THE ZOO IN YOU

How Your Gut Bacteria Affect Your Brain Health

In recent years, an explosion of research has connected the bacteria in the human gut to a whole range of health conditions—everything from obesity to diabetes to cancer. Increasingly, researchers are showing a connection between gut bacteria and brain health as well. Here's what we currently know about how the gut microbiome influences cognitive function and mental health—plus how you can promote the best bacteria in your own body.

By Jamie Santa Cruz

It sounds downright creepy at first. As human beings, each of us has 300–500 different species of bacteria living in a complex ecosystem within our guts. In fact, the bacteria living in our guts nearly outnumber our own cells.

But while the idea might sound creepy, these "bugs" in our intestines are actually quite important to our health and well-being, says Sara Campbell, assistant professor of kinesiology and health at Rutgers University. They aid in digestion, breaking down nutrients for us that we wouldn't otherwise be able to access, and they also work in concert with our immune system to protect us from

disease. "These tummy bugs are there to help us, and without them, we wouldn't be able to survive," explains Campbell.

Where do we get those bugs?

At a macro level, every human gut microbiome has a lot in common, says Hannah Holscher, assistant professor of food science and human nutrition at the University of Illinois at Urbana-Champaign. We all tend to have the same five basic phyla (categories) of bacteria in our guts. But at a micro level, there are substantial differences from one person to the next, since we each carry different strains of microbes within those five broad phyla. "It's somewhat similar to our fingerprints, in that you'll have your own unique composition of gut microbiome," says Holscher.

The specific composition of a person's gut bacteria is influenced right from birth. As a baby passes out of its mother's body, the baby is colonized with bacteria from the mother, which passes into the infant's gut. (Importantly, the gut microbiomes of babies born via C-section are typically not as rich as those born vaginally.) A baby's earliest feeding experiences also have an impact. Those who are breastfed have markedly different gut microbiomes than babies who are formula fed. And antibiotic use, especially in the first few years of life, also plays a role. Two Finnish studies published in 2016 both showed that when children received antibiotics early in life—especially the broad-spectrum antibiotics commonly used to treat respiratory infections—their gut microbiomes developed at a slower rate and showed less diversity than peers who hadn't taken antibiotics.

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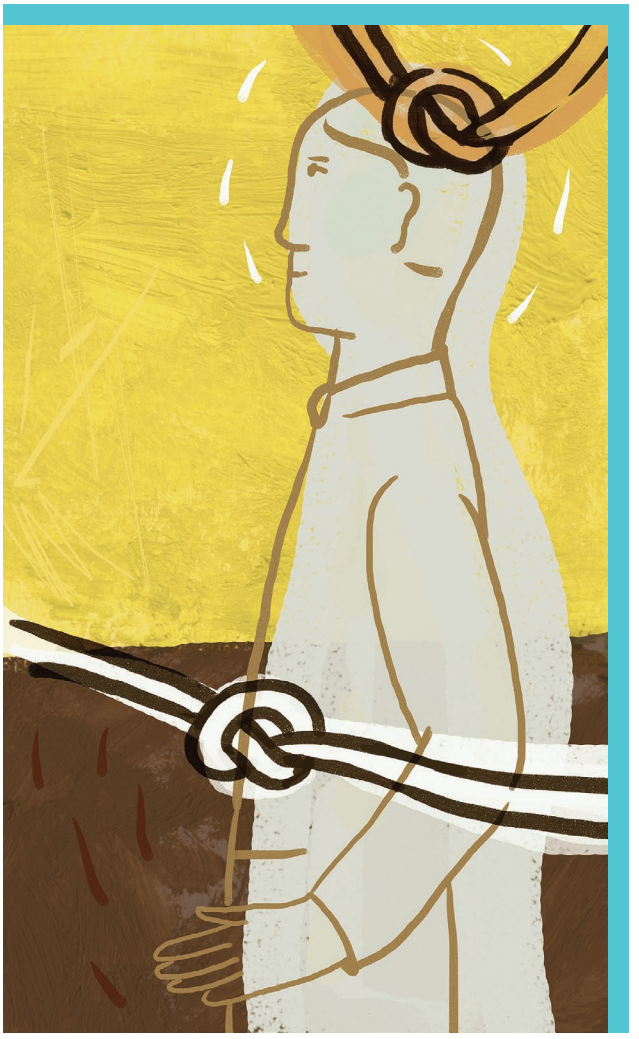
THE GUT-BRAIN CONNECTION

Although it might seem like the gut and the brain should be separate from each other, they're actually not. In fact, the two are directly connected by the vagus nerve, a "walkie-talkie" of sorts that allows microbes in the gut to send nerve signals to the brain. The vagus nerve is a two-way line of communication, says Holscher, with the gut sending signals to the brain and the brain, in turn, sending signals back to the gut.



That gut-brain connection, as it turns out, is an important key to our cognitive functioning and our mental health. Indeed, scientists are currently uncovering evidence that specific compositions of gut bacteria are related both to mood and to a number of cognitive disorders and diseases. Here's what we currently know about the impact of the gut microbiome on several aspects of brain health:

Depression and anxiety

There are multiple routes through which people can develop symptoms of clinical depression and anxiety, says Ruth Ann Luna, director of medical metagenomics at the Microbiome Center at Texas Children's Hospital. Therefore, people with such mood disorders can have gut microbiomes that look quite different. In other words, there's no

Just as you have a unique fingerprint, you have your own unique composition of gut microbiome.

single gut bacterial profile that "marks" all individuals with depression.

Still, says Luna, there is convincing evidence of a link between the gut microbiome and mood disorders. Much of the research so far has been in animals rather than humans, but several studies have shown that when researchers deplete the microbiomes of mice—in other words, when they deprive the mice of a normal, healthy mix of bacteria in their guts—there is a measurable effect on their moods. "That absence of a healthy microbiome can contribute to a variety of emotional and behavioral symptoms, like anxiety, increased pain perception, and depression," says Luna.

If a lack of good bacteria in the microbiome can cause mood disorders, new research shows that introducing "good" bacteria into the gut can improve symptoms of depression. Several studies have found such an effect in animals, but a small 2017 study from researchers in Canada found that the effect occurs in human beings too. Patients with depression who were given a specific type of probiotic—a dietary supplement containing healthy bacteria—had reduced depression scores at the end of 10 weeks compared to patients who were given a placebo.

Although probiotics can have a positive effect on mood, that doesn't mean the same probiotic would work for everyone, says Luna. That's because people with mood disorders have different types of imbalances in their gut microbiomes. "Across-the-board interventions are not always effective because we're not considering what's already there," she says.

Autism

First things first. There is little to suggest that gut bacteria *causes* autism, per se; most of the work connecting gut bacteria to autism shows only a correlation between the two, not a cause-effect relationship. There are some studies suggesting that a specific bacterial community in the gut can induce a condition in animals that looks like autism spectrum disorder, according to Luna, but the more important question is what causes such a bacterial community to exist in the first place.

That said, problems with gut function—such as constipation—are a common complaint among individuals on the autism spectrum, says Luna, and the constant pain associated with these gut malfunctions appears to drive at least some of the characteristic behavioral symptoms associated with autism. "We've finally hit the point where there is a general acceptance that the gut microbiome does play a role," says Luna.

As is the case with mood disorders, scientists haven't been able to tease out any single bacteria (or set of bacteria) that "identifies" individuals with autism, simply because autism is a spectrum disorder and there is variation in the gut profiles of people on different ends of the spectrum. Still, says Luna, studies in mice have shown that there are meaningful differences in the gut microbiomes of individuals with autism spectrum disorder compared to individuals without the disorder.

Perhaps more importantly, altering the gut microbiome—for example, through taking probiotics or adhering to a specific diet—has been shown to correct some of the gastrointestinal symptoms associated with autism spectrum disorder. Improving those symptoms, in turn, appears to impact the behavioral symptoms of autism. Therefore, according to Luna, research on the connection between gut bacteria and autism may not necessarily provide a "cure" for autism, but it *is* providing significant hope for improving the lives of individuals who live with the disorder.

Cognitive function

One exciting frontier in research on the gut microbiome is its relationship to crippling cognitive diseases, such as Alzheimer's disease.

In early 2017, researchers in Sweden who were studying the development of Alzheimer's in mice found that mice with Alzheimer's showed a different composition of bacteria in their guts than mice without the disease. Not only that, they were able to show that there is actually a cause-effect link between the gut microbiome and Alzheimer's. The researchers took bacteria from the guts of diseased mice and transferred them into the guts of germ-free mice (mice who had no bacteria in their guts at all). Those who received bacteria from diseased mice developed

Boost Your Bugs

So there's increasing evidence that the "bugs" in our guts play a significant role in health and disease, but what can we do to create the healthiest gut microbiome possible?

For starters, it's worth noting that a "healthy" gut microbiome generally means one that is diverse, according to Sara Campbell, a Rutgers University professor. More diversity means more bacteria that can carry out different types of beneficial functions in the body. And there are at least two major lifestyle choices you can make to promote bacterial diversity:

A 2-Step Plan for Cultivating a Healthy Gut Microbiome

1 Eat the rainbow.

The biggest key to gut health, says Hannah Holscher, a professor from the University of Illinois, is to eat an array of plant foods, including a variety of fruits, vegetables, whole grains, legumes, and nuts. In sum, she says, "Eat the rainbow." Plant foods naturally contain fiber, but each one has different types and amounts of fiber, which is important because fiber is used as an energy source ("food") for microbes in the gut. "Since different microbes have different tools to break down different fibers, eating various kinds of fiber helps contribute to a more diverse gut microbiome," explains Holscher.

Making a dietary change in favor of more plant foods alters the gut microbiome, and the change can happen quite quickly—in a matter of days. A 2013 study conducted by researchers at Harvard University put participants on an extreme diet heavy in meat and cheese for five days. Next, they switched all the participants to the other extreme—a diet based completely on plant foods—for another five days. Within just two to three days of the change, the bacterial composition in the participants' guts had notably improved. That's good news—you can start impacting your gut microbiome this very week!

2 Get moving.

Research on exercise and its impact on the gut microbiome is still developing. However, says Campbell, "the one big thing that most everyone will agree upon is that exercise increases diversity." Currently, nothing is known about exactly *how* exercise produces this impact, but for whatever reason, it works.

There's been no research so far on weight training, so it's not clear what impact that form of exercise might have specifically on gut microbes (although we know weight training is important for other reasons). If you're looking to produce good gut bugs, says Campbell, your best bet at this point is to engage in either high-intensity interval training or regular endurance training—such as going for a run.

more of the classic signs of Alzheimer's disease than mice who remained germ-free.

If that's depressing, there's good news as well. Research has also shown that introducing healthy bacteria into the gut microbiome of people suffering from Alzheimer's can have a positive influence on their cognitive function.

In one 2016 study, for example, researchers in Iran gave Alzheimer's patients a daily dose of probiotics that contained two different kinds of beneficial bacteria. After just 12 weeks, those who had been taking the probiotics showed a moderate improvement in their performance on a standard test designed to measure cognitive impairment. Previous studies had shown similar effects in animals, but this was the first study to show that altering the gut microbiome improves cognition in human beings as well. According to the researchers, the findings offer hope that improving the mix of bacteria in the gut might be a way to slow down or even prevent the development of Alzheimer's and related diseases.

Jamie Santa Cruz writes from Colorado.