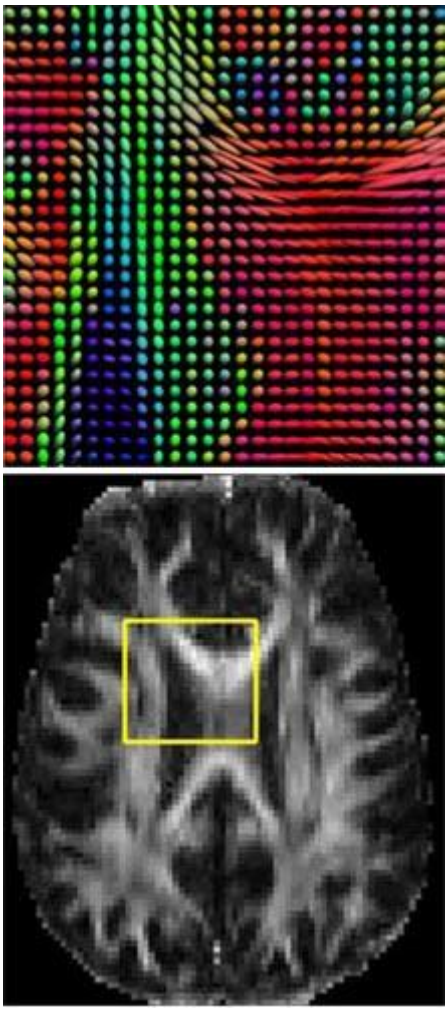
Brain Images Reveal the Secret to Higher IQ

The integrity of neural wiring is a big factor in determining intelligence. It's also inheritable.

New research suggests that the layer of insulation coating neural wiring in the brain plays a critical role in determining intelligence. In addition, the quality of this insulation appears to be largely genetically determined, providing further support for the idea that IQ is partly inherited.



Pixilated brain: At the bottom, an MRI image shows a slice of the human brain. At the top is shown a magnified portion of this section, created using diffusion imaging. To create the image, scientists measured the direction of the water diffusion in brain tissue. The "flower petals" at each point show the directions of fastest diffusion. These are aligned along the neural pathways of the brain, because water diffuses directionally along the well-insulated neural wires that carry electrical signals. The different directions of diffusion are color-coded red, green, and blue. In this example, the bright red areas reveal the thick fiber tract, called the *corpus callosum*, which transfers information between the left and right sides of the brain.

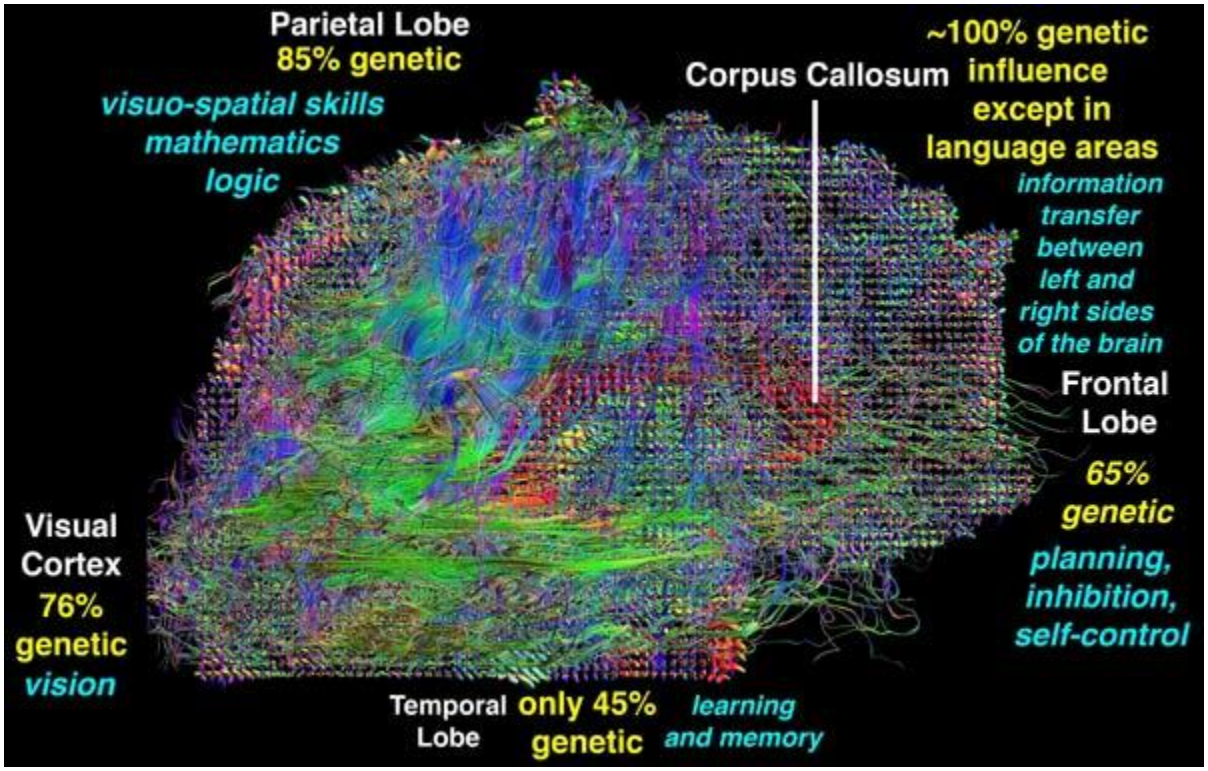
The findings, which result from a detailed study of twins' brains, hint at how ever-improving brain-imaging technology could shed light on some of our most basic characteristics.

"The study answers some very fundamental questions about how the brain expresses intelligence," says Philip Shaw, a child psychiatrist at the National Institute of Mental Health, in Bethesda, MD, who was not involved in the research.

The neural wires that transmit electrical messages from cell to cell in the brain are coated with a fatty layer called myelin. Much like the insulation on an electrical wire, myelin stops current from leaking out of the wire and boosts the speed with which messages travel through the brain–the higher quality the myelin, the faster the messages travel. These myelin-coated tracts make up the brain's white matter, while the bodies of neural cells are called grey matter.

White matter is invisible on most brain scans, but a recently developed variation of magnetic resonance imaging, called diffusion-tensor imaging (DTI), allows scientists to map the complex neural wiring in our brains by measuring the diffusion of water molecules through tissue. Thanks to the fatty myelin coating, water diffuses along the length of neural wires, while in other types of brain tissue it moves in all different directions. Researchers can calculate the direction of fastest diffusion at each point in the brain and then construct a picture of the brain's fiber tracts. A well-organized brain has well-functioning myelin, in which water can be seen clearly moving along specific paths. "Diffusion imaging gives a picture of how intact your brain connections are," says Paul Thompson, a neuroscientist at the University of California, Los Angeles, who lead the study.

Thompson and his colleagues took DTI scans of 92 pairs of fraternal and identical twins. They found a strong correlation between the integrity of the white matter and performance on a standard IQ test. "Going forward, we are certainly going to think of white matter structure as an important contributor of intelligence," says Van Wedeen, a neuroscientist at Massachusetts General Hospital in Boston, who was also not involved in the research. "It also changes how you think about what IQ is measuring," says Wedeen. The research was published last month in the *Journal of Neuroscience.*



IQ inheritance: By comparing the brain scans of twins, scientists discovered that the quality of the fatty tissue that insulates neural wires is largely inherited. The parietal lobe, which is involved in logic and mathematics, is 85 percent genetically determined, whereas the visual cortex is about 76 percent, and the temporal lobe, which is involved in learning and memory, is only 45 percent genetically determined.

If white matter is linked to both processing speed and IQ, this raises the question: is intelligence merely a function of how fast your brain works? Previous research has linked processing speed to IQ, but the tests used in the study are measures of general intelligence, including verbal skills, math, and logic. “Processing speed plays a big part in how intelligent you are, but it’s not the only factor,” says Shaw.

The new study is among the first to link a specific neural architecture to IQ in healthy individuals. “Most people have focused on grey matter,” says Shaw. “This is good evidence we should be looking at white matter as well.” Previous studies using DTI have linked white matter damage to Alzheimer’s disease, chronic alcoholism, and traumatic brain injury.

The UCLA researchers took the study a step further by comparing the white matter architecture of identical twins, who share almost all their DNA, and fraternal twins, who share only half. Results showed that the quality of the white matter is highly genetically determined, although the influence of genetics varies by brain area. According to the findings, about 85 percent of

the variation in white matter in the parietal lobe, which is involved in mathematics, logic, and visual-spatial skills, can be attributed to genetics. But only about 45 percent of the variation in the temporal lobe, which plays a central role in learning and memory, appears to be inherited.

Thompson and his collaborators also analyzed the twins' DNA, and they are now looking for specific genetic variations that are linked to the quality of the brain's white matter. The researchers have already found a candidate–the gene for a protein called BDNF, which promotes cell growth. "People with one variation have more intact fibers," says Thompson.

The search for the genetic and neuroanatomical basis of intelligence has been controversial, largely because opponents fear it will spawn a deterministic view of abilities and education. "People worry that if something is genetic, they have no power to influence it," says Thompson. "But that's not true at all." For example, both an average runner and a genetically gifted one can benefit from training.

But the debate may be moot since, as Wedeen points out, it is unlikely that an individual brain scan could predict a person's IQ. "The report described aggregate data over number of individuals," he says. "That's not the same as saying we can do a scan and determine a person's intelligence. That may be in the offing, but we don't know that yet."