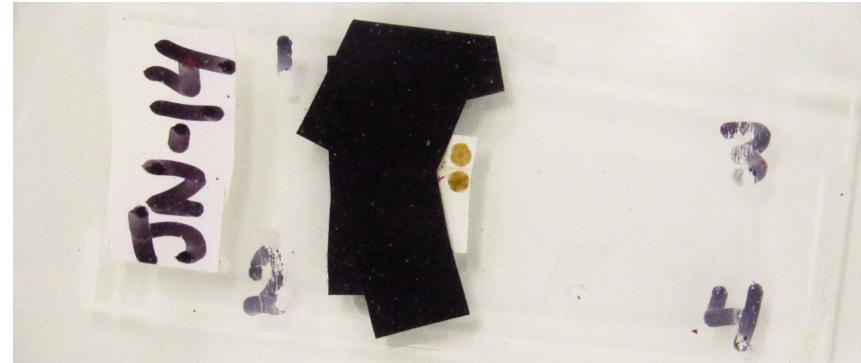
Coral Reefs
<https://doi.org/10.1007/s00338-021-02074-1>



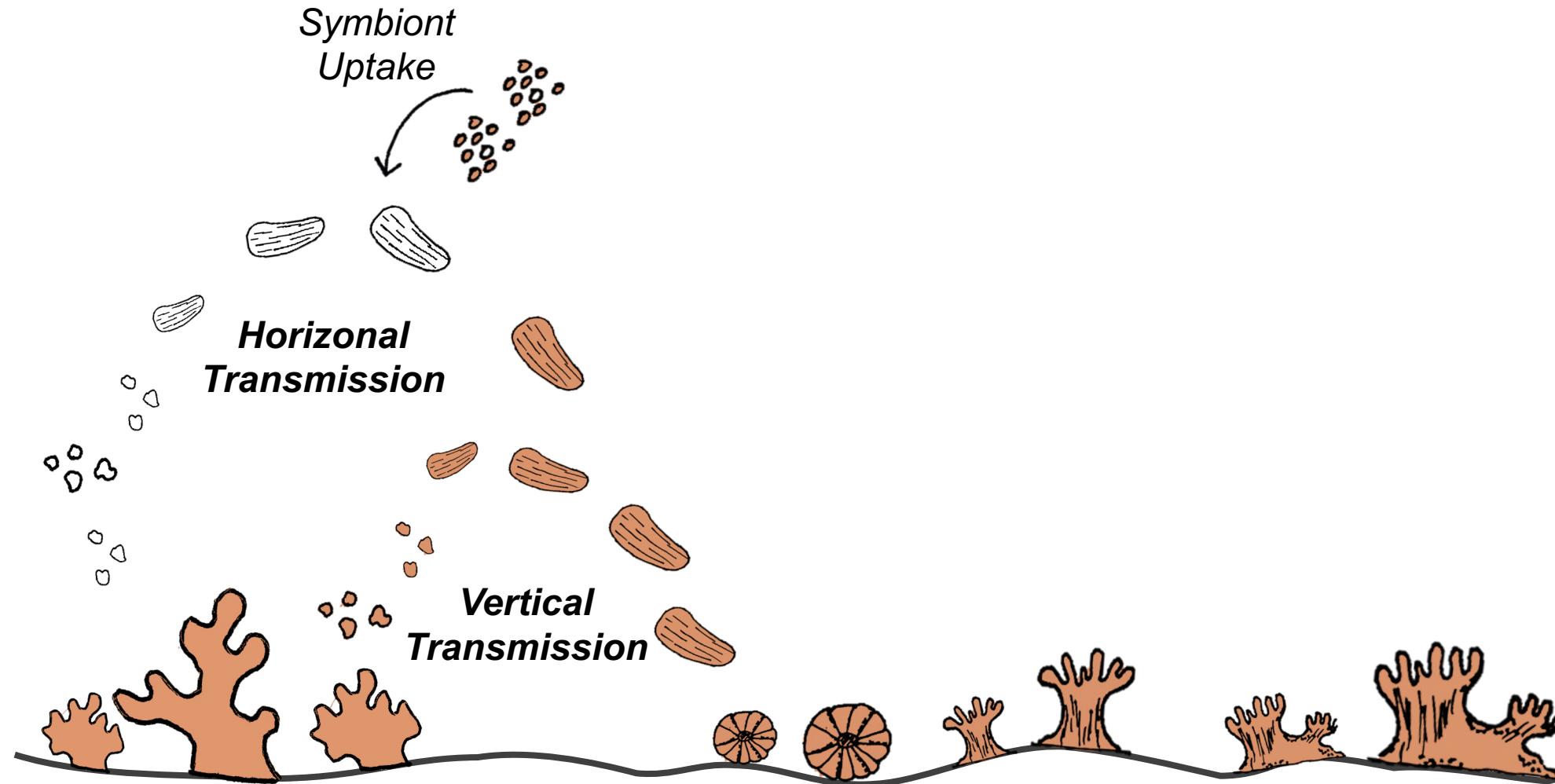
REPORT

Tissue fusion and enhanced genotypic diversity support the survival of *Pocillopora acuta* coral recruits under thermal stress

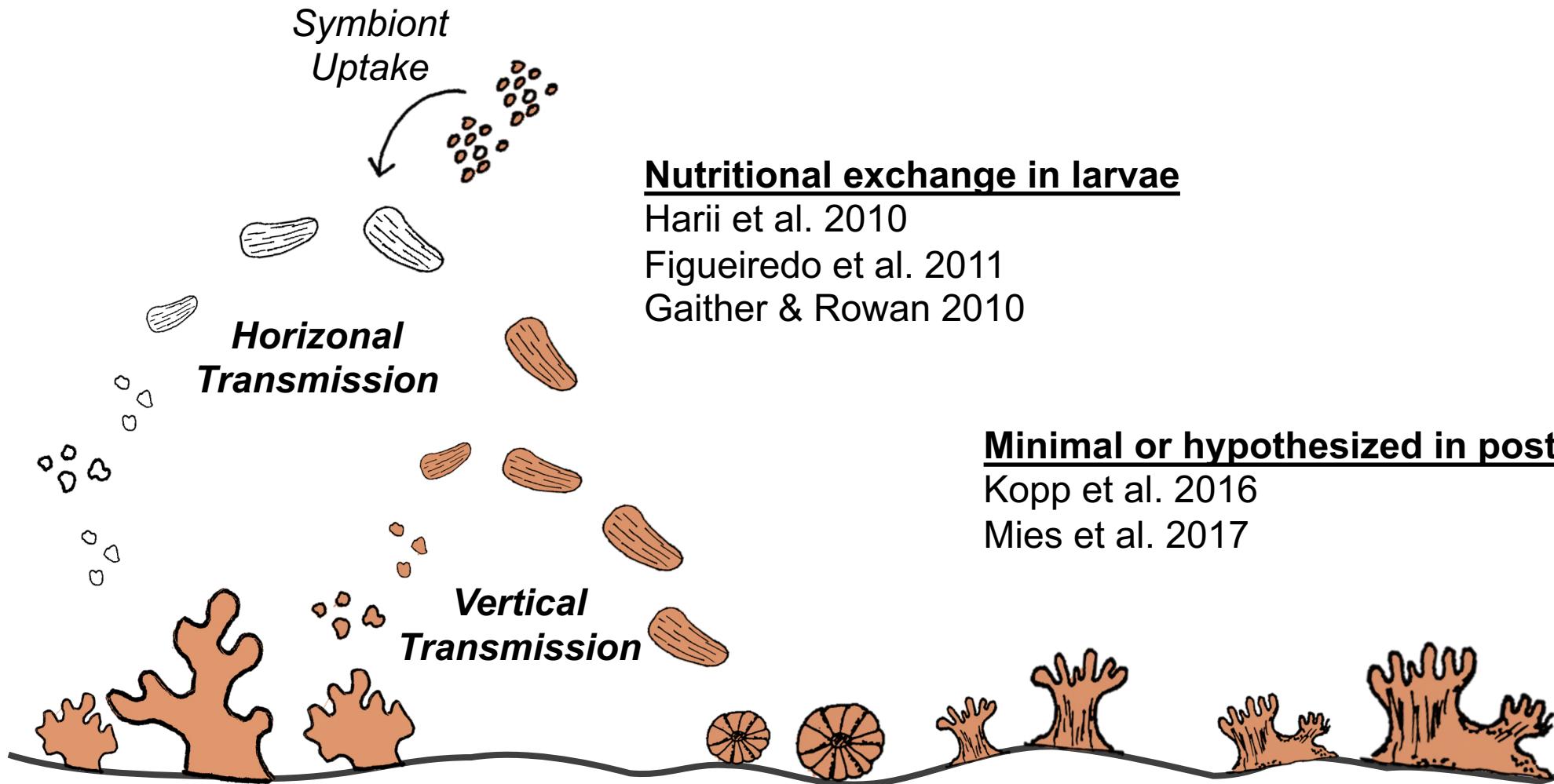
Ariana S. Huffmyer^{1,2} · Crawford Drury¹ · Eva Majerová¹ · Judith D. Lemus¹ · Ruth D. Gates¹

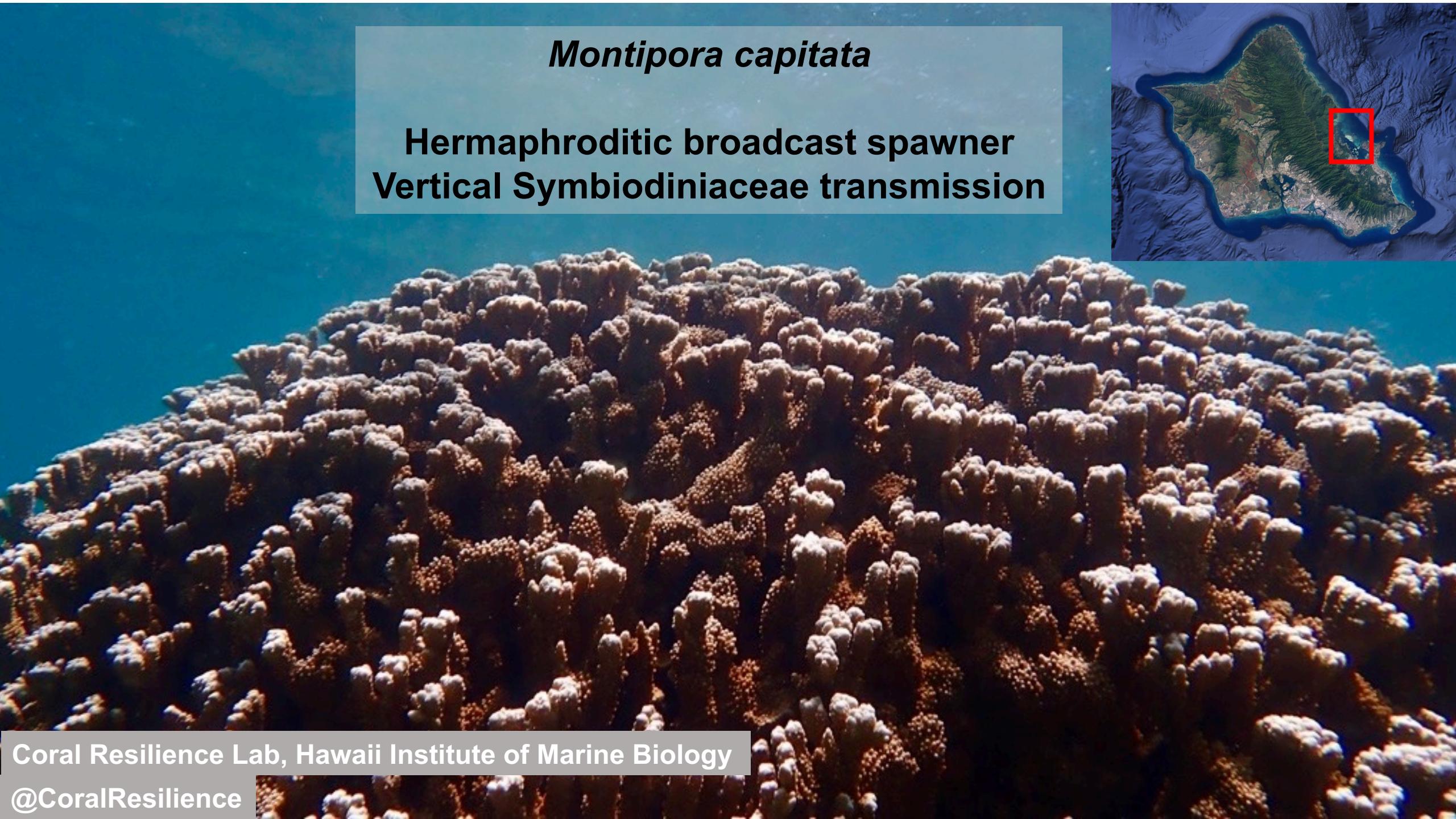


When does symbiotic nutritional exchange begin during development and how does it impact energetic capacity during recruitment?



When does symbiotic nutritional exchange begin during development and how does it impact energetic capacity during recruitment?





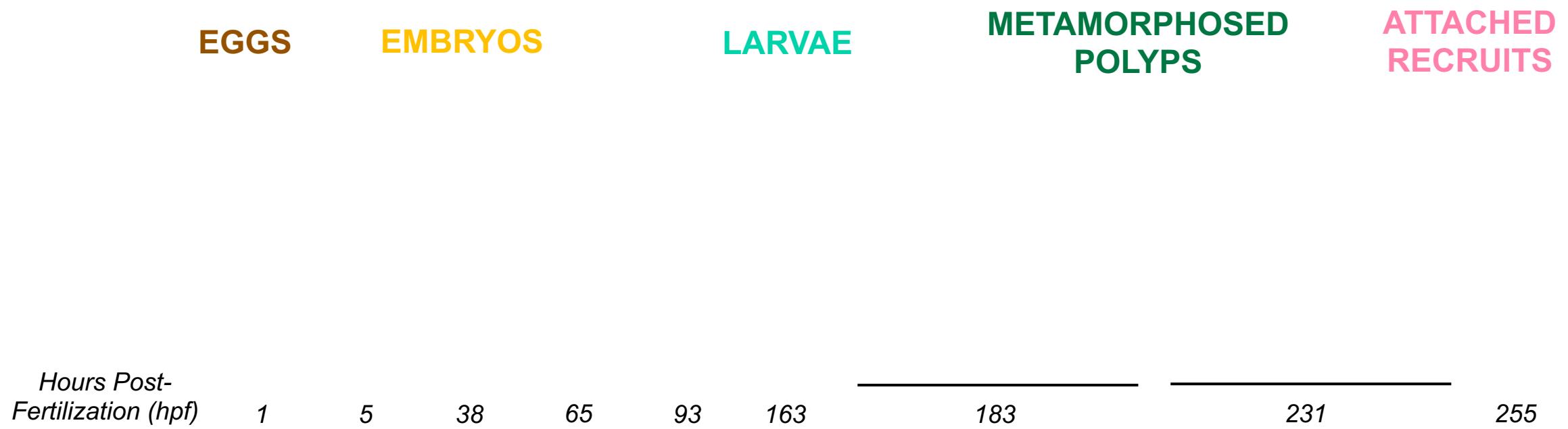
Montipora capitata

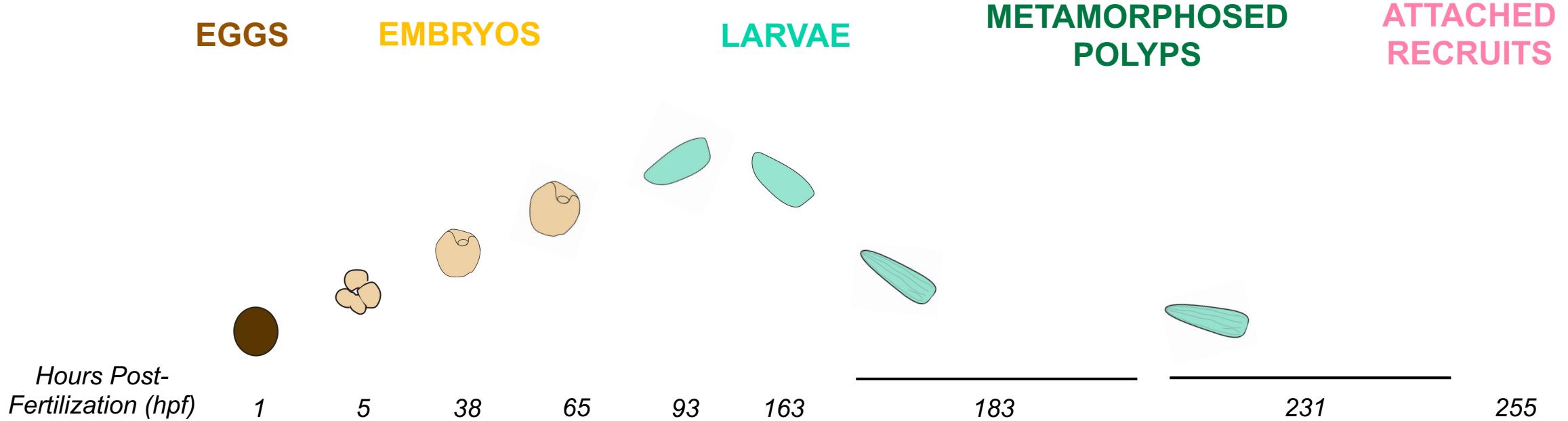
Hermaphroditic broadcast spawner
Vertical Symbiodiniaceae transmission



Coral Resilience Lab, Hawaii Institute of Marine Biology

@CoralResilience





EGGS

EMBRYOS

LARVAE

METAMORPHOSED POLYPS

ATTACHED RECRUITS

Hours Post-Fertilization (hpf)

1

5

38

65

93

163

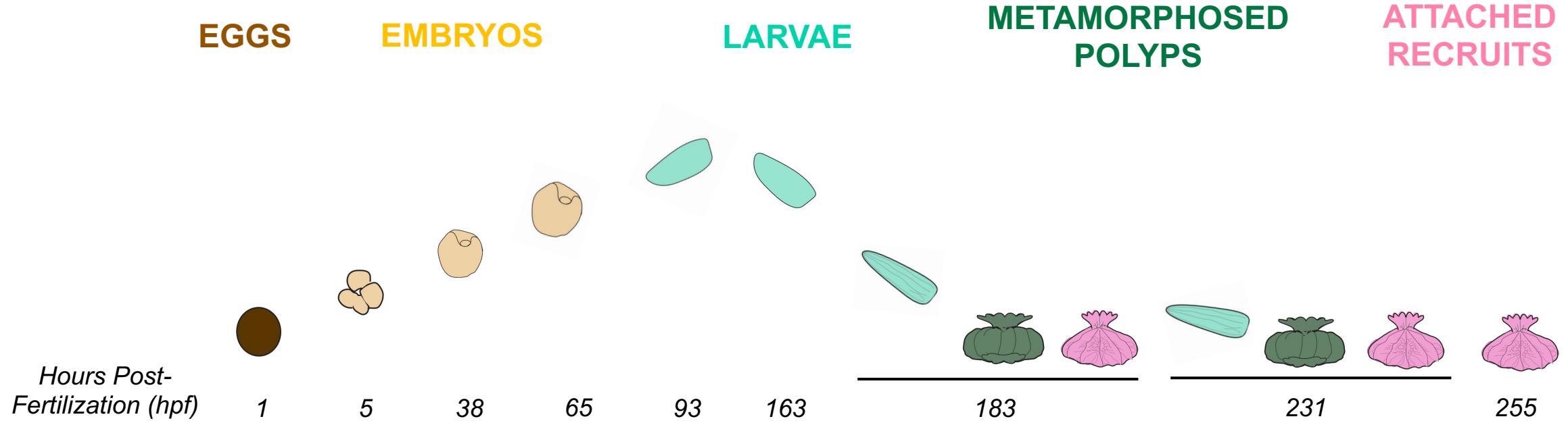
183

231

255



@CoralResilience



Respiration & Photosynthesis



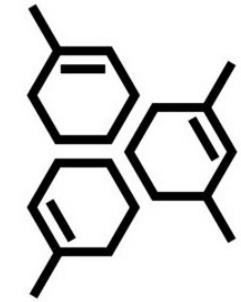
Symbiont Population

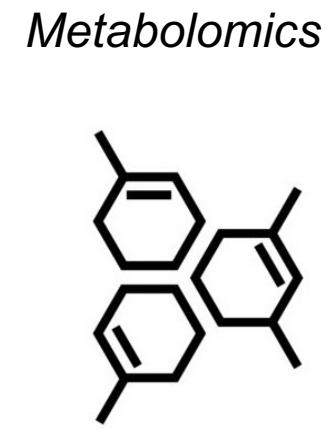
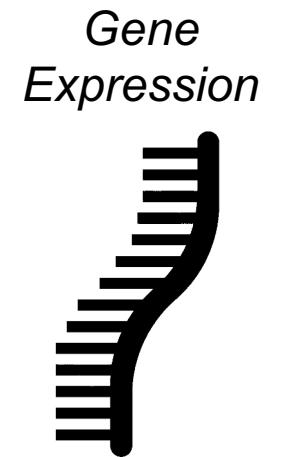
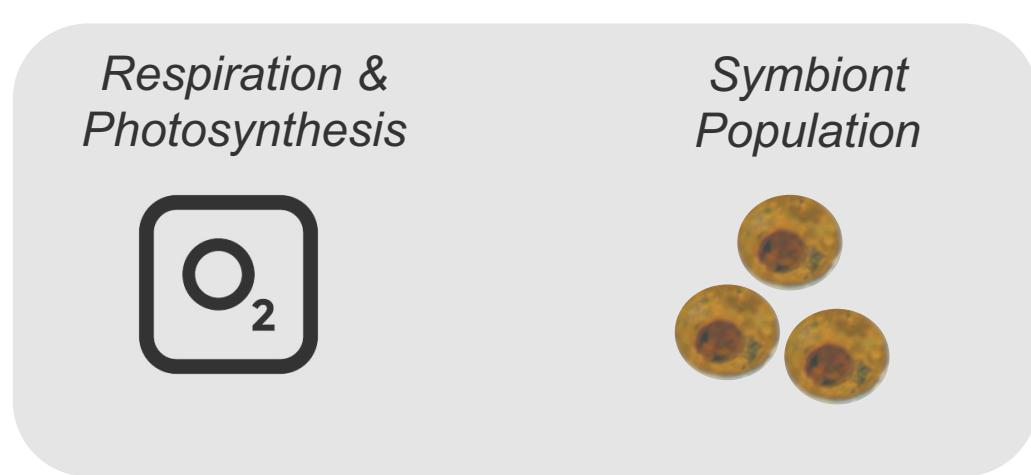
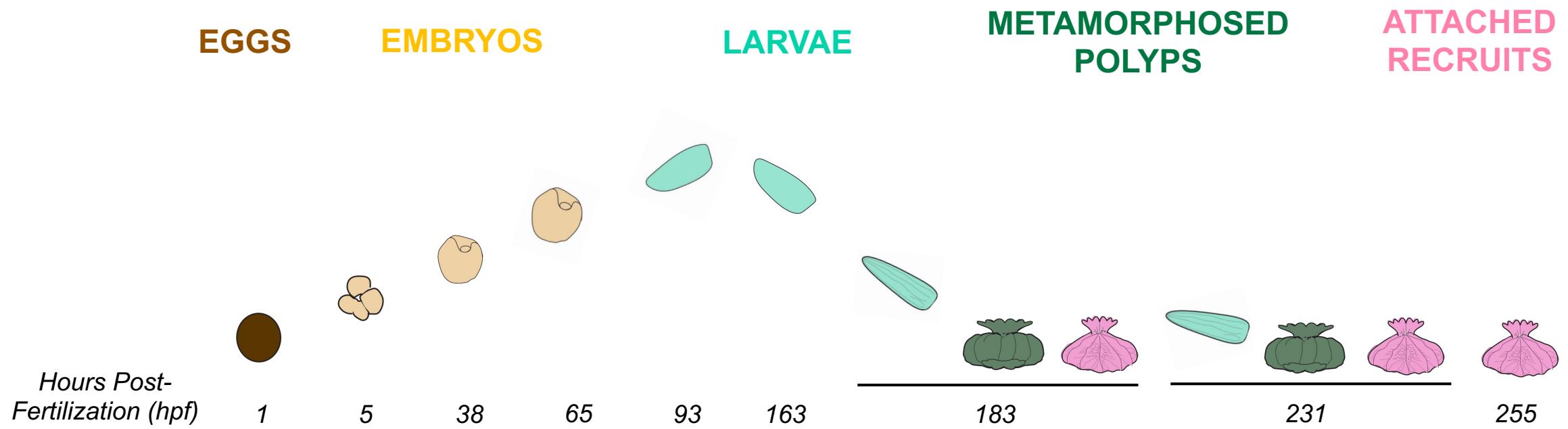


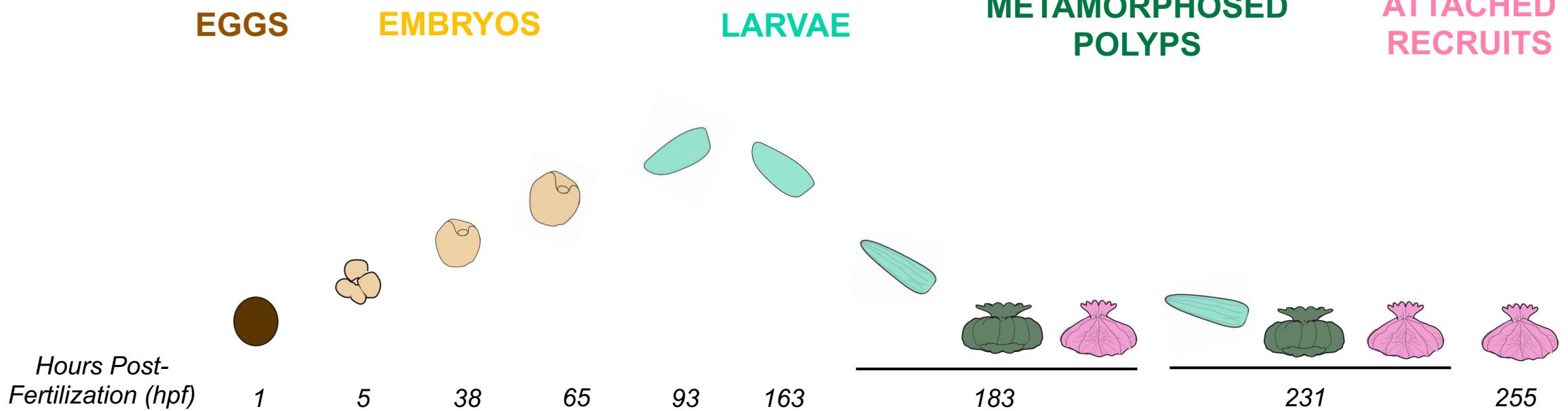
Gene Expression



Metabolomics



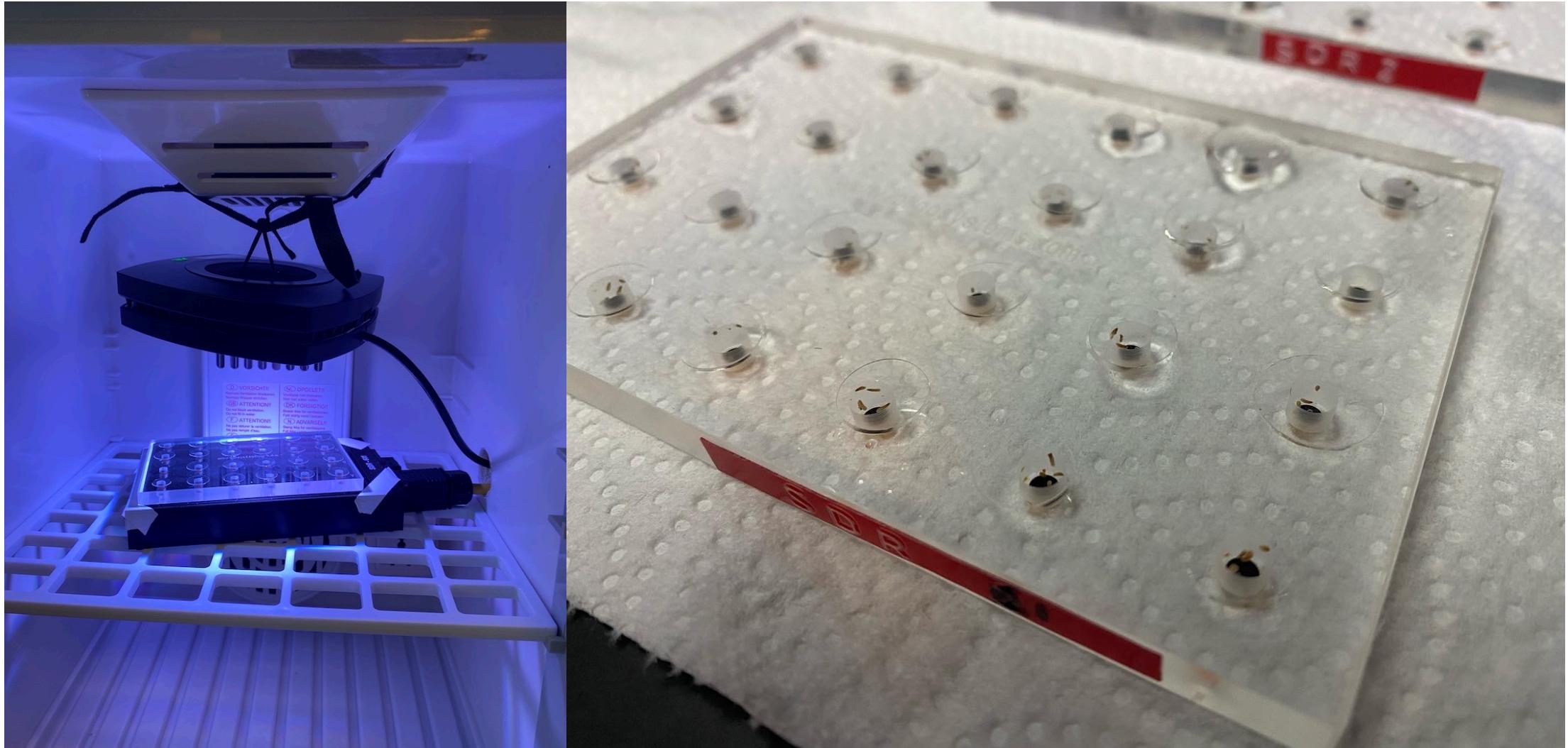




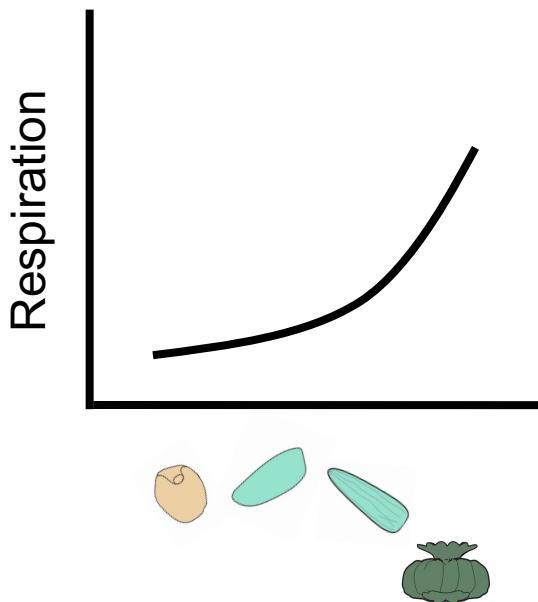
PUTNAM LAB



Energetic vulnerability & symbiont proliferation across development

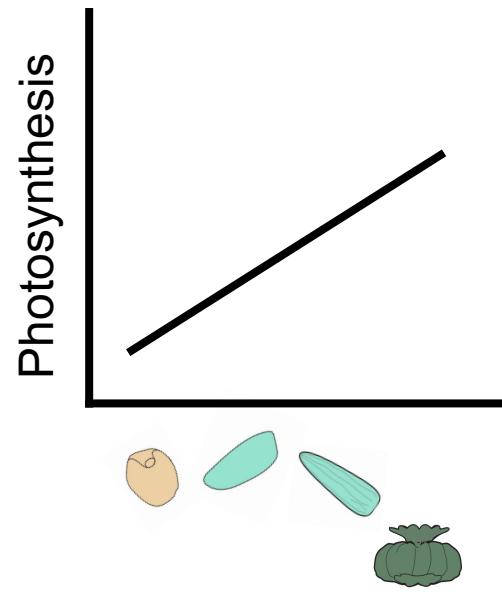
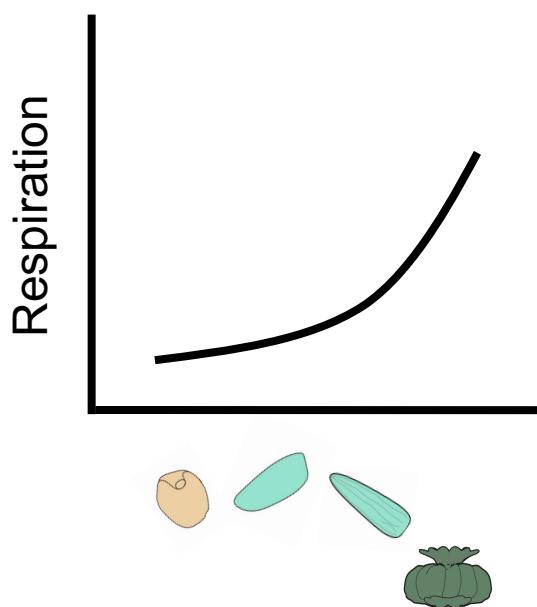


Energetic vulnerability & symbiont proliferation across development

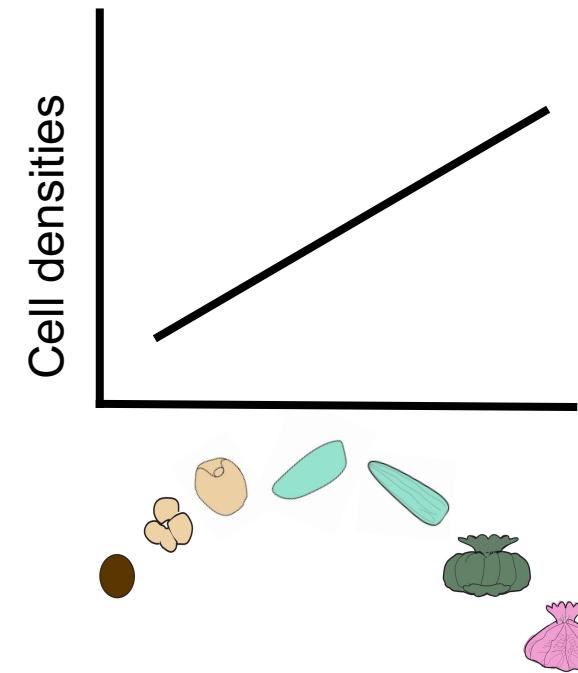
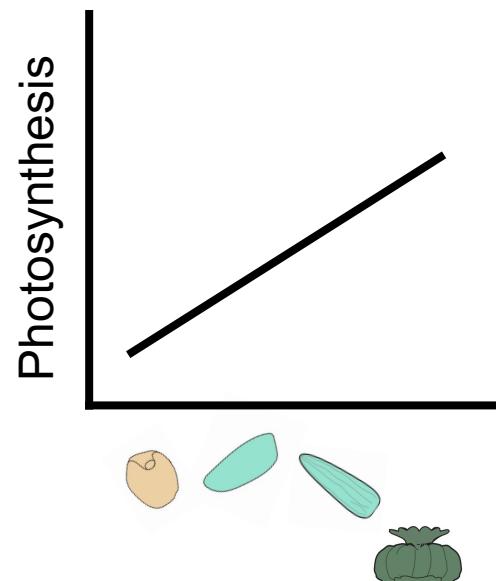
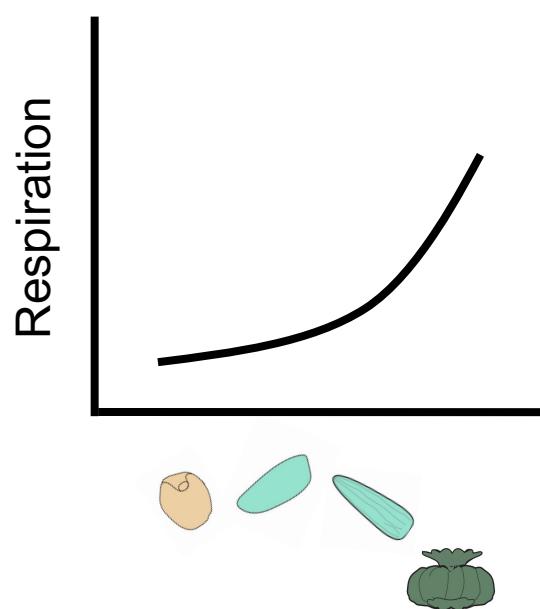


GLMM $p<0.001$
Individual normalized

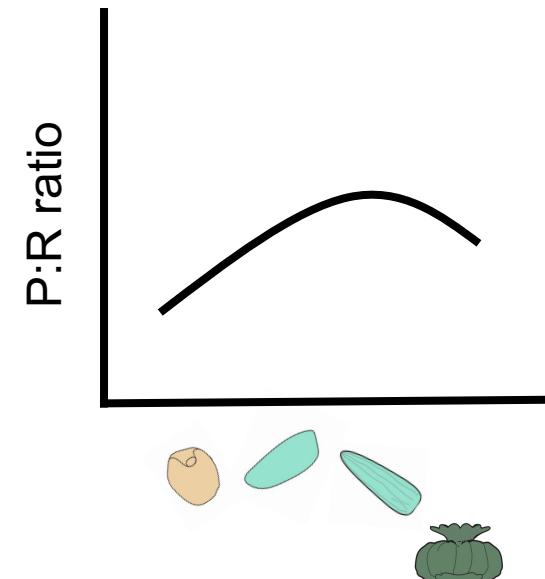
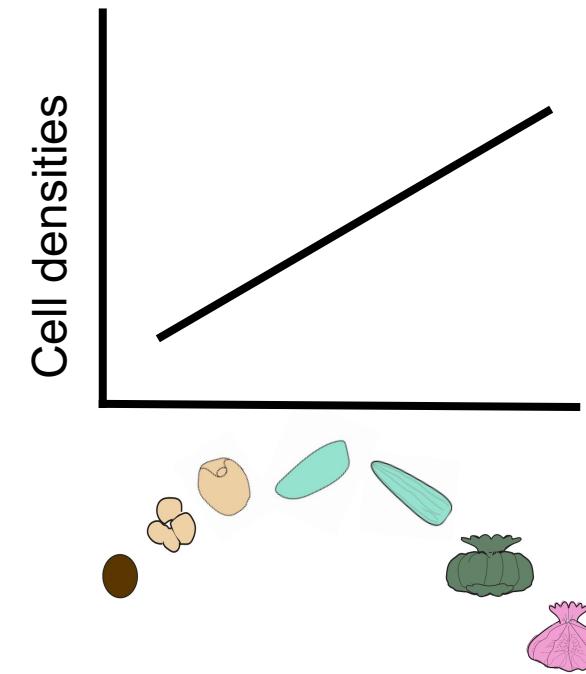
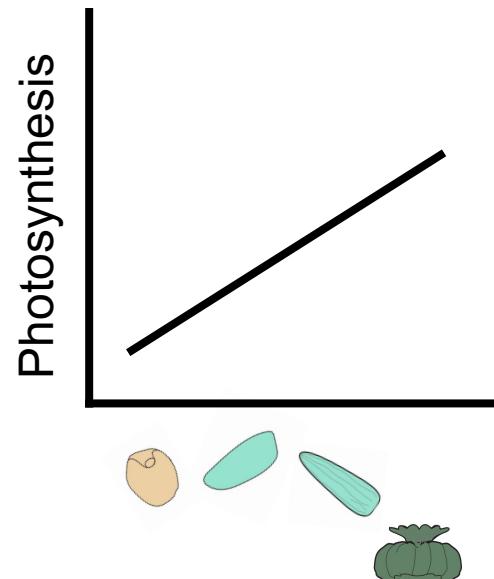
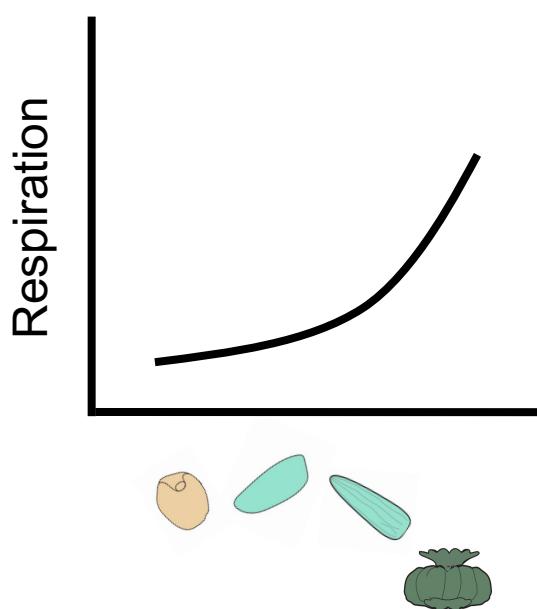
Energetic vulnerability & symbiont proliferation across development



Energetic vulnerability & symbiont proliferation across development

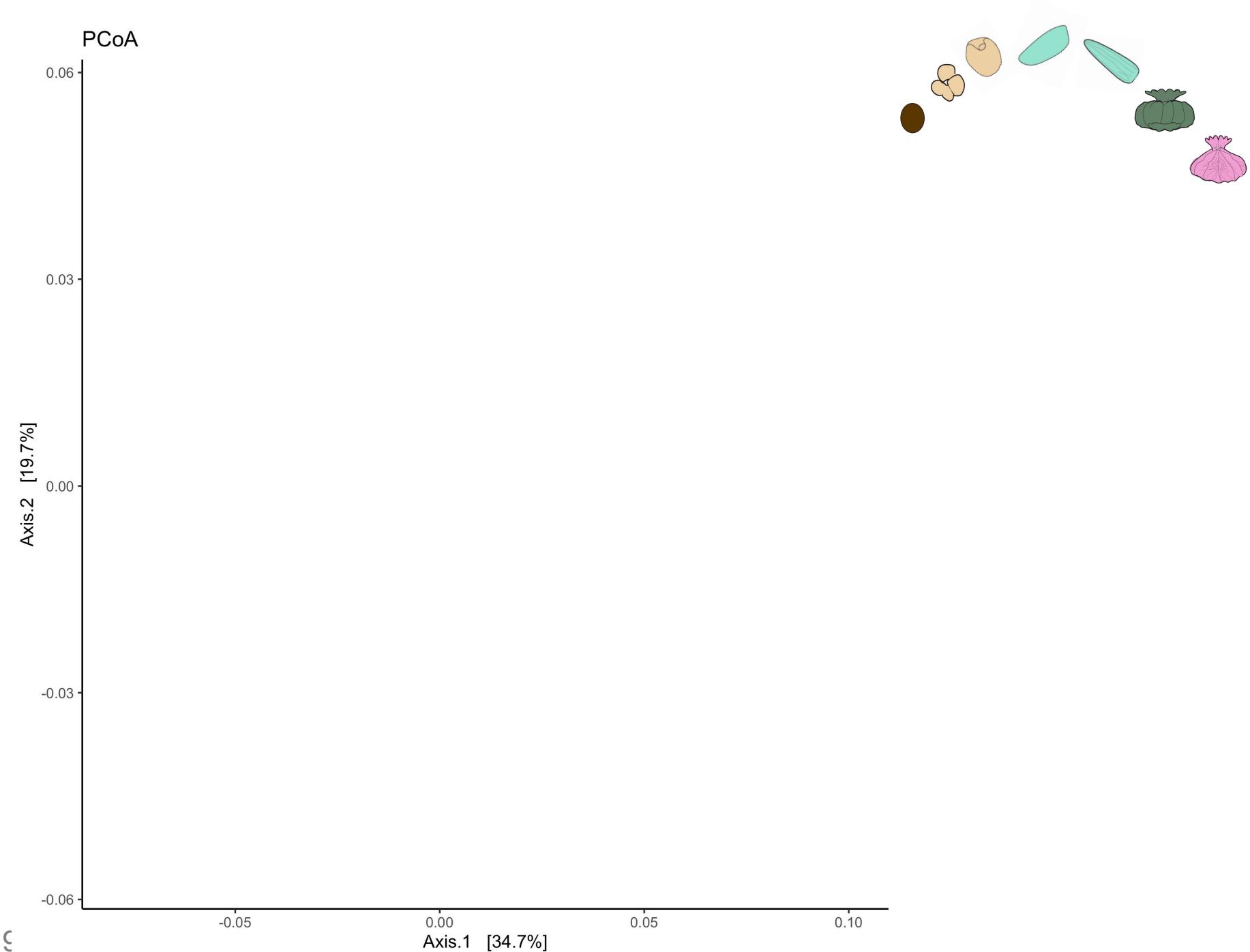


Energetic vulnerability & symbiont proliferation across development



Shifts in symbiotic community across ontogeny

ITS2 Amplicon Sequencing
SymPortal profiling (Hume et al. 2019)



Shifts in symbiotic community across ontogeny

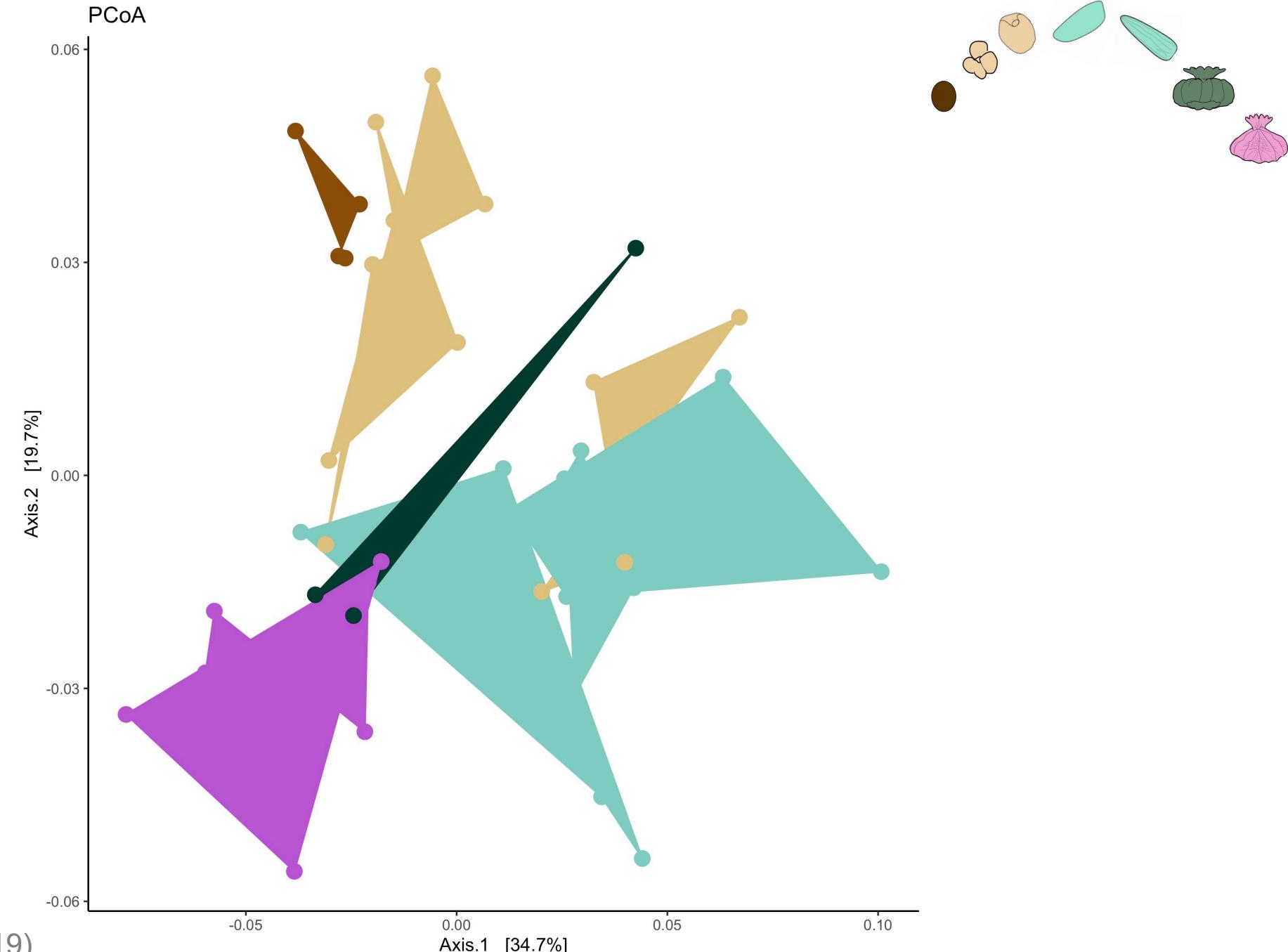
Cladocopium



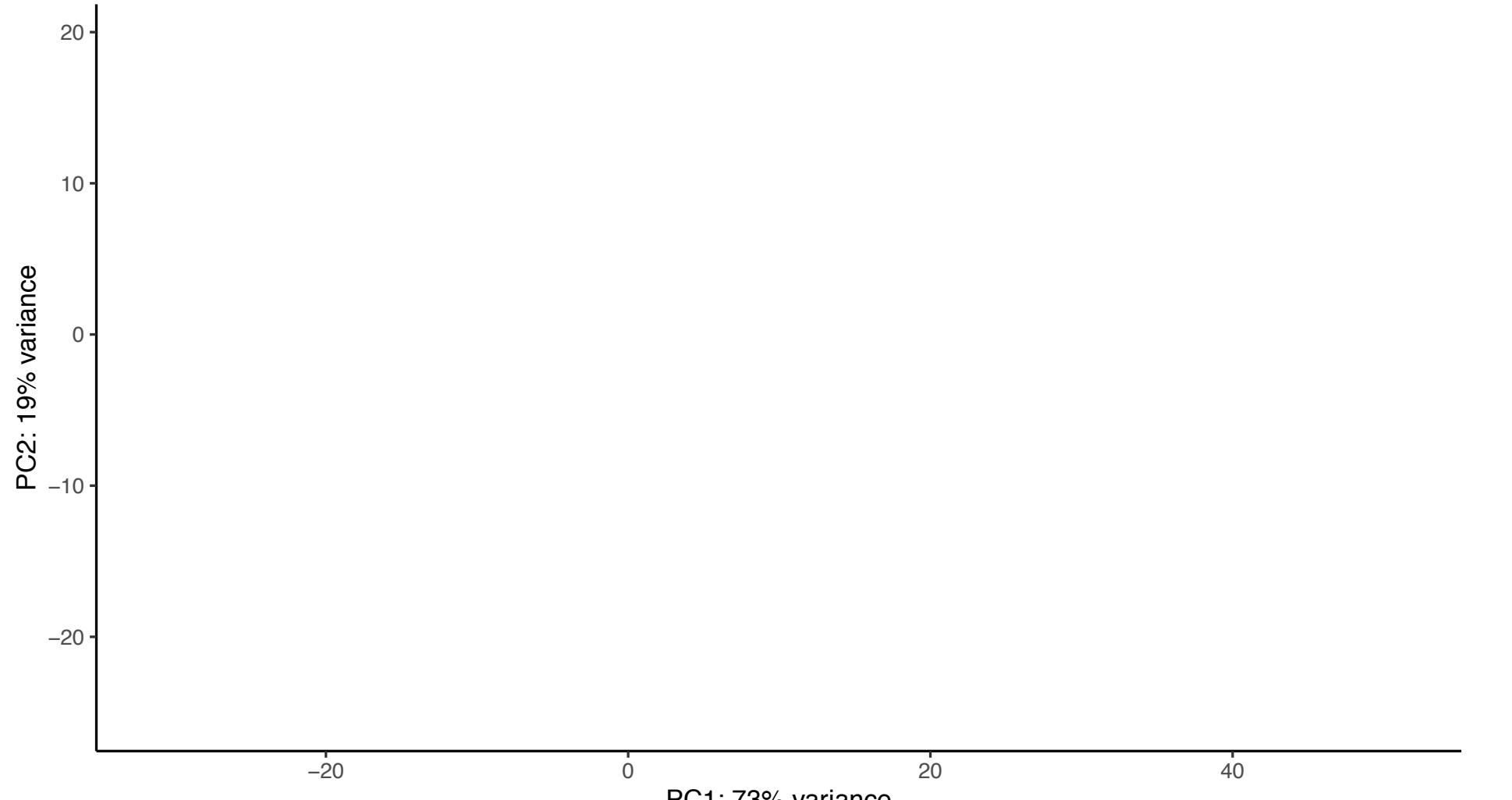
Durusdinium



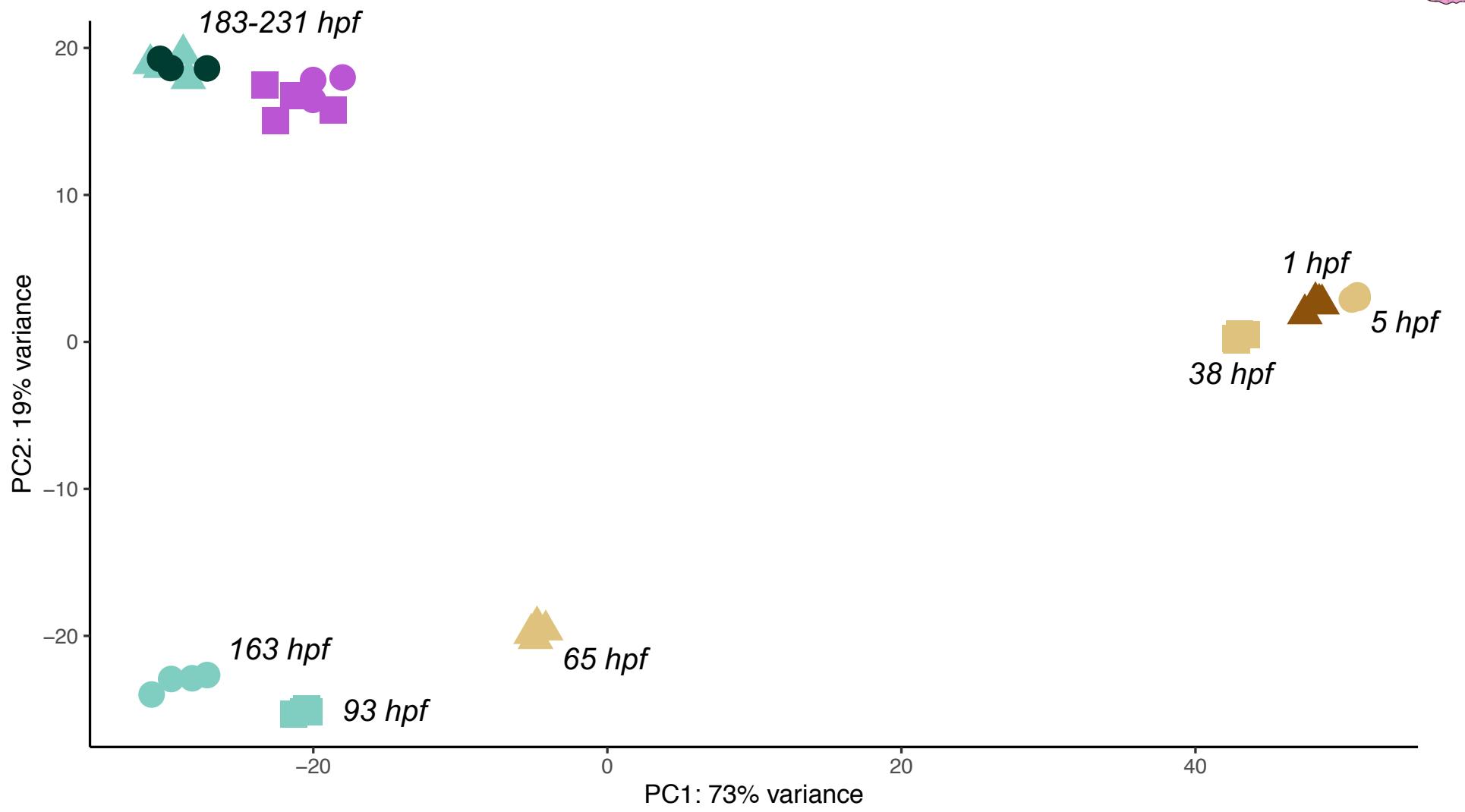
ITS2 Amplicon Sequencing
SymPortal profiling (Hume et al. 2019)



Distinct gene expression profiles across ontogeny



Distinct gene expression profiles across ontogeny



TagSeq (Lohman et al. 2016)

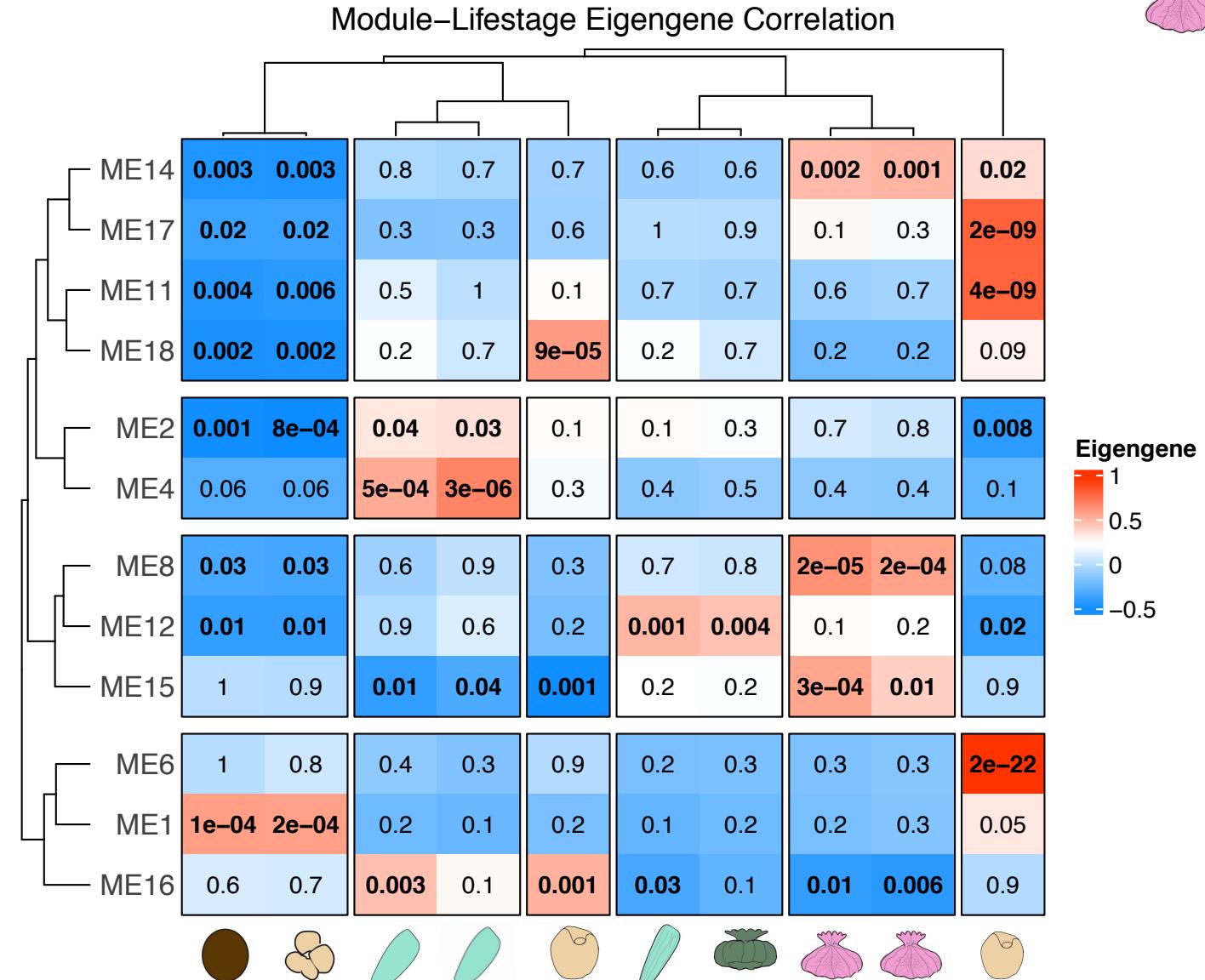
Illumina NovaSeq 100 bp sequencing (UT Austin)

Trimming & QC (FastP); alignment (HISAT2, Stringtie2)

Distinct gene expression profiles across ontogeny

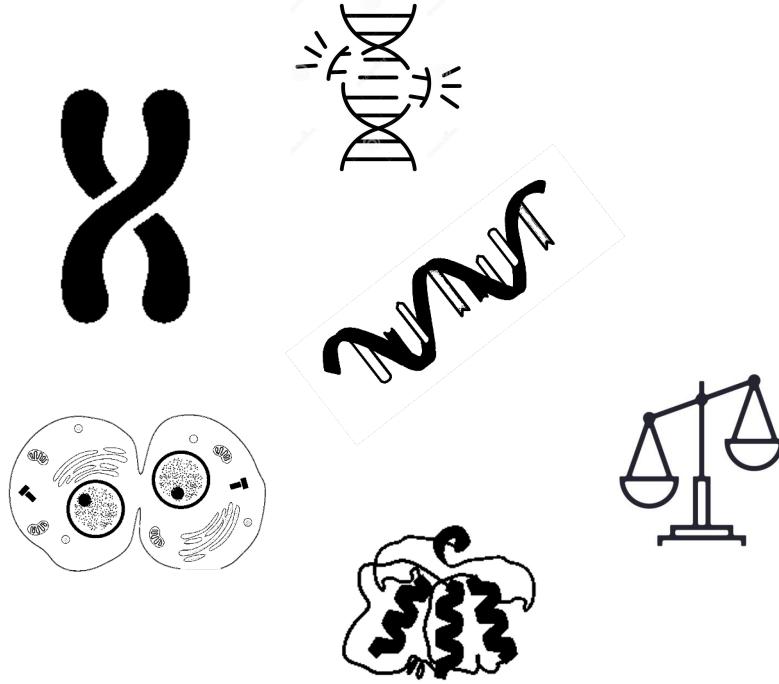
Weighted gene co-expression network analysis (WGCNA)

Dynamic tree cut module detection
GO-Seq functional enrichment
Filtered FDR<0.05

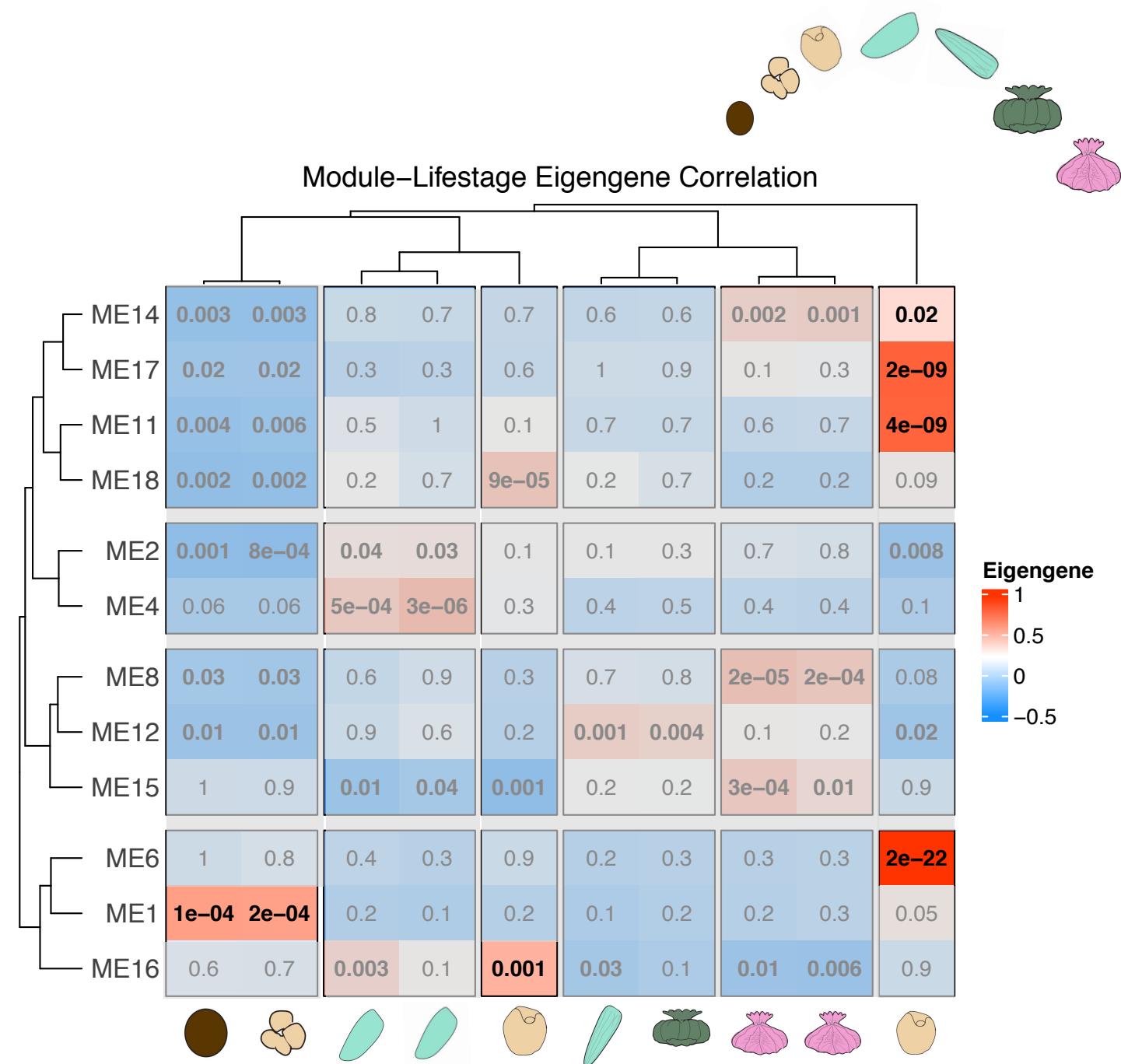


EGG-EMBRYOS

1 hpf - 65 hpf

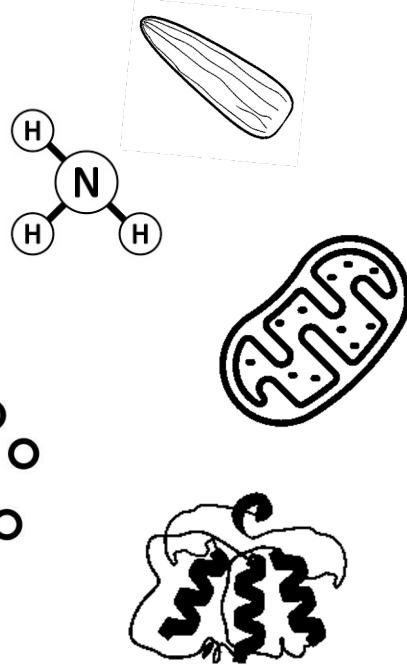
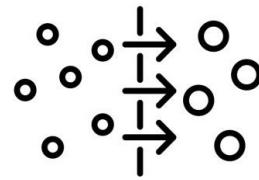


Cell division, transcription, embryonic development, DNA repair, homeostasis

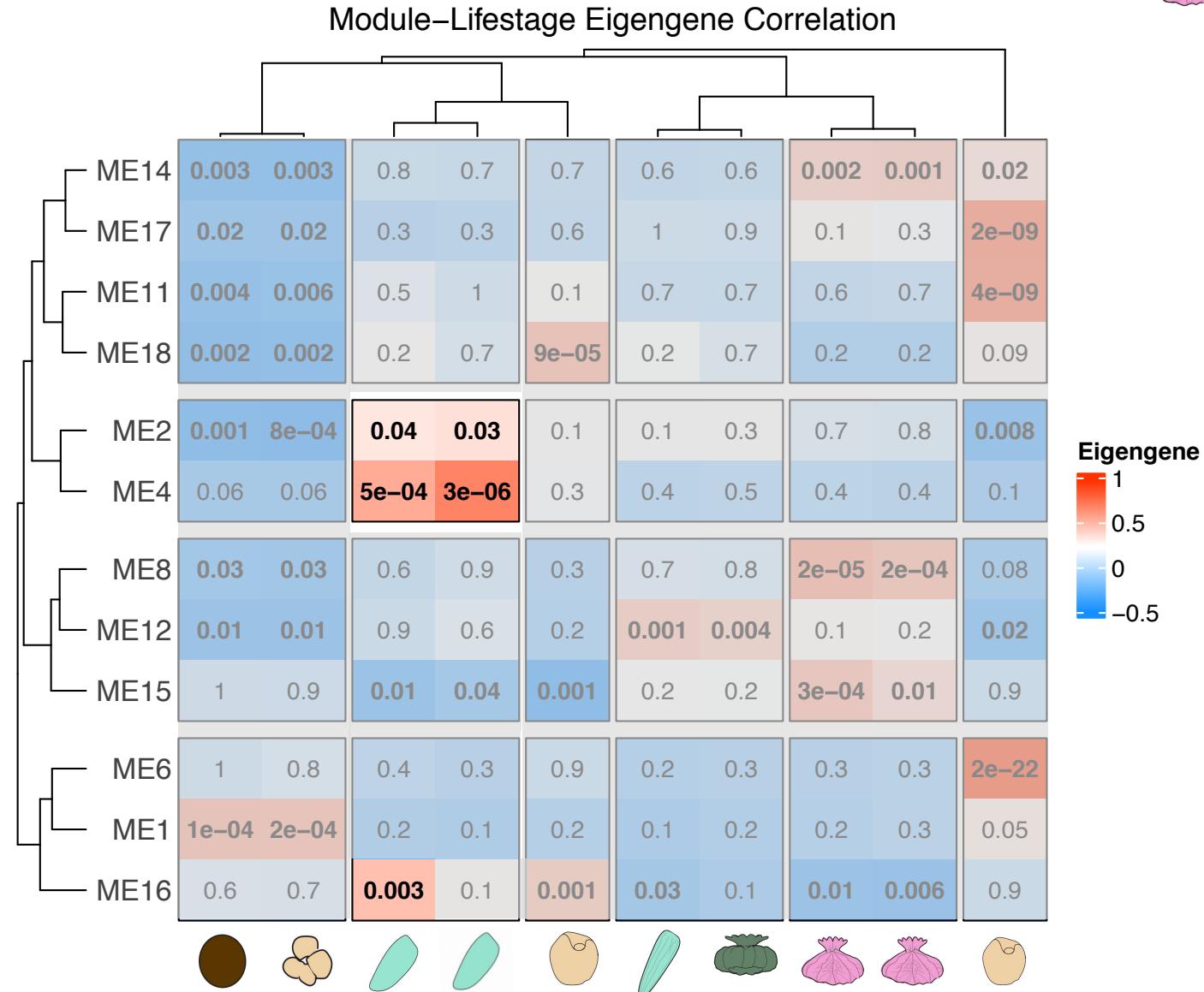


LARVAE

93 hpf – 163 hpf

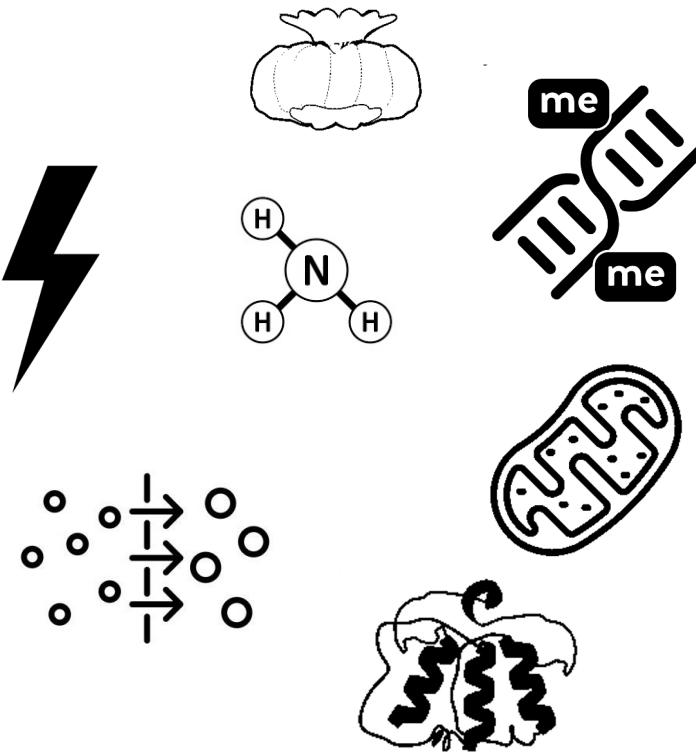


*Nitrogen and carbohydrate metabolism,
structure development, ion transport*

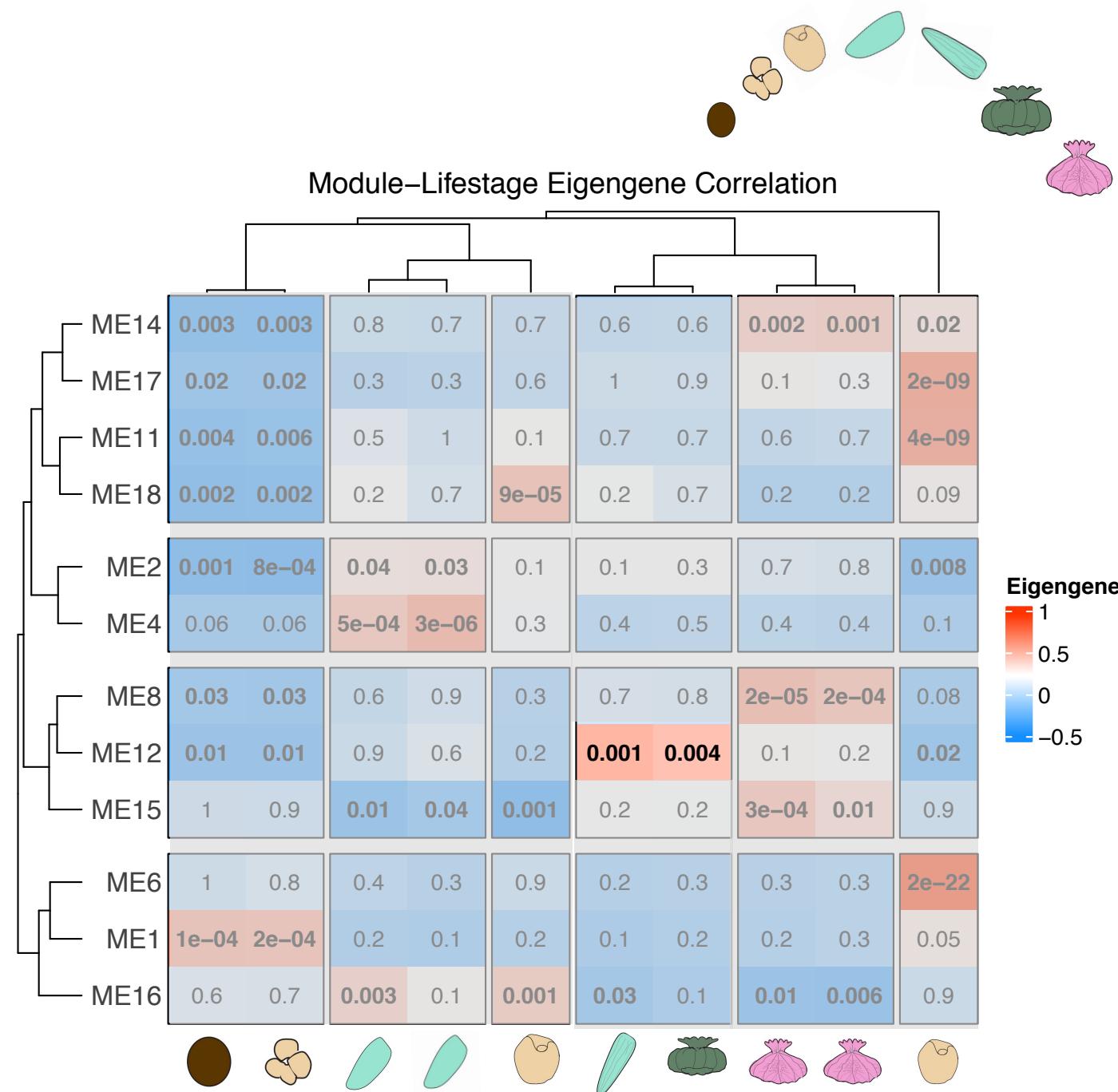


LARVAE & METAMORPHOSED POLYPS

231 hpf

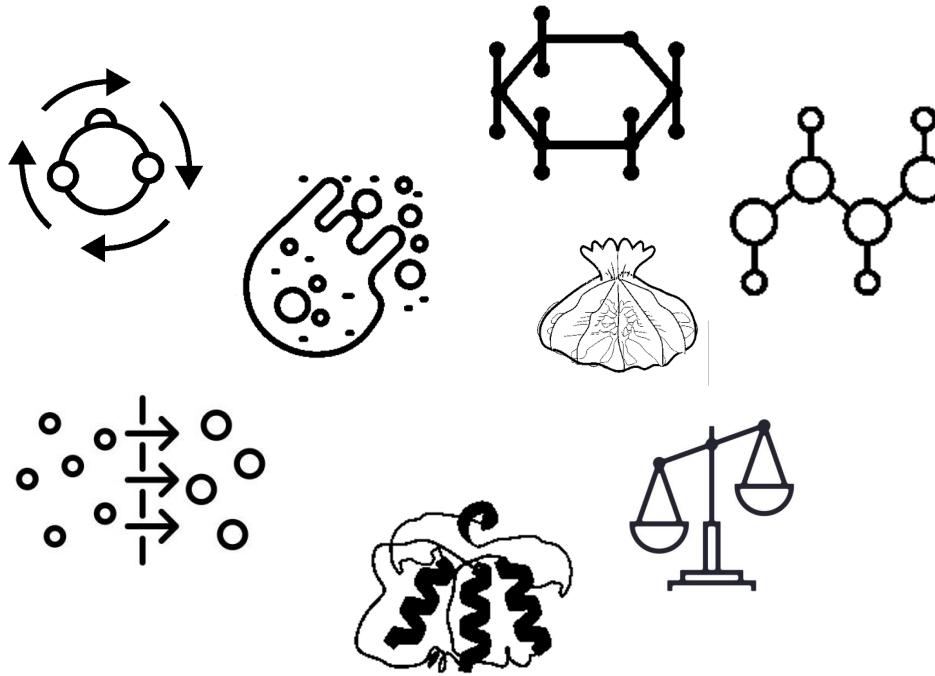


*Nitrogen metabolism, membrane transport,
protein transport, metamorphosis,
carbohydrate metabolism.*

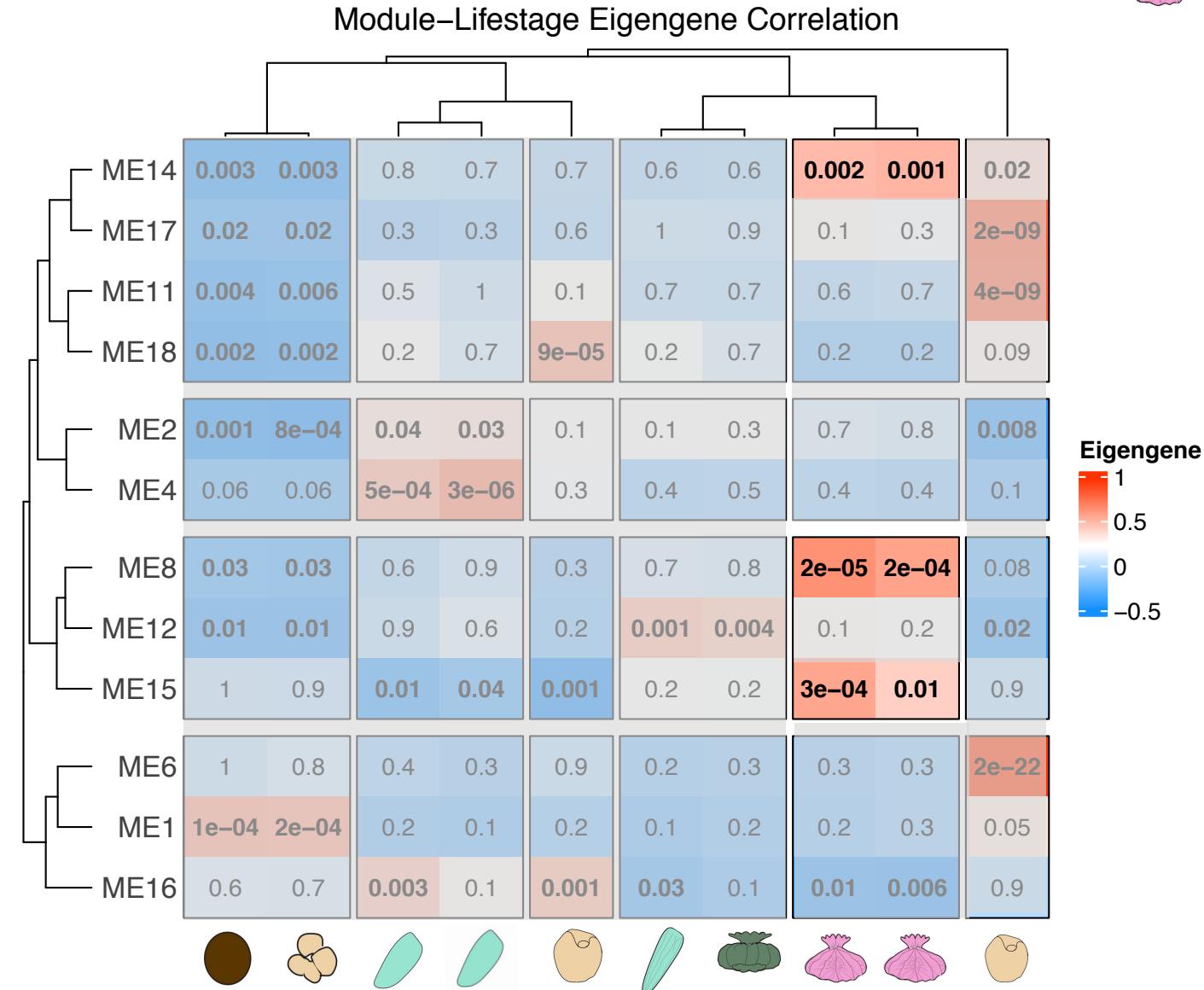


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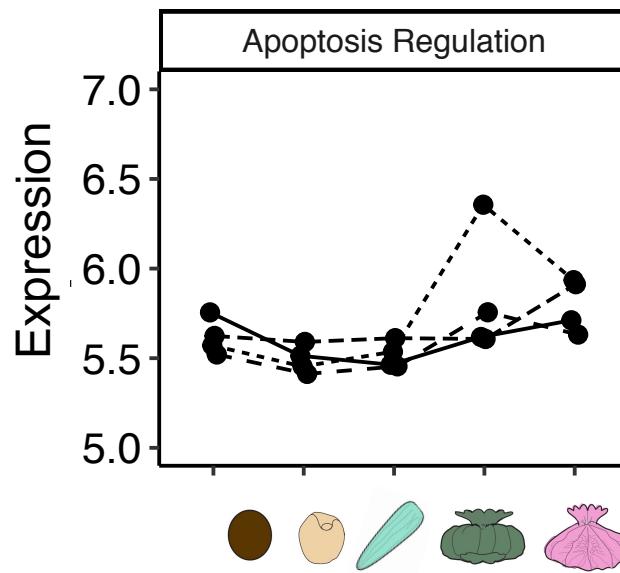
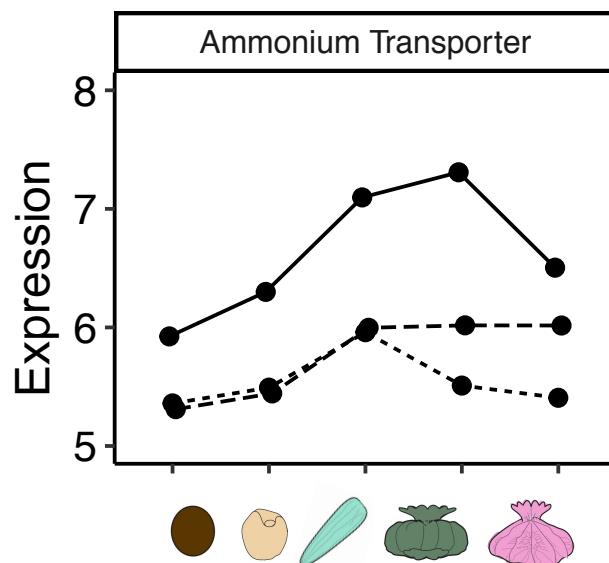
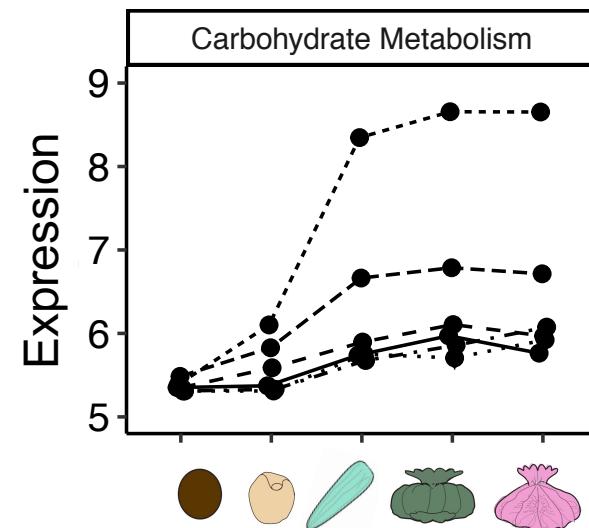
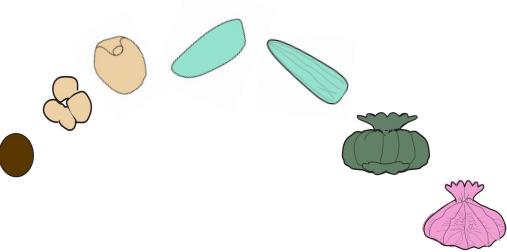
183-231 hpf



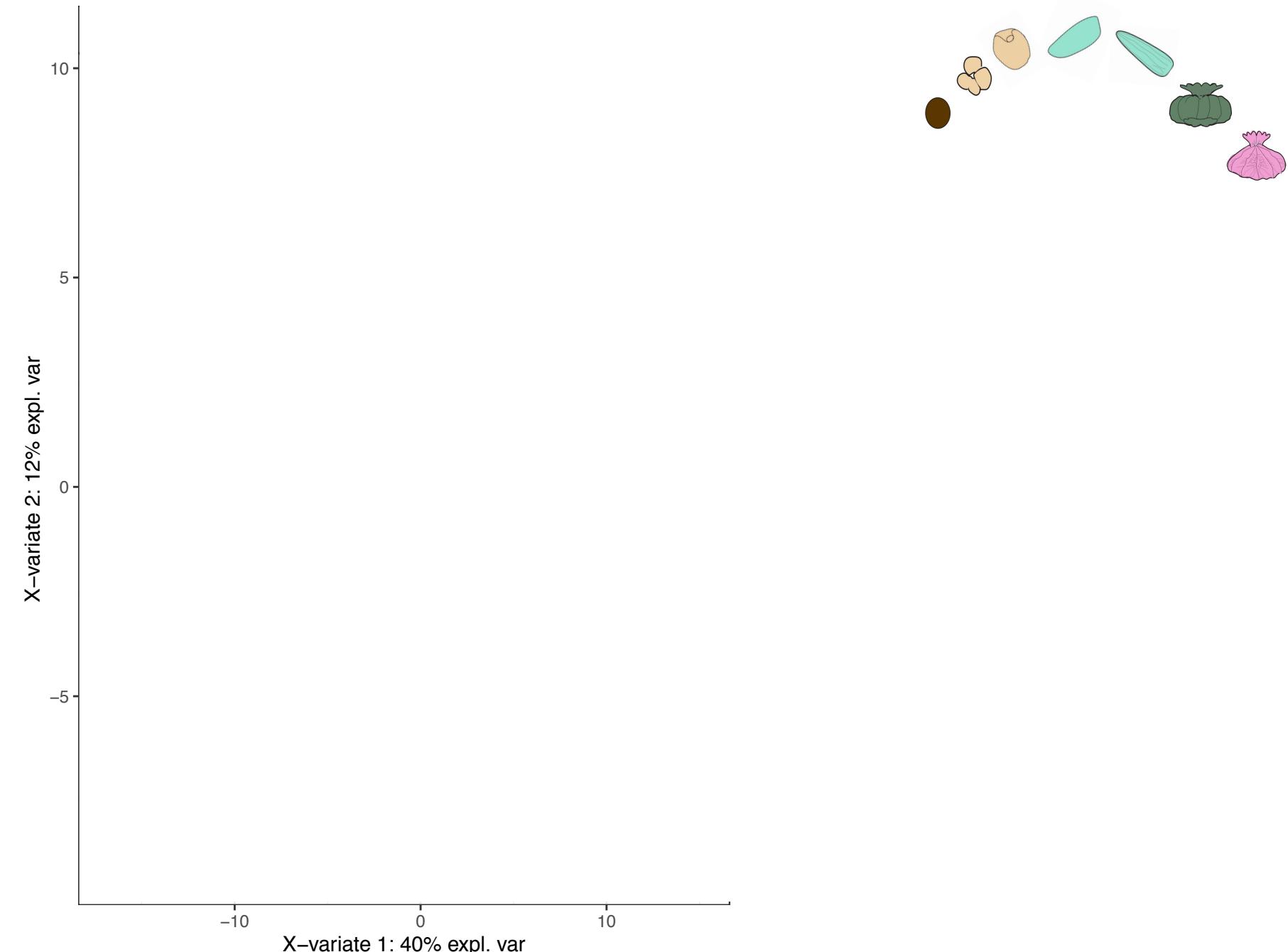
Cell communication, membrane transport, homeostasis, lipid metabolism, carbohydrate metabolism



GENE EXPRESSION SIGNATURES OF SYMBIOSIS



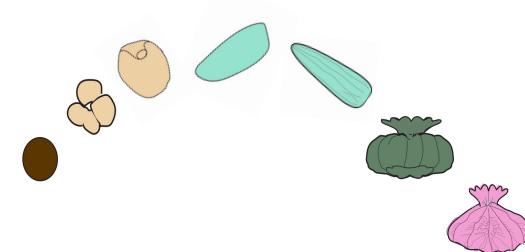
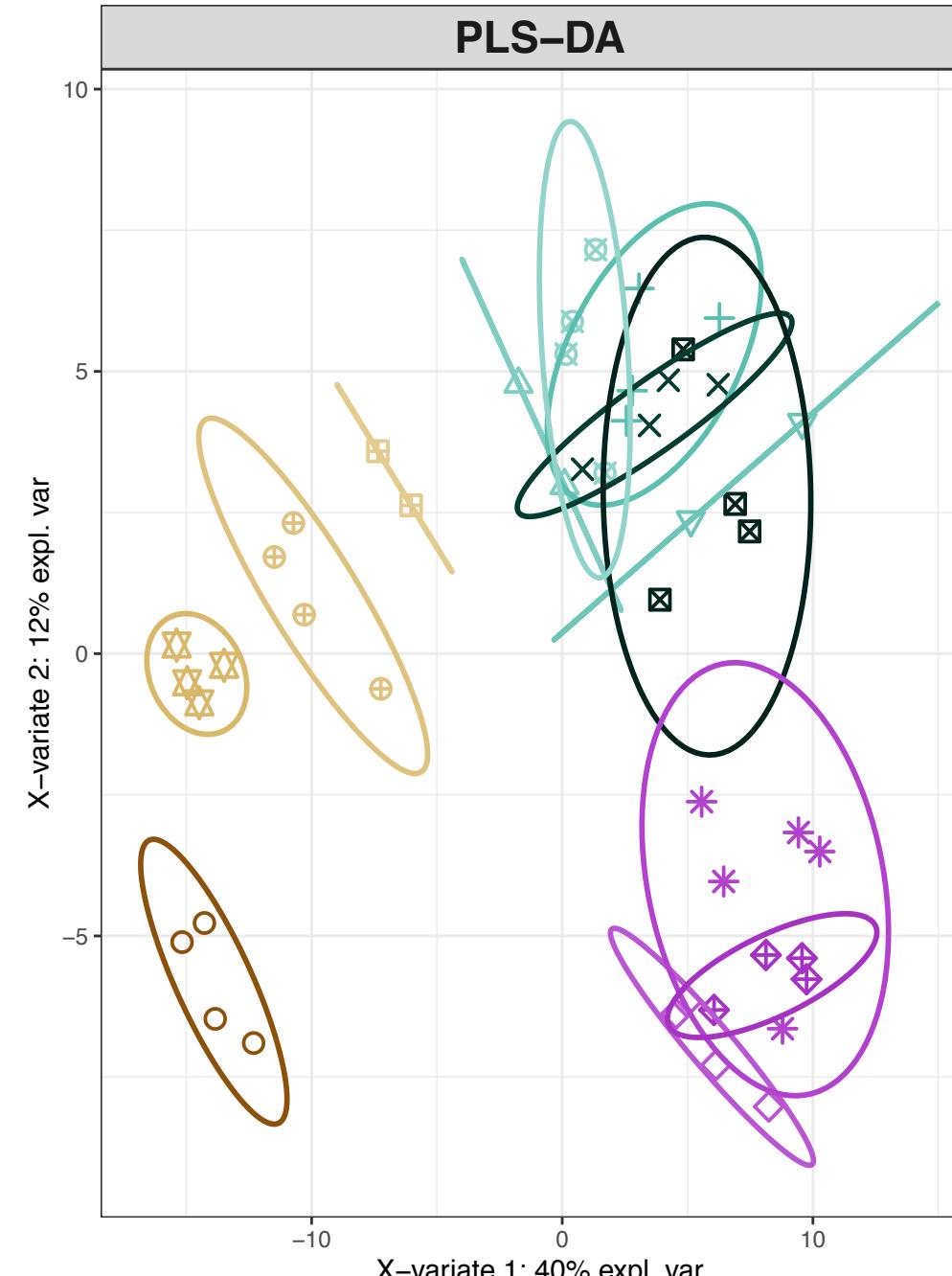
Distinct metabolomic profiles across ontogeny



Untargeted metabolomics
LC-MS

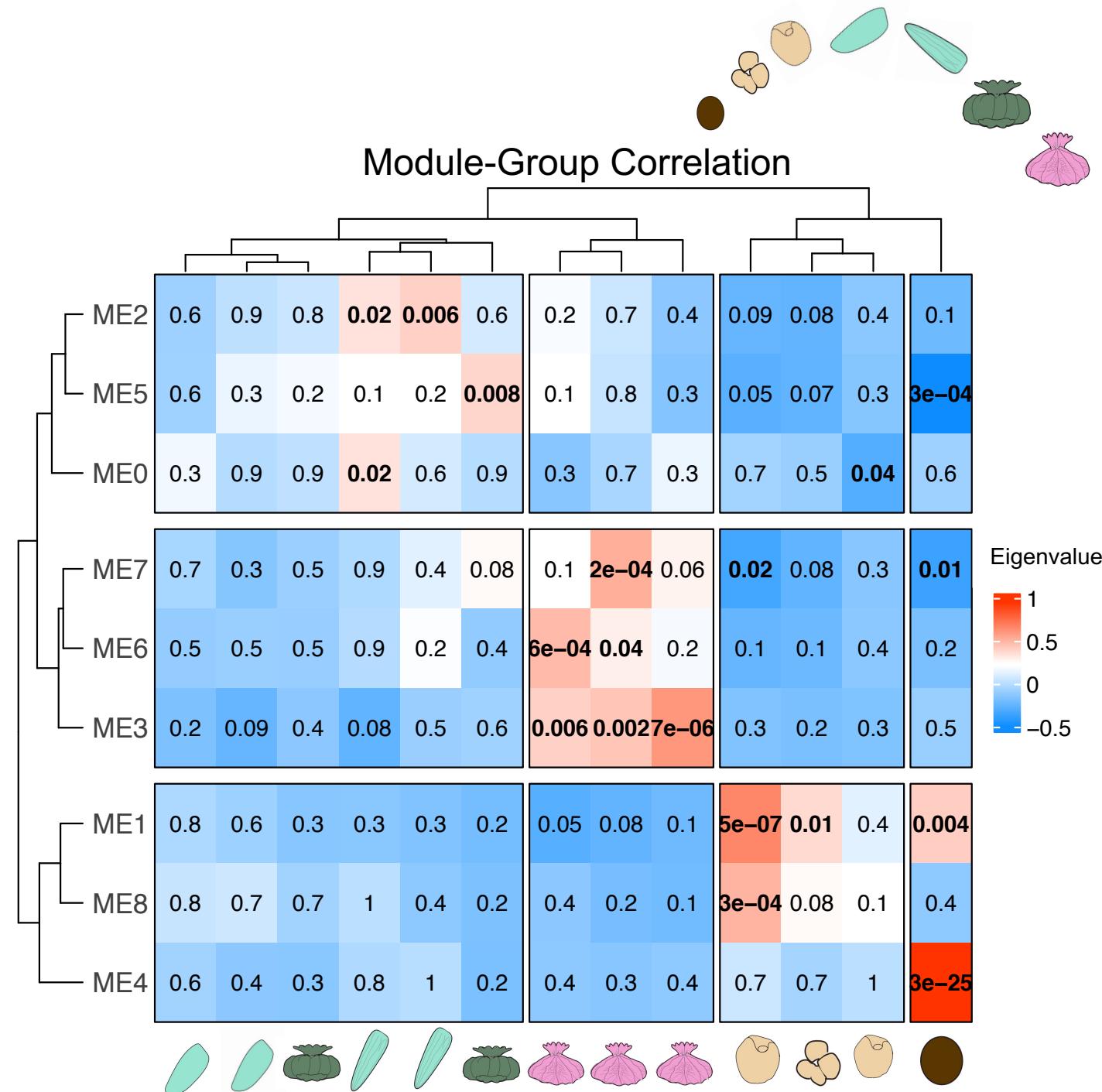
Rutgers Cancer Institute Metabolomics Facility

Distinct metabolomic profiles across ontogeny



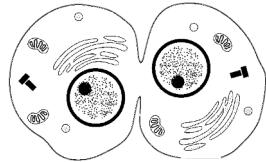
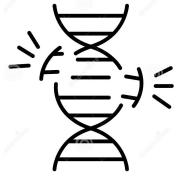
Distinct metabolomic profiles across ontogeny

Weighted correlation network analysis



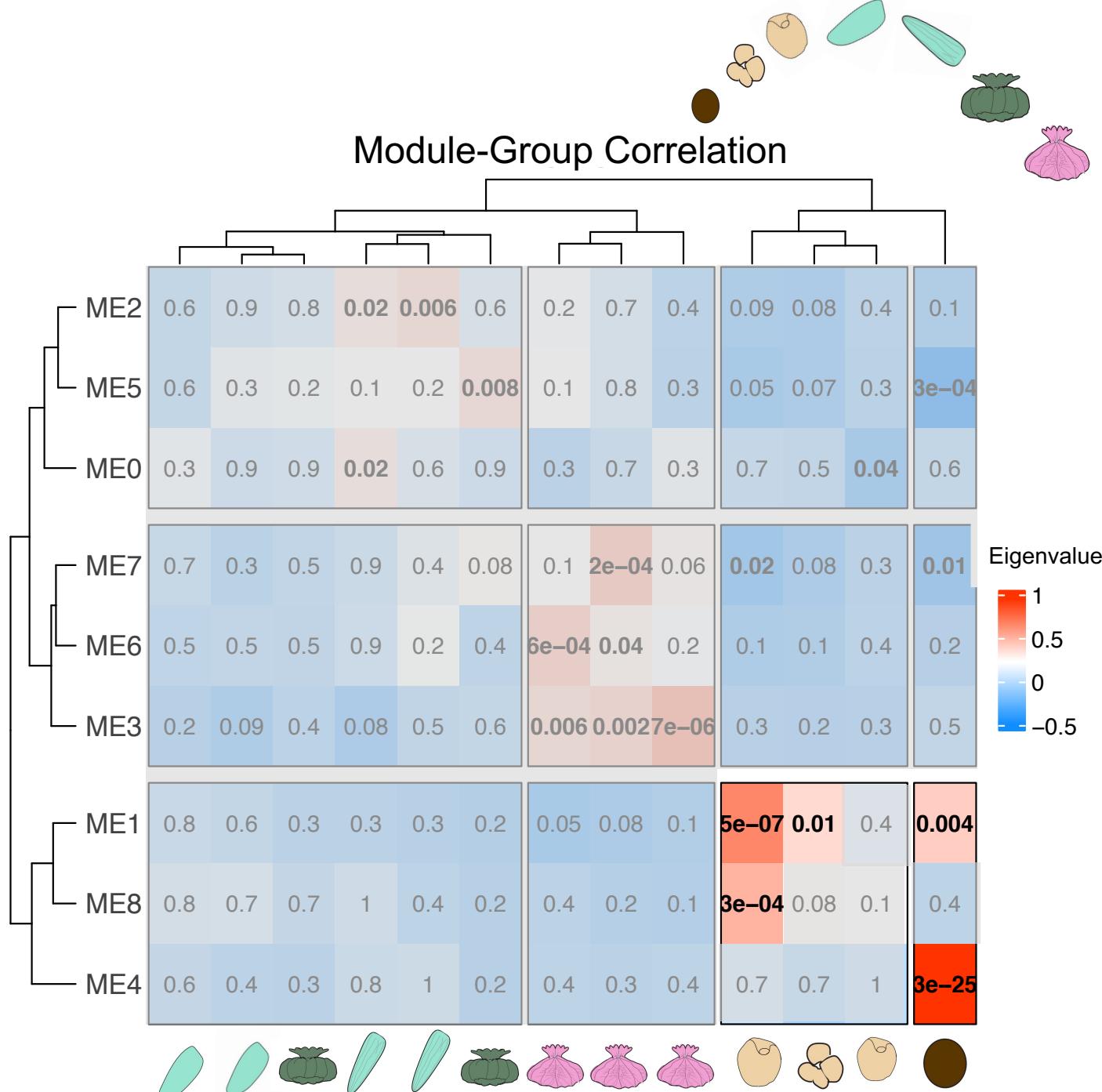
EGGS & EMBRYOS

1 hpf-65 hpf



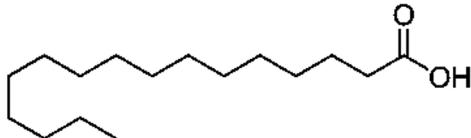
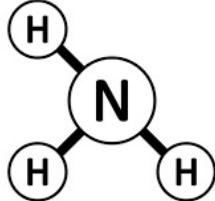
***Embryonic development
Cell division and differentiation***

Module-Group Correlation



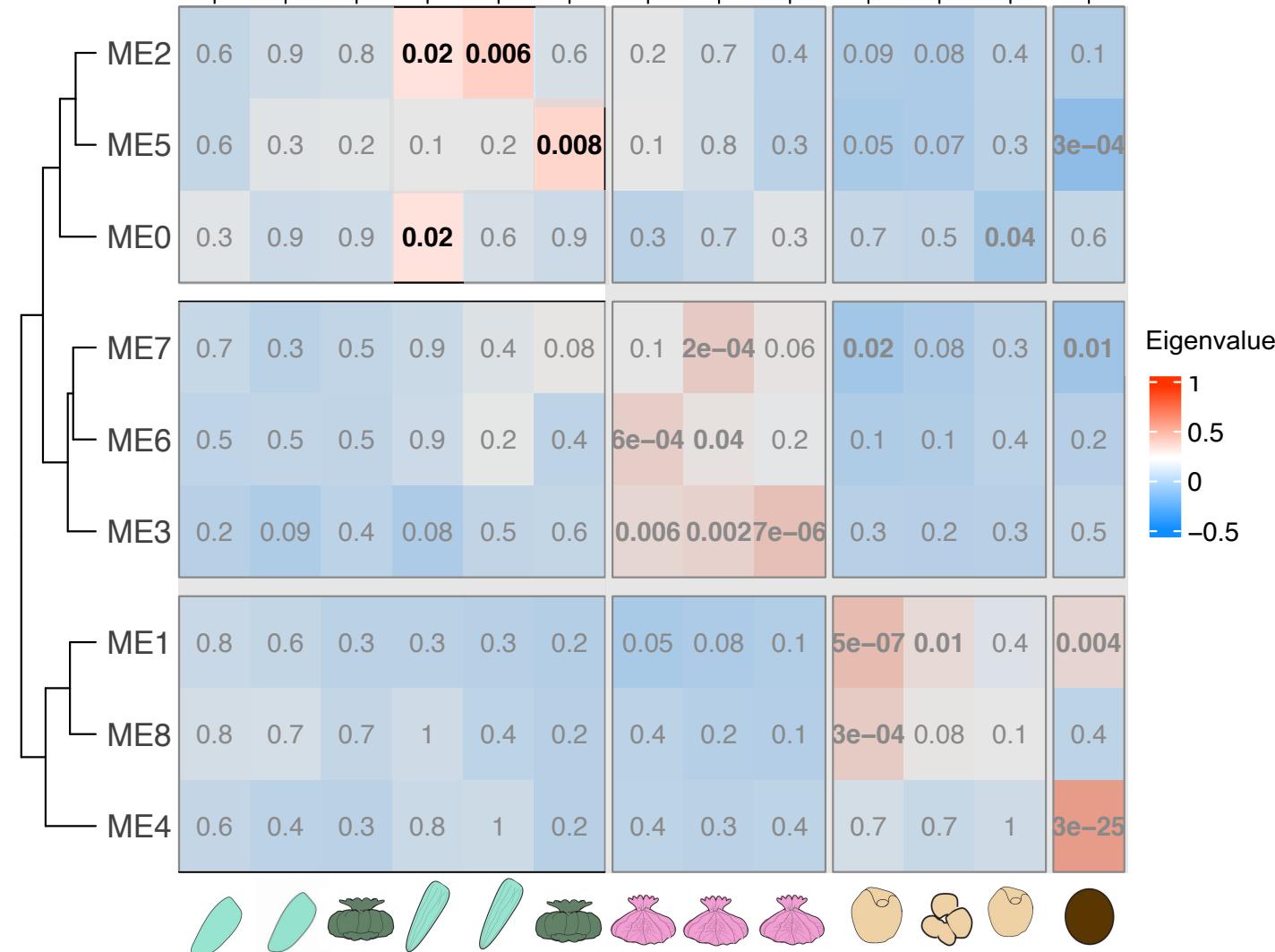
LARVAE & METAMORPHOSED POLYPS

93 hpf-231 hpf



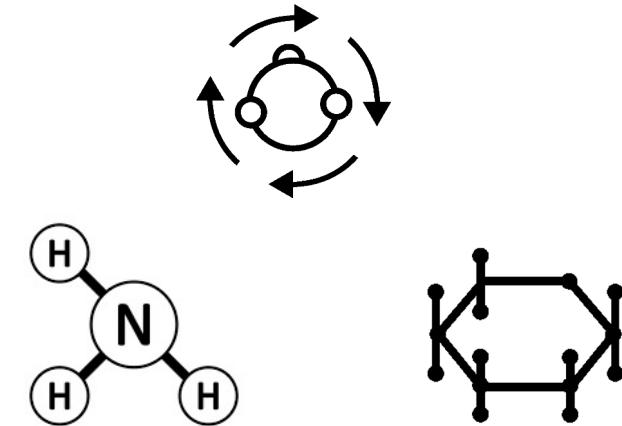
Nitrogen, protein, fatty acid metabolism

Module-Group Correlation

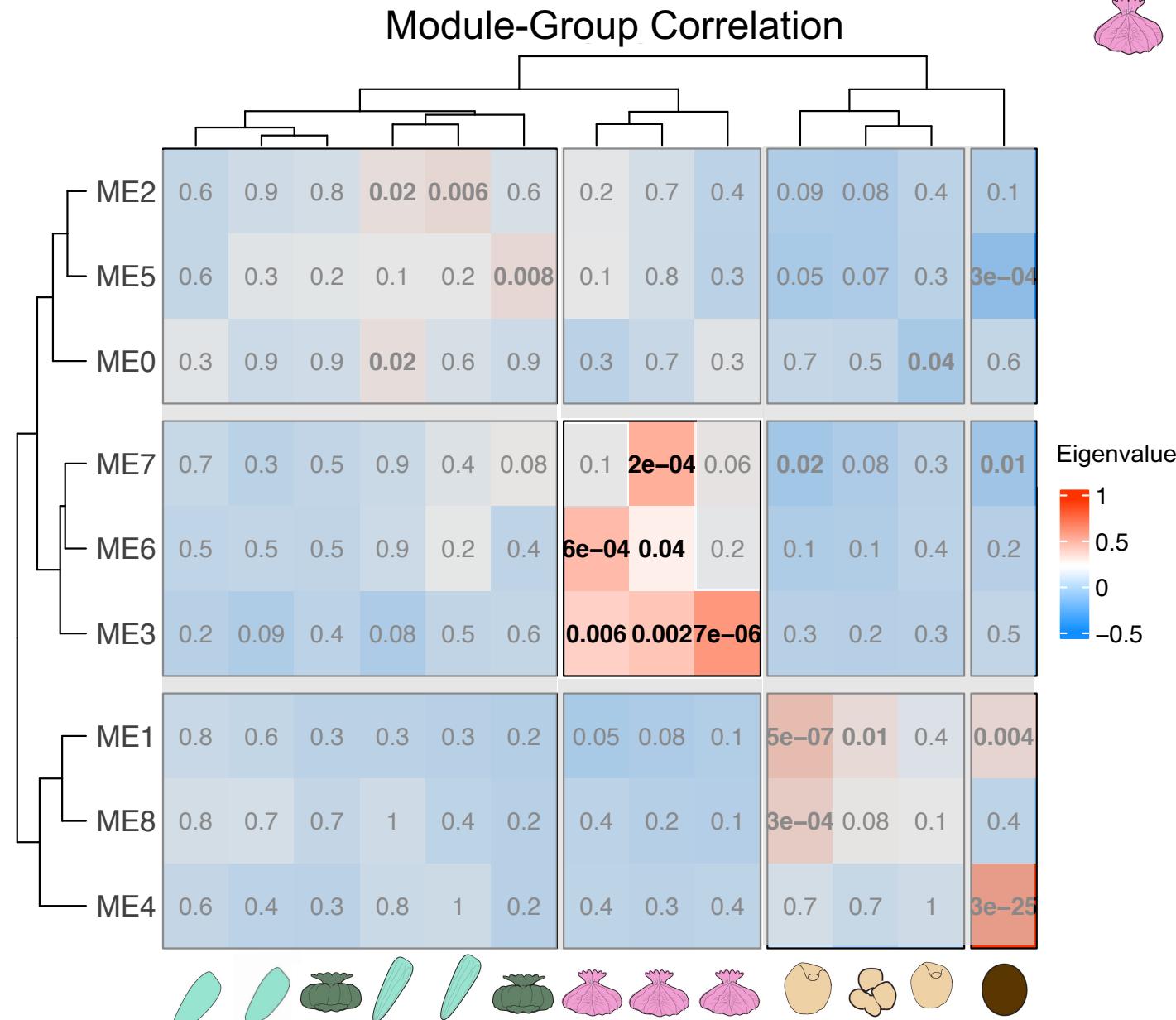


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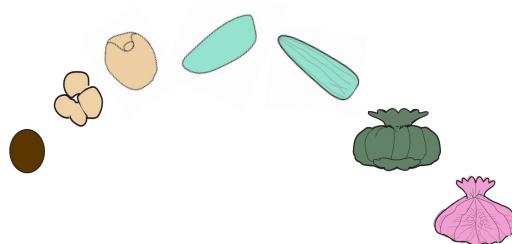
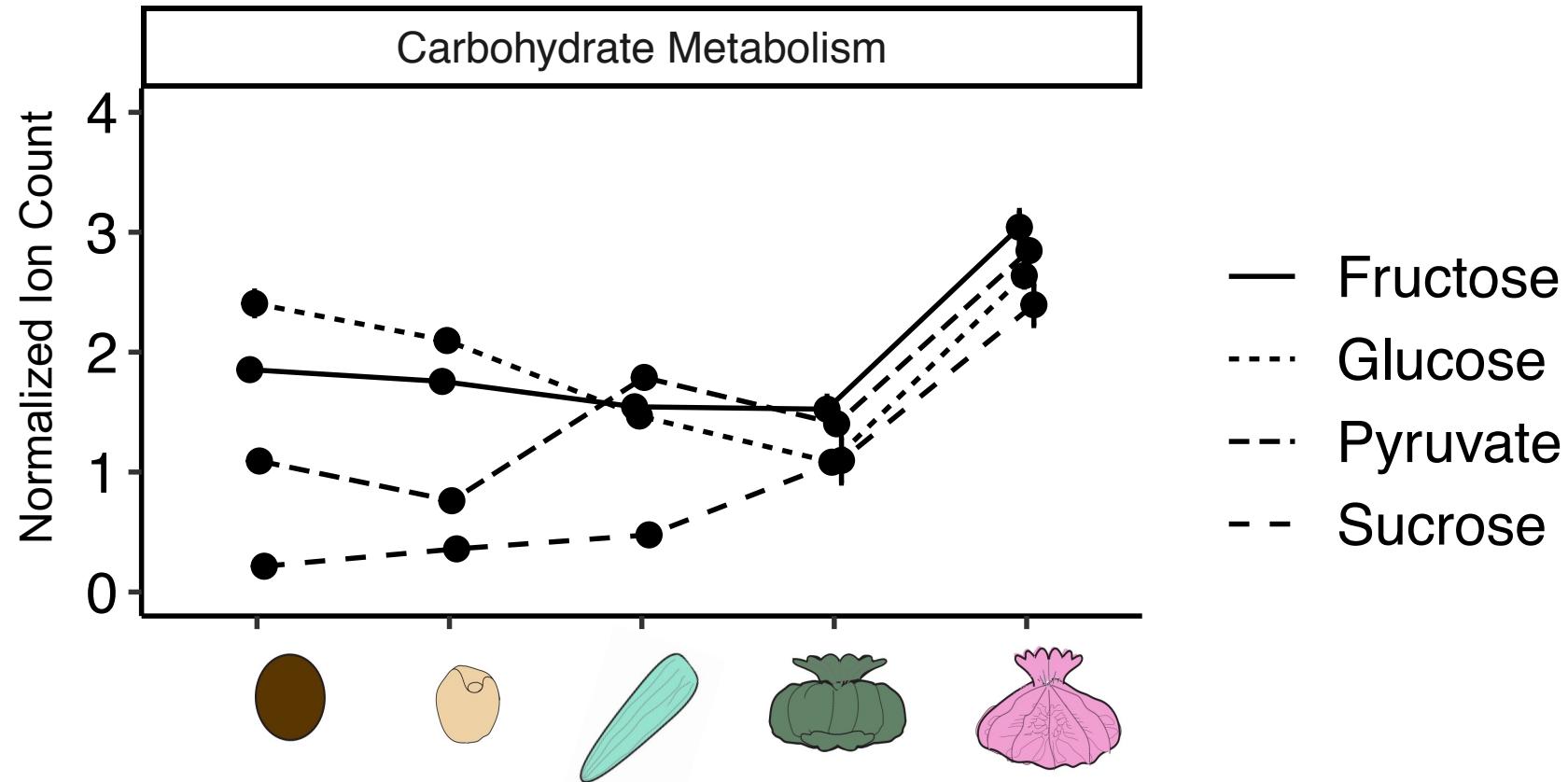
183 hpf-255 hpf



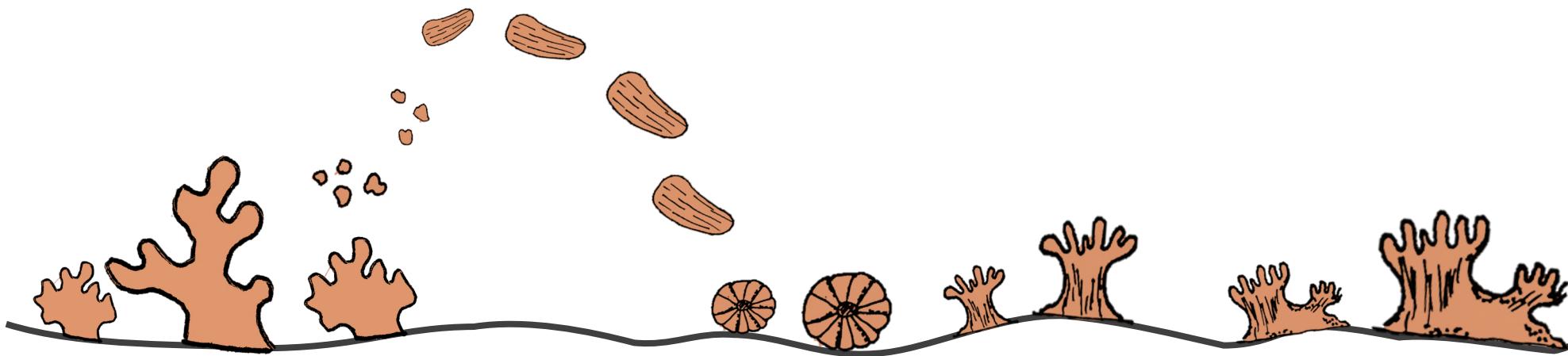
Nitrogen, carbohydrate metabolism



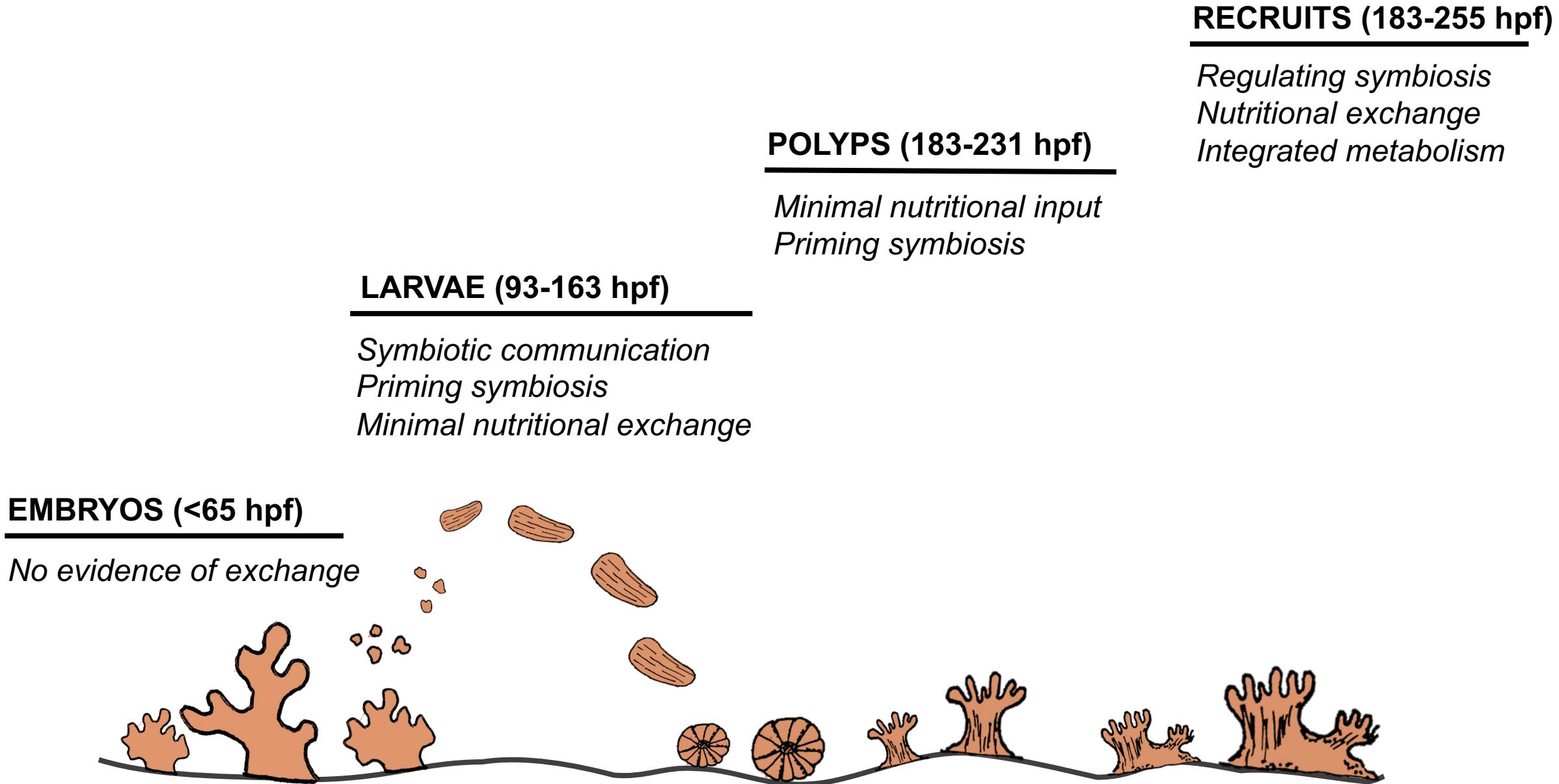
CARBON METABOLISM



When does symbiotic nutritional exchange begin during development?



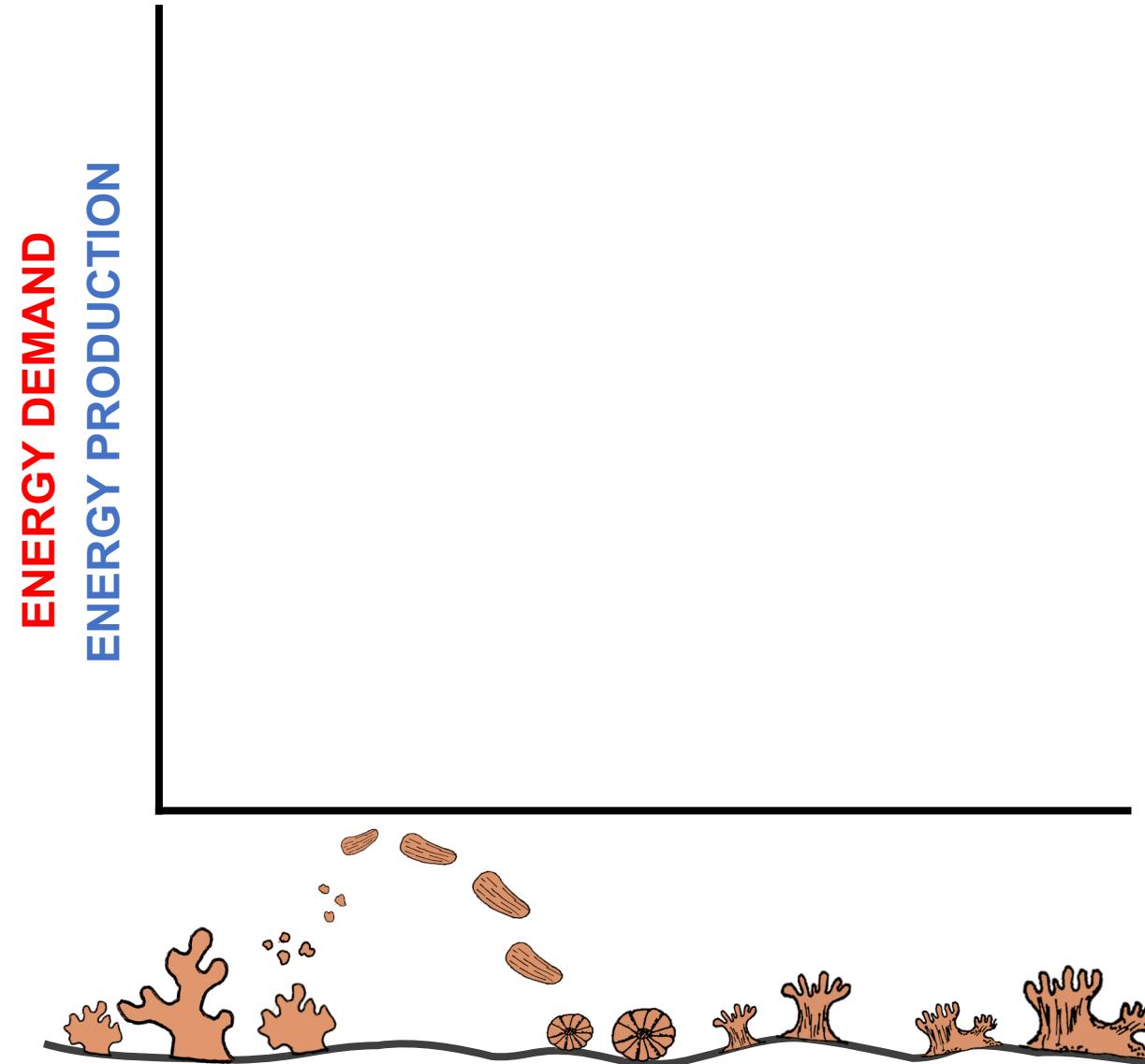
When does symbiotic nutritional exchange begin during development?



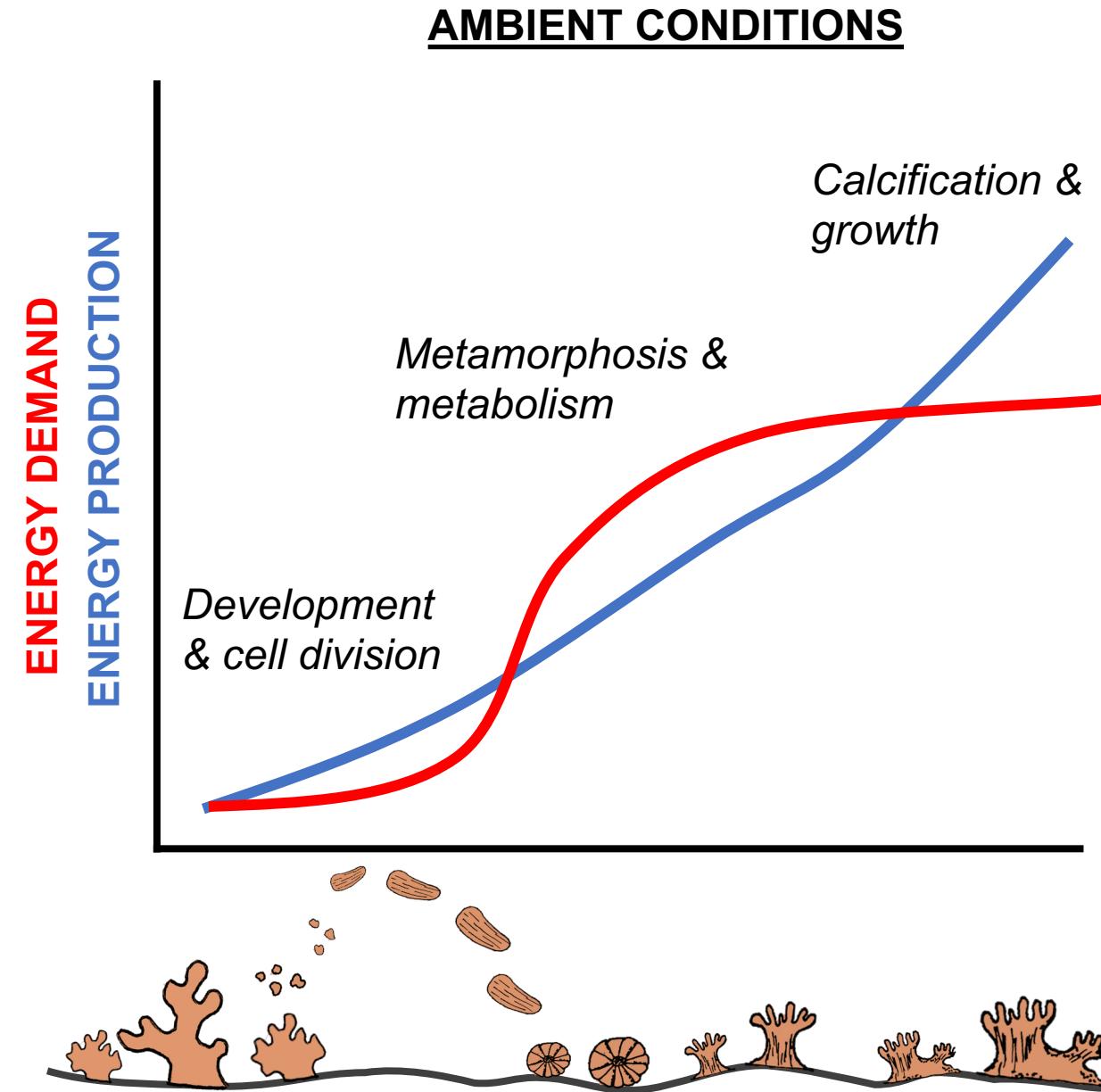
How does nutritional exchange impact energetic capacity during recruitment?



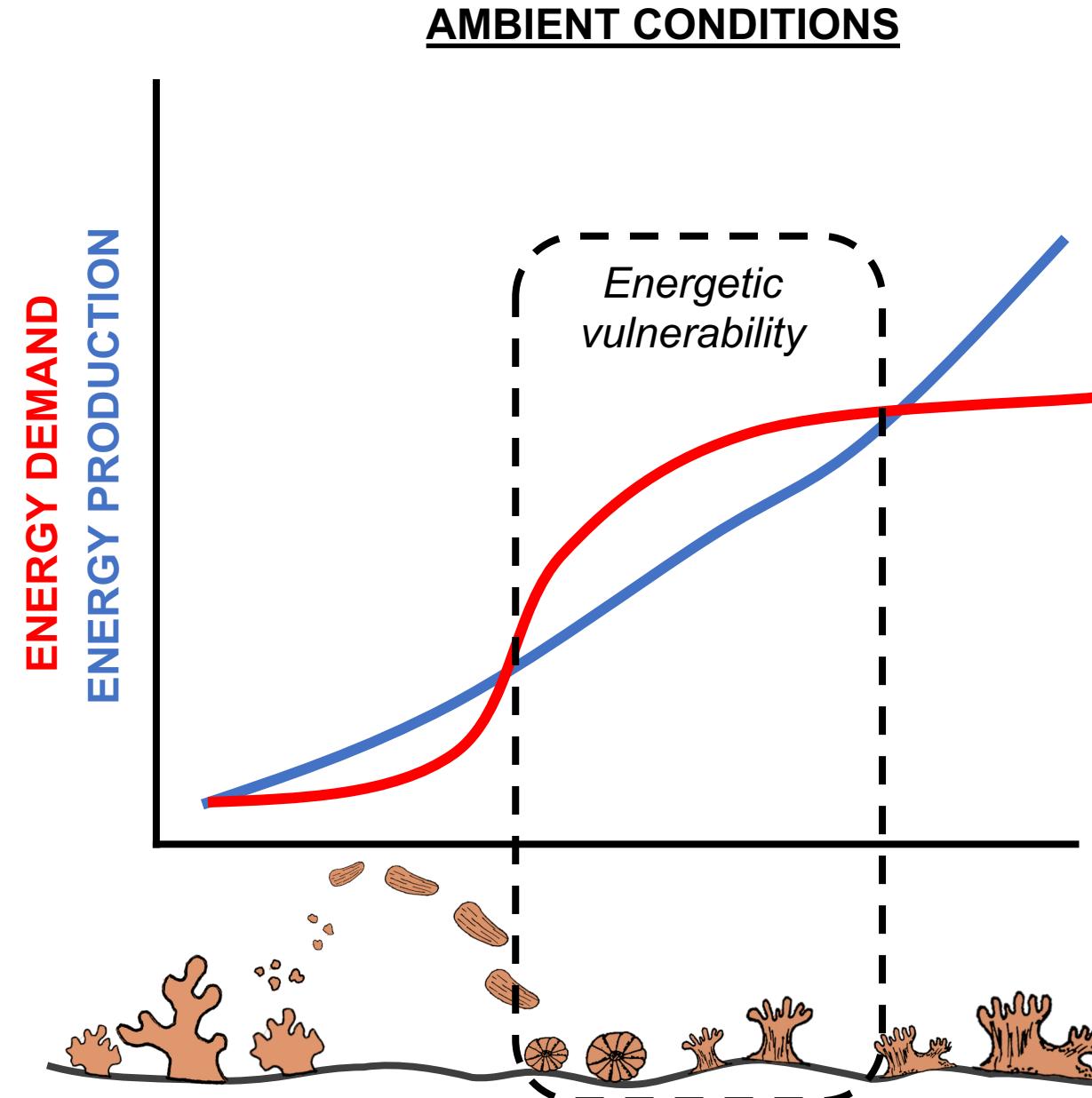
AMBIENT CONDITIONS



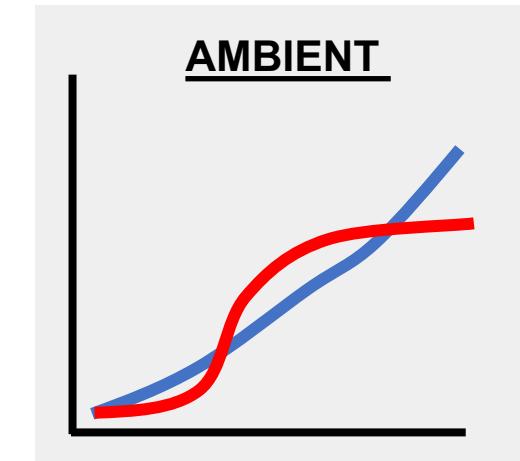
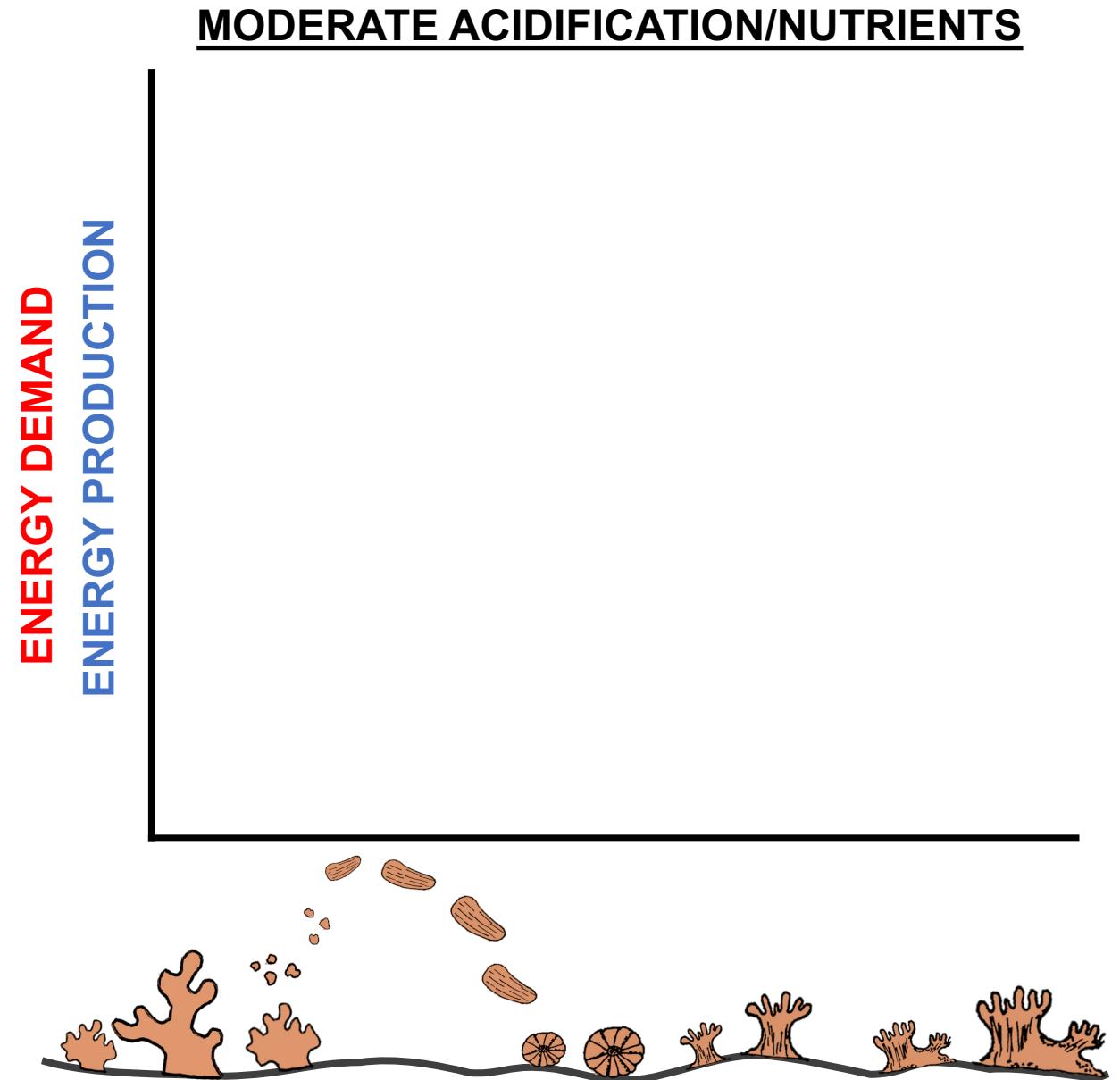
How does nutritional exchange impact energetic capacity during recruitment?



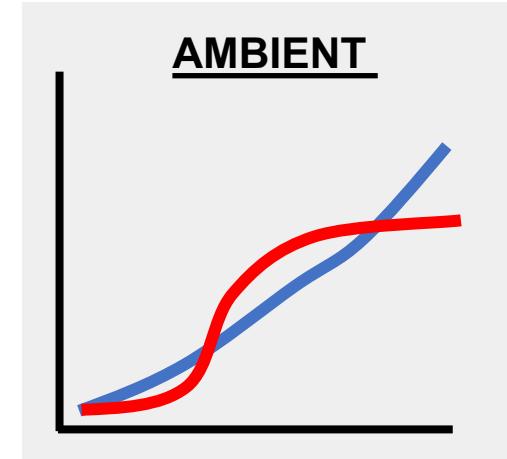
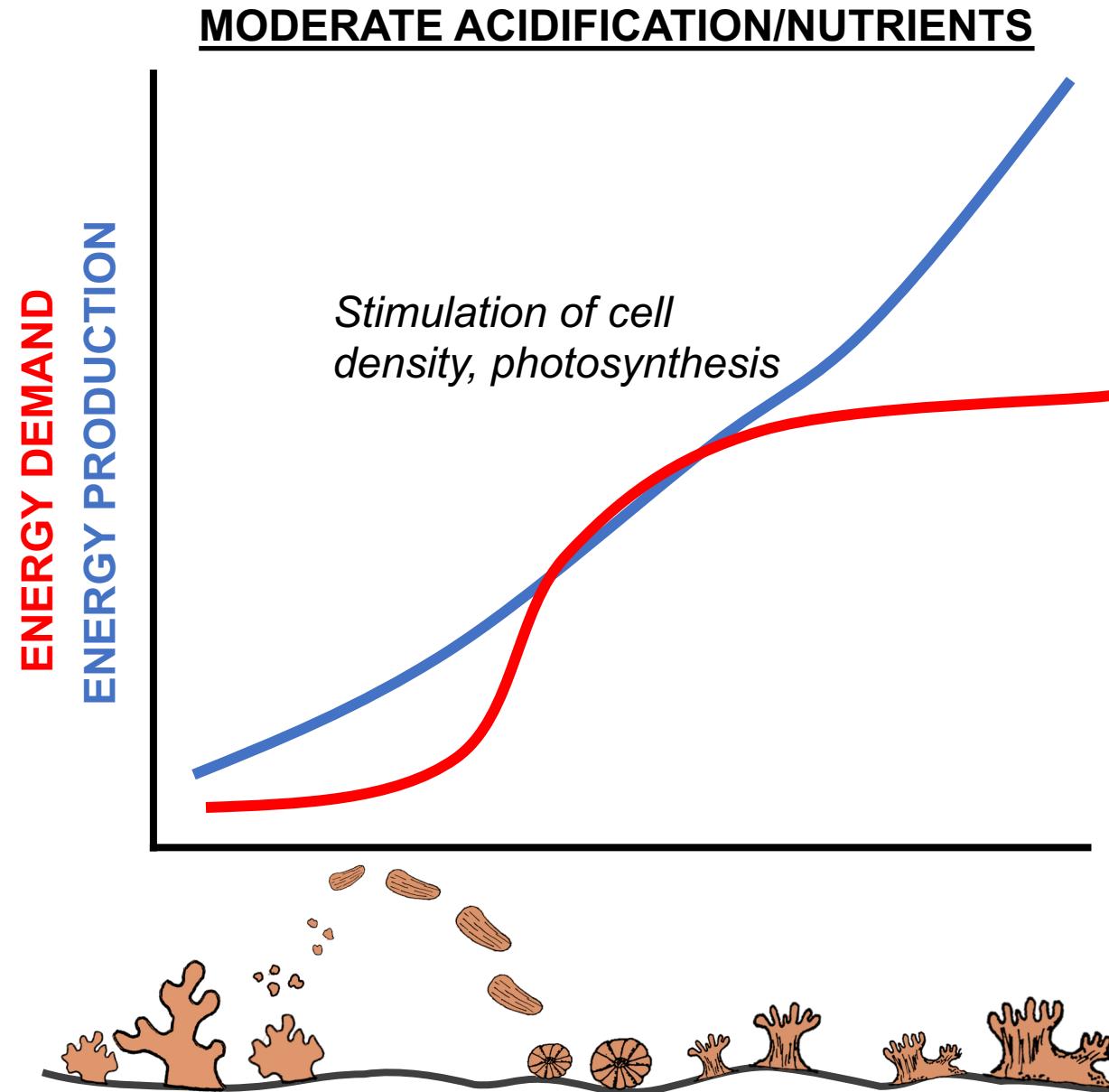
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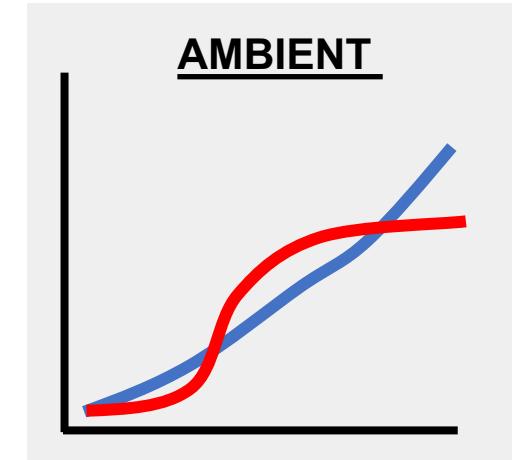
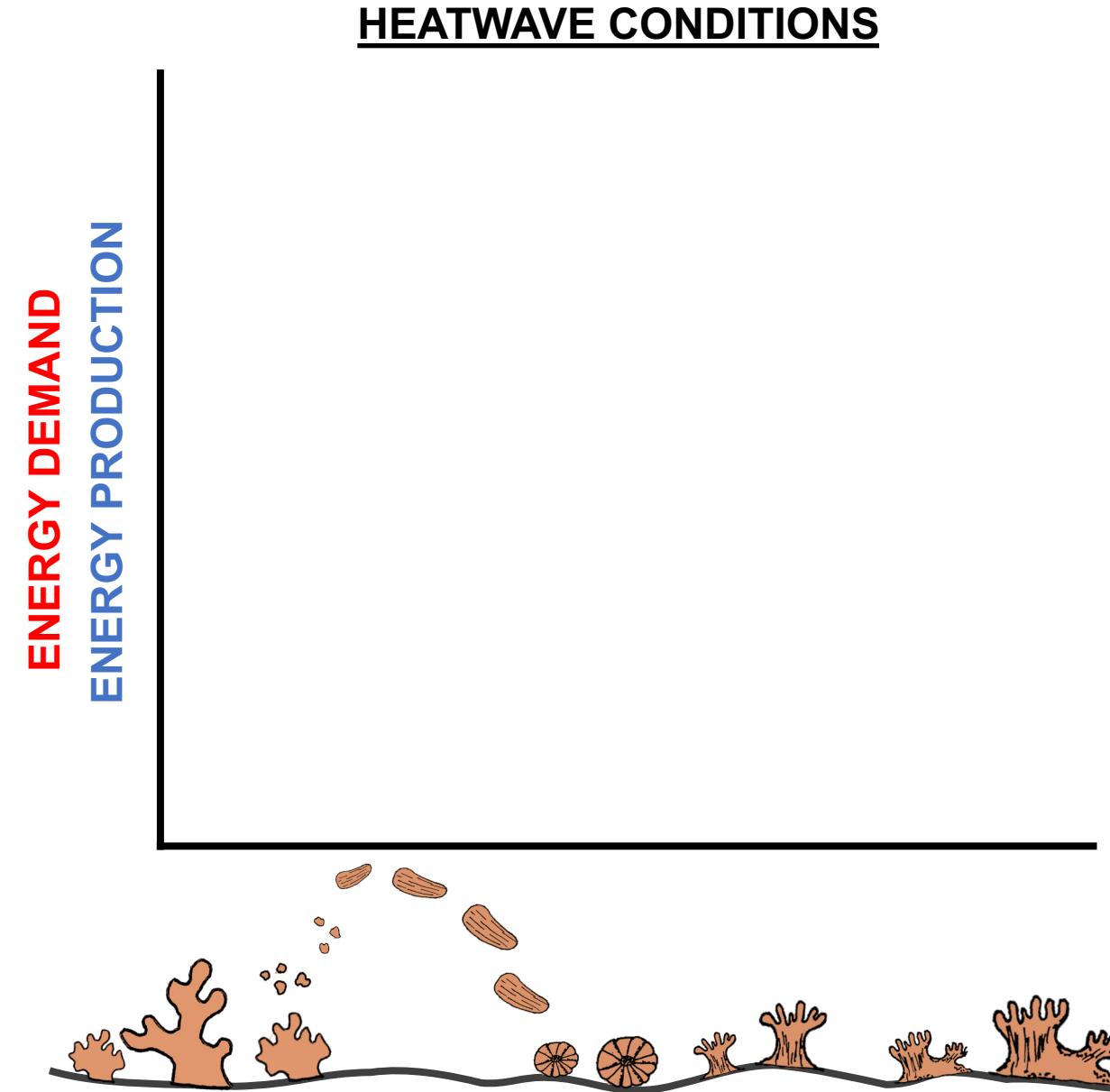
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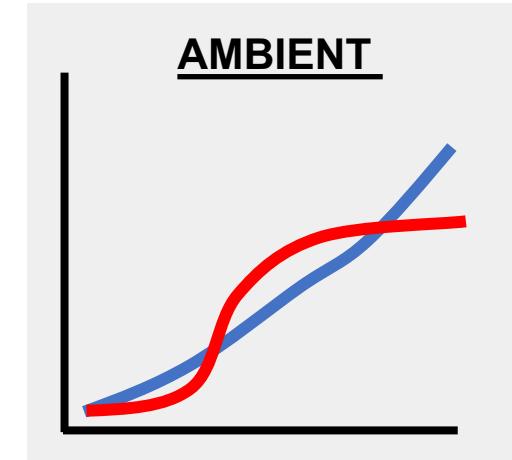
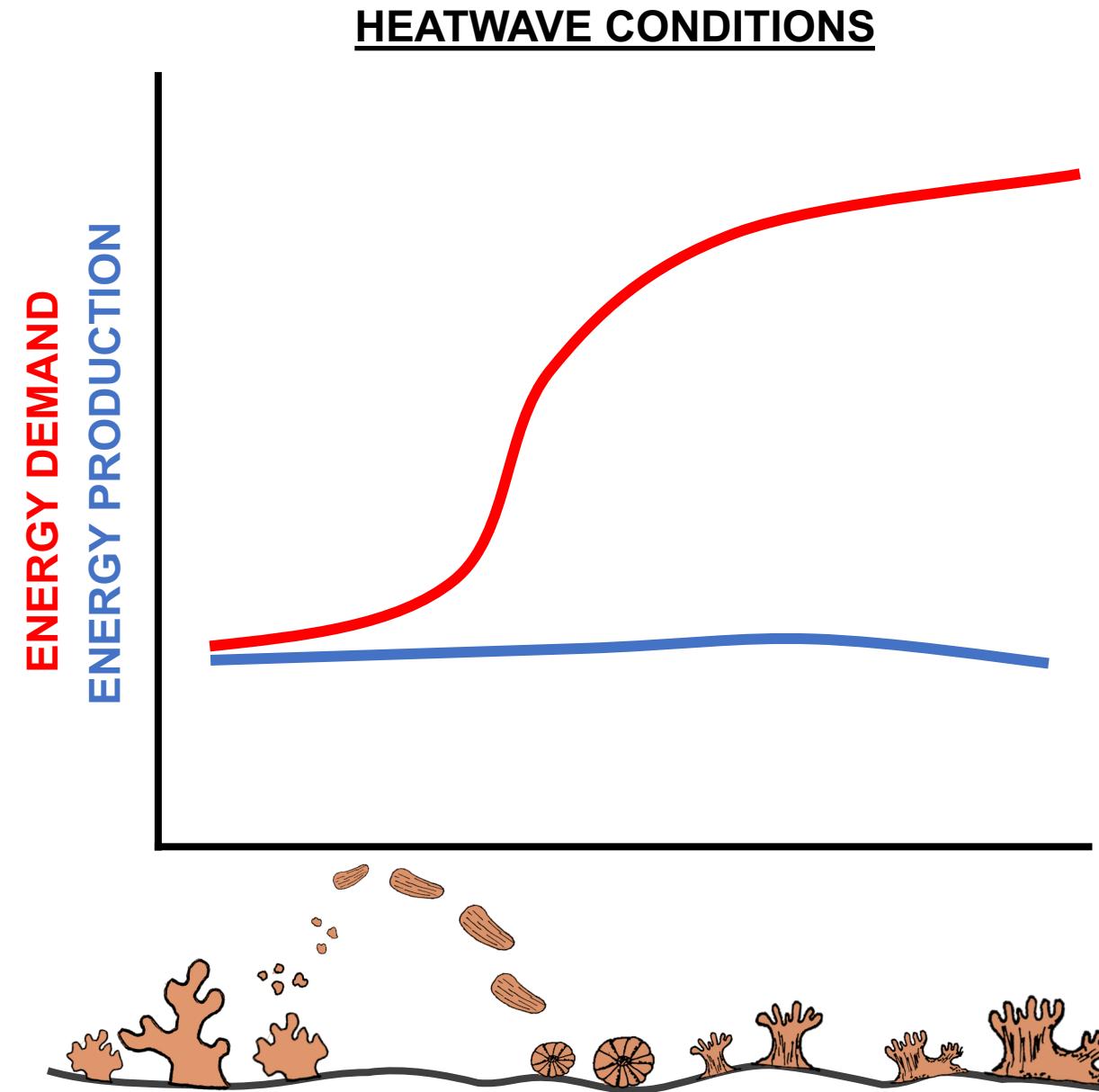
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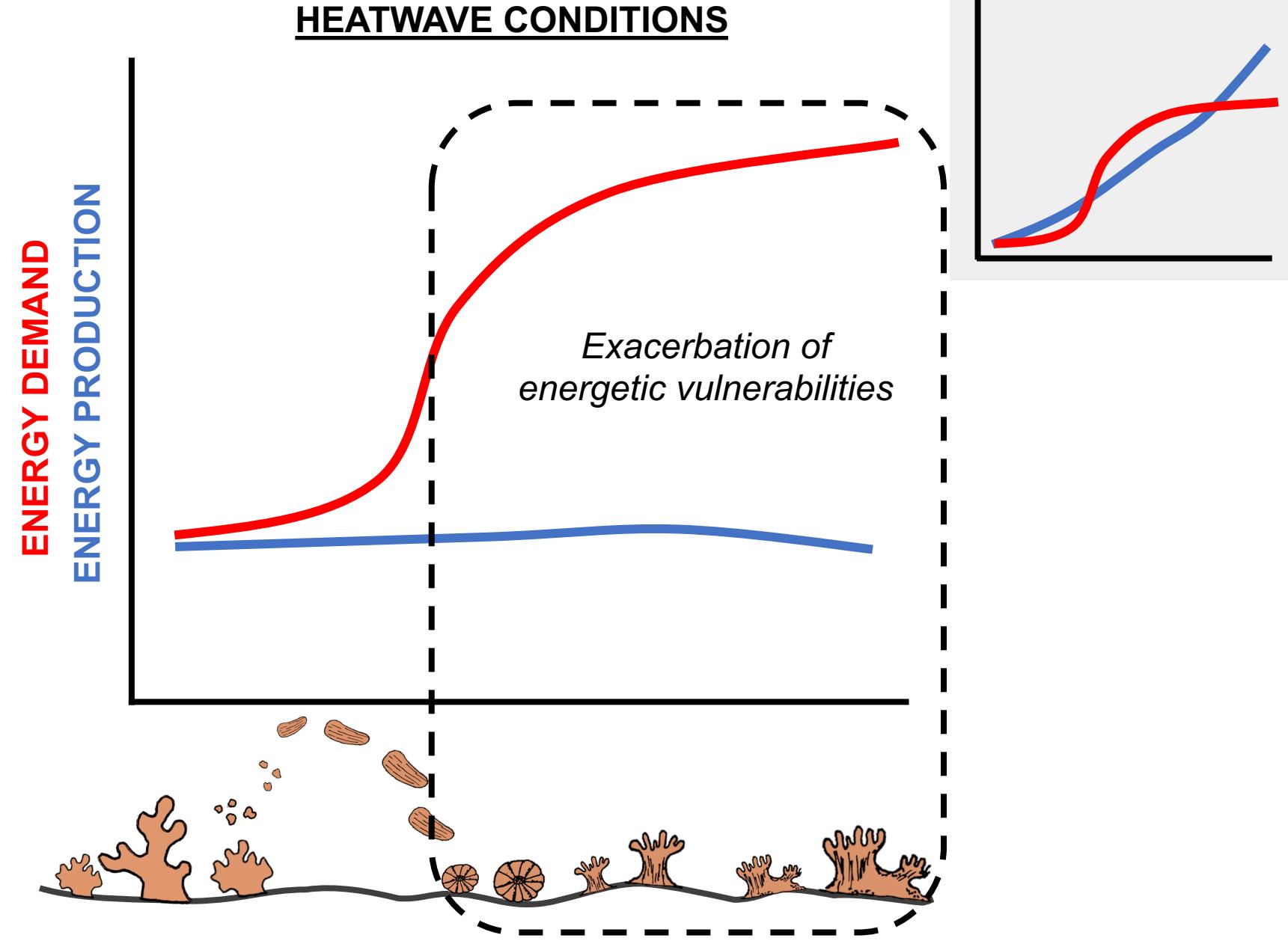
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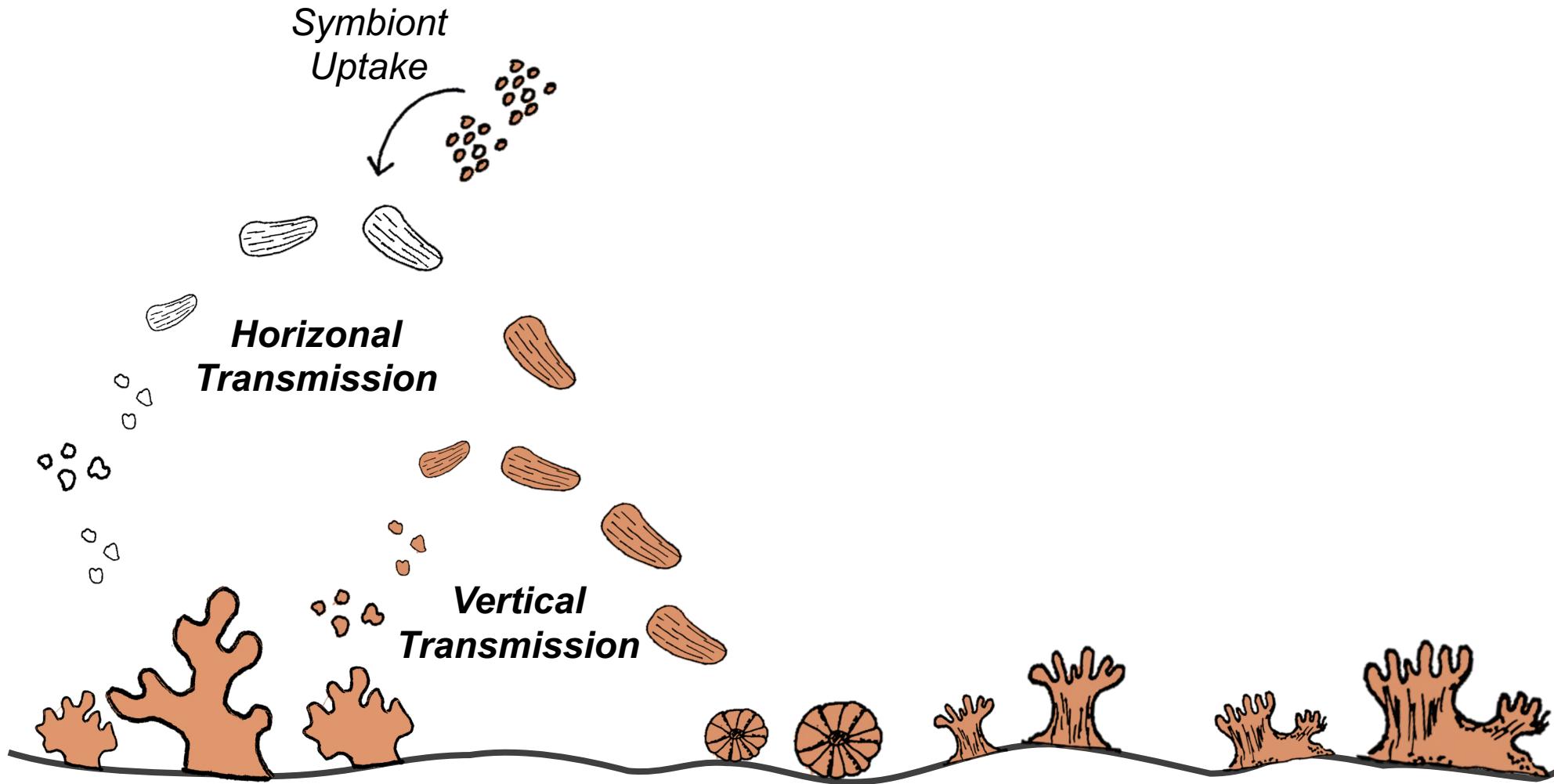


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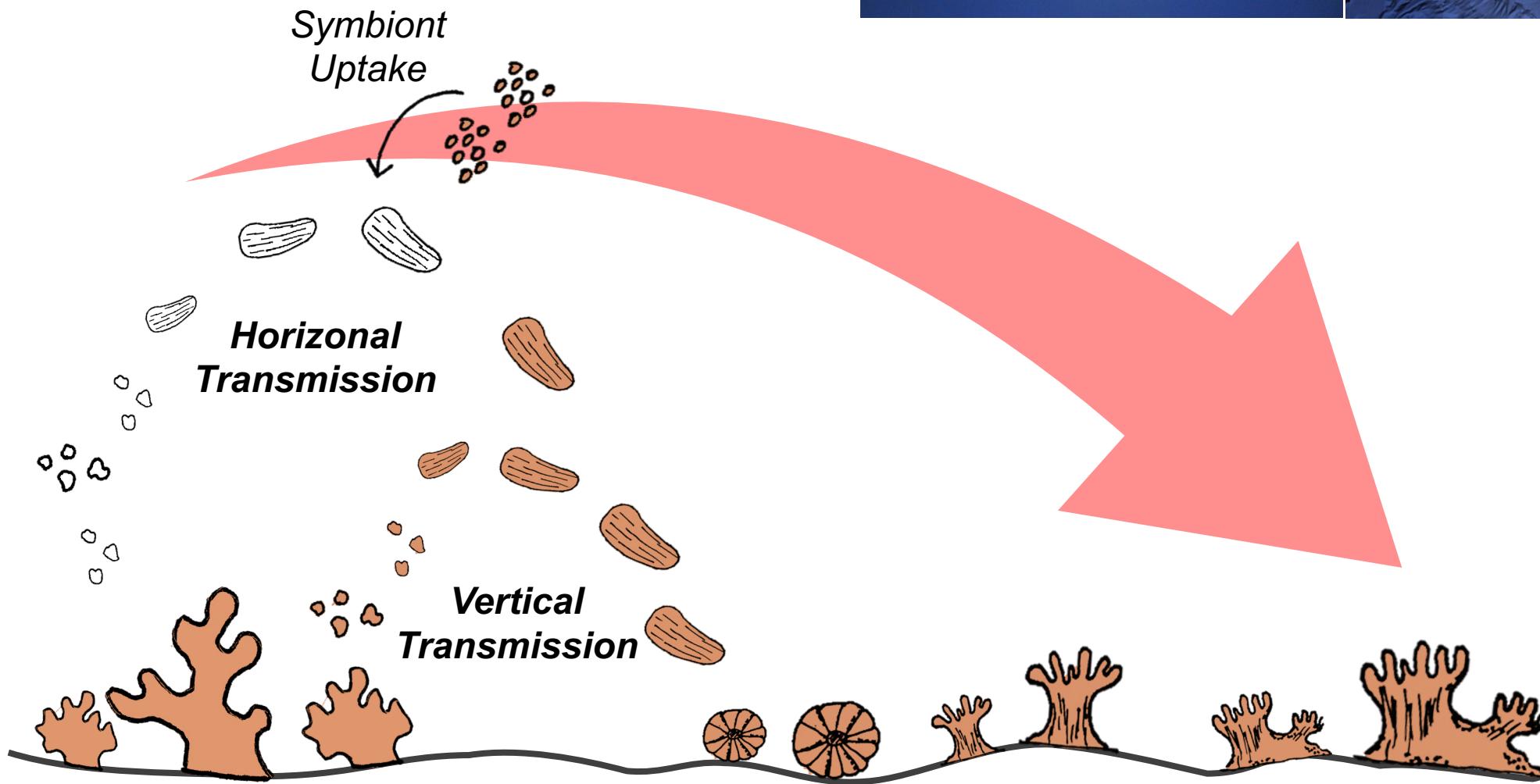


How does nutritional exchange impact energetic capacity during recruitment?



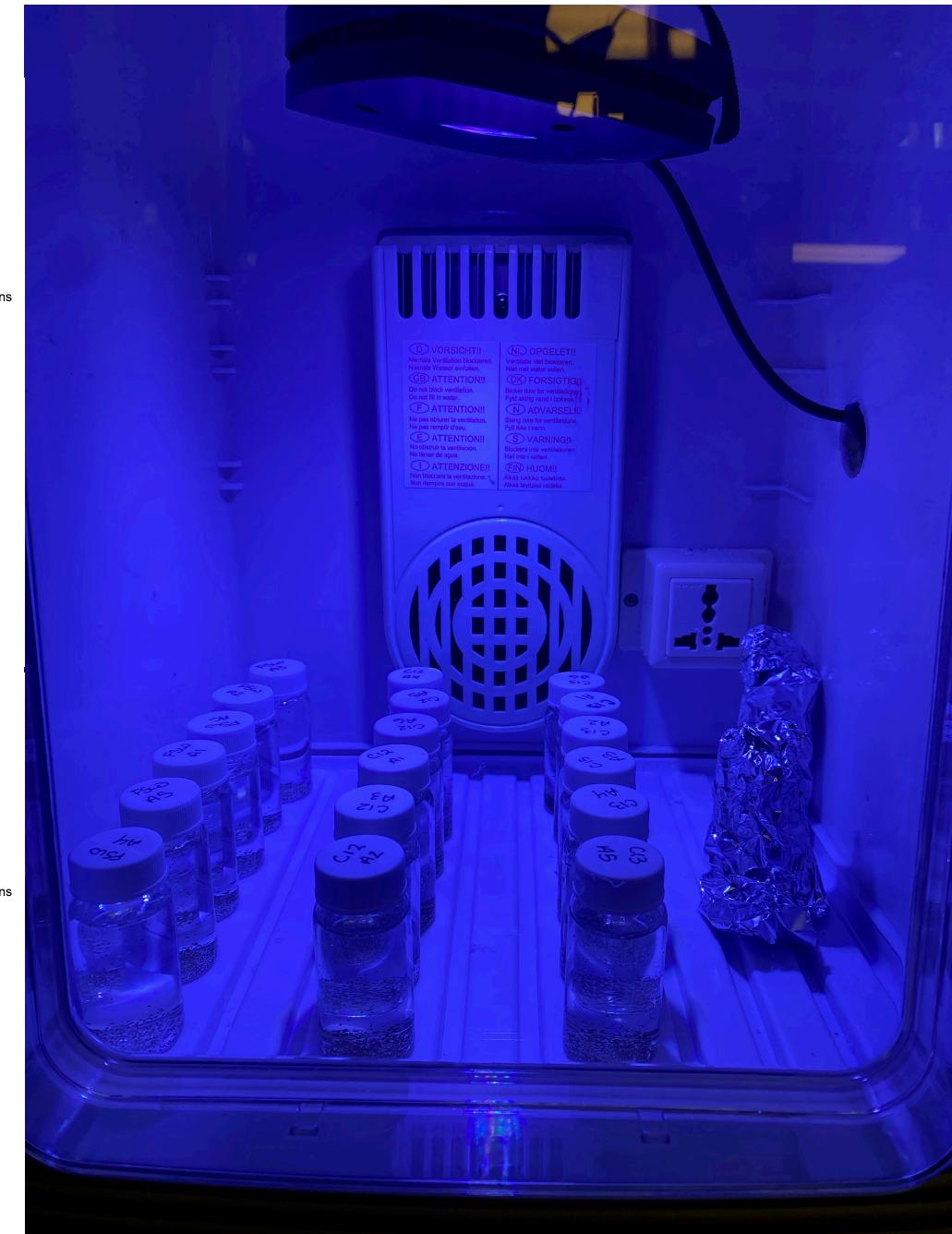
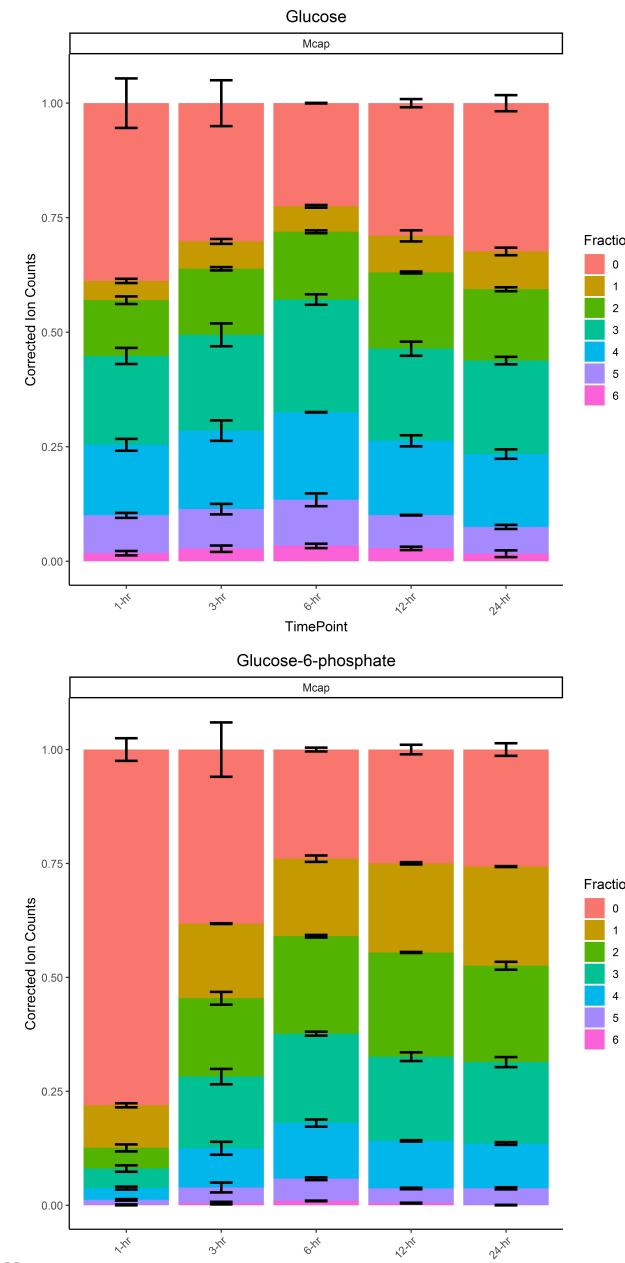


Current work: How does thermal stress impact nutritional exchange?

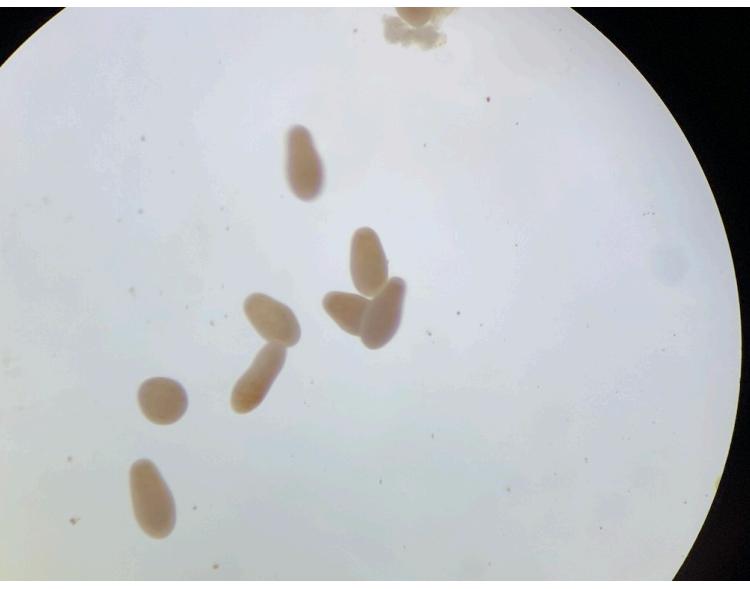
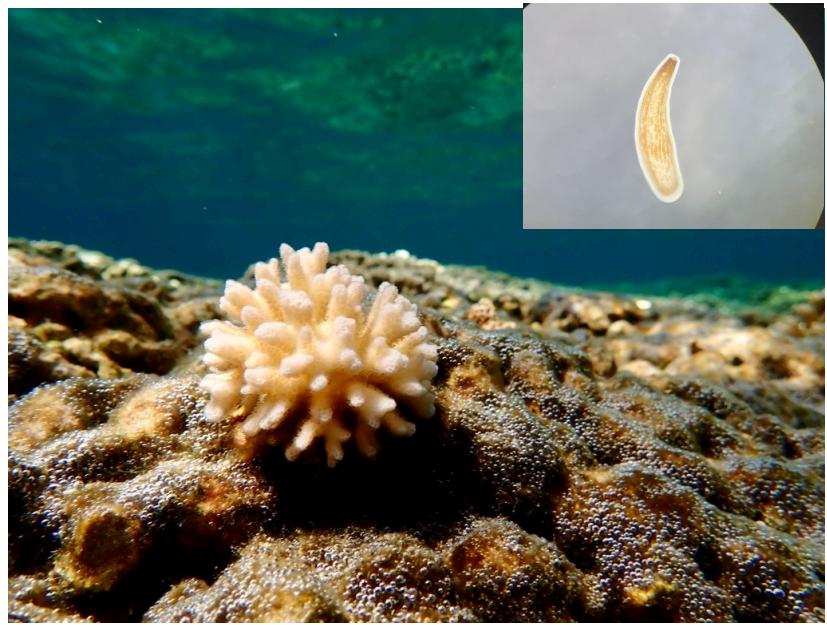


Stable isotope metabolomics

What is the identity and pool size of metabolites translocation from symbiont to host?

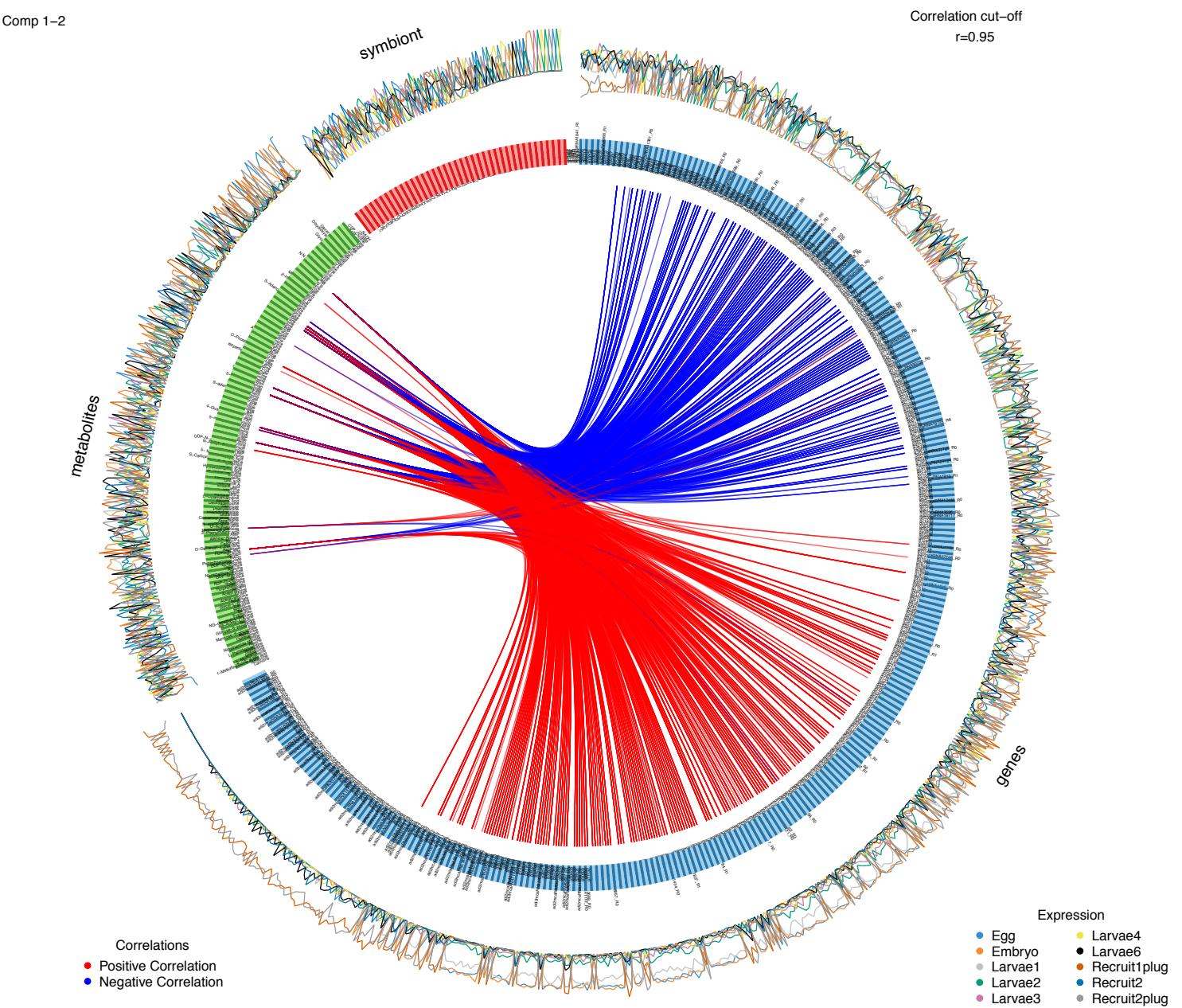


Stable isotope metabolomics



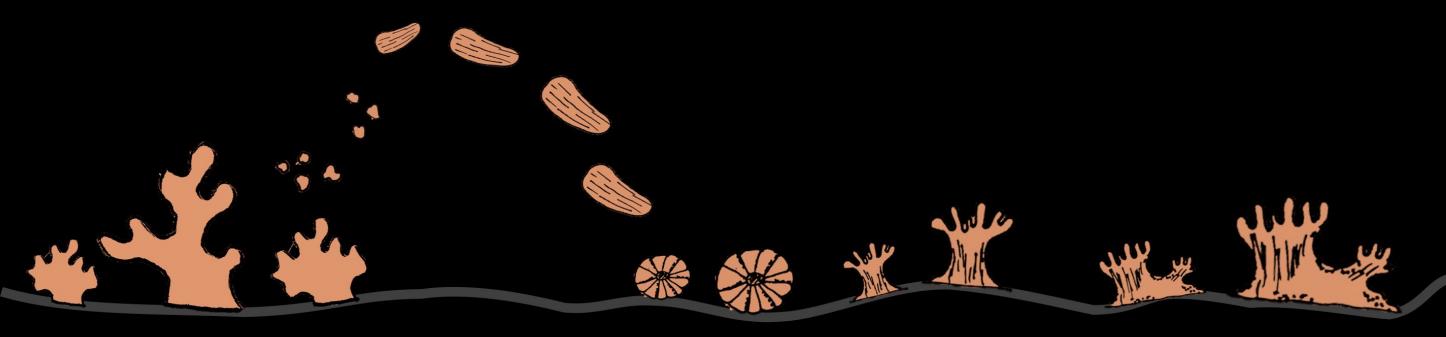
Multi-omic integration

1. Identify genes, metabolites, and microbes that are indicators of stress and development
2. Identify multi-omic holobiont responses to stress during development
3. Predict developmental phenotype under stress conditions

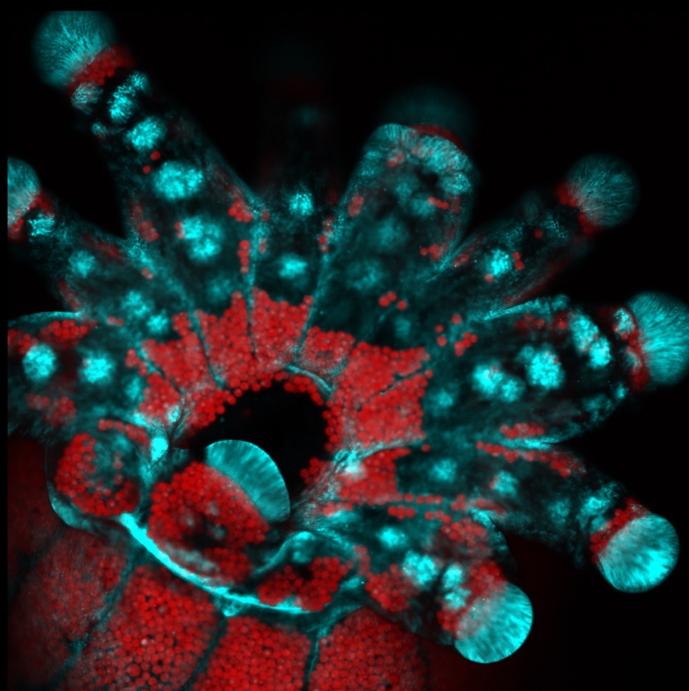


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Early life history coral reef ecophysiology and symbiosis



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