

THE GENE ENVIRONMENT CONTROVERSY

Lecture 7

GENETIC INFLUENCES AND ENVIRONMENTAL FACTORS

- Throughout your studies of psychology, you will find that individuals have many differing features, from personality, intelligence, and so on and so forth. What accounts for these differences?
- The nature versus nurture debate has existed for many years, but we now think of these questions in terms of the extent to which our behaviour is shaped and modified by the relative contributions of both genetic influences and environmental factors.

GENES AND ENVIRONMENT

GENES

- Genetics
- Pre natal
- DNA
- Heritability
- Predisposition

ENVIRONMENT

- Pre natal
- Post natal
- People
- Family
- Peers
- Experience
- Circumstances

CECI & WILLIAMS(1999)

- All responsible researchers now acknowledge that human traits are determined by a combination of genes and environmental factors, although often the relative contribution of each can be hotly debated.
- For example – how much of human intelligence is determined by genes?
- To what extent is our temperament determined by heritable factors?
- Researchers also agree that the argument must consider the role of the developing foetus, the impact of nutrition and the combination of learning and experience.

GENE ENVIRONMENT INTERACTION - PLOMIN (1994)

- Genes can influence our behaviour in three ways:
- 1. Passive gene environment interaction- one example is children passively inheriting a particular environmental trait which correlates with their genetic tendencies. I.e intelligent parents providing a stimulating environment for their children.
- 2. Reactive gene environment interaction – genetics create a micro environment where aggressive behaviours provoke an aggressive response.
- 3. Active gene environment interaction – niche picking: a child constructs experiences consistent with their genetic tendencies. E.g. a child with a high need for cognition will actively ask questions and seek answers.
- Children picking environments to suit their genes. As age increases, so does genetic influences and environmental influences less so.

EXAMPLES: GENES AND INTELLIGENCE

- Twin and adoption studies
- Chorney (1998)
- Bouchard & Megue (1981)
- Mun Singer (1975)
- BUT...
- Many issues with these findings, sampling problems, similar appearances, similar placements, SES and the Flynn Effect (Turkheimer, 2003).

EXAMPLES - PSYCHOPATHOLOGY

- SCHIZOPHRENIA
- Kendler, Masterson & Davis (1985) – families of sufferers 18 times more likely to receive a diagnosis
- Gottesman (1991) 48% concordance in MZ
- 17% concordance in DZ

EXAMPLES - PSYCHOPATHOLOGY

- DEPRESSION
- Katz & McGuffin (1993) genetics responsible for 52% of variation in MDD and 80% in BDD
- Oruc et al., (1998) first degree relatives are two to three times more likely to develop the disorder
- McGuffin et al., (1996) 200 pairs of twins. If one has depression the other has 40% chance of developing it in MZ twins compared to 20% in DZ pairs.

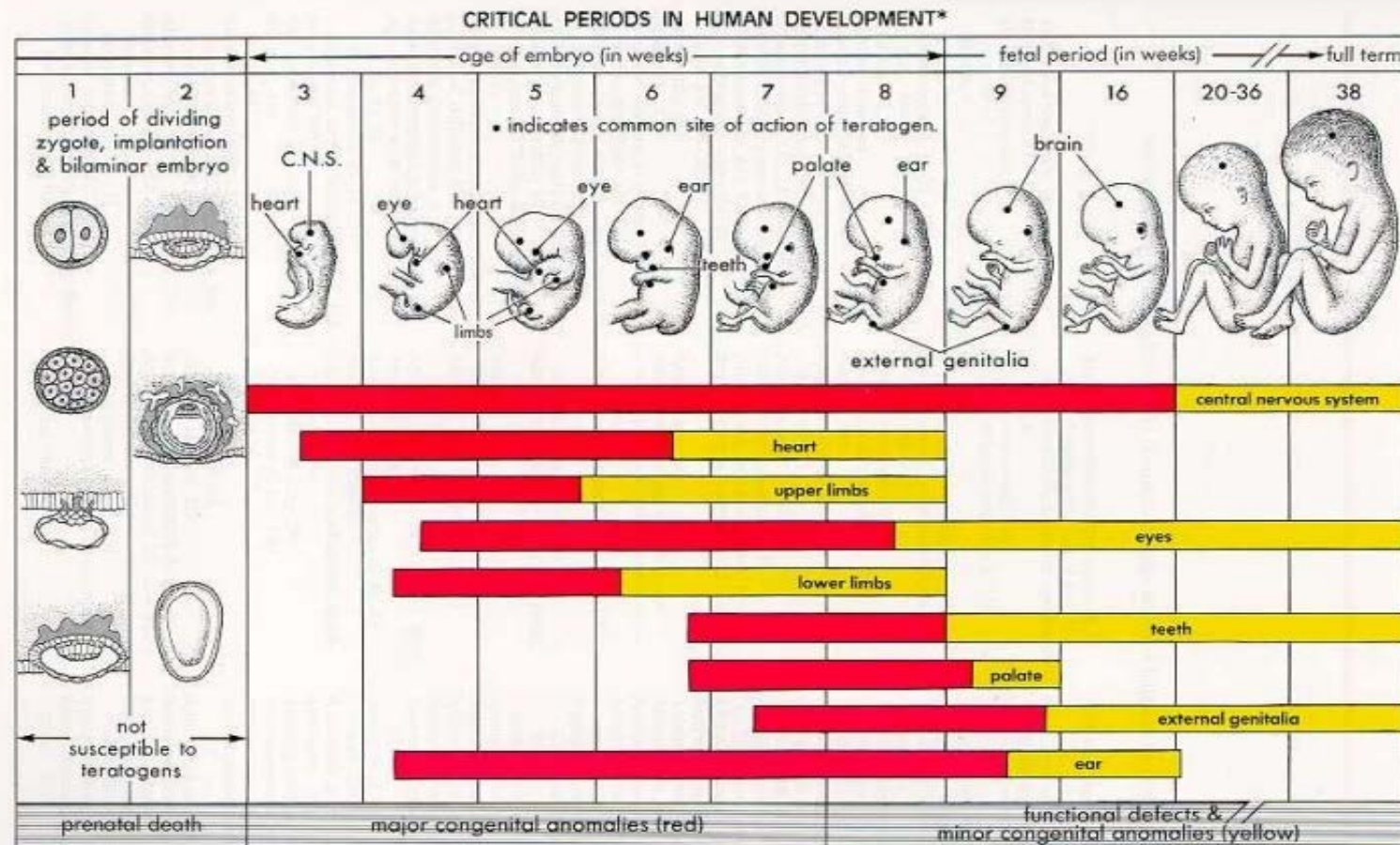
OTHER CONSIDERATIONS

- Diathesis stress is a popular concept within modern psychological explanations of many behaviours.
- One illustration comes in the example of PKU- phenylketonuria the inherited disorder that prevents amino acid metabolism resulting in brain damage. However, if detected before birth, a special diet can completely prevent this from occurring.
- Other such examples come from aggression amongst others. Diathesis stress does not ignore biology, but rather that our make up creates a potential whilst our expression of that potential is learned.

NEURAL PLASTICITY

- The amazing ability of the brain to modify and adapt according to our experience.
- Some examples include Blakemore & Coopers' kittens, Maguire (2000) studies of London Taxi drivers and Pascual-Leone (1995) research on repetitive piano finger playing.
- What do these findings imply?
- <https://www.youtube.com/watch?v=dmEOJyWVQj4>

CRITICAL PERIODS



* Red indicates highly sensitive periods when teratogens may induce major anomalies.

WHAT ARE CRITICAL OR SENSITIVE PERIODS?

- What is the critical period? Also known as the sensitive period, the critical period is a time during early postnatal life when the development and maturation of functional properties of the brain, its 'plasticity', is strongly dependent on experience or environmental influences.
- The concept of a critical period therefore plays an important role in the age-old nature versus nurture debate — to what extent are our abilities determined by intrinsic factors, such as our genes, or by extrinsic factors, such as childhood experiences?
- To be precise, there isn't a single critical period, but there are different critical periods for different brain functions, for example binocular vision or language acquisition.

LANGUAGE ACQUISITION

- There is a strong biological basis for language acquisition exists. In 1967, Eric Lenneberg first proposed the notion of a critical period for language acquisition.
- He suggested that the period between infancy and puberty (the beginning of adolescence) was a critical period for language acquisition. This critical period was thought to end at puberty because of important maturational changes in the brain that occur at this time.
- Language must be acquired during the critical period if it is to be acquired at all.
- Alternatively, if the period from infancy to puberty is viewed as a sensitive period, rather than a critical period, language will be learned most easily during this period. After the sensitive period, language can be learned, but with greater difficulty and less efficiency.
- Example: Genie – the wild child (in next seminar session)

FINALLY, EPIGENETICS

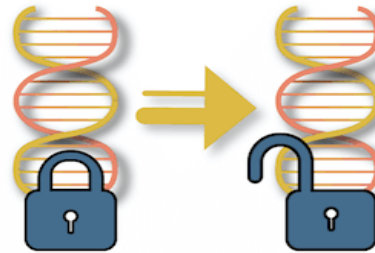
- An exciting and fascinating area of research to contribute to the understanding of human behaviour, epigenetics explores how the environment affects our genes, particularly the material in the cell bodies responsible for switching the expression of the gene off or on.
- Of greatest interest may be the fact that it has the potential to be passed onto the behaviour of future generations.
- Wondering why identical twins aren't actually, well, identical? Epigenetics!
- Want to blame your parents for something that doesn't seem to be genetic? Epigenetics!
- Got a weird result from an experiment that doesn't seem to make sense? Epigenetics!
- Want to think yourself healthy? That's not epigenetics! (Sorry 'bout that).

EPIGENETICS

WHAT IS EPIGENETICS?

AND HOW DOES IT RELATE TO CHILD DEVELOPMENT?

“Epigenetics” is an emerging area of scientific research that shows how environmental influences—children’s experiences—actually affect the expression of their genes.



This means the old idea that genes are “set in stone” has been disproven. Nature vs. Nurture is no longer a debate. It’s nearly always both!

During development, the DNA that makes up our genes accumulates chemical marks that determine how much or little of the genes is expressed. This collection of chemical marks is known as the “epigenome.” The different experiences children have rearrange those chemical marks. This explains why genetically identical twins can exhibit different behaviors, skills, health, and achievement.



HOW DO EPIGENETICS WORK?

- Epigenetics is the study of characteristics or “phenotypes” that do not involve changes to the DNA sequence, for example - how starvation in human populations may affect the health and longevity of the next generation.
- Traditional genetics describes the way the DNA sequences in our genes are passed from one generation to the next, epigenetics describes passing on the way the genes are used.
- Take this analogy: If you own an MP3 player, it will contain a lot of data, the MP3 files. Think of these as analogous to genes. But you will also probably have playlists or you may play tracks by artist or genre. This information, playlist, artist, genre etc. is metadata. It determines which tracks are played and in what order, and this is what epigenetics is to genetics. It is a set of processes that effects which genes are switched-on, or “expressed”, as molecular biologists would say.

HOW IT WORKS

- Epigenetics is essentially additional information layered on top of the sequence of letters (strings of molecules called A, C, G, and T) that makes up DNA.
- Epigenetics is about how genes are expressed and used, rather than the DNA sequence of the genes themselves.
- Many researchers have been studying epigenetics and it is an area of intense research activity. We know that a part of how epigenetics works is by adding and removing small chemical tags to DNA.
- You can think of these tags as post-it notes that highlight particular genes with information about whether they should be switched on or off. In fact the chemical tag is called a methyl group and it is used to modify one of the four bases or “chemical letters”, A, C, T and G, that makes up the genetic code of our DNA.

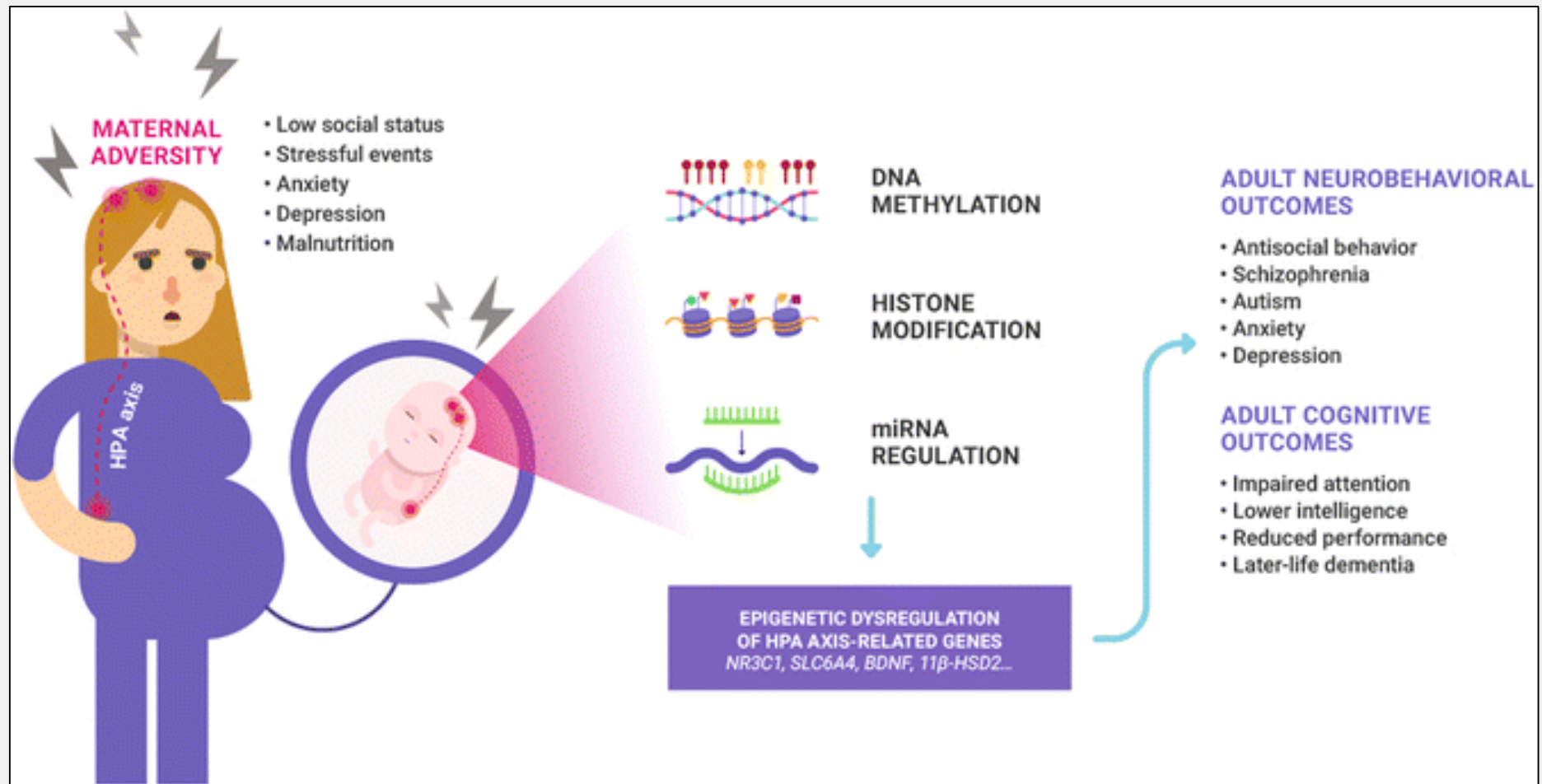
AN EXAMPLE: DUTCH HUNGER WINTER

- In the last year of the Second World War in Europe, a food embargo imposed by occupying German forces on the civilian population of the Netherlands resulted in a severe famine, coinciding with a particularly harsh winter. About 20,000 people died from starvation as rations dropped to below 1000 kilocalories per day.
- Medical care and records remained intact allowing scientists to subsequently study the effects of famine.
- They found that children who were in the womb during the famine experienced a life-long increase in their chances of developing various health problems compared to children conceived after the famine.
- The most sensitive period for this effect was the first few months of pregnancy. Thus, something appears to have happened early in development within the womb that could affect the individual for the rest of their lives.

EPIGENETICS AND GRANDCHILDREN

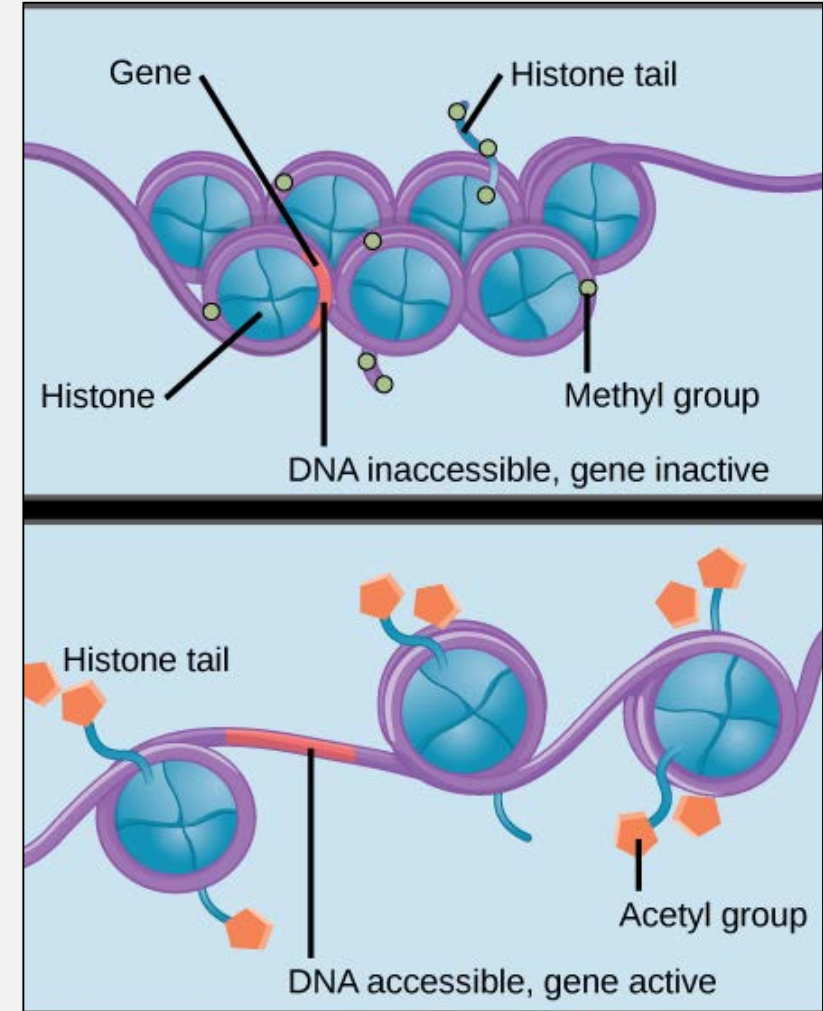
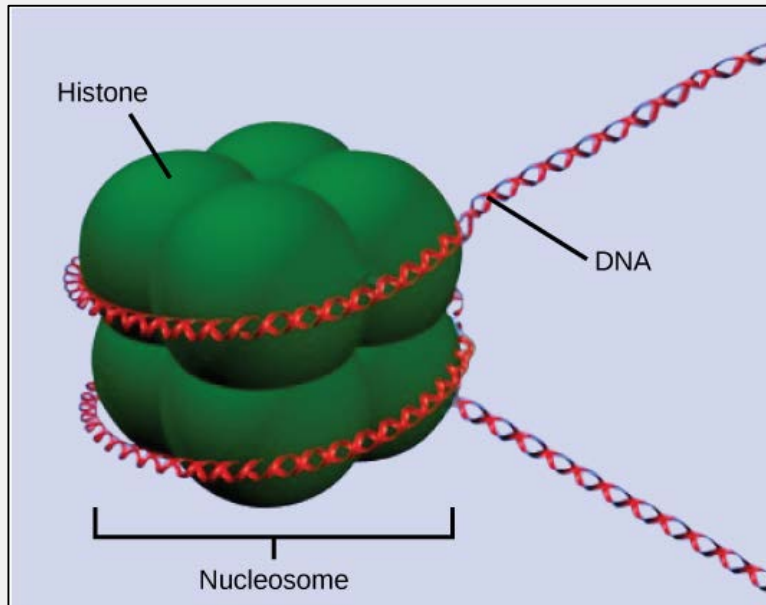
- The grandchildren of women who were pregnant during the Hunger Winter experience some of these effects, which strongly suggests an epigenetic mechanism.
- Research with the Dutch Hunger Winter families continues, and a recent study looking at a gene called IGF2 found lower levels of the methyl tag in the DNA of this gene in individuals exposed to the famine before birth.
- Although IGF2 may not itself be involved in the increased risk of poor health, it shows that epigenetic effects (i.e. reduction of the number of methyl tags on particular genes) that are produced before birth can last for many decades.
- Studies in animals have also found that the diet of the mother can have effects on her offspring. For example, feeding sheep a diet lacking the types of food required to make methyl groups leads to offspring with altered patterns of DNA methylation and which have higher than expected rates of certain health problems.

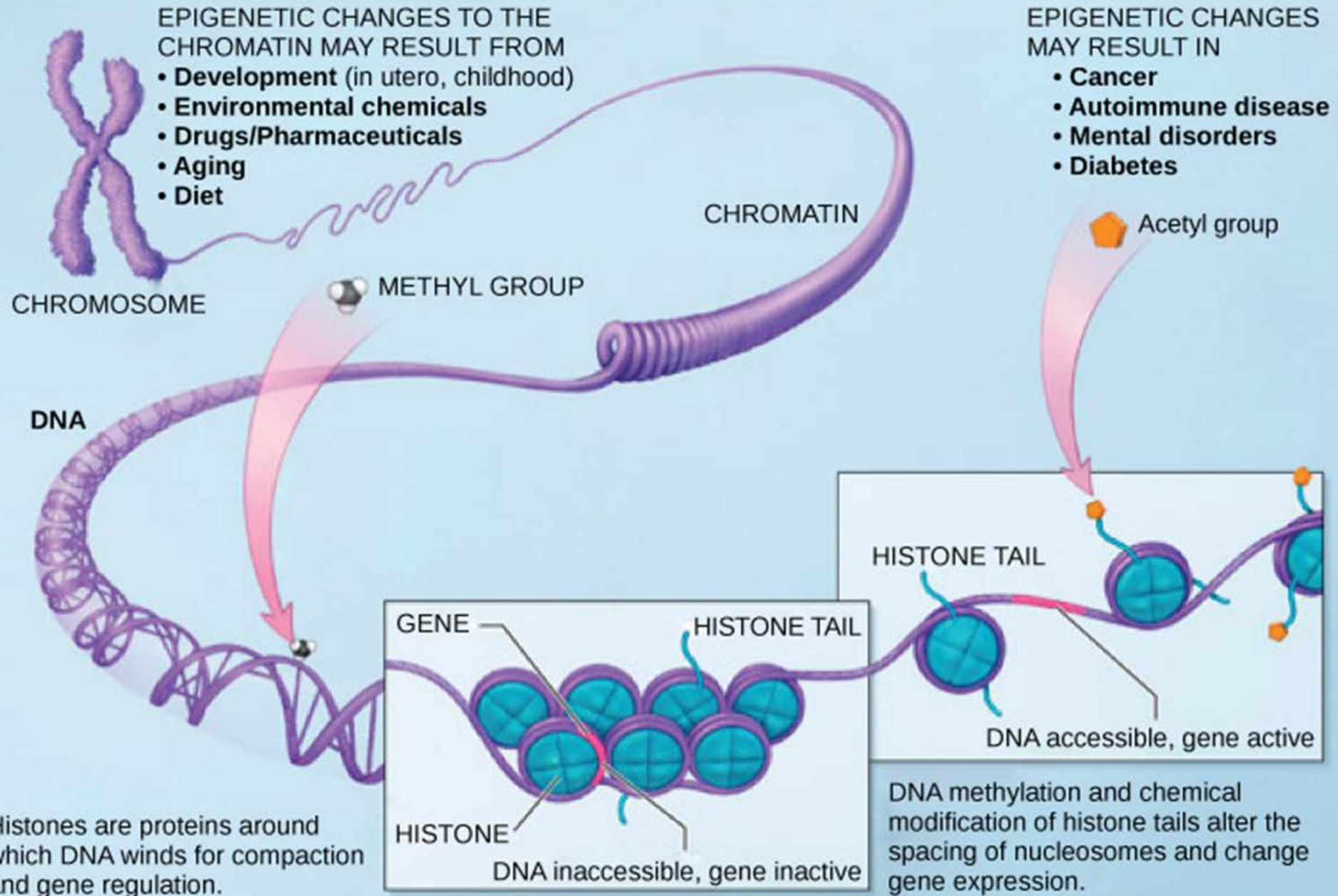
EARLY ADVERSITY AND LIFE LONG OUTCOMES



EXPLAINED:

- DNA methylation: the addition of methyl to DNA which alters the function of DNA
- Histone modification: the process by which the proteins (histones) that support the structure of chromosomes are regulated during development
- miRNA regulation: the nucleotide molecules that regulate gene expression





EPIGENETICS AND IMPRINTING, WHY GENES FROM MUM AND DAD ARE NOT ALWAYS EQUIVALENT

- We all have 23 pairs of chromosomes in our cells. For each pair, one comes from mother and one from father. Thus, we inherit one copy of each gene from each parent and we assume that the function of the gene does not depend on which parent it came from.
- However, for imprinted genes things are different. For these genes, either the maternal or paternal copy of the gene is active, while the other one is silent. There are at least 80 imprinted genes in humans, many of which are involved in growth of the embryo or the placenta.
- How can one copy of a gene be switched off, while the other copy in the same cell is switched on? The answer is epigenetics.
- Probably the most studied imprinted gene is IGF2. One part of IGF2 operates as a switch. If the DNA is methylated here the IGF2 gene can be expressed. If the switch is only methylated in Dad's copy of the gene only this copy is expressed, the maternal copy is silent. This switch is set up in the eggs and sperm, so right from the beginning, genes received from Mum and those from Dad are labelled differently with epigenetic tags and so are not equivalent.

BOYS VERSUS GIRLS

- At the beginning of our existence each of us receive one X chromosome from our Mum via the egg, and while the girls received another X chromosome from their dads sperm, the boys get a Y chromosome.
- The Y chromosome in the cells of a male embryo directs it to develop into a boy, while with two X and no Y chromosome the female embryo develops into a girl. Hence there is an imbalance. We all have two each of all the other chromosomes, but for the sex chromosomes (X and Y) the girls have two X's while the boys only have one X and a Y.
- The Y chromosome contains few genes, mostly involved in “maleness”, the X chromosome contains quite a few genes involved in important processes such as colour vision, blood clotting and muscle function. In order to even up the “dosage” of X chromosome genes between male and female cells, one entire X chromosome is switched off in female cells.
- This is called X-chromosome inactivation and happens very early in the womb. In this process cells randomly switch off either the paternal or maternal X chromosome, so that when a girl baby is born her body is a mixture of cells where either the maternal or paternal X-chromosome is switched off. The way that this happens involves the type of epigenetic tags that we have discussed.

SO... WHAT DOES THIS ALL MEAN FOR HUMAN BEHAVIOUR?

- We are more than the sum of our genes.
- Epigenetic mechanisms modulated by environmental cues such as diet, disease or our lifestyle take a major role in regulating the DNA by switching genes on and off.
- It has been long debated if epigenetic modifications accumulated throughout the entire life can cross the border of generations and be inherited to children or even grand children.
- Now researchers show robust evidence that not only the inherited DNA itself but also the inherited epigenetic instructions contribute in regulating gene expression in the offspring.