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MATTER

You Are Shaped by the Genes You Inherit. And Maybe by Those You Don't.

By Carl Zimmer

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For centuries, people have drawn the line between nature and nurture.

In the nineteenth century, the English polymath Francis Galton cast nature-versus-nurture in scientific terms. He envisioned a battle between heredity and experience that shapes each of us.

"When nature and nurture compete for supremacy…the former proves the stronger," Galton wrote in 1874.

Today, scientists can do something Galton couldn't imagine: they can track the genes we inherit from our parents. They are gaining clues to how that genetic legacy influences many aspects of our experience, from our risk of developing cancer to our tendency to take up smoking.

But determining exactly how any particular variation in DNA shapes the course of our life is proving far trickier than Galton would have guessed. There is no clean line between nature and nurture: How a particular variant acts, if at all, may depend on your environment.

A study published on Thursday offers a striking new demonstration of this complexity. Genes may help determine how long children stay in school, the researchers found, but some of those genes operate at a distance — by influencing parents. The study was published in Science.

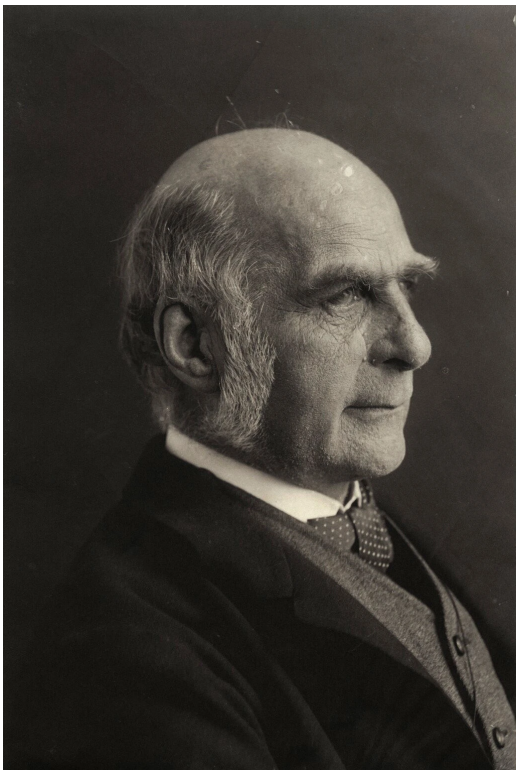
The authors go on coin a new phrase for this effect: "genetic nurture." To scientists accustomed to tracing the links between the genes you carry and the traits they govern, it's a headspinning idea.

A genetic variant may shape you not because it directly influences you, but because it changes those around you, noted Paige Harden, a psychologist at the University of Texas who co-authored a commentary on the new study: "Something is happening outside your

own skin.”

Long before scientists could easily read DNA, there were clues that genes influence how many years people stay in school. Researchers compared identical twins — who have virtually identical DNA — to fraternal twins, and in study after study the educational attainment of identical twins tended to be closer than that of fraternal twins.

The recent revolution in DNA sequencing gave researchers a new way to study the link. In 2016, for example, researchers in England surveyed hundreds of thousands of people and linked 74 different gene variants to how long the participants stayed in school.



Sir Francis Galton
Eveleen Tennant Myers

Some of those variants were in genes active in the developing brain, perhaps influencing relevant traits — everything from how well people learn new words to how motivated they are by long-term goals.

Yet the connection between genes and education remains murky. Each gene variant, on average, accounts for just a few weeks of the total. And when researchers try to estimate how important these variations are in entire populations, they end up with different figures. Some researchers estimate the proportion at 21 percent; others have put it at as high as 40 percent.

Either figure means that a lot of variation cannot be accounted for by genetics. Factors in the environment may explain some of the variation: a family's wealth, for example, or the quality of schools children go to, or their exposure to pollution.

When the first DNA-based studies of educational attainment came out in 2013, a geneticist named Augustine Kong sifted through the results. At the time, Dr. Kong was working at DeCode, a genetics company based in Iceland, and so he was able to look for some of the variants in the company's database of Icelandic DNA.

Dr. Kong wondered if other researchers had missed something very important. "It suddenly occurred to me that part of this effect could be coming through the parents," he said. "And then I got obsessed with the idea."

Children, after all, get their genes from their parents. It was possible, Dr. Kong reasoned, that genes could influence how far children got through school by influencing their parents' behavior rather than the actions of the children themselves.

Dr. Kong was well placed to test that idea. DeCode has genetic records for many of the island's 338,349 residents, including many pairs of parents and children. And among the questions that DeCode had asked its subjects was how many years of school they completed.

In the new study, Dr. Kong and his colleagues used a new method to measure the influence of genes on education. They didn't inspect individual variants to see if each clearly had an impact; instead, they added up the influence of hundreds of thousands of variants in people's DNA, even if they had a very weak influence at best.

The researchers compared 21,637 Icelanders to their parents. The parents, of course, passed down one copy of each of their genes to their children. Some of these might be related to educational attainment, and some not.

But Dr. Kong and his colleagues focused their attention on variants carried by parents but not passed to their children. These variants, the researchers found, predicted how long the children stayed in school — even though the children had not inherited them.

Any single variant in the parents had a minuscule effect on the children's education. But combined, the researchers found, the untransmitted genes had a significant impact. Their combined effect was about 30 percent as big as that of the genes that the children actually inherited.

Animal researchers have amassed a wealth of evidence showing that animals are influenced not just by their own genes but by the genes of their parents.
Brianna Soukup/Portland Press Herald

“The direct genetic effect is quite a bit smaller than what people thought,” said Dr. Kong, who now a professor at the University of Oxford.

How can that be? Dr. Kong speculated that the genes carried by parents influence the environment in which their children grow up. “Variants that have to do with planning with the future could have the biggest effect on nurturing,” he said.

Dr. Harden expected that genetic nurture would turn out to be a very complex phenomenon. “My intuition is that it’s not any one thing, but a constellation of things,” she said.

While Dr. Harden and other researchers on human behavior hailed the study for revealing something new about nature and nurture, researchers who study animals recalled familiar echoes in their own work.

“I am not surprised by the findings,” said Piter Bijma, who studies livestock at Wageningen University in the Netherlands. “These are to be expected.”

Dr. Bijma and other researchers have amassed a wealth of evidence showing that animals are influenced not just by their own genes but by the genes of their parents. Calves may grow quickly thanks to their own growth-promoting genes, or because the same genes in their mothers make them produce more milk.

A calf may inherit those milk-boosting variants from its mother. But just because the calf carries them doesn't mean they directly make the calves bigger.

Compared to other mammals, Dr. Bijma observed, human children are especially dependent on their parents — not just for food and other essentials, but for social development. So it stands to reason that they'd experience similar effects.

"Humans provide substantial care to their offspring, and so the nurture they create is very likely to have a genetic component," said Dr. Bijma.

Dr. Harden said that taking account of genetic nurture could improve research on the effects of poverty on how children do in school, as well as studies of methods to improve educational attainment.

"It's so obvious in retrospect, and so elegant," she said. "A lot of people are going to say, 'I can see my data in a new light with this.'"

Correction: *Jan. 28, 2018*
An earlier version of this article misstated the given name of a geneticist. He is Augustine Kong, not Albert.

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