Ulisses

UNIVERSITY OF LISBON
INTERDISCIPLINARY STUDIES
ON SUSTAINABLE ENVIRONMENT AND SEAS

EPIGENETICS – The regulation of gene expression

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Part I

1. What Is Epigenetics ?
2. Epigenetics And Regulation of Gene Expression
3. Major Epigenetic Mechanisms; The Epigenetic Code

Part II

4. The Influence of The Environment on Epigenetic Control

What Is Epigenetics ?

Epigenetics = Epi + Genetics

Epi (Greek) = above, upon

Genetics = the study of heredity i.e. the way the genes are transmitted from parents to the offsprings

Epigenetics = In addition to genetics

BUT .....

Genotype + Environment = Phenotype

AND .....

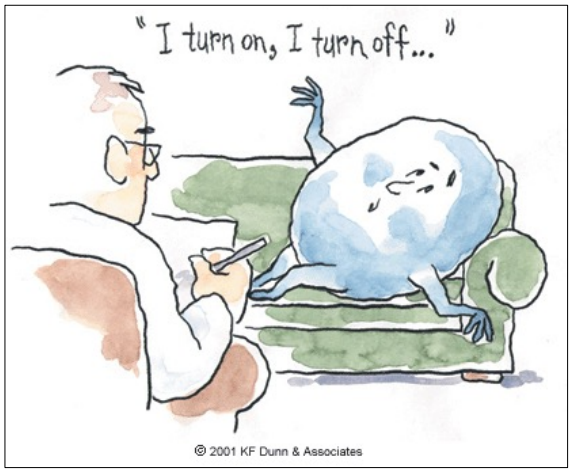
Epigenetic processes generate multiple phenotypes from the same genotype

Genes are portions of DNA that when expressed produce proteins

All the cells in the body have the same genetic information but they are organized in different tissues like skin, lungs, heart or bones. In each tissue cells have a memory, and all maintain the same characteristics although they are different from tissue to tissue.

What makes these cells different from each other?

In each tissue, some genes are active making specific proteins whereas other genes are silent, what enables tissue differentiation



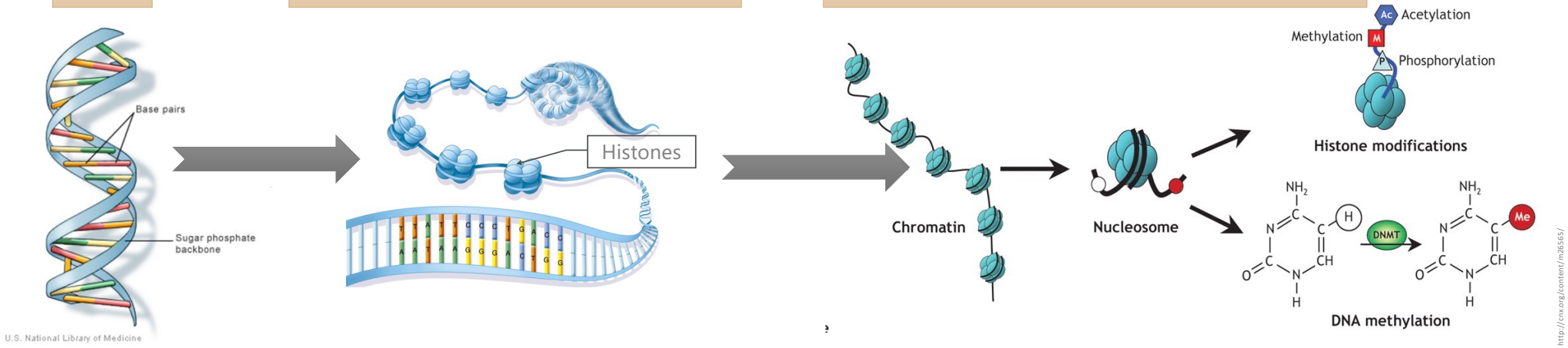
What makes genes being turned on or off in each cell of the body if they all have the same genetic information, *i.e.* the same DNA sequences?

Genes are turned on or off according to chemical modifications of the chromatin, either in the DNA or in the histone proteins. Chromatin and the nucleosome are key players in epigenetic processes

DNA

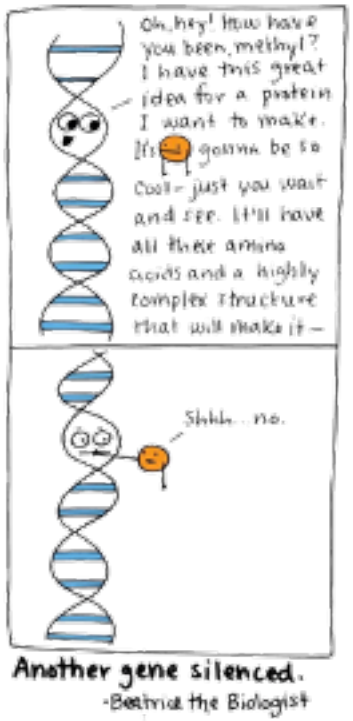
Chromatin = DNA + Histones

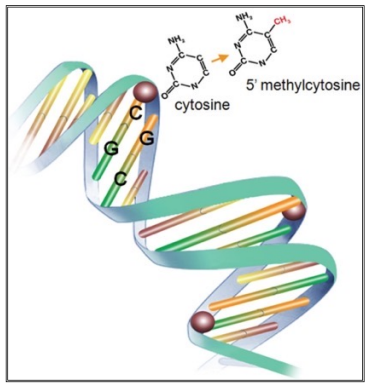
DNA and Histones can be modified

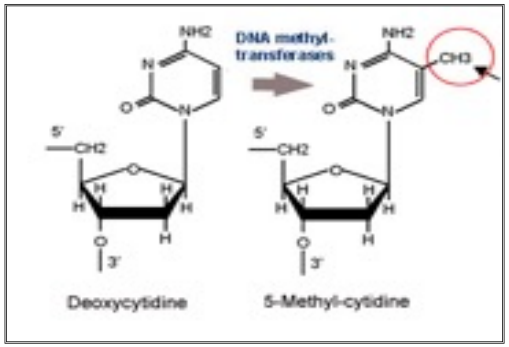


DNA can be methylated and histones can be methylated, acetylated and phosphorylated

Cytosine methylation occurs in several DNA sequences, and leads to gene silence

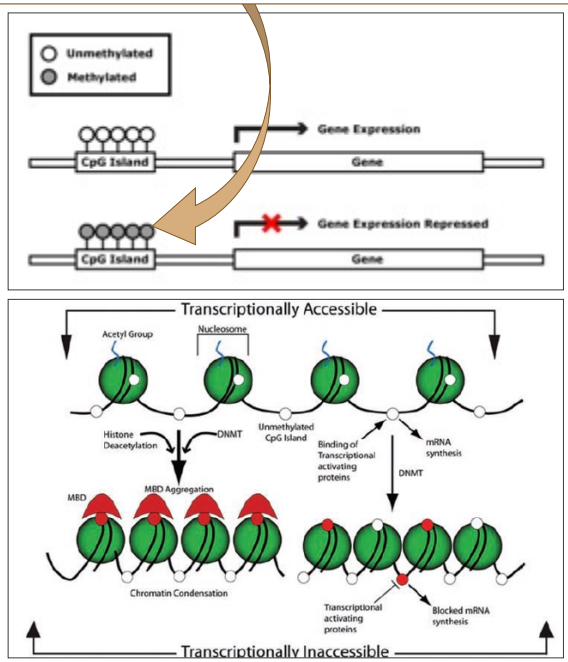




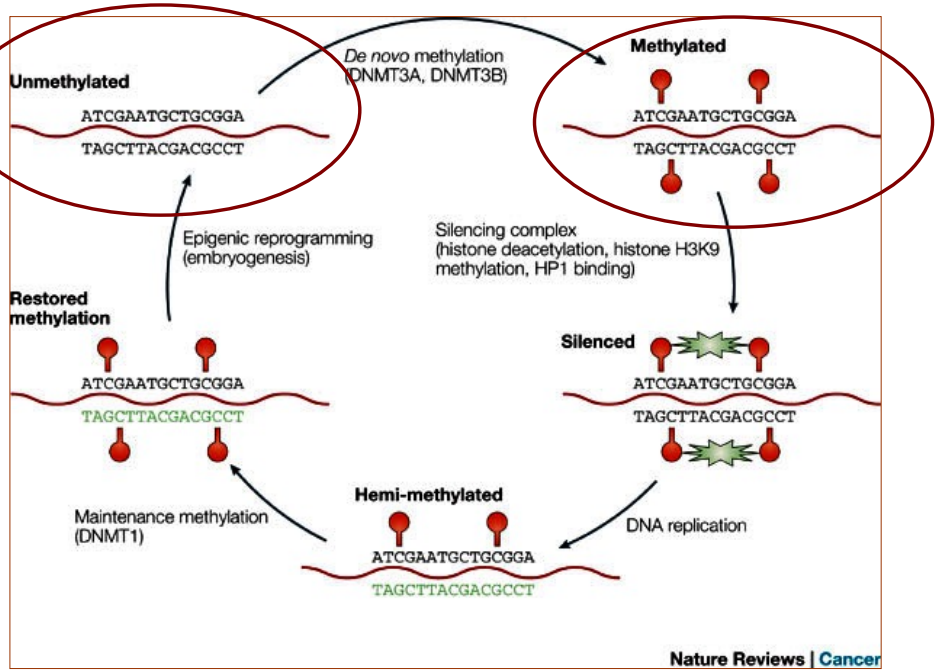


Adapted from Taylor, 2006

DNA methylation reduces the binding affinity of sequence–specific transcription factors

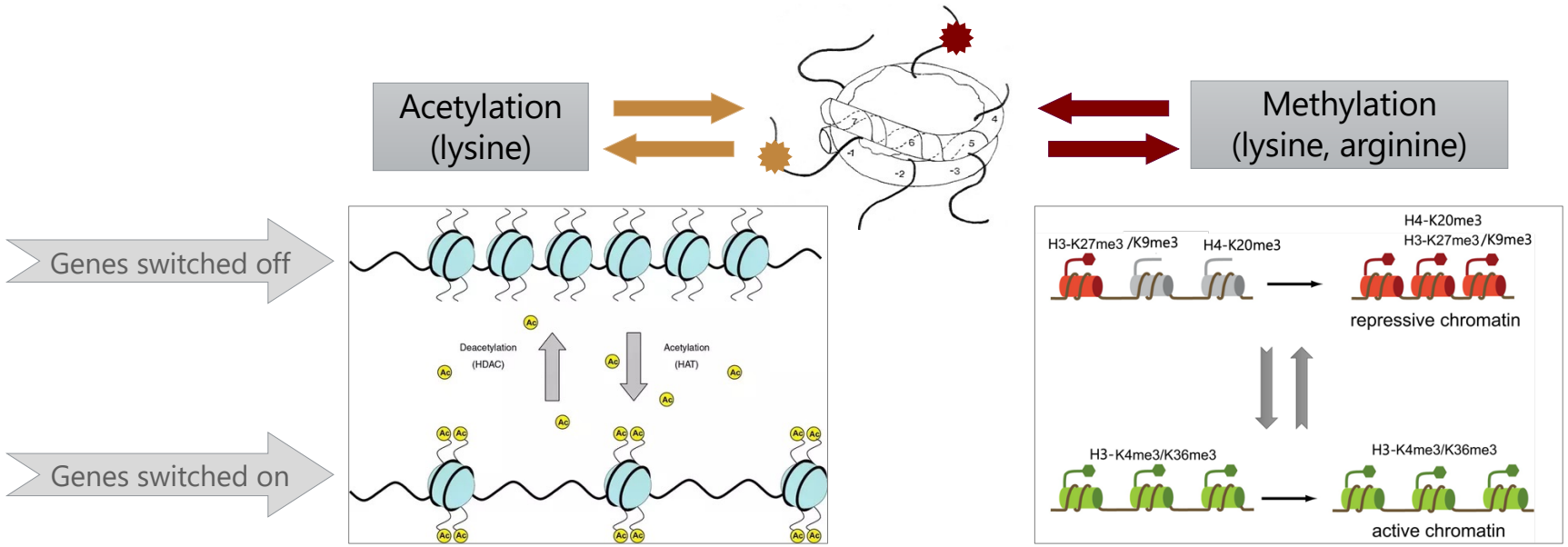


DNA methylation is a dynamic process. Methylation can be imposed and removed in different genes according to the need of the cell



Issa, 2004

Histone tails can be modified after translation. They can be methylated at lysines and arginines, acetylated at lysines and phosphorylated at serines. These marks are dynamic, can be imposed and removed



Epigenetic marks affect chromatin (DNA + Histones) structure

Open **Euchromatin** = active = transcription possible or

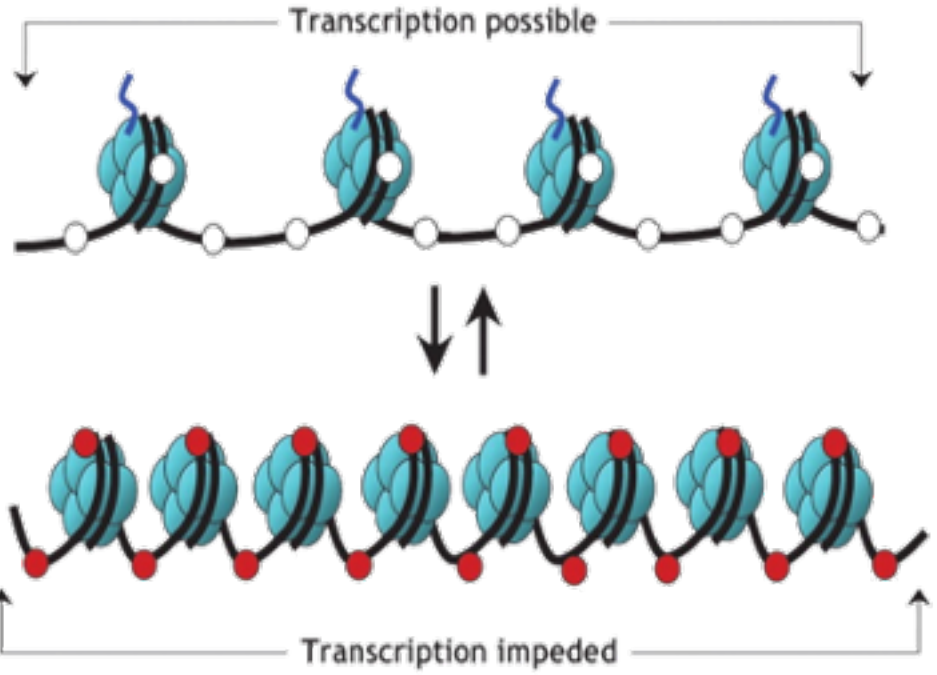
Condensed **Heterochromatin** = silenced = transcription impeded

Genes **switched on**

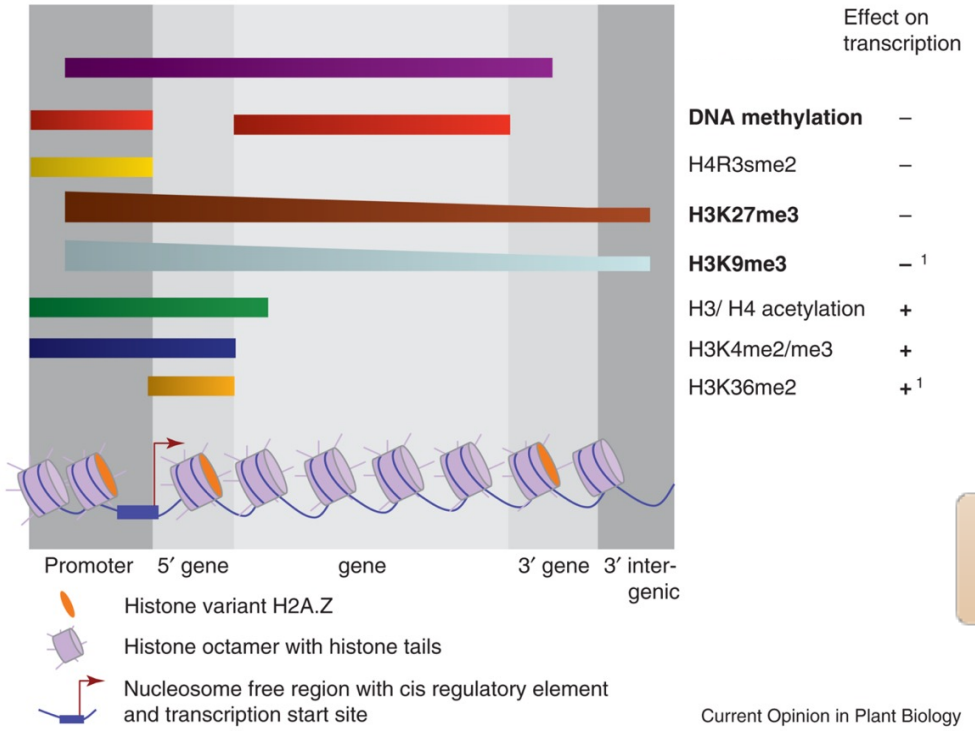
- ✓ Euchromatin
- ○ unmethylated cytosines
- ✓ acetylated histones

Genes **switched off**

- ✓ Heterochromatin
- ✓ methylated cytosines
- ○ deacetylated histones



The epigenetic Code



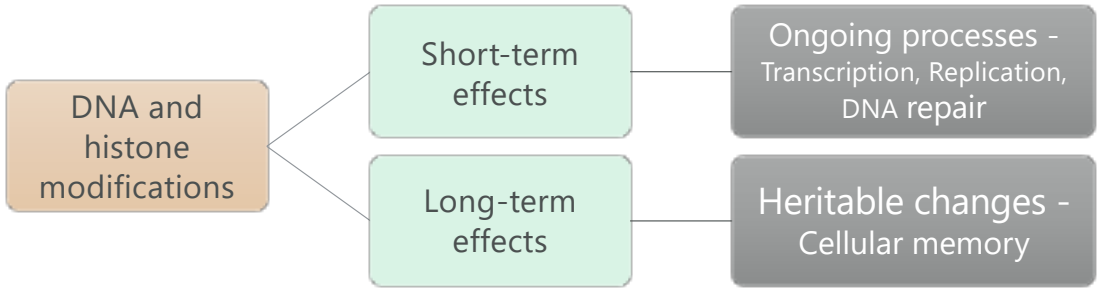
Properties of the epigenetic code

Stable and Heritable: across cell generation

Consistent: associated with a defined chromatin behaviour

Predictive: a particular mark predicts a specific chromatin behaviour

Epigenetic modifications can have short or long-term effets



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In summary:

Epigenetics is the changing of phenotype without changing the genotype. These changes are caused by internal or developmental factors and by external or environmental features. These factors can alter which genes are switched on and which are switched off, thereby changing the phenotype. Sometimes these changes are heritable.

DNA is just a “sleeping beauty” coding molecule, that can be awaken by epigenetic processes. These processes allows the interpretation of the messages encoded in the DNA.


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