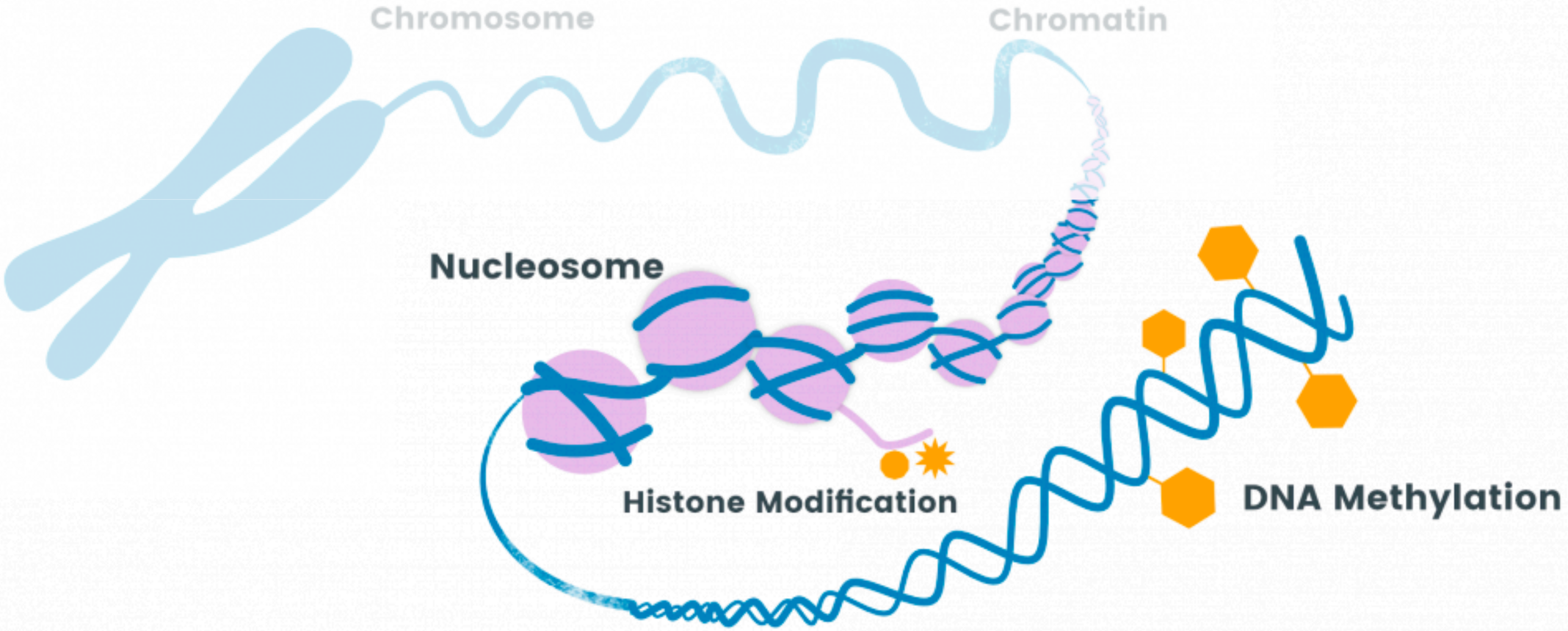
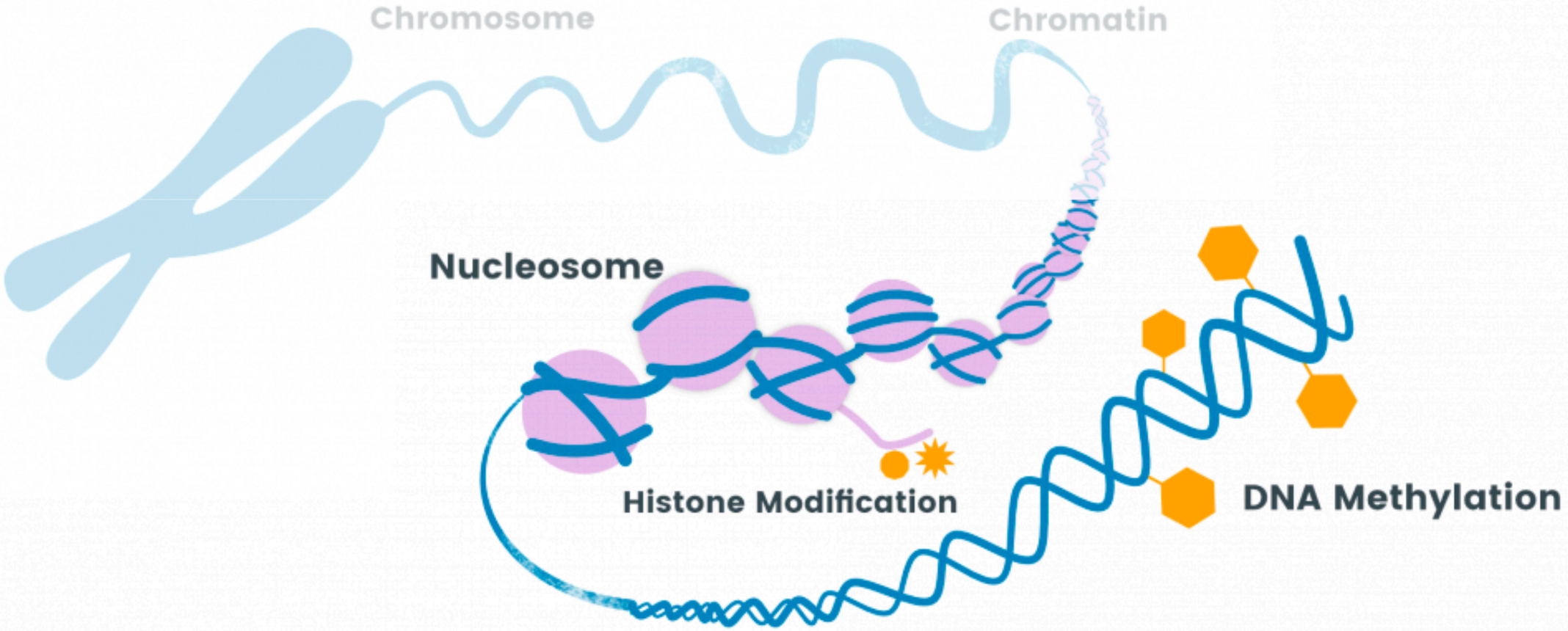
STEVEN ROBERTS
SCHOOL OF AQUATIC AND FISHERY SCIENCES
UNIVERSITY OF WASHINGTON

A PERSPECTIVE ON DNA METHYLATION IN BIVALVES

ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE



ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE): HERITABLE



CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

ECOLOGICAL EPIGENETICS

Ecology Letters, (2008) **11**: 106–115 doi: 10.1111/j.1461-0248.2007.01130.x

IDEA AND PERSPECTIVE

Epigenetics for ecologists

O Bossdorf, CL Richards, M Pigliucci

PHYSIOLOGY

ECOLOGICAL EPIGENETICS

Ecology Letters, (2008) **11**: 106–115 doi: 10.1111/j.1461-0248.2007.01130.x

IDEA AND PERSPECTIVE

Epigenetics for ecologists

O Bossdorf, CL Richards, M Pigliucci

PHYSIOLOGY

ECOLOGICAL EPIGENETICS

Ecology Letters, (2008) **11**: 106–115 doi: 10.1111/j.1461-0248.2007.01130.x

IDEA AND PERSPECTIVE

Epigenetics for ecologists

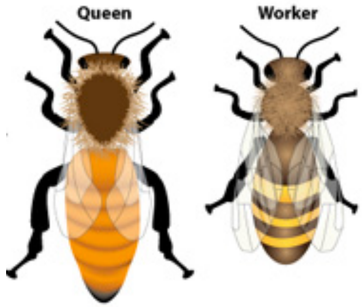
O Bossdorf, CL Richards, M Pigliucci

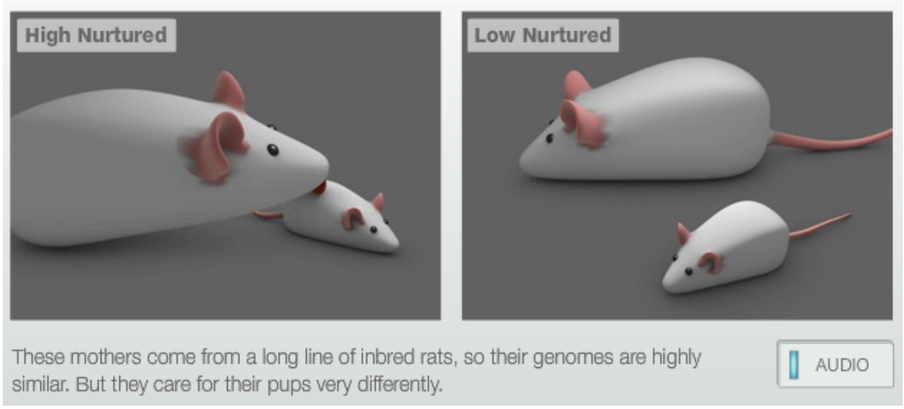
PHYSIOLOGY

DNA METHYLATION

Male and female *Lates calcarifer*

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

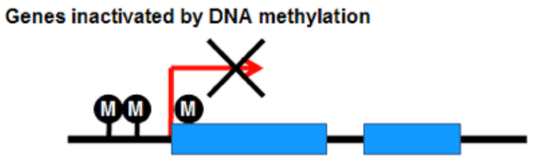




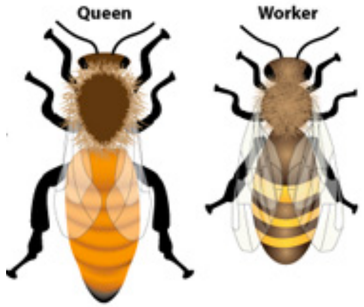
DNA METHYLATION

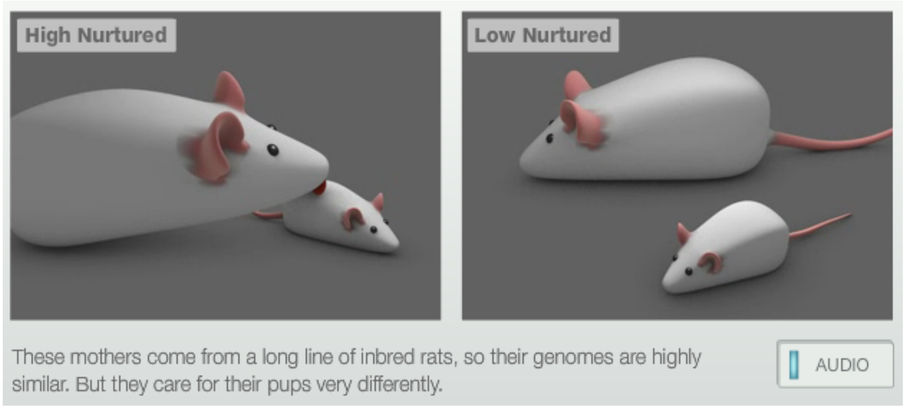
Male and female *Lates calcarifer*

High temp.



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





DNA METHYLATION

Male and female *Lates calcarifer*

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

global methylation

(except CpG islands)

no methylation

mosiac pattern

These Two Mice are Genetically Identical and the Same Age

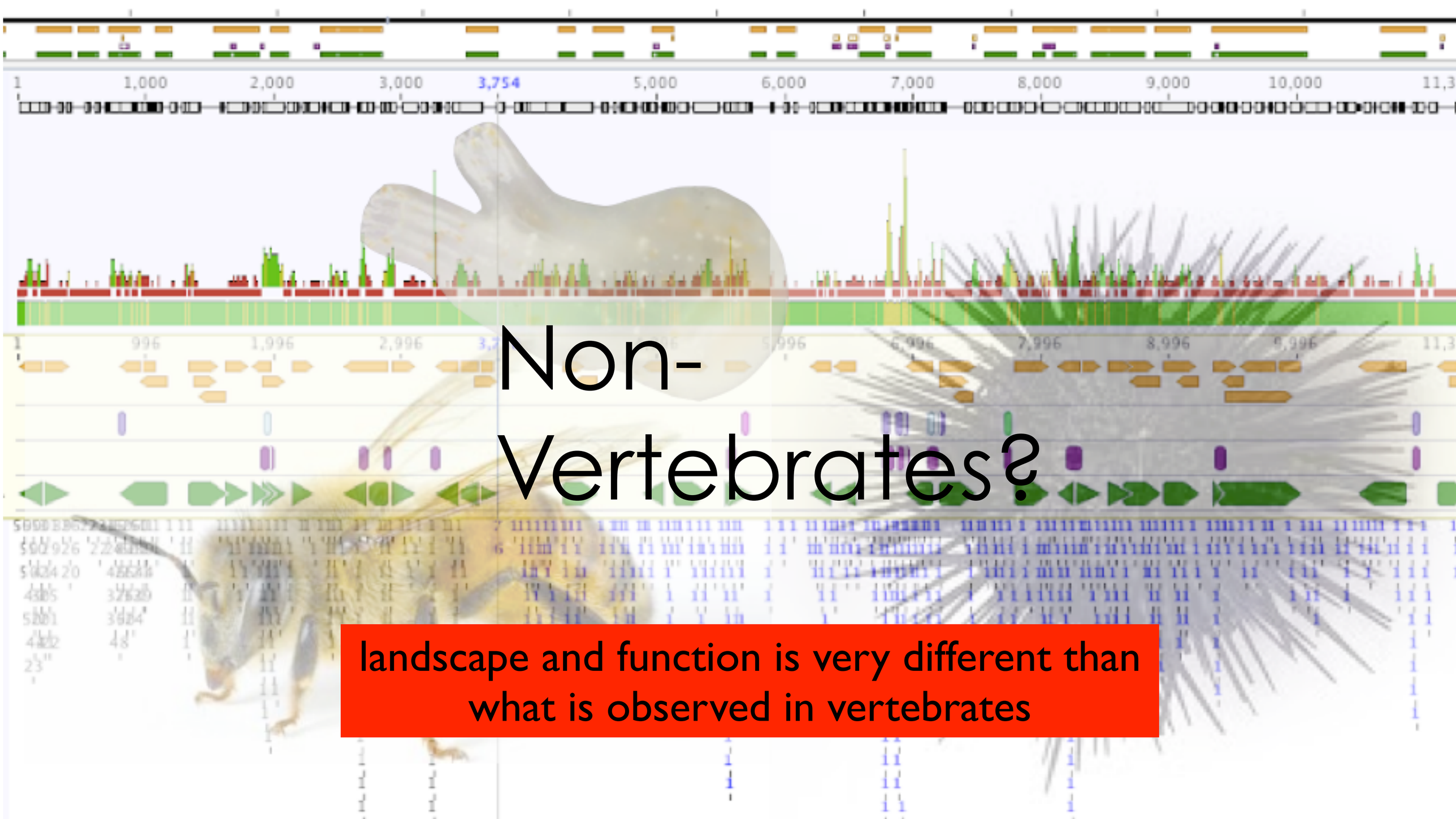
While pregnant, both of their mothers were fed Bisphenol A (BPA) but DIFFERENT DIETS:

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

their genomes are highly

AUDIO

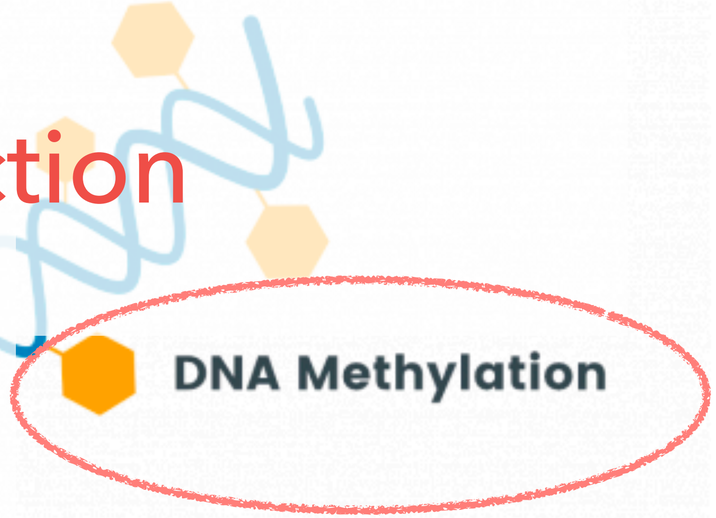

Non-
Vertebrates?
landscape and function is very different than
what is observed in vertebrates

ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE

CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE): HERITABLE

1 Function



2

CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

3

ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE

1 Function

DNA Methylation

2

CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

4 ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE 3

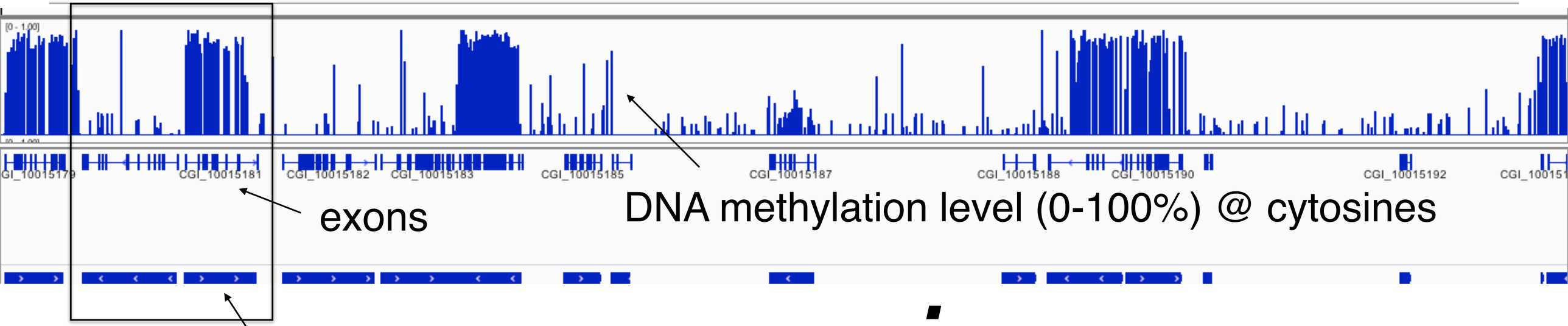
1 Function

DNA Methylation

2

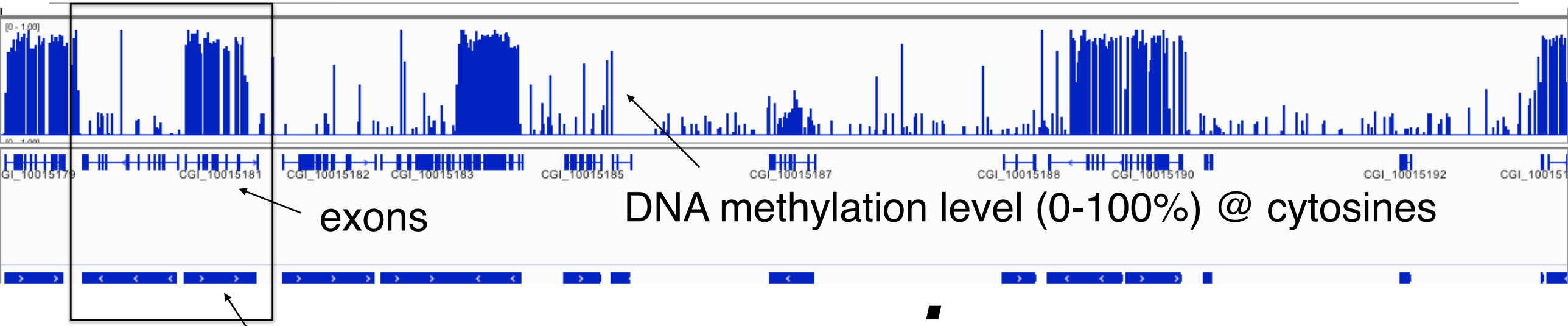
CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

METHYLATION LANDSCAPE IN MARINE INVERTEBRATES



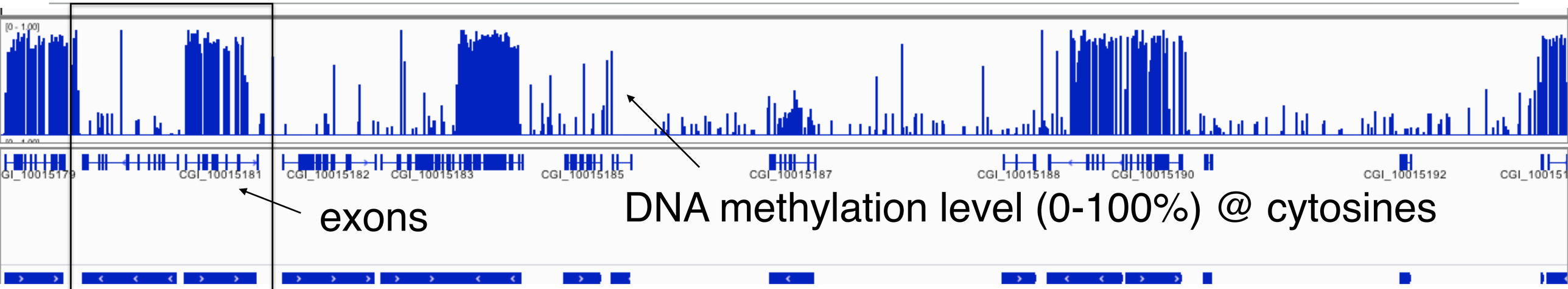
mosaic

METHYLATION LANDSCAPE IN MARINE INVERTEBRATES



mosaic

associated with gene bodies

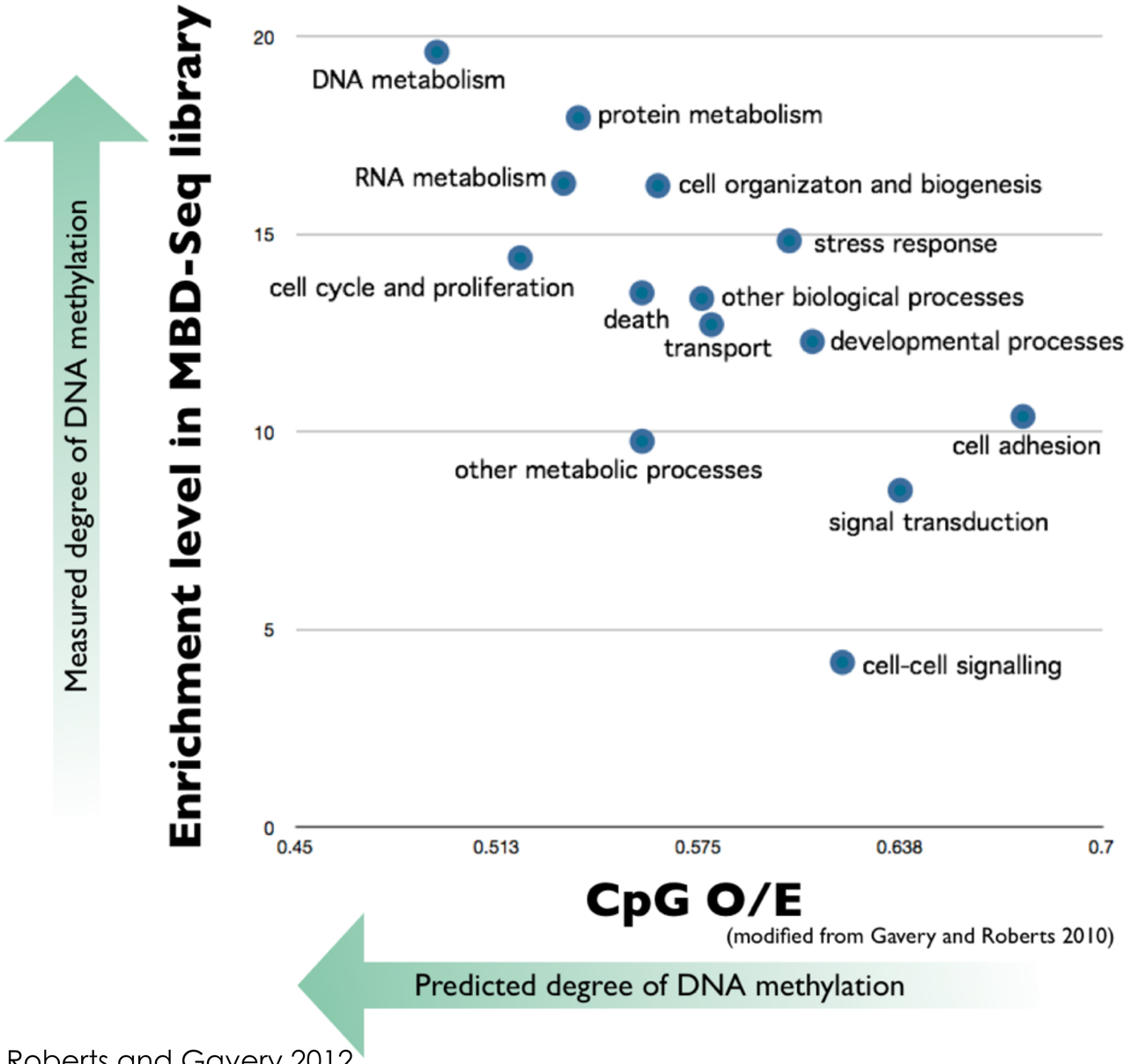


mosaic

associated with gene bodies

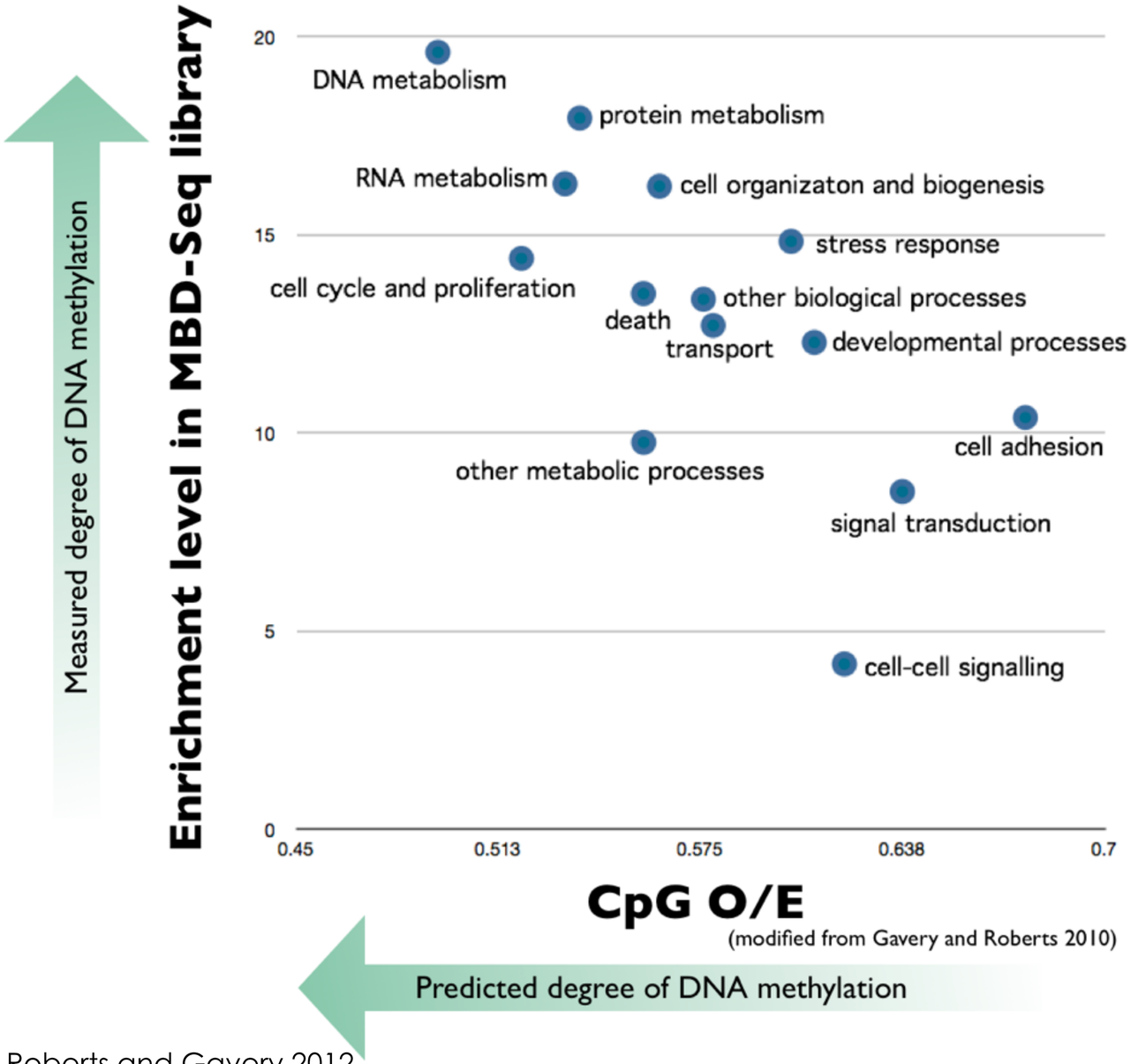
Why are only a subset of genes methylated?

METHYLATION LANDSCAPE IN MARINE INVERTEBRATES

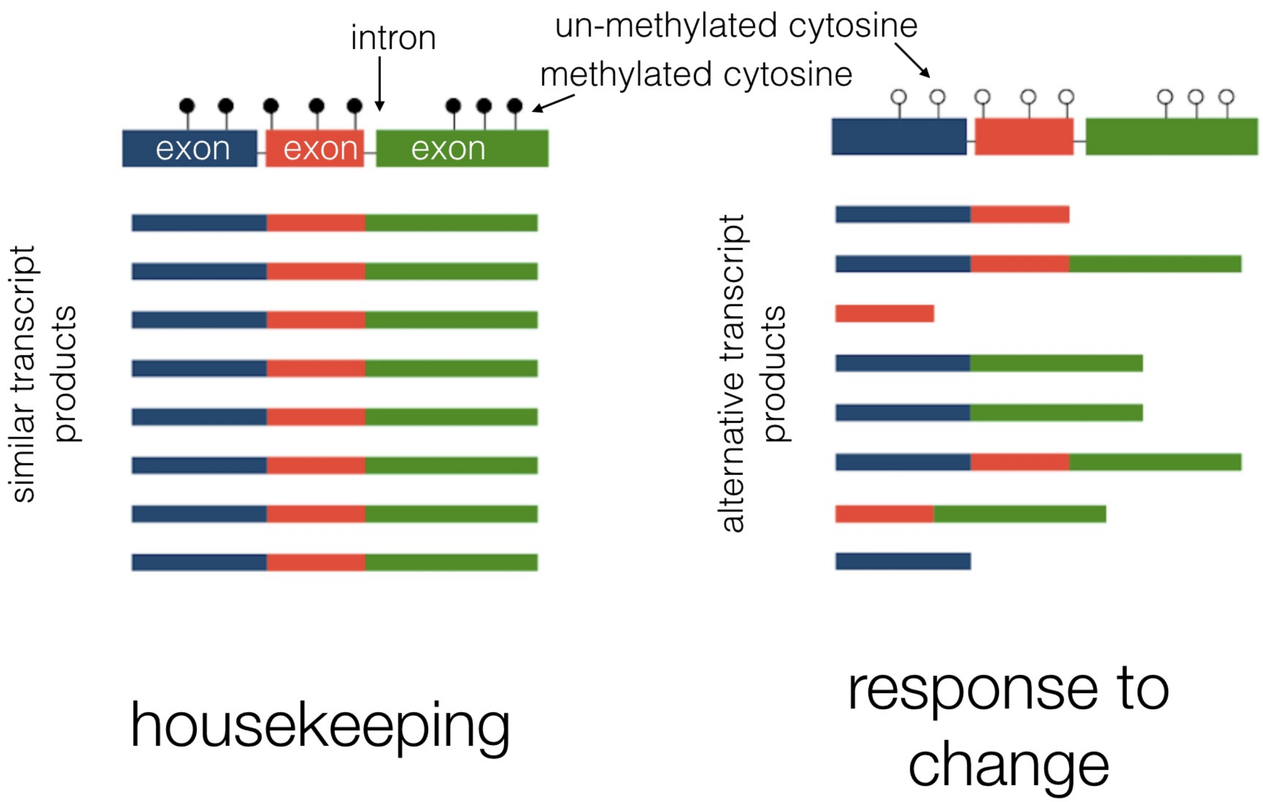


Roberts and Gavery 2012

METHYLATION LANDSCAPE IN MARINE INVERTEBRATES



Roberts and Gavery 2012



housekeeping

response to change

A context dependent role for DNA methylation in bivalves FREE

Mackenzie R. Gavery, Steven B. Roberts

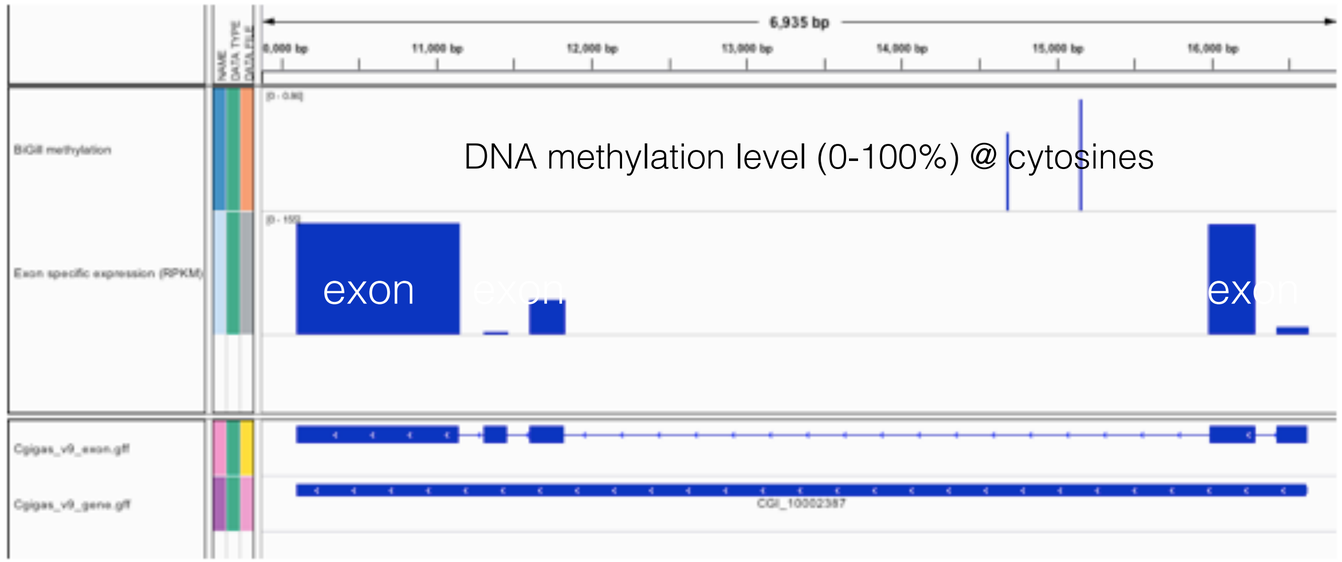
Briefings in Functional Genomics, Volume 13, Issue 3, May 2014, Pages 217–222, https://doi.org/10.1093/bfgp/elt054

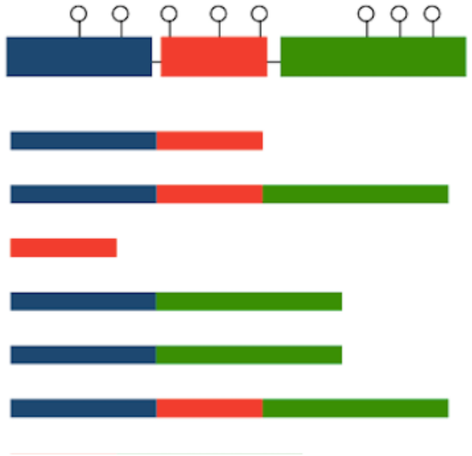
Could STOCHASTIC VARIATION contribute to ACCLIMATIZATION and ADAPTATION?

Heat shock 70 kDa protein 12A

avg exp
199

%meth
2%

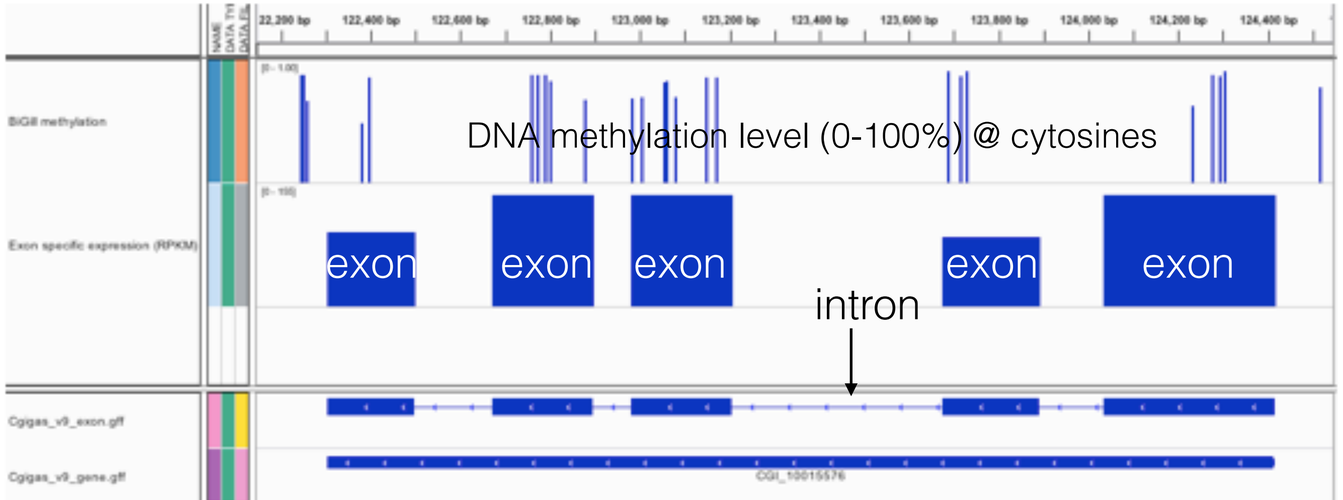


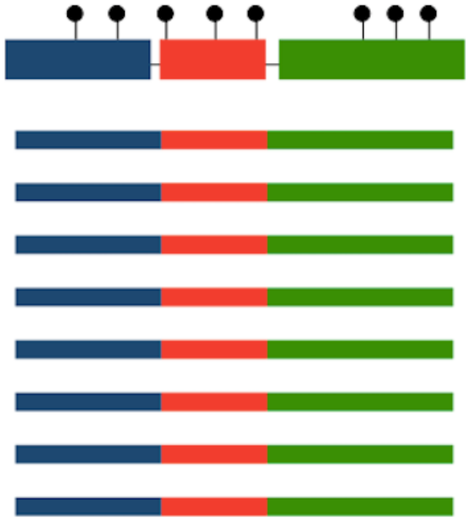


Tektin-2

avg exp
197

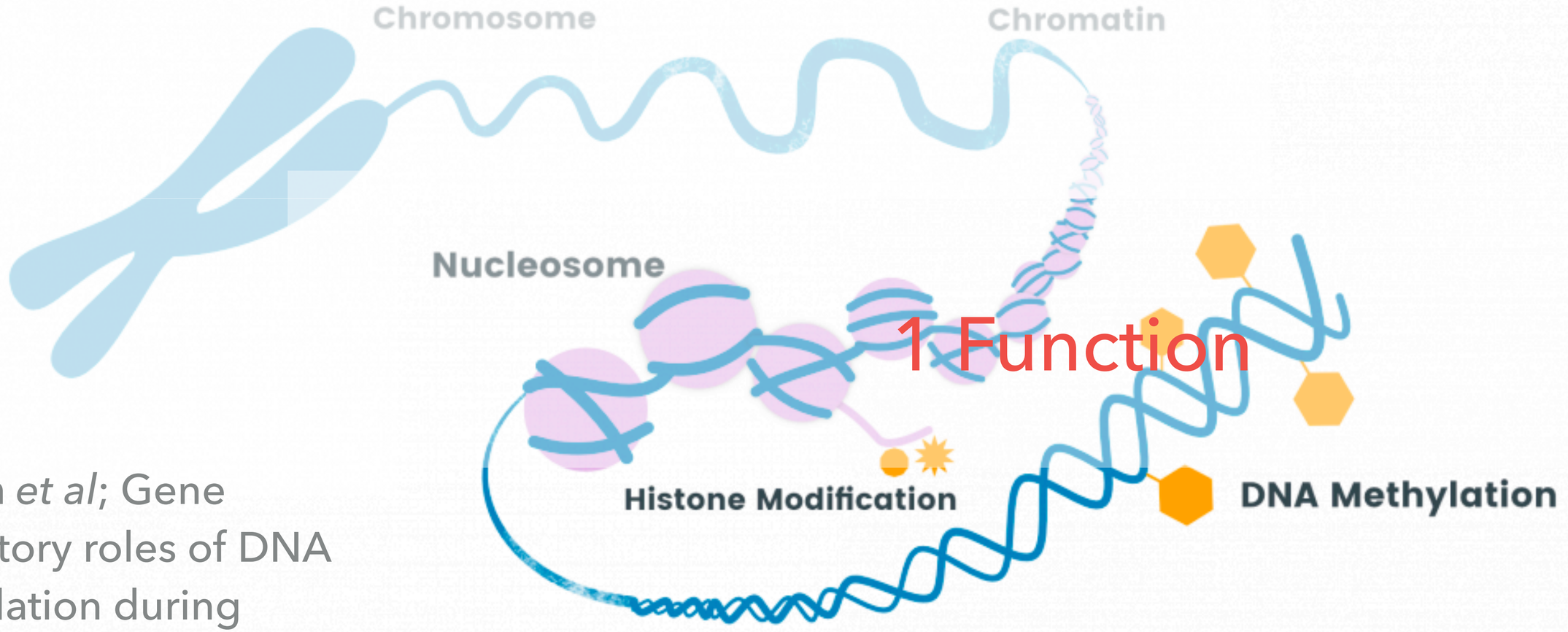
%meth
91%





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



1 Function

#26-1

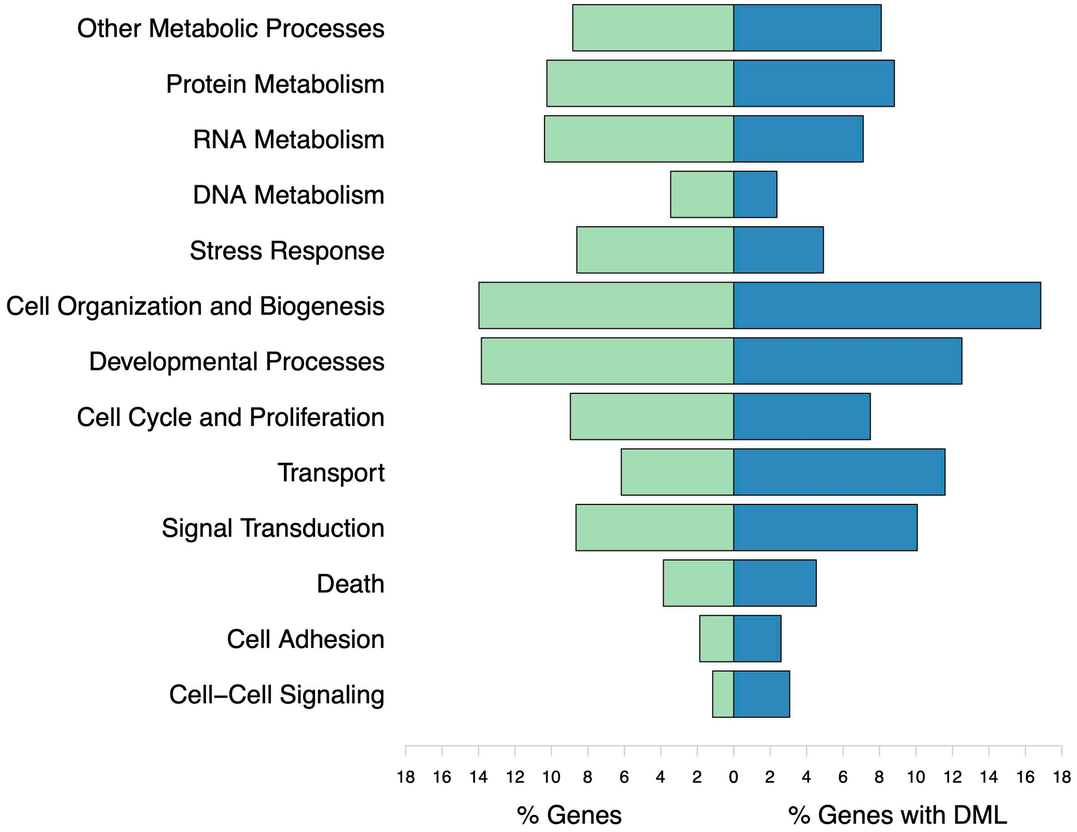
Bogan *et al*; Gene regulatory roles of DNA methylation during transgenerational plasticity in the sea urchin *Strongylocentrotus purpuratus*

ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE

2

CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

Ocean Acidification



MBD-BSseq

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

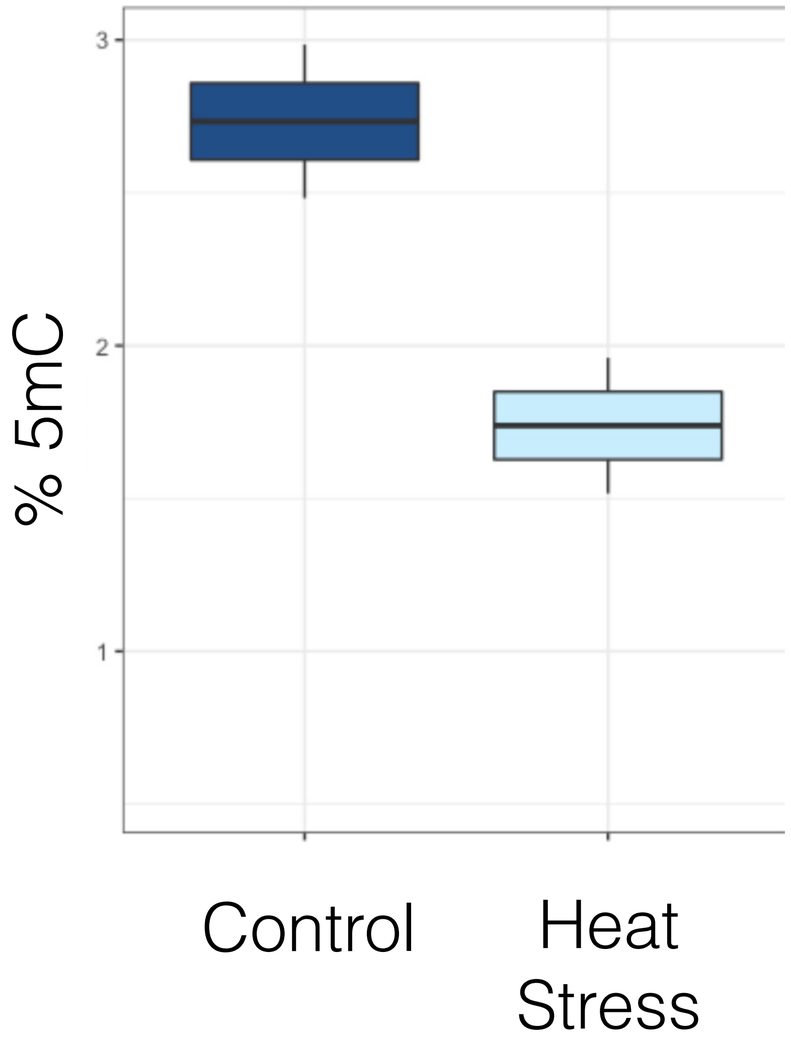
Yaamini R. Venkataraman[1*], Alan M. Downey-Wall[2], Justin Ries[2], Isaac Westfield[2], Samuel J. White[1], Steven B. Roberts[1] and Kathleen E. Lotterhos[2]

#2-11

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

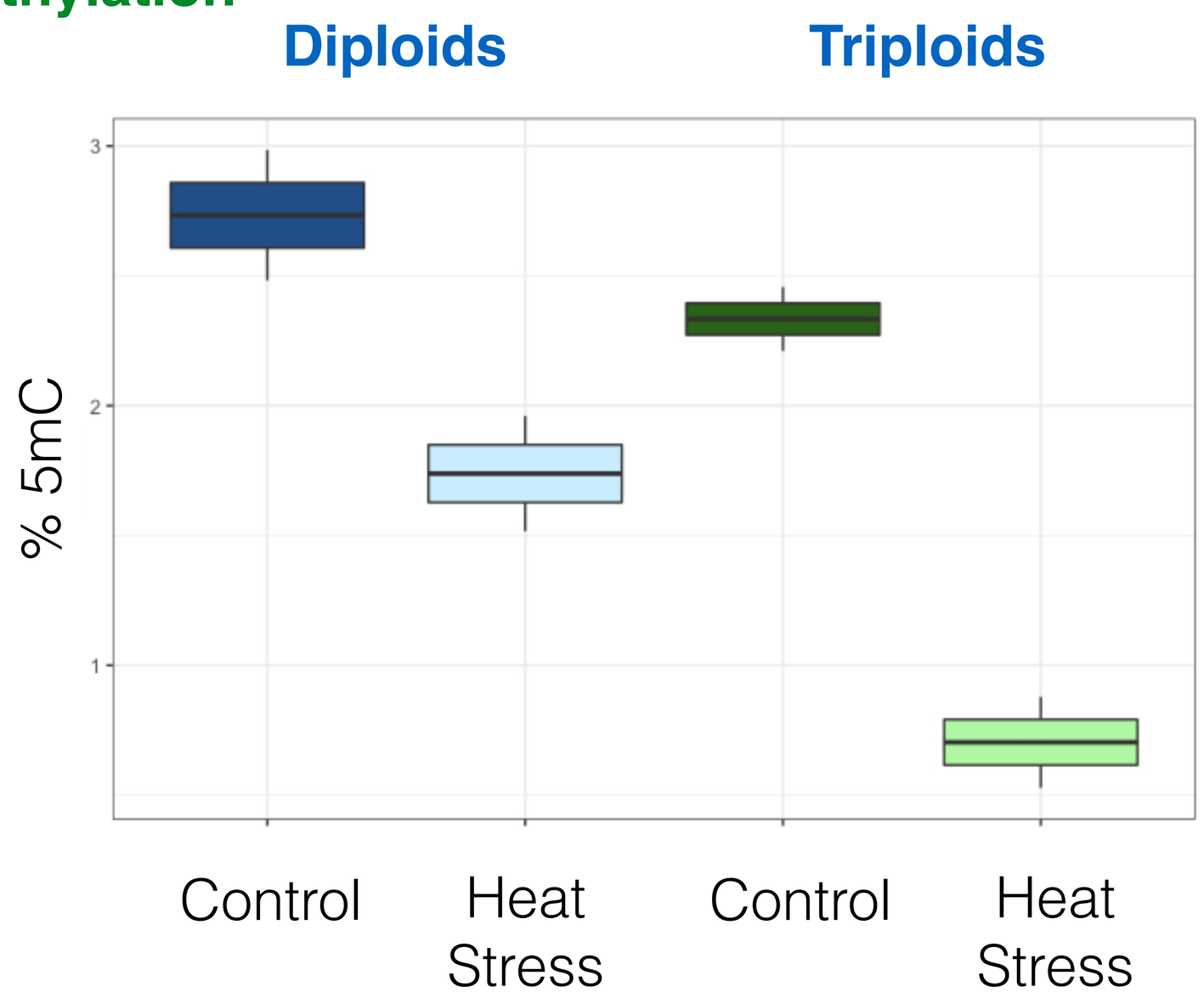
Temperature and Desiccation Decreases Global DNA Methylation

DNA Methylation ELISA

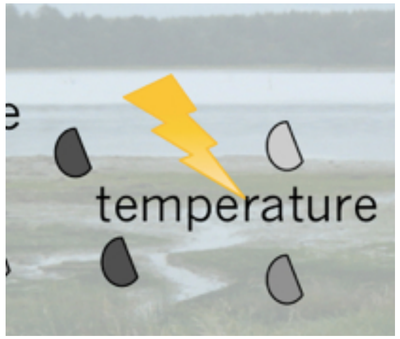


Temperature and Desiccation Decreases Global DNA Methylation

DNA Methylation ELISA



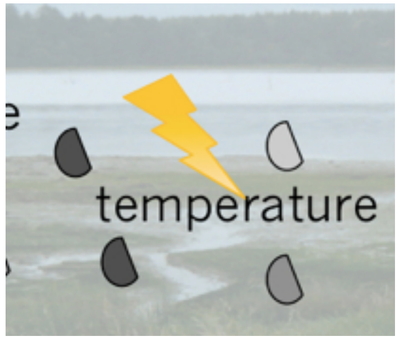
Temperature Alters CpG Methylation

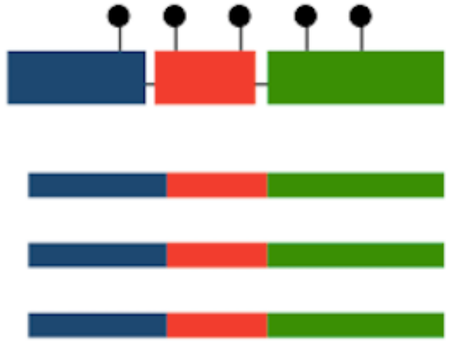


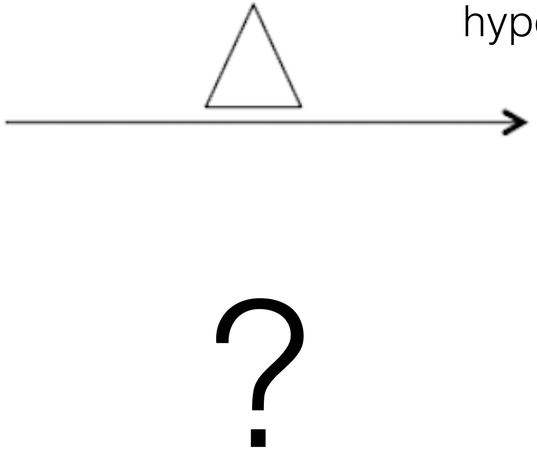
Oyster	Hypo-methylated	Hyper-methylated
2	7224	2803
4	6560	3587
6	7645	4044

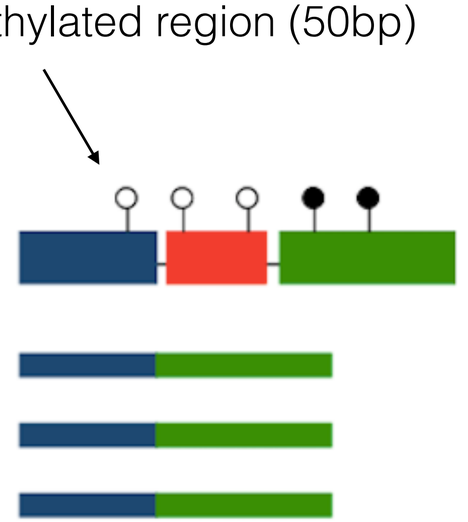
MBD-Array

Temperature Alters CpG Methylation





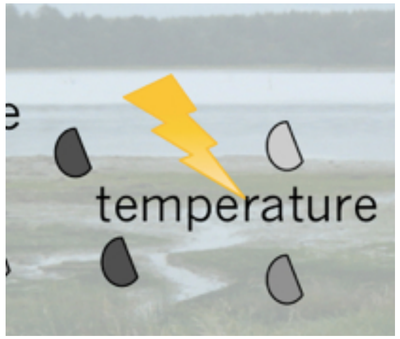




Oyster	Hypo-methylated	Hyper-methylated
2	7224	2803
4	6560	3587
6	7645	4044

MBD-Array

Temperature Alters CpG Methylation

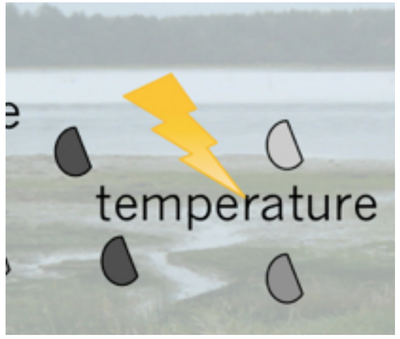


Oyster	Hypo-methylated	Hyper-methylated
2	7224	2803
4	6560	3587
6	7645	4044

No obvious association with genome feature including *differentially expressed genes*

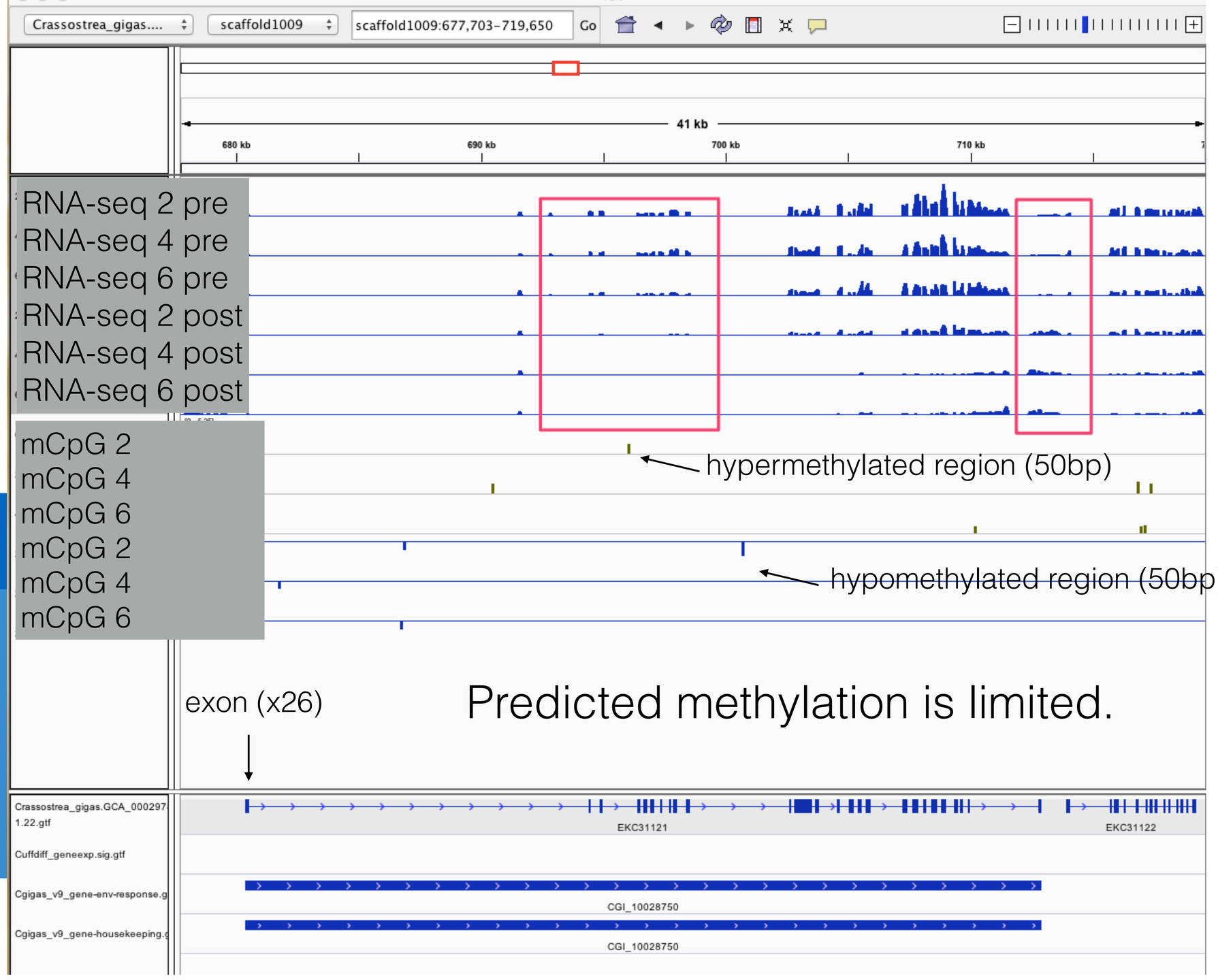
MBD-Array

Temperature Alters CpG Methylation



Oyster
2
4
6

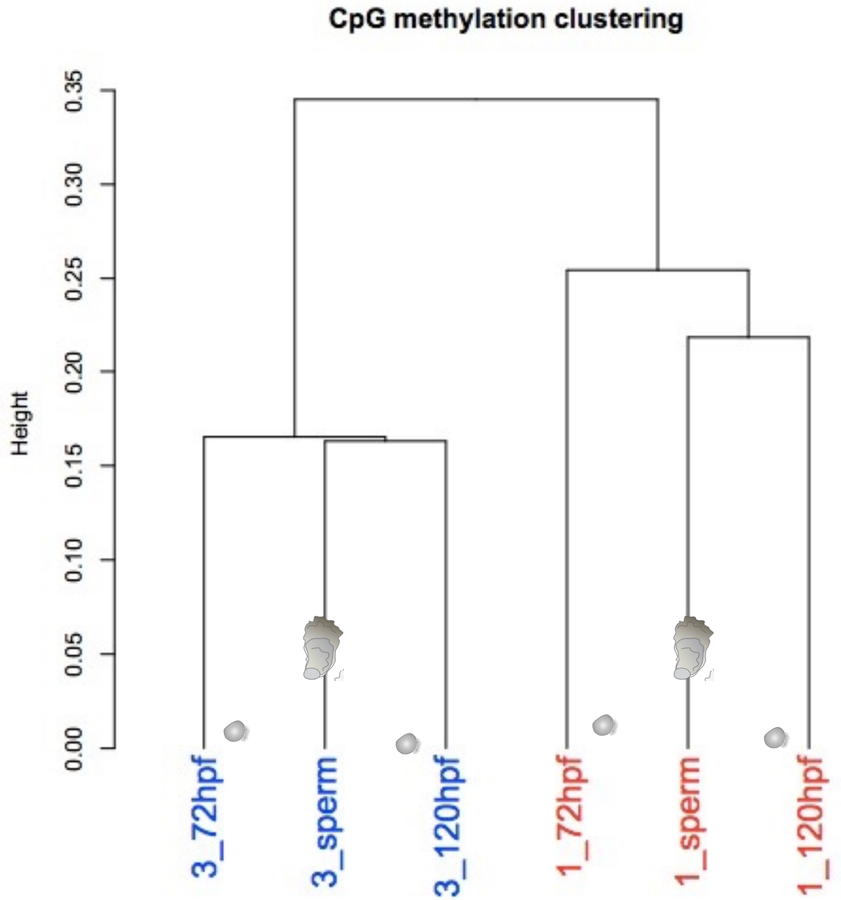
MBD-Array



ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE

CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

Family Specific DNA Methylation Patterns Exist



Cold Spring Harbor Laboratory

bioRxiv beta

THE PREPRINT SERVER FOR BIOLOGY

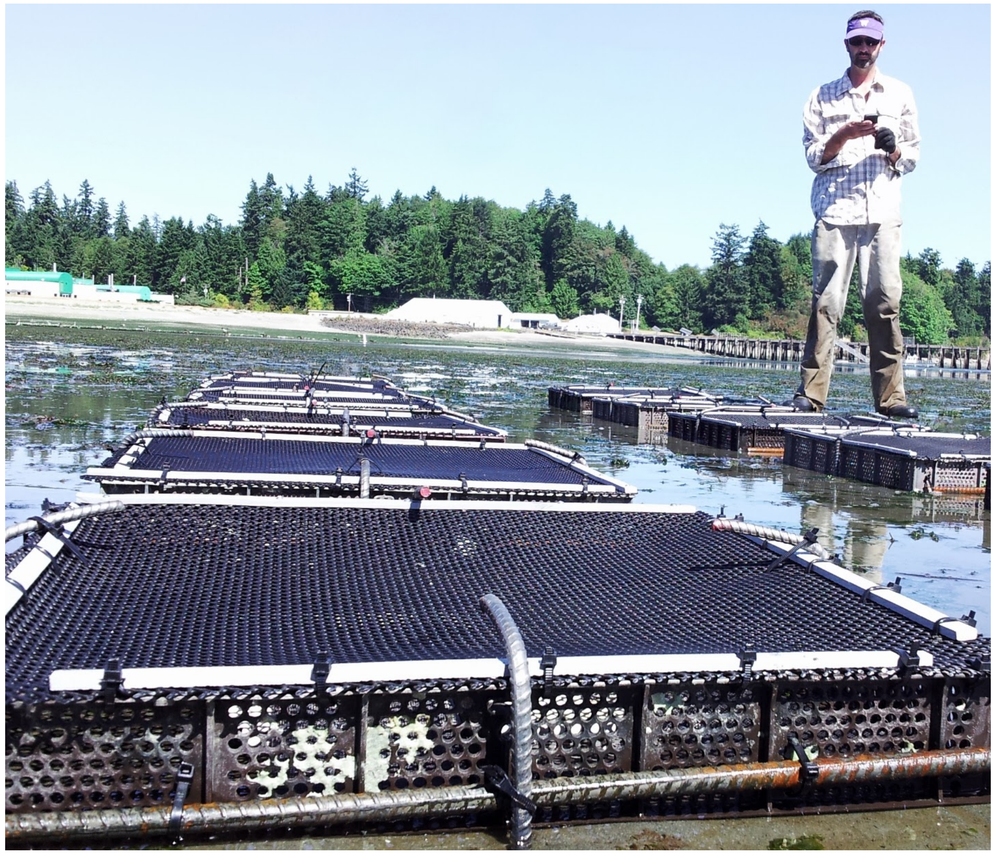
New Results

Indication of family-specific DNA methylation patterns in developing oysters

Claire E. Olson , Steven B. Roberts

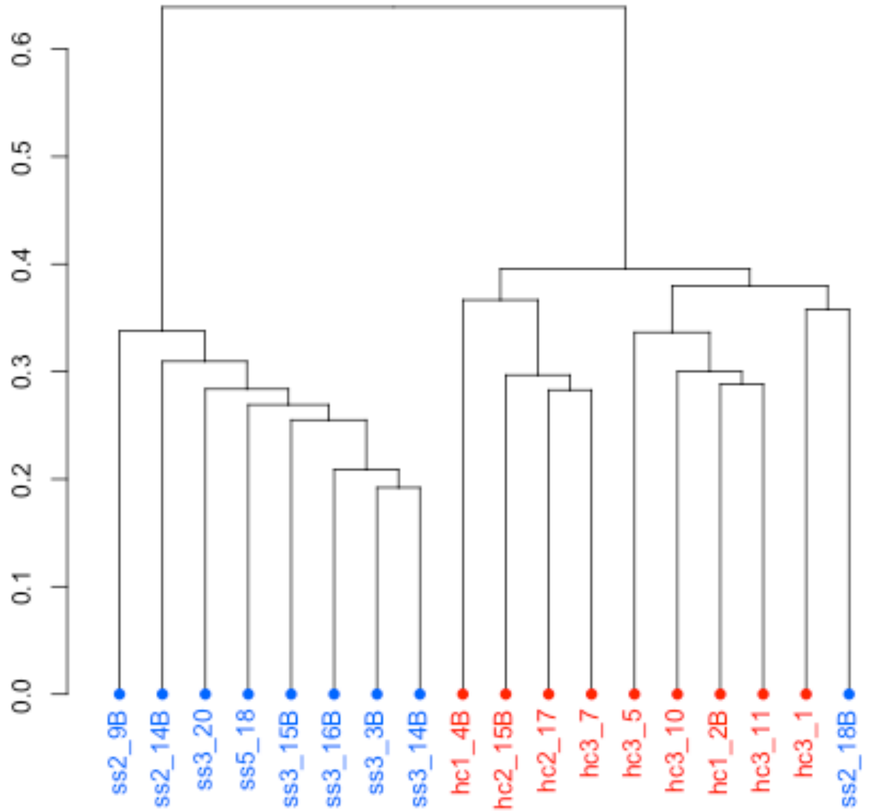
doi: http://dx.doi.org/10.1101/012831

Population DNA Methylation Patterns Persist in Transplant Experiment



Population DNA Methylation Patterns Persist in Transplant Experiment

CpG methylation clustering

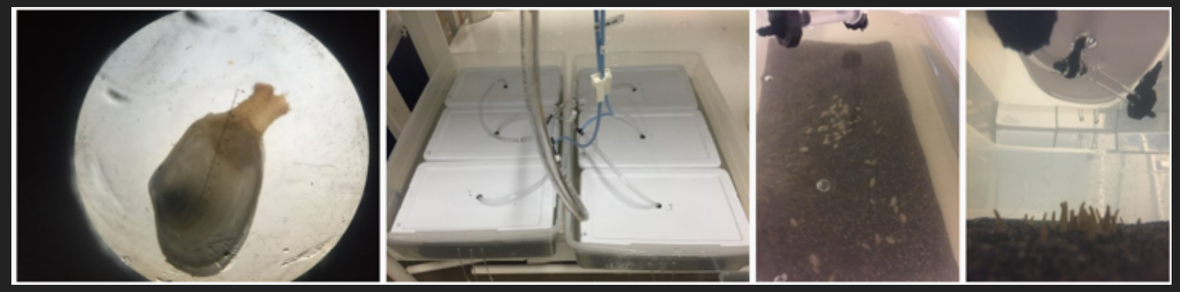


ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE

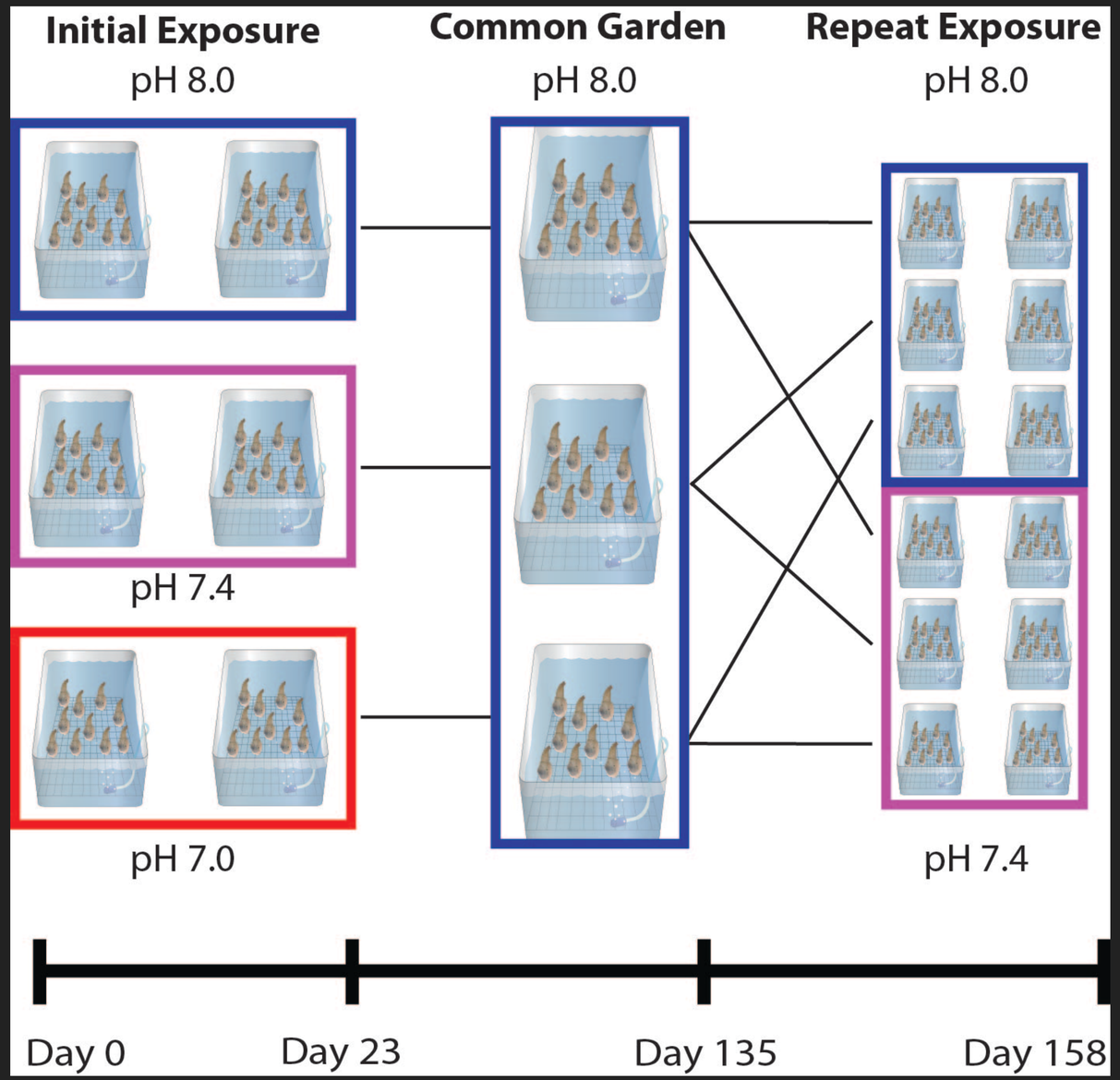
What about within generation? Priming?

CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

GEODUCKS AND OA

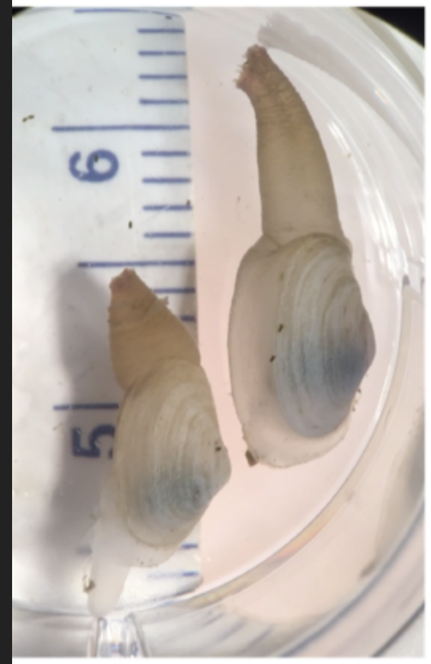


- Does conditioning to low pH confer tolerance within a generation?

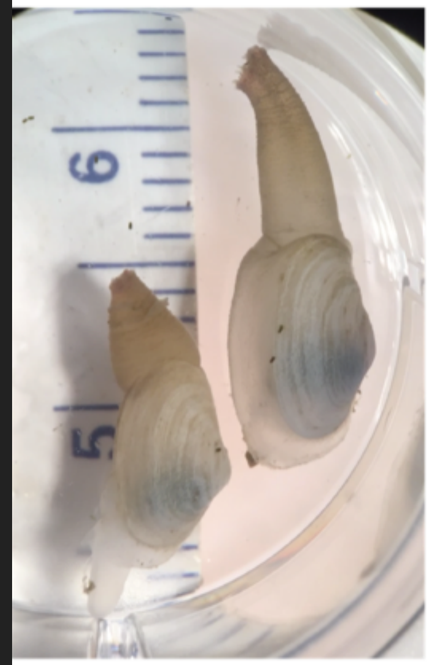


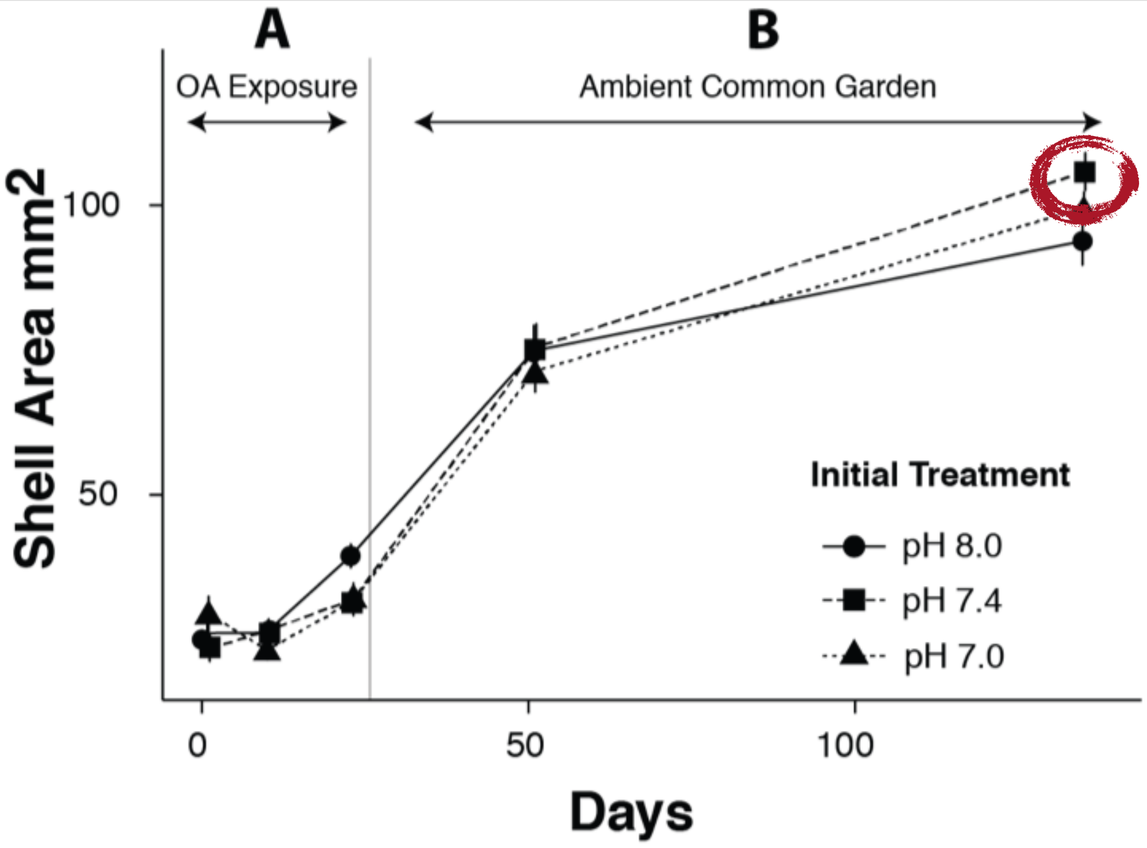
GEODUCKS AND OA

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

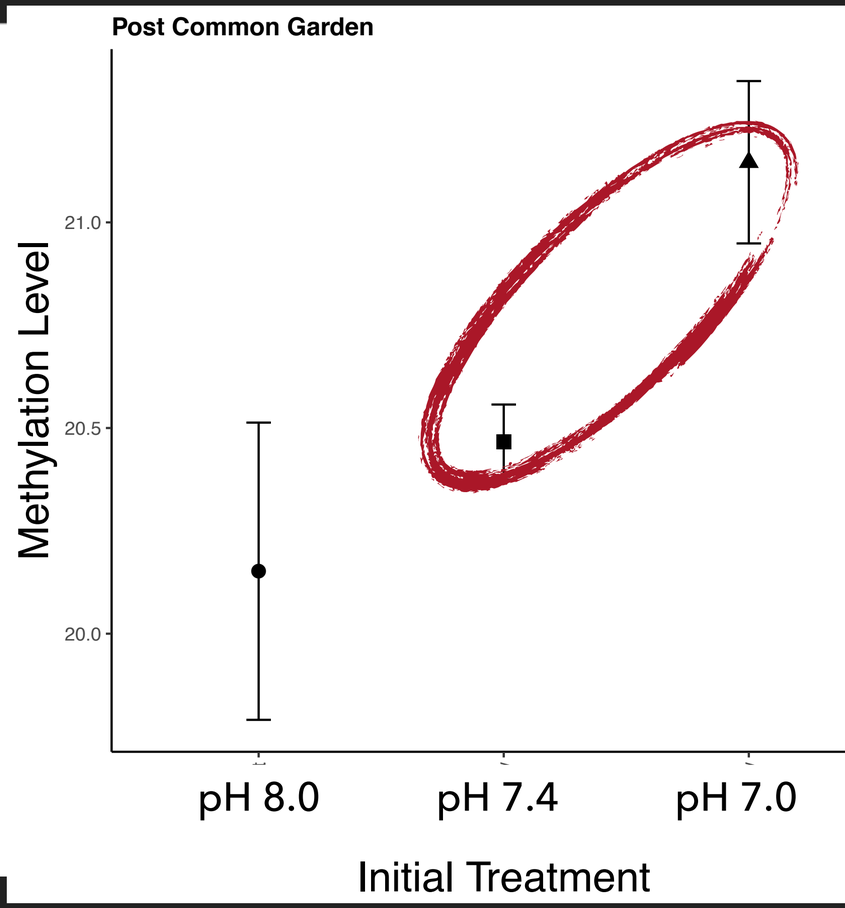


GEODUCKS AND OA



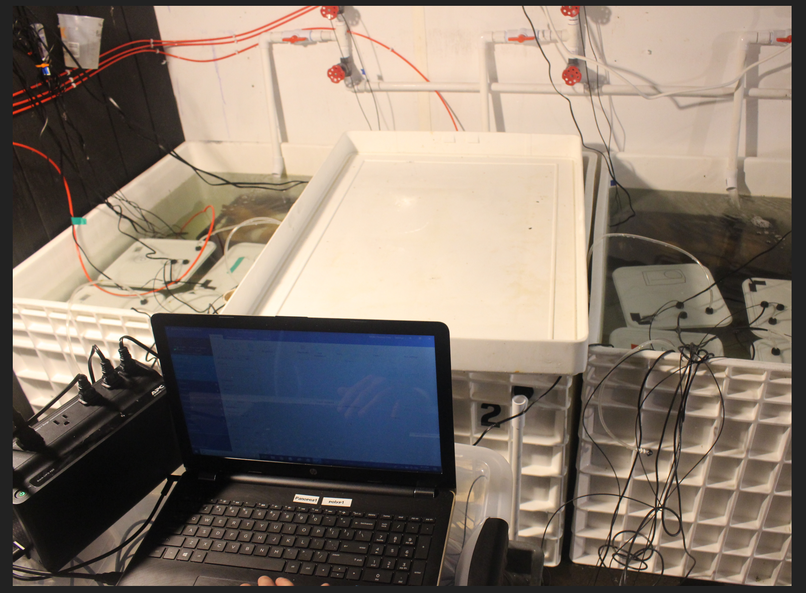


DNA METHYLATION



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

GEODUCKS AND OA

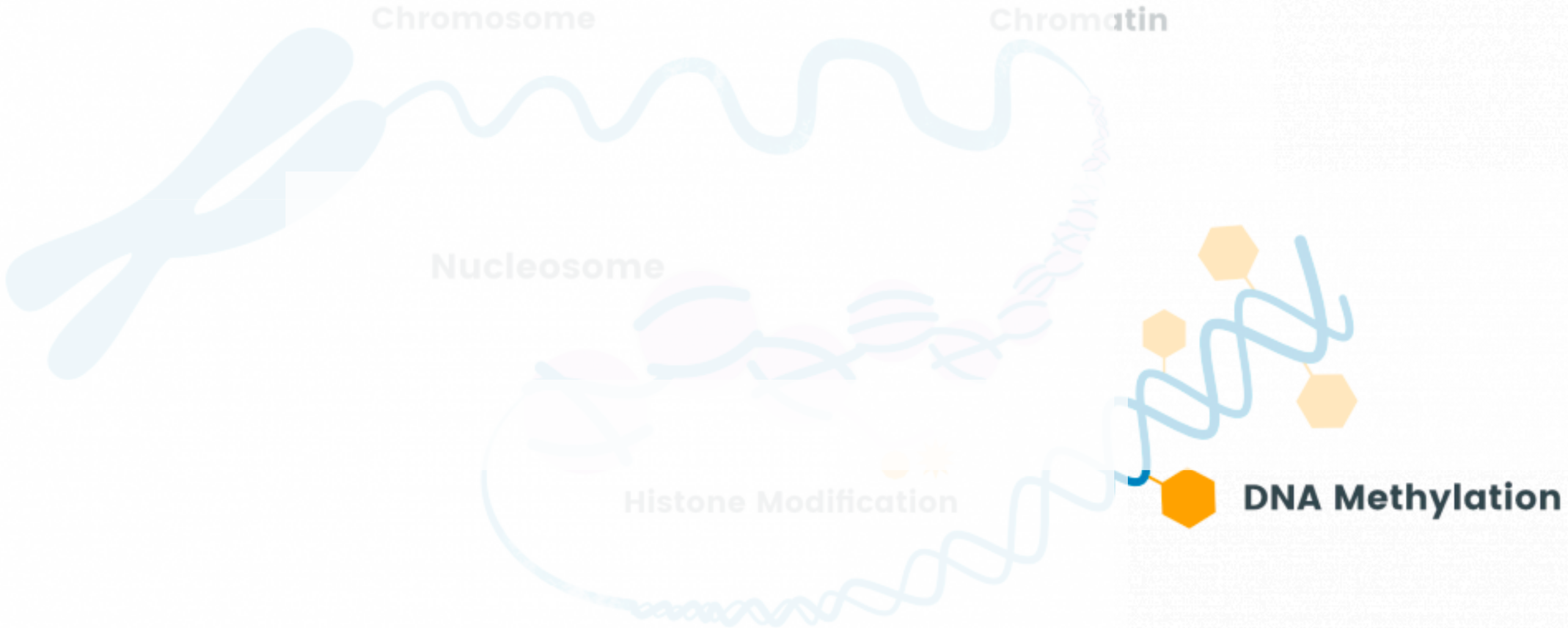


GEODUCKS AND OA

#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

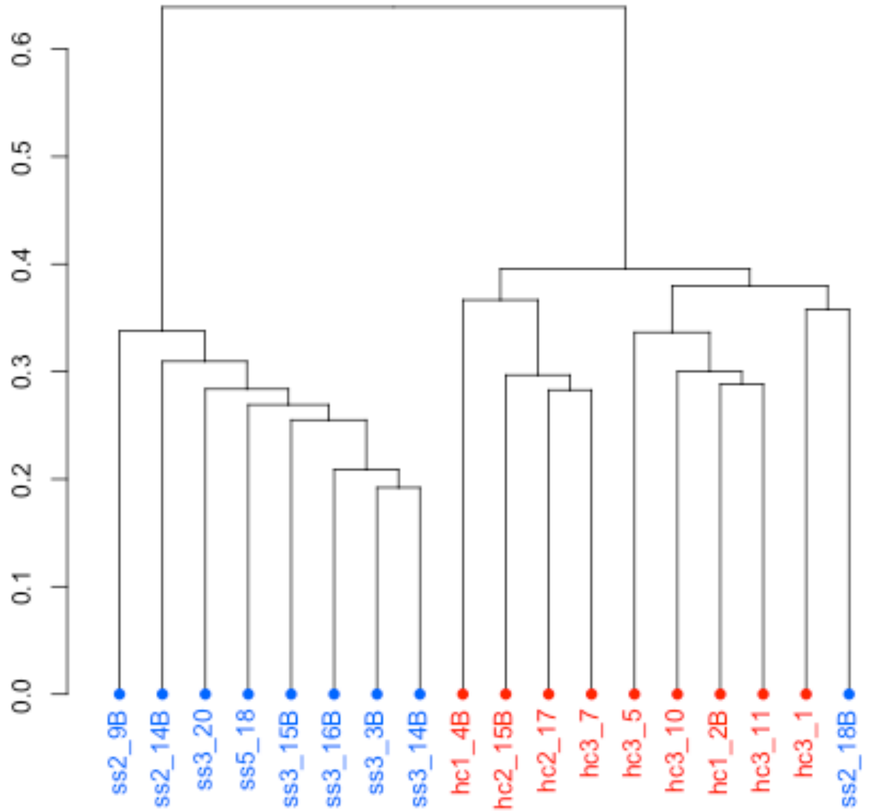
4 ALTERS THE PHENOTYPE (WITHOUT CHANGING DNA CODE); HERITABLE



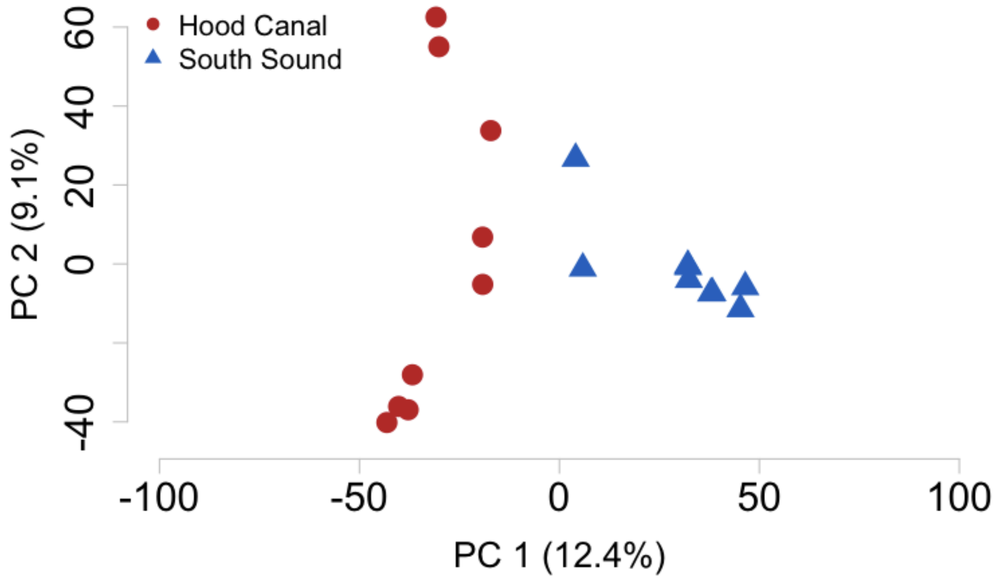
CAN BE INDUCED WITH THROUGH ENVIRONMENTAL ALTERATION

Population DNA Methylation Patterns Persist in Transplant Experiment

CpG methylation clustering



Genetic Differentiation exists



no direct linkages between genetic and epigenetic differences

Silliman and Spencer

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

Silliman and Spencer

ECOLOGICAL EPIGENETICS

Ecology Letters, (2008) **11**: 106–115 doi: 10.1111/j.1461-0248.2007.01130.x

IDEA AND PERSPECTIVE

Epigenetics for ecologists

O Bossdorf, CL Richards, M Pigliucci

PHYSIOLOGY

ECOLOGICAL EPIGENETICS

Ecology Letters, (2008) **11**: 106–115 doi: 10.1111/j.1461-0248.2007.01130.x

IDEA AND PERSPECTIVE

Epigenetics for ecologists

O Bossdorf, CL Richards, M Pigliucci

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