



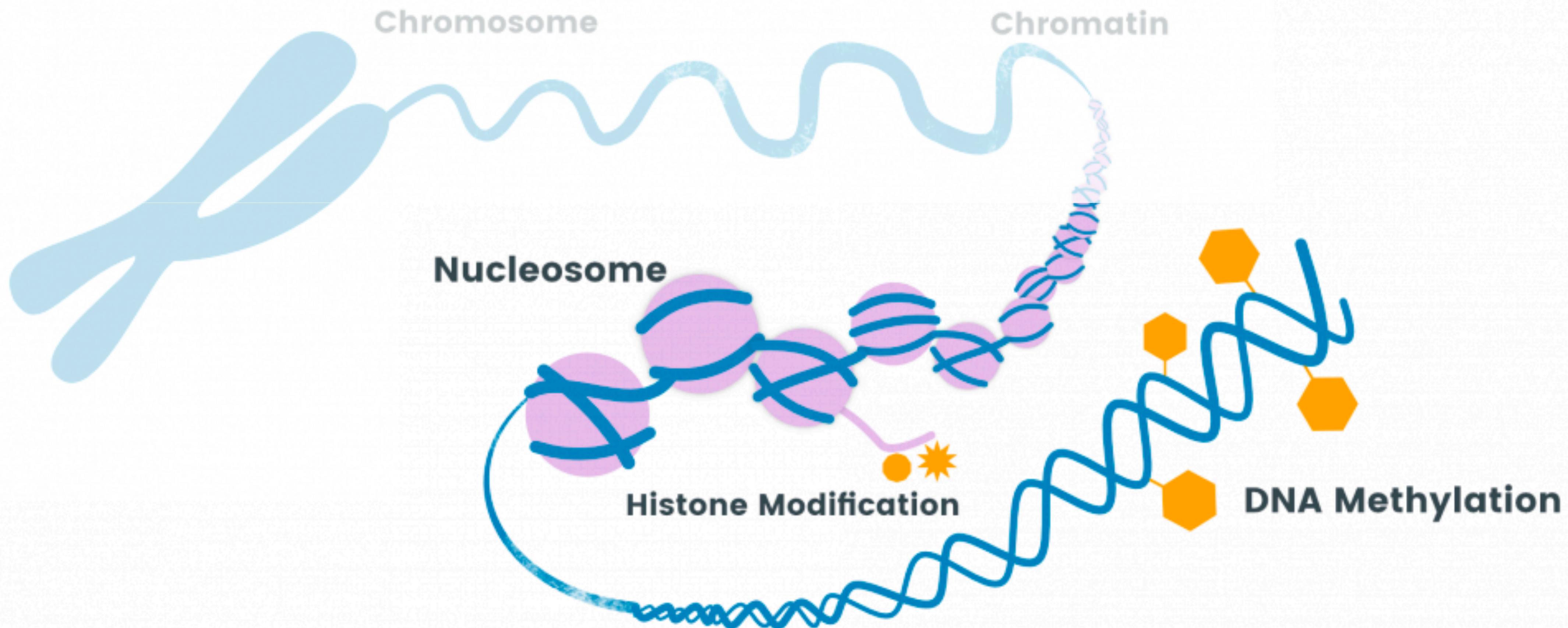
STEVEN ROBERTS  
SCHOOL OF AQUATIC AND FISHERY SCIENCES  
UNIVERSITY OF WASHINGTON

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# A PERSPECTIVE ON DNA METHYLATION IN BIVALVES

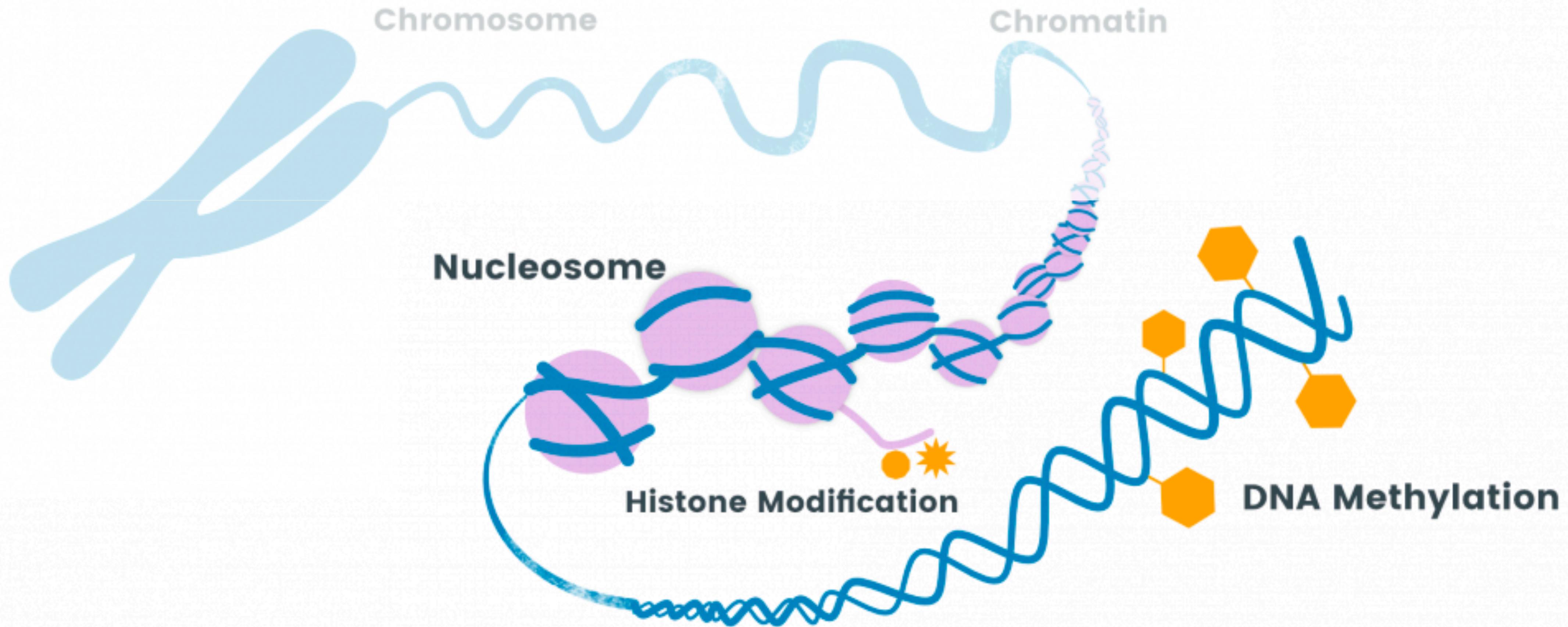
## WHAT IS EPIGENETICS?

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



## WHAT IS EPIGENETICS?

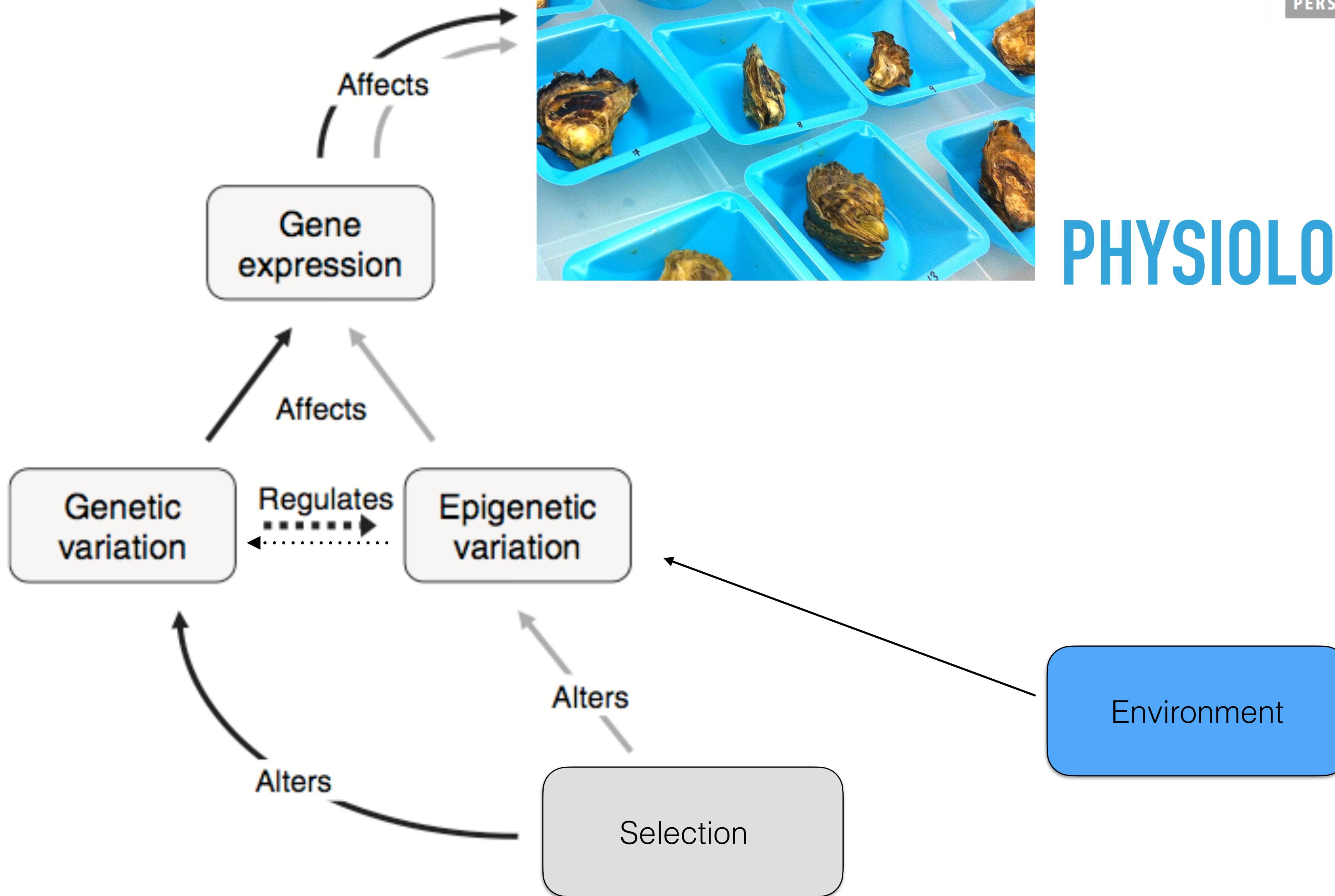
**ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE**



**CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION**

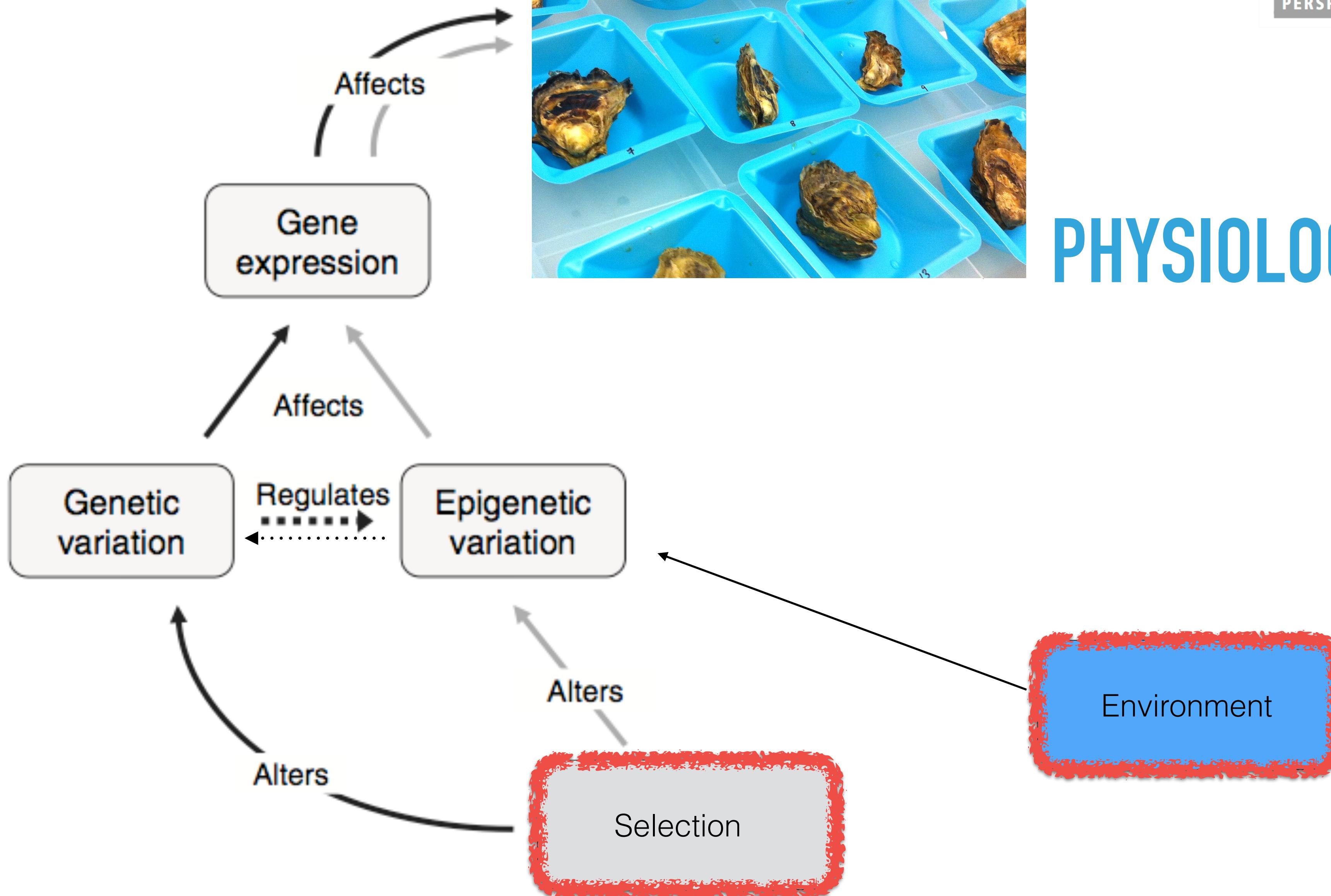


## PHYSIOLOGY



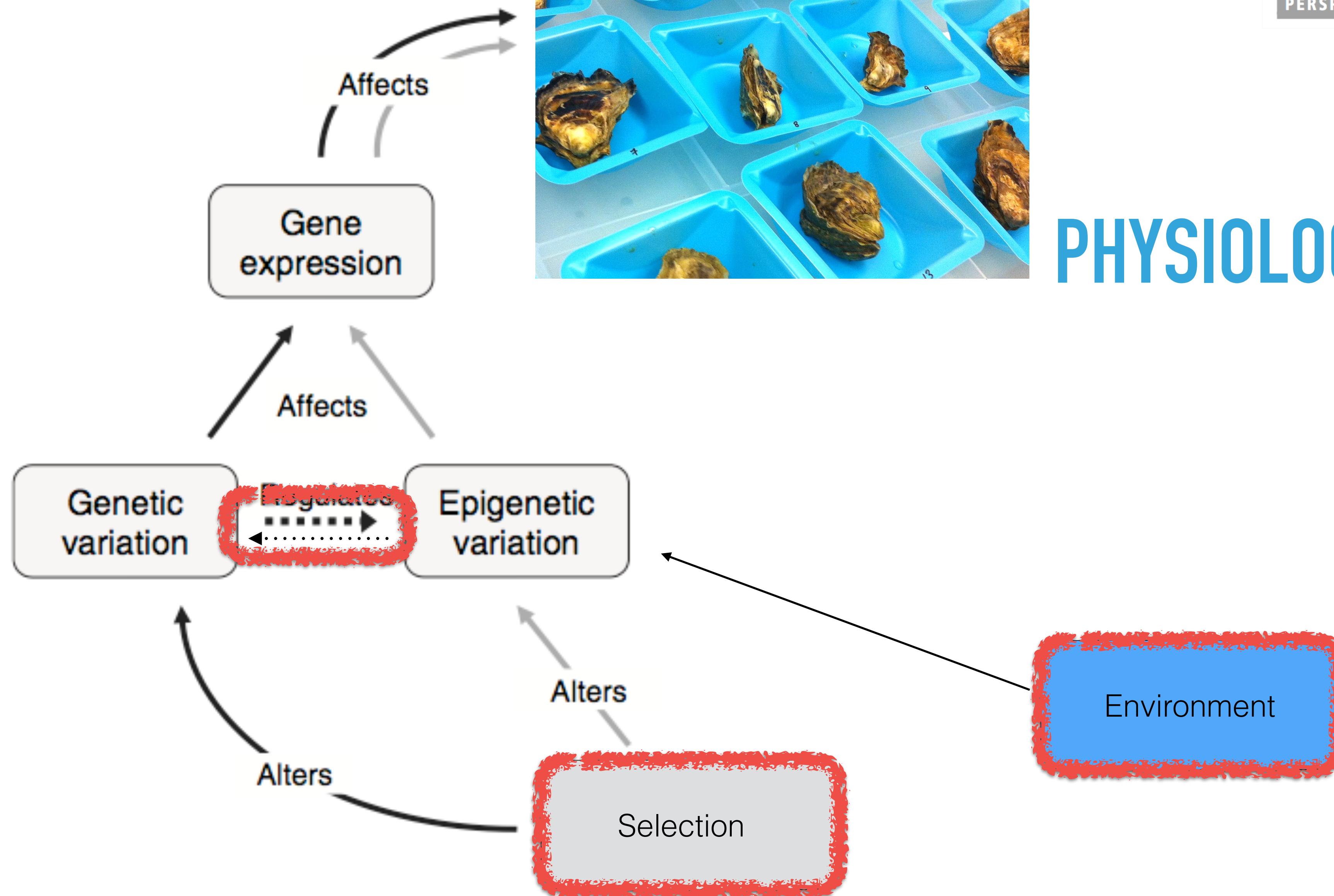


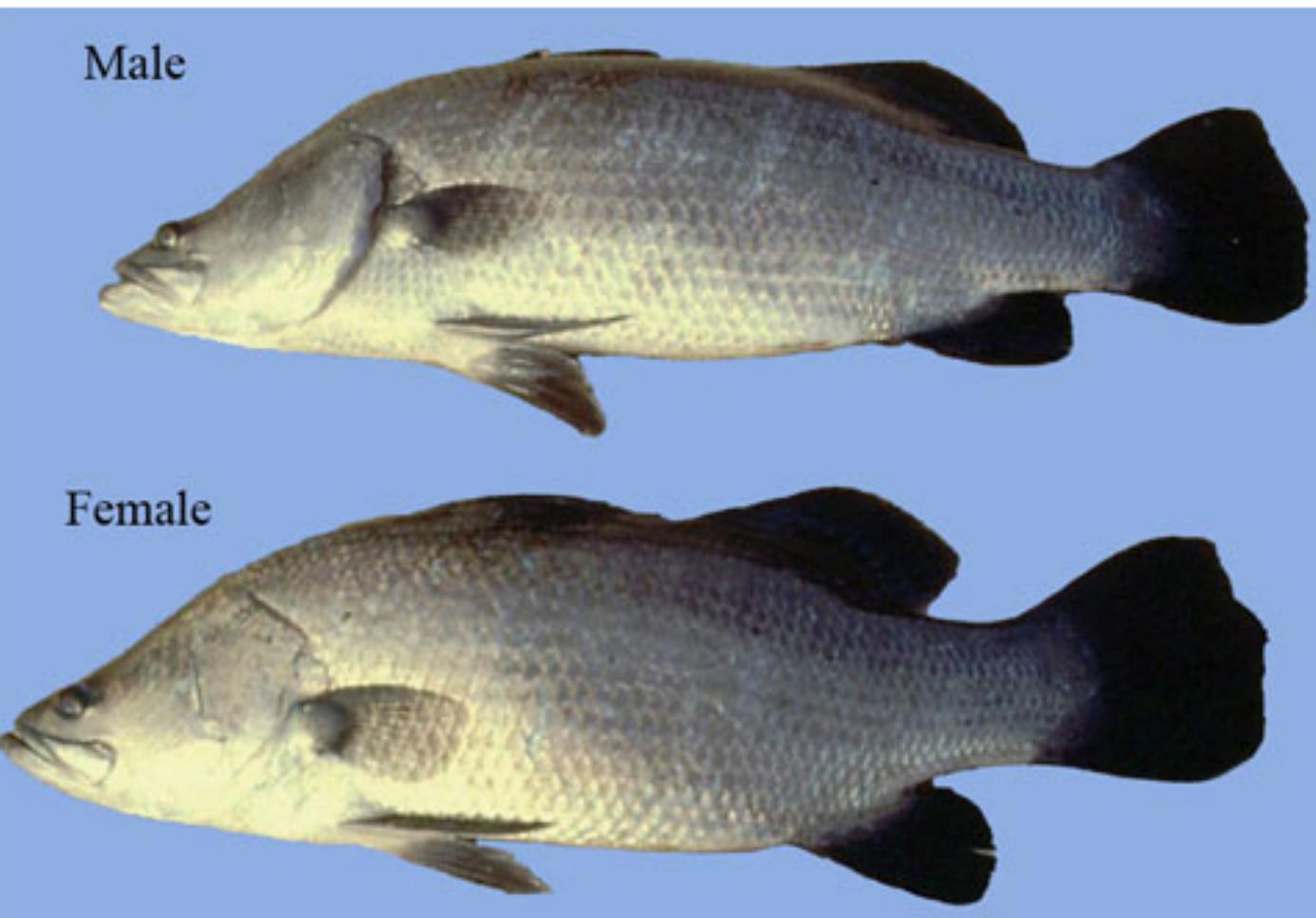
## PHYSIOLOGY





## PHYSIOLOGY

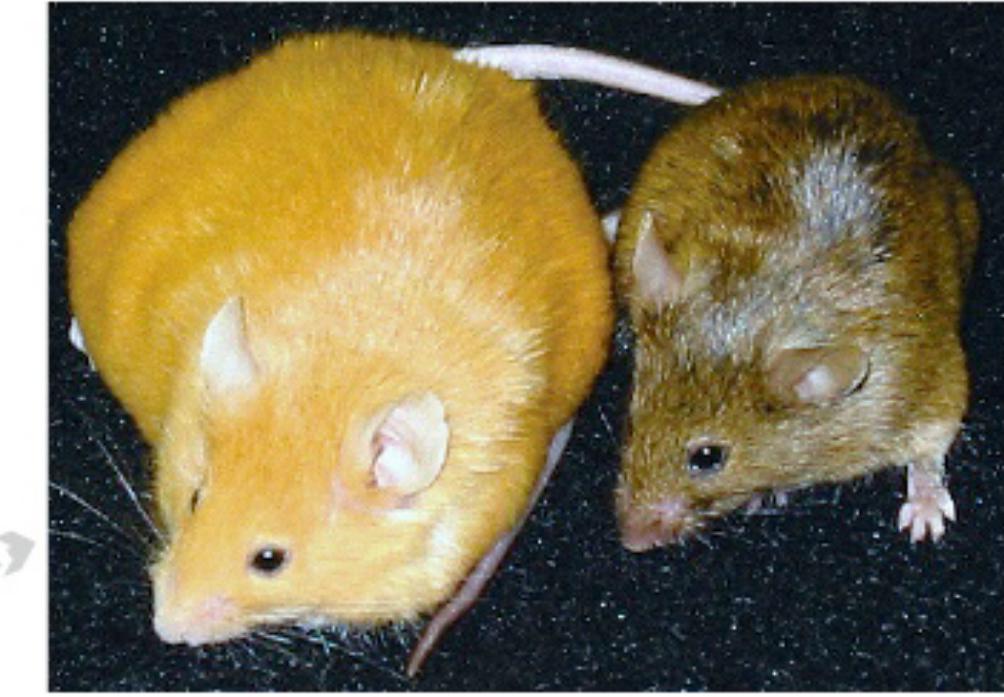




Male and female *Lates calcarifer*

# DNA METHYLATION

These Two Mice are Genetically Identical and the Same Age



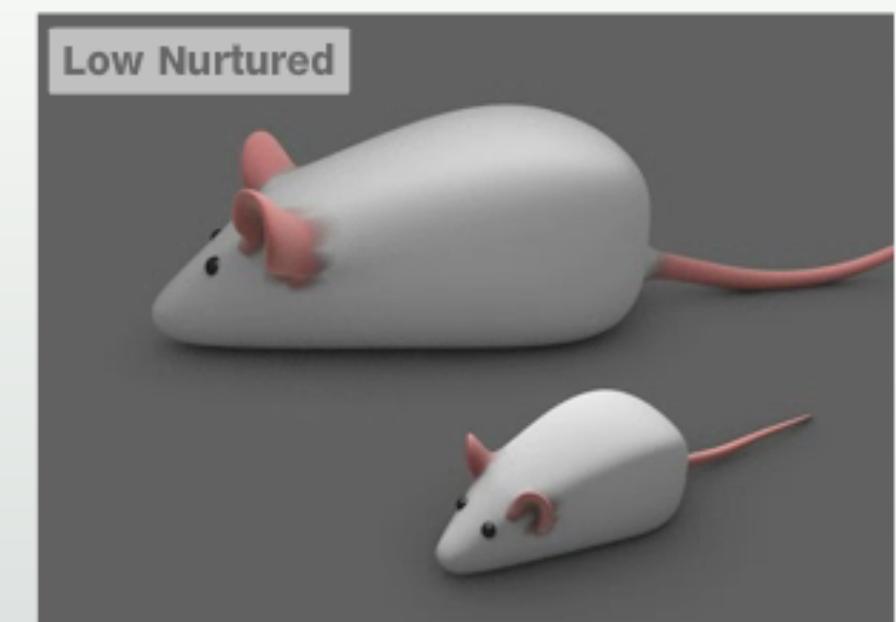
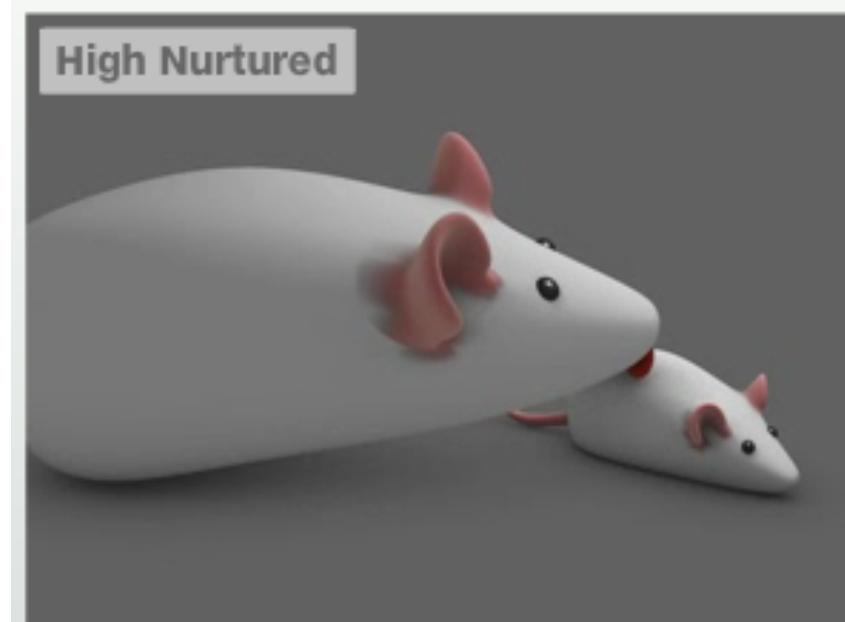
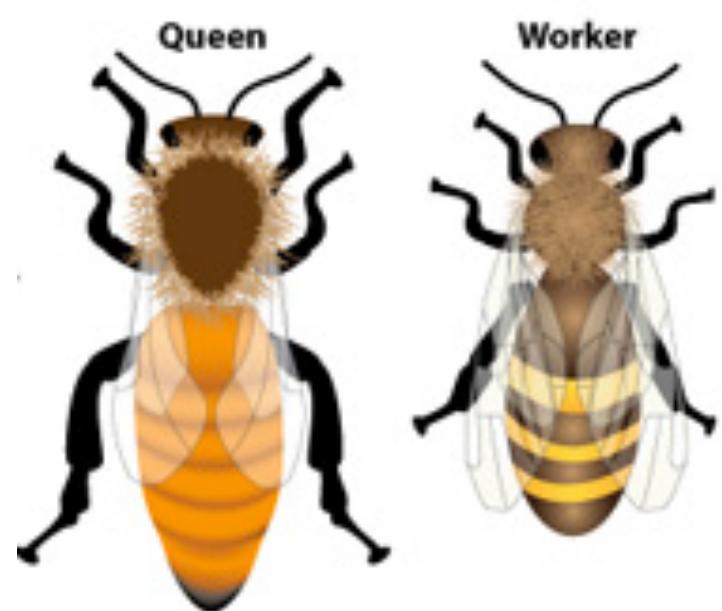
While pregnant, both of their mothers were fed Bisphenol A (BPA) but DIFFERENT DIETS:

The mother of this mouse received a **normal mouse diet**

The mother of this mouse received a diet **supplemented** with choline, folic acid, betaine and vitamin B12



Queen Bee Larvae: Queens are raised in specially constructed cells called "queen cups," which are filled with royal jelly.



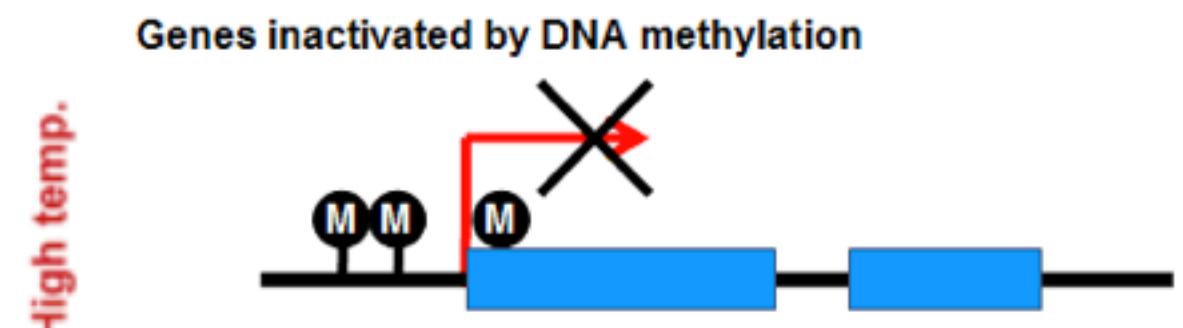
These mothers come from a long line of inbred rats, so their genomes are highly similar. But they care for their pups very differently.

AUDIO

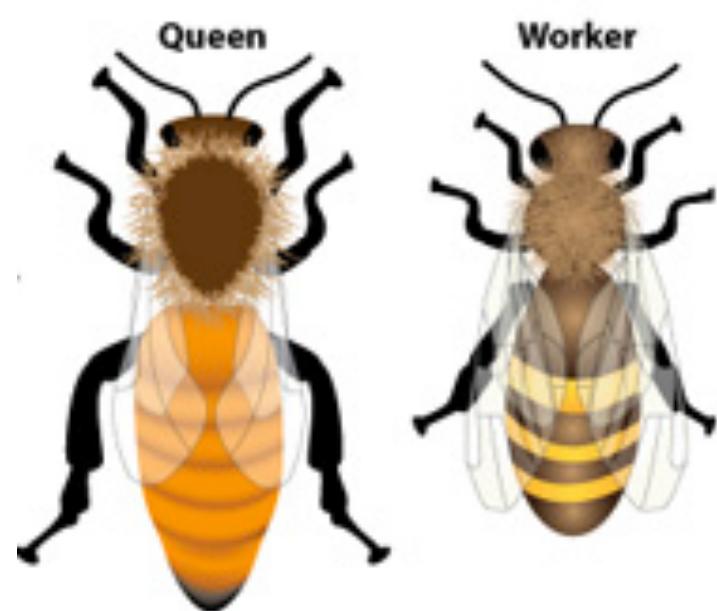


Male and female *Lates calcarifer*

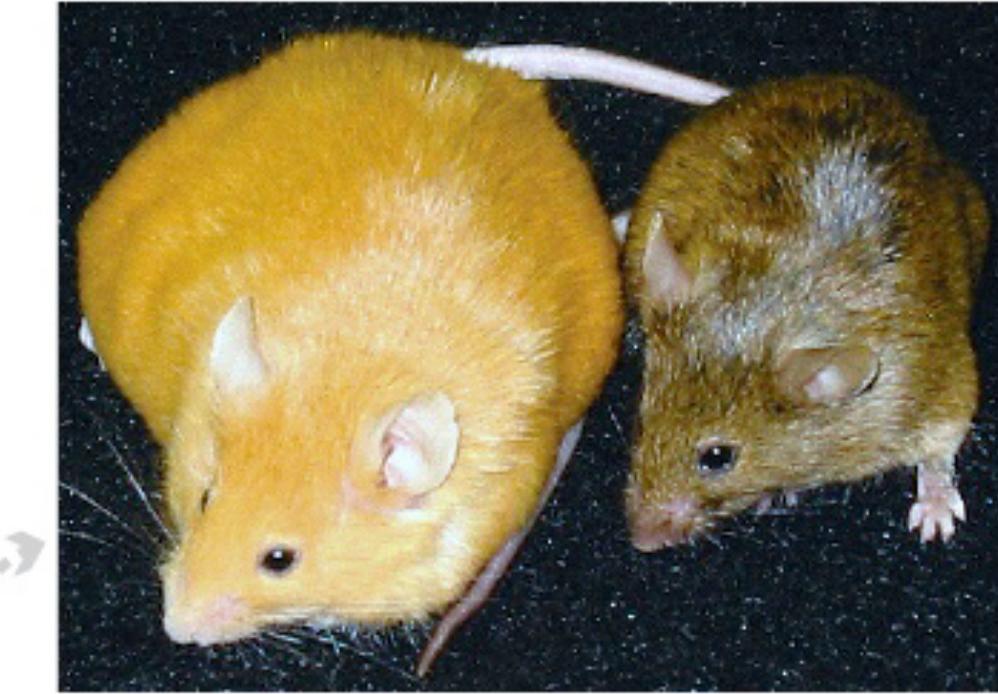
# DNA METHYLATION



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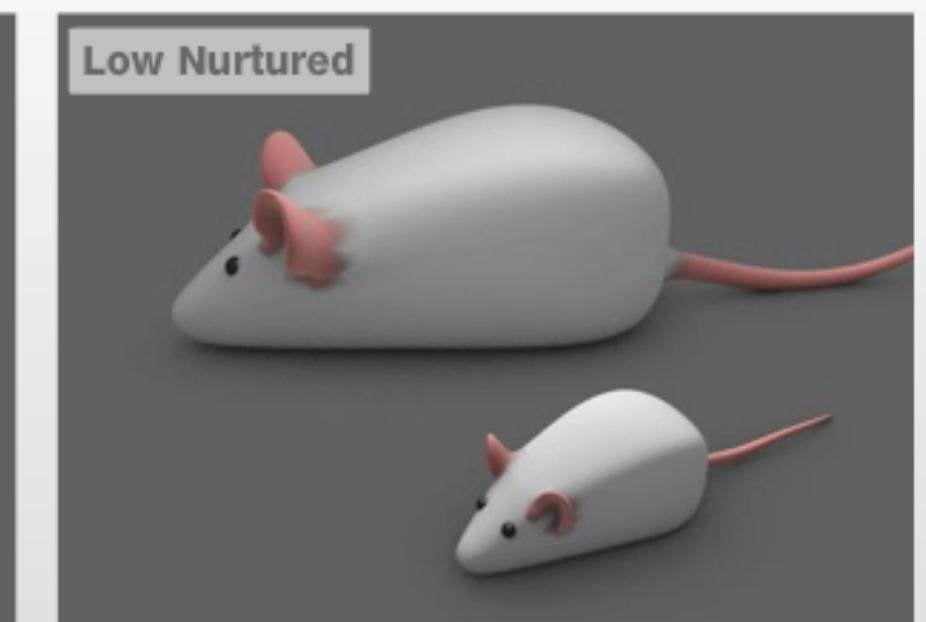
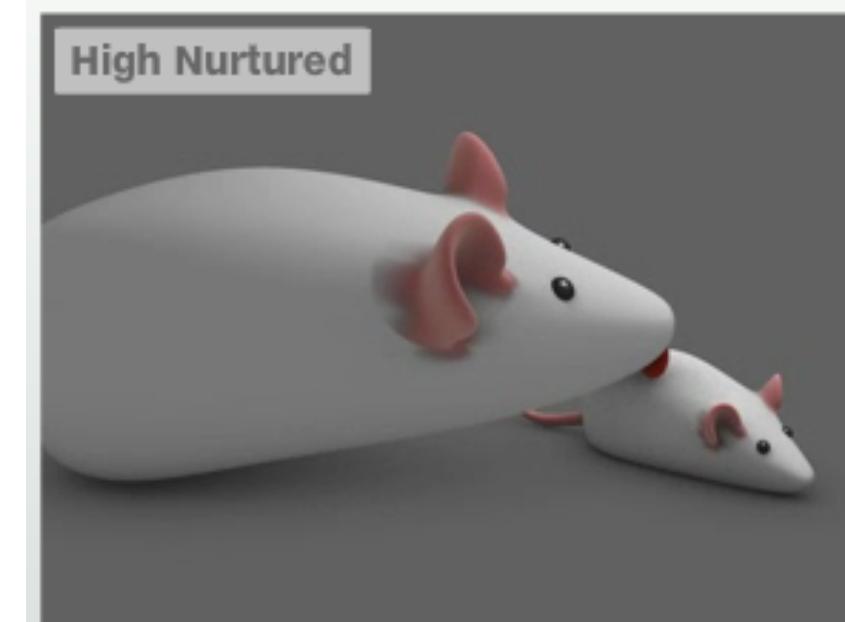
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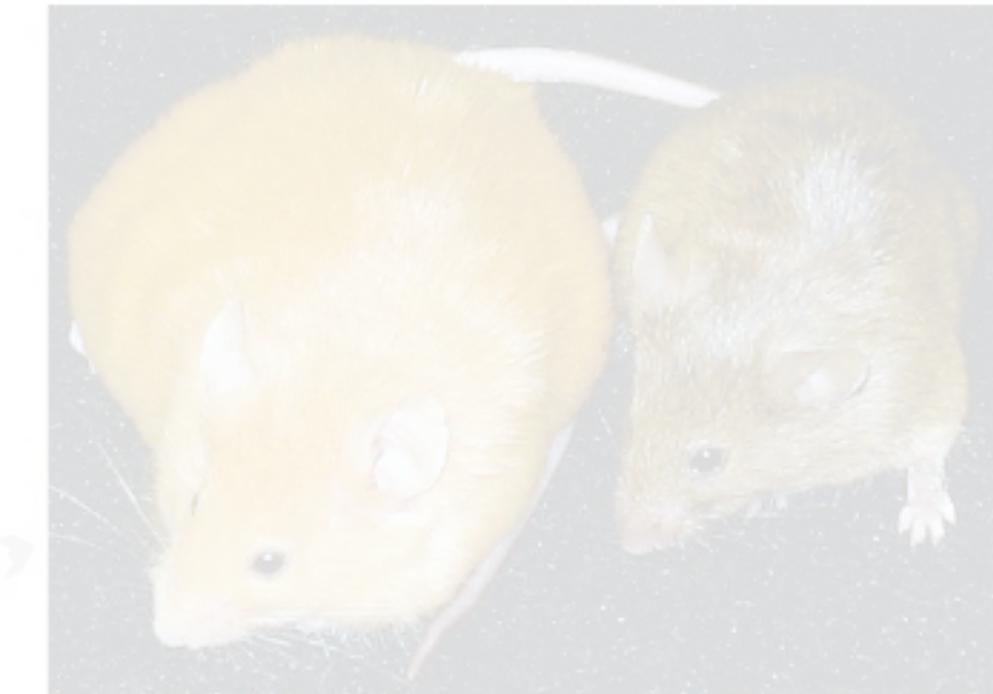
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AUDIO



# DNA METHYLATION

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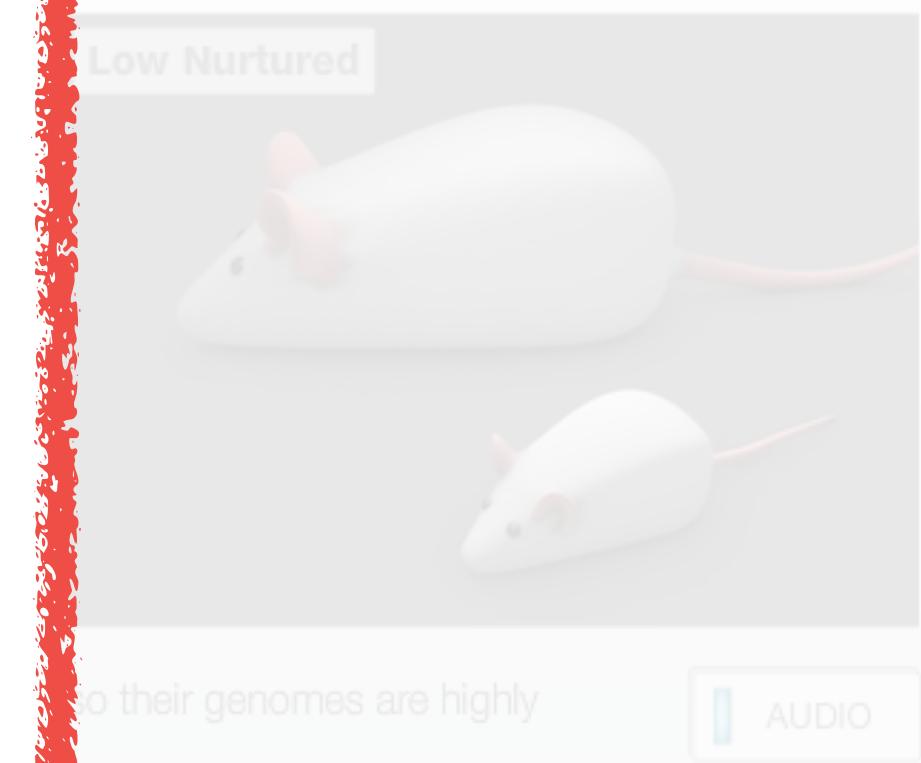
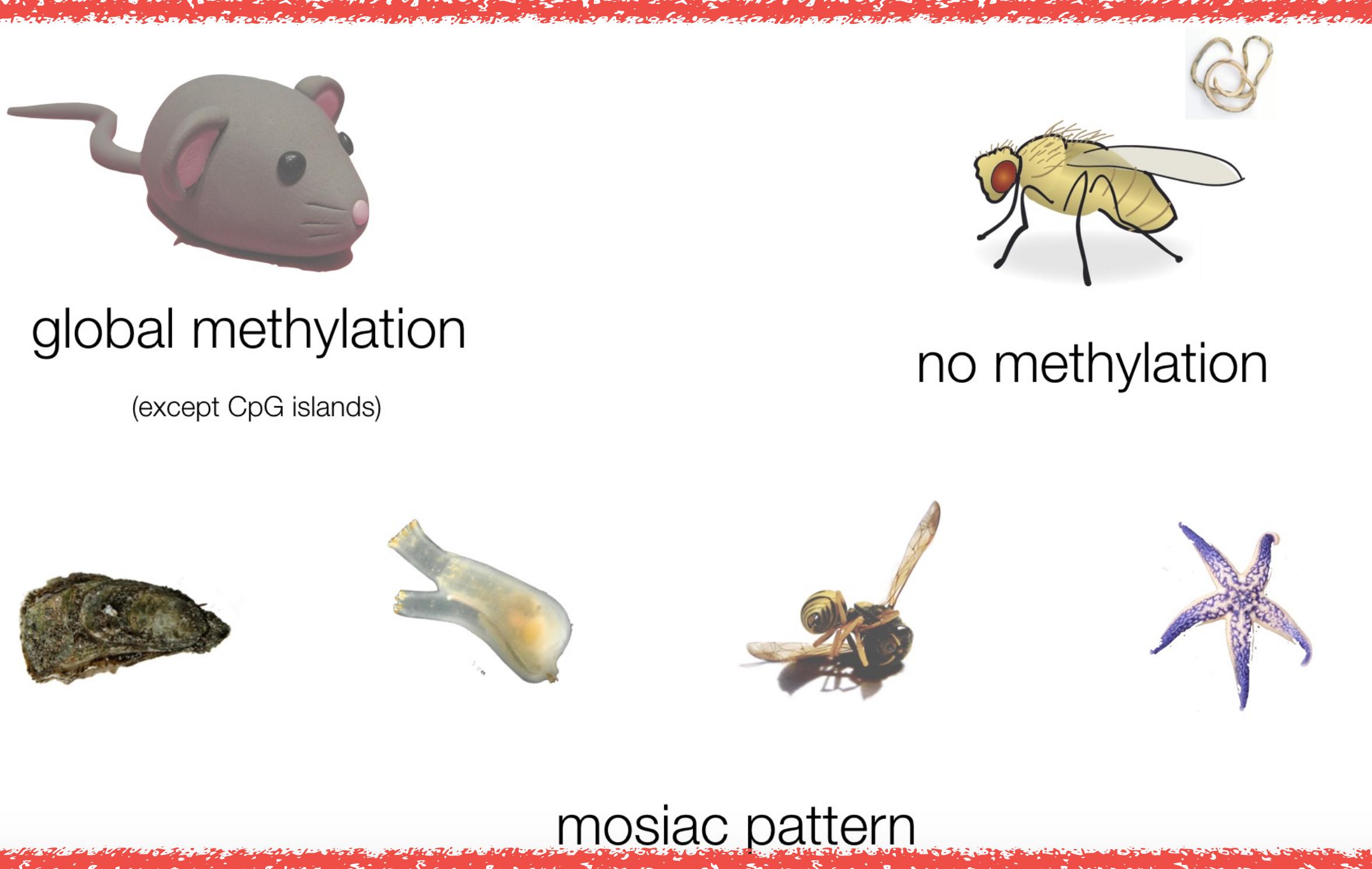
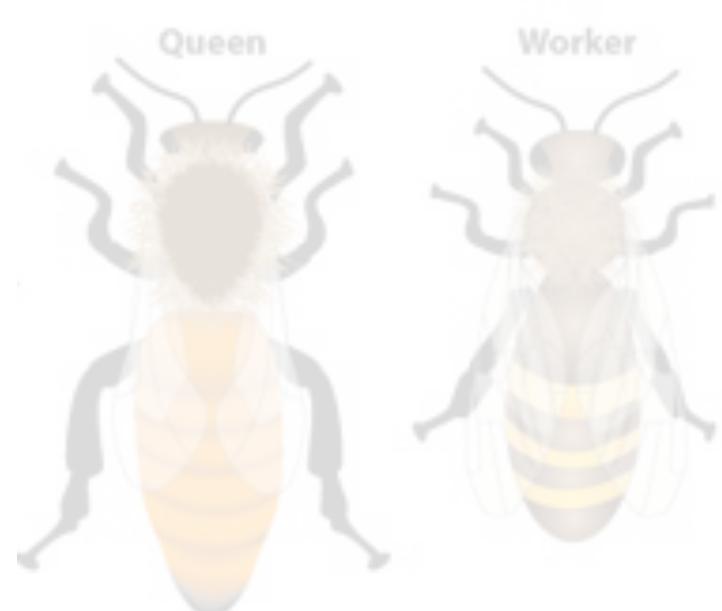
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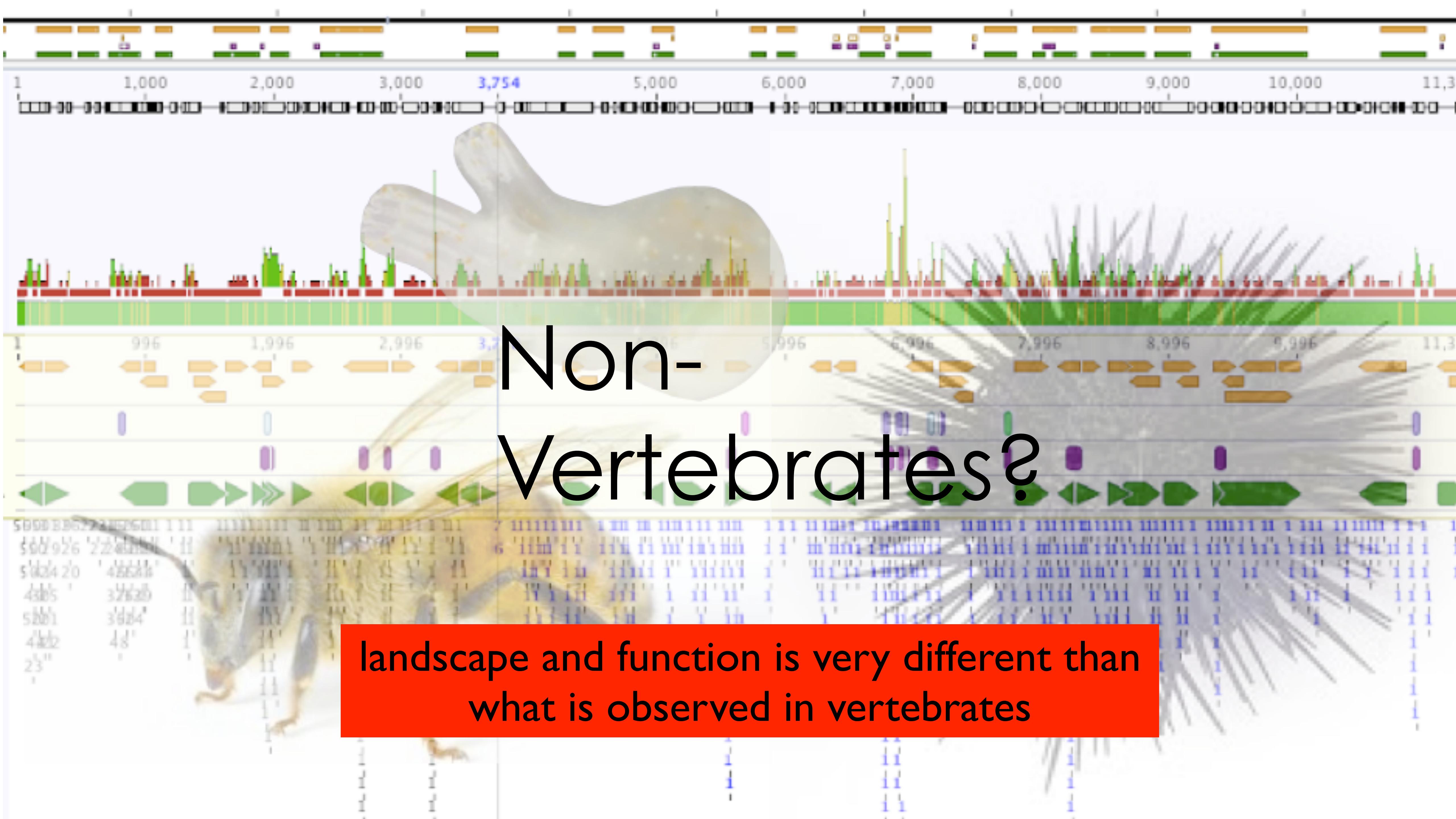
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# Non- Vertebrates?

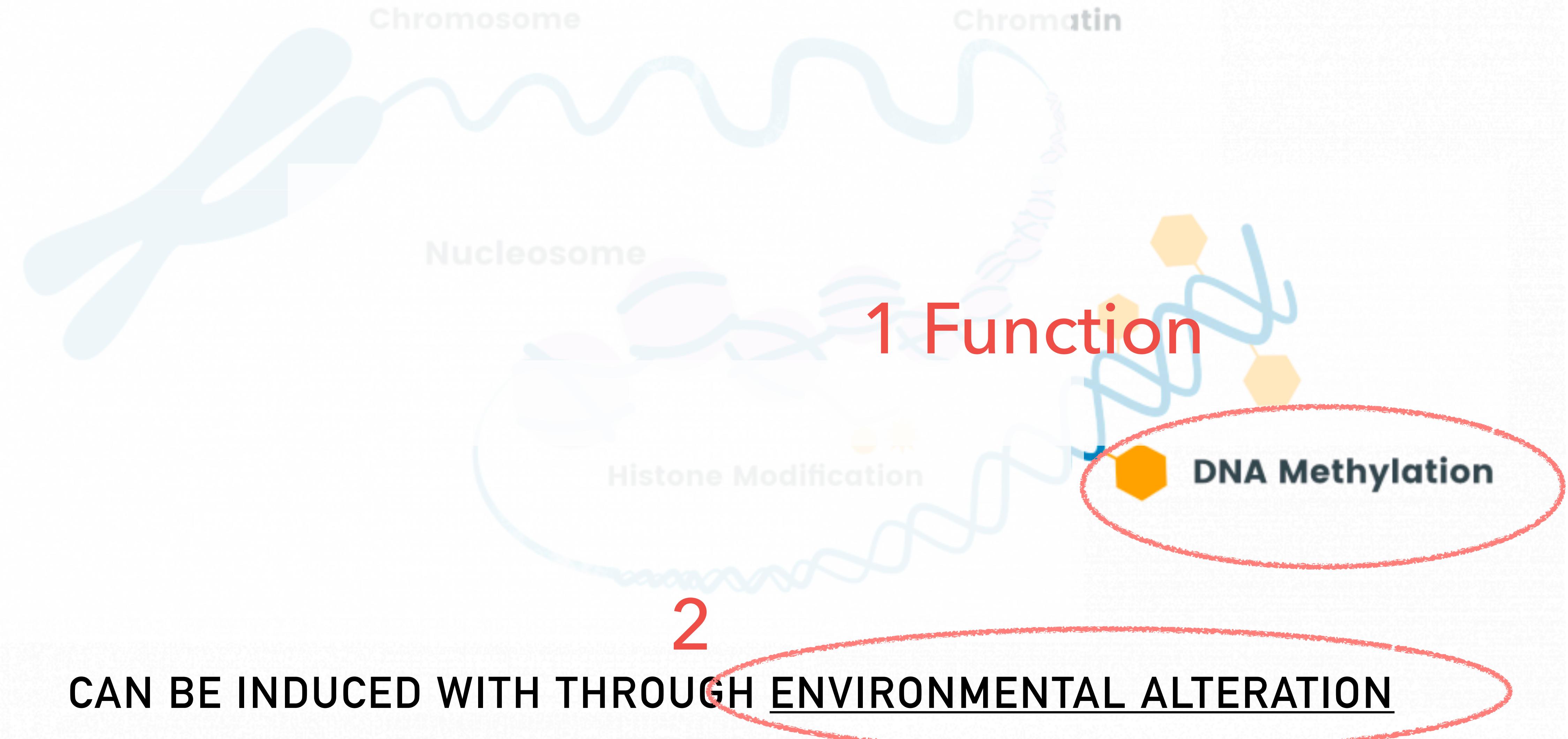
landscape and function is very different than  
what is observed in vertebrates

ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE



CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE



ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE

3

1 Function

DNA Methylation

2

CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION



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

3

1 Function

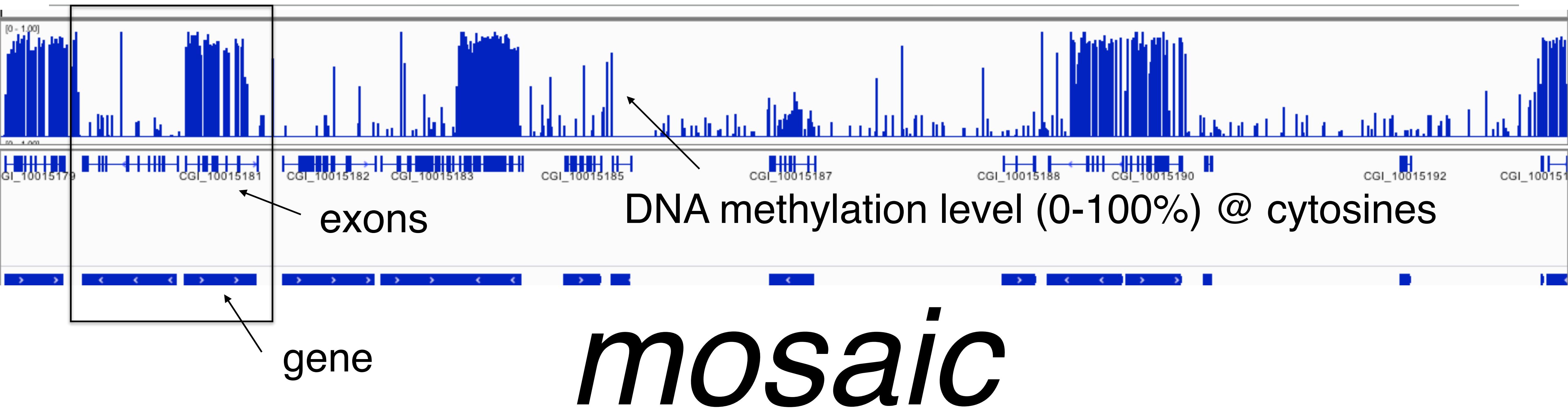
DNA Methylation

2

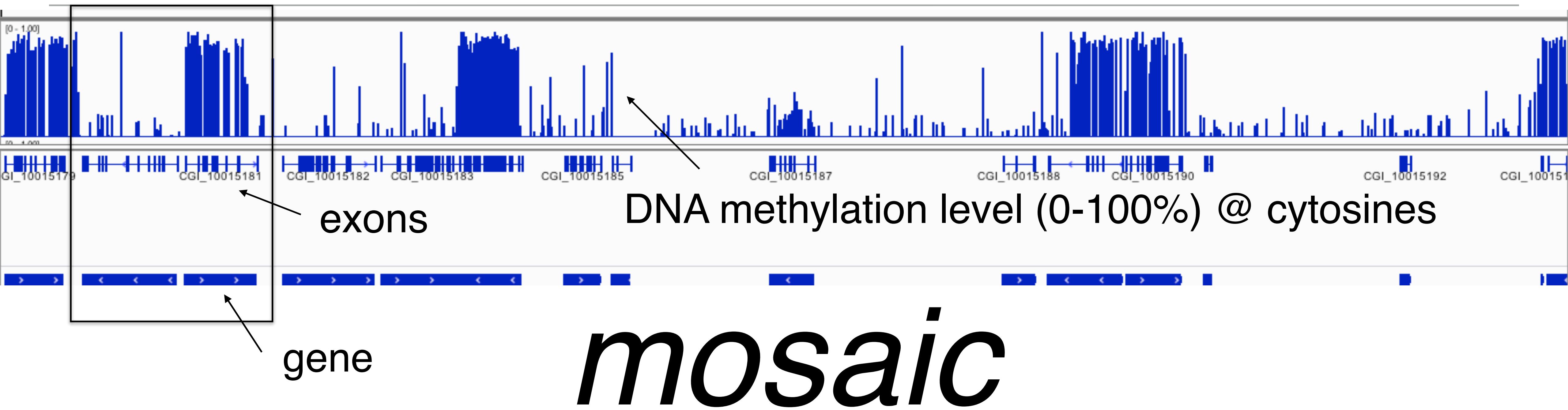
CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION



## METHYLATION LANDSCAPE IN MARINE INVERTEBRATES

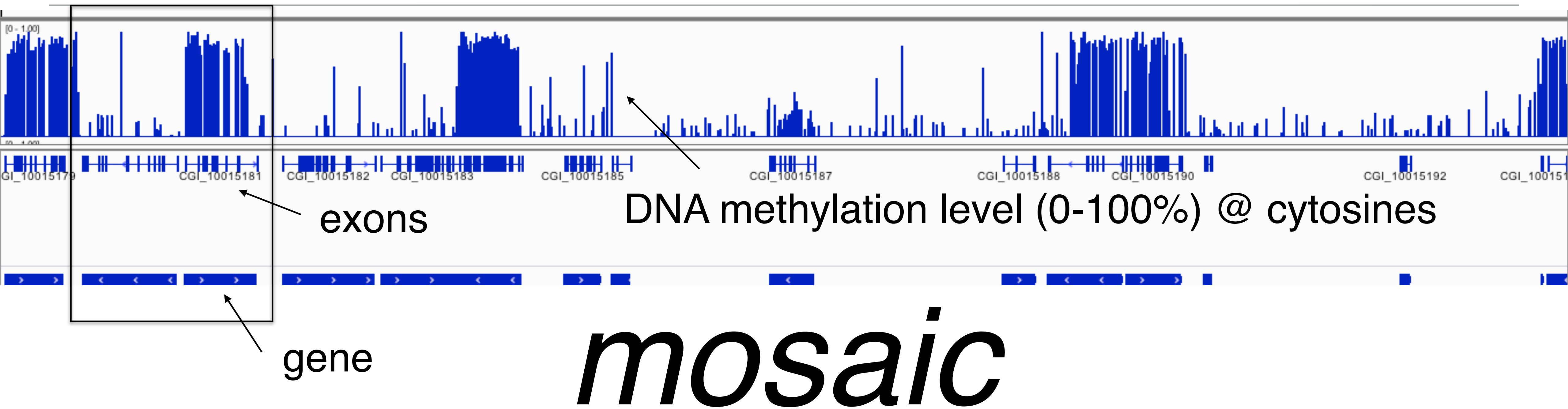


## METHYLATION LANDSCAPE IN MARINE INVERTEBRATES



associated with gene bodies

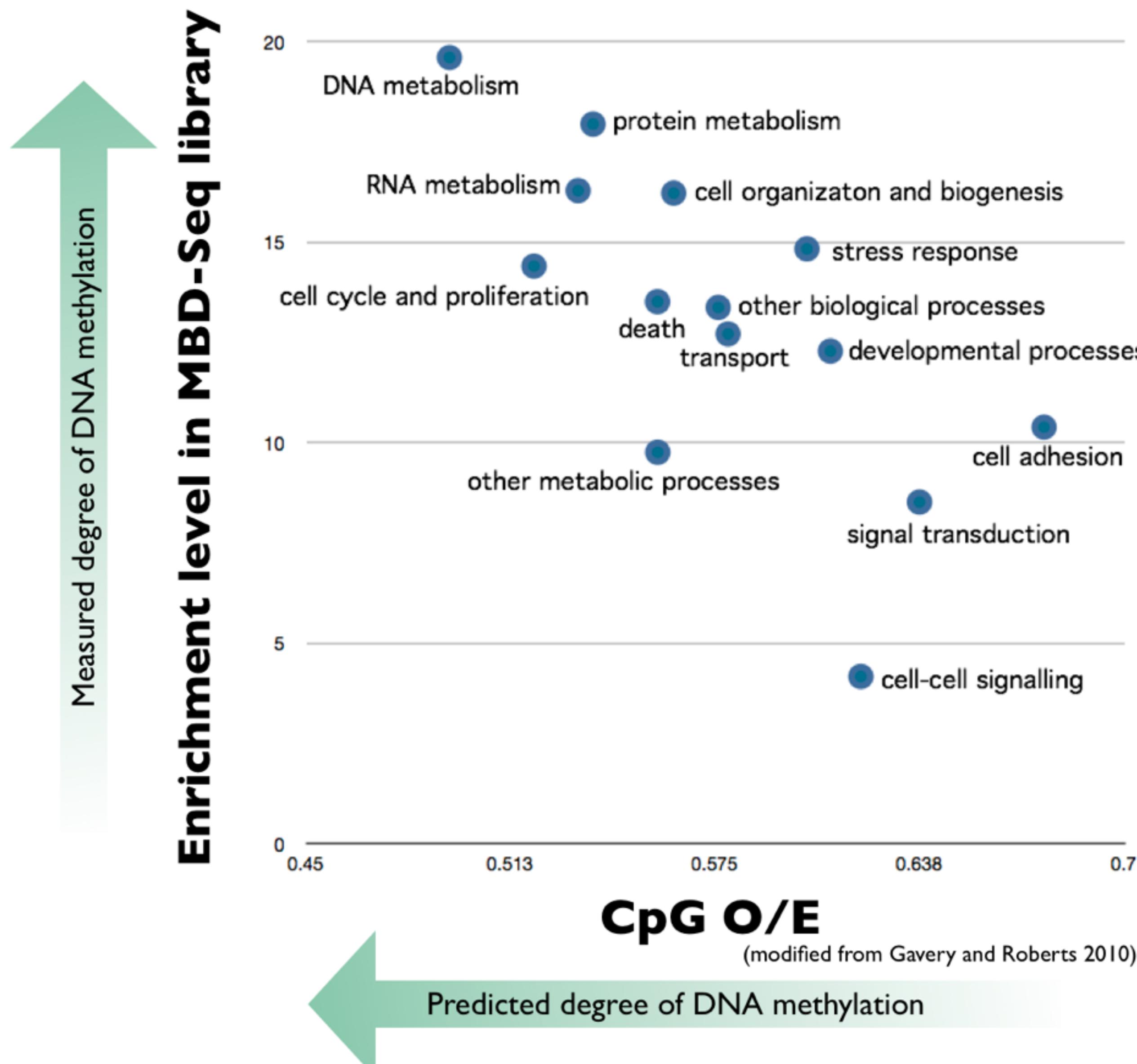
## METHYLATION LANDSCAPE IN MARINE INVERTEBRATES



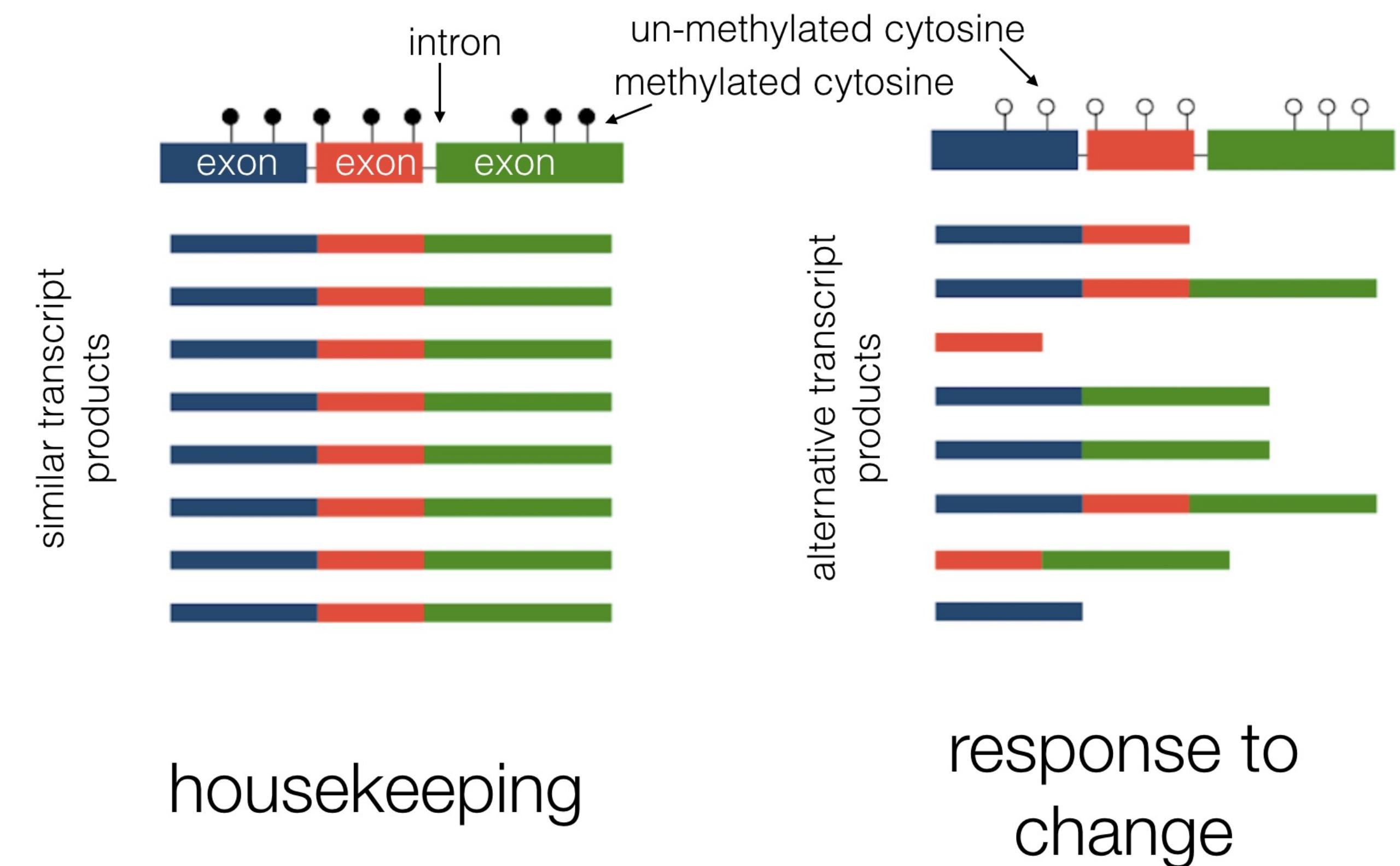
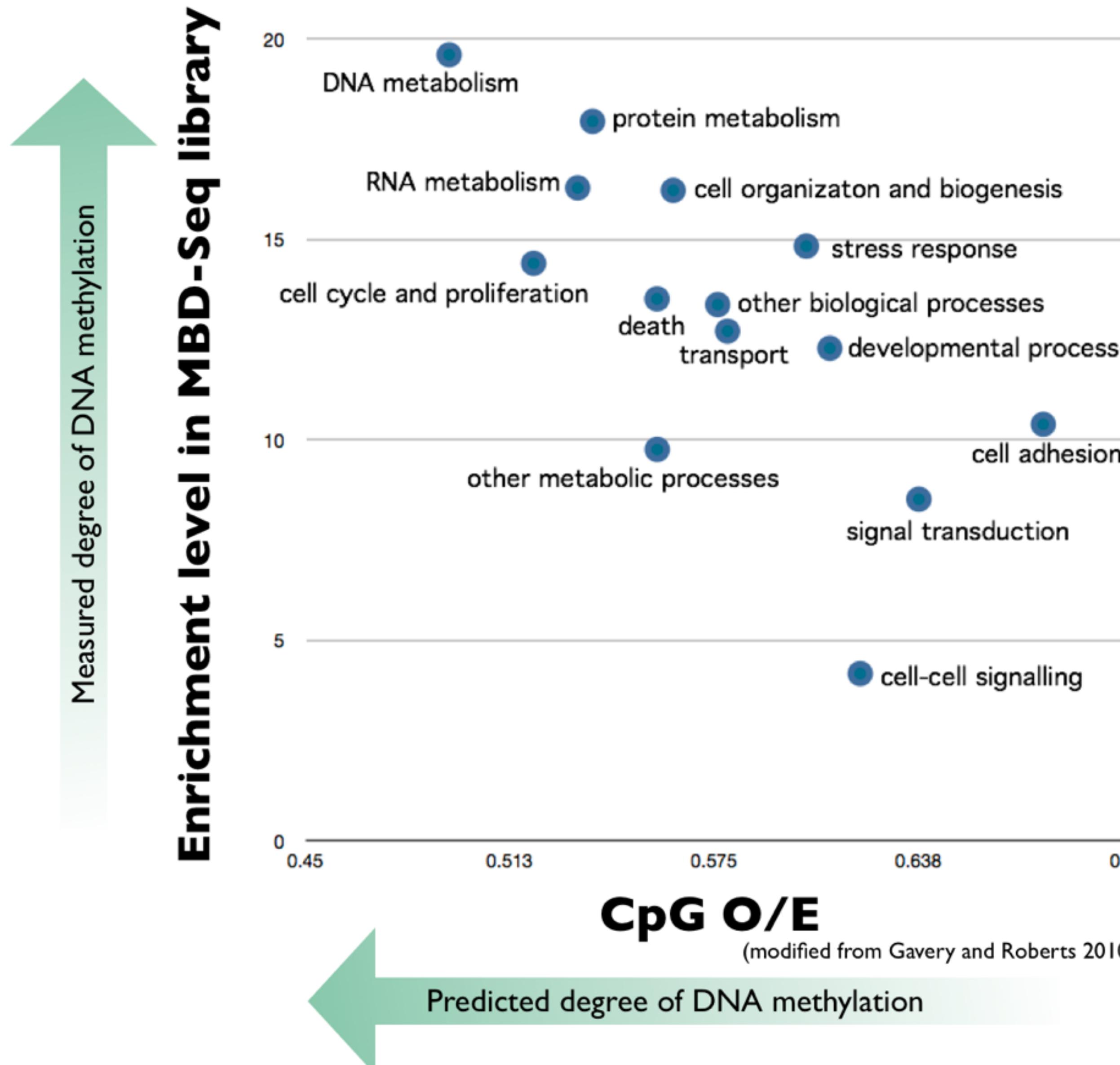
associated with gene bodies

Why are only a subset of genes methylated?

# METHYLATION LANDSCAPE IN MARINE INVERTEBRATES



# METHYLATION LANDSCAPE IN MARINE INVERTEBRATES



A context dependent role for DNA methylation in bivalves

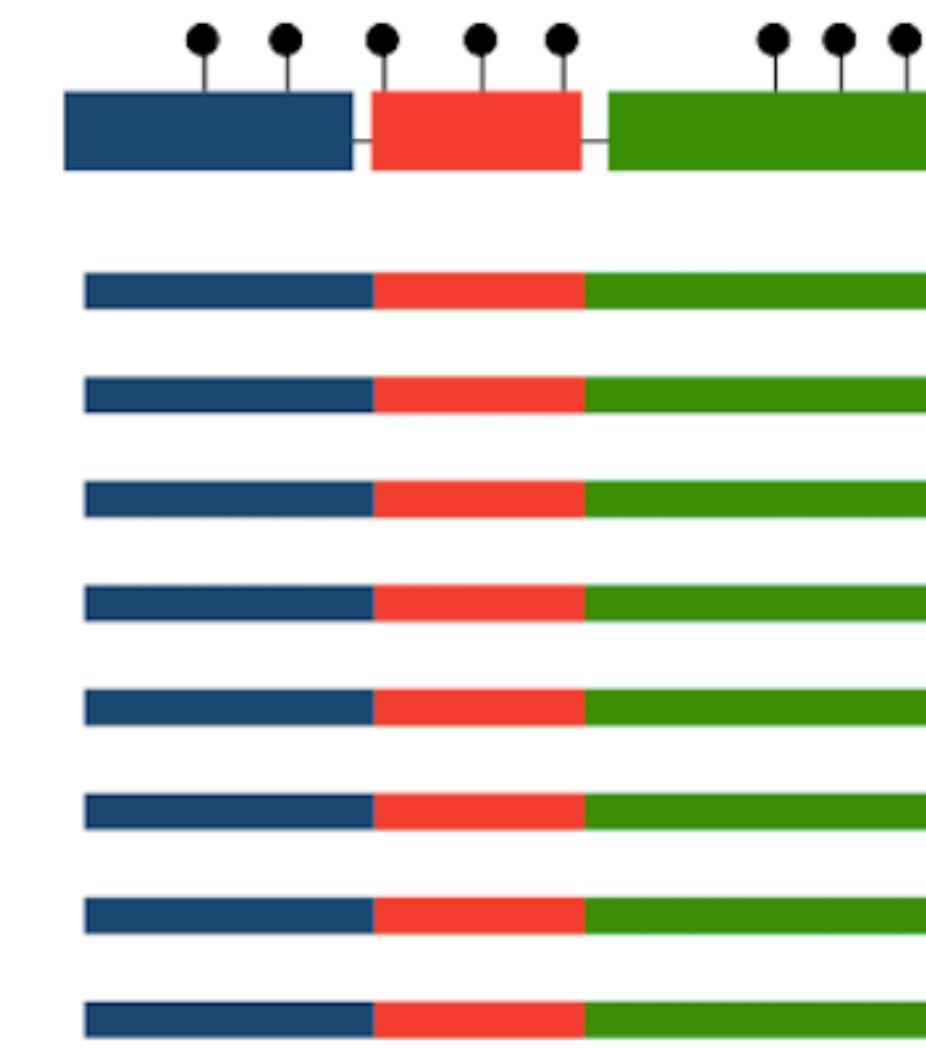
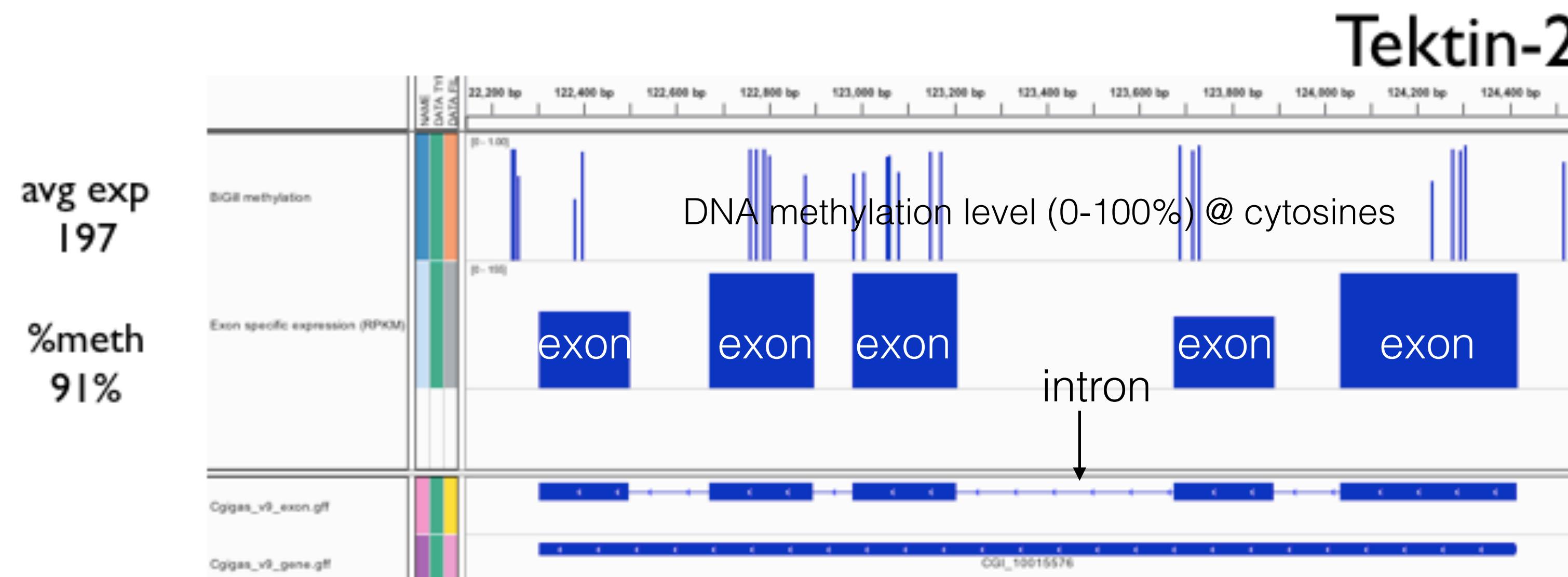
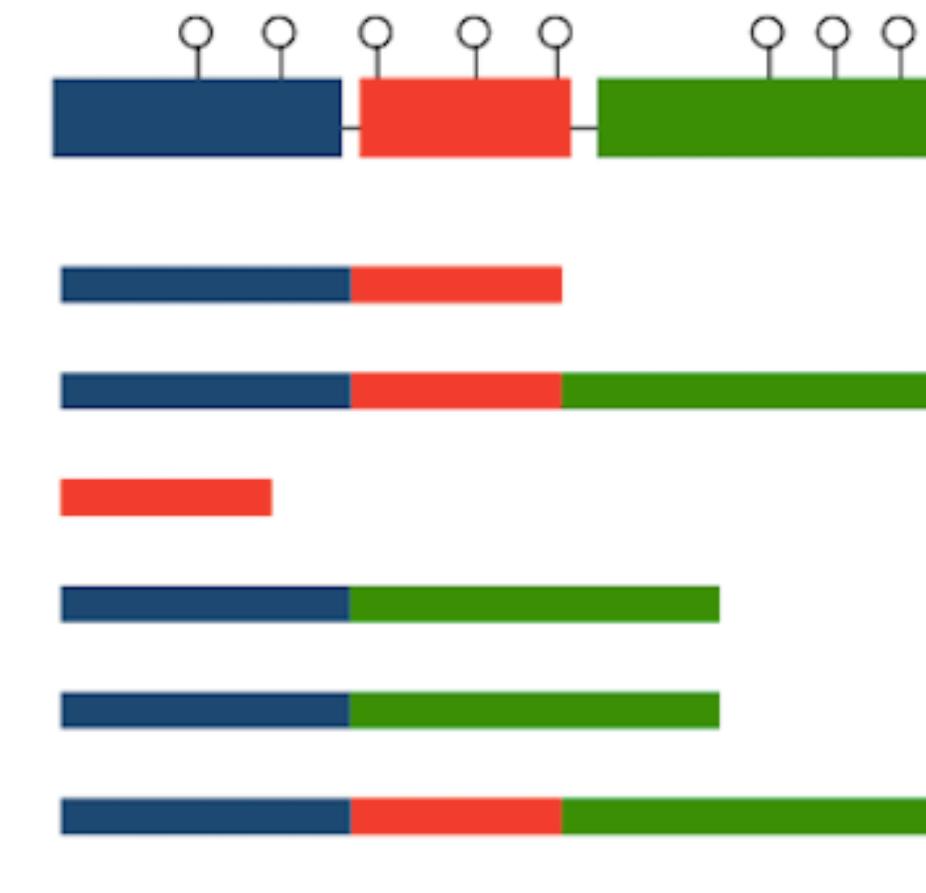
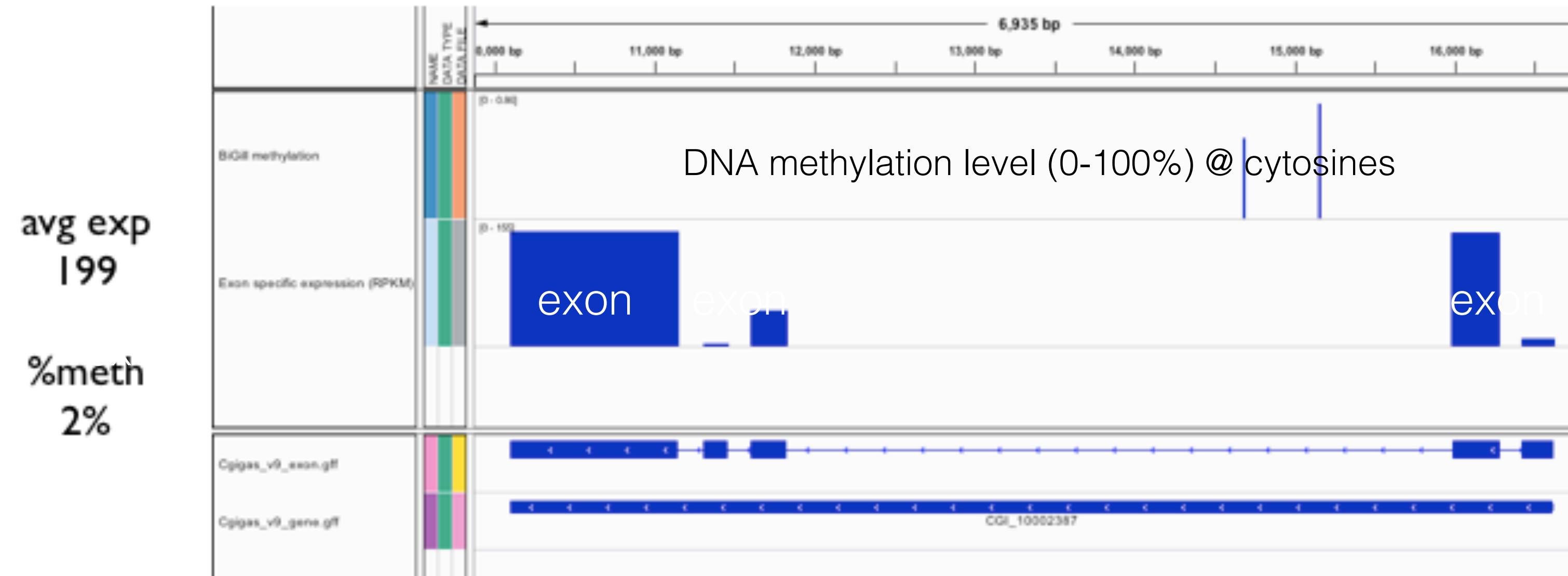
Mackenzie R. Gavery, Steven B. Roberts

Briefings in Functional Genomics, Volume 13, Issue 3, May 2014, Pages 217–222,

<https://doi.org/10.1093/bfgp/elt054>

# Could STOCHASTIC VARIATION contribute to ACCLIMATIZATION and ADAPTATION?

## Heat shock 70 kDa protein 12A

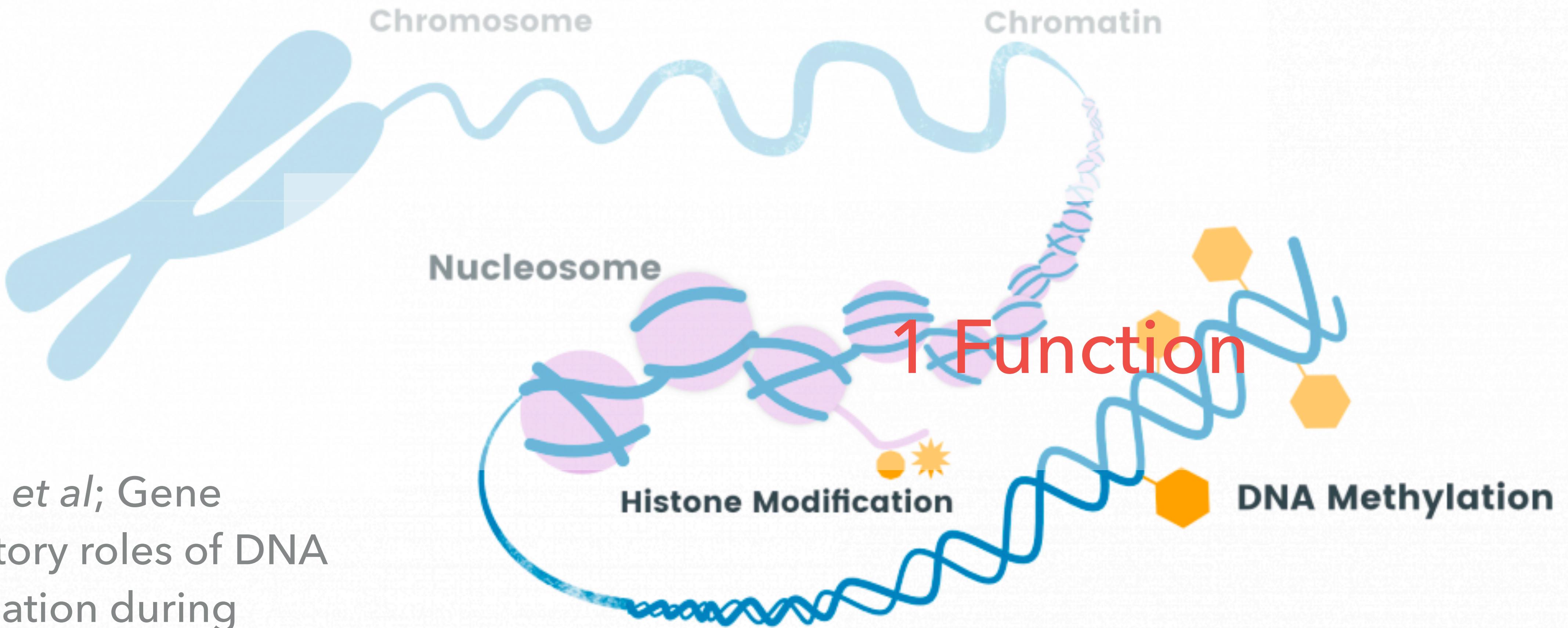




In species that experience a diverse range of environmental conditions, processes have evolved to increase the number of potential phenotypes in a population in order to improve the chances for an individual's survival.



ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE



#26-1

**Bogan et al;** Gene regulatory roles of DNA methylation during transgenerational plasticity in the sea urchin *Strongylocentrotus purpuratus*

ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE



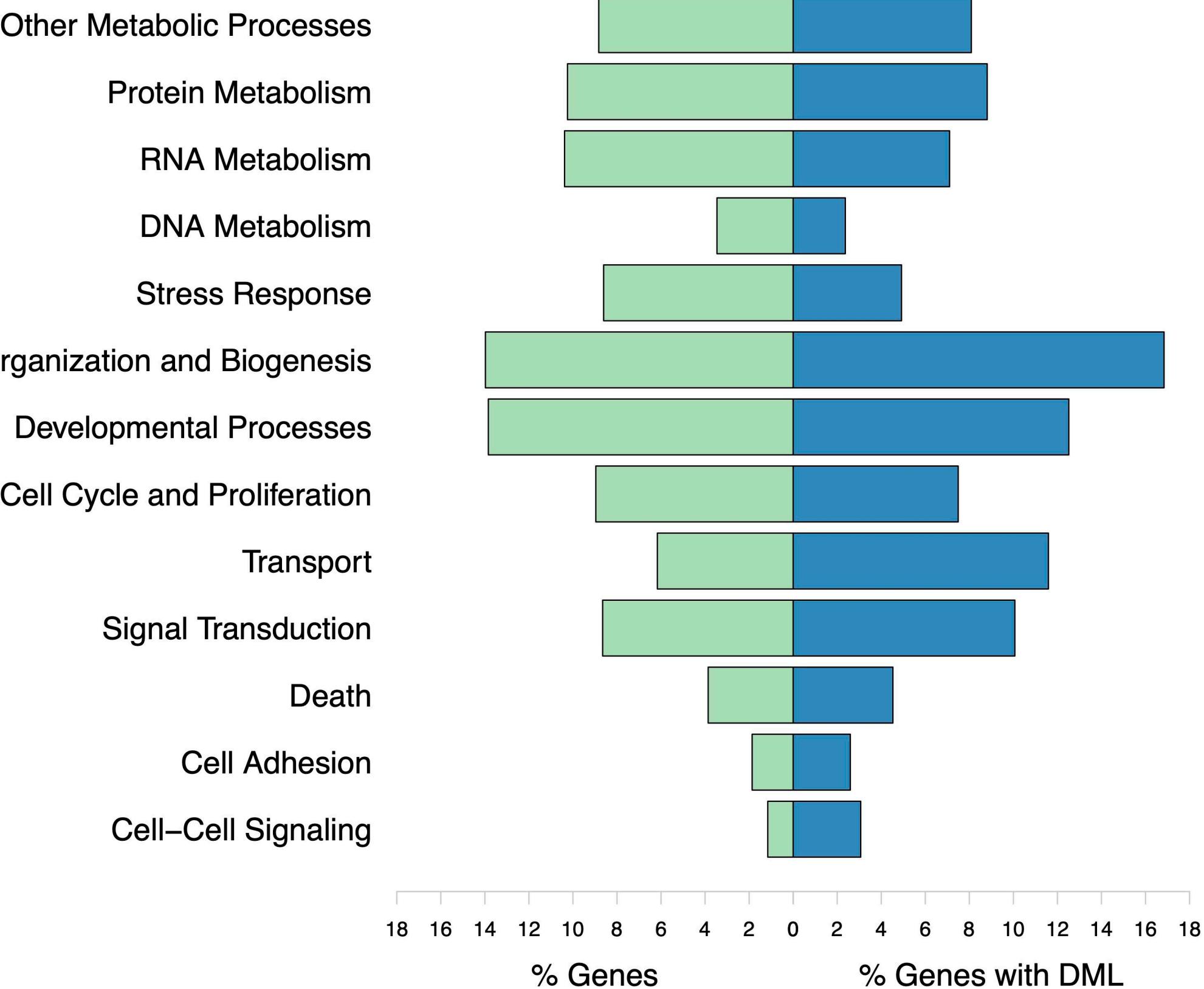
2

CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

# Ocean Acidification



**MBD-BSseq**



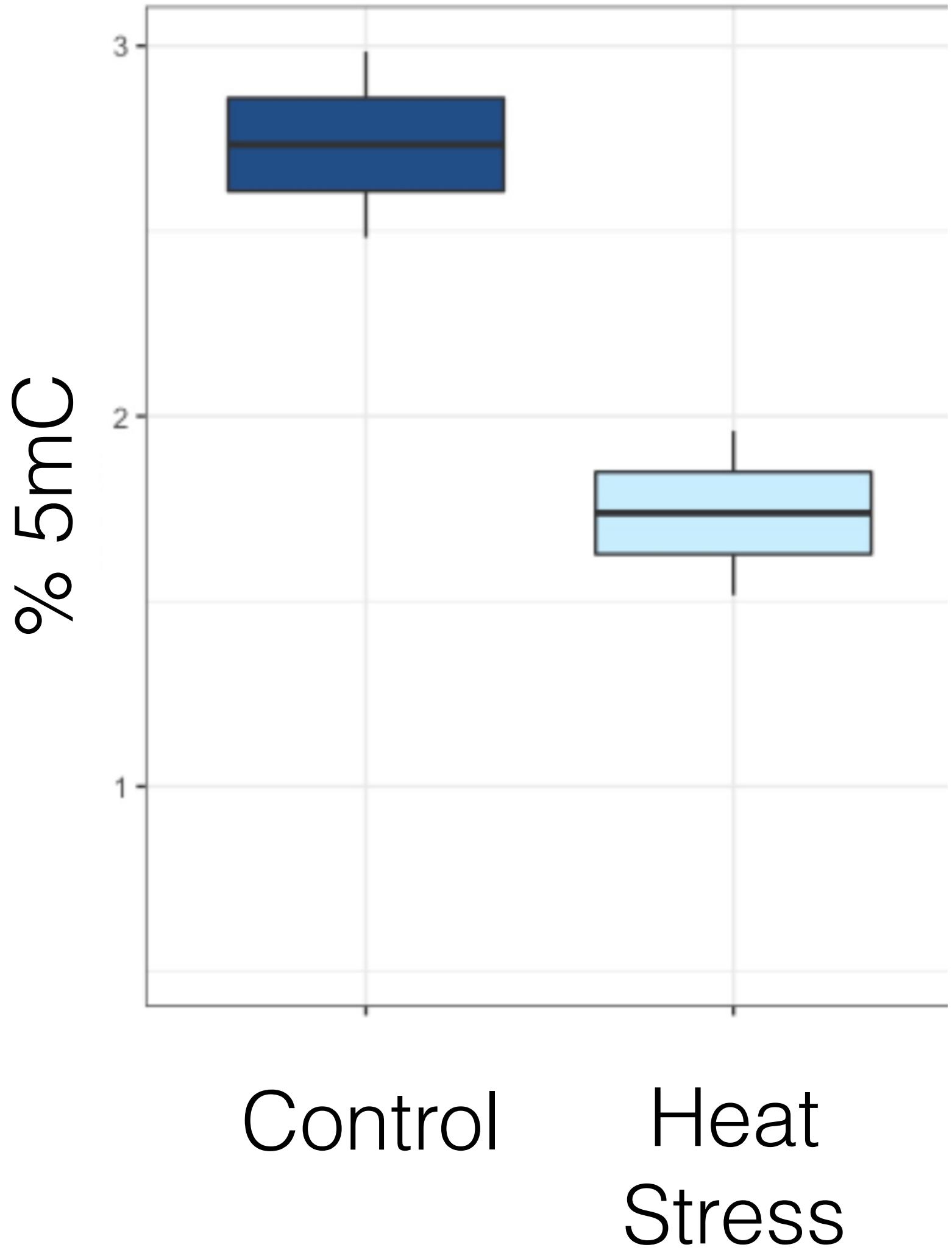
#2-11

**Venkataram et al;** Influence  
of ocean acidification on  
Pacific oyster (*Crassostrea  
gigas*) DNA methylation

**General DNA Methylation Patterns and  
Environmentally-Induced Differential Methylation in  
the Eastern Oyster (*Crassostrea virginica*)**

Yaamini R. Venkataraman<sup>1\*</sup>, Alan M. Downey-Wall<sup>2</sup>, Justin Ries<sup>2</sup>, Isaac Westfield<sup>2</sup>, Samuel J. White<sup>1</sup>, Steven B. Roberts<sup>1</sup> and Kathleen E. Lotterhos<sup>2</sup>

# Temperature and Desiccation Decreases Global DNA Methylation

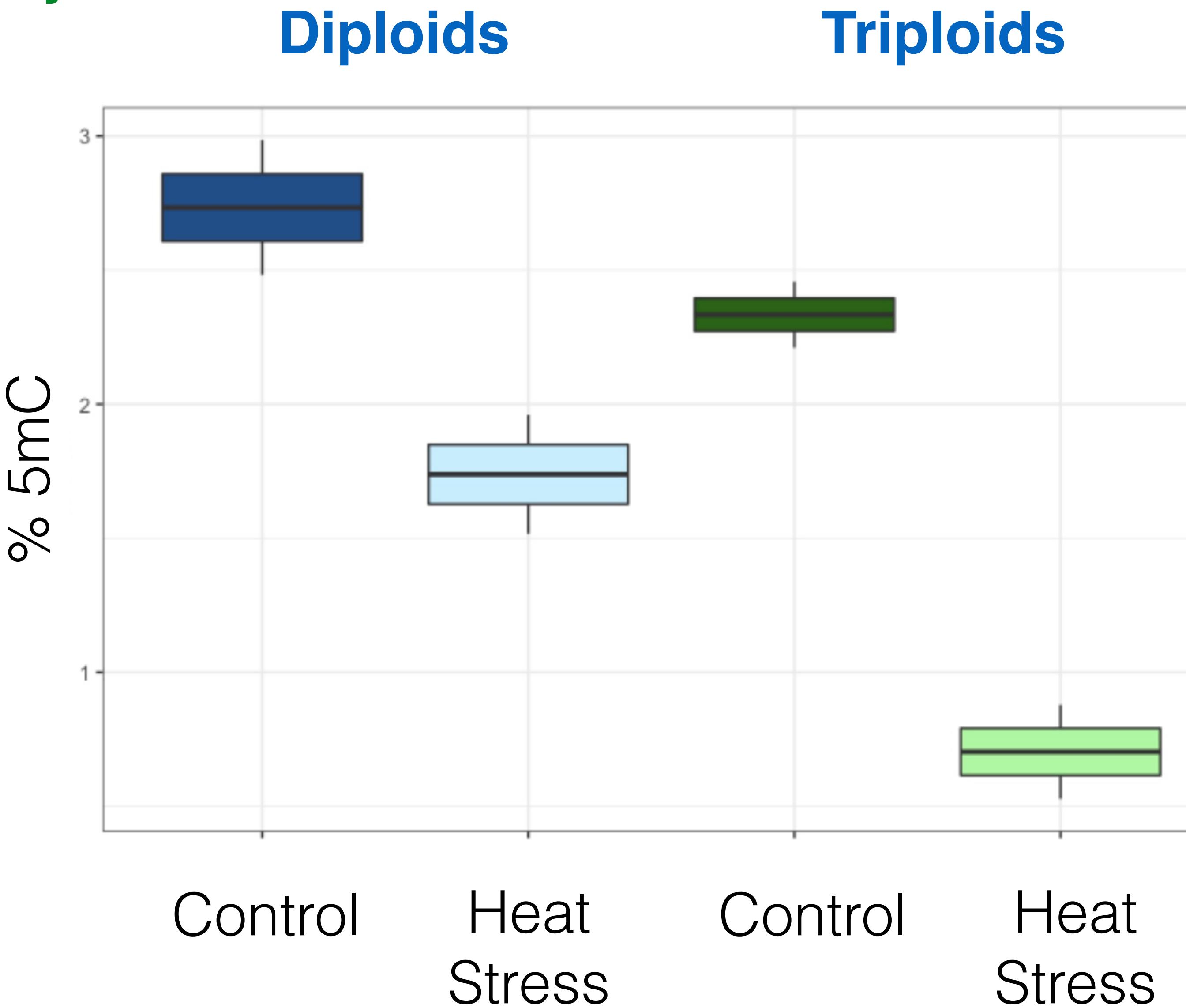


**DNA Methylation ELISA**

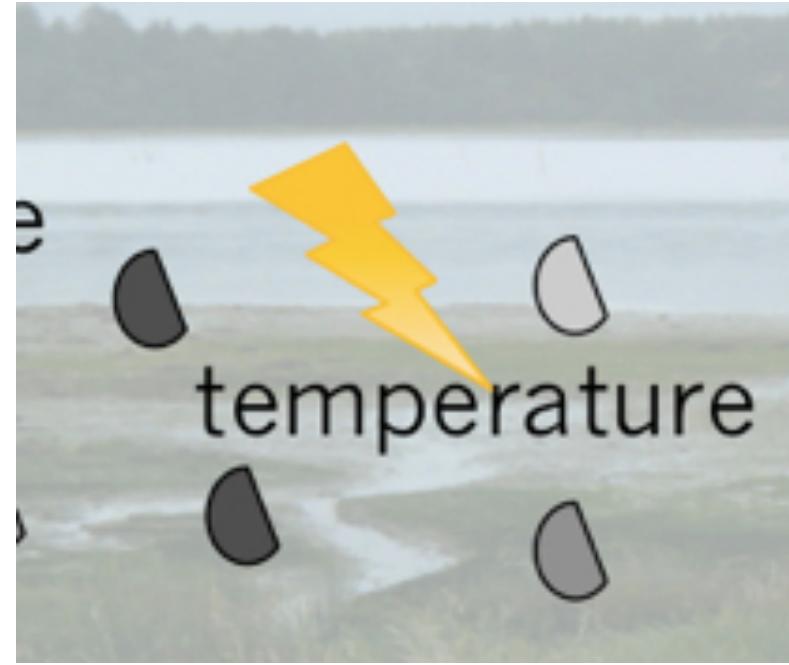
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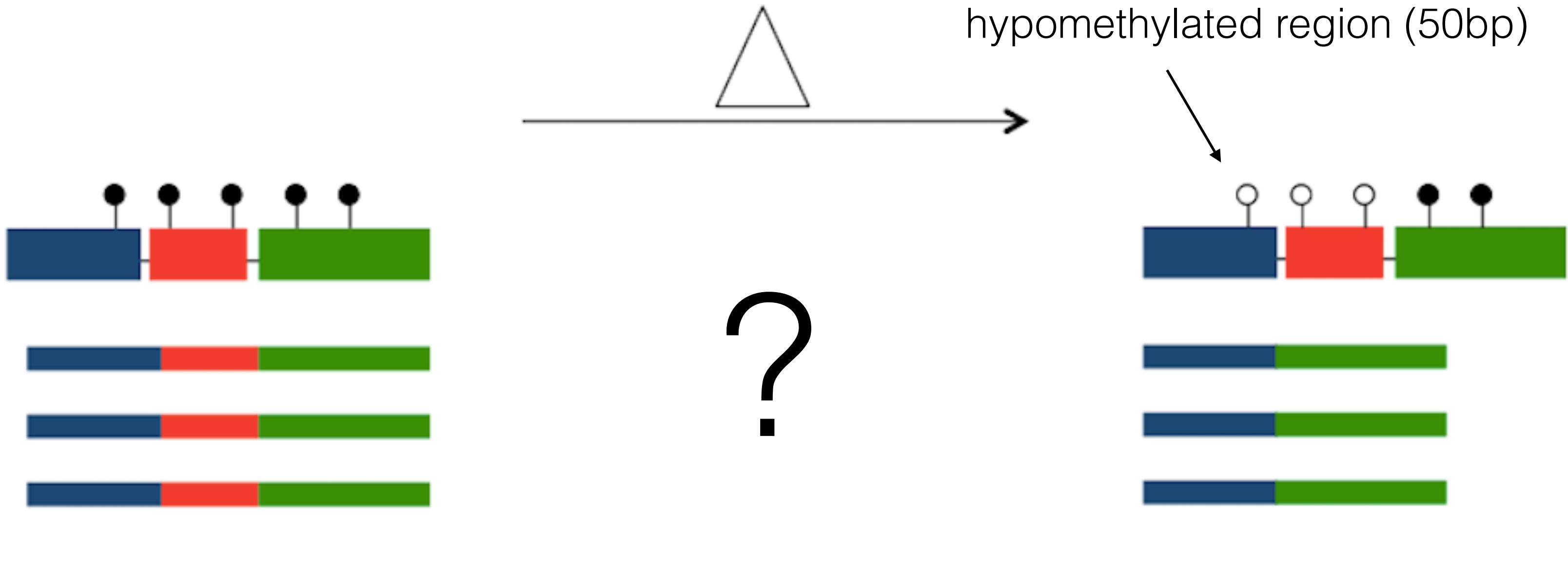
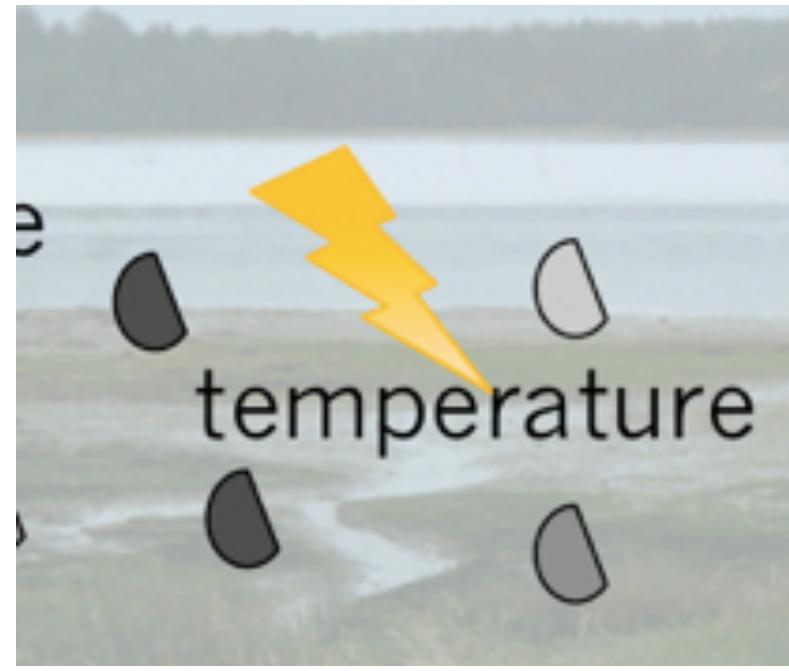
# Temperature Alters CpG Methylation



Oyster	Hypo-methylated	Hyper-methylated
2	7224	2803
4	6560	3587
6	7645	4044

***MBD-Array***

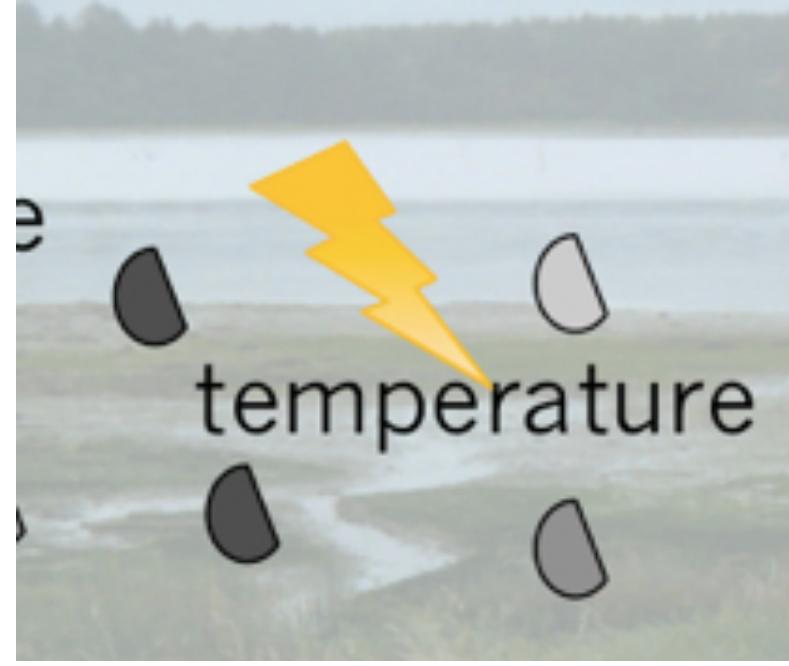
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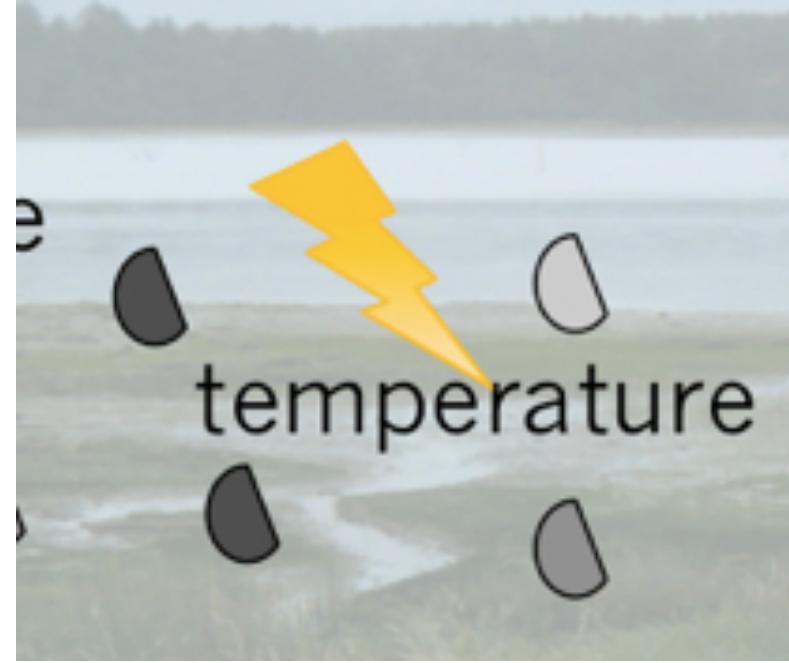
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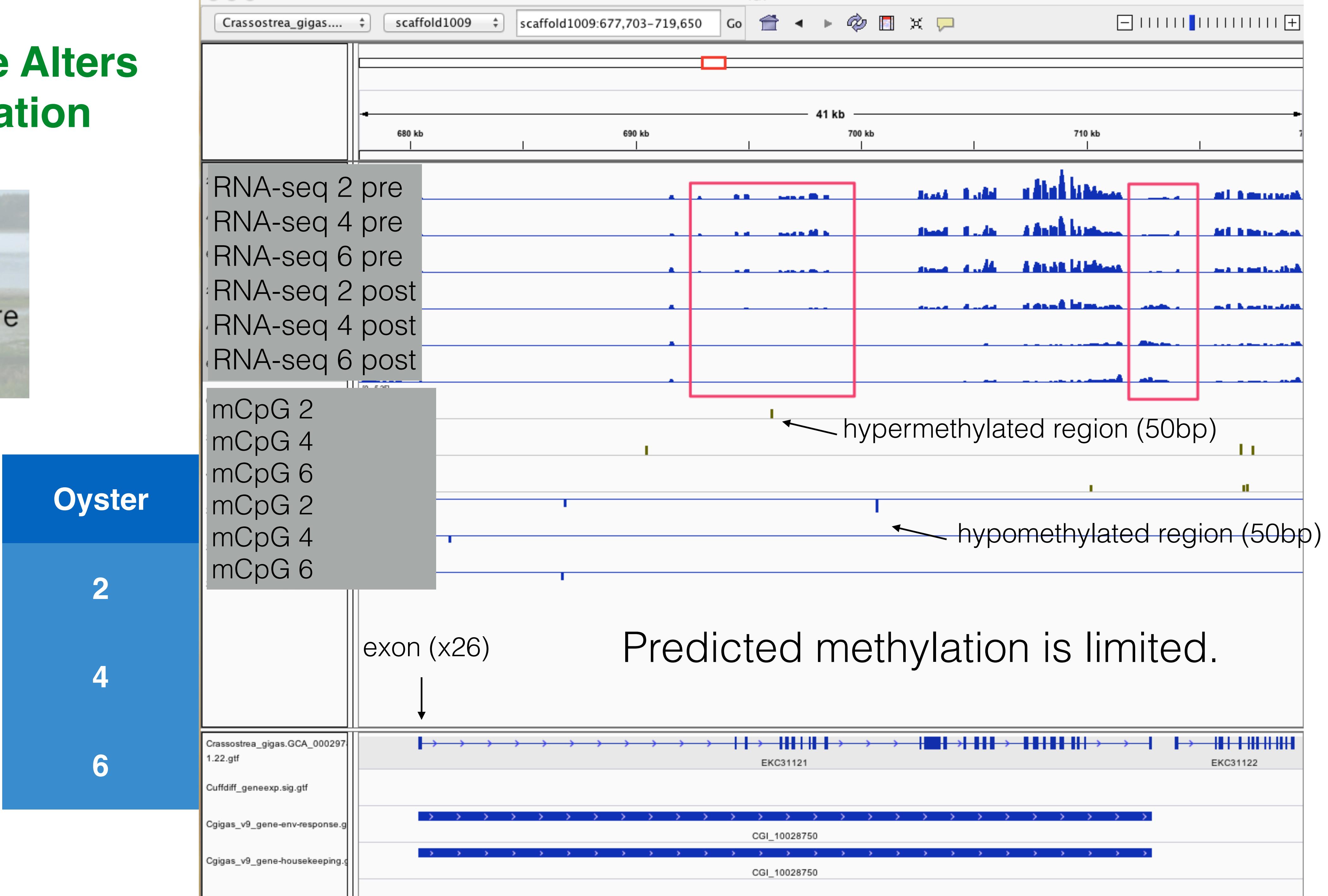
Oyster	Hypo-methylated	Hyper-methylated
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No obvious association  
with genome feature  
including *differentially*  
*expressed*  
*genes*

# Temperature Alters CpG Methylation



**MBD-Array**



ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE

3



CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

# Family Specific DNA Methylation Patterns Exist



Cold  
Spring  
Harbor  
Laboratory

**bioRxiv**  
beta

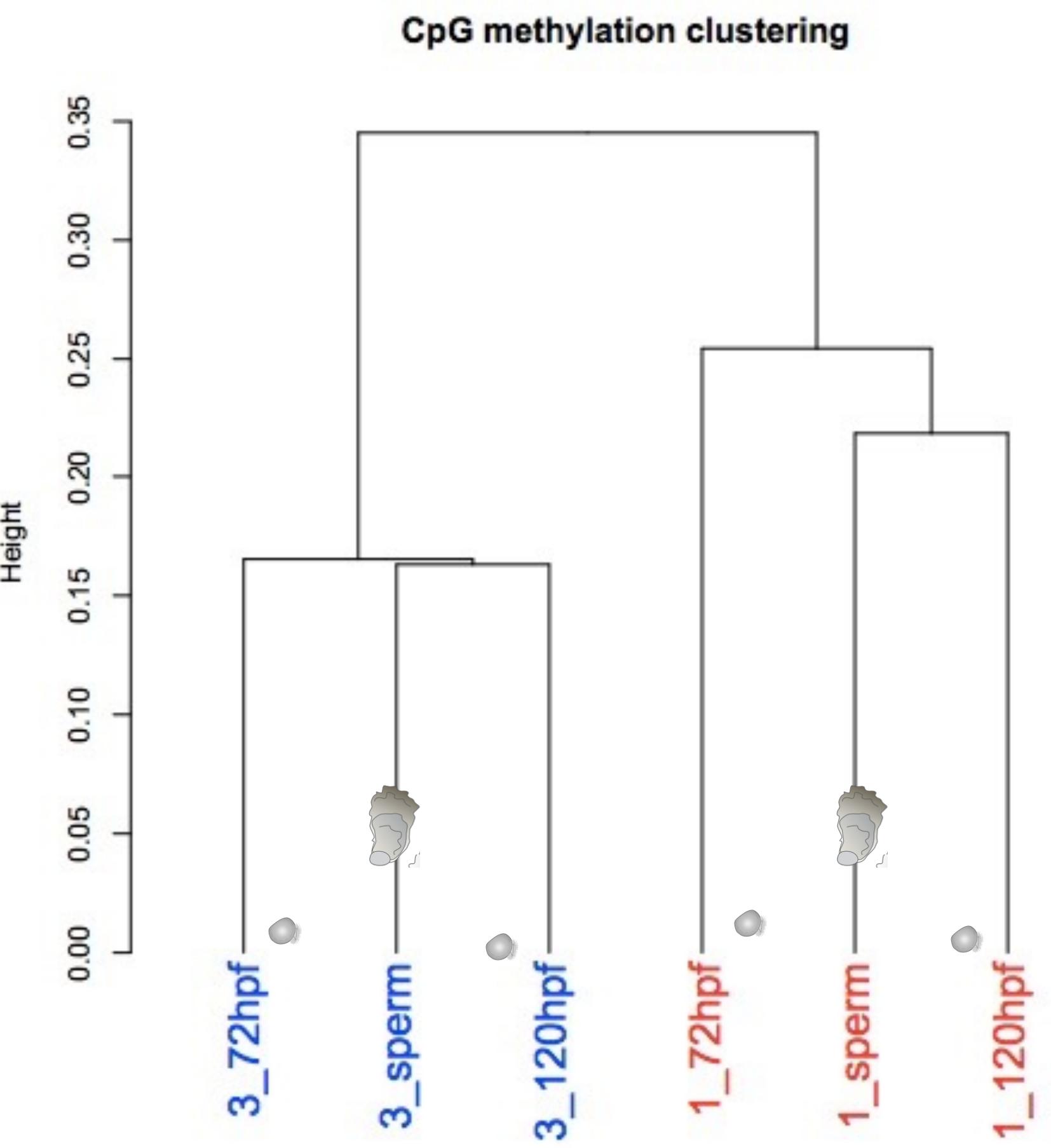
THE PREPRINT SERVER FOR BIOLOGY

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>

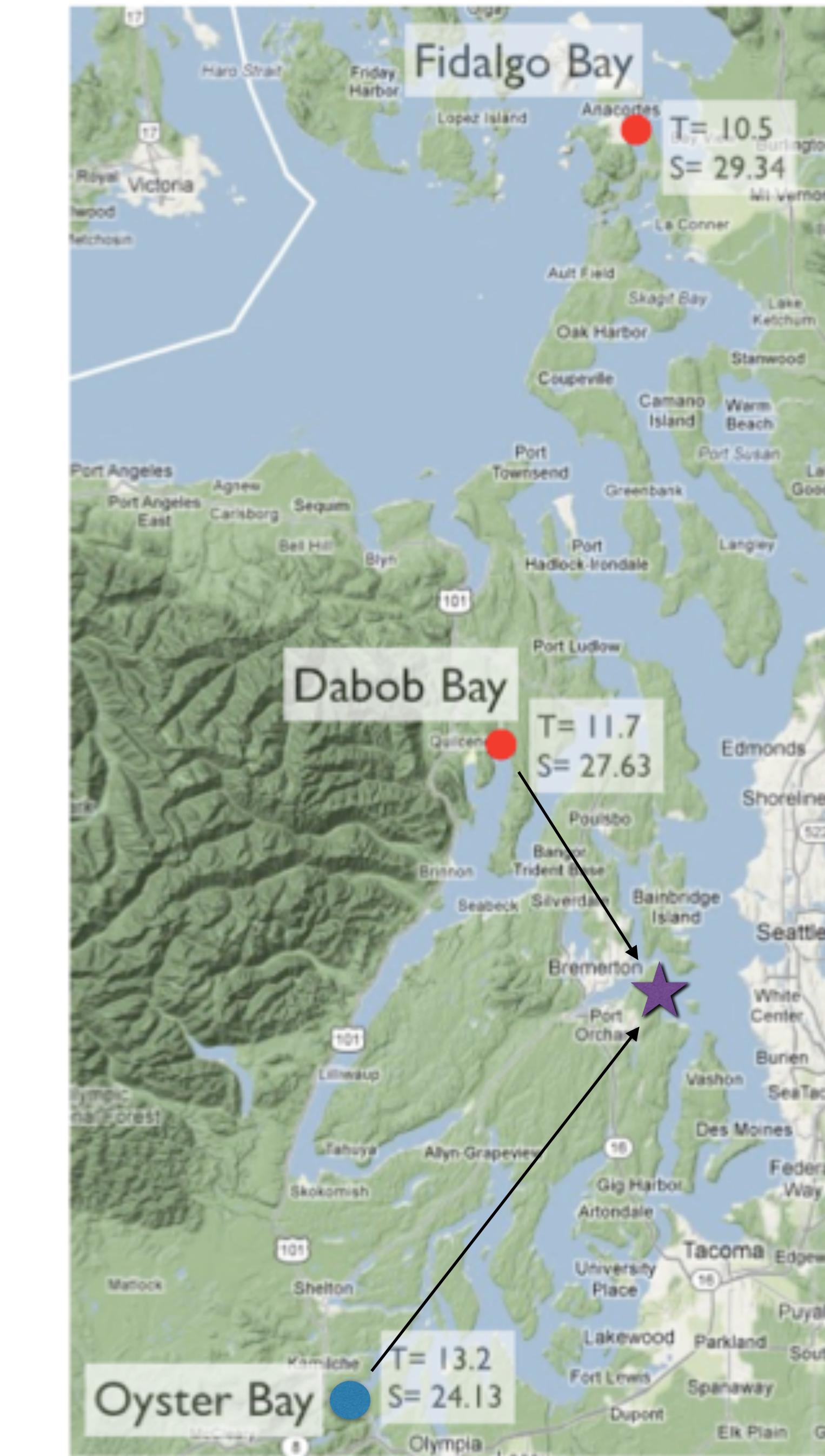
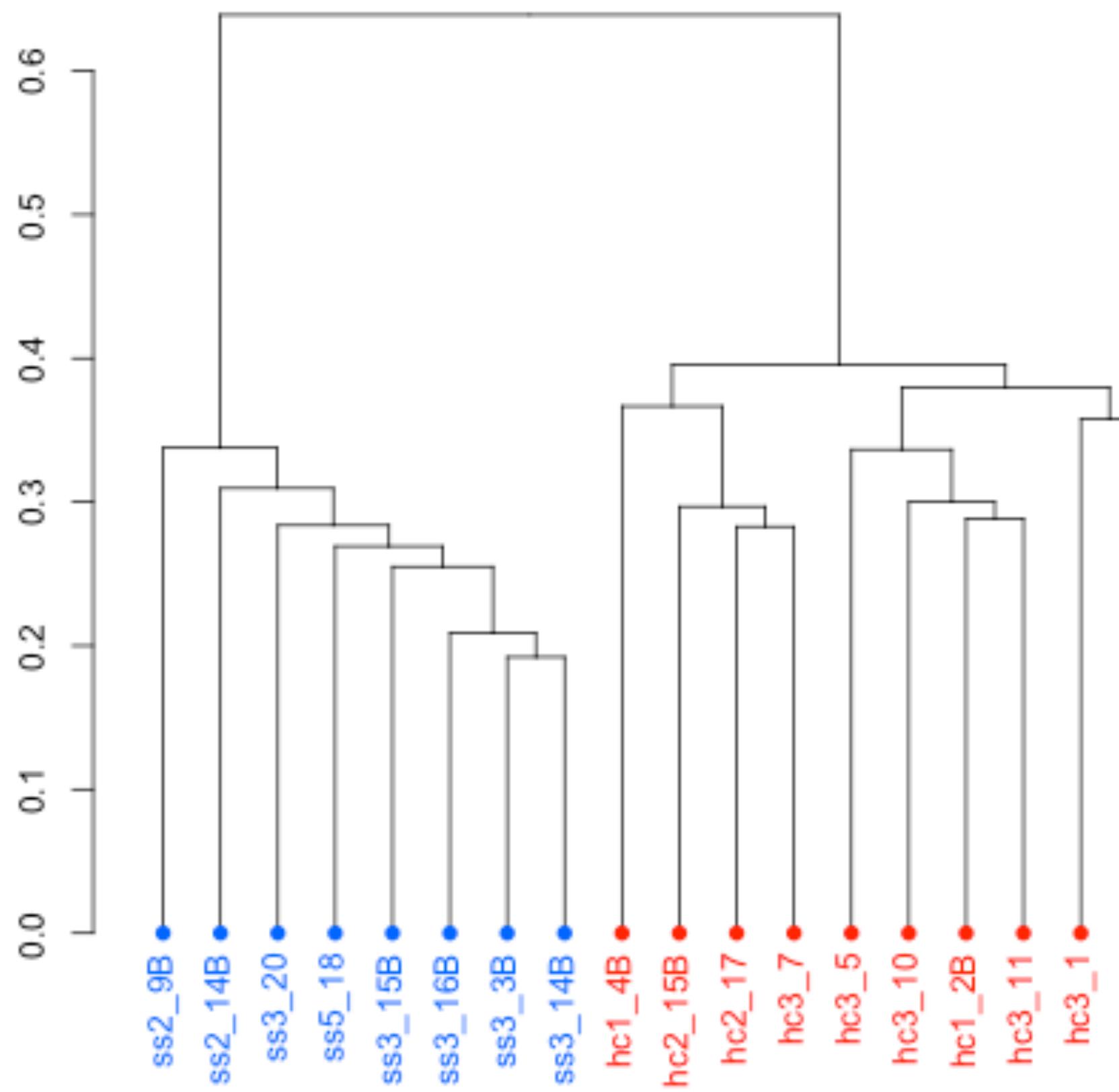


# Population DNA Methylation Patterns Persist in Transplant Experiment



# Population DNA Methylation Patterns Persist in Transplant Experiment

CpG methylation clustering



ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE

3

What about within generation? Priming?

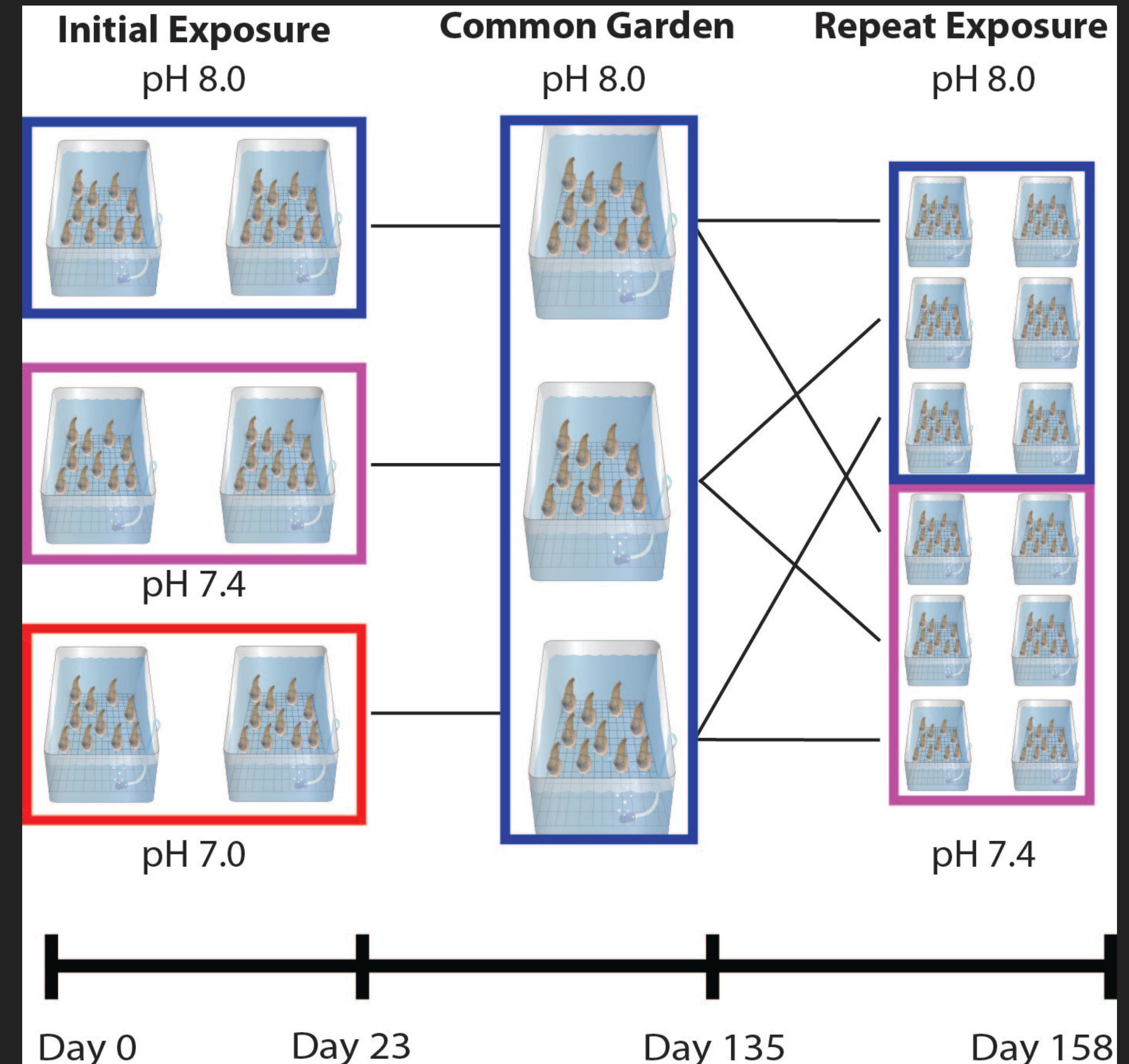


CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

## GEODUCKS AND OA

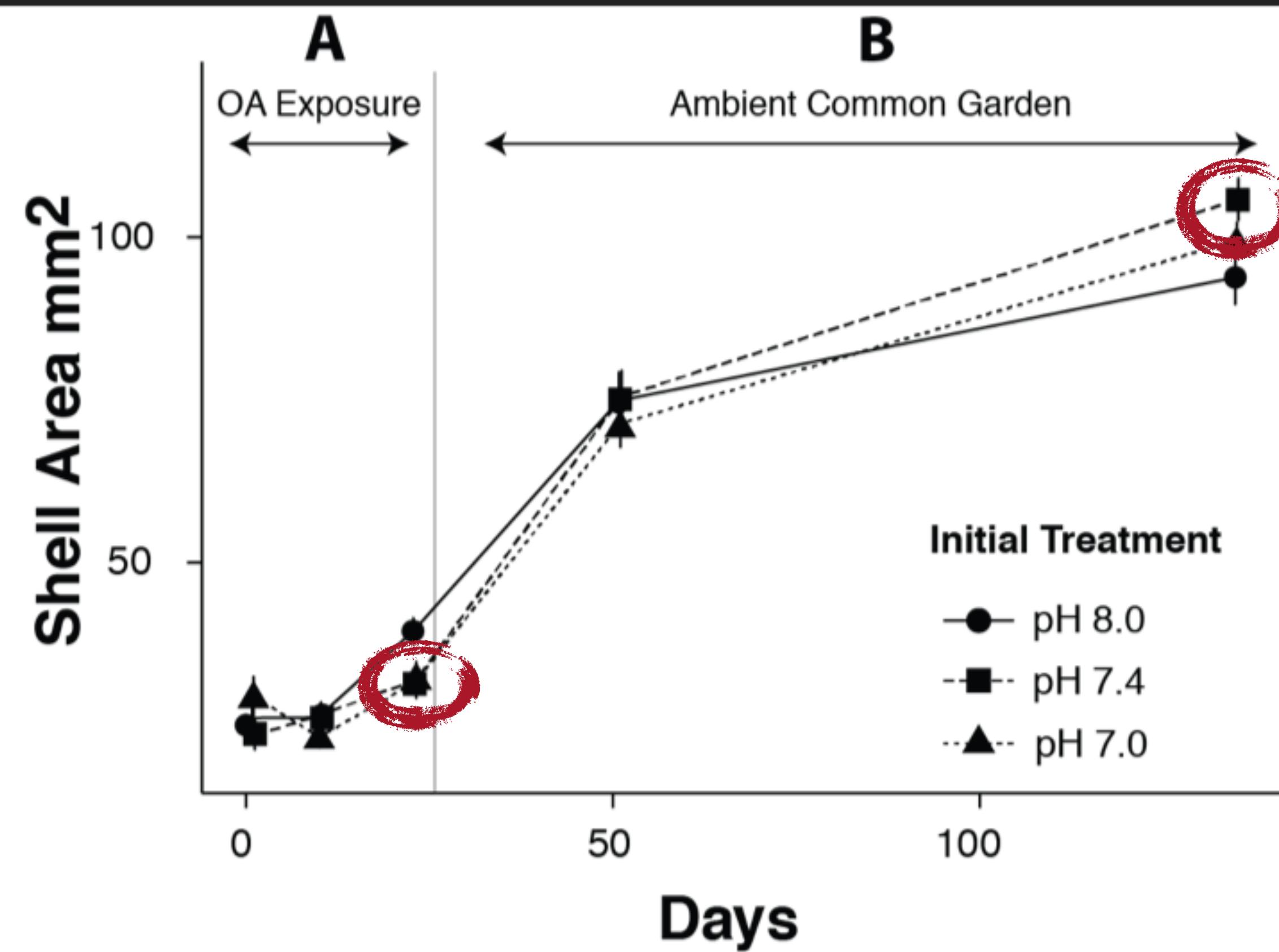
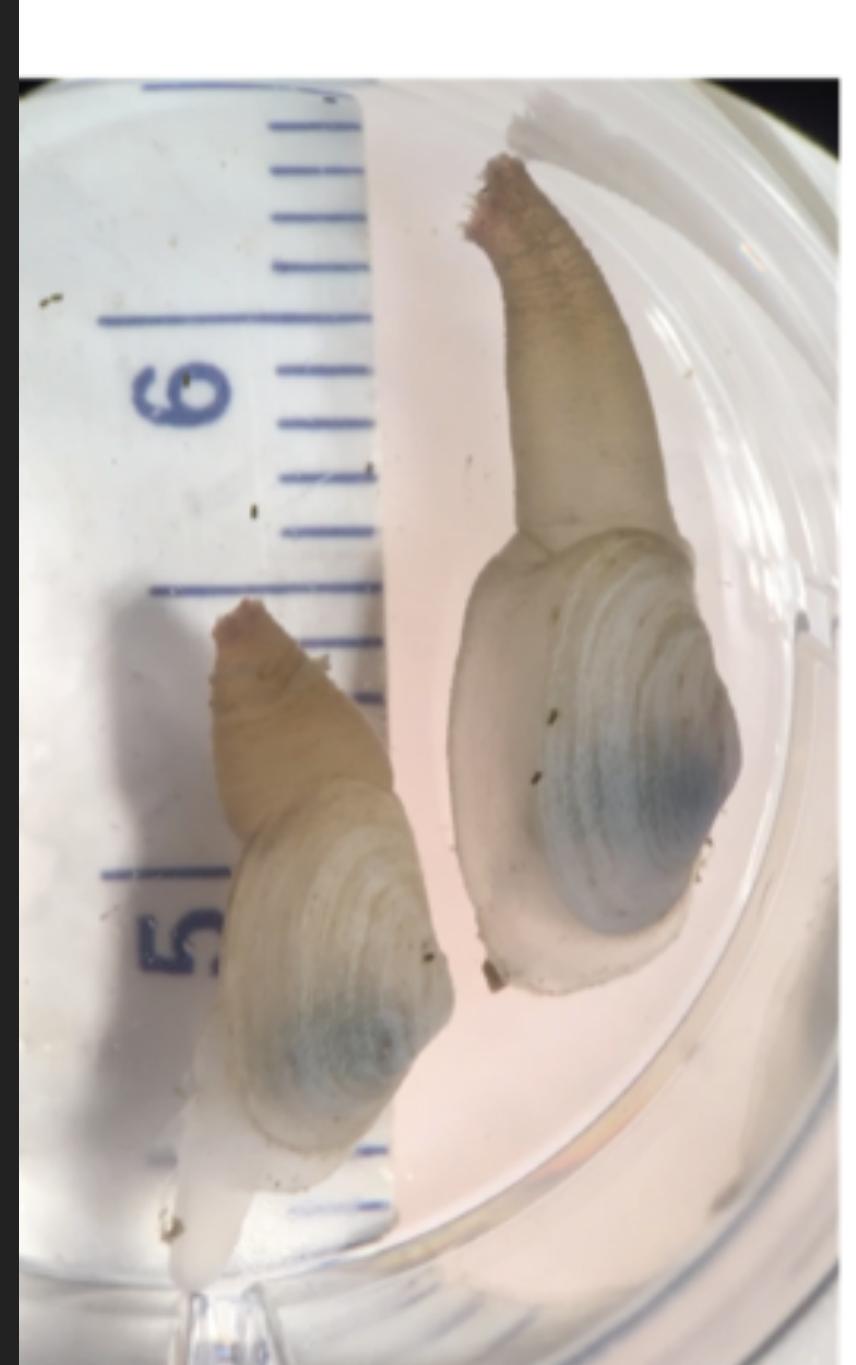


- ▶ Does conditioning to low pH confer tolerance within a generation?



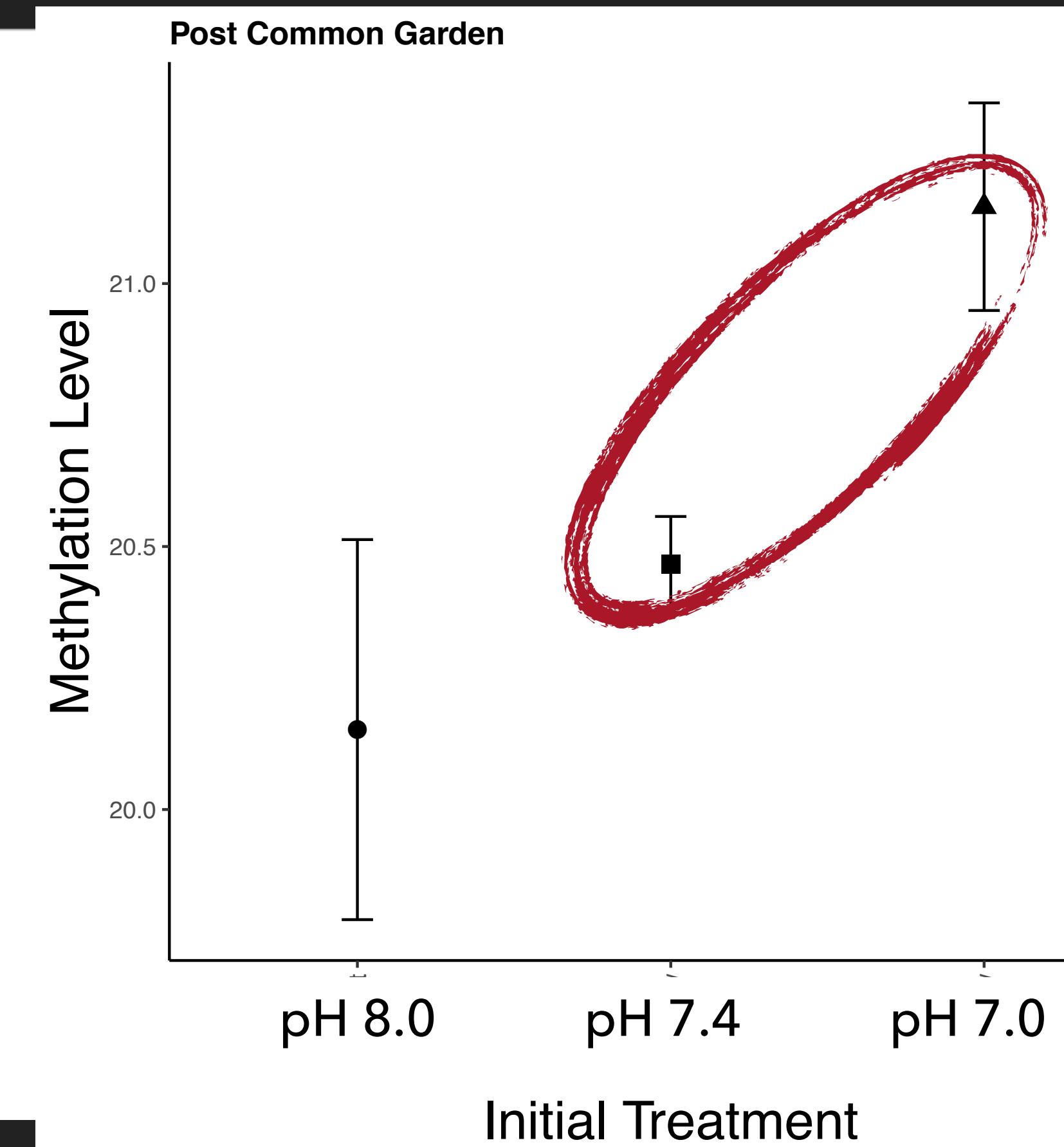
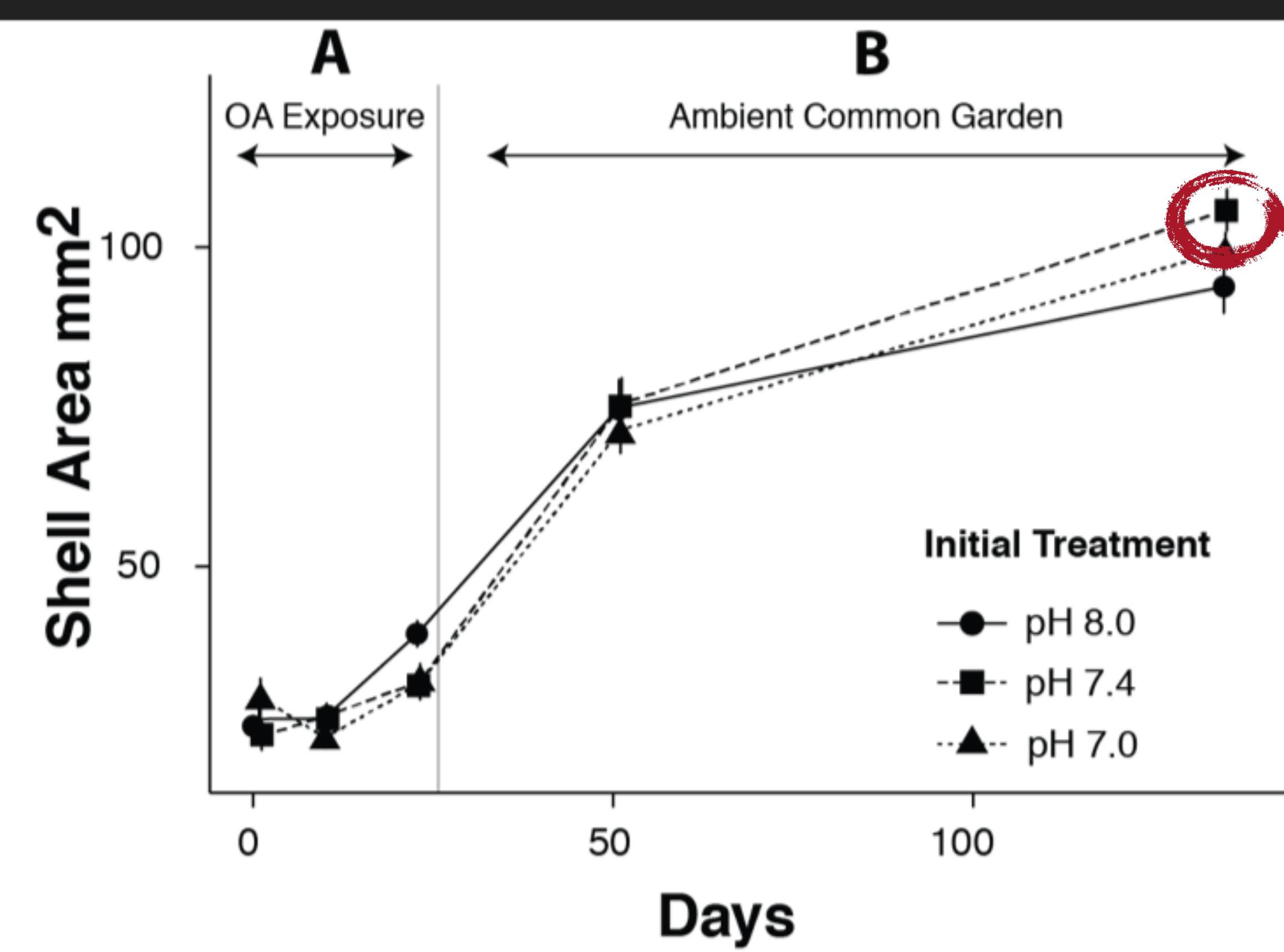
# GEODUCKS AND OA

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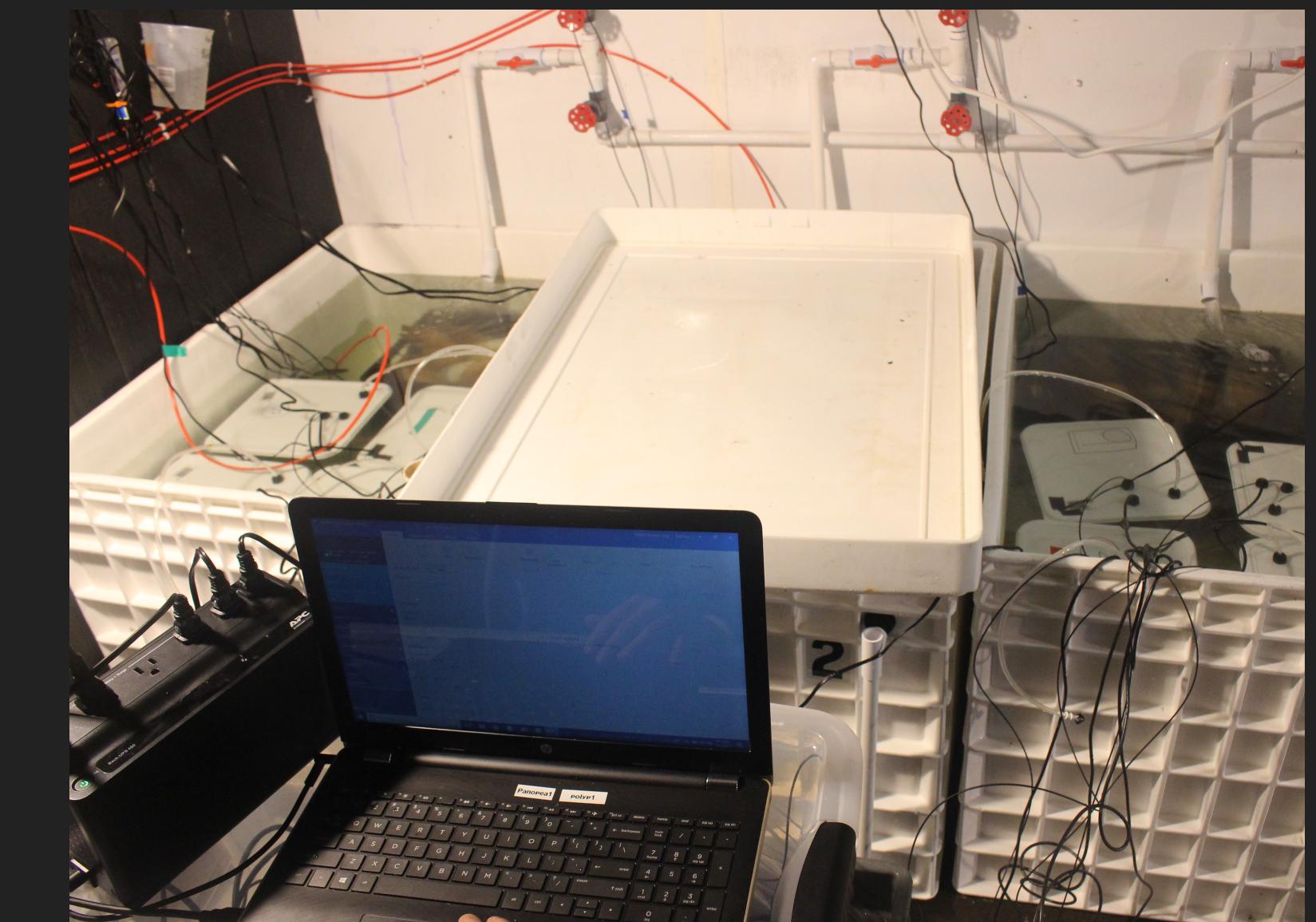
# GEODUCKS AND OA

# DNA METHYLATION



HOLLIE PUTNAM, SAM GURR, BRENT VADOPALAS, SHELLY TRIGG, JAMESTOWN S'KLALLAM TRIBE

## GEODUCKS AND OA



## GEODUCKS AND OA



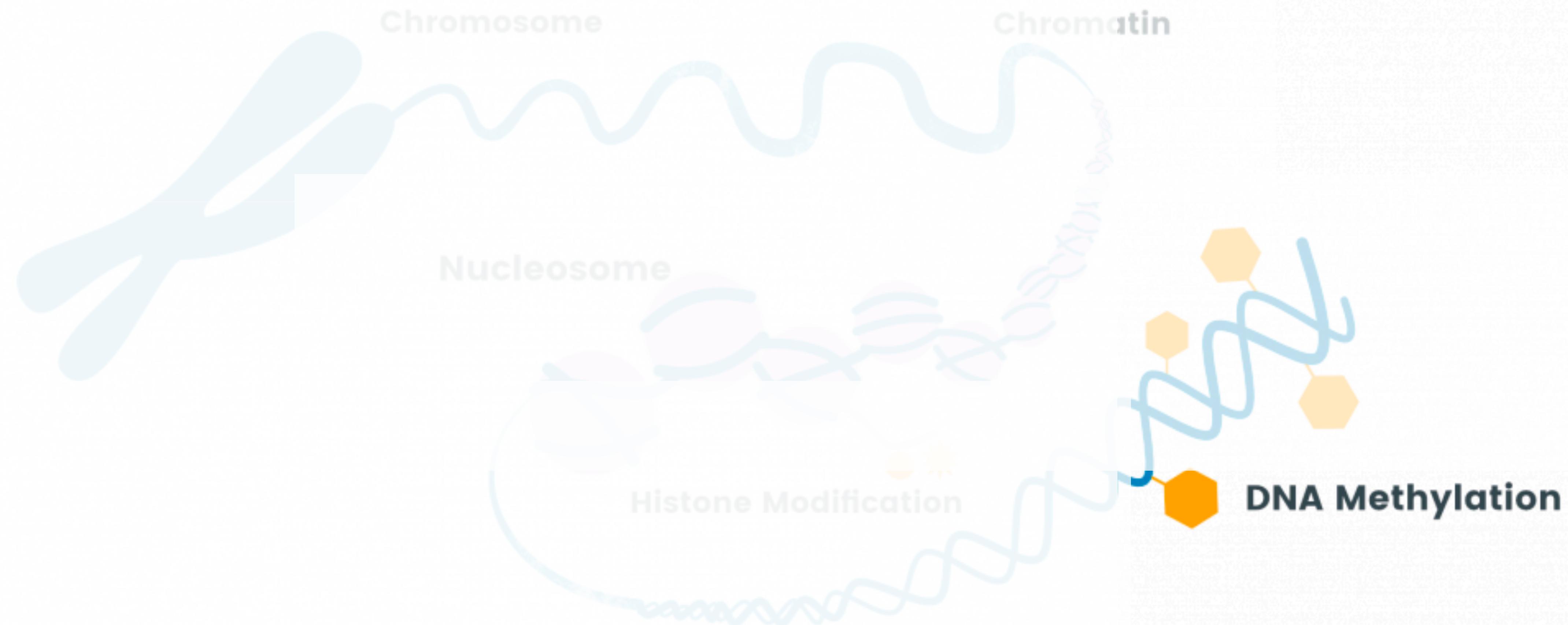
#2-12

**Gurr et al;** Environmental learning in a tolerant commercial clam: Insights from phenotypic and subcellular adjustments to hypercapnia seawater

#2-10

**Trigg et al;** Exploring the tolerance of Pacific geoduck to low pH through comparative physiology, genomics, and DNA methylation

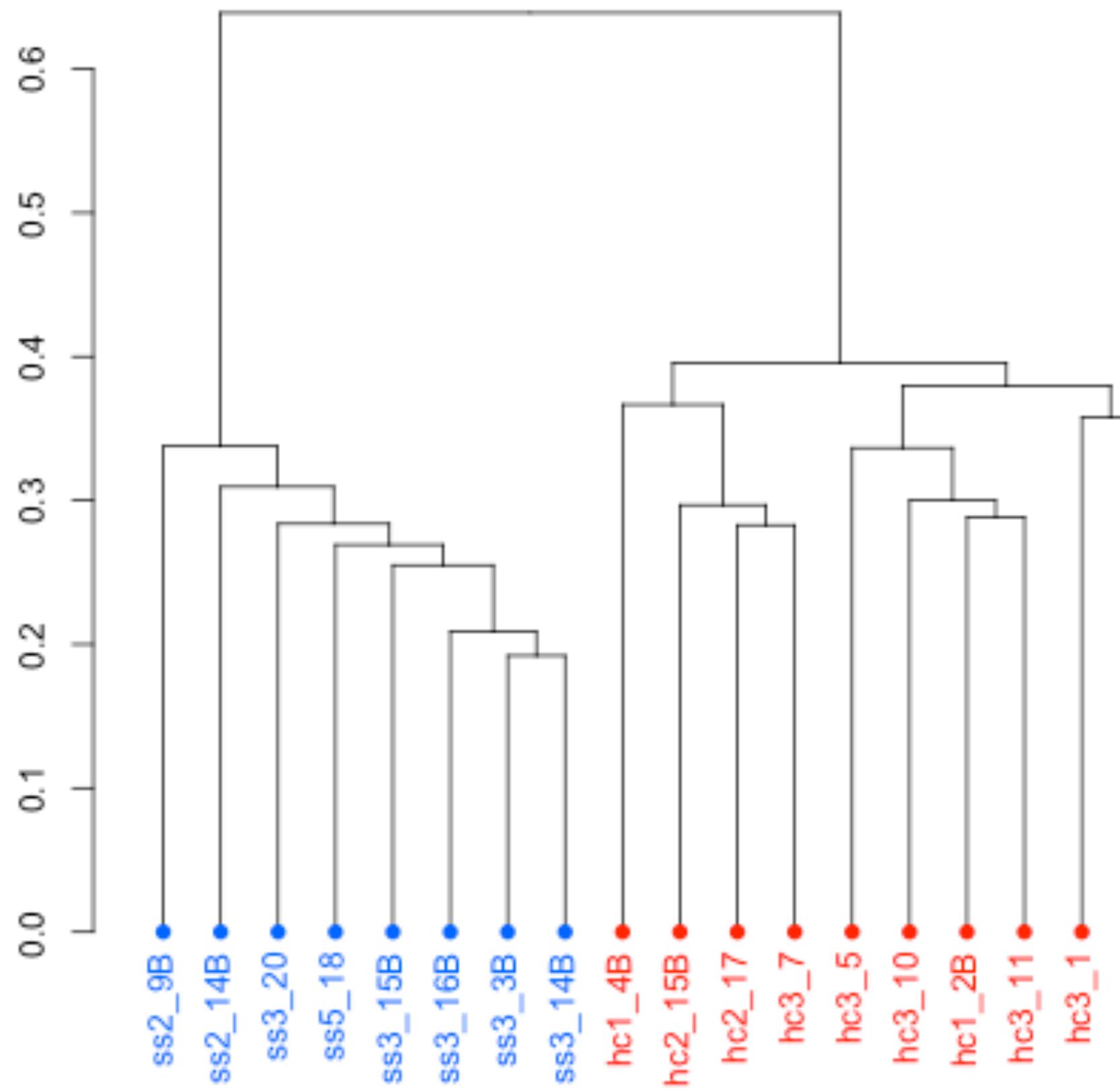
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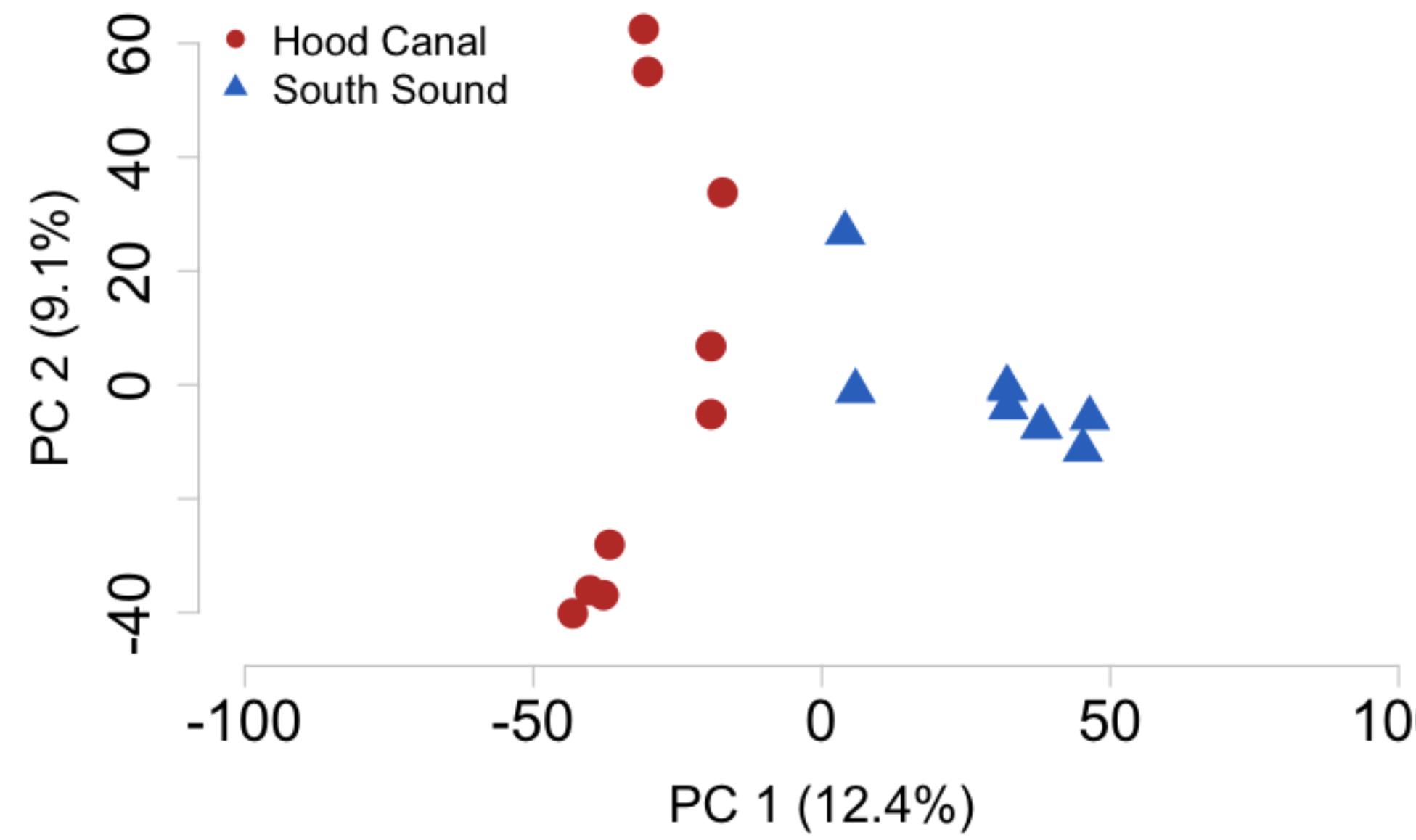
CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

# Population DNA Methylation Patterns Persist in Transplant Experiment

CpG methylation clustering



# Genetic Differentiation exists



*no direct linkages between genetic and epigenetic differences*

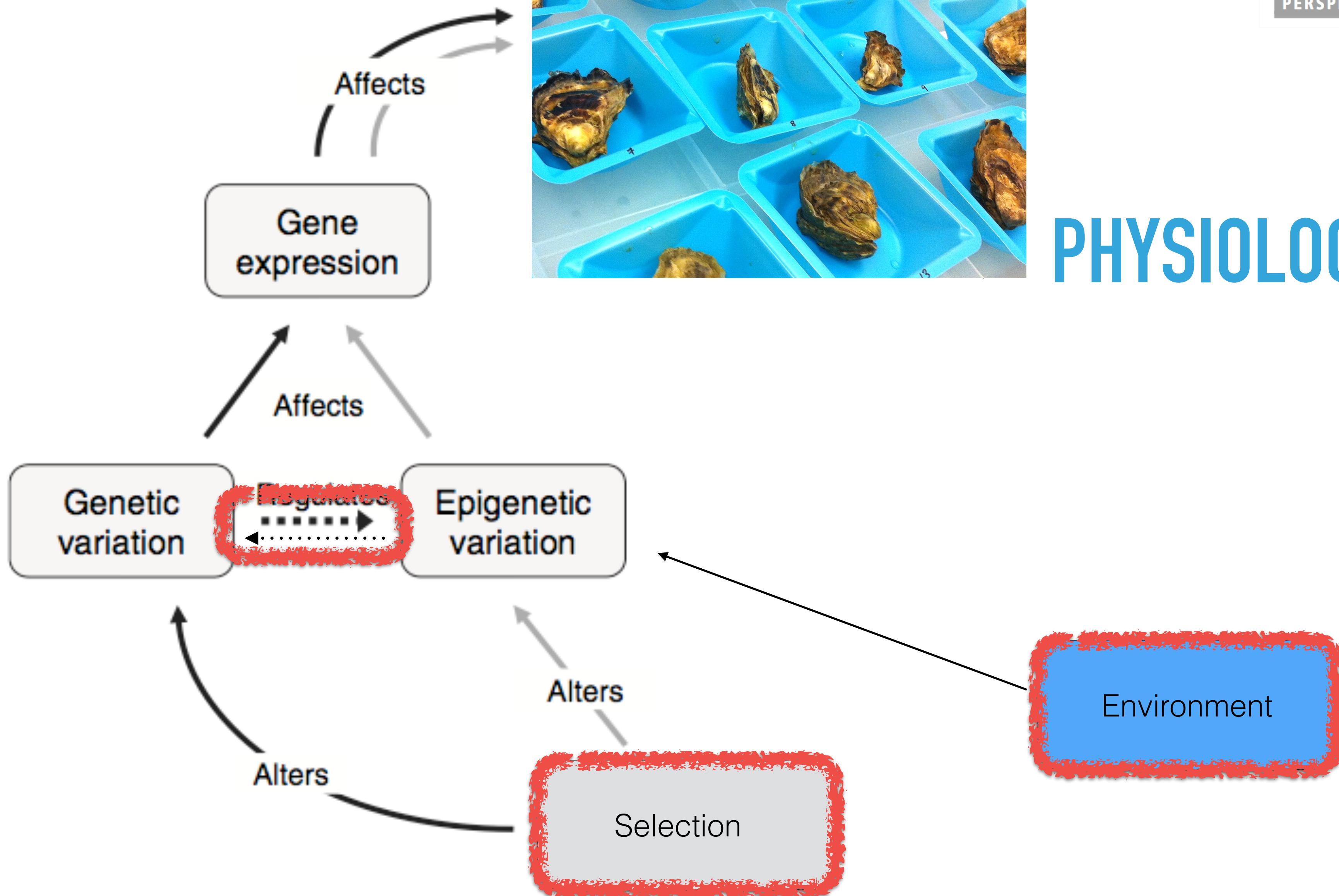
# Phenotype associated loci after taking genetics into consideration

Table 2: Genes that contain loci in which methylation status is associated with oyster size (SALs)		
Uniprot Accession	Gene Name	Protein Name
Q5W0Q7	USPL1	SUMO-specific isopeptidase
Q15937	ZNF79	zinc finger protein 79
Q9QXV3	Ing1	inhibitor of growth family, member 1
Q23551	unc-22	Twitchin
A4II09	eif3a	eukaryotic translation initiation factor 3 subunit A
Q3UCV8	Otulin	Ubiquitin thioesterase otulin
Q28I85	poc1a	POC1 centriolar protein A
Q8BGS3	Zkscan1	zinc finger with KRAB and SCAN domains 1
Q8BFY9	Tnpo1	transportin 1
H2QII6	RANBP2	E3 SUMO-protein ligase
Q14315	FLNC	filamin C



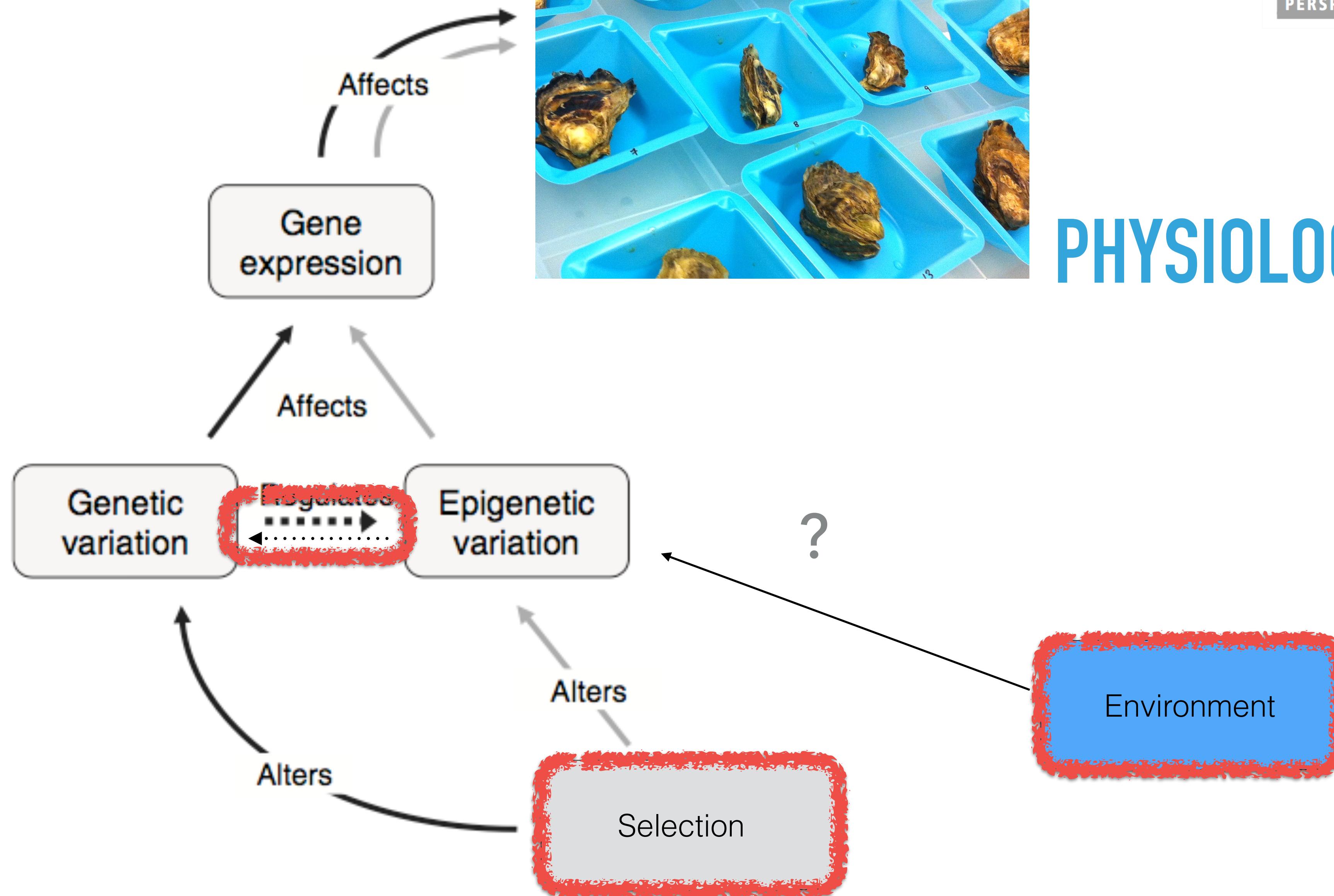


## PHYSIOLOGY





## PHYSIOLOGY



## SUMMARY

1. There is a lot we still do not understand with regard to the functional role of DNA methylation in marine invertebrates. (*If in fact one exists*)
2. We have just begun to look at epigenetic phenomenon in marine invertebrates.
3. Based on numerous within and across generation studies in marine invertebrates (ie. priming, transgenerational plasticity) there are exciting possibilities to explore on how species can effectively respond to environmental change.

## ACKNOWLEDGEMENTS

- ▶ Mackenzie Gavery, Claire Olson, Sam White, Brent Vadopalas, Shelly Trigg, Sam Gurr, Hollie Putnam, Laura Spencer, Katherine Silliman, Yaamini Venkataraman, Alan Downey-Wall, Justin Ries, Katie Lotterhos

[GITHUB.COM/SR320/TALK-SICB-2021](https://github.com/SR320/TALK-SICB-2021)



FFAR

