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PARENTAL "SUPERPOWERS": HOW CAREGIVING CAN SHAPE KIDS' DNA

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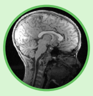
YOUNG REVIEWERS:

HENRY
AGE: 13



JANE
AGE: 13

JINYI
AGE: 9

Every day, parents take care of children and by doing so they promote their children's emotional wellbeing and the way their brains work. Are you curious about how such parenting "superpowers" work? It turns out that tiny chemical tags on people's DNA, known as epigenetic markers, play a big role. These markers act like switches, turning genes on or off, and they can be influenced by people's experiences. In this article, we focus on the effects of parents' nurturing behavior on kids' epigenetic markers, which can pass messages from the environment (the parenting kids receive) to kids' genes, influencing gene function. Understanding how these markers work can help people understand why they feel certain emotions and behave in specific ways. Through this article, we aim to inspire curiosity and understanding in young minds about the fascinating interplay between experiences, genes, and emotions.

WELCOME TO THE GENETIC ORCHESTRA

Welcome to the fascinating realm of **DNA** (*aka* Deoxyribonucleic acid), the small molecule in each of our cells where the secrets of life are encoded. How did scientists unravel the mysteries of this extraordinary molecule? Let us journey back to the mid-20th century when a team of brilliant minds (James Watson, Francis Crick, Rosalind Franklin, and many others) unlocked the enigma of DNA. Their groundbreaking discoveries have revealed the true nature of DNA, not like any molecule, but as the very essence of existence.

DNA contains vital information on how each part of our bodies should work. Every specific piece of information is contained in portions of the DNA called **genes**. Genes are made of a series of smaller units called nucleotides. There are four unique nucleotides: adenine (A), thymine (T), cytosine (C) and guanine (G), which are ordered in unique sequences in every gene. Each gene can be used as instructions to prepare one of the many **proteins** that the body uses for most of its functions. The cellular process of turning genes into proteins is called **gene expression**. If you like music, you can think of the nucleotides as the notes on the staff. Similar to how sequences of nucleotides make up different genes, musical notes can be combined to create different melodies. Thus, DNA is like a collection of different melodies that can be played together like an orchestra score, creating a functioning human body.

Although all cells contain the same DNA, not all genes need to be "turned on" in every cell all of the time. Differences in gene expression are what give cells their unique functions. Genes can be used to create proteins or left unused. This can be thought of like a musical score that is played in different ways by the orchestra, silencing or highlighting various melodies. Interestingly, science has revealed that things in the world around us can impact our DNA, turning genes on or off.

REGULATING THE "MUSICAL SCORE" OF DNA

So, if DNA is not just a static musical score, how can it be "played" in different ways? Gene expression can be influenced by chemical changes to the DNA called **epigenetic** mechanisms [1]. But how does it work? Epigenetic mechanisms can change the structure of DNA, turning genes on or off, like a switch. For example, adding a small group of carbon and hydrogen molecules (called a methyl group) to the DNA changes the shape of the molecule and basically "blocks" nearby genes from being turned into proteins. So, depending on their placement, methyl groups and other **epigenetic markers** can cause some genes to be more expressed, producing more proteins, and others to be less expressed, producing less proteins (Read more on epigenetics here). Epigenetic mechanisms are like the conductor of

DNA

A molecule in most cells that contains instructions for building the body and keeping it functioning.

GENES

Sections of DNA that are each responsible for a specific characteristic or function.

PROTEINS

Molecules produced from genes, which are used by the body for many purposes, including building tissues, sending signals, speeding up reactions, and defending against illnesses.

GENE EXPRESSION

The cellular process of turning genes into proteins.

EPIGENETICS

The study of changes in gene activity that do not change the DNA sequence but are caused by chemical markers, affecting how genes are turned on or off.

EPIGENETIC MARKERS

Molecules linked to DNA that can cause some genes to be more or less expressed.

the orchestra, telling each instrument when and how to play its melody and transforming the musical score into a dynamic symphony.

Here is the really interesting part: while our DNA remains the same throughout our lives, the genes that are expressed can vary based on things in our surrounding physical and social worlds. The information that comes from our environments (for example, how our parents take care of us) and other experiences we have can leave their mark on our "genetic melody", shaping who we are and who we will become. It is through the interplay between genetics and epigenetics what makes each one of us unique.

WHAT MAKES A GOOD RAT MAMA?

Our work started with a question that might sound rather strange at first: What makes a good rat mama? In the enchanting world of rats, rat mothers use special behaviors when then take care of their offspring. Imagine a rat mama gently licking her young ones, grooming them with tender care, and arching her back to nurse them affectionately—a set of caregiving behaviors called licking, grooming and arched-back nursing (LG-ABN). These behaviors weave a cocoon of love and warmth around the babies.

About 30 years ago, Canadian scientists embarked on an adventure to understand the power of rat mamas' behaviors [2]. Specifically, they wondered whether the way a rat mama takes care of her babies could leave a special mark on the pups' DNA. To study this, they observed rat mamas that showed different levels of LG-ABN behaviors. Some mothers were very loving, showering their babies with lots of care. Others were a bit more reserved, giving their babies less attention.

They discovered that the pups of the very loving rat mamas, who received lots of care and affectionate touch, had a specific set of epigenetic markers on their DNA. In particular, genes related to stress management had epigenetic markers that helped them produce more proteins. In rats whose mothers were more reserved, these same genes had epigenetic markers that led to the production of less of those proteins (Figure 1). This finding indicates that rats who had caring mothers may have an easier time dealing with any stressful situations they experience in their own lives, while rats raised by reserved mothers may have more trouble coping with or recovering from stress. Overall, these results showed that the way a rat mama takes care of her little ones can leave a lasting impression on their DNA. It is as if her love and tenderness sculpted the way her babies could respond to stressful situations and manage the ups and downs of life. But does this also apply to humans?

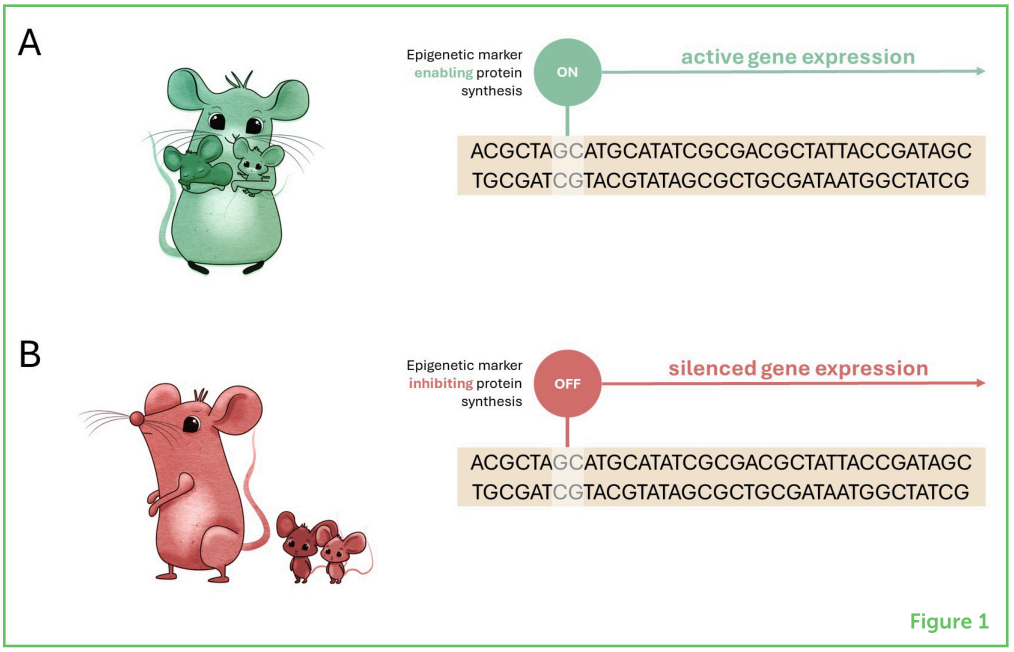


Figure 1

Variations in caregiving behaviors in rats can change the epigenetic markers in their offsprings' DNA. **(A)** The genes of pups raised by mothers who display nurturing caregiving behaviors can be expressed and produce proteins. **(B)** In pups raised by mothers who display less nurturing caregiving behaviors, the same genes may have epigenetic markers that turn the genes off, resulting in less protein production from those genes.

PARENTAL CARE IS AN EPIGENETIC "SUPERPOWER"

Scientists have uncovered a similar connection between caregiving and epigenetics in humans. Imagine a parent's touch, a warm hug, or a gentle caress acting as a protective "shield", nurturing their child's development from the inside out. Just like the loving grooming and nurturing behaviors of rat mamas, human caregiving behaviors, especially **social touch**, leave a lasting imprint on a child's DNA [3]. When parents shower their children with love, affection, and care, they induce a cascade of epigenetic changes activating the expression of protective genes. As in rats, some of the proteins made from these activated genes improve the way the body responds to stressful situations. Thus, parental care can result in an epigenetic "shield" that can protect children from the storms of life, helping them to navigate any rough times they face as they grow up. But the power of parental care does not stop here! Some epigenetic changes caused by caring parents support the development of the child's brain, nurturing their potential and helping them reach for the stars [4].

SOCIAL TOUCH

Physical contact between individuals that has an affectionate and nurturing meaning.

Such parental "superpowers" are even more important when infants face greater challenges, such as babies born earlier than expected who need special care in the hospital before they can go home. In such cases there is an extra ingredient needed: skin-to-skin contact. Studies have shown that the loving embrace called "kangaroo care", in which babies are held skin-to-skin against a parent's chest, can have powerful epigenetic effects, promoting healthy development and enhancing the ability to bounce back from stress [5].

LOVING PARENTS, HEALTHY KIDS

As our journey through the world of epigenetics comes to an end, let us reflect on what we have learned. Like a music score, our DNA holds the information needed for our existence. Epigenetics adds dynamic and adaptable features to this "music". Parents wield a remarkable "superpower": the power of caregiving. Through loving interactions with their children, parents can help their kids successfully navigate and recover from challenging times in their lives. Tender caregiving behaviors like social touch and skin-to-skin contact allow parents to imprint their children's DNA with the echoes of love and affection. These epigenetic markers can regulate gene expression and activate a "shield" that protects their children from life's storms and empowers them to thrive in the face of adversity. In cities, countries, and cultures around the world, parents have the power to release their full epigenetic potential and to help shape and the development of their infants and children, making each one of us different and special.

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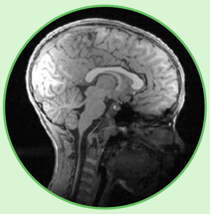
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

HENRY, AGE: 13
I love to draw and write, and I actually made and self-published my own book! I love climbing and reading, also. Some of my favorite book series are "Arc of a Scythe" and "Spy School".



JANE, AGE: 13
I love to learn and work on interesting projects. I enjoy writing fantasy stories, being outside, and spending time with friends. I love working with animals and hope to become a zookeeper one day.

JINYI, AGE: 9
I am Jinyi, and I am nine and a half years old. I love doing crafts, and lately, I have gotten into using AI to make presentations that bring my ideas to life. I hope to make more friends along the way!

AUTHORS

LIVIO PROVENZI
Livio Provenzi is a vanilla nerd, an academic professor of developmental psychobiology at the University of Pavia (Italy) and a researcher with a keen interest in how early interactions between infants and their social and physical environments shape human development. He loves exploring new ways to understand the complexity of child development and is convinced that the secret to child wellbeing lies within caregiver-infant interactions. He feels lucky as his job allows him to travel extensively and explore different cultures... and cuisines. When not conducting

research, he enjoys immersing himself in nerd pop culture and playing the piano. *livio.provenzi@unipv.it

CAMILLA DE SANTIS

Camilla De Santis is a master's student in clinical psychology and cognitive experimental neuroscience at the University of Pavia (Italy). She is looking forward to starting a PhD focused on developmental neuroscience. Her mantra is: "Millions saw an apple fall, but only one wondered why". She believes that this one person is like a small child who wonders about the whys of the world. In the end, scientific research and children have much more in common than you might think.

ELENA CAPELLI

Elena Capelli is a speech-language therapist and psychologist currently pursuing a PhD in developmental neuroscience at the University of Pavia (Italy). Her research passion lies in investigating the underlying neural mechanisms, as well as the social and environmental factors, that shape early communication development in children. She is also fascinated by innovative methods of data analysis and the power that a beautifully crafted graph can have in telling stories from mere numbers.