Tiny plastic particles like these—called microplastics—are added to some exfoliating skincare gels and can get into the environment from there. Microplastics have been found in human blood and lungs, but it's not yet clear what that means for our health.
PHOTOGRAPH BY ALEXANDER STEIN, JOKER/ULLSTEIN BILD/GETTY IMAGES

ENVIRONMENT

Microplastics are in our bodies. How much do they harm us?

The science is unsettled, but researchers say there is cause for concern.

BY **LAURA PARKER**

PUBLISHED MAY 9, 2023 • 15 MIN READ

As plastic waste proliferates around the world, an essential question remains unanswered: What harm, if any, does it cause to human health?

A few years ago, as microplastics began turning up in the guts of fish and shellfish, the concern was focused on the safety of seafood. Shellfish were a particular worry, because in their case, unlike fish, we eat the entire animal —stomach, microplastics and all. In 2017, Belgian scientists announced that seafood lovers could consume up to 11,000 plastic particles a year by eating mussels, a favorite dish in that country.

By then, however, scientists already understood that plastics continuously fragment in the environment, shredding over time into fibers even smaller than a strand of human hair —particles so small they easily become airborne. A team at the U.K.'s University of Plymouth decided to compare the threat from eating contaminated wild mussels in Scotland to that of breathing air in a typical home. Their conclusion: People will take in more plastic by inhaling or ingesting tiny, invisible plastic fibers floating in the air around them—fibers shed by their own clothes, carpets, and upholstery—than they will by eating the mussels.

A sample collected off Hawaii contains living organisms and plastic.
PHOTOGRAPH BY DAVID LIITTSCHWAGER, NAT GEO IMAGE COLLECTION

So, it wasn't much of a surprise when, in 2022, scientists from the Netherlands and the U.K. announced they had found tiny plastic particles in living humans, in two places where they hadn't been seen before: deep inside the lungs of surgical patients, and in the blood of anonymous donors. Neither of the two studies answered the question of possible harm. But together they signaled a shift in the focus of concern about plastics toward the cloud of airborne dust particles we live in, some of them so small they can penetrate deep inside the body and even inside cells, in ways that larger microplastics can't.

Dick Vethaak, a professor emeritus of ecotoxicology at the Vrije Universiteit Amsterdam and co-author of the blood study, doesn't consider his results alarming, exactly—"but, yes, we should be concerned. Plastics should not be in your blood."

"We live in a multi-particle world," he adds, alluding to the dust, pollen, and soot that humans also breathe in every day. "The trick is to figure out how much plastics contribute to that particle burden and what does that mean."

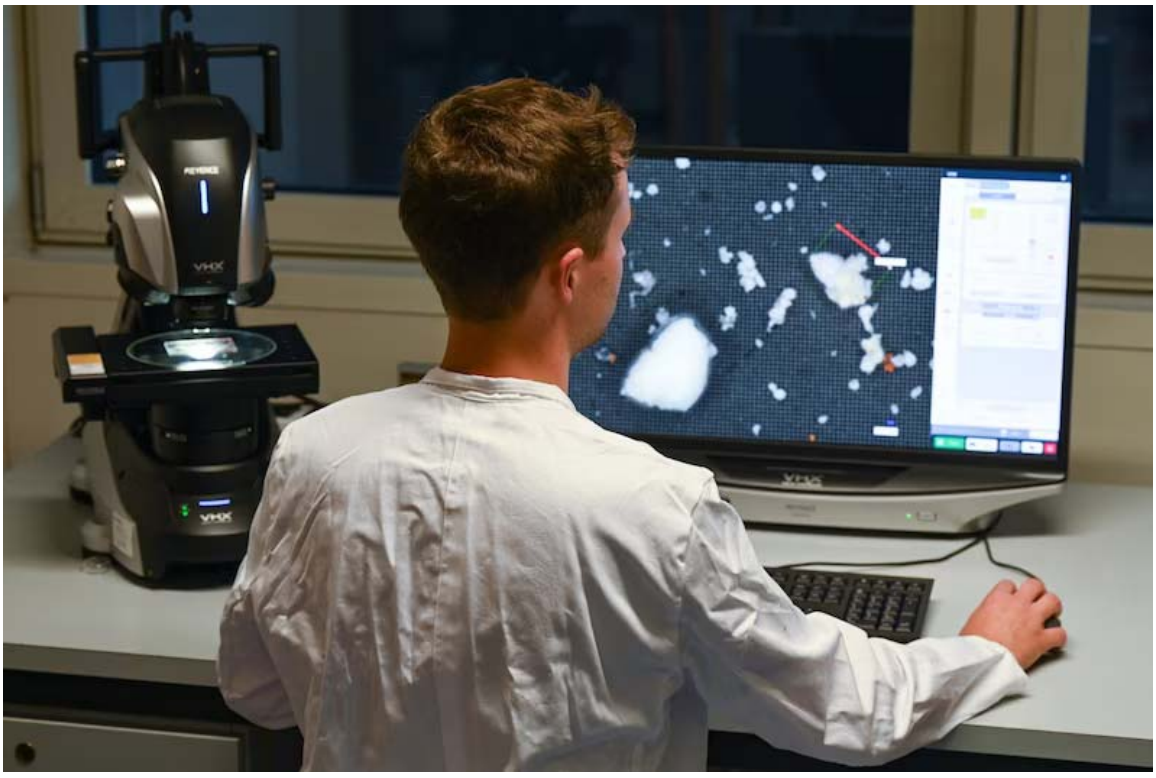
Harm is the hard part

Scientists have been studying microplastics, defined as particles measuring less than five millimeters (a fifth of an inch) across, for a quarter century. Richard Thompson, a marine scientist at the University of Plymouth, coined the term in 2004 after finding piles of rice-sized plastic bits above the tideline on an English beach. In the ensuing years, scientists located microplastics all over the globe, from the floor of the Mariana Trench to the summit of Mount Everest.

Microplastics are in salt, beer, fresh fruit and vegetables, and drinking water. Airborne particles can circle the globe in a matter of days and fall from the sky like rain. Seagoing expeditions to count microplastics in the ocean produce incomprehensible numbers, which have multiplied over time as more tonnage of plastic waste enters the oceans every year and disintegrates. A peer-reviewed count published in 2014 put the total at five trillion. In a 2021 tally, Japanese scientists from Kyushu University estimated 24.4 trillion microplastics in the world's upper oceans—the equivalent of roughly 30 billion half-liter water bottles—a number in itself hard to fathom.

“When I started doing this work in 2014, the only studies being done involved looking for where they are,” says Alice Horton, a marine scientist at the U.K.’s National Oceanography Center who specializes in microplastic pollution. “We can stop looking now. We know wherever we look, we will find them.”

But determining if they cause harm is much harder. Plastics are made from a complex combination of chemicals, including additives that give them strength and flexibility. Both plastics and chemical additives can be toxic. A 2021 analysis identified more than 10,000 unique chemicals used in plastics, of which more than 2,400 are of potential concern, says Scott Coffin, a research scientist at the California State Water Resource Control Board. Many are “not adequately regulated” in many countries, the study says, and includes 901 chemicals that are not approved for use in food packaging in some jurisdictions.



Felix Weber, research associate at the Institute of Environmental and Process Engineering at RhineMain University of Applied Sciences in Germany, sits in front of a picture of a 3-D microscope with plastic particles.
PHOTOGRAPH BY ARNE DEDERT, PICTURE ALLIANCE/GETTY IMAGES

Additives can also leach into water, and one study found that up to 88 percent could leach, depending on factors that include sunlight and length of immersion time. The same study found up to 8,681 unique chemicals and additives associated with a single plastic product. Sorting out which particular chemical combinations are problematic, and finding the level and length of exposure that causes harm in such a convoluted brew is no easy task.

“You may find a correlation, but you would be hard pressed to find causation because of the sheer number of chemicals we’re exposed to in our daily lives,” says Denise Hardesty, a research scientist who has studied plastic waste for 15 years at Australia’s Commonwealth Scientific and Industrial Research Organization.

Janice Brahney, a biochemist at Utah State University who studies how dust transports nutrients, pathogens, and contaminants, says she is concerned because plastic production continues to increase dramatically, while so much about microplastics remains unknown. In 2020, 367 million metric tons of plastics were manufactured, an amount that is forecast to triple by 2050. “It is alarming because we are far into this problem and we still don’t understand the consequences, and it is going to be very difficult to back out of it if we have to,” she says.

(*How the plastic bottle went from miracle container to hated garbage.*)

The American Chemical Council (ACC), an industry trade group, maintains a lengthy collection of statements on its website explaining chemical composition of various plastics and rebuttals to research claims that certain plastics are toxic.

“No, microplastics are not the ‘New Acid Rain.’ Not even close,” the council said in response to media coverage of Brahney’s 2020 paper, published in *Science*, which estimated that 11 billion metric tons of plastic will accumulate in the environment by 2025. (Brahney calculated that just in the western U.S., more than 1,000 metric tons of tiny particles are carried by the wind and fall out of the air every year.)

The ACC also criticized that finding, saying, “The amount of microplastics in the environment represents only 4 percent of particles collected on average... The other 96 percent is comprised of natural materials like minerals, dirt and sand, insect parts, pollen and more.”

Meanwhile, the ACC said through a spokesman it has launched a research program to help answer outstanding questions of microplastics, including those surrounding household dust, and help establish a global exchange of microplastics research between universities, research institutions, and industry. The work envisioned will include examining the environmental fate and potential routes of exposure of microplastics, identifying potential hazards, and developing a framework to assess risk. Findings will be published over the coming years.

The topic is so complicated and controversial, Hardesty says, that even the definition of harm comes up for debate at times. Should we only worry about the effects of microplastics on human health? What about the harm they might do to animals and ecosystems?

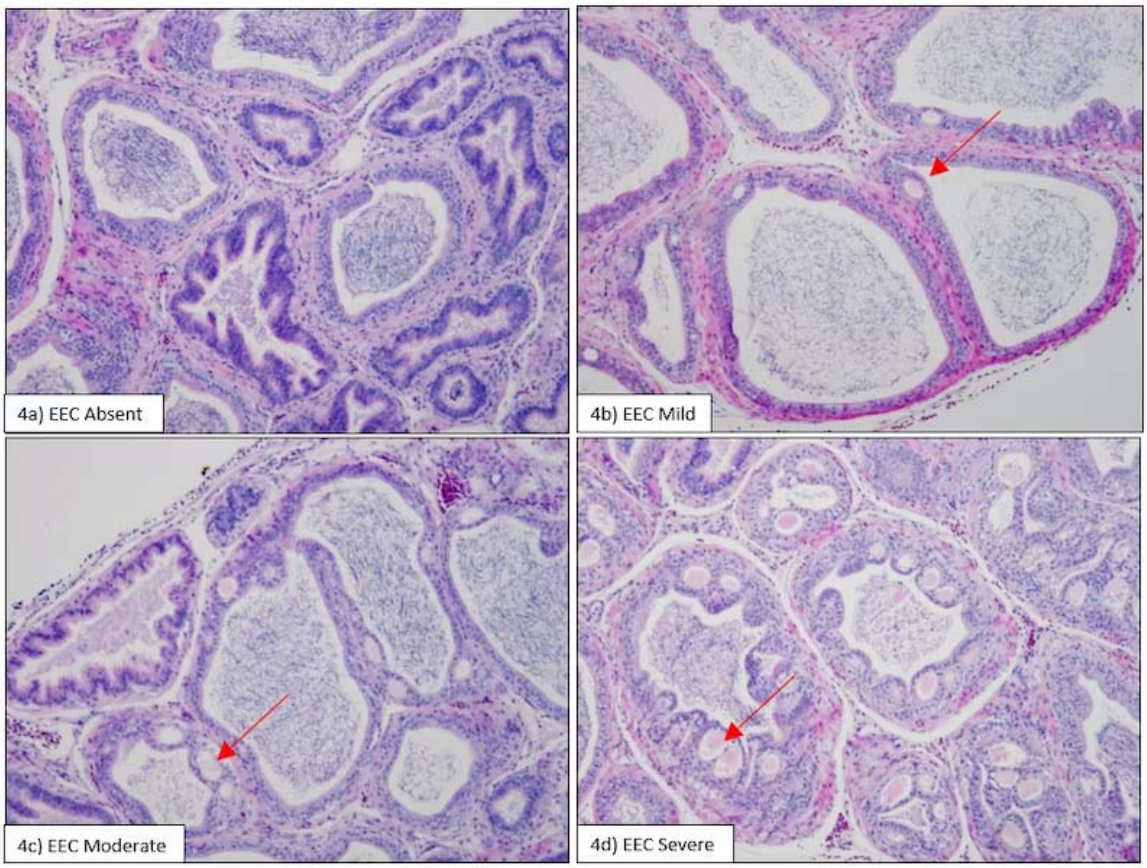
Plastics in animals

The search for potential harm from plastics actually began with animal studies some 40 years ago, when marine biologists studying the diets of seabirds began finding plastic in their stomachs. As more marine wildlife began to be affected by plastics, either by entanglement or ingestion, studies expanded beyond birds to other marine species, as well as to rats and mice.

In 2012, the Convention on Biological Diversity in Montreal declared that all seven sea turtle species, 45 percent of marine mammal species, and 21 percent of seabird species were affected by eating or becoming entangled in plastic. The same year 10 scientists unsuccessfully called on the world’s nations to officially classify the most harmful plastic as hazardous, which would give their regulatory agencies “the power to restore affected habitats.”

(*For animals, plastic is turning the ocean into a minefield*.)

In the decade since, the numbers and risks to animals have worsened. More than 700 species are affected by plastics. It is probable that hundreds of millions of wild birds have consumed plastic, scientists say, and by mid-century, all seabird species on the planet are predicted to be eating it. Certain bird populations are already thought to be threatened by widespread exposure to endocrine-disrupting chemicals contained in plastics. Laboratory studies of fish have found plastics can cause harm to reproductive systems and stress the liver.



Japanese quail chicks in a study—the results shown here—fed microplastics weren't more likely than unexposed chicks to get sick, die, or have trouble reproducing, though they did show minor delays in growth.
PHOTOGRAPH COURTESY LAUREN ROMAN

Animal studies have shown the ubiquity of plastic waste and helped inform research into its potential physiological and toxicological effects in humans.

For example, although toxins from plastics can cause adverse health effects

in birds, an Australian study in 2019, in which Japanese quail chicks were deliberately fed such toxins, found the opposite: The chicks suffered minor delays in growth and maturation, but weren't more likely than unexposed chicks to get sick, die, or have trouble reproducing. The findings surprised the scientists, who called them the "first experimental evidence" that the toxicological and endocrine effects "may not be as severe as feared for the millions of birds" carrying small loads of plastics in their stomachs.

Hardesty, one of the co-authors, says the quail study serves as a cautionary reminder that assessing the threat posed by exposure to microplastics is "not that simple." In particular, she says, the difficulty finding clear evidence of harm in quails "really highlights that we are still not able to answer the question of what the impact of eating plastic is for humans in a definitive way."

Plastics in humans

Measuring possible adverse effects of plastics on humans is far more difficult than on animals—unlike quail and fish, human subjects can't intentionally be fed a diet of plastics. In laboratory tests, microplastics have been shown to cause damage to human cells, including both allergic reactions and cell death. But so far there have been no epidemiologic studies documenting, in a large group of people, a connection between exposure to microplastics and impacts on health.

Instead, research has involved small groups of people—a factor that limits conclusions that can be drawn beyond identifying the presence of microplastics in different parts of the body. A 2018 study found microplastics in the feces of eight people. Another study documented the presence of microplastics in the placentas of unborn babies.

The recent study by Vethaak and his colleagues found plastics in the blood of 17 of 22 healthy blood donors; the lung study found microplastics in 11 of 13 lung samples taken from 11 patients. Virtually nothing is known about either group that would help inform the level and length of exposure—two essential attributes to determine harm.

In both studies the plastic particles found were primarily nanoplastics, which are smaller than one micrometer. The ones found in the blood study were small enough to have been inhaled—though Vethaak says it's also possible they were ingested. Whether such particles can pass from the blood into other organs, especially into the brain, which is protected by a unique, dense network of cells that form a barrier, isn't clear.

"We know particles can be transported throughout the body via the river of blood," Vethaak says.The study is one of 15 microplastics research studies underway at the Dutch National Organization for Health Research and Development.

(*Microplastics have moved into virtually every crevice on Earth*.)

The lung study, done at University of Hull in the U.K., showed just how intrusive airborne particles can be. While the scientists expected to find plastic fibers in the lungs of surgical patients—earlier research had documented them in cadavers—they were stunned to find the highest number, of various shapes and sizes, embedded deep in the lower lung lobe. One of the fibers was two millimeters long.

"You would not expect to find microplastics in the smallest parts of the lung with the smallest diameter," says Hull environmental ecologist Jeannette Rotchell. The study, she says, enables her team to move to the next level of questions and conduct lab studies using cells or tissue cultures of lung cells to discover the effects of the microplastics they found.

"There are many more questions," she says. "I would like to know what levels are we exposed to in the course of our lives. What microplastics are we breathing in every day, whether working at home, going to the office, outdoors, cycling, running, in different environments. There's a big knowledge gap."

The question of harm

Scientists aren't entirely fumbling around in the dark. There is extensive research on toxins found in plastics, as well as on lung diseases, from asthma and chronic obstructive pulmonary disease (COPD) to cancer, which kill millions of people every year and have been linked to exposure to other pollutants. The American Lung Association, in its 2022 report, declared COPD, which results from chronic inflammation, to be the fourth leading cause of death in the United States.

Humans inhale a variety of foreign particles every day and have been since the dawn of the Industrial Revolution. The body's first response is to find a way to expel them. Large particles in airways are typically coughed out. Mucus forms around particles further down the respiratory tract, creating a mucus "elevator" that propels them back up to the upper airway to be expelled. Immune cells surround those that remain to isolate them.

Over time, those particles could cause irritation that leads to a cascading range of symptoms from inflammation to infection to cancer. Or, they could remain as an inert presence and do nothing.

The particles identified in the U.K. lung study are made of plastics that are known to be toxic to humans and have caused lung irritation, dizziness, headaches, asthma, and cancer, says Kari Nadeau, a physician and director of allergy and asthma research at Stanford University. She ticked off the symptoms as she went through the list of fibers published in the study.

"We know this already from other published articles," she says. "It takes one minute of breathing in polyurethane and you could start wheezing."

What scientists don't know is if the plastic particles in the lung would meet the level and length of exposure to cross the threshold of harm.

Whether such particles "directly caused asthma for someone's whole life, that would be hard to prove," she says. "I am not saying we should be afraid of these things. I am saying we should be cautious. We need to understand these things that are getting into our body and possibly staying there for years."

Albert Rizzo, the American Lung Association's chief medical officer, says the science is too unclear to draw conclusions. "Are the plastics just simply there and inert or are they going to lead to an immune response by the body that will lead to scarring, fibrosis, or cancer? We know these microplastics are all over the place. We don't know whether the presence in the body leads to a problem. Duration is very important. How long you are exposed matters."

He says the most relevant analogy may be the decades-long effort to convince the government that smoking causes cancer. "By the time we got enough evidence to lead to policy change, the cat was out of the bag," he says. "I can see plastics being the same thing. Will we find out in 40 years that microplastics in the lungs led to premature aging of the lung or to emphysema? We don't know that. In the meantime, can we make plastics safer?"