

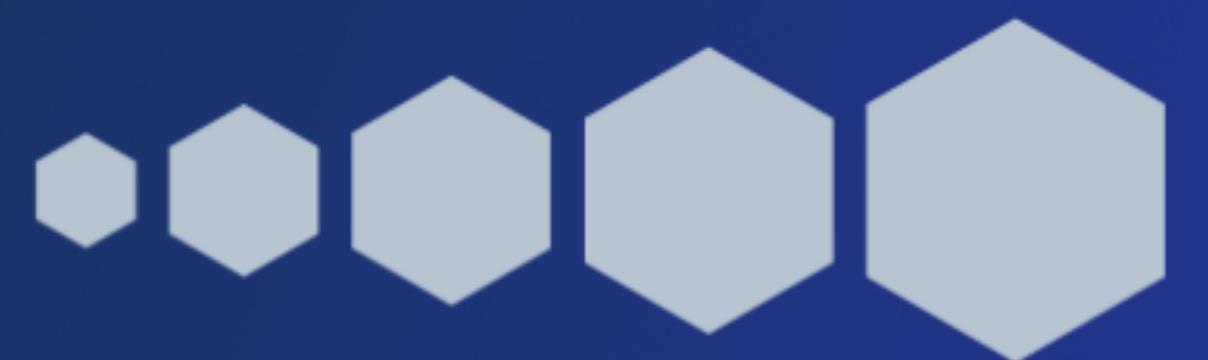
# Genomic Applications in Sustainable Aquaculture

**Steven Roberts - University of Washington**

**ROBERTSLAB.INFO**

**1<sup>er</sup> Congreso de Biología  
Experimental y Aplicada**

LA CIENCIAS DE LA VIDA A TRAVÉS DE LAS ESCALAS



# Genomic Applications in Sustainable Aquaculture

**Steven Roberts - University of Washington**

**Mackenzie Gavery - NOAA**

**Hollie Putnam - University of Rhode Island**

**Shelly Wanamaker - Glour**

**ROBERTSLAB.INFO**

**1<sup>er</sup> Congreso de Biología  
Experimental y Aplicada**  
LA CIENCIAS DE LA VIDA A TRAVÉS DE LAS ESCALAS



# Aquaculture

is key for global food production



# Environmental Challenges



Sections

The Washington Post  
*Democracy Dies in Darkness*

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Americas

## Crushing heat wave in Pacific Northwest and Canada cooked shellfish alive by the millions



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# Genomic Applications

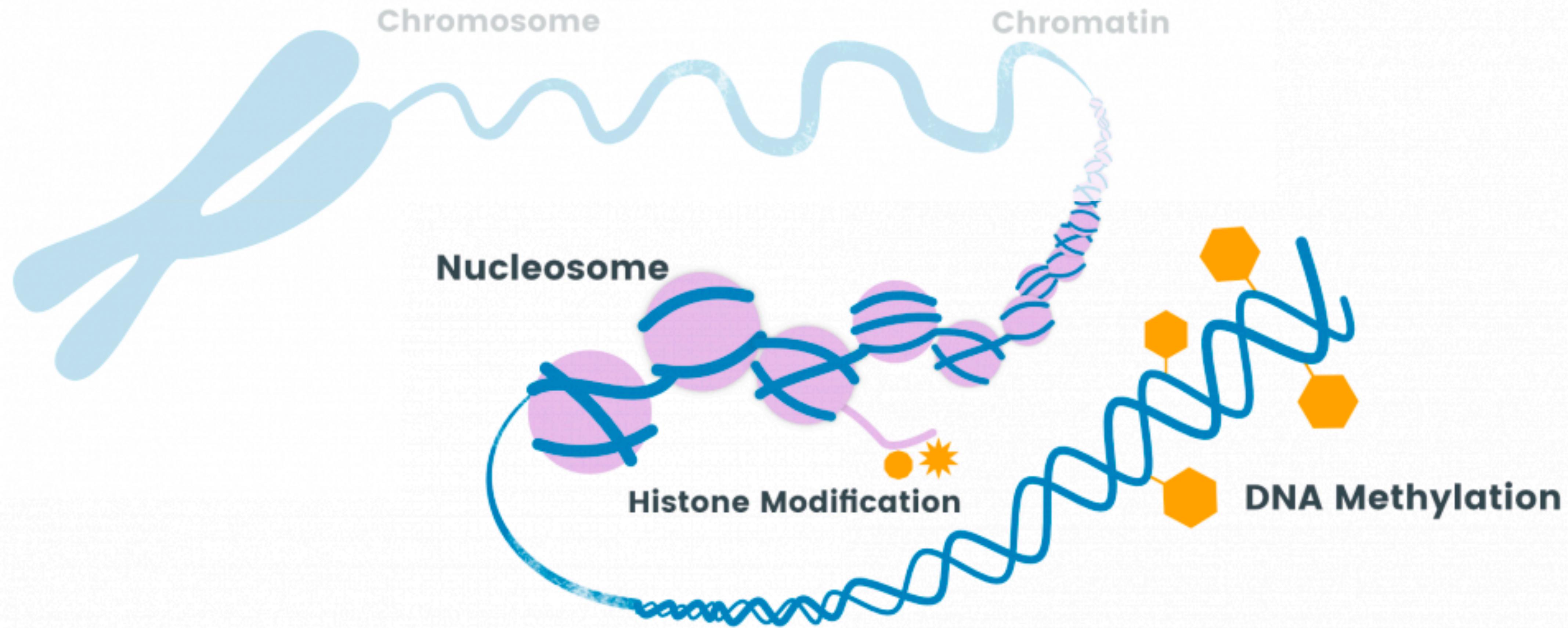
## Epigenetics – scRNASeq

- Leveraging environmental memory mechanisms to improve phenotypes
- Developing alternatives to sterility



## WHAT IS EPIGENETICS?

**ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE**



**CAN BE INDUCED WITH ENVIRONMENTAL MANIPULATION**

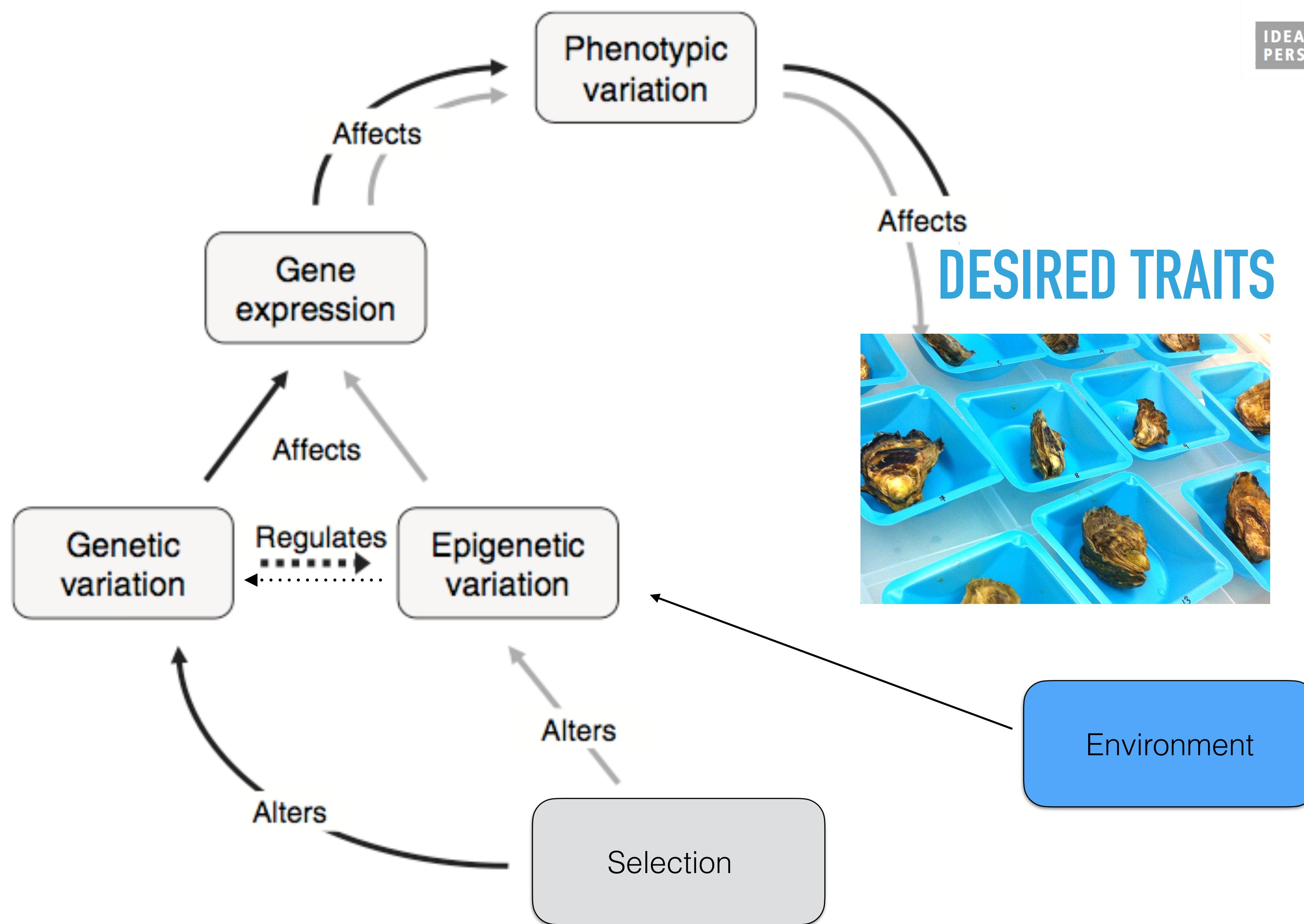
# ECOLOGICAL EPIGENETICS

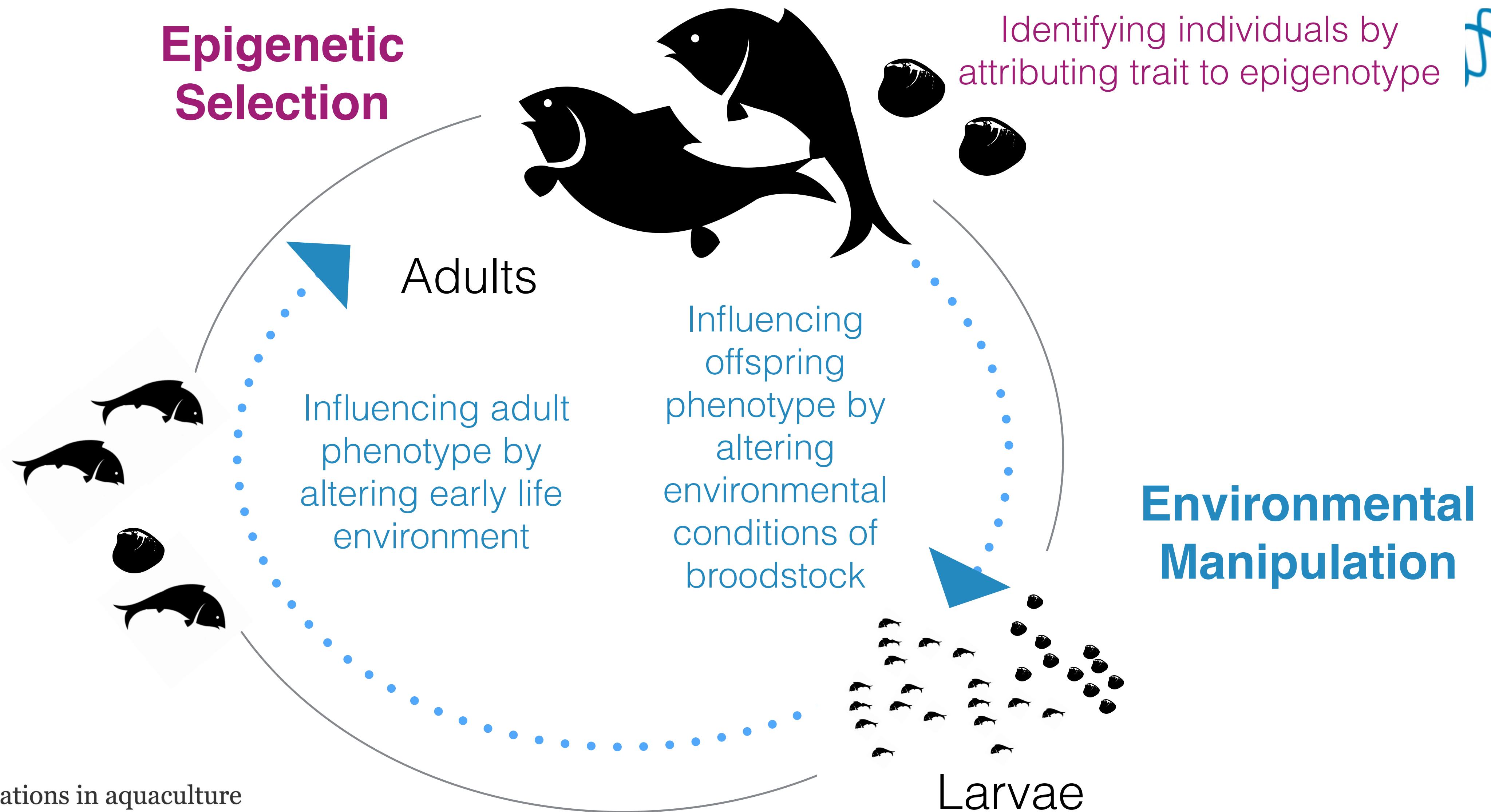
Ecology Letters, (2008) 11: 106–115

doi: 10.1111/j.1461-0248.2007.01130.x

IDEA AND  
PERSPECTIVE

Epigenetics for ecologists





✓ PEER-REVIEWED Aquatic Biology section >

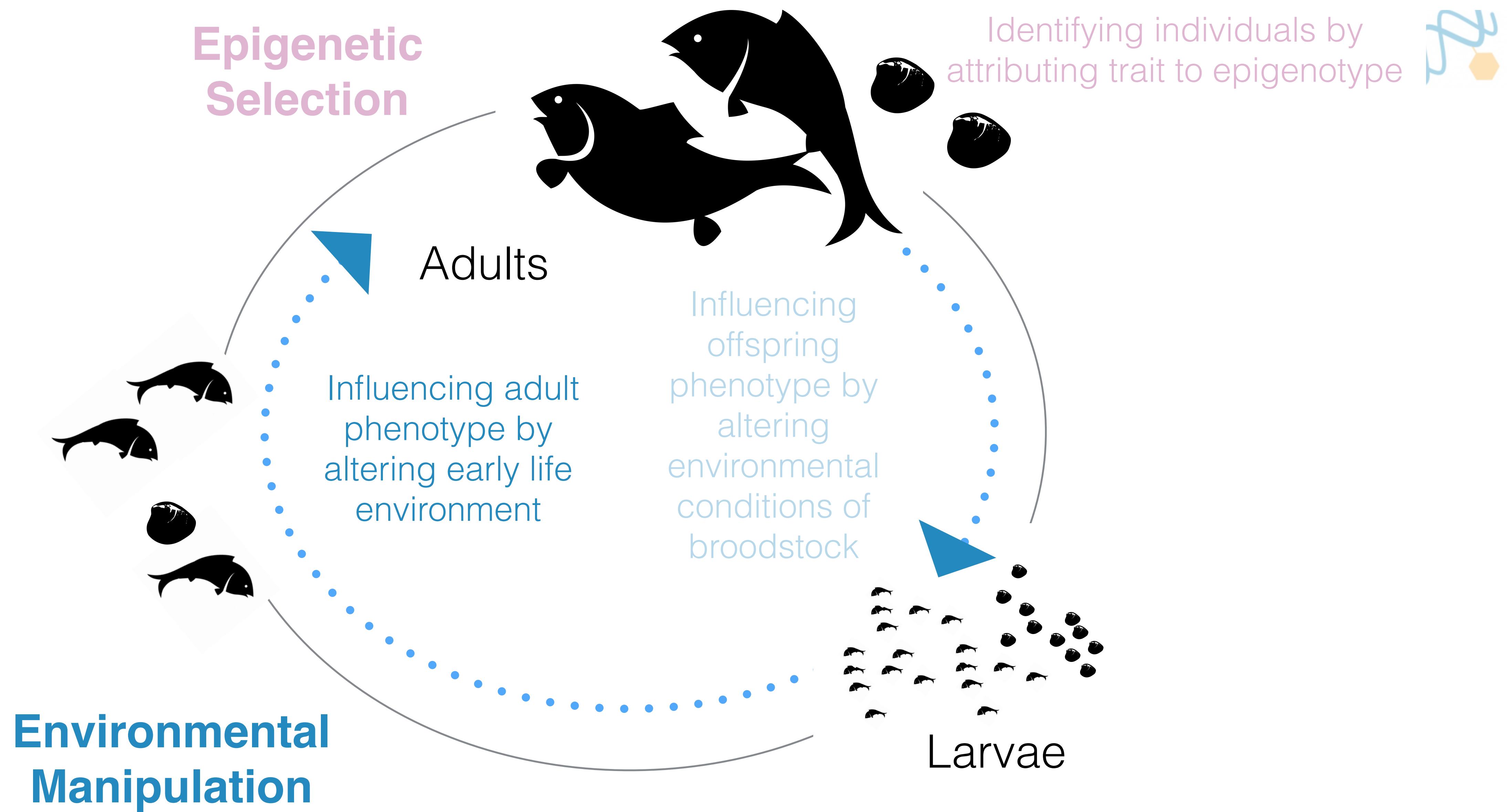
Epigenetic considerations in aquaculture

Literature review Aquaculture, Fisheries and Fish Science Molecular Biology

# DNA Methylation in Bivalves

- Early-life Environment
- Epigenetic Selection
- Future Perspectives

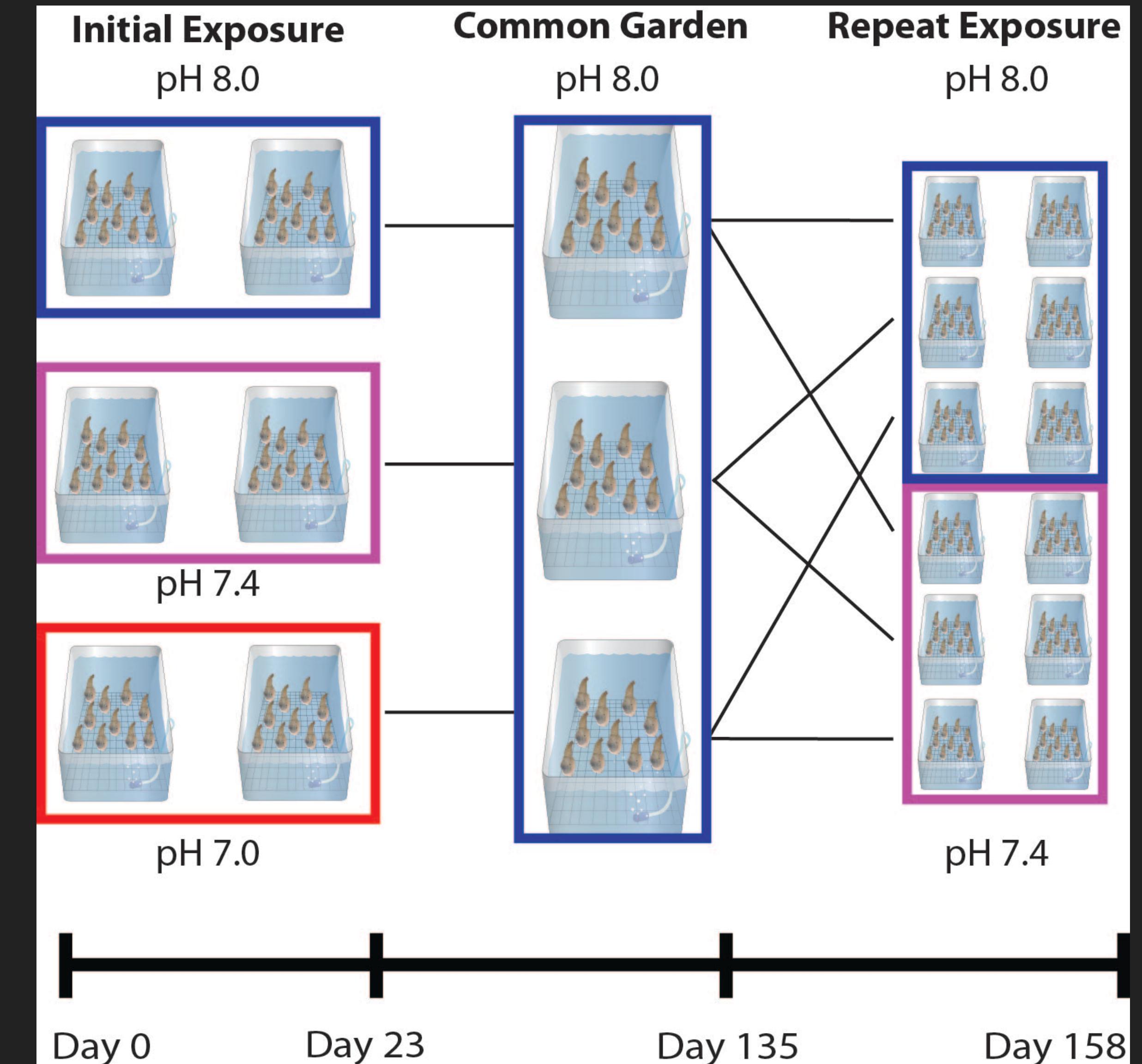




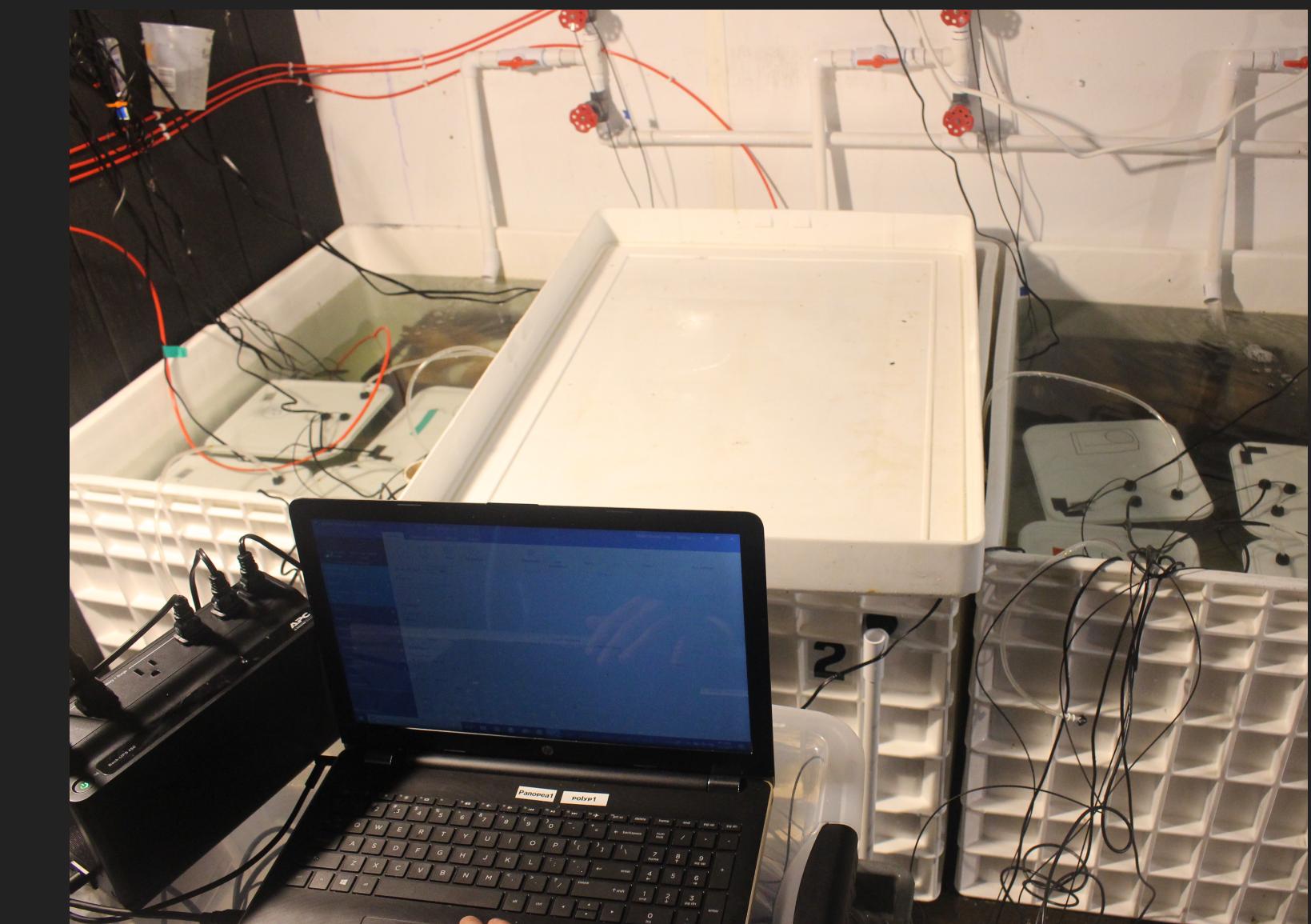
## GEODUCKS AND OA



- ▶ Does conditioning to low pH confer tolerance within a generation?

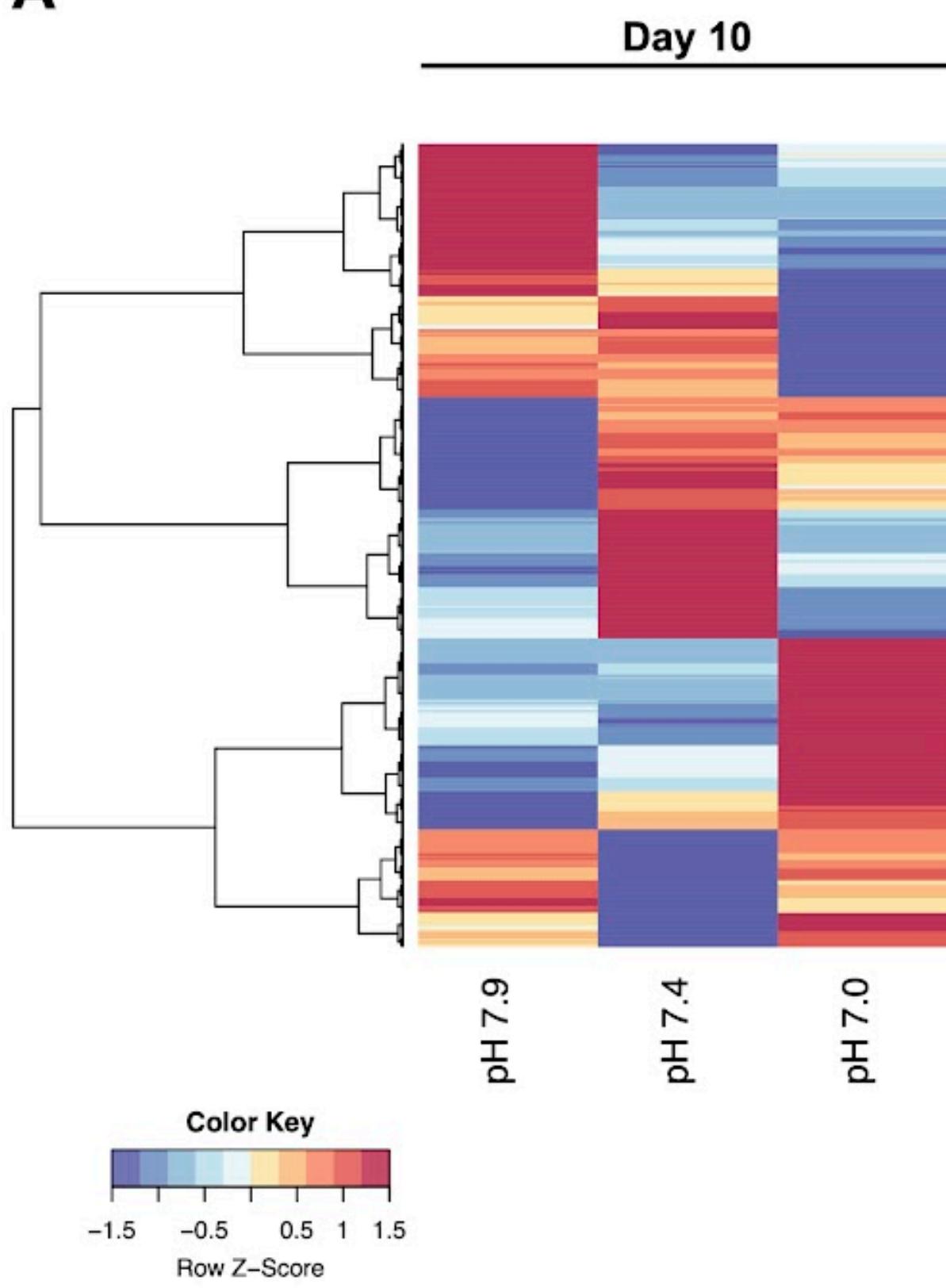


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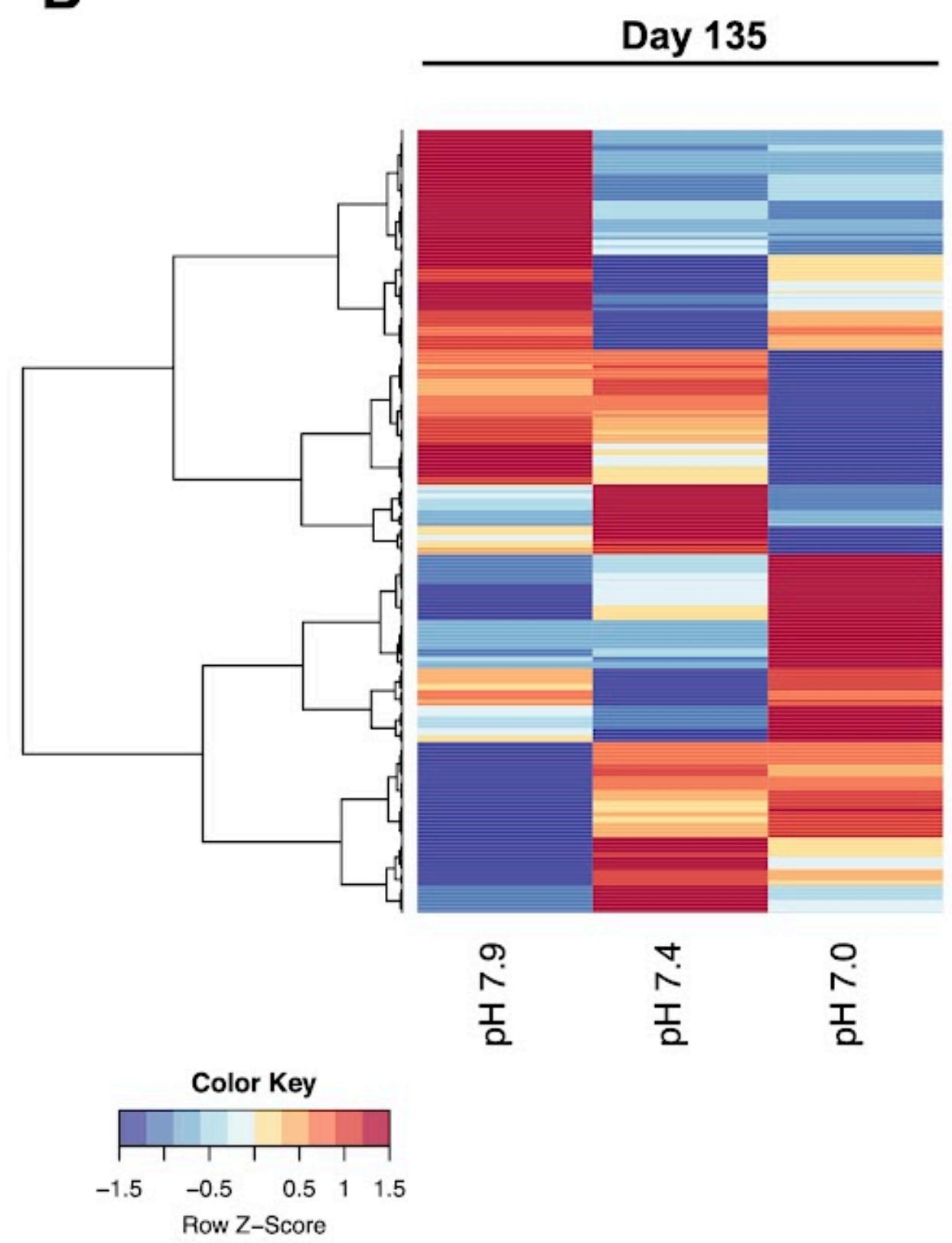


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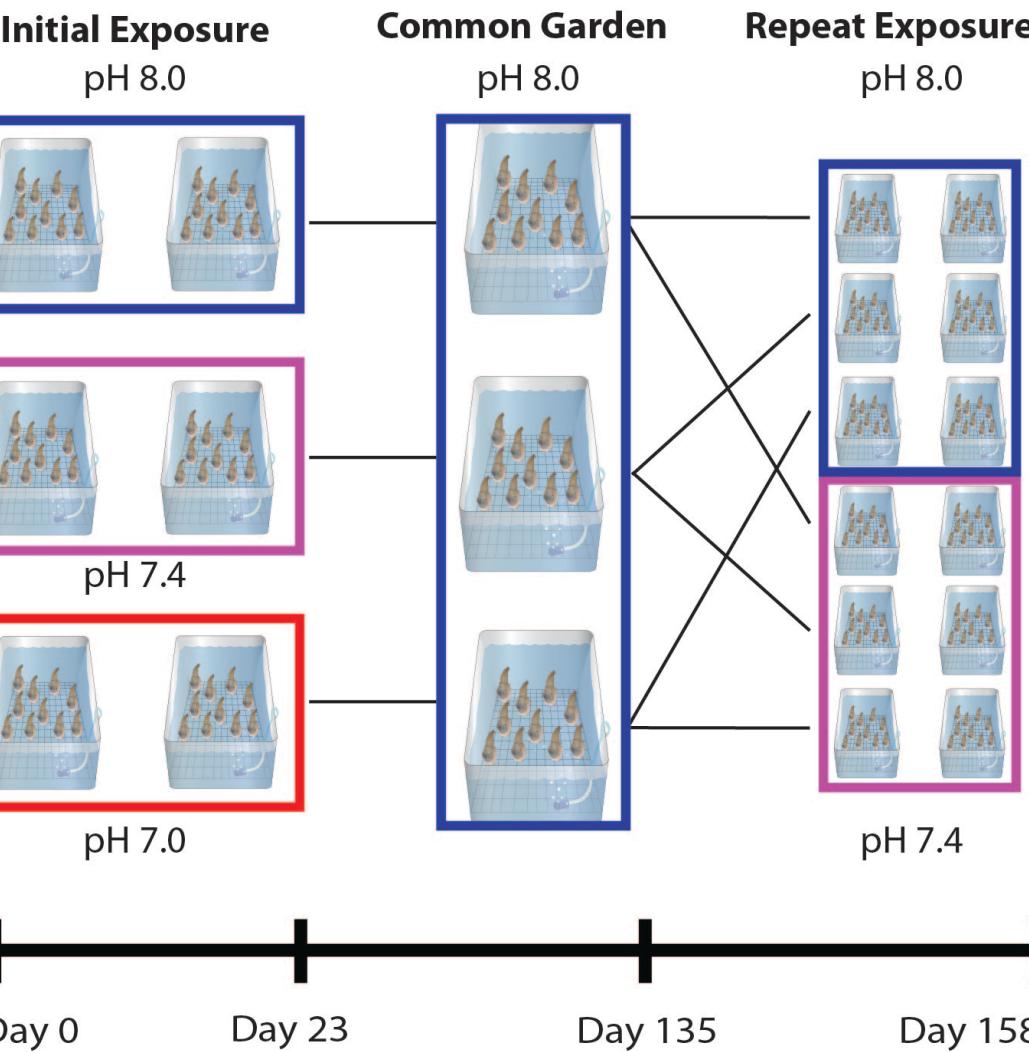
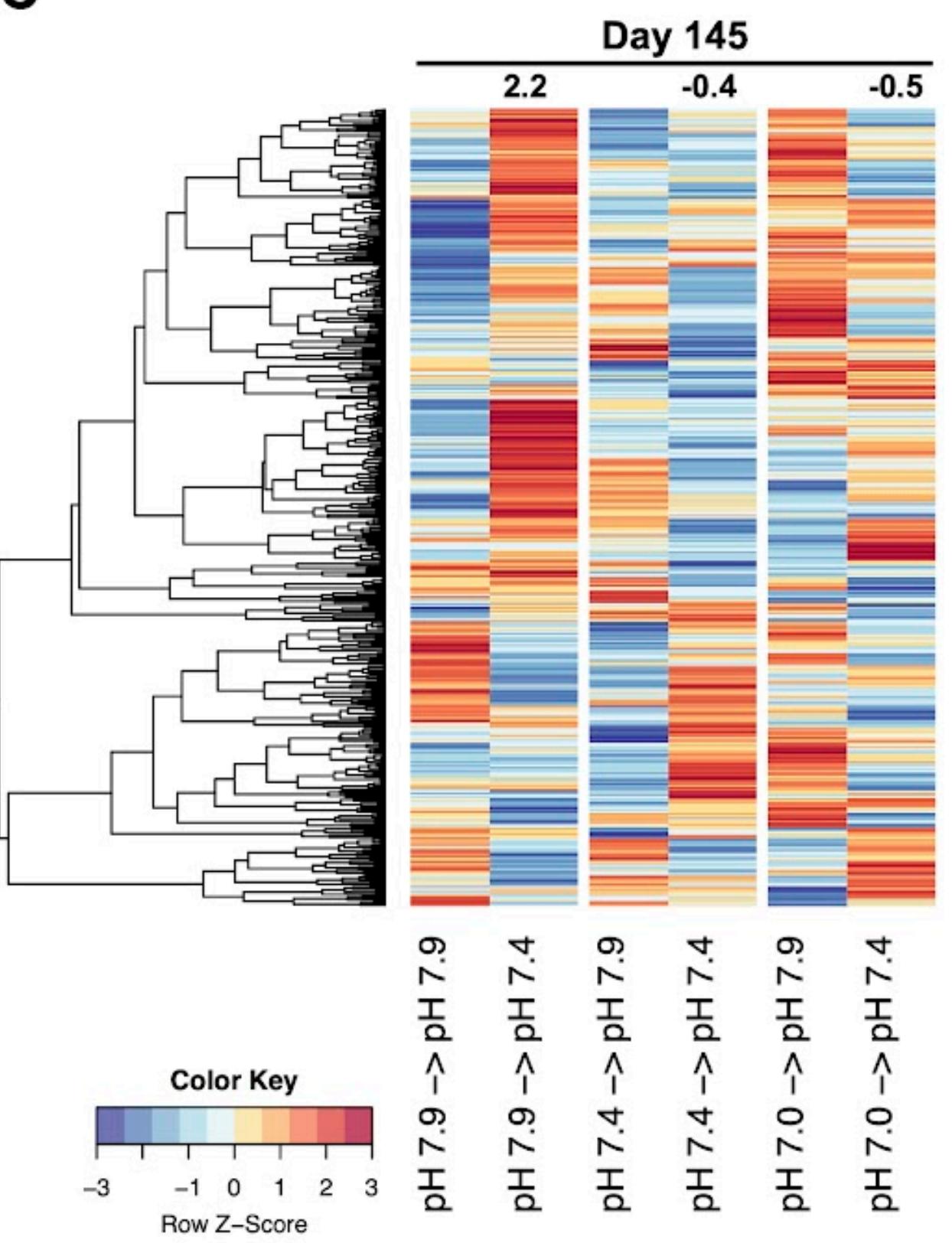
A



B



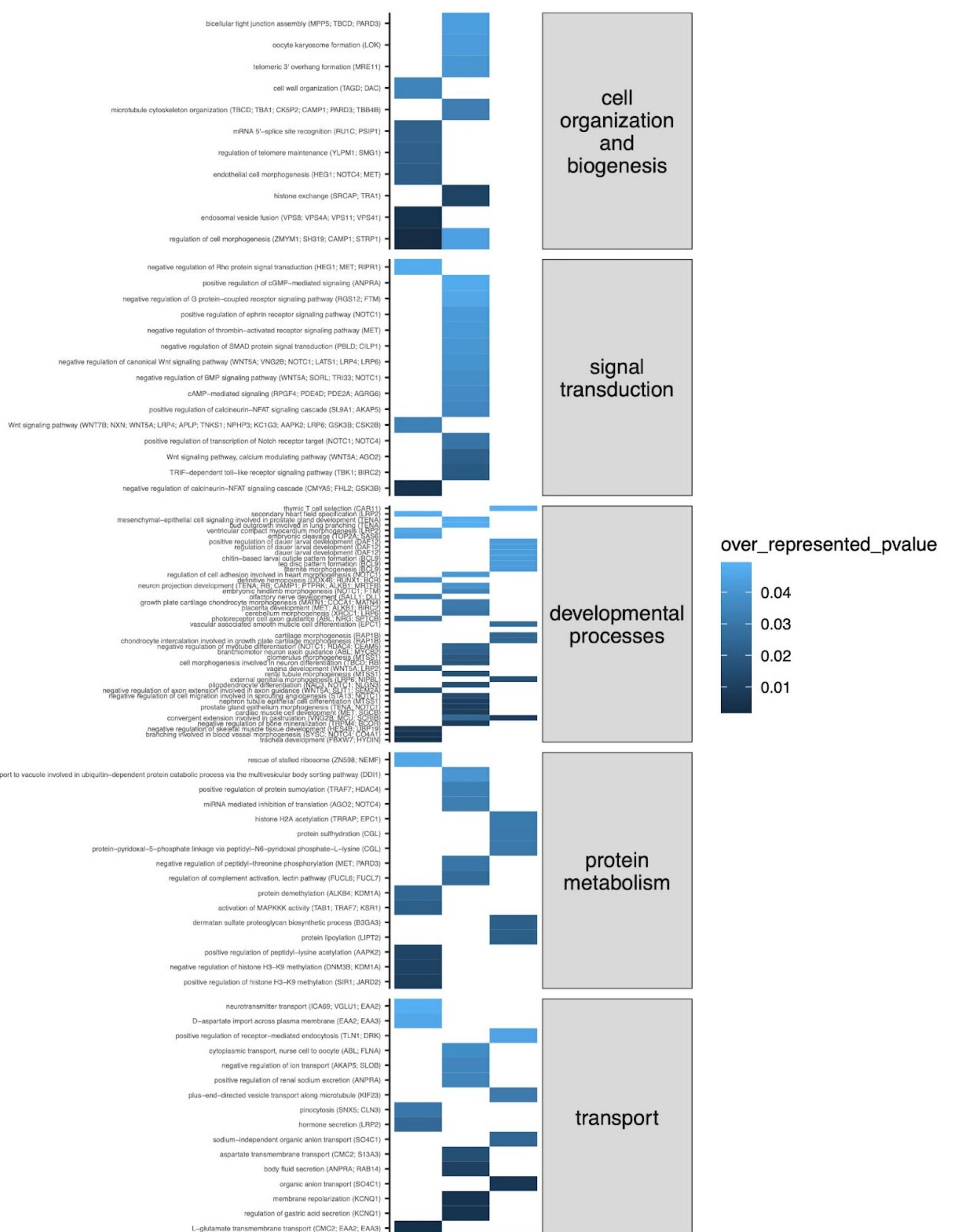
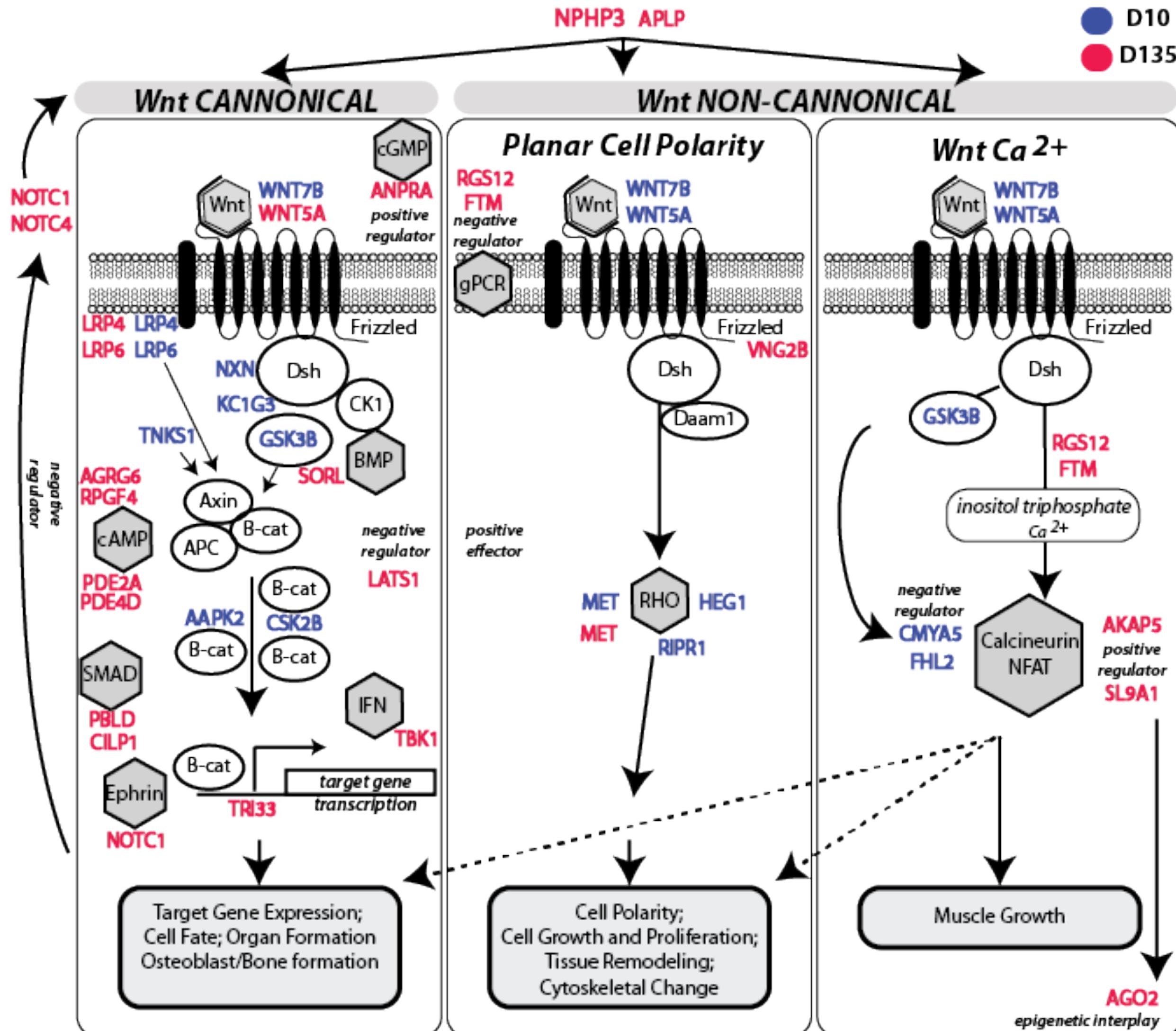
C



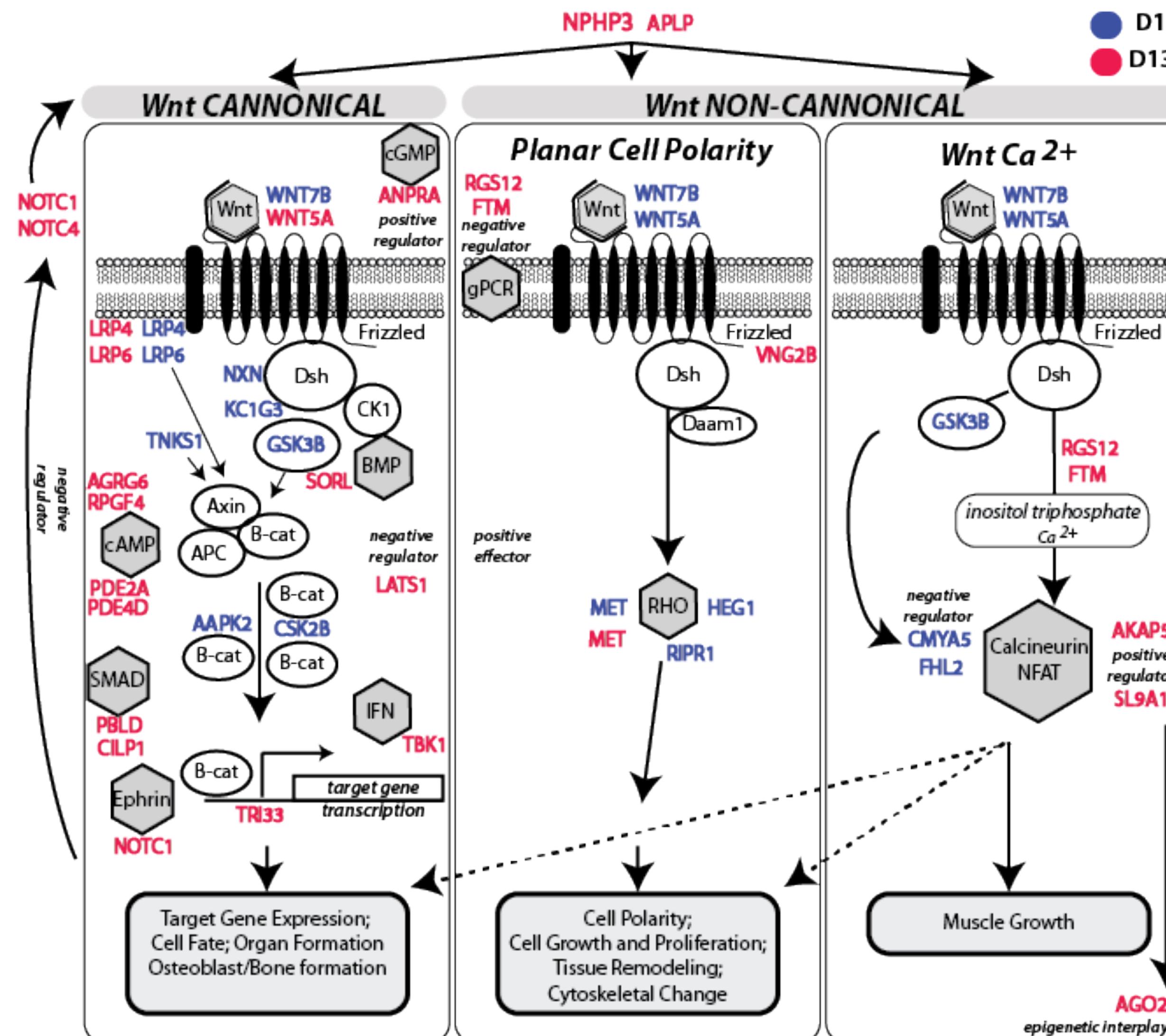
# GEODUCKS AND OA



# GEODUCKS AND OA



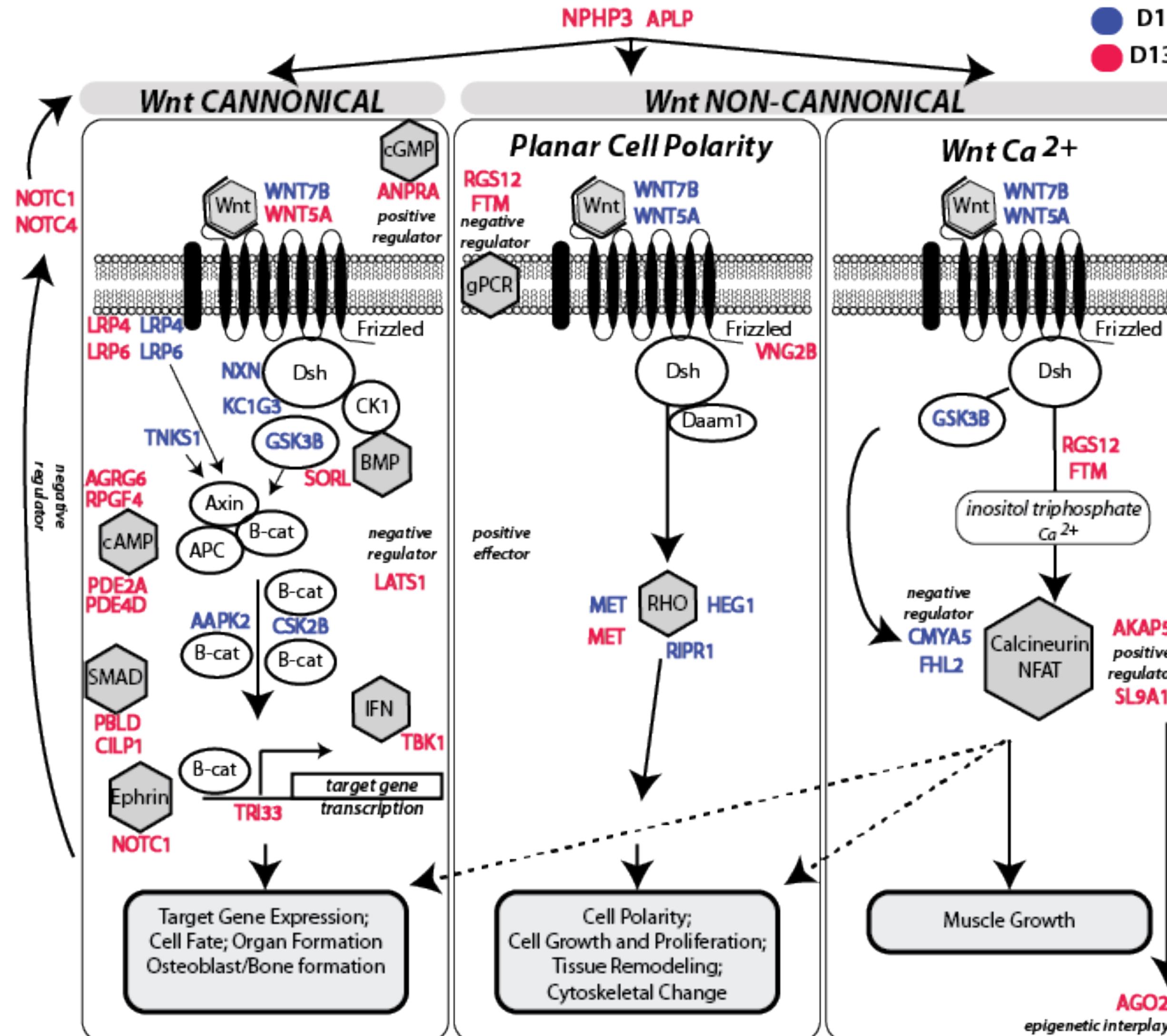
# GEODUCKS AND OA



Hollie M. Putnam, Shelly A. Trigg, Samuel J. White, Laura H. Spencer, Brent Vadopalas, Aparna Natarajan, Jonathan Hetzel, Erich Jaeger, Jonathan Soohoo, Cristian Gallardo-Escárate, Frederick W. Goetz, Steven B. Roberts

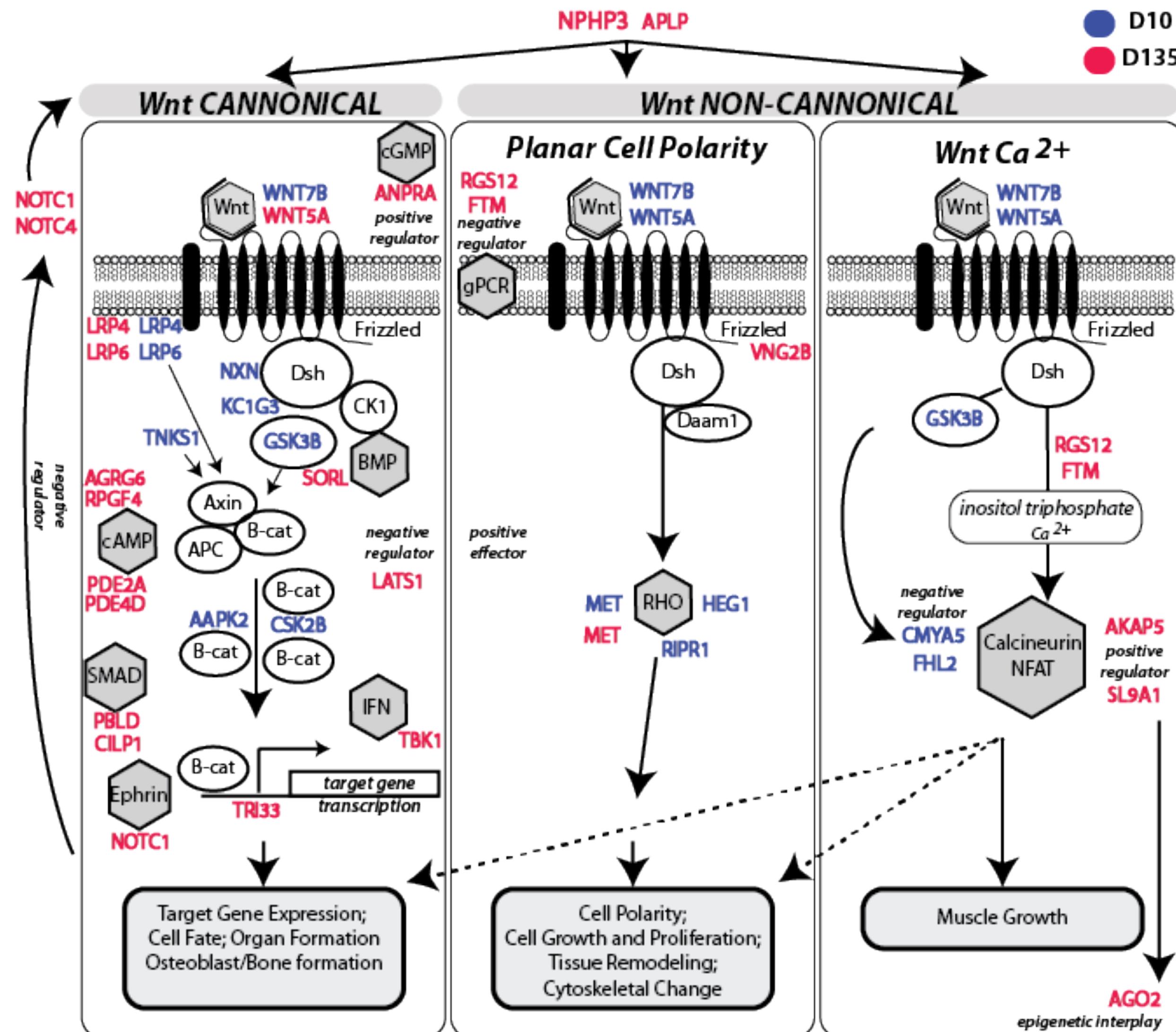
doi: <https://doi.org/10.1101/2022.06.24.497506>

# GEODUCKS AND OA



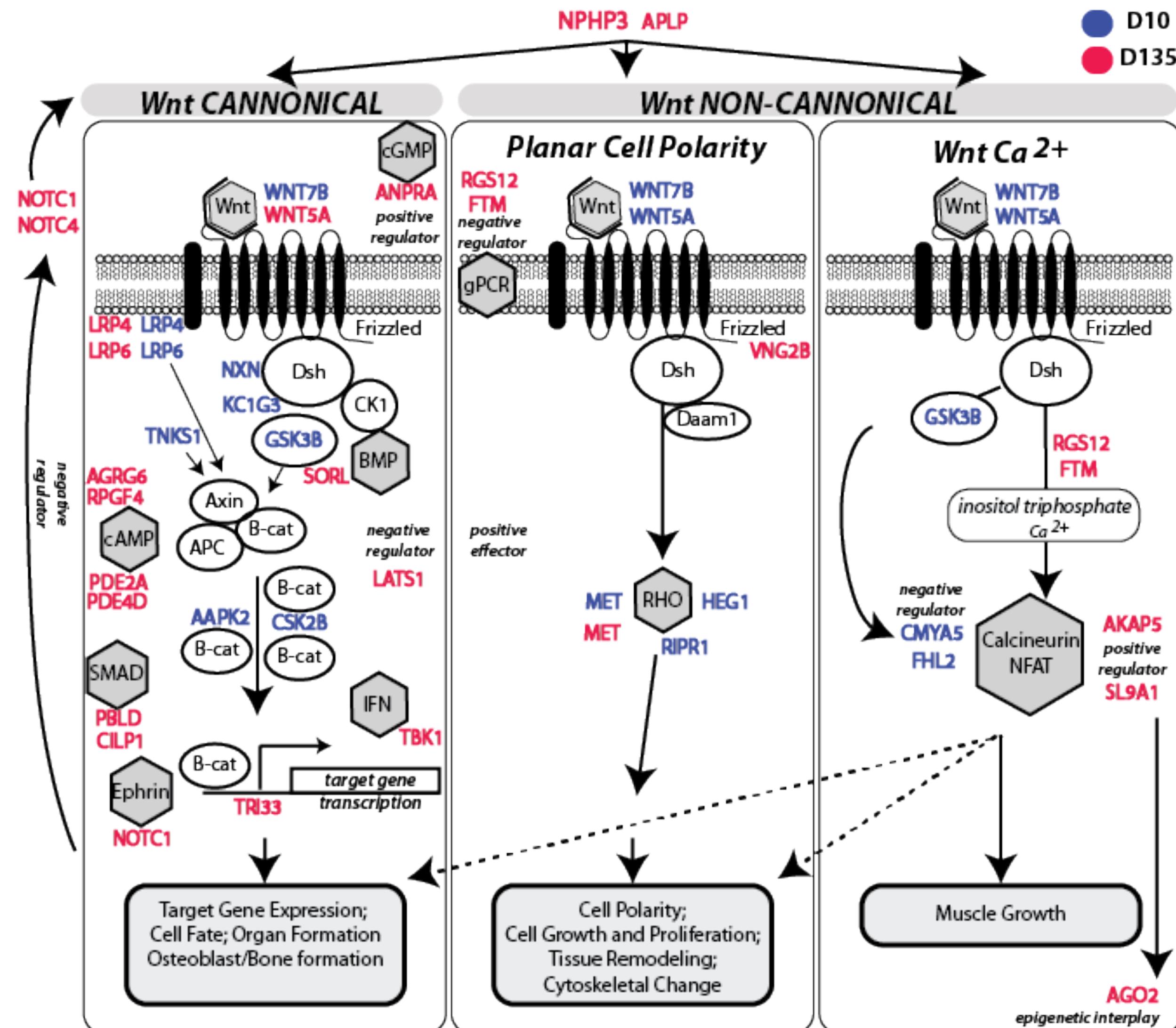
Following four months of ambient common-garden conditions, **juveniles initially exposed to low pH compensatorily grew larger**, with DNA methylation indicative of these phenotypic differences, demonstrating epigenetic carryover effects persisted months after initial exposure.

# GEODUCKS AND OA



Functional enrichment analysis of differentially methylated genes revealed regulation of signal transduction through widespread changes in the **Wnt signaling pathways that influence cell growth, proliferation, tissue and skeletal formation, and cytoskeletal change.**

# GEODUCKS AND OA

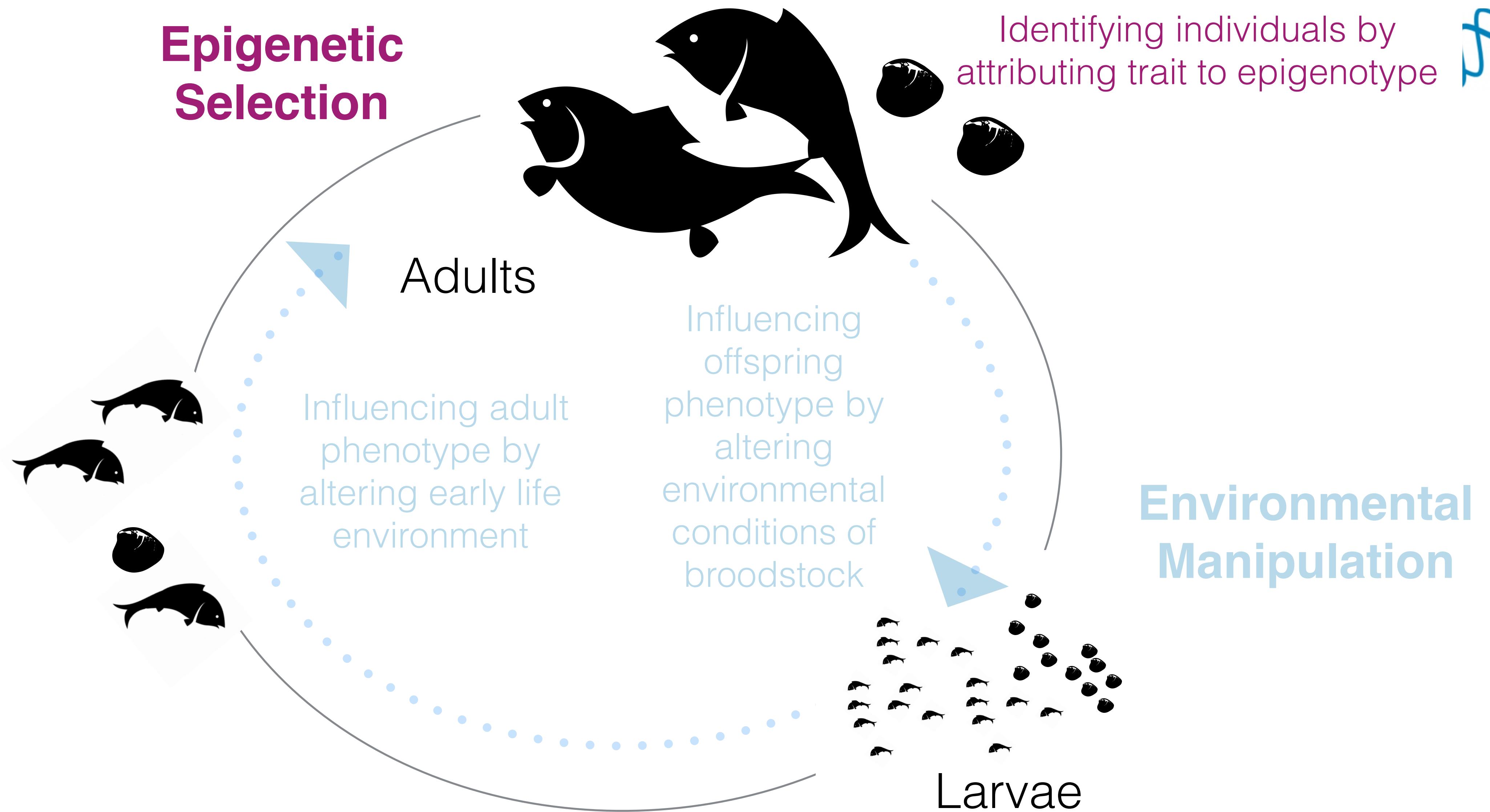


After 10 days of secondary exposure to pH 7.4, naive juvenile clams were more sensitive to low pH compared to those initially exposed, showing reduced growth and having nearly a 2-fold greater change in DNA methylation.

# DNA Methylation in Bivalves

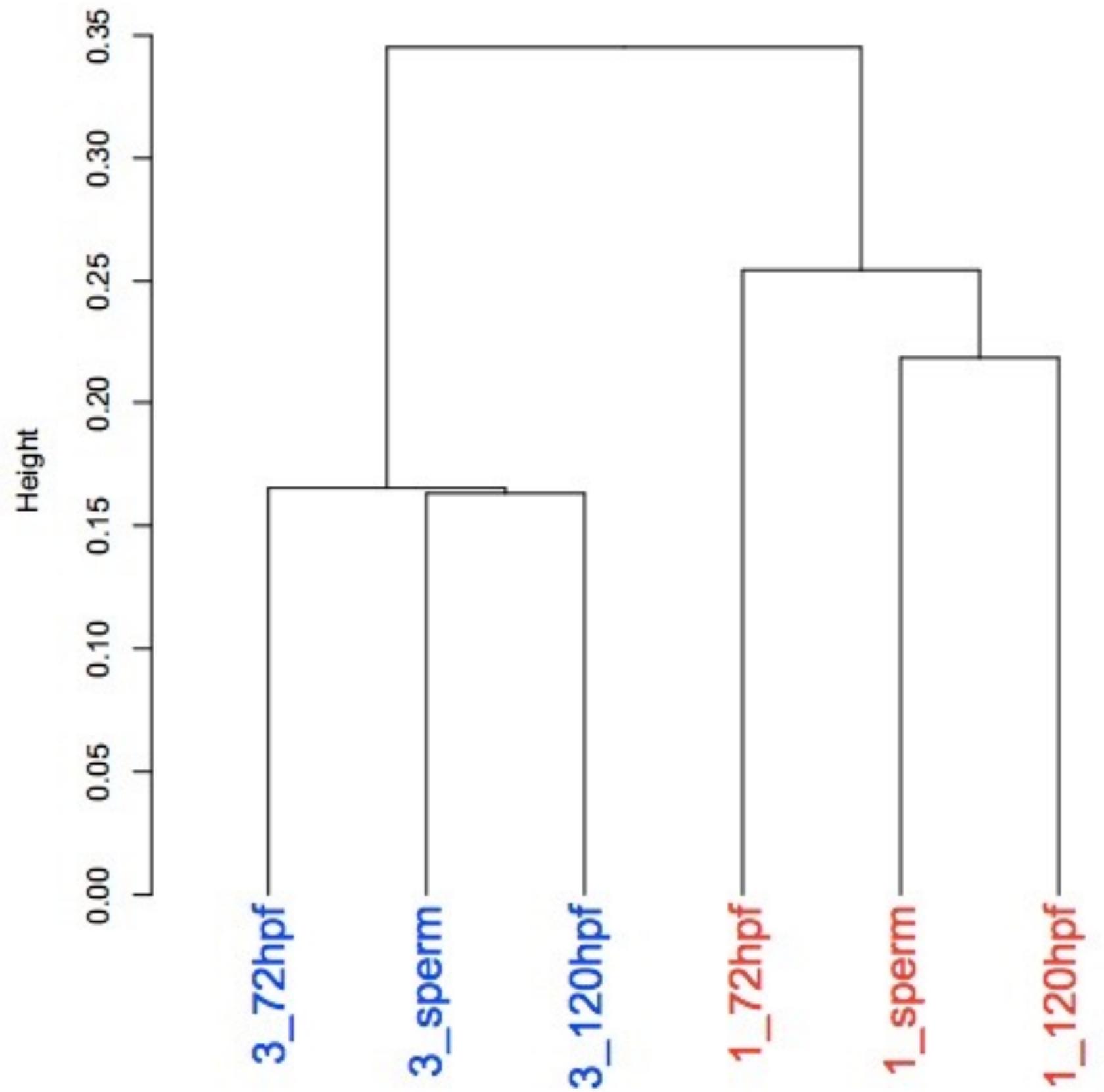
- Early-life Environment
- **Epigenetic Selection**
- Future Perspectives





# SELECTION POTENTIAL

CpG methylation clustering



New Results

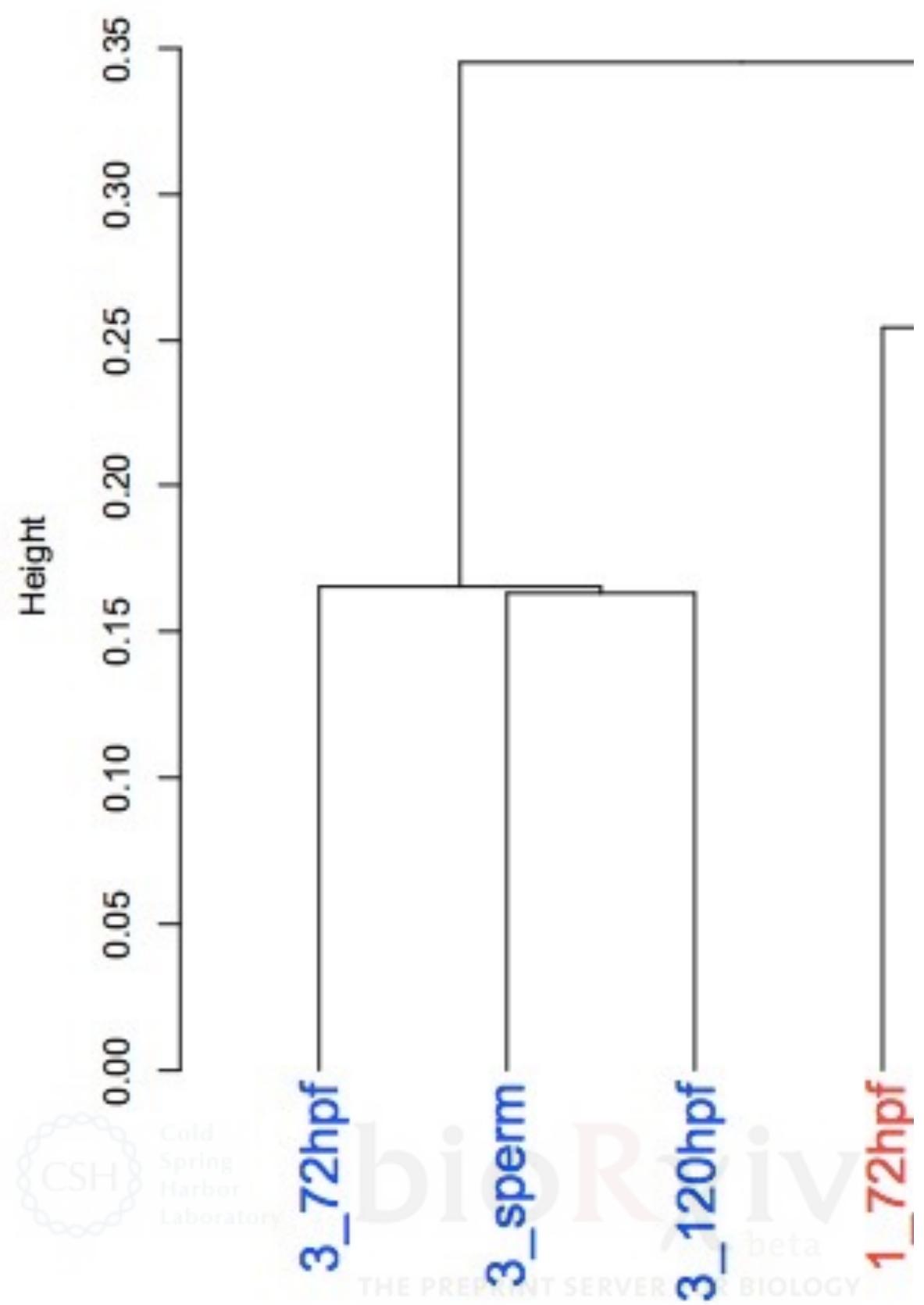
**Indication of family-specific DNA methylation patterns in developing oysters**

Claire E. Olson , Steven B. Roberts

doi: <http://dx.doi.org/10.1101/012831>

# SELECTION POTENTIAL

CpG methylation clu



Cold  
Spring  
Harbor  
Laboratory  
bioRxiv  
beta  
THE PREPRINT SERVER FOR BIOLOGY

New Results

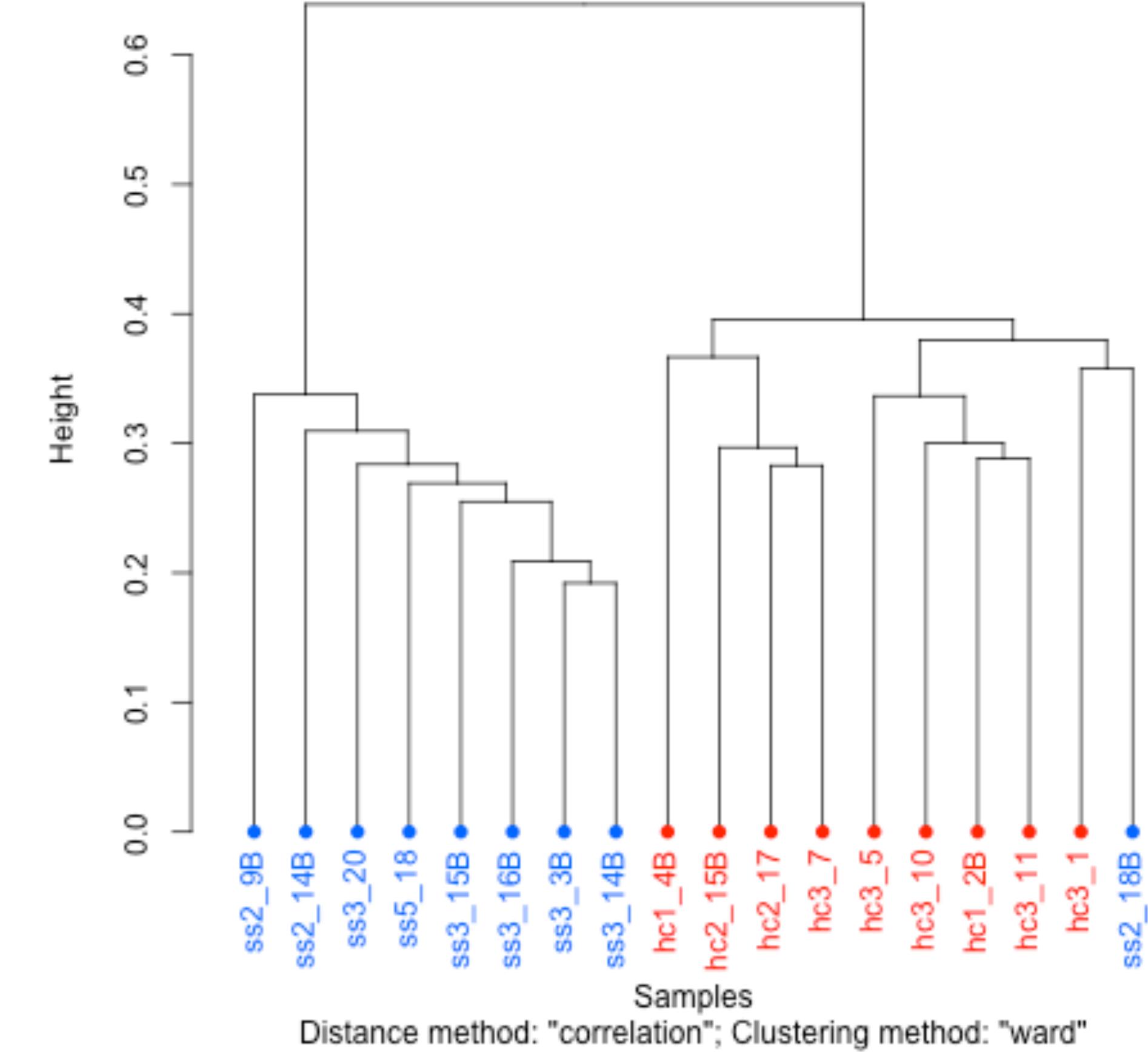
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CpG methylation clustering

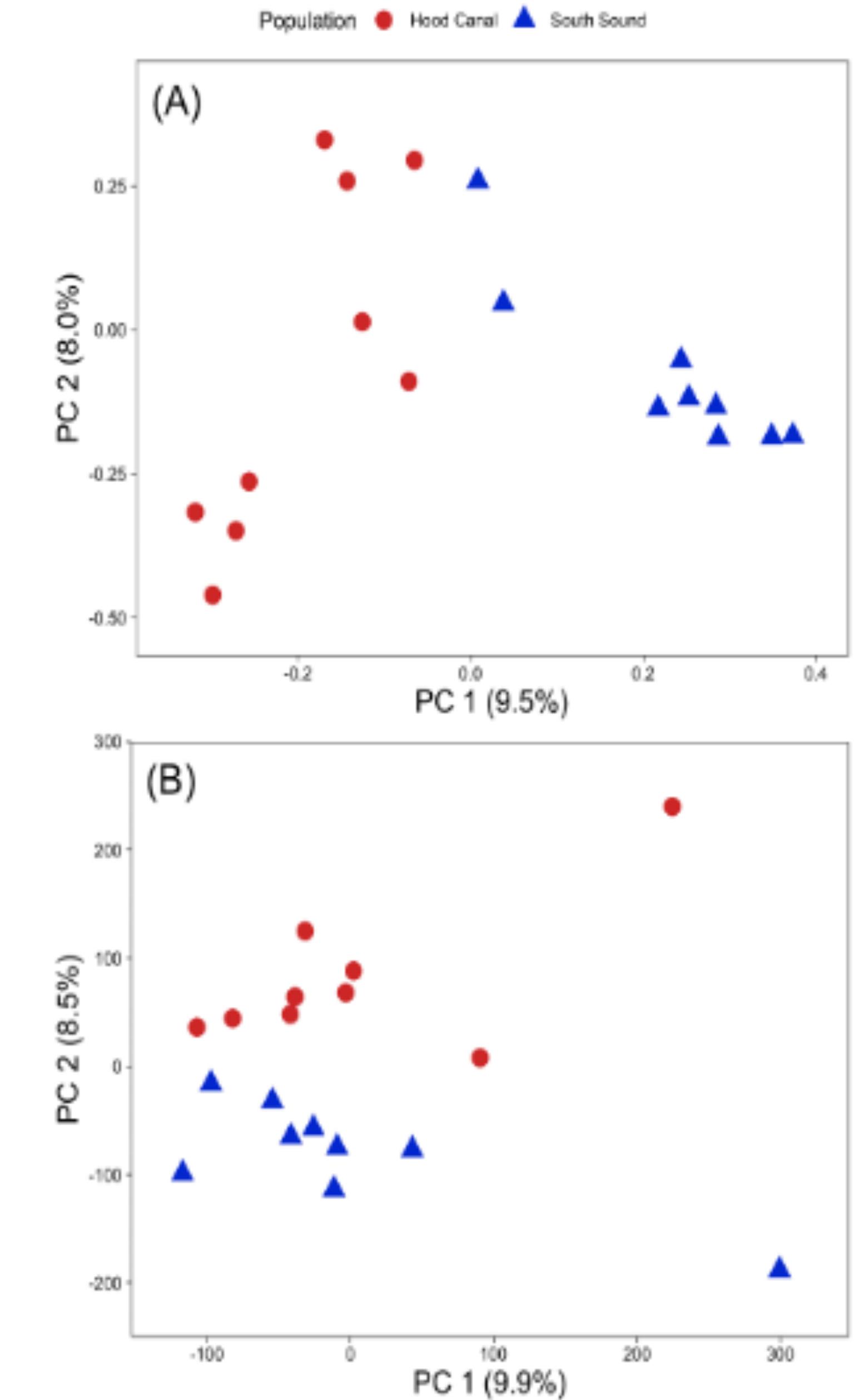


# EPIGENETIC AND GENETIC POPULATION STRUCTURE

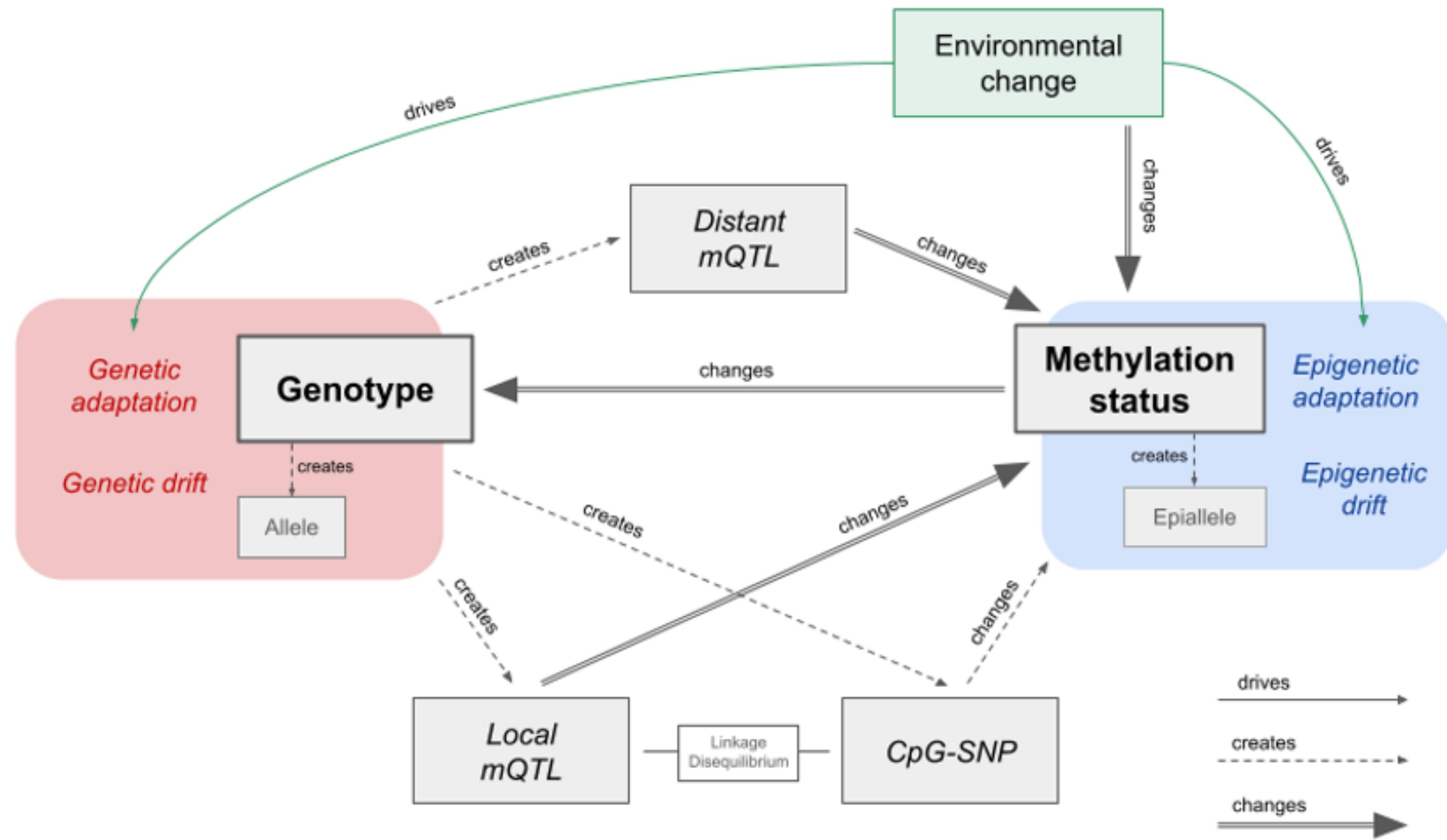
First characterization of genome-wide DNA methylation patterns in the oyster genus *Ostrea*

Identified 3,963 differentially methylated loci between populations. Clear coupling between genetic and epigenetic patterns of variation, **with 27% of variation in inter-individual methylation differences explained by genotype.**

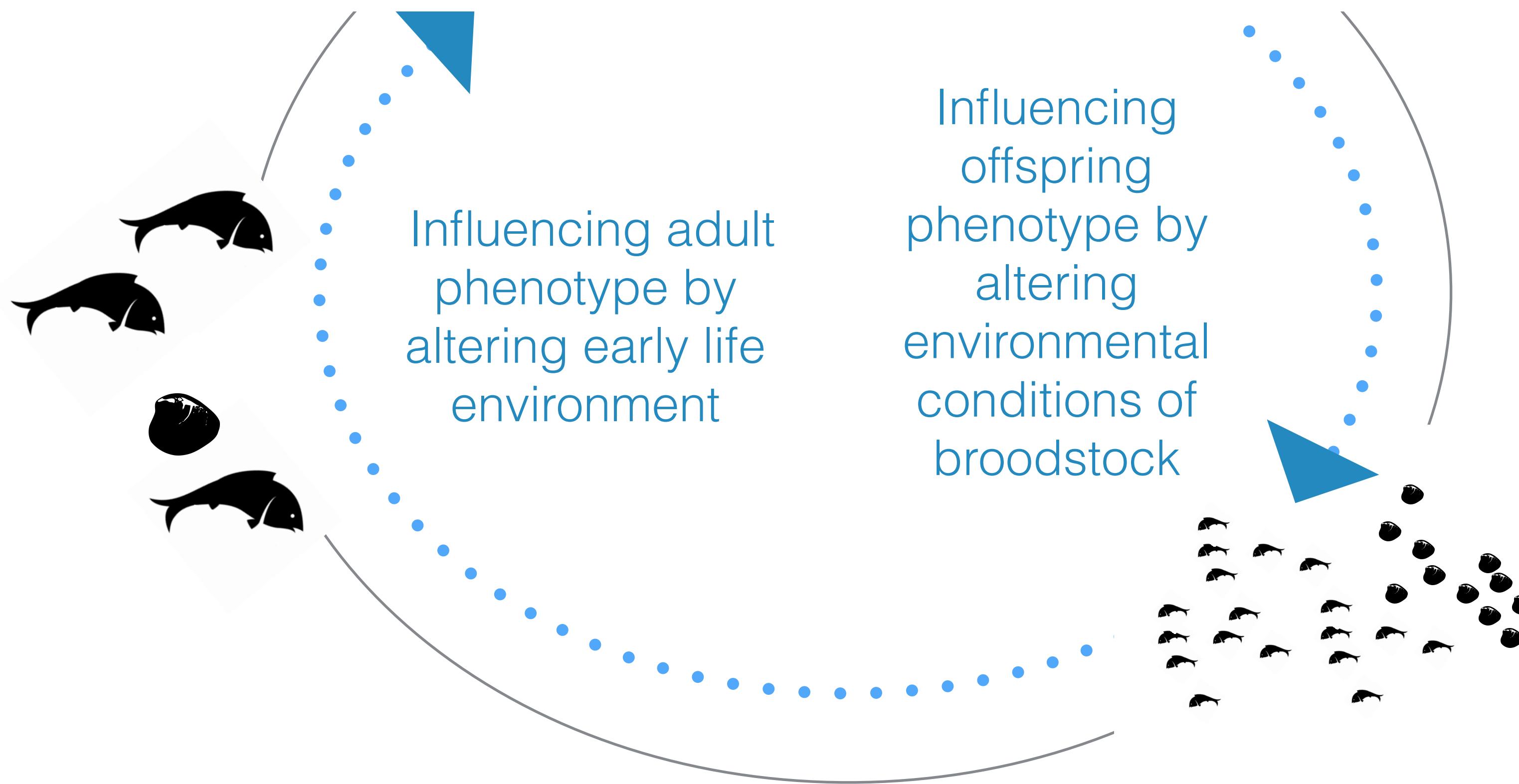
Underlying this association are both direct genetic changes in CpGs (CpG-SNPs) and genetic variation with indirect influence on methylation (mQTLs).



# EPIGENETIC AND GENETIC POPULATION STRUCTURE



## Epigenetics is an attractive lens through which to consider manipulation of traits through environmental memory or selection.



# Genomic Applications

## Epigenetics – scRNASeq

- Leveraging environmental memory mechanisms to improve phenotypes
- Developing alternatives to sterility (Gavery)



# Environmental Challenges



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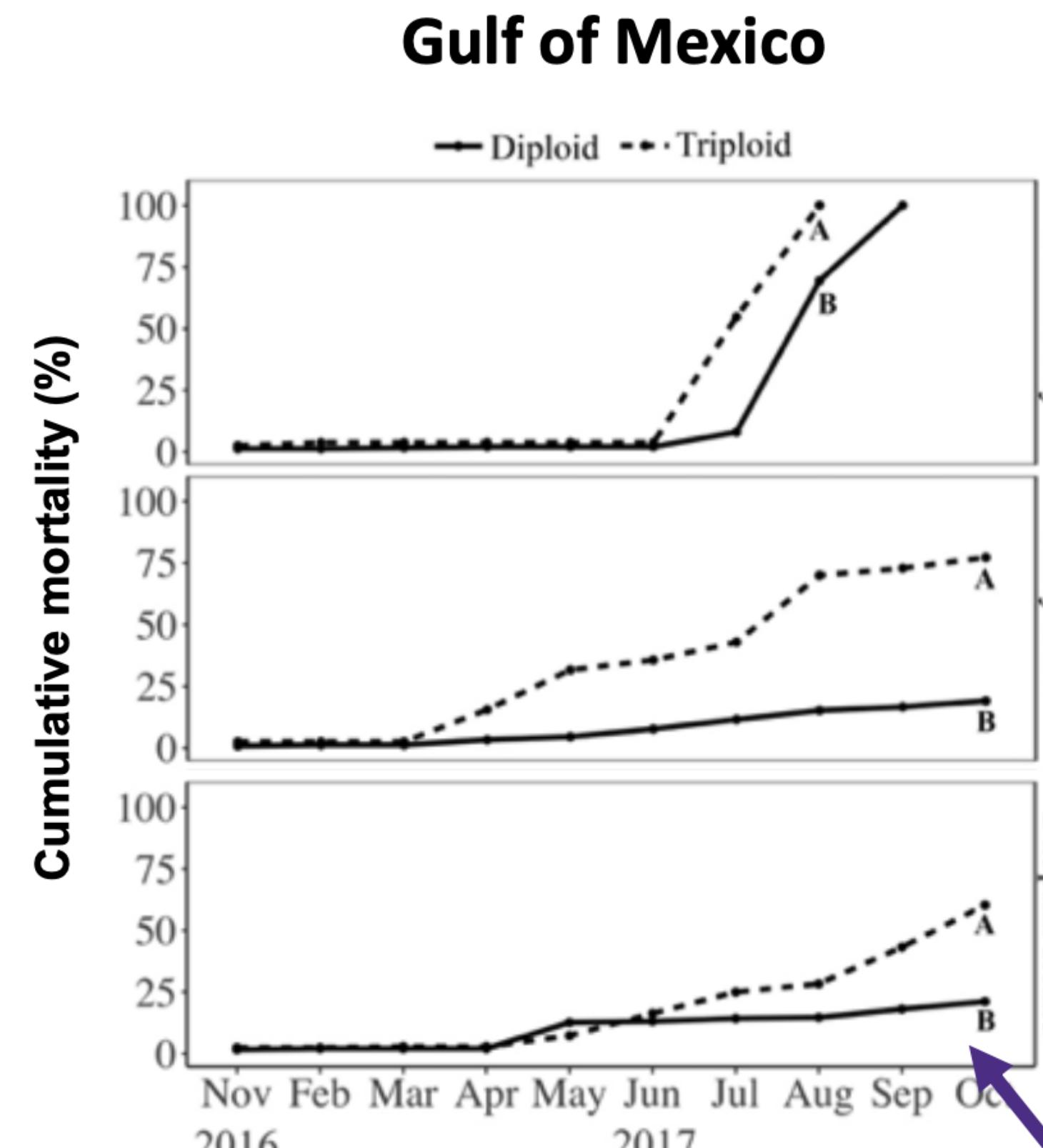


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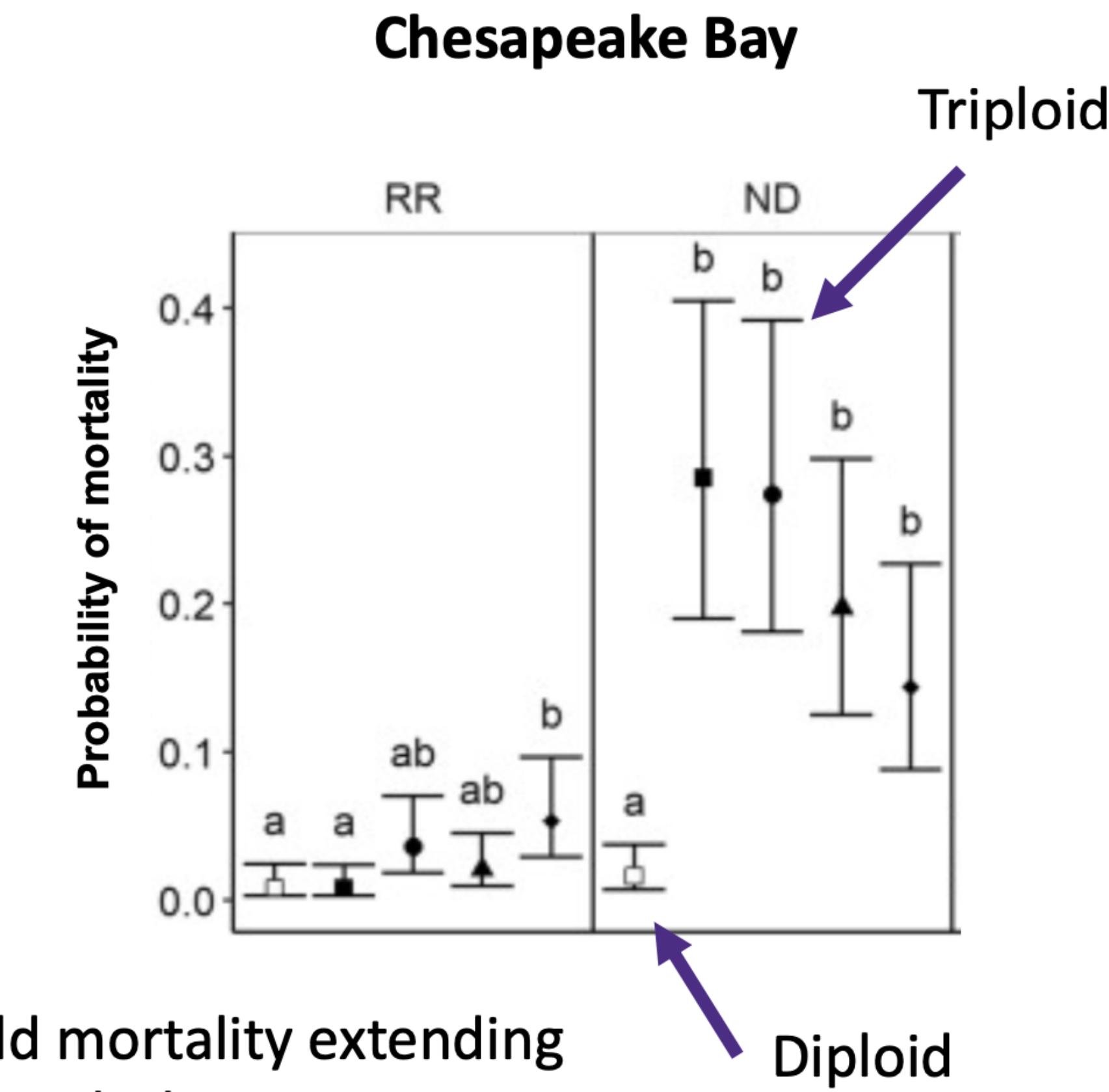


Matt George - UW

# Triploid Oysters are more susceptible Summer Mortality Syndrome



Field mortality extending  
through the summer



# Benefits of Sterility

Improved Growth



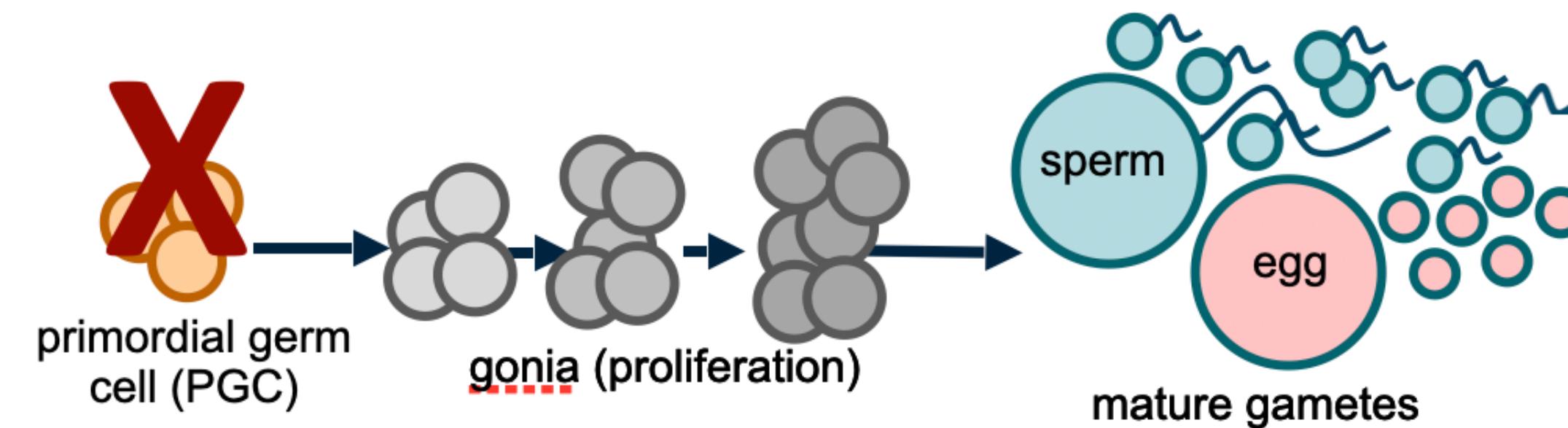
Prevents genetic contamination



Year-round Marketability



# Germ Cell Elimination



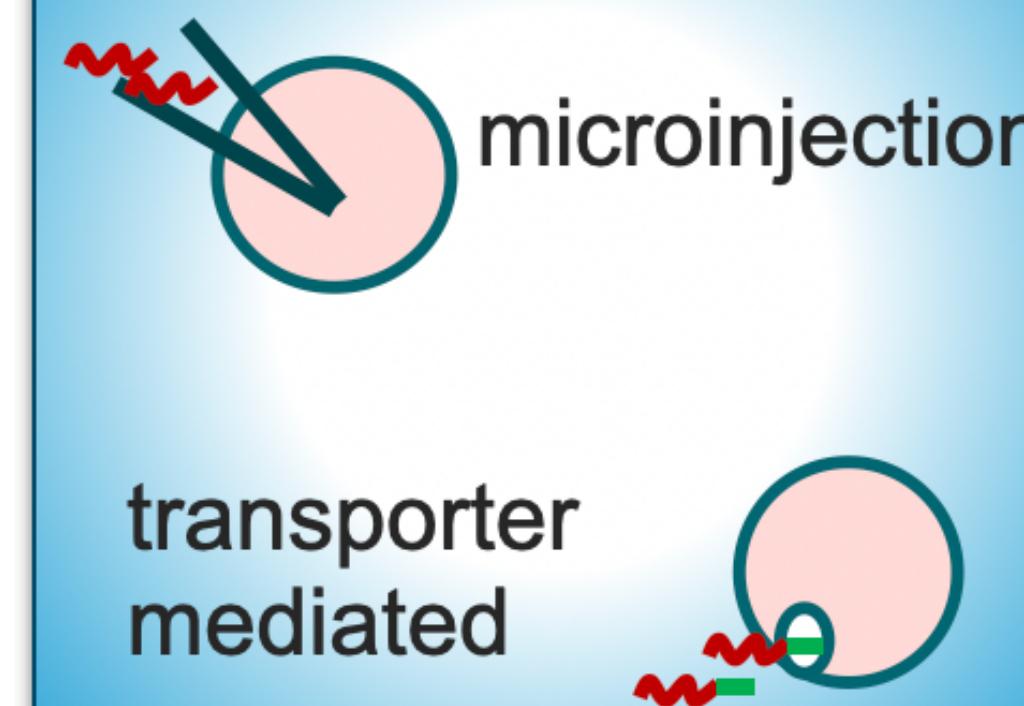
GENE

"dead end"  
(*dnd*)

MOLECULE

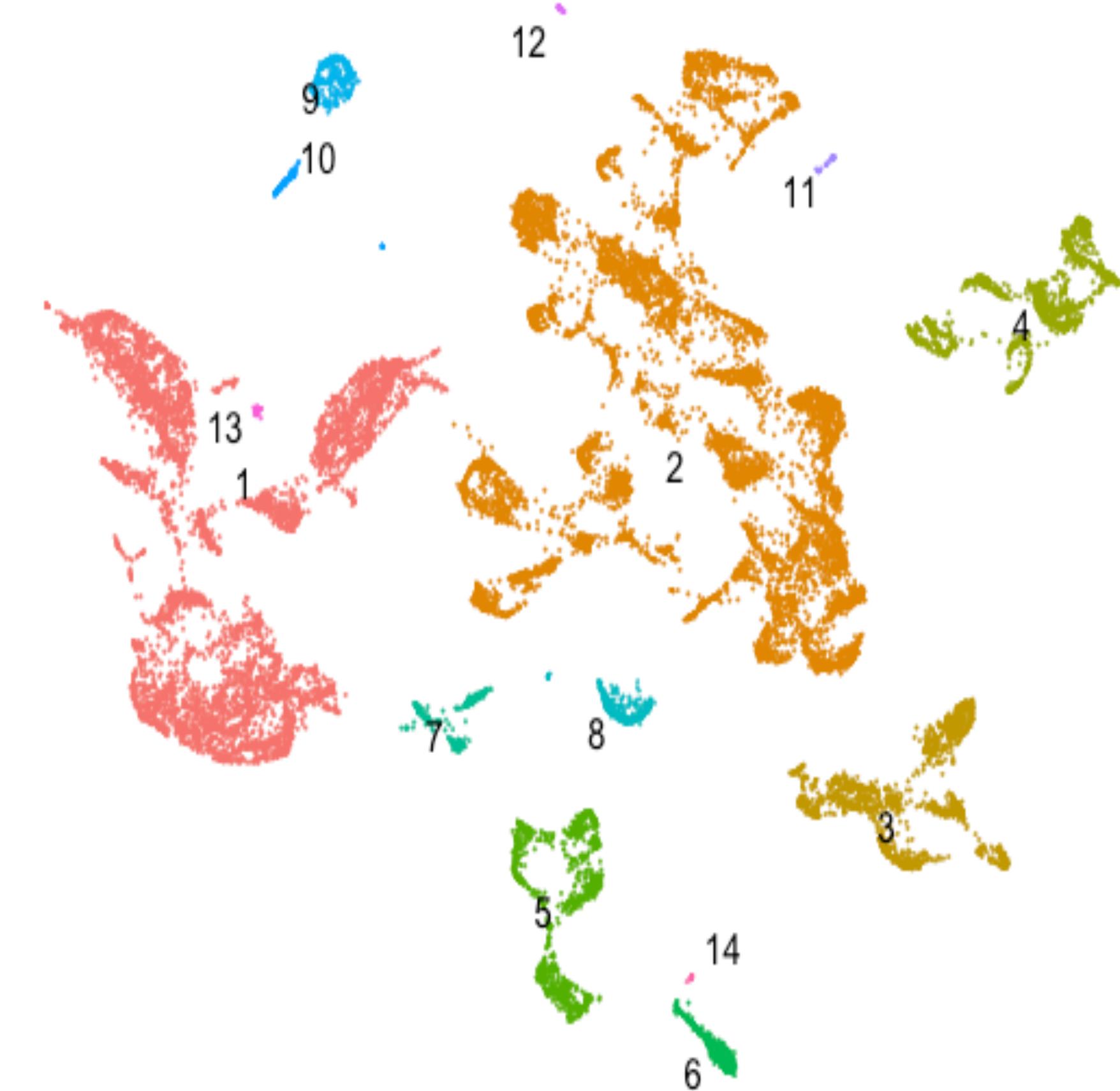


DELIVERY

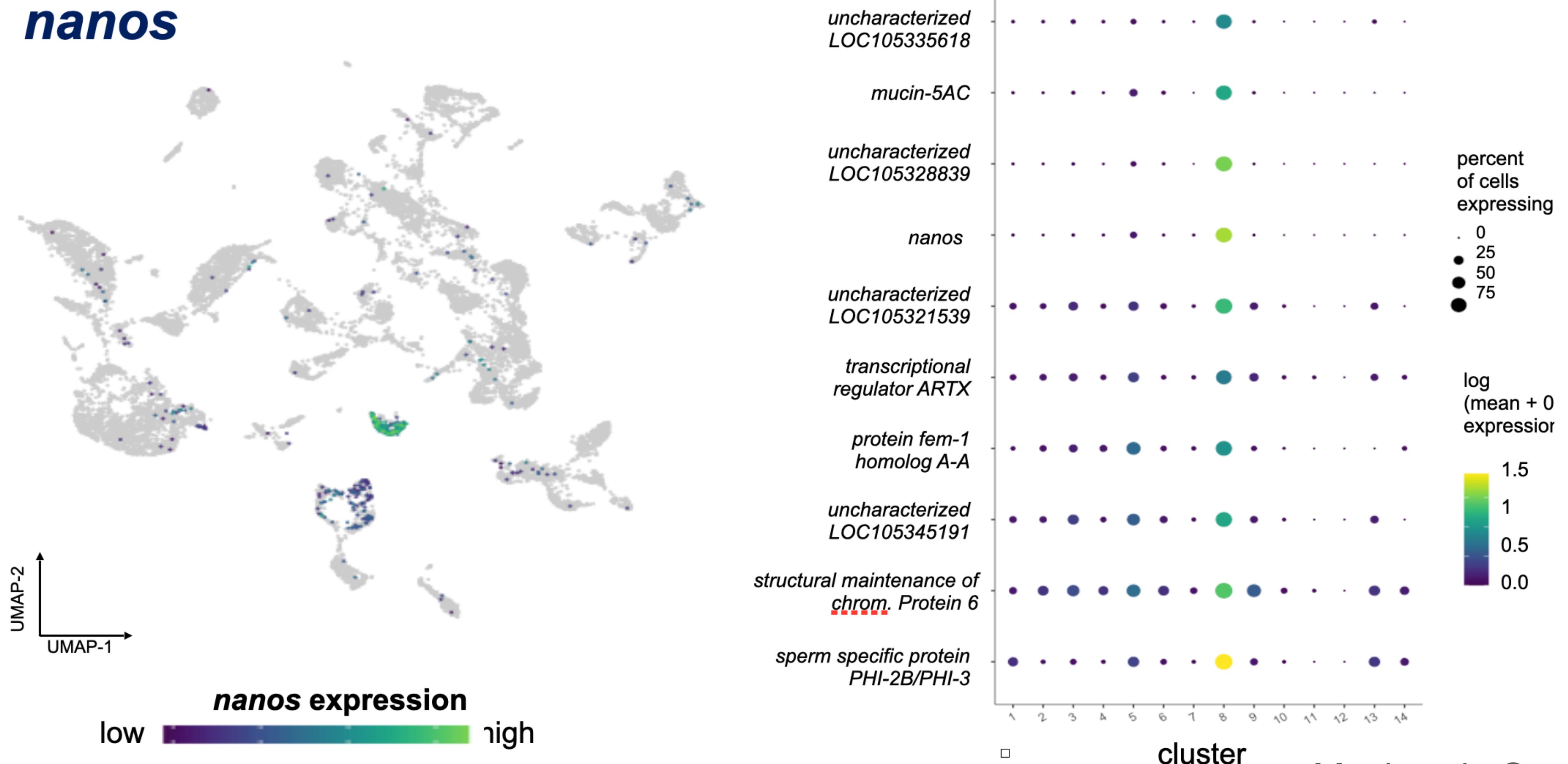


# Single Cell RNA Sequencing

1. Fertilize, monitor development, sample: cleavage through gastrula stage
2. Dissociate the embryos into a single cell suspension
3. Prepare the single-cell RNA-Seq libraries and sequence the expressed genes in each cell
4. Group the cells according to gene expression patterns (“clustering”)



# Candidates uniquely expressed in PGC



# Next Step

- We have identified candidate genes involved in primordial germ cell development in Pacific oysters
- Next Steps:
  - Develop methods to deliver gene silencing molecules to (small) bivalve embryos
  - Evaluate the effect of silencing candidate genes on reproductive phenotypes
- Long-term Goal: work collaboratively to develop protocols to induce sterility via germ cell elimination at a hatchery-scale

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## ACKNOWLEDGEMENTS



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