POLLUTION

Should we be worried about the microplastics in our bodies?

How these tiny particles may harm our health is unclear, but scientists are alarmed by what they are finding so far

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Microplastics and nanoplastics are almost everywhere—even in human bodies. Over the past 5 years or so, scientists have found them in the blood and brain, heart and kidneys, liver and lungs, human milk and placenta, and testicles and semen.

If and how these plastic particles—defined as smaller than 5 mm in size—harm our health remains unclear, but clues are emerging. In the laboratory, scientists are feeding mice microplastics to understand whether these particles pose risks to the animals' health. Researchers are also tracking health outcomes in relation to the microplastics they find in human bodies.

"It's just such a new field," says Matthew Campen, a toxicologist at the University of New Mexico who studies micro- and nanoplastics in human tissues. But even as the research continues to evolve from its early stages, the widespread presence of these plastic fragments in humans and the environment is already something "we absolutely need to be concerned about," Campen says.

To learn about the potential harm from micro- and nanoplastics, scientists will need to overcome technical challenges. The most fundamental among them is accurately detecting nanoplastics, which are less than 1 µm in size, in our tissues and bloodstream. Studies indicate that nanoplastics could be more damaging than microplastics because they're smaller and can easily enter cells. And their larger ratio of surface area to volume makes such particles more reactive.

"One of the biggest limiting steps at the moment is the technology to find those particles," says Phoebe Stapleton, a toxicologist at Rutgers University who studies the impact of exposure to micro- and nanoplastics during pregnancy. There are a few options, she says, but those tend to be "expensive, time intensive, and are focused on specific [types of nanoparticles]."

In the coming years, scientists will have their work cut out for them as they strive to better detect these tiny plastic particles invading our bodies and better understand what their presence means for our health.

"It's sort of gobsmacking how challenging the next few years are going to be as we grapple with this problem," Campen says.

How do microplastics enter our bodies?

The first step to figuring out what micro- and nanoplastics are doing to our health is knowing how they get into our bodies.

People can ingest these plastic particles via food, tap water, or bottled beverages that contain microplastics and nanoplastics. A 2020 review of 50 studies found that mollusks—including mussels, oysters, and clams—had the highest microplastic levels among seafood. Scientists have also found microplastics in commercially sold table salt and sea salt. Another study noted that fruits and vegetables sold in local markets in Catania, Italy, were contaminated with these tiny plastic particles. The authors hypothesized that the plants' roots may be absorbing the plastic bits from the water or soil.

Scientists have also found microplastics leaching from plastic food containers, beverage cups, and baby bottles—and contaminating the contents—when the containers are exposed to hot foods and drinks. A recent study analyzed three popular brands of bottled water and estimated 240,000 microscopic plastic particles, on average,

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lurking in each liter. Warm environments, exposure to sunlight, and the reuse of polyethylene terephthalate bottles can all cause shedding of micro- and nanoplastics.

Plastic particles can also be airborne or part of dust. Depending on the size, the micro- and nanoplastics can be inhaled and then deposited in the upper respiratory tract or travel deep into the lungs. The tiny particles can also be absorbed into the body through the skin via open wounds, sweat glands, and hair follicles.

While researchers are trying to determine the most pertinent human exposure pathways, "it seems that the primary source of microplastics is probably through food and then maybe drinking water," says Tracey Woodruff, an environmental health scientist at the University of California, San Francisco.

Detecting microplastics

However micro- and nanoplastics end up in the body, finding them once they are there hasn't been easy. Because of their size, it's challenging for scientists to spot the tiny plastic particles in tissue samples using light microscopy or even electron microscopy techniques. "These [particles] are not electron dense," Campen says, which makes it difficult to use electron microscopy to detect the plastic fragments.

So scientists are largely relying on pyrolysis gas chromatography/mass spectrometry (Py-GC/MS) to identify and quantify the micro- and nanoplastic levels in tissue samples. Campen and his colleagues use potassium hydroxide to first "digest" the organic tissue and then use an ultracentrifuge to separate the plastic particles from the dissolved tissue. The next step is to heat the collected plastic and use a mass spectrometer to analyze the gas emissions. The researchers identify and quantify the different polymers on the basis of the gas signatures they emit. In a recent study, Campen's team used this technique to analyze 62 human placenta samples collected between 2011 and 2015 and found microplastics—particularly polyethylene microplastics—in all of them.

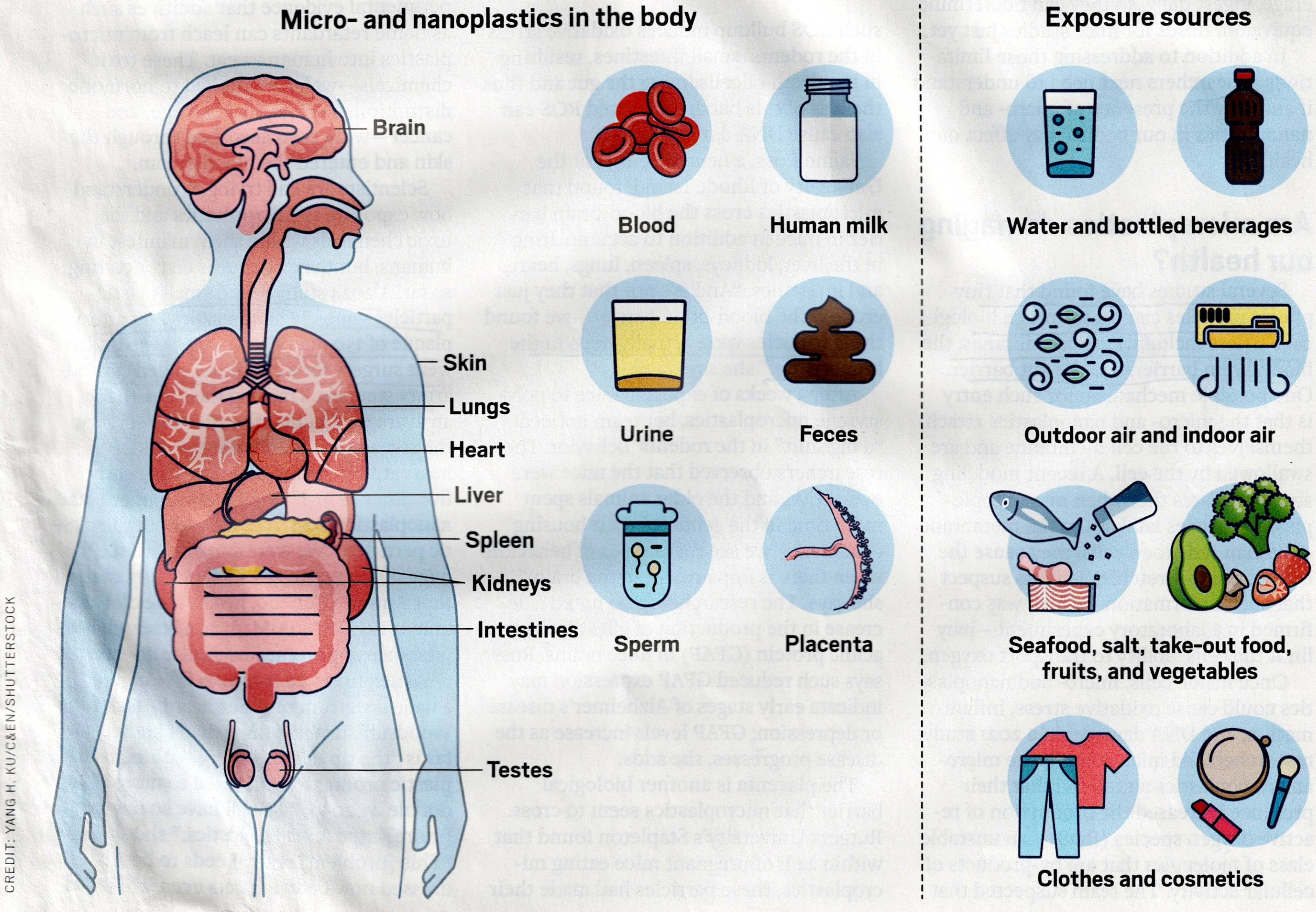
"The problem is that there are a lot of chemicals that are unknown in this [digestion] process," he says. "Potassium hydroxide causes all kinds of havoc with biological proteins, carbohydrates, and lipids, and there's always some residue." Additional extraction steps to eliminate this residue could destroy the plastic particles. "We could lose the plastics as we go," he says.

And some plastics are easier to detect than others using Py-GC/MS. For instance, Campen has found that spotting polypropylene and polystyrene polymers is relatively easy, but accurately detecting polyethylene and polyvinyl chloride can be tricky. "It's very challenging to extract and be confident that you've totally removed all the biological lipids from your analysis that might falsely represent polyethylene," he says.

Stapleton points out a different limitation of using Py-GC/MS: it doesn't allow researchers to count or assess the shape

Finding microplastics

Scientists have found micro- and nanoplastics in many parts of the human body, including the kidneys, heart, lungs, intestines, testes, and placenta.

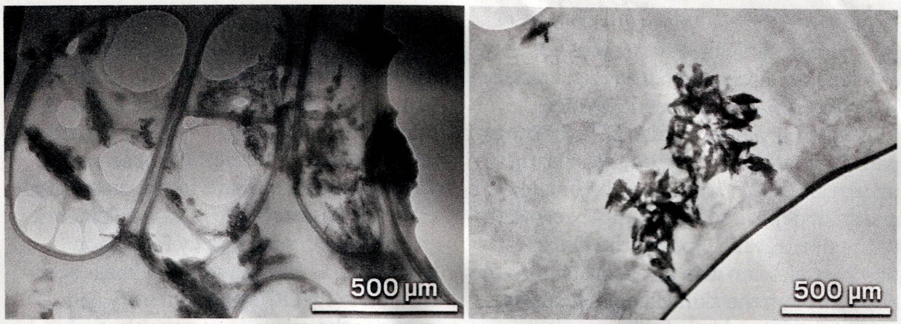


and size of micro- and nanoplastics in the tissue samples. "It just tells us the concentration of the plastics," she says. But information about the number of plastic particles and their morphology is important for researchers to figure out the potential damage they could cause to a person's health.

Thus, some researchers are opting for Raman microspectroscopy to uncover details about the structures of individual plastic particles found in the tissue samples. But more scientists are calling for the use of multiple detection methods so they can accurately quantify and characterize the microplastics infiltrating our bodies. Charles Rolsky, executive director at the Shaw Institute, which conducts research on microplastics, also urges better control to avoid cross contamination caused by handling, processing, and transporting tissue samples with disposable gloves, plastic packaging, or reagents tainted with microplastics.

Another area where Rolsky believes researchers should take special care is in animal studies. He's calling for more "realistic exposures" of lab subjects, such as mice, to these plastic particles. But Stapleton says scientists don't know the quantity of micro- and nanoplastics that humans, on average, ingest daily, so they can't determine equivalent doses for mice studies just yet.

In addition to addressing those limitations, researchers next need to understand if and how the presence of micro- and nanoplastics in our bodies may affect our health.



Transmission electron microscopy images showing nanoplastic fragments derived from human brain (left) and kidney (right) tissues.

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Are microplastics damaging our health?

Several studies have found that tiny plastic particles can pass through biological barriers including cell membranes, the blood-brain barrier, and the gut barrier. One possible mechanism for such entry is that the micro- and nanoplastics attach themselves to the cell membrane and are swallowed by the cell. A recent modeling study indicates that when microscopic plastic particles latch on to the membrane of human red blood cells, they cause the membrane to stretch. Scientists suspect that such deformation—which was confirmed in a laboratory experiment—may limit the cells' ability to transport oxygen.

Once inside cells, micro- and nanoplastics could cause oxidative stress, inflammation, and DNA damage. In a 2021 study, researchers fed mice polystyrene micro- and nanoplastics and found that their presence increased the production of reactive oxygen species (ROS)—an unstable class of molecules that are by-products of cellular activity. The team suspected that

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—Tracey Woodruff, environmental health scientist, University of California, San Francisco

such ROS buildup induces oxidative stress in the rodents' small intestines, resulting in the death of cells lining the gut and thus the loss of this barrier. Elevated ROS can also cause DNA damage.

Jaime Ross, a neuroscientist at the University of Rhode Island, found that microplastics cross the blood-brain barrier in mice in addition to accumulating in the liver, kidneys, spleen, lungs, heart, and intestines. "And it's not that they just crossed the blood-brain barrier—we found these particles were actually deep in the brain tissue," she says.

After 3 weeks of exposing mice to polystyrene microplastics, her team noticed "a big shift" in the rodents' behavior. The researchers observed that the mice were overactive, and the older animals spent more time in the center of their housing chambers. "We see these types of behaviors when there is impairment in the brain," she says. The researchers also noted a decrease in the production of glial fibrillary acidic protein (GFAP) in mice brains. Ross says such reduced GFAP expression may indicate early stages of Alzheimer's disease or depression; GFAP levels increase as the disease progresses, she adds.

The placenta is another biological barrier that microplastics seem to cross. Rutgers University's Stapleton found that within 24 h of pregnant mice eating microplastics, these particles had made their way into the placenta and the developing fetus. Her team continued to find microplastics in the offspring 2 weeks after birth. "We have preliminary evidence to show that we still see those particles at 3 months of age as well," Stapleton says.

Although researchers don't know how long microplastics remain in the body—and studies have found them excreted via urine and feces—Stapleton is worried about the particles that accumulate. She's concerned about the chemicals that might leach from these microplastics and harm our health. A recent study provides experimental evidence that additives such as flame retardants can leach from microplastics into human sweat. These toxic chemicals—which are linked to hormone disruption, neurological damage, and cancer—were then absorbed through the skin and entered the bloodstream.

Scientists are still trying to understand how exposure to microplastics and the toxic chemicals within them manifest in humans, but the evidence is disconcerting so far. A 2024 study found small plastic particles—mostly nanoplastics—in artery plaque of 150 out of 257 people who underwent surgery for a condition called carotid artery stenosis. Tracking their health for an average of 34 months after the surgery, the researchers found that the risk of a heart attack, stroke, or death was nearly five times as high in people with micro- and nanoplastics than in those without the plastic particles. "We were surprised to see this huge difference in risks," says study coauthor Antonio Ceriello, head of the diabetes unit at IRCCS MultiMedica, a research hospital focusing on cardiovascular diseases.

As scientists continue to investigate a wide spectrum of other health risks, Woodruff suspects that what's known so far is "the tip of the iceberg." With global plastic production expected to more than double by 2050, "we will have so many [more] exposures to plastics," she says. "This [problem] really needs to be addressed now before it gets even worse." ■