You Are What Your Mother Ate:
The Science of Epigenetics

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Today’s Lecture

Daniel Lieber
- What is epigenetics?

Kerry Samerotte
- Epigenetics and us

Brian Beliveau
- Past, present, and future
You Are What Your Mother Ate:

What is Epigenetics?

Daniel Lieber
DNA is the Source of Heritable Information in the Cell

organism

tissue

DNA

chromosomes

DNA sequence

A T G C

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Central Dogma

DNA is *transcribed* to RNA is *translated* to PROTEIN

DNA Mutation

Mutation in RNA

Altered protein
Same DNA, Different Look

- We are made up of over 200 cell types.
- Each cell has the same DNA!
- How can they look so different?

Epigenetics!

- Genes turned on or off
Epigenetic Marks

DNA is transcribed to RNA is translated to PROTEIN
Each Cell has an Epigenetic Signature

- Epigenetic state is like a barcode:

  Liver

  Skin

  Muscle

Presence of an epigenetic mark at a particular location in the DNA

- Epigenome = complete epigenetic state of a cell
Two Types of Epigenetic Marks

**Chemical**
e.g., Methylation

- Methyl group
- DNA sequence: ATGCTAGTCCGGCTCCCTTTAAAC
- Methylation: ATGCTAGTGGCTCCCTTTAAAC

**Protein**
e.g., Histones

- Histone
- DNA
- Accessible
Combinations of Epigenetic Marks

**Chemical**  
e.g., Methylation

**Protein**  
e.g., Histones

**Transcription machinery**

**mRNA**

**DNA**

**Histone**

**Nucleosome**

Modified from J. Corum for NYTimes
What do epigenetic marks do?

If DNA is like the alphabet, epigenetic marks are like the **accents** and **punctuation**

**DNA sequence**

TAG   CAT   ACT

TAG!  CAT?  ACT

Epigenetic marks

If DNA is like a book, epigenetic marks are like **sticky notes**

Epigenetic marks tell our cells whether and how to read the genes
What is Epigenetics? (Formal Definition)

- Epigenetics is the study of inherited traits caused by mechanisms other than changes in the underlying DNA sequence.

- Epi- = “above” or “upon”

- Framework for answering:
  - How can the same DNA sequence lead to different outcomes?
How Does Epigenetics Affect Us?

Tissues have different epigenetic states

Sisters? Actually, genetically identical. Mothers were on different diets!

Diet and environment impact your epigenetic state
Sources of Epigenetic Variation

Nature vs. Nurture

• **Nature:** Epigenetic marks can be inherited.

• **Nurture:** Epigenetic marks can be accumulated.
  - Only those in germ line will be passed down.
Human (Epi)Genome Project

• Human Genome Project (1990-2003)
  — Sequenced all ~20,000 genes in our DNA
  — 3 billion basepairs, ~3 billion dollars
  — Only 1.5% of genome codes for proteins!

• Epigenomics Road Map (2008-Present)
  — Goal: Create map of epigenome in multiple tissue types and cancers
Summary

- Epigenetics is the study of heritable changes in gene activity that do not involve alterations to the genetic code.
- Epigenetic marks tell your genes to switch on or off.
- Two types of marks: chemical (e.g., methylation) or protein (e.g., histones).
- Through epigenetic marks, environmental factors like diet, stress and prenatal nutrition can make an imprint on genes passed from one generation to the next.
- Epigenetic changes can be inherited or accumulated.
- Tissues have specific patterns of epigenetic modification.
Thank you!

Questions?