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## MATTER

### *Years of Education Influenced by Genetic Makeup, Enormous Study Finds*

More than a thousand variations in DNA were involved in how long people stayed in school, but the effect of each gene was weak, and the data did not predict educational attainment for individuals.



By Carl Zimmer

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In the largest genetics study ever published in a scientific journal, an international team of scientists on Monday identified more than a thousand variations in human genes that influence how long people stay in school.

Educational attainment has attracted great interest from researchers in recent years, because it is linked to many other aspects of people's lives, including their income as adults, overall health and even life span.

The newly discovered gene variants account for just a fraction of the differences in education observed between groups of people. Environmental influences, which may include family wealth or parental education, together play a bigger role.

Still, scientists have long known that genetic makeup explains some of the differences in time spent in school. Their hope is that the data can be used to gain a better understanding of what educators must do to keep children in school longer.

With a fuller understanding of the influences exerted by genes, scientists think they will be able to better measure what happens when they try to improve a child's learning environment.

The new study, published in the journal *Nature Genetics*, finds that many of the genetic variations implicated in educational attainment are involved in how neurons communicate in the brain.

A striking number are involved in relaying signals out of neurons and into neighboring ones through connections called synapses.

The findings are based on genetic sequencing of more than 1.1 million people. But the subjects were all white people of European descent. In order to maximize the odds of discovering genetic links, the scientists say they needed a very large, homogeneous sample.

When the team tried to use these genetic variants to explain differences in schooling time among African-Americans, the predictions failed.

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The researchers also found that genes don't have a uniform effect: The influences of the genes varied from country to country. The researchers could not pinpoint the cause of these differences.

But if educators in one country emphasize memory over problem-solving in math classes, for example, then some gene variants may provide a bigger benefit to some students than others, the scientists speculated.

A truly global understanding of these genetic influences will require similarly huge studies of people of other ancestries, the researchers said.

The data cannot be used to predict educational attainment in any particular schoolchild. The researchers cautioned that the genetic patterns are seen only in large groups; in each child, genetics will play only a small role in how long she stays in school.

“It’s not really meaningful for individuals,” said Aysu Okbay, a geneticist at Vrije University in Amsterdam and a co-author of the new study.

The first glimpses of genetic influences on education attainment came in the 1970s. In the era before cheap DNA sequencing, researchers studied families.

Identical twins, who share the same set of genes, tended to have more similar track records in school than did fraternal twins, researchers found. Later studies that compared siblings to half-siblings, or to siblings adopted into different families, also confirmed a modest genetic influence.

In the early 2000s, a few social scientists tried to confirm links between particular genes and schooling, but their efforts largely failed. One of the most important reasons was the small size of their studies.

In 2011, Daniel J. Benjamin, a behavioral economist at the University of Southern California, and his colleagues launched a large-scale expedition into human DNA. They formed the Social Science Genetic Association Consortium to bring together information on thousands of subjects.

The researchers piggybacked their educational research on medical research. When people volunteer for a genetic study on, say, blood pressure, they often fill out questionnaires about various aspects of their lives. One of the most common questions is how much education they’ve had.

By 2016, Dr. Benjamin and his colleagues had studied nearly 300,000 people and had linked 71 gene variants to education. But then two major developments in DNA testing helped the team greatly expand their research.

Recently, a genetic database called UK Biobank was launched in Britain. Some 442,183 of those genetic profiles were added to the consortium’s study. And after 23andMe scientists began sharing information about customers who volunteer to be part of scientific research, the team included 365,538 of those profiles.

Studying the DNA of these people, Dr. Benjamin and his colleagues found a number of genetic variations that were unusually common in people who finished a lot of school, and others that were more common in people who left school early.

Often, the scientists weren’t able to rule out chance as the explanation. But 1,271 of these variants were linked so tightly to schooling that they could not be dismissed.

Still, the association between each gene variant and education was very weak. When the researchers compared groups of people with or without a particular variant, their average time in school differed only by days.

The researchers scanned the DNA surrounding these influential variants and found an intriguing pattern.

“They’re not just randomly scattered around the genome,” said James J. Lee, a behavioral geneticist at the University of Minnesota and co-author of the new study.

The variants are linked to genes active in the brain, helping neurons to form connections. A key to educational attainment may not be how quickly information is acquired, but how quickly it can be shared between various regions.

“Maybe it’s not about how fast a signal can zip along a cable,” Dr. Lee said. “It’s about the complexity of the connections between point A and B.”

But the genetic links suggest another, perhaps stranger possibility: Some variants linked to education work not in the brains of students, but in the people they inherited the variants from — their parents.

By somehow shaping the behavior of parents, these variants may alter the environments in which children grow up in a way that helps or impinges on time spent in school.

Based on their findings, Dr. Benjamin and his colleagues figured out how to calculate a genetic “score” for educational success. The more variants linked to staying in school longer, the higher an individual’s score.

The researchers calculated a score for a group of 4,775 Americans, ranking them into five groups. The researchers found that 12 percent of people in the lowest fifth finished college. Among people in the top fifth, 57 percent finished college.

A similar result emerged when the scientists looked at how many people in each group had to repeat a grade in school. In the lowest fifth, 29 percent did, while in the top fifth, only 8 percent did.

But when Dr. Benjamin and his colleagues calculated scores for African-Americans, it failed to predict how well different groups had done in school. One likely reason is that genetic markers aren’t reliable guides to how genes influence traits in different populations.

Dr. Benjamin and his colleagues hope to grow their study to 2 million people or more, and expect to find thousands more genes linked to education.

He and other researchers plan to carry out other studies on behavior based on gene profiles of one million people or more.

Indeed, the latest study is just the newest in what promises to be a tide of huge genetic studies. Research on insomnia based on 1.3 million people, for example, was posted to an open access website earlier this year. A number of similar studies, each involving over a million people, are moving toward publication.

“It’s all going to happen really fast,” said Dr. Benjamin.

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