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DNA: Nature's Secret Code
Exploring the Fascinating World of Epigenetics: How Environment and Experience Shape Our Genes

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Wordcount: 1319

What if listening to your favourite song on repeat could unlock nature's secret code? Epigenetics shows that listening to music can alter your gene expression ***(Chakravarthi Kanduri et al., 2015).*** Epigenetics is an emerging area of scientific research that considers how environmental influences and children's experiences can influence gene expression. Epigenetics doesn't change your DNA; it decides how much or whether some genes are expressed in different cells of your body ***(What is Epigenetics? The Answer to the Nature vs. Nurture Debate, 2024)***. Everyone experiences epigenetics throughout their lives because their epigenomes, known as the chemical compounds that mark the genetic material, change based on their body status and environmental factors ***(Epigenetics & Inheritance, 2018).*** The key features that link to epigenetics, such as DNA, how epigenetics works, and its impact on society, will be analysed throughout this essay.

To begin, let us examine the fundamentals. DNA, which stands for Deoxyribonucleic Acid, is an essential molecule for life. DNA is found in every cell of our body except for red blood cells ***(Does every cell in our body contain DNA? - Centre of the Cell, 2025)***. It contains the instructions for a human being, telling the body how to grow, repair, and develop. The structure of DNA consists of a ladder-like structure that is twisted; this is called a double helix. One side of the double helix is made of nucleotides, which are made up of sugar, phosphate, and one of the four nitrogen-rich bases, Adenine (A), Guanine (G), Cytosine (C), and Thymine (T). These bases are paired together with a certain other to create the other side of the double helix. This is called "complementary base pairings", meaning that A pairs with T and C pairs with G. Holding all these sections is a sugar-phosphate backbone and hydrogen bonds ***('Biology for Kids: DNA and Genes', 2025).*** A sector of DNA contains a gene. These genes are like codes on DNA that create proteins through an intricate process that consists of two major steps: transcription and translation. Together, transcription and translation are known as gene expression. The gene expression determines which traits are passed down from a mother and father to their child because certain expressions may be turned "on" or "off". Each cell expresses, or in this instance, "turns on", only a fraction of its genes at a given time, leaving the remaining genes "turned off". This process is called gene regulation. Gene regulation is good for normal development, so that when cells turn off or on with a pattern, it helps to make a brain cell look and act differently from a liver cell or a muscle cell **(*MedlinePlus Genetics* 2021).** This links to epigenetics because some environmental factors can also determine which genes are turned off or on.

Epigenetics was discovered by embryologist Conrad Waddington in 1942 ***(Deichmann 2016).*** Waddington demonstrated the term when he studied fruit flies and how their environment affected their development, proving that environmental factors can change how genes are used and that these changes can be passed down to the next generation ***(Noble 2015).*** Unlike mutations (genetic changes), epigenetic changes are reversible and do not change the sequence of the DNA bases, but they can change the way that the body's DNA is read ***(CDC 2025).***

DNA methylation and histone modification are used to further explain the concept of epigenetics and how it functions. Histone modification is when tiny chemical changes are added to histone proteins. A histone protein provides structural support for the chromosome. These changes can make genes more or less active and determine how cells grow, develop, and react to the environment. It helps certain genes turn on or off so that the cell can use the genetic code in efficient ways. This process is important for things like learning, healing, and even how our bodies fight germs ***(Molina-Serrano et al. 2019).*** DNA methylation is the main way that gene activity is adjusted, especially during early development. It not only determines whether a cell will become a heart cell or a bone cell, but also regulates the amount of protein it produces. This affects how the body develops and functions, even the way we behave. Our surroundings, including our living environments and the people that we interact with, can influence the methylation of the DNA. This means that certain proteins are made due to the production of that DNA ***(Meijer et al. 2021)***.

A key surrounding that affects DNA methylation is smoking. Scientists have conducted a study on multiple sets of identical twins due to their very similar DNA. The experiment observed how smoking can affect gene expression. Although both twins share the same genetic code, their lifestyles and environmental exposures, such as smoking, diet, and stress, lead to different gene expressions over time. Smoking has been linked to increased stress, collagen breakdown, and changes in gene expression, leading to premature aging. If we examine Figure 1, it is obvious that the twin on the right was the smoker. She was exposed to premature aging, wrinkles, droopy skin, jowls, and even eye bags. The remaining twin appears significantly younger. This is not a matter of inherited genes; rather how the twins' environments have affected how their body grows, repair, and develop ***(Meijer et al. 2021)***. What is the reason for this? Well, smoking can impact gene expression by causing changes in the way that genes are turned off or on. Chemicals in tobacco smoke can lead to changes in the DNA or proteins, like histones, for example, that help organise DNA. These changes can make certain genes more active when they shouldn't be and can also turn off important protective genes. This leads to many diseases, such as cancer or lung disease. These changes can affect DNA's job, which is to help the body grow and repair. Therefore, this results in long-term damage, "messing with" the normal controls that keep the body healthy ***(Silvana et al. 2020).***

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Figure 1:
(NBCNews.com 2009)

Understanding histone modification and DNA methylation can have a huge impact on our future in several ways. By understanding how these processes affect gene expression, doctors can tailor treatment to support the individual's genetic and epigenetic profile. Therefore, this results in more effective treatments for diseases like cancer, diabetes, and neurological disorders. Knowing that environmental factors (like smoking, diet, or stress) influence these processes, strategies can be developed to prevent diseases such as lung cancer. Overall, the research into histone modification and DNA methylation can help develop more strategies for a strategic industry to help support diseases or illnesses developed by epigenetics ***(CDC, 2025)***.

Epigenetics is an emerging field of research that focuses on how each of our unique life experiences can change how our very own secret code is expressed. Epigenetics, in contrast to genetic modifications, does not modify DNA itself; rather, it controls how much of which particular genes are expressed in different bodily cells. Throughout our lives, every individual experiences epigenetics due to our genomes, which are chemical marks on genetic material, which are influenced by factors such as our body status, but most of all the environment ***(What is Epigenetics? The Answer to the Nature vs. Nurture Debate, 2024)***. Research into epigenetics is fascinating as it offers potential avenues for understanding and treating certain diseases. It supports those individuals who have been negatively impacted by their environmental factors, by creating reversibility and high therapeutic potential ***(Epigenetics: rapidly-evolving areas of research, 2022).***

Epigenetics reveals the fascinating connection between our environment, experiences, and the way our genes are expressed, showing how dynamic and adaptable our biology can be. As we uncover more about this secret code, one thing becomes clear: our environment doesn't just affect us – it speaks directly to our DNA, so if DNA is the script we're born with, could epigenetics be the pen that lets us edit the story?

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