What plastic pollution does to your body, and what you can do about it

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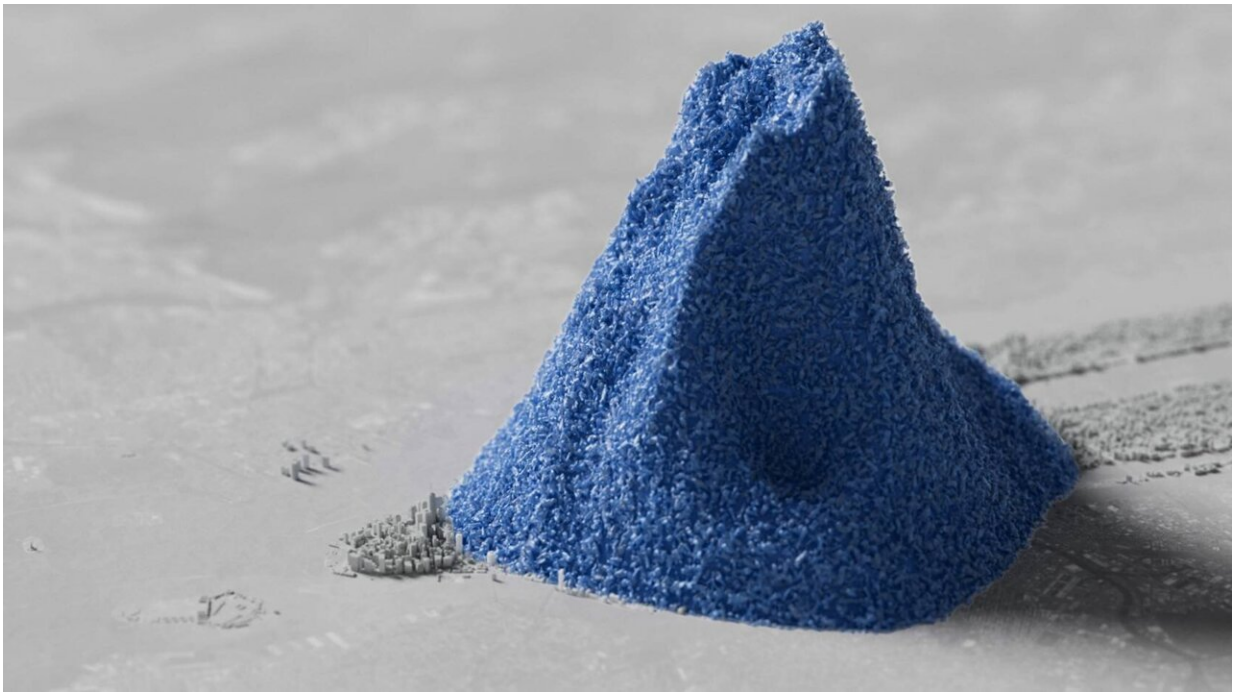

This image of a blue plastic pile represents the cumulative amount of plastic waste that would be generated between 2010 and 2050 — enough to cover the entire island of Manhattan, and ten times the height of the Empire State Building — under a business-as-usual scenario where no aggressive policy actions are taken. Credit: Benioff Ocean Science Laboratory

Plastics and the long-lasting chemicals they're made of are accumulating in our oceans, leaching into our farm fields and piling up in landfills.

Plastic is floating in the air and falling from the sky. It's also turning up in remote, isolated caves … so even if you have been living under a rock, you might have cause for concern.

What does all this plastic pollution mean for the health of people and the planet? And what can we do about it? Experts across the University of California are tackling our big plastic problem from every imaginable angle, from chemistry to engineering, policy to art, medicine to oceanography.

They're coming back with key insights for elected officials and everyday Californians. And they're developing practical solutions to many of the dangers that plastics pose.

This is your body on plastic

Scientists have documented plastic's environmental costs for decades, says Tracey Woodruff, a professor of obstetrics and gynecology at UC San Francisco. "Even though we know plastics are essentially everywhere we look, there's actually not that much research on how they affect human health," Woodruff says.

California legislators concerned about these health effects recently came to Woodruff for advice. Lacking much data on humans, Woodruff consulted research on animal subjects. Nearly two dozen scientific papers later, she and her team at UC San Francisco's Program on Reproductive Health and the Environment published a report concluding that exposure to plastics appears to reduce fertility and increase cancer risk. They also noted links to metabolic, respiratory and digestive disorders.

Woodruff's research focused on microplastics, particles smaller than about 5 millimeters. "They are essentially invisible, but they're

everywhere," Woodruff says.

These shreds and shards flake off from dishes, clothes, tires and a zillion other plastic items, and then follow gravity, wind and water into almost every environment on earth. Along the way, their chemical residues seep into our food, water, lungs and skin, and from there to our guts, blood, brains, placentas and poop.

Scientists are still trying to untangle the chain connecting plastic exposure to cancer, but they've identified a few key links.

When the immune system detects microplastics, it responds with inflammation, an all-purpose reaction to just about anything the body recognizes as foreign. And certain chemicals in plastics seem to block enzymes that your body produces to forestall the cell-damaging effects of oxidation. Oxidative stress and chronic inflammation have long been linked to cancer.

Microplastics also muck up the endocrine system, which regulates hundreds of bodily functions, from mood to sleep to sex to metabolism. Hormones are literally the key to these functions: they're teeny molecules that float around in your blood until they find and bind with the receptor that matches their specific shape, like a key fitting into a lock.

Many plastics contain a chemical called Bisphenol-A, or BPA. BPA molecules happen to look and act enough like the hormone estrogen that they can get themselves into estrogen receptors—kind of like if you accidentally jammed the wrong key in a lock.

BPA can't unlock the crucial functions that estrogen helps control, including puberty, menstruation and pregnancy. But BPA does block actual estrogen from binding to those receptors, so the hormone can't do

its job. Woodroof points to studies linking BPA to endometriosis, infertility, asthma, obesity and fetal neurodevelopment disorders.

Other plastic chemicals cause trouble before the hormones even have a chance to enter your bloodstream. For instance, pthalates, a class of chemicals that manufacturers add to hard plastics to give them some flex, interfere with the body's production of the hormone testosterone.

"There's a surge in testosterone that happens during fetal development. That's the signal that starts the development of the male reproductive system," Woodruff says. By interrupting the supply of testosterone to male fetuses, phthalates may affect sexual development for life.

"When the child grows up, they may produce less sperm, or their sperm may not all be as functional as they would have been if they hadn't had this exposure as a fetus," Woodruff says.

These findings are alarming, but Woodruff points out that population-scale research doesn't necessarily translate to a noticeable difference in most people's health.

"It's important to remember that these effects are small at the individual level," Woodruff says. That means your biology might tolerate plastic exposure without a loss of function. Or, it might not. "People who were already on the line of having, say, fully functioning sperm may drift over into the other side because of a small push by these chemicals," Woodruff says.

A 'Paris Agreement' for plastics

"Most plastics don't biodegrade in any meaningful sense, so the plastic waste humans have generated could be with us for hundreds or even thousands of years," said Jenna Jambeck, an associate professor of

engineering at the University of Georgia, in 2017. That year Jambeck teamed up with Roland Geyer, an industrial ecologist and professor at UC Santa Barbara, to study what's become of all that plastic.

Humans set over 9 billion tons of plastic loose on the face of the earth between the 1950s and 2015, Geyer estimated—enough to bury an area the size of Argentina ankle deep.

Just 9% of that has been recycled, and 12% incinerated, leaving nearly 80% of all the plastic that's ever been made to pile up in the environment. And if we keep making and tossing plastic at our current pace, we'll add another 4 billion tons by 2050.

That prospect is alarming enough to turn heads at the United Nations. The international governing body is in the process of negotiating a legally binding global treaty, a sort of Paris Accords for plastic.

Ahead of the first meeting in Nairobi last November, scientists at UC Santa Barbara and UC Berkeley launched an AI-powered online tool that integrates population growth and economic trends to forecast the future of plastic production, pollution and trade. It's been a vital source of information for negotiators to understand which strategies are likeliest to meet the goal of zeroing out plastic pollution by 2040.

Some changes matter more than others, the researchers concluded. Requiring manufacturers to use at least 30 percent recycled materials for some kinds of plastic, eliminating unnecessary single-use plastics, building up recycling and landfill capacity and charging a fee for plastic packaging could curb the annual rate of mismanaged plastic waste by 66 percent by 2050.

"I was so thrilled to see scientific proof that a strong treaty could virtually end the problem of plastic waste forever," said Douglas

McCauley, associate professor and director of the Benioff Ocean Initiative at UC Santa Barbara and co-author of the study.

What would a world without plastics look like?

The U.N. plastic treaty faces some formidable obstacles, notably petroleum producing nations, including the United States. "Fossil fuels are used to make plastics," Woodruff says, and it's a lucrative business: Oil companies "make more money off of plastic in some cases than they do off of selling oil for energy."

Anticipating the global demand for oil to recede as the climate crisis accelerates, petroleum producers are expected to ramp up plastic production to make up for lost revenue. "They're like, 'Well, what are we going to do with all this fracking we just did? Oh, we'll turn it into plastic,'" Woodruff says. "That's literally their plan."

Engineers across the UC system are helping push back by devising alternatives to conventional plastics.

- Research from scientists UC San Diego and materials-science company Algenesis shows that their plant-based polymers biodegrade in under seven months. The paper, whose authors are all UC San Diego professors, alumni or former research scientists, appears in *Scientific Reports*.

- Cruz Foam began in a basement laboratory at UC Santa Cruz, where co-founder and CEO John Felts, an electrical and computer engineering Ph.D. student at the time, made his first batch of foam using chitin, the tough, versatile, and completely biodegradable material found in natural abundance in the shells of sea life. Today the company manufactures a Styrofoam replacement used for shipping.

- Scientists at UC Berkeley invented a way to make compostable plastics break down faster and with less energy, solving a problem that has flummoxed the plastics industry and environmentalists. They embedded polyester-eating enzymes in the plastic as it's made. These enzymes are protected by a simple polymer wrapping that prevents the enzyme from untangling and becoming useless. When exposed to heat and water, the enzyme shrugs off its polymer shroud and starts chomping the plastic polymer into its building blocks, such as lactic acid, which can feed soil microbes in compost.

- Lawrence Berkeley National Lab experts engineered a strain of E. coli bacteria that turns plants into a plastic polymer that can be recycled infinitely.

Where should you focus your energy?

Woodruff has learned enough about plastics' health risks that she's changing her habits to reduce her family's exposure, and trying to spread the word far and wide to help others do the same.

But that doesn't mean she thinks the responsibility rests with everyday people, mostly because it's impossible for any one person to avoid every possible source of plastic exposure. Research shows that government bans or restrictions on chemicals tend to work: after bans go into effect, the amount of that chemical in people or the environment declines.

"I gave my kids milk in plastic bottles back when they were young, and now I'm like, 'Oh no,'" she says. "But really, it's not my fault, and it's not your fault. The government should be making sure that I don't have all these toxic chemicals in my house."

Provided by University of California, San Francisco