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THE BRAIN

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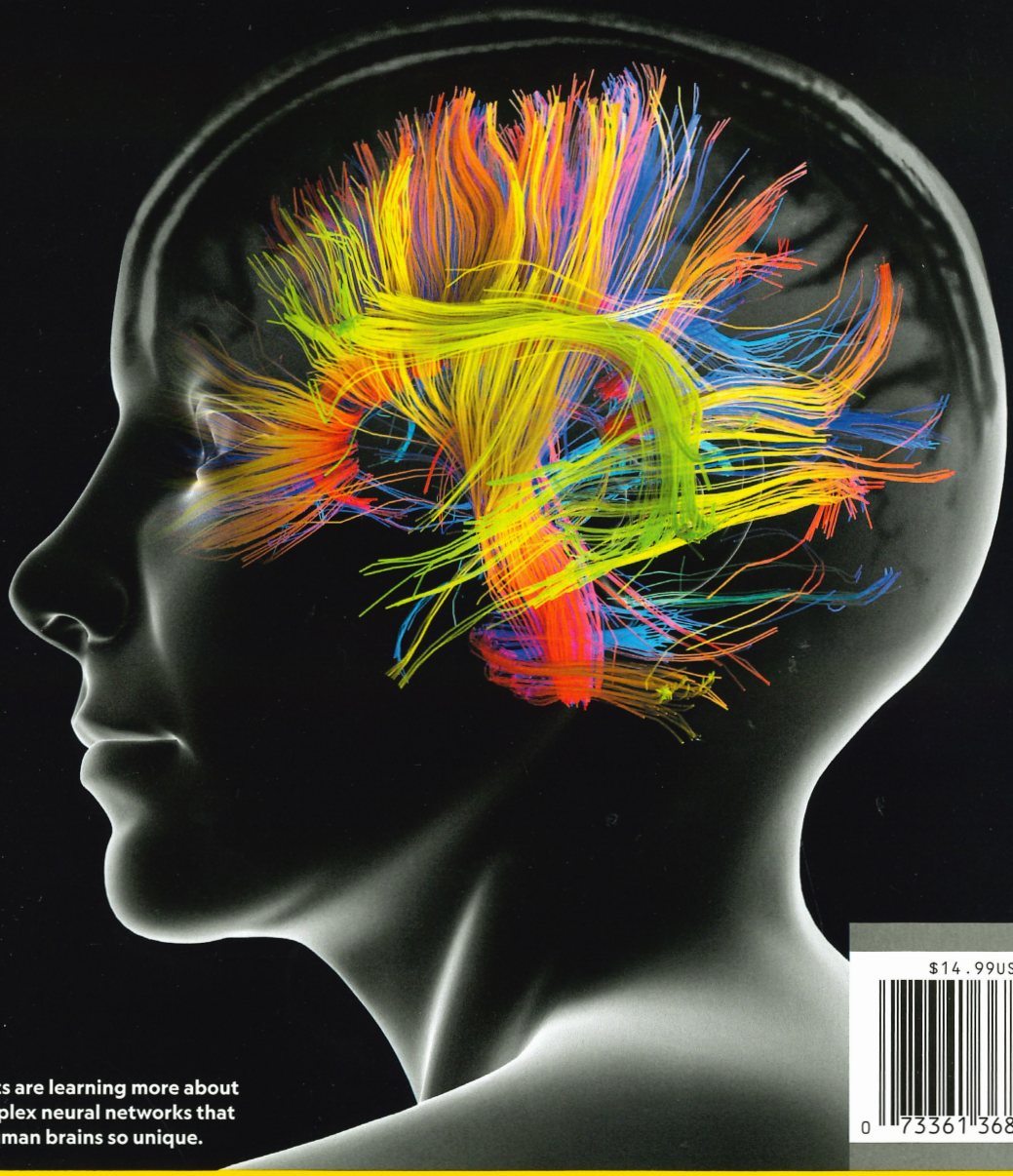

Scientists are learning more about the complex neural networks that make human brains so unique.

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CONTENTS

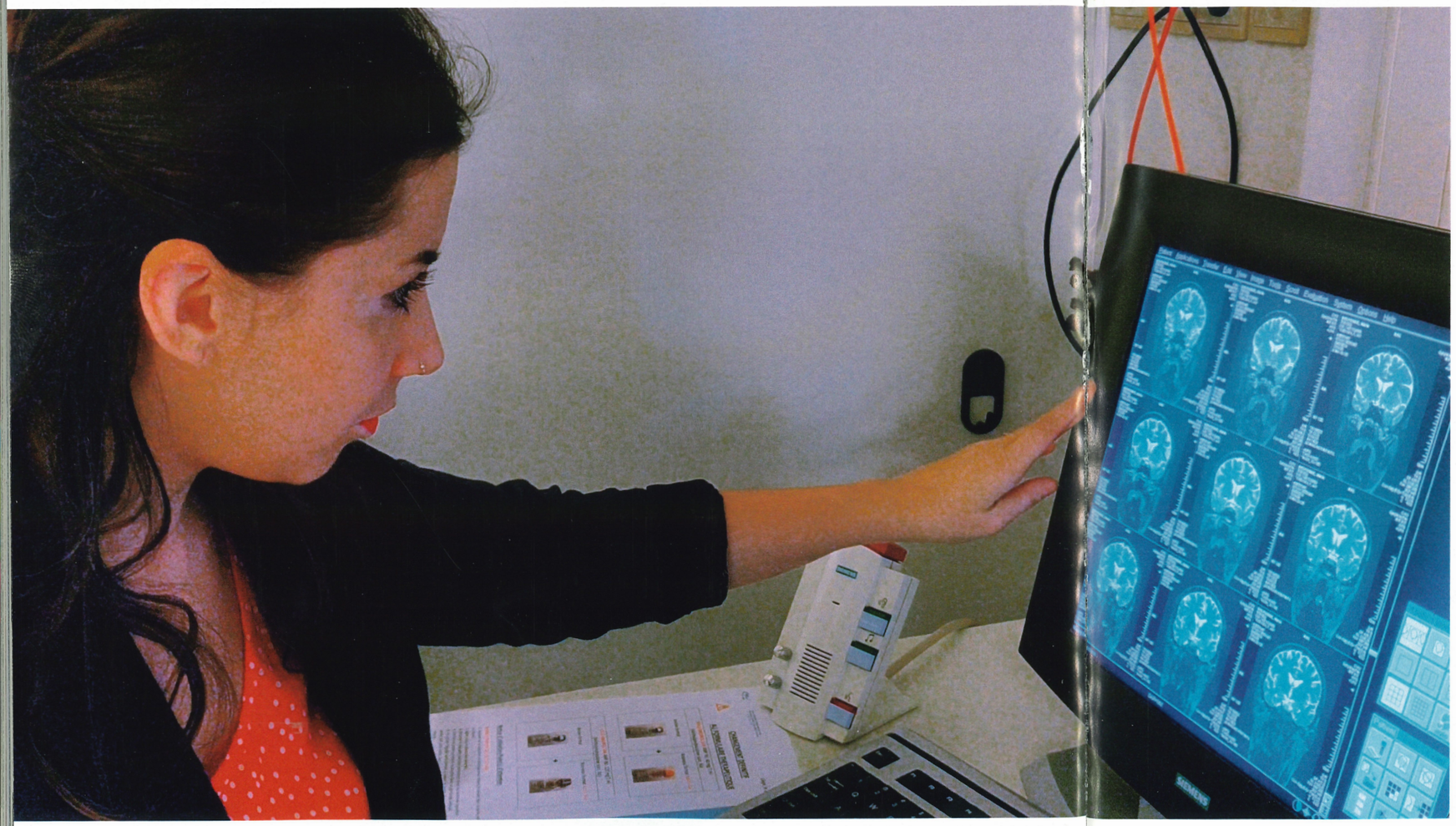
Artists create anatomically correct human brain sculptures in Bloomington, Indiana, to raise awareness about brain health. *Previous Pages:* As a woman relaxes in Dead Horse Point State Park in Utah, a researcher injects conductive solution into an EEG cap to find out how brain waves differ in nature versus urban environments.

NO SEAT OF CONSCIOUSNESS

IN 2016, A simple finding in the brainstem took the popular press by storm—the seat of consciousness had been found! Five years later, Athena Demertzi, a cognitive and clinical neuroscientist, laughs about this. While based at the Université de Liège, in Belgium, Demertzi was recruited to work on a study with a group of researchers based mainly at Harvard University. She was looking to identify specific brain lesions that cause coma, a temporary state of unconsciousness that's devastating, and not well understood.

After carefully imaging the brains of coma patients—who are difficult to find and fragile to work with—she and the team compared these brainstems with those of conscious patients who also had brainstem lesions. In coma patients, the team found that a tiny lesion in a piece of the brainstem, a critical structure that forms the bridge between body and brain, seemed to be bringing down a whole network: The pontine tegmentum appeared disconnected from the anterior insula and the anterior cingulate cortex, a network that *maintains* consciousness—maintains being the operative word.

Athena Demertzi inspects brain scans of patients with a diverse array of consciousness disorders. Some scans show brain trauma, while others show lack of oxygen to the brain.



"It just put the seat [of consciousness] into conversations," says Demertzi, but she cautions that you can't draw any major conclusions about the finding from such a correlative approach with a small number of patients. Although a localized source of consciousness has certainly not been found, having even this level of insight into how comatose states come on—and could potentially be reversed—is pretty rare.

WHERE THE BRAIN WANDERS

DEMERTZI IS ONE of the scientists who thinks that consciousness is the product of the brain reacting to the environment, not a sense that arises unprompted from within itself. The question of where consciousness comes from is too hypothetical. Instead, she turns her attention back to those so-called easy problems, and to correcting an imbalance in brain imaging studies.

The way she sees it, so many investigations into brain imaging are related to tasks, or functional experiences: What network in the brain activates when you see a face? How about when you eat or smell something? And when you're in pain? These studies are important for understanding how big cognitive processes take shape, such as memory, learning, attention, or emotion. This research has also been crucial in reframing the brain as an organ not made of distinct functional areas, but of shifting networks that alternately kick into action or get pushed to the back burner, depending on what's happening in our environment.

While we doze, the brain's immune cells, called microglia, come in to clean up the mess we made during the day.

What the brain does on its own time is far more mysterious. Imaging studies that attempt to understand the brain during a neutral resting state show that even when we externally appear to be doing nothing, the brain is busy. "Even during resting state . . . your mind still wanders," Demertzi says. "It goes here, there, everywhere—into the future and into the past. This is supported somehow. It has neural correlates, this resting state."

BUT THE BRAIN cannot always be this on. We know this because we go to sleep every day partly to let the brain refresh. While we doze, the brain's immune cells, called microglia, come in to clean up the mess we made during the day. What Demertzi is working on now is understanding whether there are times when consciousness shuts off in a healthy person's brain, but not as a function of coma or sleep. Yes, the mind sometimes wanders when there's no specific task going on, but sometimes it also seems to just . . . stop. Then something snaps you back into the here and now, and you have no

idea where you've been. Colloquially called mind-blanking, no one knows what this looks like neurobiologically. "This, for me, is very, very intriguing, because it would mean that you don't have to be unconscious only when your arousal is low," Demertzi says. "You can really be unconscious while your eyes are open and you move around."

A recent EEG study found that during wakeful mind-blanking, the brain exhibits the kind of low-wave activity that normally happens during sleep. Demertzi wants to see if this holds up in fMRI studies. Her long-term goal is to apply her findings to developing preclinical predictors of who might develop neurodegenerative diseases that also seem to alter someone's conscious experience of the world, such as Alzheimer's.

LIKE DEMERTZI, MOST researchers who are deep in the neuronal weeds think the hard problem of consciousness—why we have self-awareness in the first place—is fundamentally unanswerable, which is incredible to think about. "I don't know why we have it," says Demertzi. "I think, personally, it's an evolutionary accident that we are both cursed and blessed to have."

There's some final frontier that our strong, complex brains can't reason through. They compose music, bring us to outer space, create groundbreaking vaccines in the middle of a pandemic; they make memories and create flavor. But at the deepest level, it seems a brain can't follow its own consciousness to the end of the trail.

Electrodes measure the brain activity of a meditating Buddhist monk in Dengfeng, Zhengzhou, Henan Province, China.

THE BRAIN

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Opposite: Santiago Ramon y Cajal's turn of the 20th-century drawings of microscopic neurons paved the way for modern neuroscience.