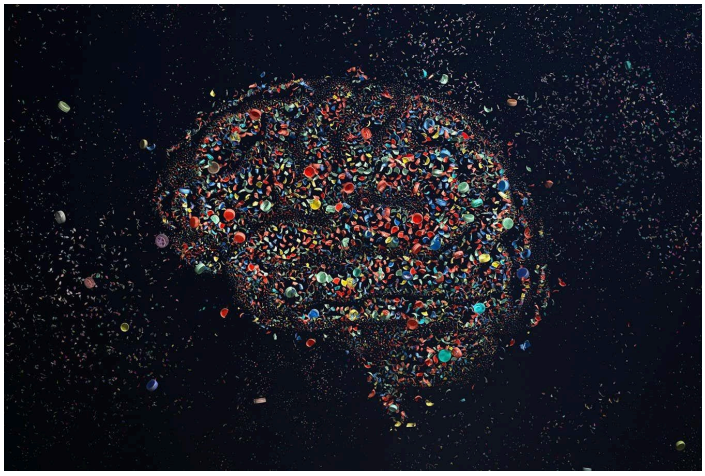
What are microplastics doing to your brain? We're starting to find out

The average human brain contains around 7 grams of plastic, but it's unclear how this affects us. Now animal studies are revealing links to poor cognition and weird behaviour

By Marta Zaraska on May 7, 2025



Simon Danaher

GIVEN a choice between two sea snail shells, hermit crabs know which will make a better home. That is, unless their thinking has been muddled by ingesting microplastics. Then, they struggle with a decision that could be crucial for survival. They aren't alone: across the animal kingdom, it appears, tiny bits of plastic change behaviours and mess up cognition. Exposure to these particles makes mice more forgetful and less social. Bees have trouble learning. Zebrafish act more anxious.

Such discoveries sound a warning bell for people, too. These so-called microplastic fragments are everywhere, from Arctic snow to the Amazon rainforest. Perhaps worse, they are in our foods: from beer and table salt to seafood and honey. "If you turn the top of your plastic bottle, you shower tiny pieces of plastic down into the water," says Tamara Galloway, an ecotoxicologist at the University of Exeter, UK, whose work focuses on the environmental and health effects of pollultants like microplastics. People consume around 52,000 microplastic particles per year – or around 121,000 if you include those we inhale. What's more, recent research shows that some of these can cross the barrier designed to stop toxins from getting from blood vessels into brain tissues.

Exactly if and how this might mess with our minds is unclear because we can't subject people to the sorts of experiments we do with the likes of mice – though Galloway's opinion is that the effects on humans could be serious.

We do however, have animal studies to illuminate how microplastics affect the brain and behaviour of other species. Plus, there is an emerging picture of evidence about the volume of microplastics in the human brain – with some data pointing to a link between higher levels and a greater risk of neurological conditions, such as dementia. So, how worried should we be?

The current situation's origins lie in 1907, when a Belgian chemist named Leo Baekeland invented the first synthetic plastic using phenol and formaldehyde. He named it Bakelite after himself. Soon, commercial production began – initially for use in insulating electrical cables – in Baekeland's home lab in New York. Plastic flowed out into the world.

By the late 1950s, humanity was producing around a million tons of various plastics a year. Today, our output is 400 times that. Between the 1950s and 2017 we created 9.2 billion tonnes of the stuff. In its multitude of forms, this material is now found in everything from clothing and disposable diapers to teabags and toothpaste. Recycling helps reduce the amount that goes to waste, but we manage to recycle only a mere 9 per cent of plastic each year. Most plastic still ends up in landfill or goes directly into the environment, washed into rivers and oceans or contaminating fields and wildlands.

"Crabs exposed to microplastics seemed confused

Assailed by sun, water and wind, plastic disintegrates into ever smaller pieces. Once it is smaller than 5 millimetres in diameter, we call these microplastics. Those smaller than 0.001 millimetres are referred to as nanoplastics. The tinier the fragments, the easier it is for them to get swallowed by aquatic organisms, taken up by plants through their roots and inhaled by insects. "They can become part of the food chain," says Galloway. We now know that some of them end up in the brains of animals and, if a slew of recent studies is anything to go by, that is a problem.

Hermit crabs find it hard to choose a good home after ingesting microplastics. Johner Images/Alamy

Take those hermit crabs. When Andrew Crump at London's Royal Veterinary College set out to study how microplastics might affect their behaviour, he didn't expect to uncover anything startling. It was an enthusiastic undergraduate student who convinced him to do the experiment, which entailed keeping dozens of the crabs in various tanks with either clean water or water polluted with tiny pieces of polyethylene — a common component of grocery bags and packaging. After five days, each crab was offered a choice of two shells – these animals occupy the empty shells of other species to protect themselves, routinely trading up to a new one as they grow. In this case, one shell was smaller than their current one – a downgrade – and the other larger – an upgrade. "The results were quite striking," says Crump. The animals kept in clean water tended to make good assessments and opt for the better shell. But crabs exposed to microplastics seemed confused: they would often choose the worse option.

Messing with animal minds

This was one of the first pieces of work indicating that microplastics might be getting into the brains of animals and affecting their behaviour. Other examples have followed, many involving rodents. For instance, it has now been shown that ingesting microplastics compromises the ability of mice to navigate mazes. And there is more evidence that this makes learning and remembering more difficult. Show normal mice a wooden block, and 24 hours later they tend to recognise it as something they have seen before. Not so for microplastic-exposed mice: a single day is enough for them to forget they have seen the block, evidenced by the fact that they sniff it for just as long as an object that is new to them.

Mice dosed with microplastics are also more reckless when faced with predators. This became clear when groups of the animals were put into a large, rectangular box with a copper-coloured North American corn snake – a natural enemy (the snake was kept well-fed to ensure it didn't attack the mice). Control mice not exposed to microplastics were added to the box. When faced with the reptile, they did what they normally do – huddled together for security and retreated into a corner. But when the researchers tried the same thing with mice fed polystyrene microplastics, they seemed fearless. Instead of bunching up into a tight group, they kept exploring and even boldly approached the snake. In nature, such behaviour would have been disastrous.

Recent studies with other animals are producing similar results. One found that after ingesting tiny bits of polyethylene, a species of black-and-white striped fish called a convict cichlid have trouble swimming through a simple maze towards an appetising odour of fish food. Another found that freshwater shrimp become hyperactive. A third showed that microplastics hamper memory in honeybees. David Baracchi at the University of Florence, Italy, and his colleagues made this discovery when they trained bees to respond to certain aromas. To do this, the insects were restrained inside a narrow tube where they could smell the scent, and then the researchers touched their antennae with sugar, which taught them to associate the aroma with the sweet reward. "They start responding to the odour after a few trials, and this is the proof

that the bee has learned," says Baracchi. At least, that is how it worked with regular bees. However, those that had eaten a solution of sucrose laced with microplastics for several days had trouble learning. They also quickly forgot any lessons they had learned, which could lead to problems in the wild. "They need to go around and look for flowers. They need to recognise and remember which type of flower is more rewarding. They also need to be able to go back home," says Baracchi.

The conclusion that such behavioural changes are caused by consuming microplastics is strengthened when you look inside the animals' brains. Baracchi and his colleagues fed honeybees fluorescent microplastics and later saw the tiny particles embedded in their brains. Perhaps that is to be expected given that bees, like other invertebrates, lack a vertebrate-style blood-brain barrier – the special buffer between blood vessels and brain tissue that is supposed to keep toxins and pathogens at bay. But the discovery of microplastics in the brains of fish is more surprising. And it has been shown that they appear in the brains of mice just 2 hours and 20 minutes after being eaten.

Microplastics in your brain

As to a possible impact in humans? Recent work is showing that our brains aren't immune to the plastic invasion. In a study published in February, tissue was taken from the brains of dozens of dead people and soaked in potassium hydroxide to make it transparent. Examining samples under a microscope, the team behind the research found they contained tiny pieces of plastic – mostly minuscule, shard-like fragments of polyethylene. "One of the big findings from our study was how many of the plastic particles were in the nanoscale," says lead author Matthew Campen at the University of New Mexico. What's more, the brains of people who had died in 2024 contained around 50 per cent more microplastics than the brains of those who had died in 2016. For that earlier group, it came to around 7 grams of plastic per brain, or a few water bottle caps. "That's troublesome," says neuroscientist Jaime Ross at the University of Rhode Island. "It tells me that we are being exposed to more."

More than 90 per cent of the plastic we produce ends up in the environment. Timur Matahari/AFP via Getty Images

It seems that the blood-brain barrier isn't much of an obstacle to microplastics. In fact, there is evidence that the fragments make it leakier – at least in mice. "We had this assumption that the blood-brain barrier stopped everything, but the more we look, the more we find [microplastics] in brain tissue," says Galloway.

If that barrier is compromised, what might happen afterwards? Once it is breached and microplastics are in the brain, they encounter microglia, the organ's own immune cells, which gobble up and destroy invaders.

"Microplastics hamper the memories of honeybees

Here things go from bad to worse. A recent study found that when microglia consume microplastics, they tend to swell up and can obstruct blood flow in the human brain, potentially leading to neurological problems.

After mopping up microplastics, microglia also set off inflammation in surrounding neurons, damaging them. Several animal studies have linked such inflammation to behavioural issues. In zebrafish, for instance, it undermines swimming ability and produces depression-like behaviour. In addition, research on newborn mice found that microplastics mess up the way microglia prune connections between neurons — a process that normally helps shape the developing brain and make it more efficient. As a result, the animals grew up struggling with social interactions.

Animal studies also indicate that microplastics in the brain can reduce levels of neurotransmitters, including acetylcholine, which is important for memory and learning, and oxytocin, often called "the love hormone". In a study on mice, after long-term intake of microplastics, the animals not only had lower levels of oxytocin in their brains, but were also less social.

Trouble with the gut-brain axis

It also turns out that microplastics don't even have to enter the brain to jumble up animals' minds. They can wreak havoc at a distance, by affecting the gut-brain axis – a two-way communication network between these body parts. One way they do this is by upsetting the balance of friendly gut bacteria. It has been found that, as a result of this, mice become asocial. And it can cause problems with short-term memory.

Once again, hard evidence of specific effects in living brains comes via experiments of the sort we can't do on people. However, we can see what happens when our brain cells are exposed to microplastics in a lab dish. For example, when researchers dumped large amounts of microplastics – they called it "a year exposure" – on nerve cells, they all died. At smaller doses,

the neurons accumulated the particles inside, becoming damaged and misshapen. Other lab dish experiments, meanwhile, confirm a key finding from animal studies: that human microglia eat up microplastics, resulting in increased inflammation.

Despite the experimental restrictions, there are some hints of effects on living people. Work published in 2024 found that people in China aged 60 and older who reported higher potential exposure to microplastics – from things like using plastic tableware and regularly drinking water from plastic bottles – had a raised risk of mild cognitive impairment. That was especially true for regular users of plastic utensils, whose risk increased by 24 per cent. This fits with another finding from Campen's work: people diagnosed with dementia had more microplastics in their brain than others, which has worrying echoes of the findings in animal experiments. Research with mice shows that exposure to microplastics can lead to changes in the brain that resemble those seen in rodents bred to have a version of Alzheimer's disease. And Ross's team found that dosing mice with microplastics altered their behaviour in what she describes as "a way that is akin to dementia". They were unusually restless and careless for their own safety.

Such findings raise concerns as to other possible neurological impacts of microplastics in humans, though solid research investigating further links is pending. Although many lab animal studies use levels of microplastics beyond those currently in the environment, Galloway points out that the effects on human brains could be even worse than in other species because we are so much more exposed to plastic. We even wrap food in it.

Even with research into microplastics' impact on humans still in its early days, there are steps people can take to reduce their intake. "I do everything I can to avoid undue exposure," says Galloway. She doesn't use plastic containers for cooking or storing food. She also buys organic produce because it is less likely to come from farming that uses sewage sludge for irrigation – a mud-like residue from wastewater treatment that has been shown to contain high levels of microplastics. And research suggests a few other measures that might limit the potential risks we face. These include the discovery that taking probiotics can reinforce the blood-brain barrier. Another study, in mice, found that memory troubles triggered by exposure to tiny pieces of polystyrene went away after treatment with vitamin E, which is an antioxidant and so reduces inflammation. Foods such as almonds, spinach and broccoli are good sources of this vitamin.

It may be premature to panic but, amid all the uncertainty, one thing is for sure: "We're full of plastic," says Galloway. "We're not really sure what the risks are, but we need to understand them."