THE WEEK
http://theweek.com/article/index/238907/epigenetics-how-our-experiences-affect-our-offspring

IN-DEPTH BRIEFING

Epigenetics: How our experiences affect our offspring

New research suggests that people's experiences, not just their genes, can affect the biological legacy of their offspring

PUBLISHED JANUARY 20, 2013, AT 3:50 PM

Isn't our genetic legacy hardwired?
From Mendel and Darwin in the 19th century to Watson and Crick in the 20th, scientists have shown that chromosomes passed from parent to child form a genetic blueprint for development. But in a quiet scientific revolution, researchers have in recent years come to realize that genes aren't a fixed, predetermined program simply passed from one generation to the next. Instead, genes can be turned on and off by experiences and environment. What we eat, how much stress we undergo, and what toxins we're exposed to can all alter the genetic legacy we pass on to our children and even grandchildren. In this new science of "epigenetics," researchers are exploring how nature and nurture combine to cause behavior, traits, and illnesses that genes alone can't explain, ranging from sexual orientation to autism to cancer. "We were all brought up to think the genome was it," said Rockefeller University molecular biologist C. David Allis. "It's really been a watershed in understanding that there is something beyond the genome."

In this new science of "epigenetics," researchers are exploring how nature and nurture combine to cause behavior, traits, and illnesses that genes alone can't explain. *Photo: Randy Faris/Corbis*

What is epigenetics?
The word literally means "on top of genetics," and it's the study of how individual genes can be activated or deactivated by life experiences. Each one of our cells, from skin cells to neurons, contains an identical DNA blueprint, yet they perform vastly different functions. That's because epigenetic "tags" block developing fetal cells from following any genetic instructions that don't pertain to their intended roles. That biochemical process, scientists have discovered, occurs not just during gestation and early development but throughout adulthood, switching genes on or off and altering our mental and physical health.

How does that affect who we are?
We're only beginning to find out. A woman's diet during pregnancy seems to have a major impact on her baby's epigenetic tags. Prenatal diets that are low in folic acid, vitamin B-12, and other nutrients containing "methyl groups" — a set of molecules that can tag genes and cause epigenetic changes — have been linked to an increased risk of asthma and brain and spinal cord defects in children.

Stress, too, can alter fetal epigenetic tags. Pregnant women who were traumatized at the World Trade Center on 9/11 were far more likely than other women to give birth to infants who reacted with unusual levels of fear and stress when faced with loud noises, unfamiliar people, or new foods.

Can changes occur later in life?
Absolutely. Young children who are abused are more likely to have epigenetic changes that make coping with stress more difficult. Twins may inherit a gene that predisposes them to cancer, but only one will develop the disease because diet, toxins, or smoking turn on that gene, while the other has different habits and goes cancer-free. "We're not completely at the mercy of our genes," writes health journalist Alice G. Walton. "In many ways, they are at the mercy of our health and lifestyle decisions and habits."

Are epigenetic changes hereditary?
To the consternation of strict Darwinists, they can be. Researchers used to think that when a sperm and egg combined, all their epigenetic tags were erased, leaving the resulting embryo with a clean slate. Now they know that about 1 percent of our epigenetic tags escape erasure and pass directly to our offspring — and potentially *their* offspring and beyond. Scientists have discovered, for instance, that a group of children conceived during the Netherlands' desperate wartime famine of 1944–45 tended themselves to have smaller-than-usual offspring. That suggests that what men and women eat and smoke, and what toxins and traumas they're exposed to, can affect their children and even grandchildren. University of Texas zoologist David Crews has done multigenerational studies with rats that led him to speculate that soaring obesity and autism rates could be due to our grandparents' exposure to "the chemical revolution of the 1940s," including the introduction of new plastics, fertilizers, detergents, and pesticides.

Are these insights yielding medical therapies?
Over the past five years, evidence that epigenetics plays a major role in cancer has become "absolutely rock solid," says Robert A. Weinberg, a biologist at the Whitehead Institute in Cambridge, Mass. Andrew Feinberg, director of Johns Hopkins University's Epigenetics Center, thinks it's a factor in autism and diabetes as well. Drugs are in the works aimed at undoing cancerous epigenetic changes. Even eating foods rich in gene-altering methyl groups — such as soybeans, red grapes, and green tea — might protect against disease by silencing detrimental genes. In one famous experiment, researchers fed a methyl-rich diet to pregnant female mice that carried a gene that made them fat, yellow, and prone to cancer and diabetes. Though their offspring carried the same gene, they were born slim, brown, and disease-free. But researchers are still trying to work out how to use this powerful tool to address specific health problems. "Did this change in diet increase cancer risk?" asks McGill University pharmacologist Moshe Szyf. "Did it increase depression? Did it increase dementia or Alzheimer's? We don't know yet, and it will take some time to sort it out."

Darwin vs. Lamarck
Before Darwin laid out the principles of natural selection in *On the Origin of Species*, an 18th-century French naturalist, Jean-Baptiste Lamarck, proposed a very different theory of evolution. Organisms, he thought, could pass on traits they'd acquired over their lifetime. Lamarckism — typified by the (incorrect) idea that giraffes have long necks because they're constantly stretching them to reach high leaves — faced ridicule after Darwinism took hold. At the turn of the 20th century, August Weismann debunked the theory by chopping off the tails of mice to prove that their pups would not inherit their taillessness. But even though "Darwin was 100 percent right" about how creatures evolve, said Swiss bioengineer Renato Paro, epigenetics suggests that the Frenchman may have been on to something after all. "Passing on gained characteristics," he said, "fits more to Lamarck's theory of evolution."