

# Epigenetic variation in oysters and implications for aquaculture

Steven Roberts

Kenneth K. Chew Endowed Professor

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School of Aquatic and Fishery Sciences

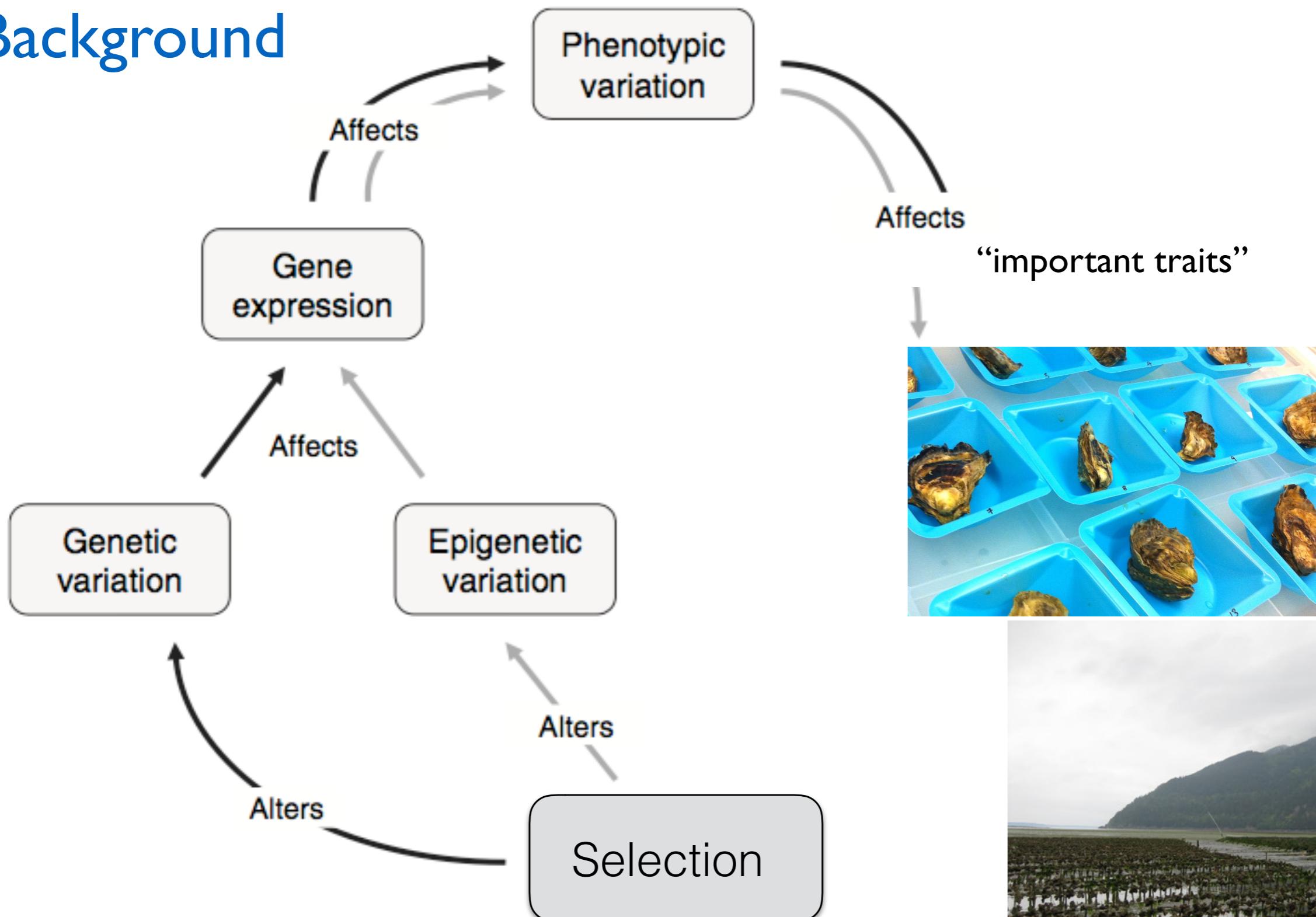
Seattle, Washington, United States

**robertslab.info**

@sr320



# Background



*Ecology Letters*, (2008) 11: 106–115

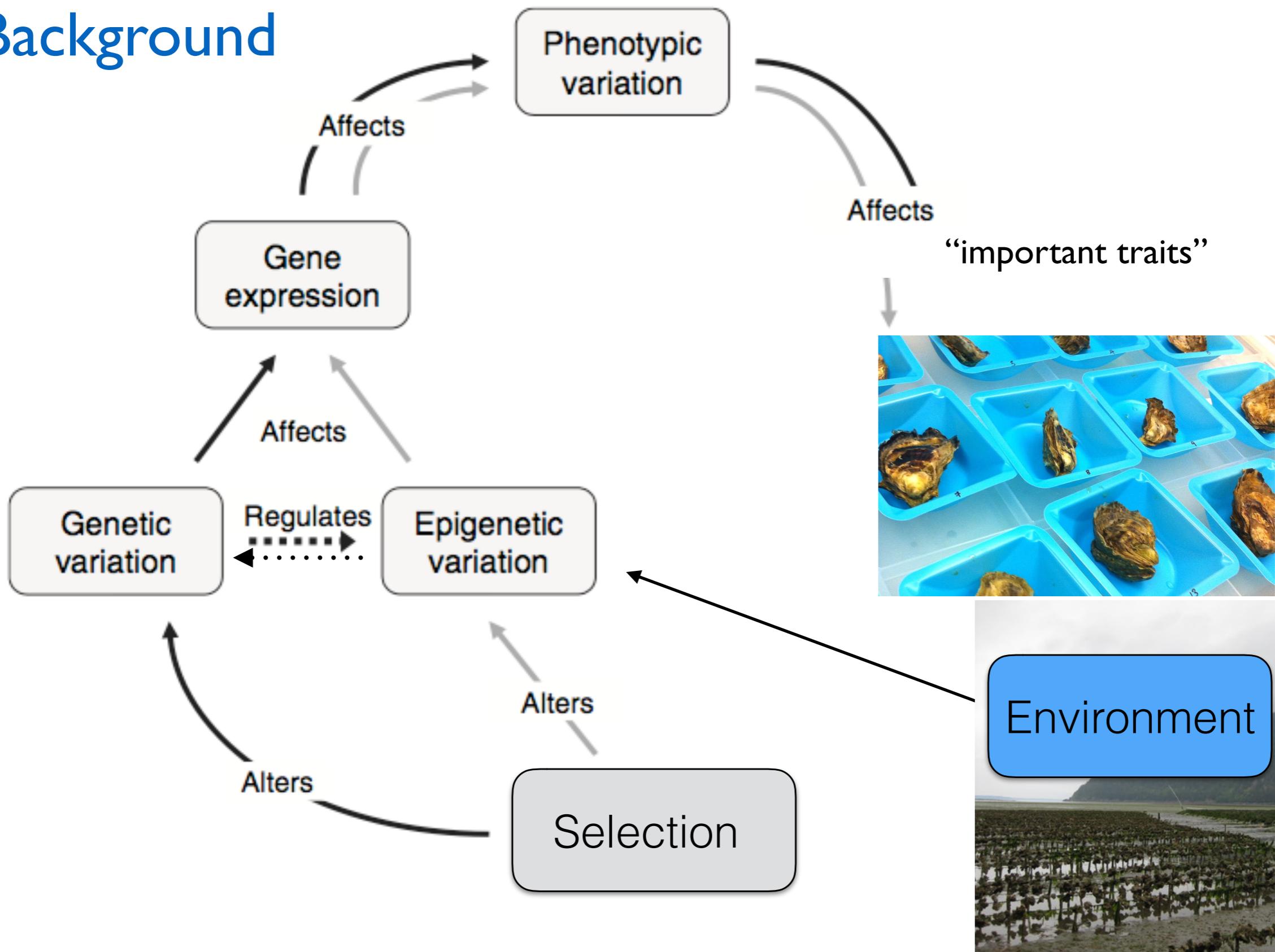
doi: 10.1111/j.1461-0248.2007.01130.x

modified from

IDEA AND  
PERSPECTIVE

Epigenetics for ecologists

# Background



*Ecology Letters*, (2008) 11: 106–115

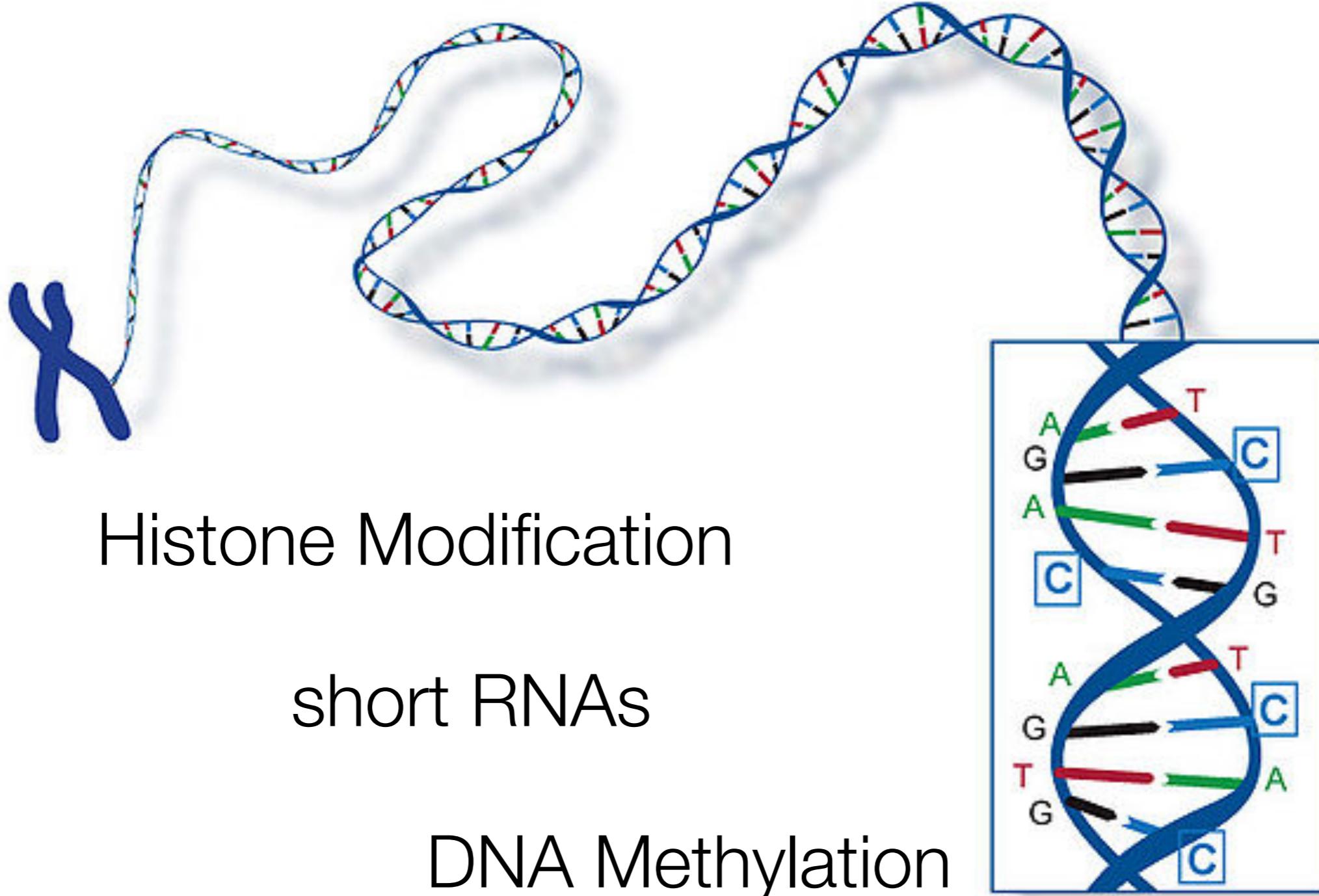
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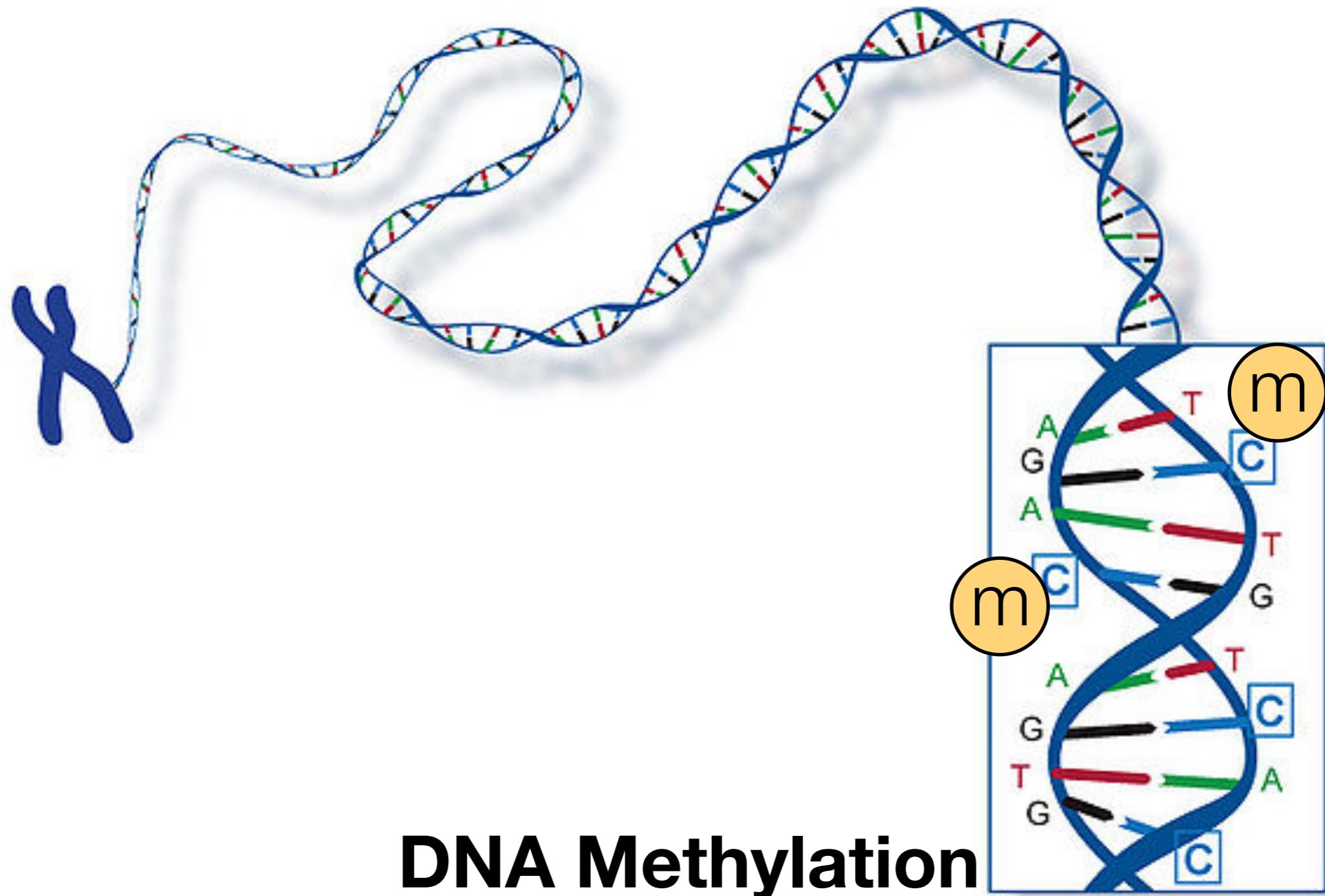
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IDEA AND  
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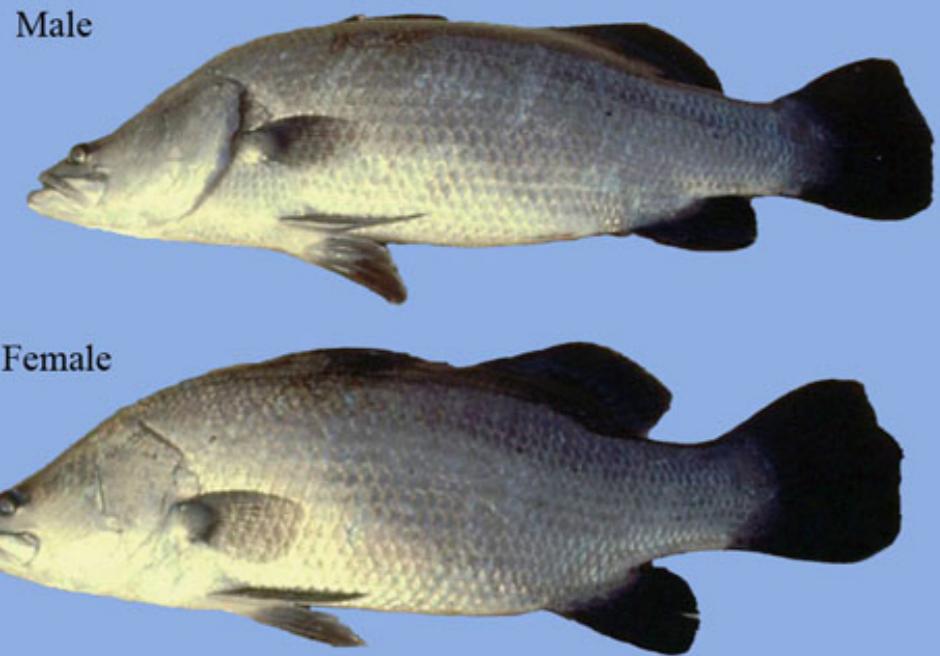
Epigenetics for ecologists

# Epigenetics





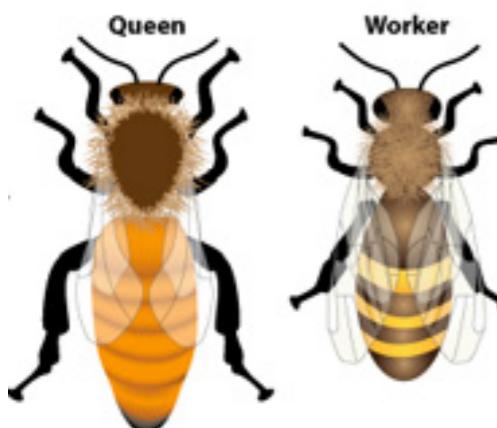
Male



Male and female *Lates calcarifer*



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



These Two Mice are Genetically Identical and the Same Age



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

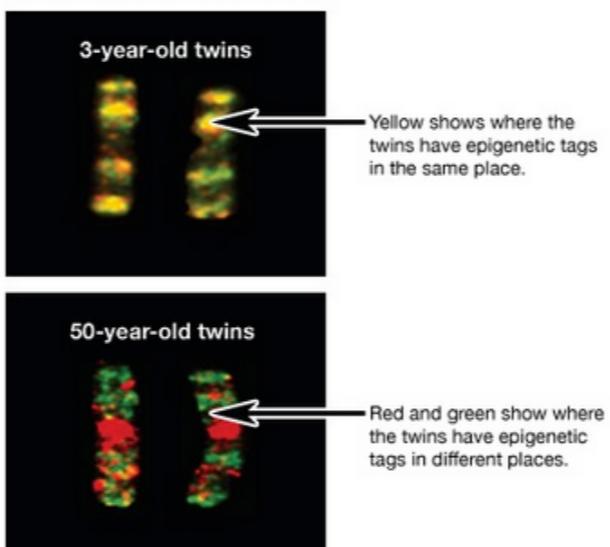
The mother of this mouse received a **normal mouse diet**

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

## Nature AND Nurture

### Chromosome 3 Pairs

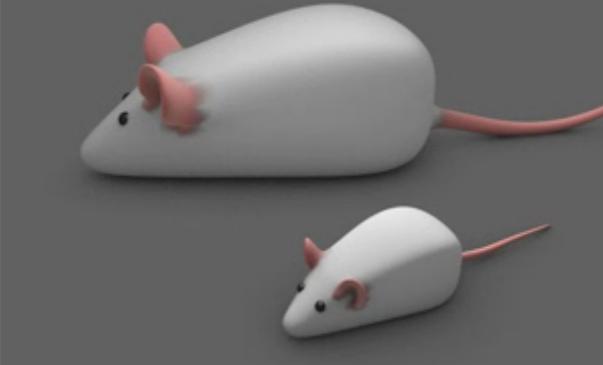
3-year old twins vs. 50-year-old twins



High Nurtured



Low Nurtured



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

# Applications in Aquaculture

## Epigenetic Selection

Identifying individuals by attributing trait to epigenotype

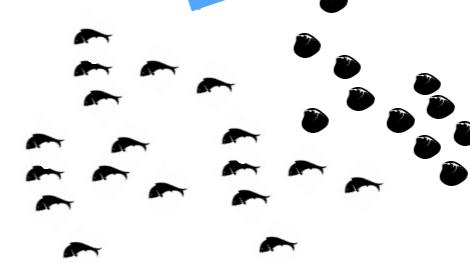
Adults



## Environmental Manipulation

Influencing offspring phenotype by altering environmental conditions of broodstock

Larvae



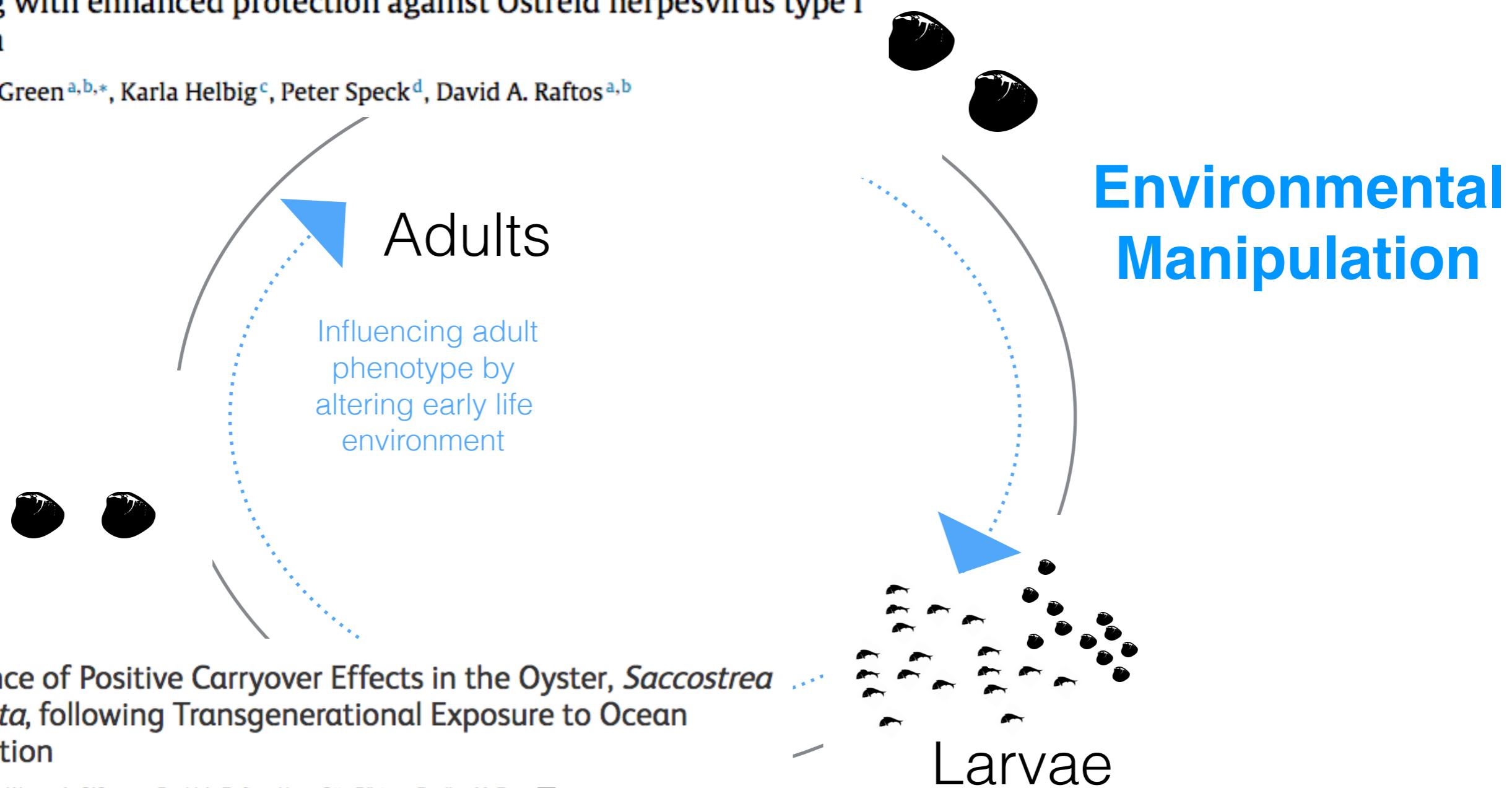
Influencing adult phenotype by altering early life environment



# Applications in Aquaculture

Primed for success: Oyster parents treated with poly(I:C) produce offspring with enhanced protection against Ostreid herpesvirus type I infection

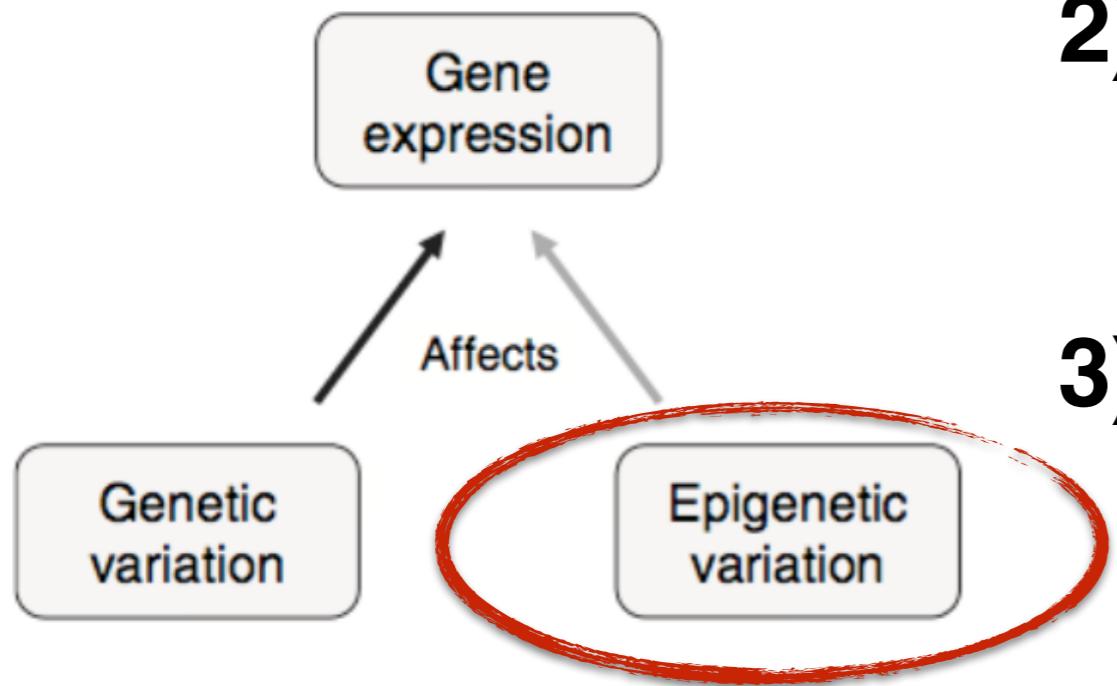
Timothy J. Green<sup>a,b,\*</sup>, Karla Helbig<sup>c</sup>, Peter Speck<sup>d</sup>, David A. Raftos<sup>a,b</sup>



Laura M. Parker, Wayne A. O'Connor, David A. Raftos, Hans-Otto Pörtner, Pauline M. Ross

Published: July 6, 2015 • <http://dx.doi.org/10.1371/journal.pone.0132276>

# Big Questions



- 1) What is the function of DNA methylation in marine invertebrates?**
- 2) To what degree is epigenetic variation heritable?**
- 3) Is epigenetic variation independent of genetic variation?**
- 4) How do environmental conditions influence epigenetic variation?**

# Outline

**Methylation landscape**

**Population studies**

**Environmental change**

- 1) What is the function of DNA methylation in marine invertebrates?
- 2) To what degree is epigenetic variation heritable?
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# Outline

## Methylation landscape

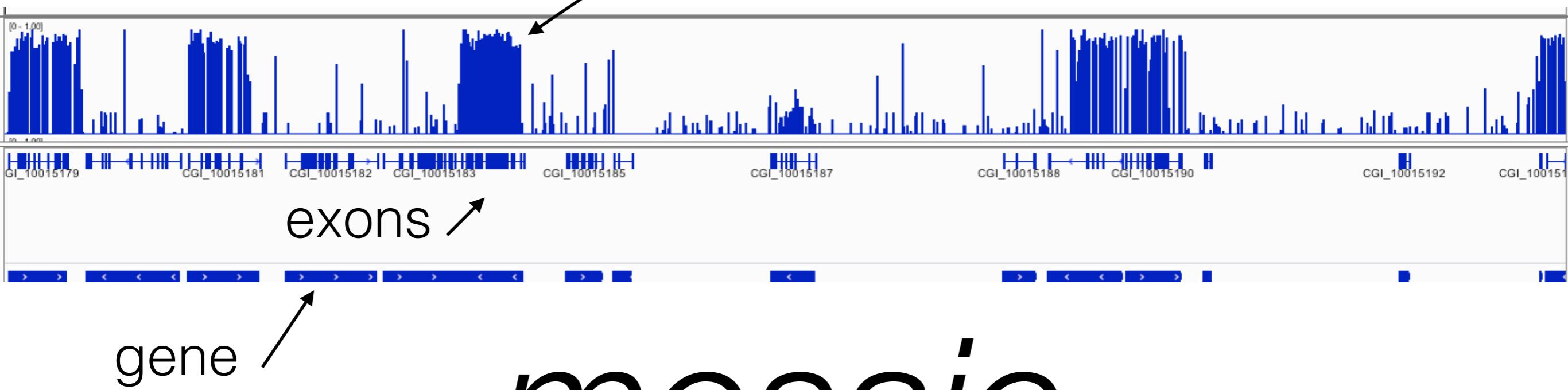
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# Methylation landscape

DNA methylation level (0-100%) @ cytosines

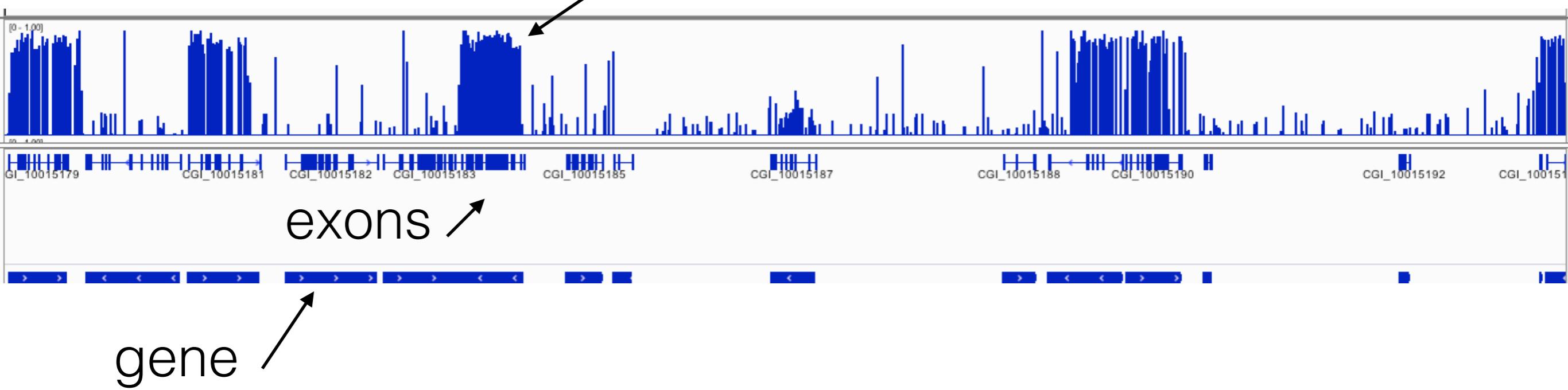


*mosaic*

associated with gene bodies

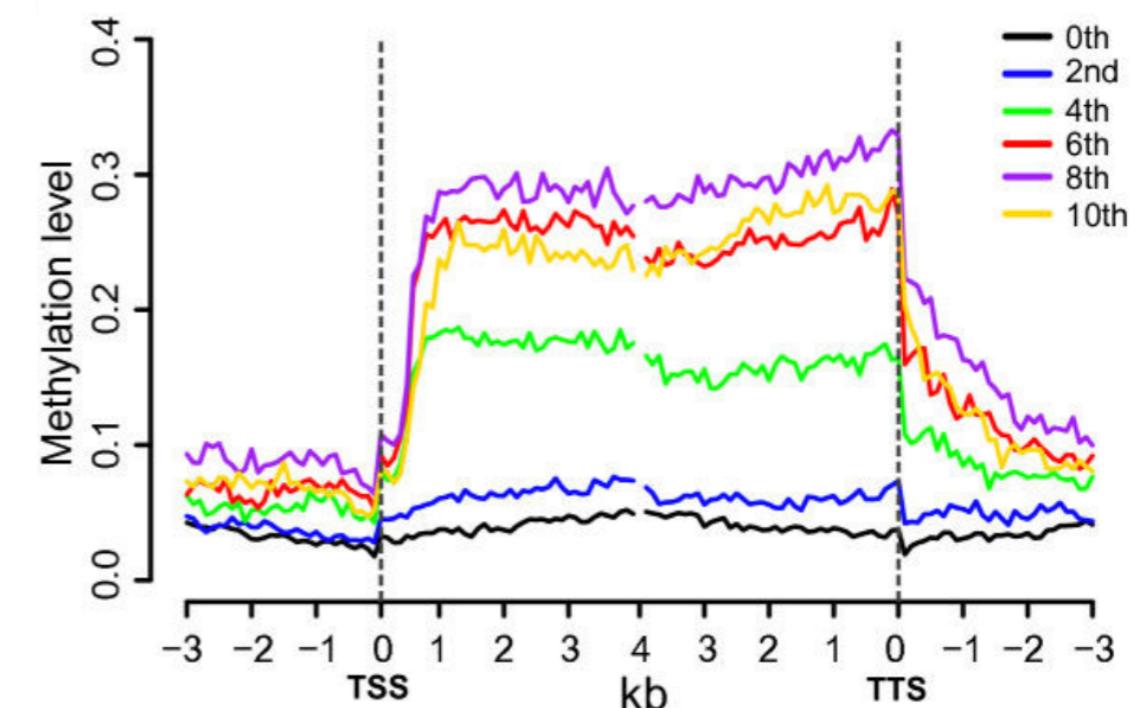
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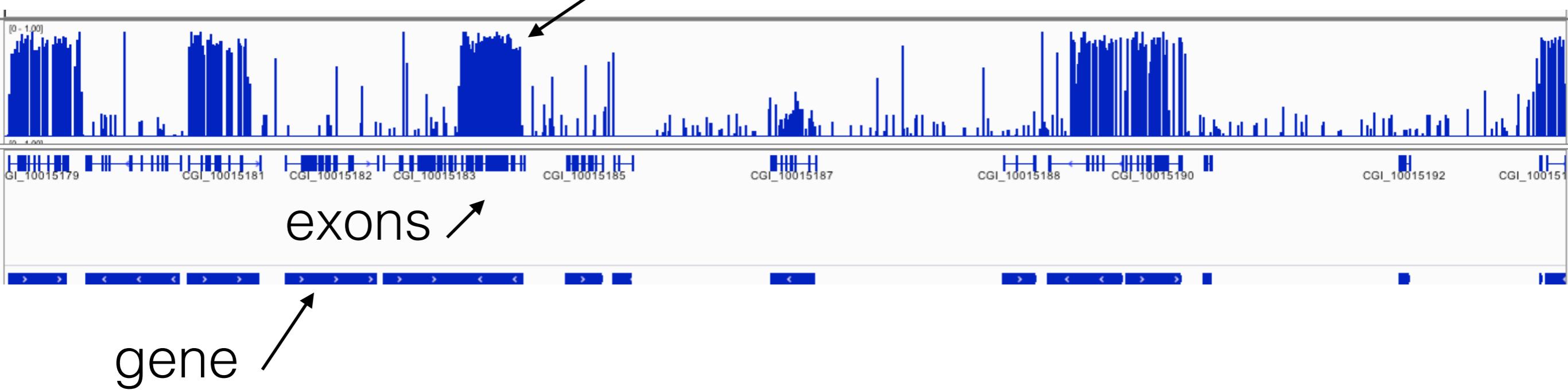
Genome-wide and single-base resolution  
DNA methylomes of the Pacific oyster  
*Crassostrea gigas* provide insight into the  
evolution of invertebrate CpG methylation

Xiaotong Wang <sup>†</sup>, Qiye Li <sup>†</sup>, Jinmin Lian <sup>†</sup>, Li Li <sup>†</sup>, Lijun Jin, Huimin Cai, Fei Xu, Haigang Qi,  
Linlin Zhang, Fucun Wu, Jie Meng, Huayong Que, Xiaodong Fang, Ximing Guo and  
Guofan Zhang



# Methylation landscape

DNA methylation level (0-100%) @ cytosines



[PLoS One](#). 2017; 12(9): e0185224.

Published online 2017 Sep 25. doi: [10.1371/journal.pone.0185224](https://doi.org/10.1371/journal.pone.0185224)

PMCID: PMC5612690

PMID: [28945769](#)

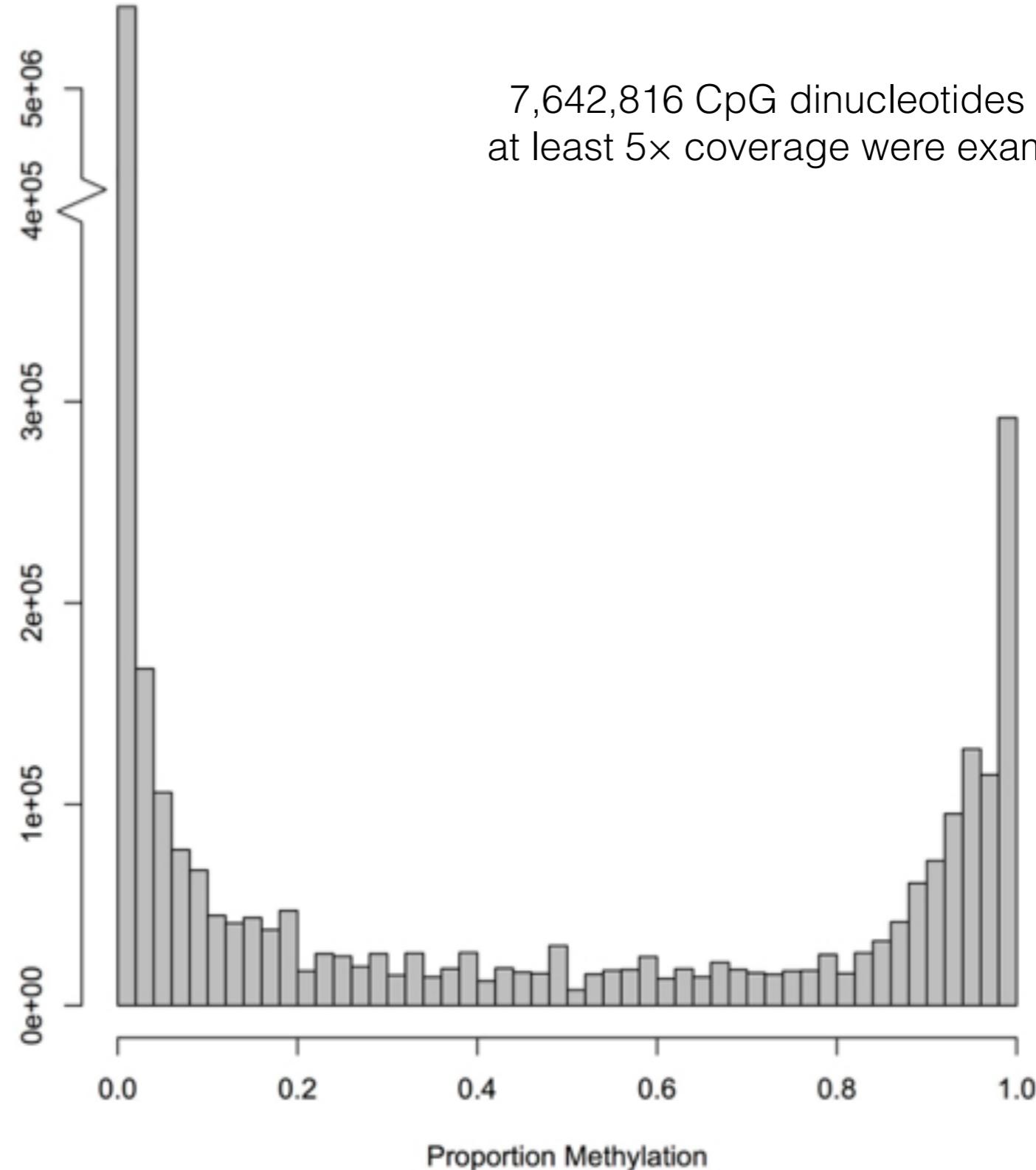
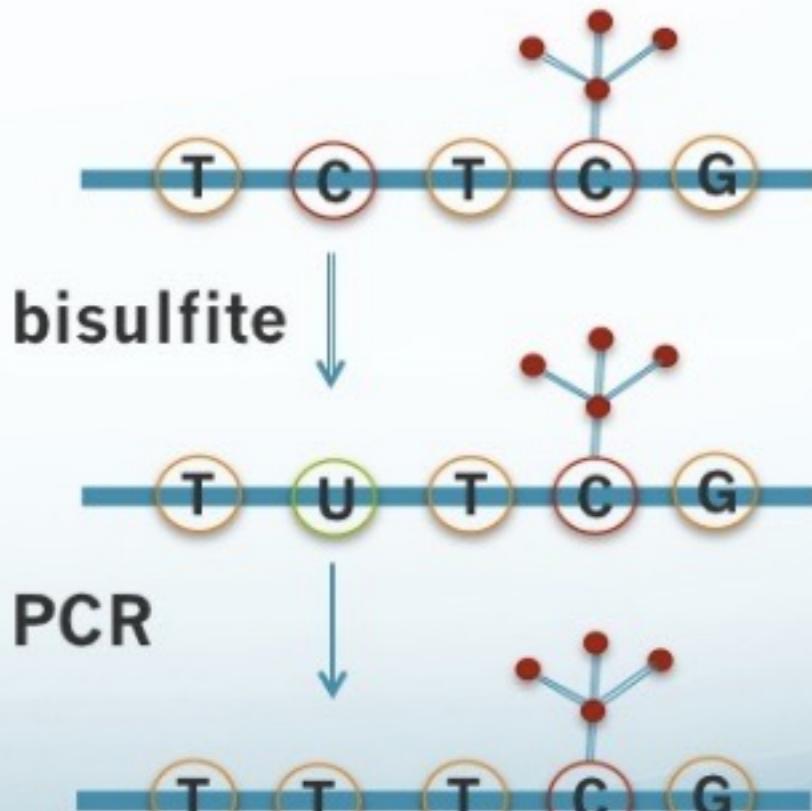
The association between DNA methylation and exon expression in the Pacific oyster *Crassostrea gigas*

[Kai Song](#), Conceptualization, Data curation, Formal analysis, Investigation, Methodology,<sup>1,2,3</sup> [Li Li](#), Conceptualization, Validation,<sup>1,2,3,\*</sup> and [Guofan Zhang](#), Conceptualization, Funding acquisition, Validation<sup>1,3,4,\*</sup>

# Methylation landscape

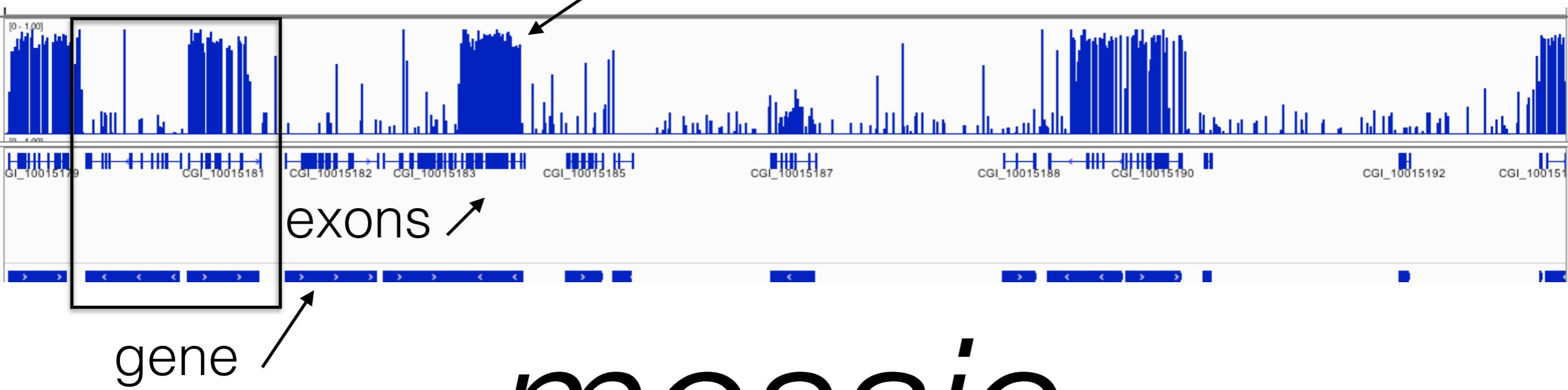
7,642,816 CpG dinucleotides with at least 5x coverage were examined

## - Bisulfite conversion



# Methylation landscape

DNA methylation level (0-100%) @ cytosines

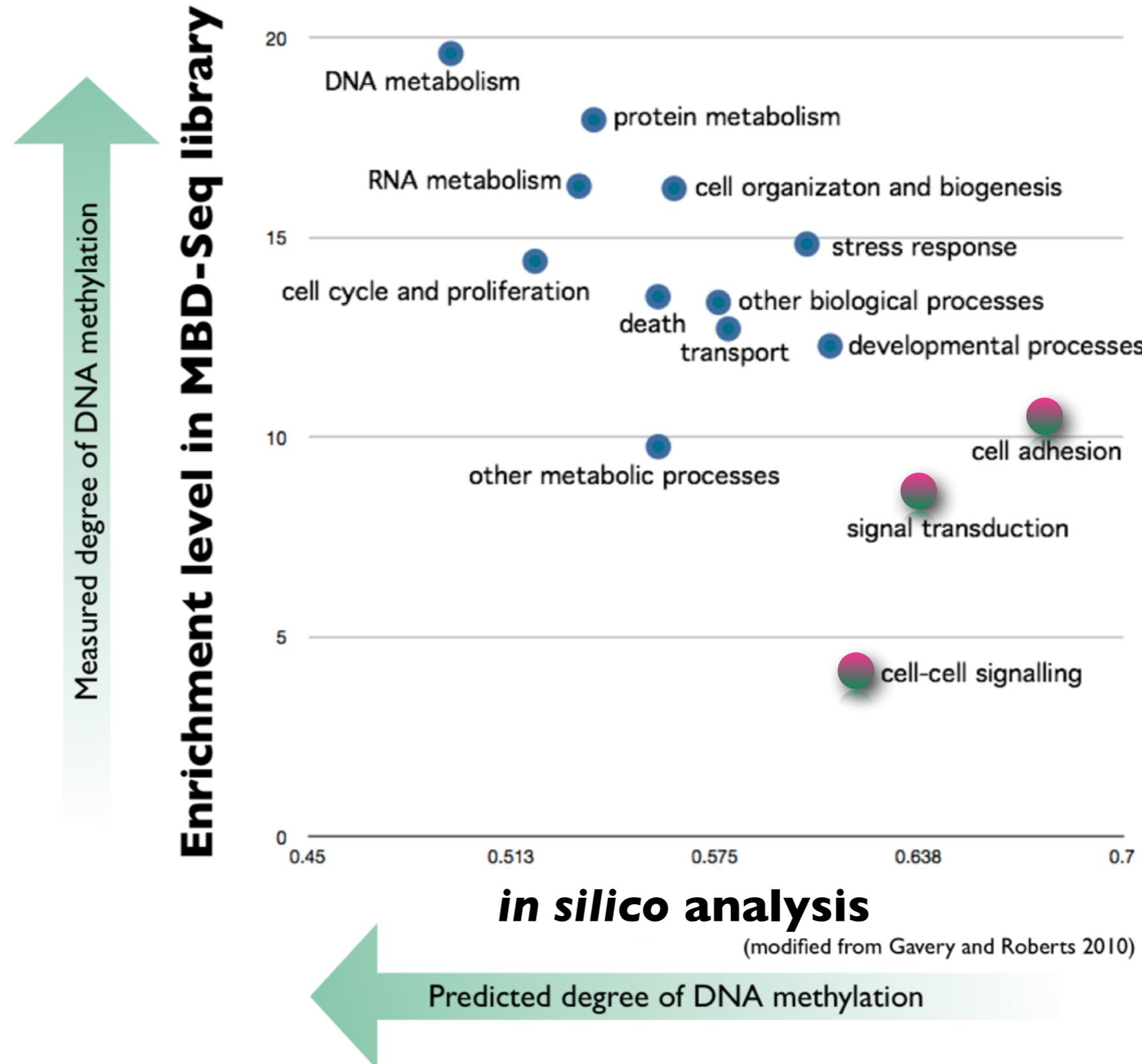


*mosaic*

**Why are only a subset of genes methylated?**

associated with gene bodies

# Methylation landscape

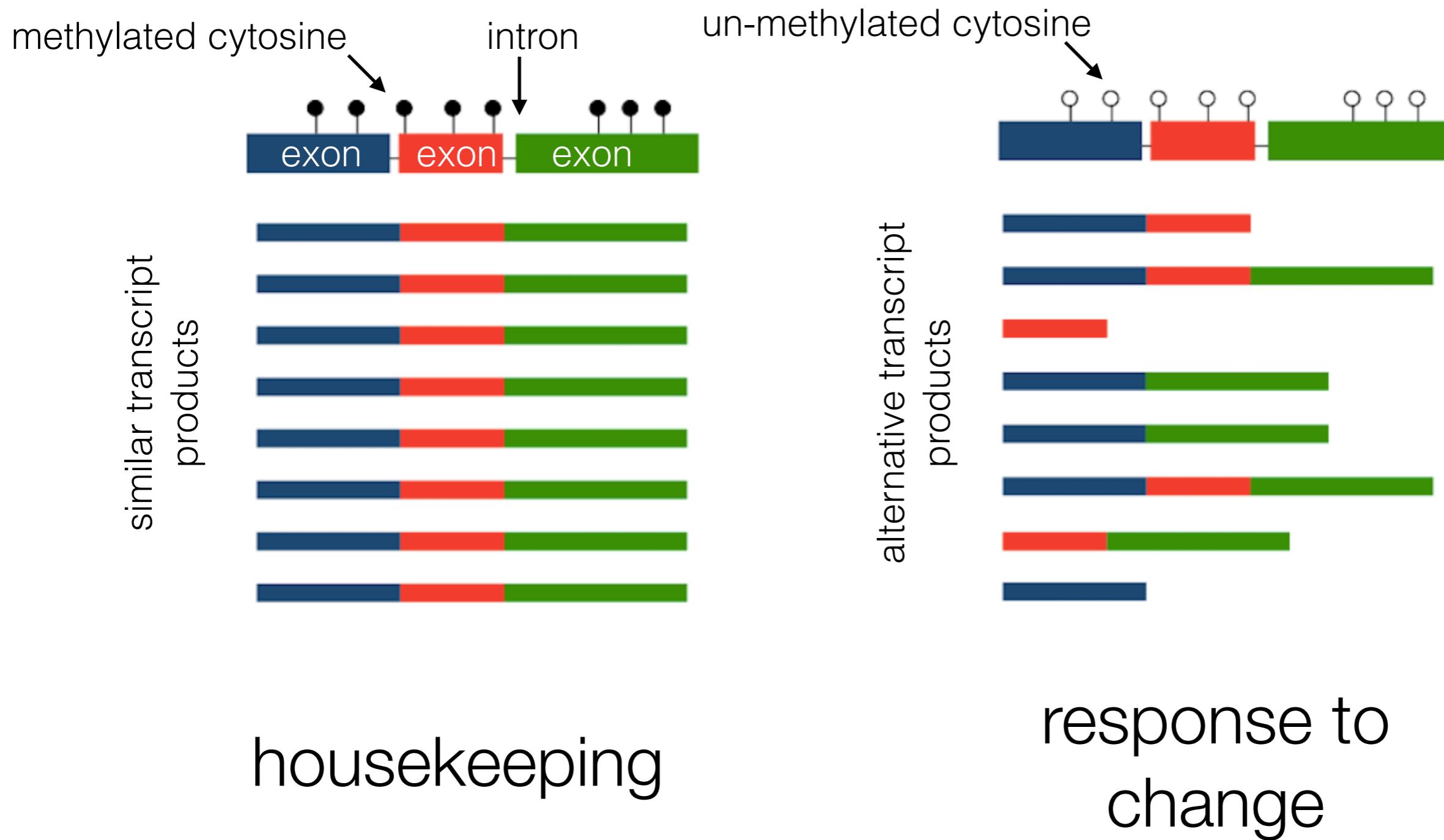


# Stochastic Variation

**A context dependent role for DNA methylation in bivalves**

Mackenzie R. Gavery and Steven B. Roberts

Advance Access publication date 7 January 2014



# Outline

Methylation landscape

Population studies

Environmental change

- 1) What is the function of DNA methylation in marine invertebrates?
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- 3) Is epigenetic variation independent of genetic variation?
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# Population studies



## Reciprocal Transplant Experiment



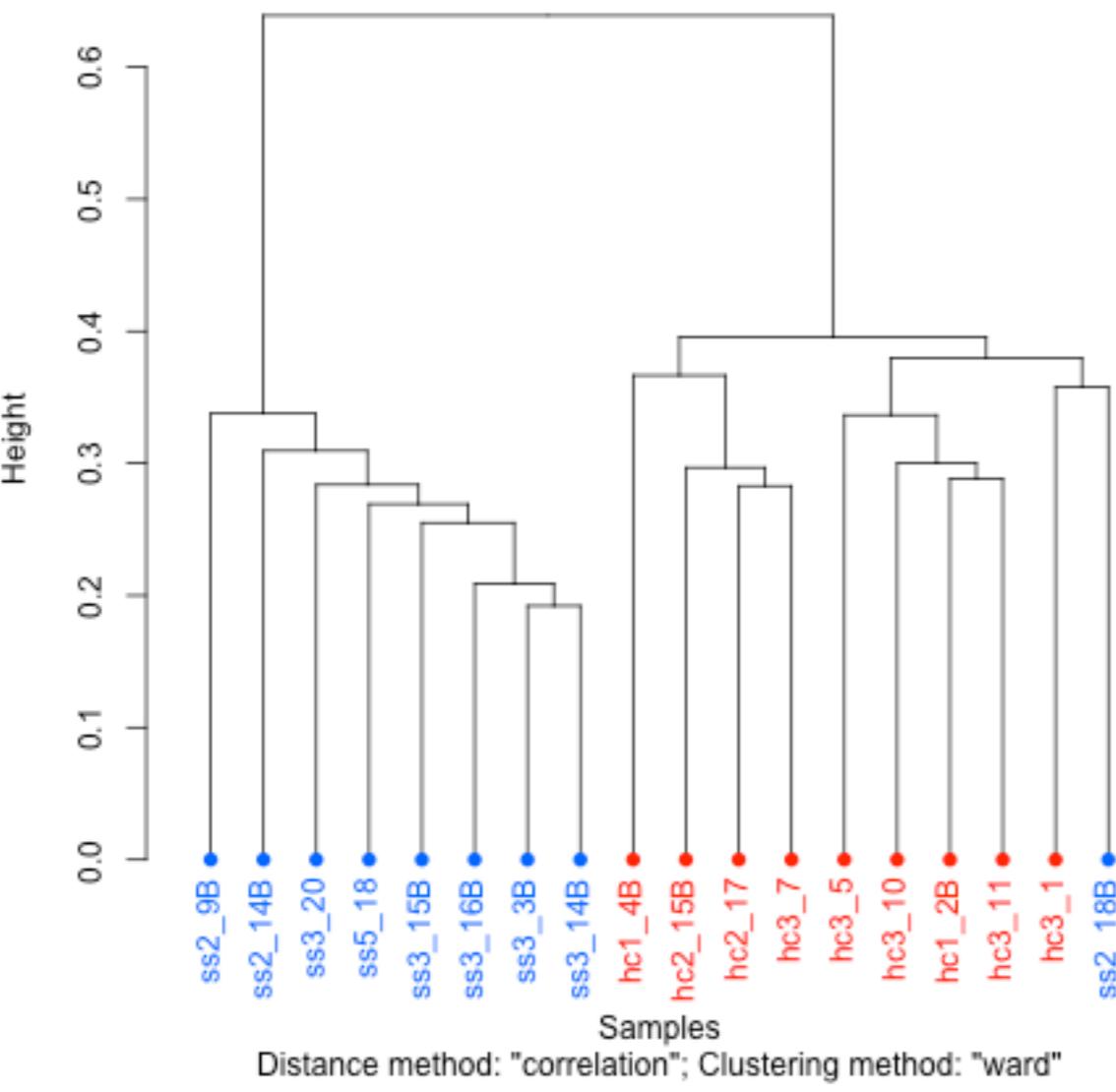
Manchester

# Population studies



## Reciprocal Transplant Experiment

CpG methylation clustering



Manchester

# Population studies



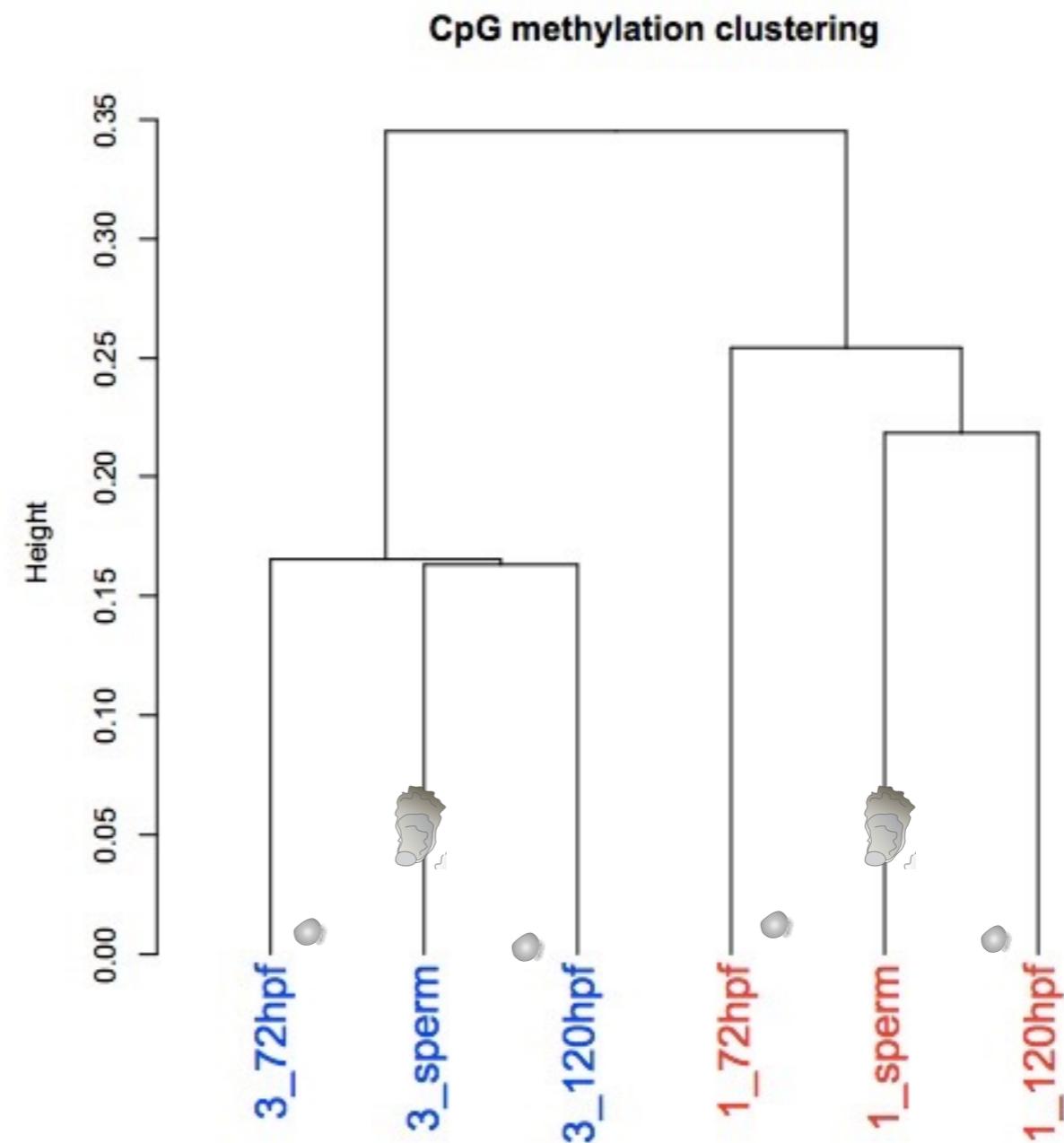
**bioRxiv**  
beta  
THE PREPRINT SERVER FOR BIOLOGY

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>



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- 3) Is epigenetic variation

[Genes & Genomics](#)

... November 2017, Volume 39, [Issue 11](#), pp 1173–1181 | [Cite as](#)

DNA methylation changes detected by methylation-sensitive amplified polymorphism in the Pacific oyster (*Crassostrea gigas*) in response to salinity stress

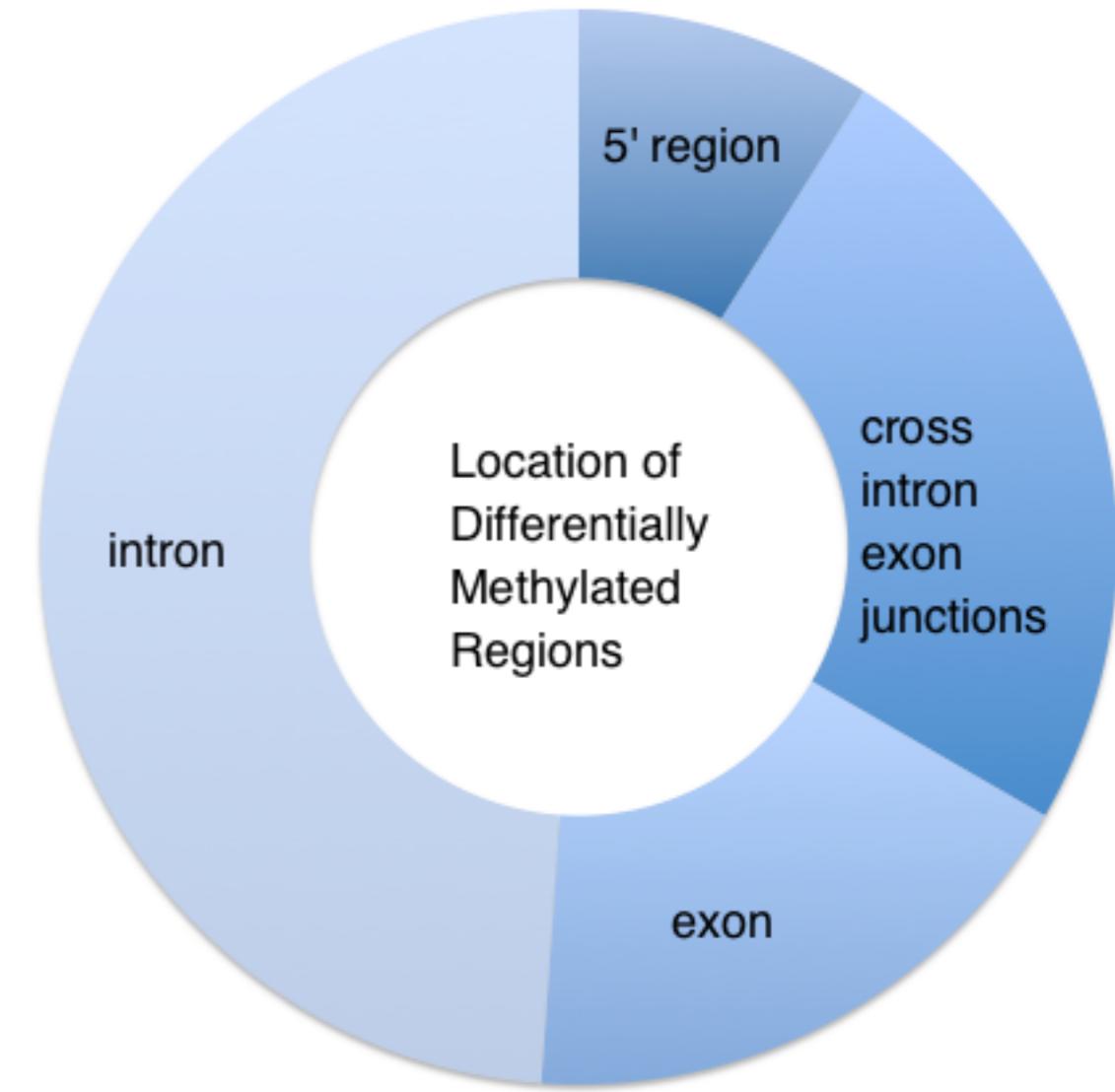
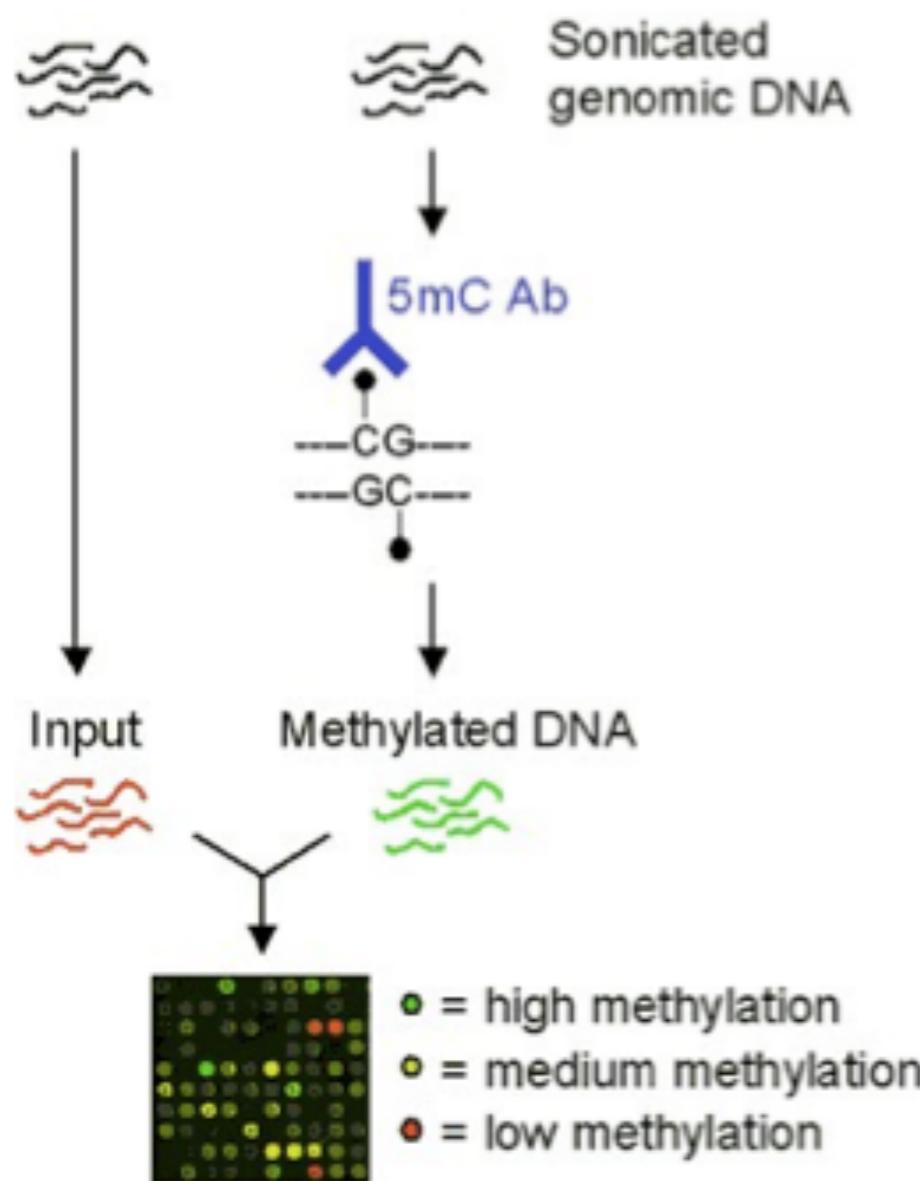
Xin Zhang, Qi Li , Lingfeng Kong, Hong Yu

Key Laboratory of Mariculture, Ministry of Education, Ocean University of China, Qingdao, China

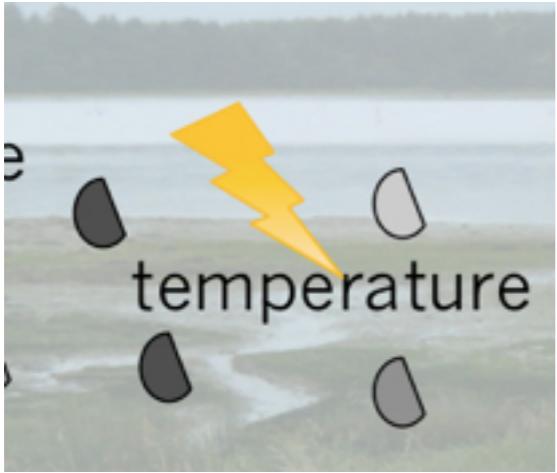
Laboratory for Marine Fisheries Science and Food Production Processes, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China

# Environmental change

## Hypomethylation



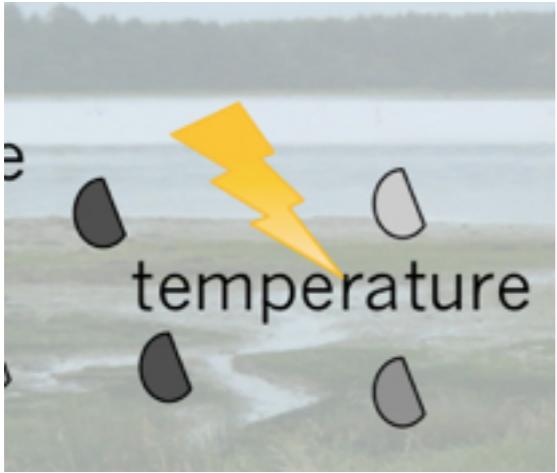
# Environmental change



*stochastic or targeted?*

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

# Environmental change



*stochastic or targeted?*

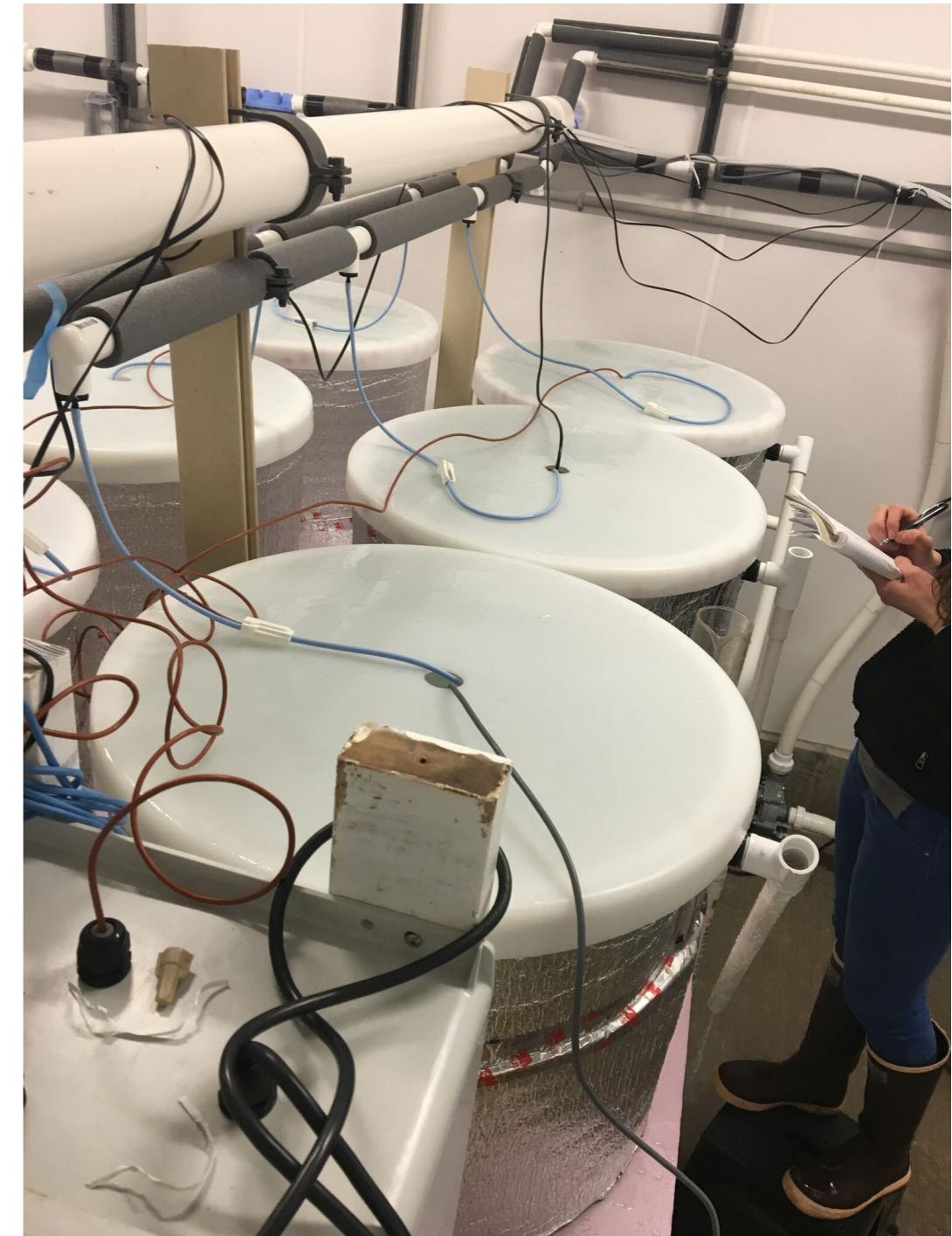
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No obvious association  
with genome feature  
including *differentially  
expressed  
genes*

# Environmental change

Very new data

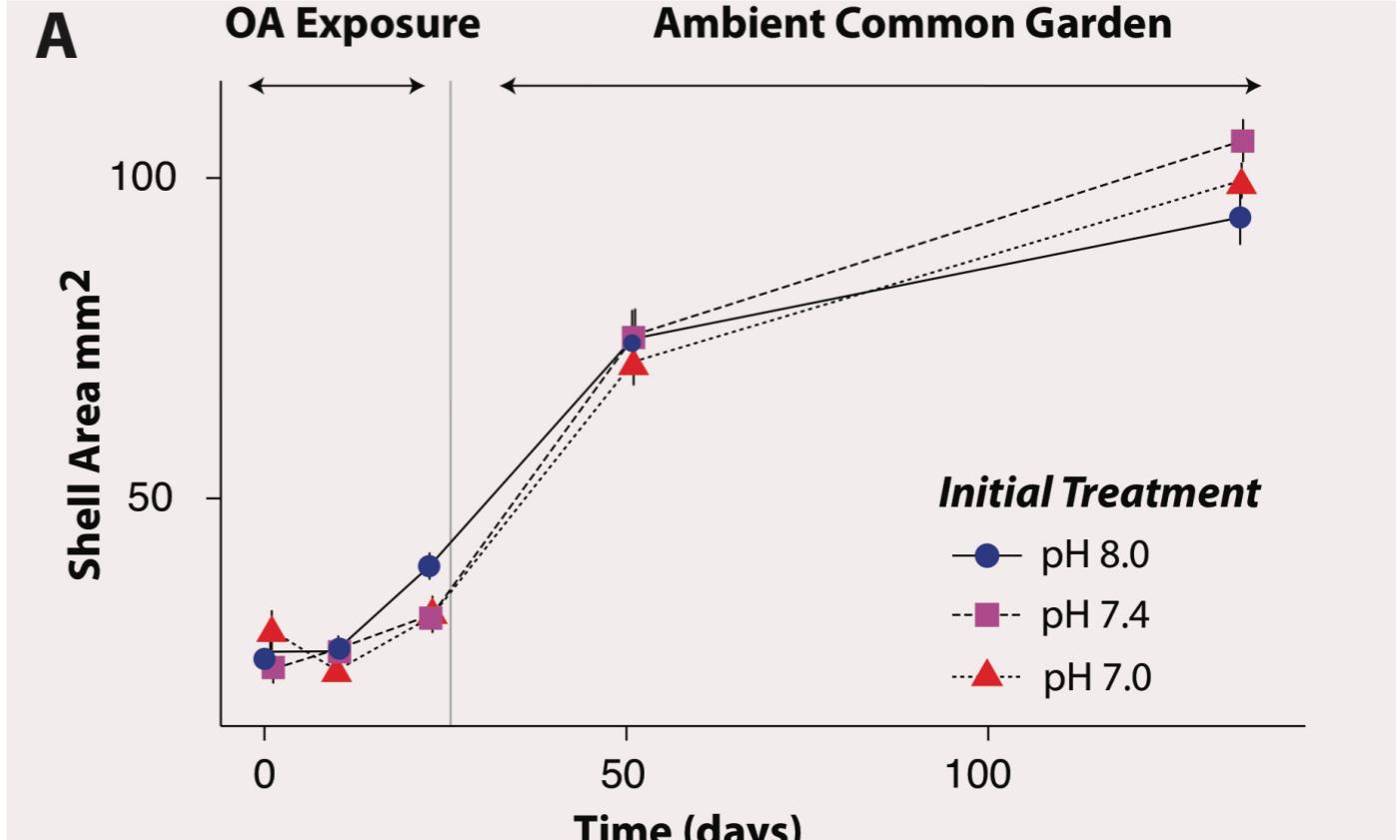
Ocean Acidification



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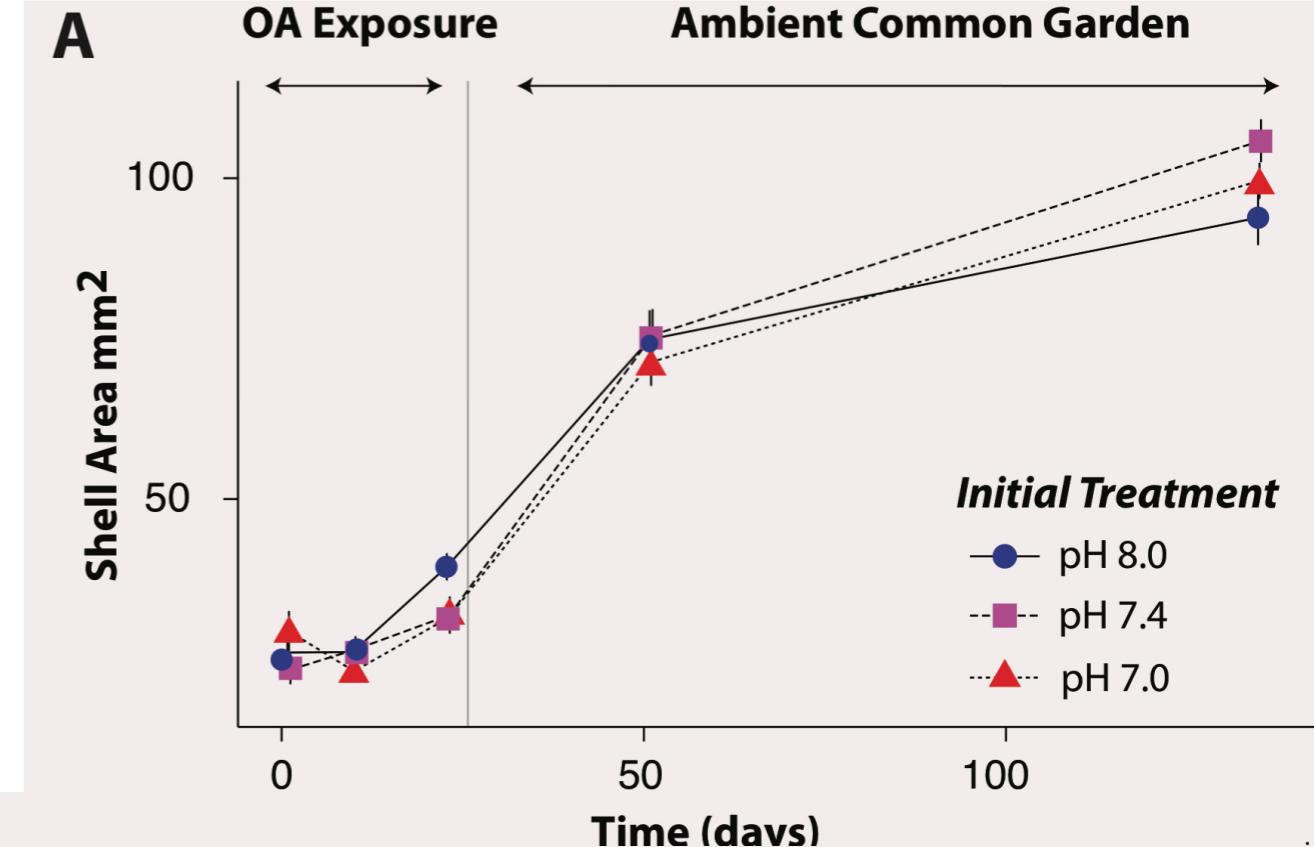
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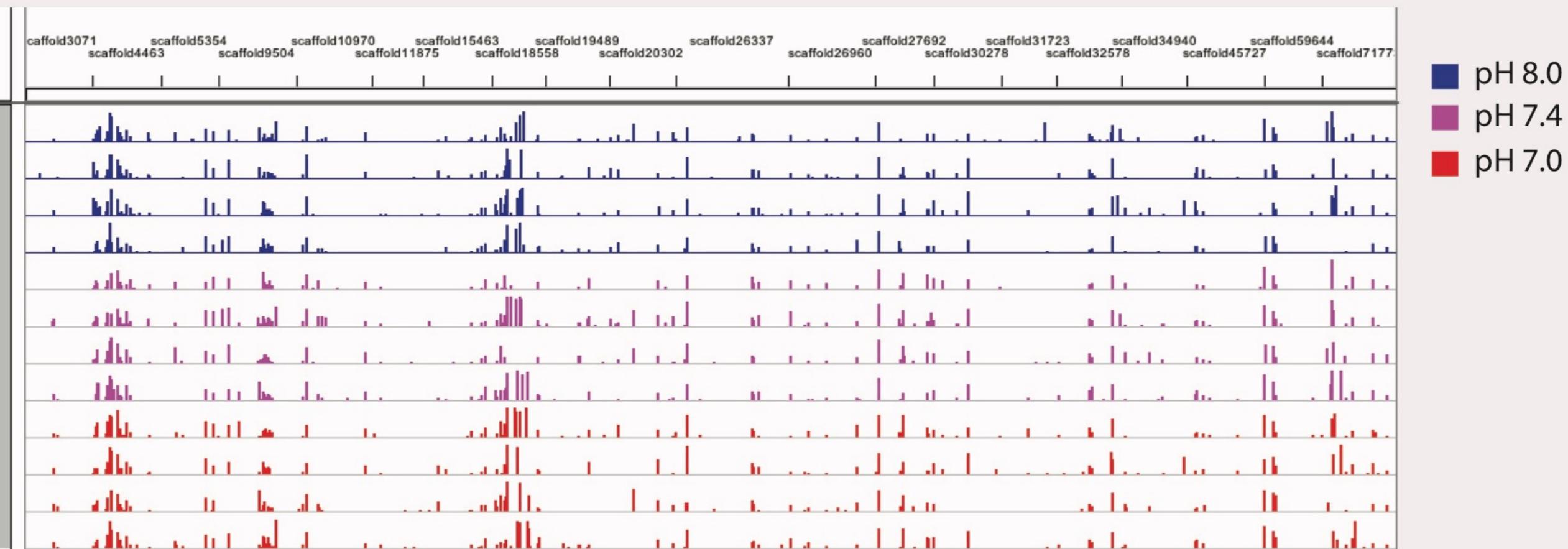
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## Day 10 DNA methylation patterns



# Applications in Aquaculture

## Epigenetic Selection

Identifying individuals by attributing trait to epigenotype

Adults



Influencing adult phenotype by altering early life environment

## Environmental Manipulation

Influencing offspring phenotype by altering environmental conditions of broodstock

Larvae



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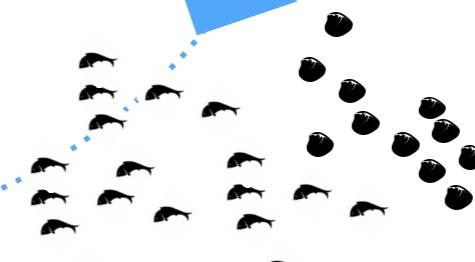
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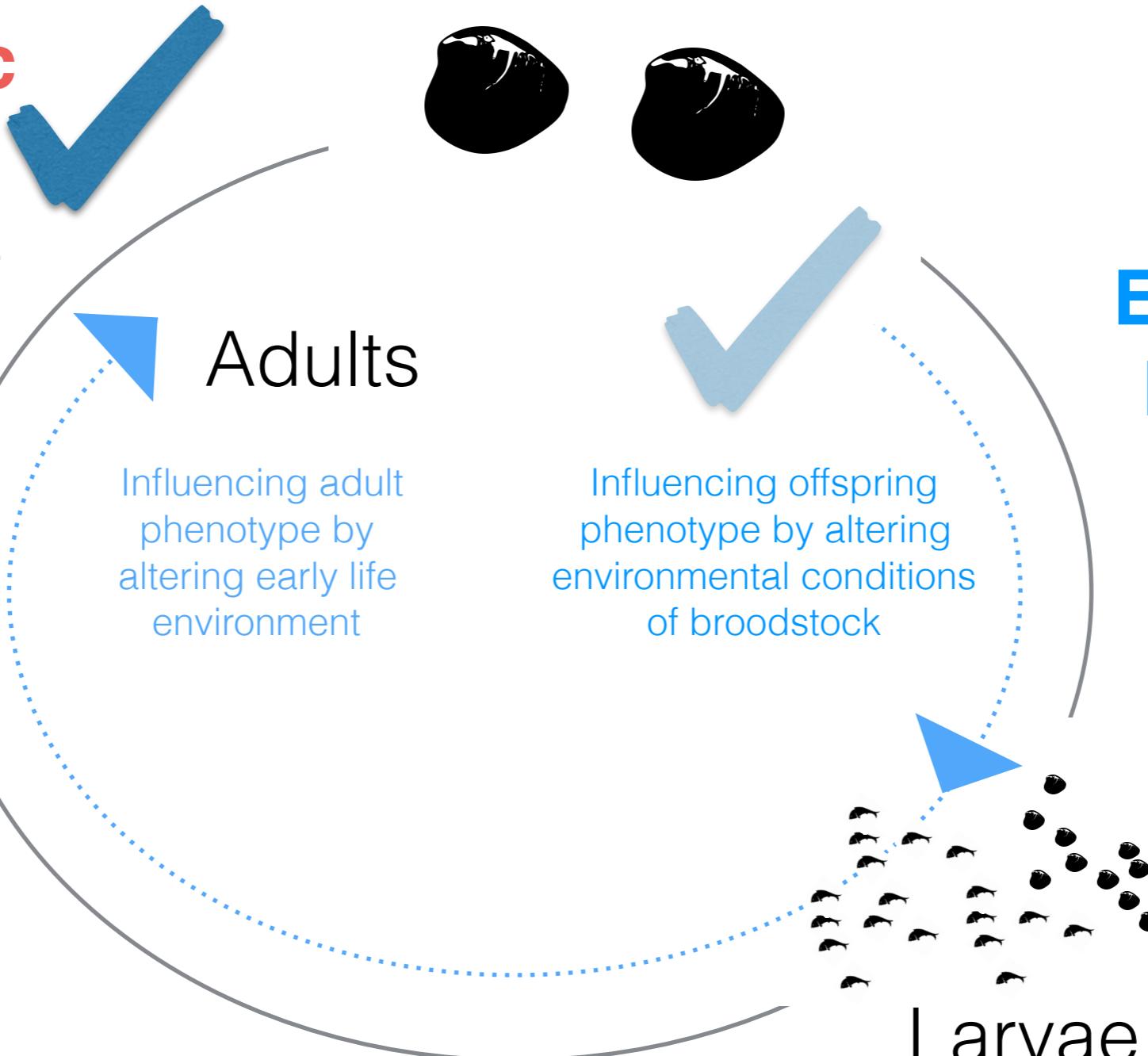


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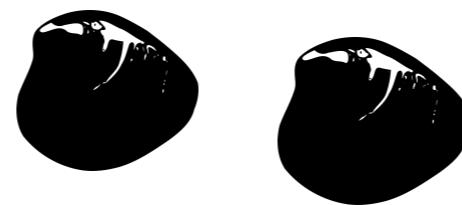
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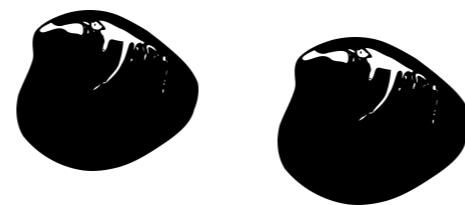
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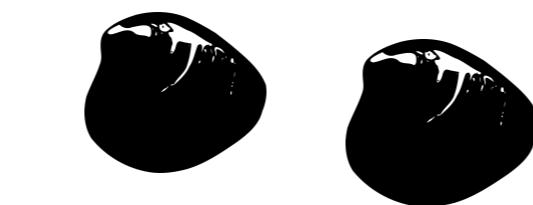
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*What is the function of DNA methylation in marine invertebrates?*

*How do environmental conditions influence epigenetic variation?*

Larvae

## Summary

Particularly in *shellfish*, epigenetics should be given considerable attention in understanding and optimizing phenotype.

# Considerations in Aquaculture

1. Epigenetics is an attractive lens through which to consider manipulation of traits through environmental memory or selection.
2. Epigenetics may also function to disrupt predictable phenotypes through the creation of unexpected variation.

# Acknowledgements

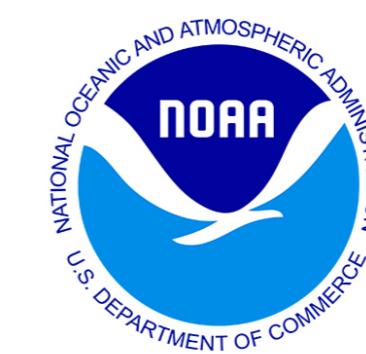
Mackenzie Gavery

Claire Olson

Sam White

Brent Vadopalas

Hollie Putnam



slides, data & more @

<https://github.com/sr320/talk-Rushan-2018>