

# You Are What Your Mother Ate: The Science of Epigenetics



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You are what your mother ate:

*Does your lifestyle  
alter your  
epigenetic marks?*

Kerry Samerotte

# The Time of Your Life

**Our epigenetic markings change over the course of our lives**



# The Time of Your Life

## Do our lifestyles affect these changes?

(The alternative is that these changes are set onto an unalterable course at birth)



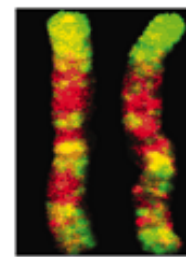
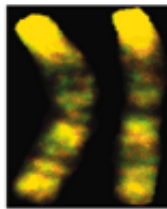
# DNA is not Destiny

Twins are genetically identical, but epigenetic differences accumulate over time.

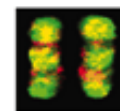
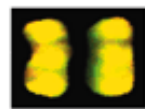
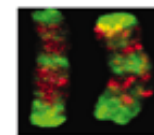
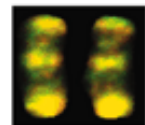
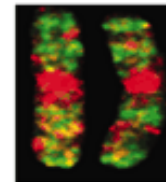
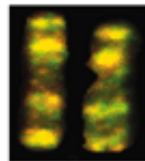
3 year old twins

50 year old twins

Yellow = Same  
methylation level



Red/Green = Different  
methylation levels





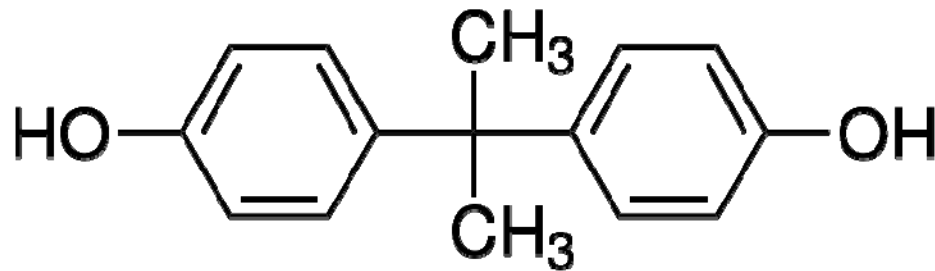
# What affects epigenetic modification?

**Diet?**



**Behavior?**

**Exposure to harmful substances?**



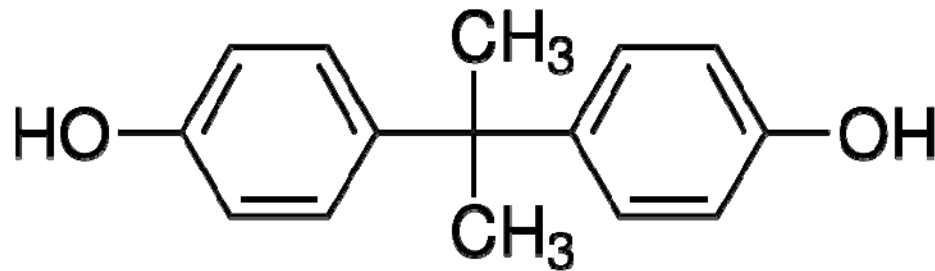
# We don't know!

**Diet?**



**Behavior?**

**Exposure to harmful substances?**



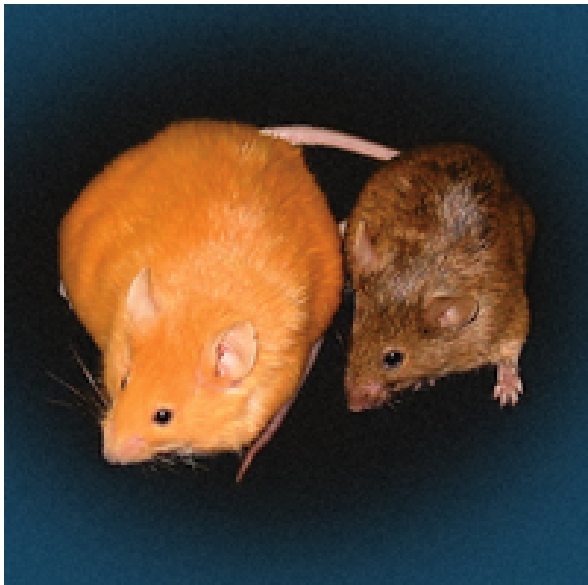
# Beginning to Explore

Current research is focused on early life





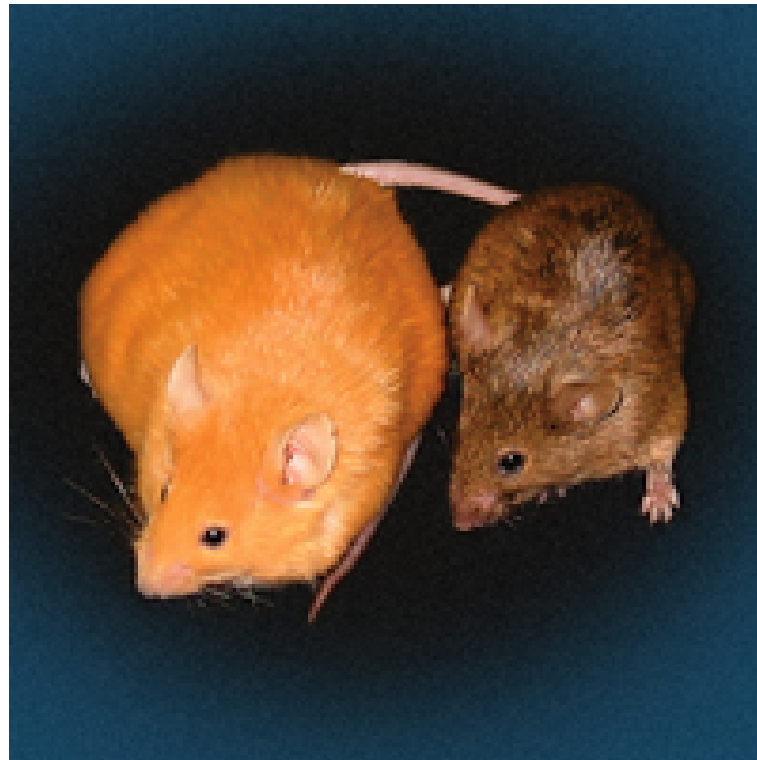
# Epigenetics in Early Animal Life



# Of Mice and Methyl

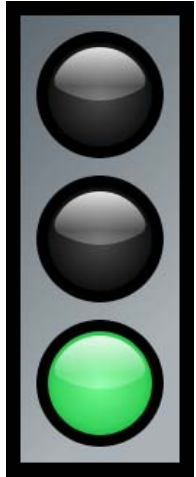
Remember these mice?

They are genetically identical

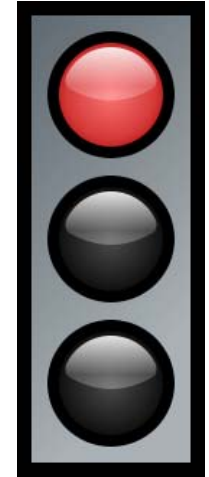


How can they be different colors?

# Epigenetic Methylation Turns Genes Off

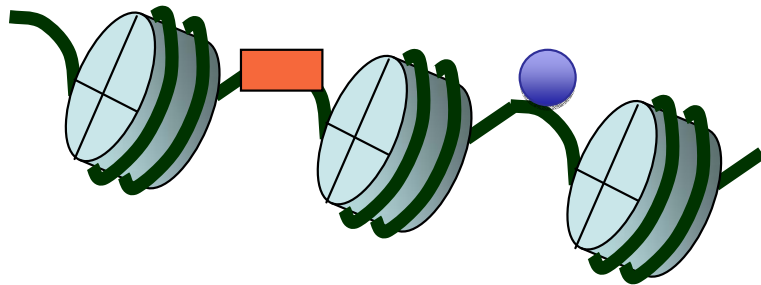


Epigenetic modification alters which genes are on or off

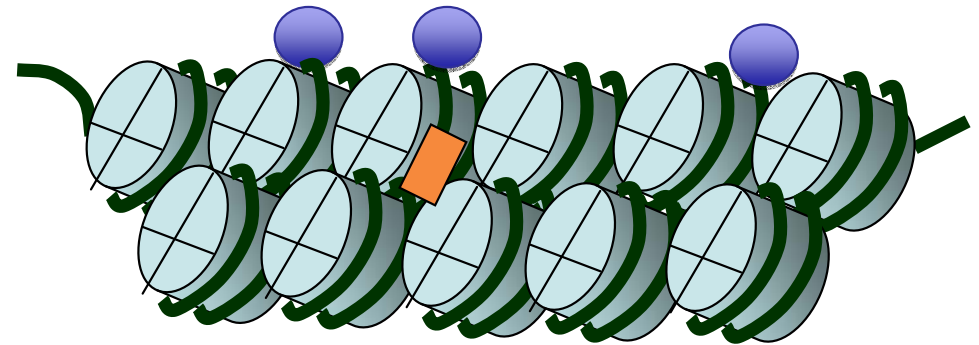


**ON**

**OFF**

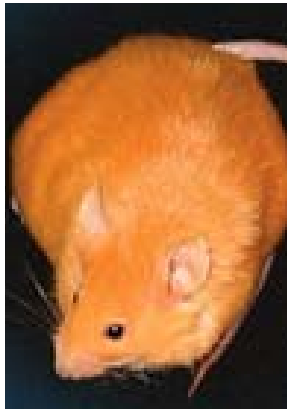


vs.



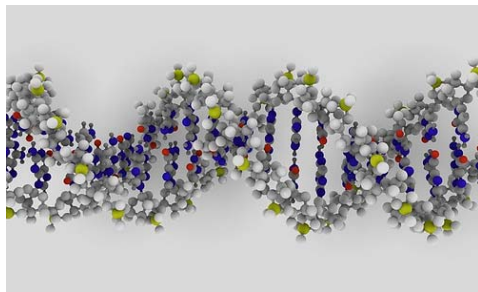
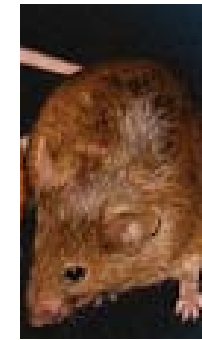
# You Are What Your Mother Ate

This mouse's mother ate a typical diet

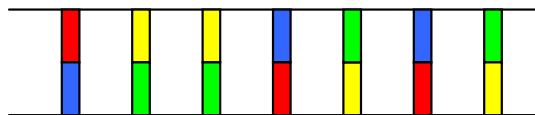
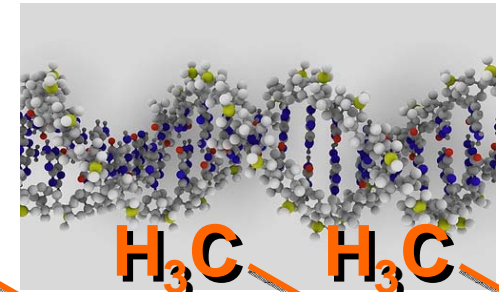


Methylation stopped the yellow "agouti" gene from being expressed!

This mouse's mother ate a **high methyl diet**

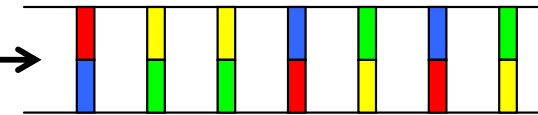


← Identical DNA! →



Yellow "agouti" gene

← This gene confers Yellow coat color →



Yellow "agouti" gene



# The Queen Stands Alone

Worker and queen bees are genetically identical



Worker Bees



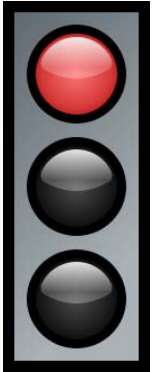
Queen Bee

Social insects: Only the queen can reproduce

How? Ovary development genes are methylated in workers!

# A Diet Fit for Queens

## Worker Bees



Fed honey

**By default**, ovary genes are methylated

Workers cannot reproduce

## Queen Bee



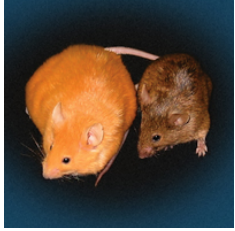
Fed “royal jelly”

Royal jelly prevents methylation of DNA

Ovary genes expressed and queens emerge!

# On or Off?

Mouse example: diet added methyl groups and turned a gene off



Default state is unmethylated

Bee example: diet removed methyl groups and turned genes on



Default state is methylated

Whether methylation is beneficial or detrimental depends on the particular gene and on the environment

# All You Need is Love

Maternal behavior can also have epigenetic consequences

Rats receiving good maternal care are more resilient to stress.

- increased stress hormone receptors (glucocorticoids)
- more willingly eat novel foods
- explore new environments

Nature or Nurture?





# The Switch



High handling, low stress mom



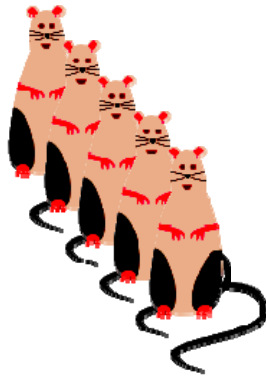
Low handling, high stress mom

If stress is **genetic**, offspring will have same stress level as **biological parent**  
If stress is **environmental**, offspring will have same stress level as **foster parent**

# The Switch



High handling, low stress mom



Low handling, high stress mom



If stress is **genetic**, offspring will have same stress level as **biological parent**

If stress is **environmental**, offspring will have same stress level as **foster parent**

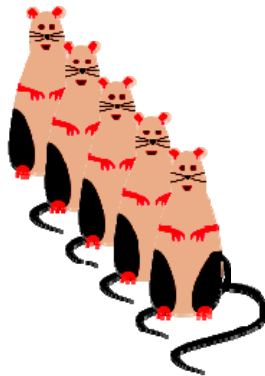
# The Switch



High handling, low stress mom



Low handling, high stress mom



Switch offspring



If stress is **genetic**, offspring will have same stress level as **biological parent**  
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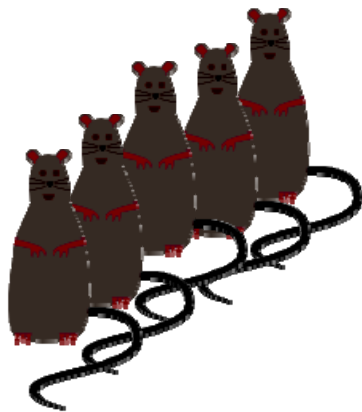
# The Switch



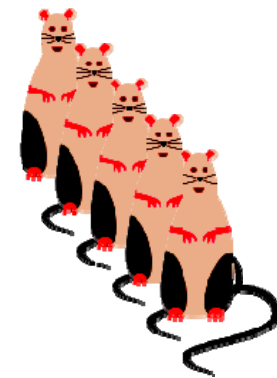
High handling, low stress mom



Low handling, high stress mom



Switch offspring



If stress is **genetic**, offspring will have same stress level as **biological parent**  
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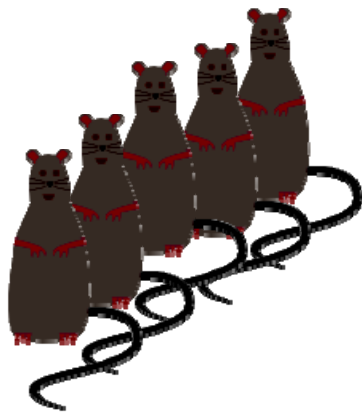
# The Switch



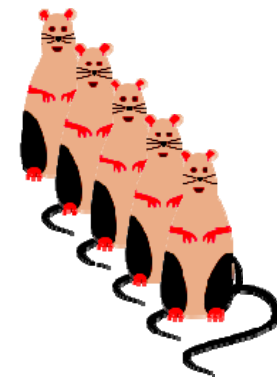
High handling, low stress mom



Low handling, high stress mom



Switch offspring



~~If stress is **genetic**, offspring will have same stress level as **biological parent**~~

If stress is **environmental**, offspring will have same stress level as **foster parent**

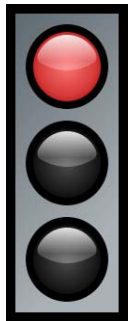
# Nurture! (but how?)

Differences in the amount of glucocorticoid receptor proteins  
These prevent overproduction of stress hormones

Mice with absent moms:

Less glucocorticoid receptor

Gene encoding glucocorticoid receptor is  
methylated & bound by histones



Mice with attentive moms:

More glucocorticoid receptor

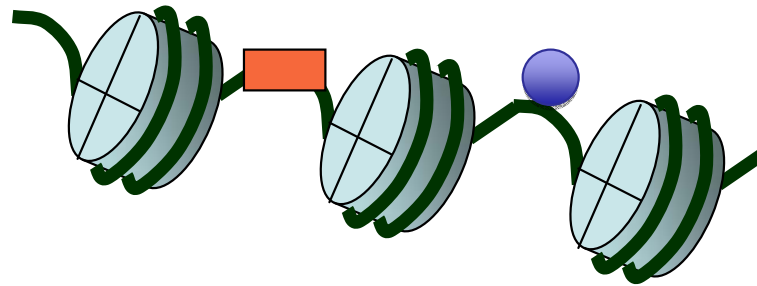
Gene encoding glucocorticoid receptor has  
decreased methylation and histones



# Nurture! (but how?)

Differences in amount of glucocorticoid receptor proteins  
These prevent overproduction of stress hormones

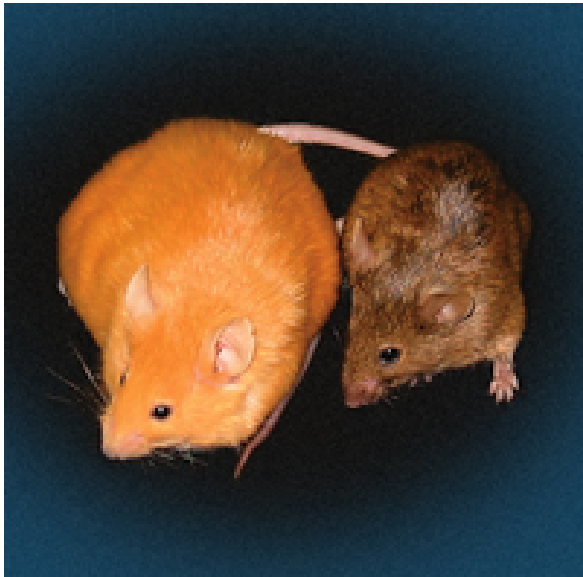
Maternal care removes epigenetic modifications to turn  
glucocorticoid receptor gene on



# What causes epigenetic modification?

## Diet?

Methyl source in mice



## Behavior?

Parental care in rats



Royal Jelly in bees



## What about toxins?

# Environmental Toxins

CANADA LIKELY TO LABEL PLASTIC INGREDIENT “TOXIC:

*Invisible Danger? Parents Look Inside the Lunchbox.*

F.D.A. to Reconsider Plastic Bottle Risk

**A HARD PLASTIC IS RAISING HARD QUESTIONS**

That Plastic Baby Bottle

CANADA TAKES STEPS TO BAN MOST PLASTIC BABY BOTTLES

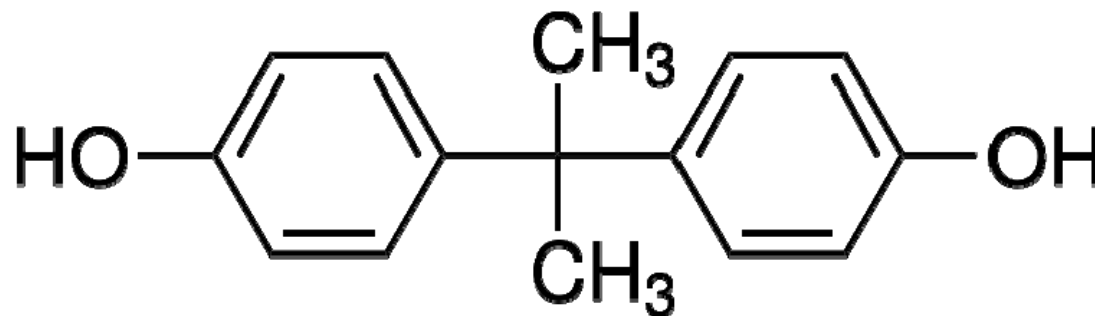
# BPA Plastics: An Intense Debate

In a Feast of Data  
on BPA Plastic,  
No Final Answer



# The BPA Basics

BPA = Bisphenol A



There are various health concerns

We'll only talk about the possible epigenetic effects highlighted in a 2007 study by Dolinoy and colleagues from PNAS

## **Caveats:**

Single study

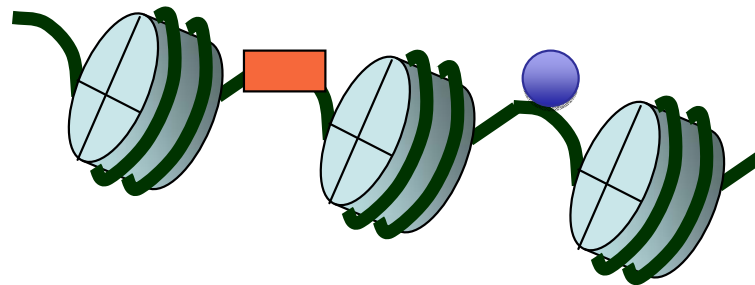
Less than 100 mice

High concentrations of BPA

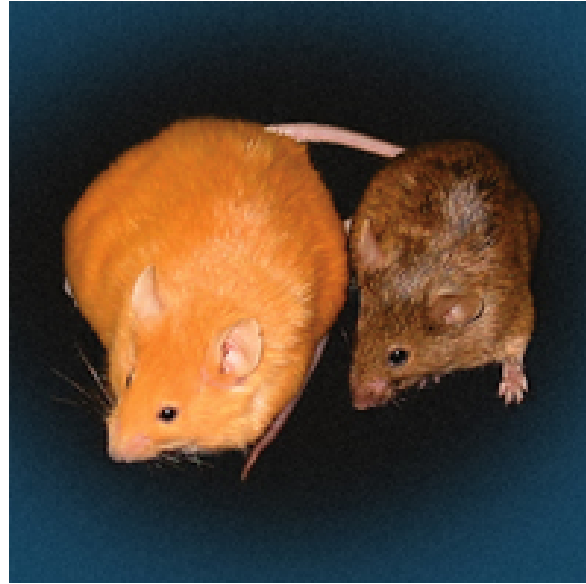
# The BPA Hypothesis

Bisphenol A **REMOVES** DNA methylation

This alters patterns of gene expression

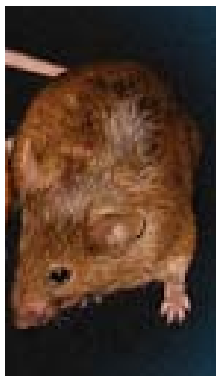


# Experimental Design



# Experimental Design

Mother mice  
Fed a typical diet



60 offspring

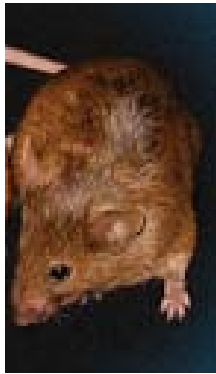
Mother mice  
Fed a BPA rich diet



72 offspring

# Experimental Design

Mother mice  
Fed a typical diet



↓  
60 offspring

Mother mice  
Fed a BPA rich diet



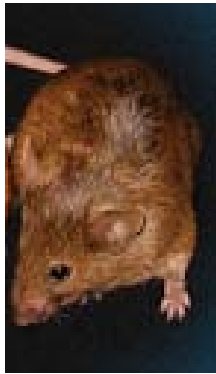
↓  
72 offspring

Question:  
How many are yellow?  
(Methylation removed)



# Experimental Design

Mother mice  
Fed a typical diet



↓  
60 offspring

Mother mice  
Fed a BPA rich diet



↓  
72 offspring

Mice fed **200x more BPA** per kg than the **Maximum EPA Recommended Dose**:

10mg/kg bodyweight > 0.05mg/kg

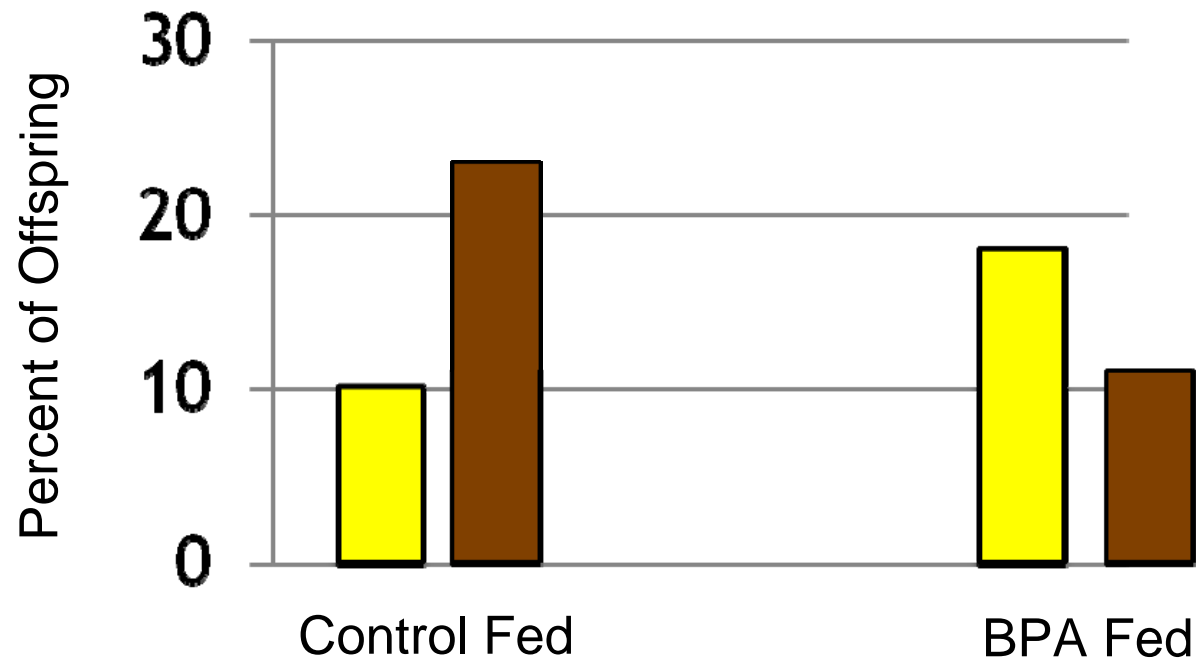
Mice fed **10,000x more BPA** per kg than **average human intake**:

10mg/kg bodyweight > 0.00011mg/kg



# Coat Color Data

Mice from mothers fed diets rich in BPA vs. no BPA



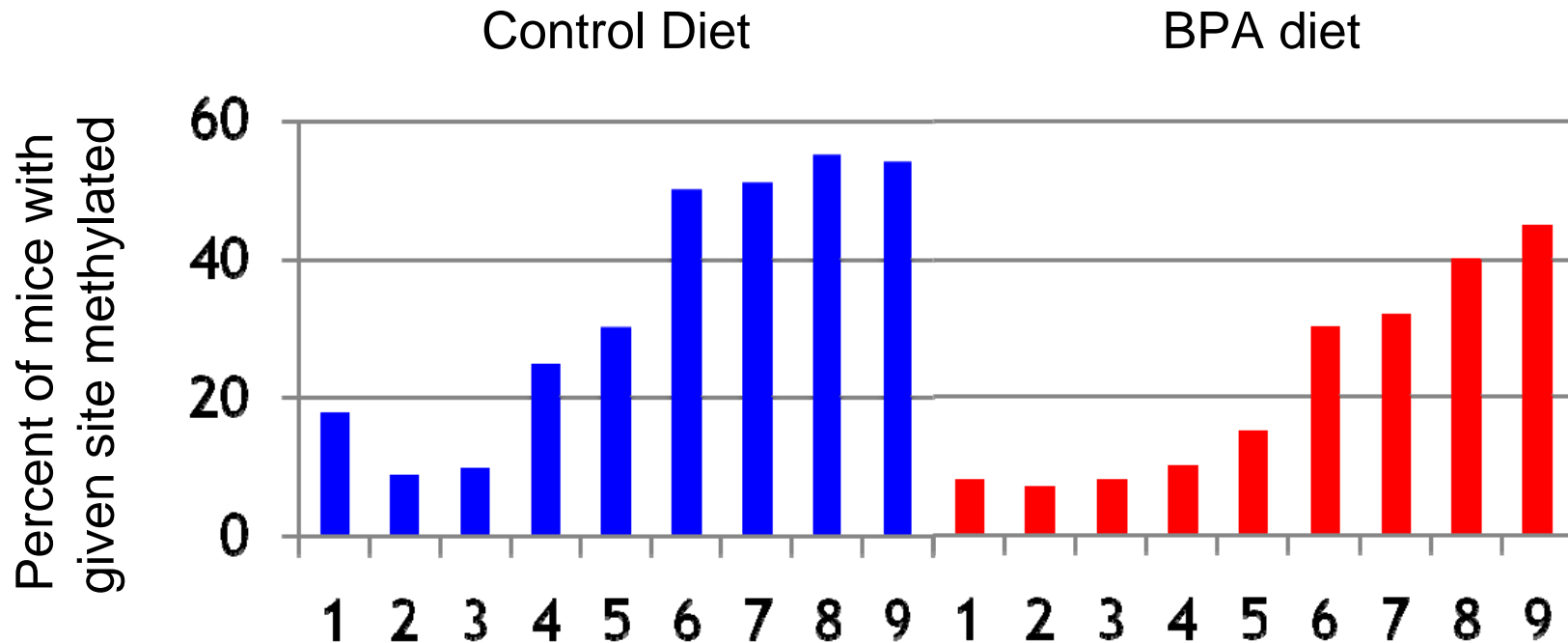
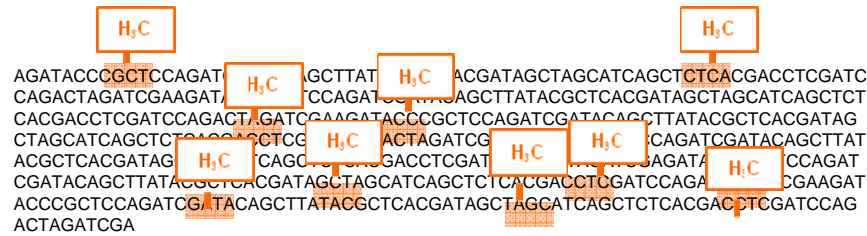
# Epigenetic Data

Nine sites commonly methylated on yellow “agouti” gene



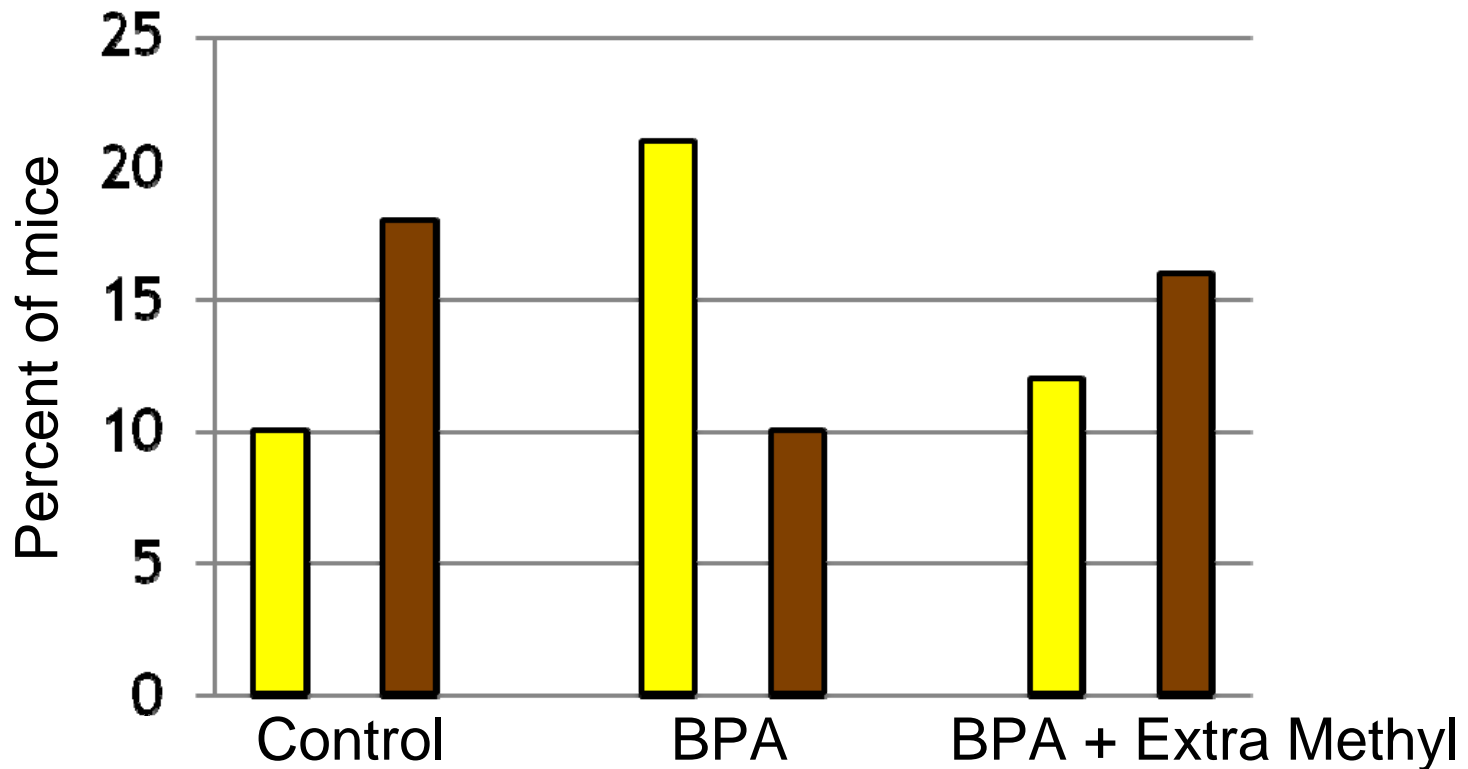
# Epigenetic Data

Hypothesis: BPA removes methylation at these nine sites



# Can proper nutrition combat toxins?

Extra methyl diet increased methylation: More brown mice  
High BPA diet decreased methylation: More yellow mice  
What about BPA + extra methyl?



# Conclusions about BPA

Although intriguing, this study is not conclusive evidence that BPA is unsafe at current levels.

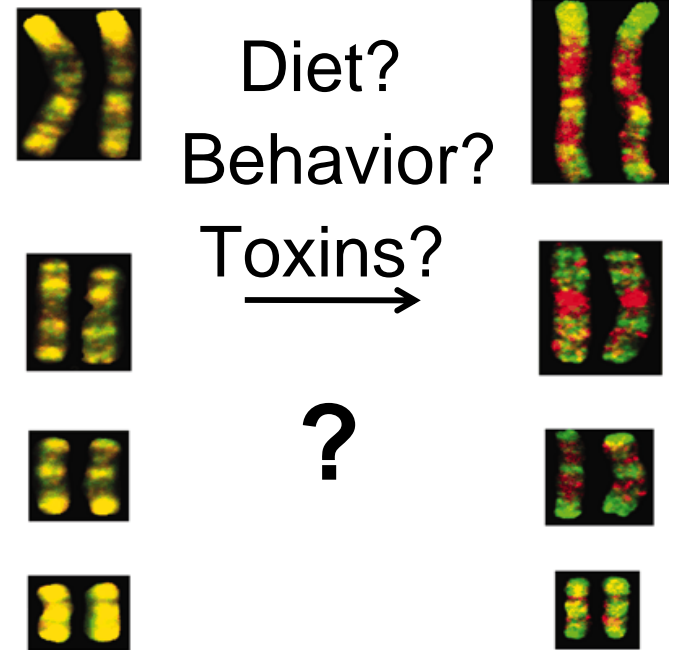
## Caveats:

Not enough mice  
Multiple effects of BPA  
Single lab's results  
Quantity of BPA

## What's next:

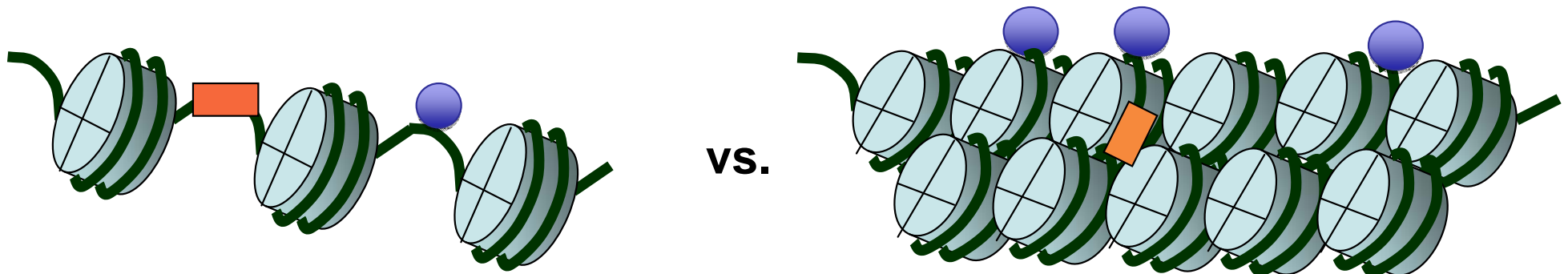
More research...

that goes for everything



# Summary

There is mounting evidence that epigenetic modifications like methylation and histone binding are affected by lifestyle and environment





Thank you!

Questions?