ATOM & COSMOS

# Hunt for Planet Nine heats up

## Computer simulations add to evidence for presence of orb

**BY CHRISTOPHER CROCKETT**

For a planet that hasn't technically been discovered yet, Planet Nine is generating a lot of buzz. Astronomers have not actually found a new planet orbiting the sun, but some remote icy bodies are dropping tantalizing clues that a giant orb is lurking in the fringes of the solar system.

Six hunks of ice in the debris field beyond Neptune travel on orbits that are aligned with one another, Caltech planetary scientists Konstantin Batygin and Mike Brown report (*SN Online: 1/20/16*). Gravitational tugs from the known planets should have twisted the orbits around by now. But computer simulations suggest the continuing alignment could be explained by the effects from a planet roughly 10 times as massive as Earth that comes no closer to the sun than about 30 billion kilometers — 200 times the distance between the sun and Earth. The results appear in the February *Astronomical Journal*.

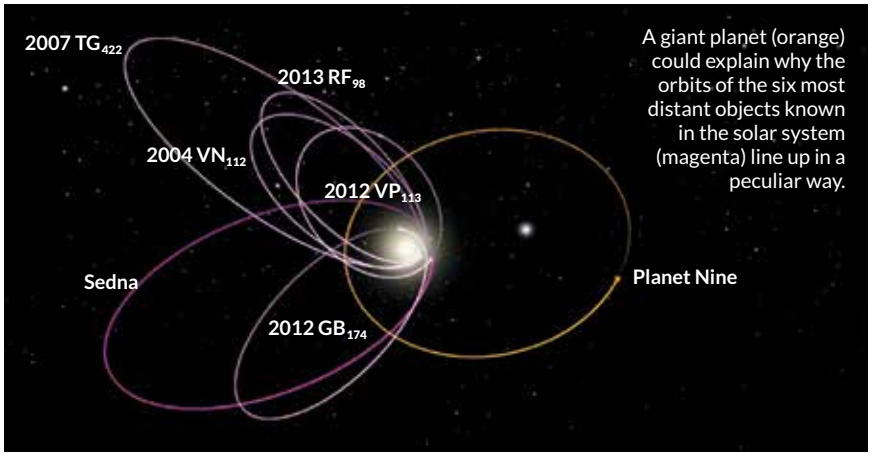
Evidence for a stealth planet is scant, and finding such a world will be tough. Discovering hordes of other icy nuggets on overlapping orbits could make a stronger case for the planet and even help point to where it is in the sky. Until then, researchers are intrigued about a potential new member of the solar system but cautious about a still theoretical result.

"It's exciting and very compelling work," says Meg Schwamb, a planetary scientist at Academia Sinica in Taipei, Taiwan. But only six bodies lead the way to the putative planet. "Whether that's enough is still a question," she says.

Hints of a hidden planet go back to 2014. Twelve bodies in the Kuiper belt, the ring of frozen fossils where Pluto lives, cross the midplane of the solar system at roughly the same time as their closest approach to the sun (*SN: 11/29/14, p. 18*). Some external force — such as a large planet — appears to hold the orbits in place, reported planetary scientists Chad Trujillo of the Gemini Observatory in Hilo, Hawaii, and Scott Sheppard of the Carnegie Institution for Science in Washington, D.C.

This new analysis "takes the next step in trying to find this giant planet," says Sheppard. "It makes it a much more real possibility."

In addition to what Sheppard and Trujillo found, the long axes of six of these orbits point in roughly the same direction, Batygin and Brown report. Those orbits also lie in nearly the same plane. The probability that these alignments are just a chance occurrence is 0.007 percent.




A giant planet (orange) could explain why the orbits of the six most distant objects known in the solar system (magenta) line up in a peculiar way.

R. HURT/IPAC/CALTECH, WORLDWIDE TELESCOPE

"Imagine having pencils scattered around a desktop," says Renu Malhotra, a planetary scientist at the University of Arizona in Tucson. "If all are pointing in the same quarter of a circle, that's somewhat unusual."

A hidden world might explain a couple of other oddities about the outer solar system. Dwarf planets Sedna and 2012 $VP_{113}$, for example, are far removed from the eight known planets (*SN: 5/3/14, p. 16*). Maybe Planet Nine put them there.

The planet would also stir up some of the denizens of the Kuiper belt into orbits that are roughly perpendicular to the rest of the solar system. Batygin was surprised to learn that a population of five such objects exists. When he and Brown compared their simulations of an agitated Kuiper belt with these bodies' cockeyed trajectories, they found a match. "If there was one dramatic moment in the past year and a half, this was it," Batygin says. "We didn't really believe our own story for the longest time. But here was the strongest line of evidence."

Given what scientists know about how the solar system formed, the proposed planet is not native to its current environment. It probably originated closer to the sun and was kicked to the hinterlands after flirtations with the current roster of giant planets.

This wouldn't be the first time scientists were led to a new world by the odd behavior of another. Astronomer Johann Galle found Neptune in 1846 after mathematicians Urbain Le Verrier and John Couch Adams calculated that an unknown planet could be causing Uranus to speed up and slow down along its orbit (see Page 24).

Uranus was a more clearly defined problem, says Scott Tremaine, an astrophysicist at the Institute for Advanced Study in Princeton, N.J. Le Verrier and Adams were trying to understand why Uranus appeared to defy the law of gravity, whereas Batygin and Brown are piecing together a story of how the solar system evolves.

"When we're talking about history rather than laws, it's always easier to go astray," Tremaine says.

The orbital alignments are striking, he says, and Batygin and Brown have done sensible calculations. But he worries about hunting for statistical significance after noting a possible oddity. "That can be very misleading," he says. "The numbers that won the Powerball lottery are an unusual combo, but that doesn't mean anything."

In the meantime, "the hunt for Planet Nine is on," Batygin says. Data from NASA's WISE satellite, which spent nearly nine months making an infrared map of the sky, rule out the existence of a planet as massive as Saturn out to 4.2 trillion kilometers from the sun, and a Jupiter-like world out to three times as far. If a smaller, cooler planet is out there, it's probably in the outer third of its orbit, which puts it against a dense background of Milky Way stars, a planetary needle in a galactic haystack. "It's not going to be impossible," he says. "It just makes it harder."

The Victor Blanco Telescope in Chile and Subaru Telescope in Hawaii are the best facilities for undertaking the search, Schwamb says. Both have cameras that can see large swaths of sky. If scientists don't mind waiting, the Large Synoptic Survey Telescope will come online in 2023. Currently being built in Chile, LSST will image the entire sky once every three days.

"We would be able to detect Planet Nine even if it was moving slowly," says Lynne Jones, an astronomer and LSST scientist at the University of Washington in Seattle. "We could look for motion from month to month or over the course of a year and quickly pick it out from the background stars."

There's also the possibility, though remote, that a serendipitous picture of the planet already exists. Uranus, Neptune and Pluto were all seen before anyone realized they were planets, dwarf or otherwise. Most observations don't record things as faint as Planet Nine. "But there's lots of archival data," Sheppard says, accumulated in observatories as astronomers gather images of stars, nebulas and galaxies. Planet Nine "could be sitting there somewhere." ■

BODY & BRAIN

# Schizophrenia tied to synapse pruning

## Variants of immune system gene implicated in mental disorder

**BY LAURA SANDERS**

From the tangled web of schizophrenia biology, scientists have pulled out one tantalizing thread. Variants of a protein that helps snip connections between nerve cells in the brain may contribute to the disorder, scientists report online January 27 in *Nature*.

"It's not the answer, but it's an answer," says psychiatrist and neuroscientist Henry Nasrallah of Saint Louis University School of Medicine. The findings give scientists a clue that may offer insights into how schizophrenia takes hold of the brain, he says.

This is the first time scientists have moved from genetic studies to a biological insight into schizophrenia risk, says geneticist David Goldstein of Columbia University. "That's why this is a big deal."

The research was sparked by genetic studies that identified a mammoth stretch of DNA on chromosome 6 as particularly suspicious. Called the major histocompatibility complex, or MHC, this DNA chunk carries information used by the immune system to help identify invaders. Why these genes are involved in schizophrenia was a mystery. "The MHC association in schizophrenia was considered an almost intractable problem in human genetics," says study coauthor Steven McCarroll of Harvard Medical School and the Broad Institute.

New ways of analyzing genetic structure gave an answer. It has to do with the snipping of connections, called synapses, between brain cells, McCarroll says. This process, called synaptic pruning, is in full swing during adolescence, when schizophrenia symptoms often appear.

By looking at genetic material of more than 60,000 people with or without schizophrenia, McCarroll and colleagues pinpointed versions of a gene within the MHC called complement component 4, or *C4*, that elevate the risk of schizophrenia. About 1 percent of people get schizophrenia. For people with a version of the *C4* gene that leads to more C4 protein in the brain, the risk increases to 1.27 percent, the researchers calculate.

C4 protein is often found at synapses. In postmortem brains from people with schizophrenia, there were signs that the *C4* gene had been more active than in people without the disorder, the team found. Further experiments with mice showed that C4 protein helps control synaptic pruning. Synapses in the brains of mice that didn't have C4 weren't pruned effectively. That result hints that the opposite might be going on in people with schizophrenia: Too much C4 might cause excessive pruning. A surplus of synapse trimming, particularly during adolescence, may disrupt neural connections and lead to the scattered thinking and hallucinations that often come with schizophrenia.

**1 percent**
Estimated fraction of people who have schizophrenia

Some scientists had suspected that synaptic pruning goes into overdrive in schizophrenia, Goldstein says. Postmortem brains showed a paucity of synapses, for instance. But this study is the "clearest, strongest evidence we have of synaptic pruning" being implicated in schizophrenia, he says.

Synaptic pruning is probably not the only thing that matters for schizophrenia, Nasrallah cautions. A range of genetic and environmental influences could all contribute to the disorder. "There are so many different ways to become schizophrenic," he says. But studying the link between the gene and synaptic pruning may help pinpoint where and how those influences converge in the brain, he says.

Geneticist Dimitrios Avramopoulos of Johns Hopkins University says that while the evidence for C4-related pruning is interesting, it's "not undisputable proof at this point." ■

of PCBs, but females typically discharge most of theirs while lactating. The bad news: The PCBs go into their milk.

The researchers looked at two thresholds at which PCBs cause physiological effects. A lower threshold of 9 milligrams of PCBs per kilogram of body fat comes from experimental studies, and a higher one (41 mg/kg) is linked to reproductive troubles in ringed seals in the Baltic Sea. In comparison, male killer whales sampled in the United Kingdom had mean PCB concentrations of almost 108 mg/kg.

The survey can't say for certain what problems come from the high concentrations. Previous work suggests that PCBs impair reproduction. Jepson notes that Scotland's small population of killer whales looks as if it's going extinct. Only eight known survivors remain.

The high PCB concentrations don't surprise marine mammal toxicologist Peter Ross of the Vancouver Aquarium. He has studied PCB contamination in aquatic life and hasn't seen much improvement in decades. In terms of spotting a menace to the environment before it spreads, "we learned a very hard lesson with PCBs," he says. ■

around a preserved sample of the detritus from which the solar system formed 4.6 billion years ago (*SN: 8/22/15, p. 13*).

Philae and Rosetta showed that features both tiny and enormous look similar on the comet, Sunshine says. Without context, it's hard to distinguish between the rugged terrain around the lander and the cliffs towering about 900 meters over the comet's midsection. "That's telling us something about how this comet was put together and evolved," she says.

Philae might be done exploring, but it won't be forgotten. Ulamec hopes to get some images of Philae this summer as Rosetta cozies up to get a closer look at how 67P changed during its closest approach to the sun. At the end of the mission in September, Rosetta will crash on the comet, snapping pictures all the way down. "It won't be a proper landing," Ulamec says. But at least Philae will finally have some company. ■

M.M. LAHR, FABIO LAHR

HUMANS & SOCIETY

# Massacre hints at early origin of war

## 10,000-year-old skeletons show signs of lethal violence

**BY BRUCE BOWER**

Along the edge of a dried-out lagoon in East Africa, researchers have discovered skeletal relics of the oldest known instance of small-scale warfare.

In a planned assault, attackers killed 12 hunter-gatherers some 9,500 to 10,500 years ago, say biological anthropologist Marta Mirazón Lahr of the University of Cambridge and colleagues. The skeletons unearthed at Nataruk, a site near Kenya's Lake Turkana, show that ancient hunter-gatherers were capable of deadly group raids, a precursor of the more complex forms of war launched by societies and nations, the scientists report in the Jan. 21 *Nature*.

"Lethal raids by competing groups were part of life for hunter-gatherer communities at the time of the Nataruk attack," Lahr says.

The new report adds to the debate over whether war originated tens of thousands of years ago or relatively recently (*SN: 8/10/13, p. 10*).

Lahr's report "is another nail in the coffin of the false idea that mobile hunter-gatherer bands are pacifists," says anthropologist Lawrence Keeley of the University of Illinois at Chicago. Lethal raiding by modern hunter-gatherers, along with the new evidence, supports the view that warfare occurred among similarly nomadic bands of Stone Age people, perhaps by 60,000 years ago, Keeley says.

Biological anthropologist Christian Meyer of the University of Mainz in Germany says the new findings "support the notion that serious intergroup conflict might be as ancient as group identity itself." Group identity is tough to glean from ancient stones and bones. Some researchers suspect that marriages between men and women from neighboring bands fostered alliances and group identities as early as 2 million years ago

This man, clubbed to death sometime between 9,500 and 10,500 years ago, was one of 12 victims of the earliest known example of warfare.

(*SN: 4/9/11, p. 13*). If so, small-scale warfare originated long before the Nataruk attack, says Meyer, who has studied a 7,000-year-old massacre at a European farming village (*SN: 9/19/15, p. 8*).

Anthropologist Douglas Fry of the University of Alabama at Birmingham disagrees. Group conflicts arose approximately 10,000 years ago as some hunter-gatherers established long-term camps in areas with abundant food and water, he argues. Population growth ensued, as did competition for resources, in his view. That's probably what inspired the Nataruk attack, Fry says.

Excavations by Lahr's team at Nataruk and over a dozen nearby sites indicate that the region was an attractive place to live between about 11,500 and 8,000 years ago. Nataruk was probably a few kilometers from the lake near a lagoon. Fossils show that a variety of animals once lived in and around Lake Turkana, including elephants, antelopes and fish.

Age estimates for 12 human skeletons came from radiocarbon analyses of soil, shells and burned wood, as well as two other dating methods.

Ten of the 12 skeletons had signs of lethal wounds. Five, maybe six, individuals displayed probable arrow wounds to the head and neck. Five people had been hit with clubs, three between the face and ear. Clubs of at least two sizes were used, a sign that there were multiple attackers.

Two obsidian arrow points were found among the skeletons. Obsidian is rare in the vicinity, Lahr says, so the attackers probably came from elsewhere.

The two undamaged skeletons had their hands crossed. These individuals were probably bound, Lahr says. ■

GENES & CELLS

# Signs of food allergies seen at birth

## Babies' overactive immune cells may prime body for reactions

**BY TINA HESMAN SAEY**

Some babies are born with immune cells primed to cause food allergies, a new study suggests.

Umbilical cord blood of infants who developed food allergies was loaded with overactive versions of immune cells called monocytes, researchers report in the Jan. 13 *Science Translational Medicine*. Those overexcited cells may push other immune cells to cause allergies, immunology researcher Yuxia Zhang of the Walter and Eliza Hall Institute of Medical Research in Parkville, Australia, and colleagues discovered. The findings may help researchers better understand how food allergies develop and devise strategies to prevent these potentially life-threatening immune reactions.

In the United States, an estimated 4 to 6 percent of children have allergies to such foods as milk, eggs, peanuts and shellfish. In Australia, the rate is even higher: About 10 percent of kids in a recent study in Melbourne had food allergies. Food allergies are on the rise and no one knows why, says Anne Marie Singh, a pediatric allergist and immunologist at Northwestern University's Feinberg School of Medicine in Chicago. Research such as Zhang and colleagues' may help uncover the mechanism behind that increase, she says.

The new results come from the ongoing Barwon Infant Study, which is collecting data on more than 1,000 babies born from 2010 to 2013 in southeastern Australia. The food allergy conclusions come from analyzing data from nearly 700 babies who had blood taken from their umbilical cords after birth. At age 1, 54 of those kids had food allergies.

Children who developed food allergies tended to have monocytes in their cord blood that reacted more strongly to components of bacterial cell walls than did monocytes from kids who didn't get food allergies. How eagerly these white blood cells attack the cell wall component is a measure of immune system activity. For food-allergic kids, the pugnacious monocytes may be an early warning sign that the immune system will go on to attack harmless food proteins.

Overactive monocytes make more inflammation-stimulating chemicals, called cytokines, than normal monocytes do, the researchers found. Those cytokines may push untrained immune cells called T cells into becoming allergy-provoking cells instead of ones that quiet immune reactions, the researchers think. Those cytokines may also prevent T cells from making a protein called IL2, which protects them from morphing into allergy inducers, the researchers say.

Not all of the kids who had the hyperexcitable cells went on to have allergic reactions to foods at age 1, though. "I don't think you could look at our data and cleanly predict a group of children who will go on to develop food allergies," says study coauthor Peter Vuillermin of Deakin University in Geelong, Australia.

James R. Baker Jr. says the new data "fly in the face of some dogma." Usually, a strong inflammatory reaction in babies is associated with a healthy immune response to infections and vaccines, not with allergies, says Baker, an allergist and immunologist at the University of Michigan in Ann Arbor. These results don't indicate how the immune system gets primed, nor do they demonstrate exactly how or why the shift toward allergies happens in some kids but not others.

Singh says she didn't find the results counterintuitive. Evidence suggests that things that occur in pregnancy could influence the development of allergies in kids. But "there are so many complex factors we can't tease out a direct cause and effect," she says. The study picks out "one small piece in a very, very big puzzle." ■

EARTH & ENVIRONMENT

# 2015 smashed heat records

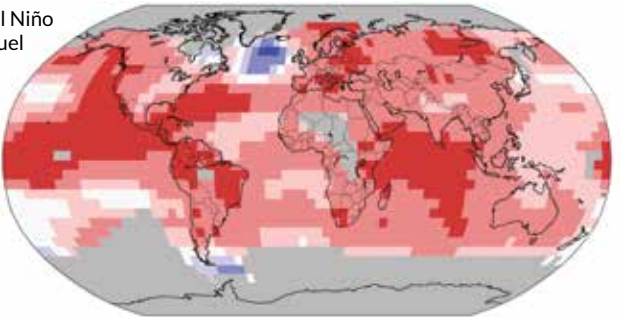
## Warming and El Niño pushed global temperatures up

**BY THOMAS SUMNER**

Things are definitely heating up. Spurred by global warming and a "super El Niño," 2015 became, by far, the hottest year since record keeping began in 1880.

Worldwide surface temperatures were on average 0.9 degrees Celsius higher than the 20th century average of 13.9°, the National Oceanic and Atmospheric Administration and NASA reported January 20 in a joint announcement. That's well above the previous record of 0.74 degrees above average set in 2014.

"2015 was the warmest year because it was warm throughout," Gavin Schmidt, director of NASA's Goddard Institute for Space Studies in New York City, said at a news conference. Ten months set all-time records during 2015. El Niño contributed to higher temperatures near the end of the year, Schmidt said. But even without that extra boost, 2015 "still would have been the warmest year on record," he said. ■




**Heating up** The ongoing strong El Niño and global warming fueled by fossil fuel emissions made 2015 the hottest year on record. Blue areas were cooler than their long-term averages; red areas were warmer.

NOAA

BODY & BRAIN

# Rapid spread of Zika virus raises alarm

## Disease linked to birth defect is pushing northward from Brazil

**BY MEGHAN ROSEN**

The latest virus to break out of the tropics may be the most frightening.

Zika virus, which has already blazed across Brazil and pressed northward into Central America and Mexico, is now poised to jump to the United States. Infection typically causes minor or even no symptoms. But in pregnant women, it has been linked to a birth defect called microcephaly, which leaves babies with abnormally small heads and partially developed brains (*SN Online: 12/2/15*).

The mysterious tropical virus is an arbovirus, one of many that are spread by insects such as mosquitoes and ticks. With the rise in international travel, the rapid emergence — and reemergence — of little-known arboviruses such as Zika may be the new normal, Anthony Fauci and his colleague David Morens suggest online January 13 in the *New England Journal of Medicine*.

"Dengue hit with a vengeance in the '90s. Then we had West Nile in 1999, chikungunya in 2013, and lo and behold, now we have Zika in 2015 and 2016," says Fauci, director of the National Institute of Allergy and Infectious Diseases in Bethesda, Md. "This is a disturbing, remarkable pattern."

Already, travelers have brought Zika home to several states, though the virus doesn't seem to have infiltrated U.S. mosquitoes yet. But the United States, with its warm, humid regions, pockets of poverty and ready fleet of mosquitoes capable of carrying the virus, has all the right ingredients for an outbreak, says Peter Hotez, a pediatrician and microbiologist at Baylor College of Medicine in Houston.

"We've been wringing our hands about Ebola," he says, but "Ebola was never a threat to the Western Hemisphere." Zika is.

Scientists first collected Zika virus in 1947 from a rhesus monkey that was part of an infectious-disease study in the wetland-edged Zika forest of southern Uganda. For decades, the virus flitted between monkeys and mosquitoes, infecting humans only rarely — and until 2007, never outside of Africa and Asia. That's when Zika escaped into the Pacific, causing an outbreak on Yap Island in the Federated States of Micronesia. The virus was spotted in French Polynesia next, in 2013. It came to Easter Island the next year, and in May 2015, the first confirmed cases cropped up in Brazil. There, Zika flourished, gaining a firm foothold in the Americas.

**20**
**percent**
Estimated fraction of people infected with Zika virus who get sick

In less than nine months, Zika infected as many as 1.3 million people in Brazil, the European Centre for Disease Prevention and Control reported on January 21, and some estimates put the number even higher. Zika virus has now spread through 25 countries and territories in Latin America and the Caribbean, the Pan American Health Organization and World Health Organization report.

"The cat's out of the bag now," Hotez says. "Zika virus is going to be all over."

On January 15, the U.S. Centers for Disease Control and Prevention issued warnings for people traveling to countries with Zika (*SN Online: 1/15/16*). Pregnant women, in particular, should be especially cautious, the CDC advised. On February 1, WHO declared Zika virus and its possible link to birth defects a "public health emergency of international concern."

A Brazilian boy holds his baby brother, born with microcephaly in 2015. The birth defect may be linked to maternal Zika virus infections.

FELIPE DANA/AP

Some people consider Zika virus a mild cousin of dengue: Only about 20 percent of infected people get sick, and symptoms (typically a slight fever, rash and pinkeye, to name a few) fade quickly. But a growing body of evidence suggests that the virus could also cause a devastating birth defect.

In Brazil, the number of babies born with microcephaly is steadily ticking up. In 2015, the country recorded roughly 20 times as many cases as in previous years, and new cases — sometimes hundreds — appear every week. On January 27, Brazilian health officials reported a total of 4,180 cases since October 2015, 287 more than a week earlier.

Based on the number of babies born in Brazil in 2015 and the number of microcephaly cases that year, public health researcher Ernesto Marques of the University of Pittsburgh estimates that roughly 1 in 150 babies were born with the birth defect.

"This is just a huge number," he says. "And it's in an outbreak that has just started."

That Zika might wreak havoc in fetal brains isn't all that surprising, given the virus's effect on mice and the neurological problems sometimes observed in infected adults, says Carlos Brisola Marcondes, an entomologist who studies disease-carrying insects at the Federal University of Santa Catarina in Brazil. In lab mice, Zika virus makes a beeline for the brain. "It causes serious damage," says Marcondes. Nerve cells break down and brain tissue softens.

Microcephaly was reported in the 2013–2014 French Polynesia outbreak. In addition, at least 73 people developed neurological conditions such as Guillain-Barré syndrome, which can cause paralysis. Health officials have linked that condition to Zika virus infection in the current outbreak as well.

Early this year, scientists discovered

the most concrete clues yet that Zika virus can cause microcephaly: genetic traces of Zika in the amniotic fluid of two pregnant women carrying fetuses diagnosed with the birth defect, and in four babies who were miscarried or died shortly after birth.

"The evidence is very, very strong," says Marques, but only a few babies have been tested.

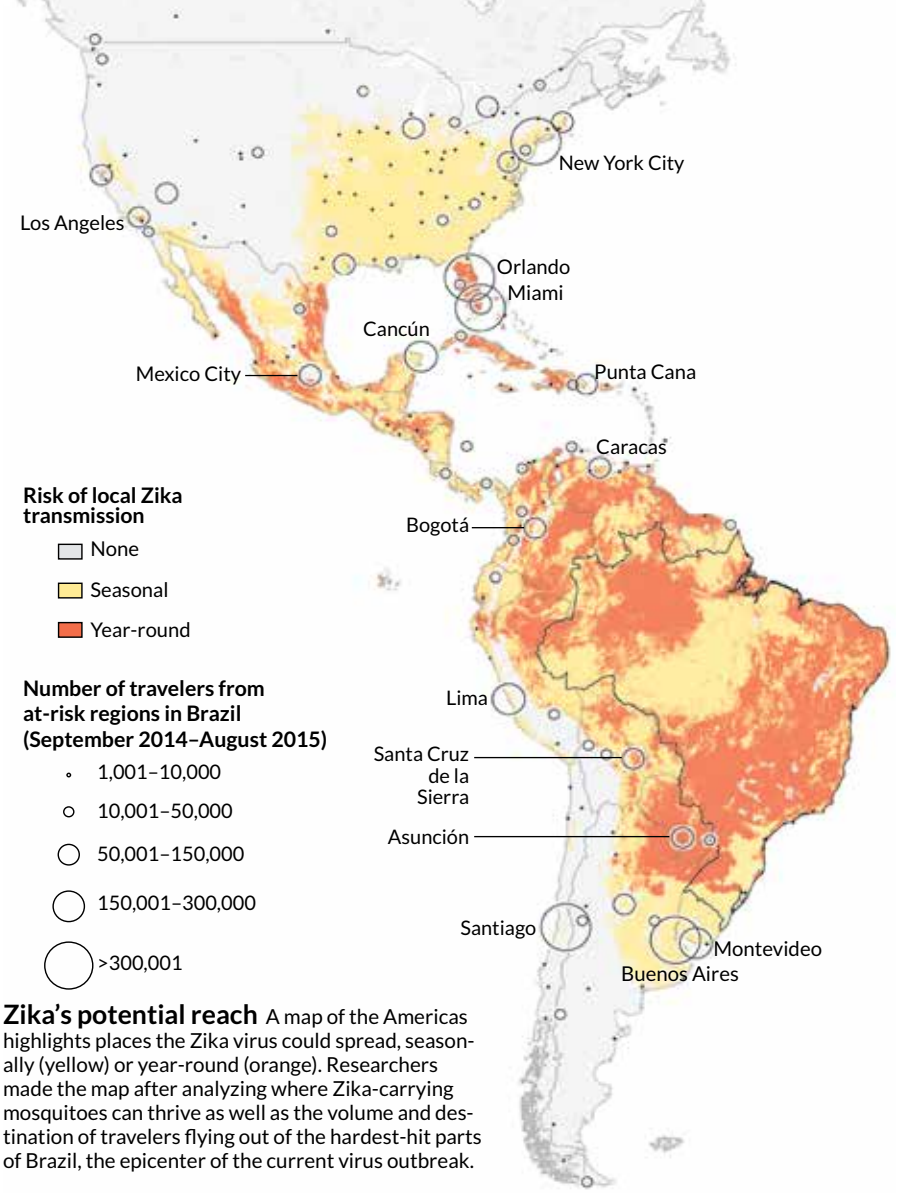
Marques and collaborators in Brazil, England and the United States have begun a study to examine more babies. The researchers aim to enroll 200 infants with microcephaly and 400 infants without the birth defect (all from the hard-hit Brazilian state of Pernambuco) and will look for traces of Zika in maternal blood, umbilical cord blood, amniotic fluid and other tissues.

At this point, Marques isn't expecting to figure out how the virus may cause brain damage; he just wants enough cases to tease out any link between Zika and microcephaly. "If we see signs of viral infection in the placenta or the blood or brain tissue of these babies, that would strengthen the case," he says. The researchers have already begun enrolling people, and Marques hopes to recruit all 600 participants by June or July.

Scientists still have a lot to learn about Zika virus, Hotez says, such as how the virus passes from mother to fetus, and — if infection does cause microcephaly — what exactly Zika virus does to developing brains.

Currently, there's no antiviral therapy for Zika infection and no vaccine. Developing a vaccine could take years, Fauci says. "Even though we started aggressively on it a month or two ago, it's going to take a while before we get one."

In the United States, that could leave millions of people at risk for infection, Isaac Bogoch and colleagues report in the Jan. 23 *Lancet*. Bogoch's team made a global map of places Zika virus could readily spread. The researchers factored in climate, flight patterns out of Brazil and mosquito species that can carry Zika virus, *Aedes aegypti* and *Aedes albopictus*. (Both species hug the U.S. Gulf Coast, and *A. albopictus* fans out across the Southeast and up along the East Coast, ranging as far north as Connecticut.)




**Zika's potential reach** A map of the Americas highlights places the Zika virus could spread, seasonally (yellow) or year-round (orange). Researchers made the map after analyzing where Zika-carrying mosquitoes can thrive as well as the volume and destination of travelers flying out of the hardest-hit parts of Brazil, the epicenter of the current virus outbreak.

Over 60 percent of U.S. residents live in areas threatened by Zika virus (at least during warm seasons), the team found. For southern states, especially, "there's a potential for ongoing transmission," says Bogoch, a tropical infectious disease physician at Toronto General Hospital.

Still, that doesn't mean a Zika virus outbreak is imminent, or inevitable, he says. The virus doesn't ordinarily pass directly from person to person, although at least one sexually transmitted case has been reported. And it might not move beyond a handful of confined cases. After all, chikungunya (*SN: 6/13/15, p. 16*) and dengue virus, which ride the same mosquitoes as Zika, haven't hit the United States especially hard.

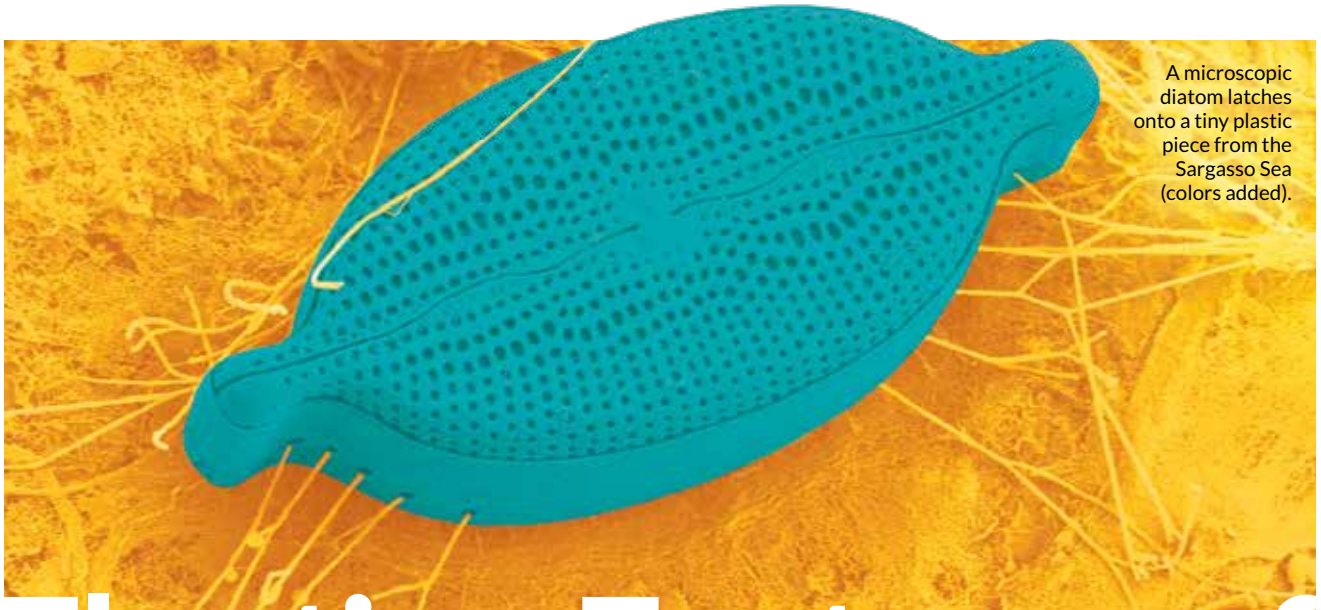
For all these viruses, getting control of an outbreak requires getting rid of mosquitoes, Marcondes advises in a review published online December 22 in the *Journal of the Brazilian Society of Tropical Medicine*. "Preventing breeding is the only way," he says.

Already, Brazil is trying an approach to cut wild mosquito populations by genetically engineering and releasing mosquitoes that can't reproduce.

Fauci agrees that controlling mosquito populations is key. But the recent emergence of so many tropical viruses might also require some new defensive strategies, he says. By finding an antiviral drug that targeted the larger group of viruses that Zika belongs to, for instance, scientists could knock out several threats.

"You would automatically get chikungunya, West Nile, yellow fever, Zika and dengue with one shot," he says. ■

I.I. BOGOCH ET AL/LANCET 2016



A microscopic diatom latches onto a tiny plastic piece from the Sargasso Sea (colors added).

# Floating Fortress of MICROBES

## Microscopic creatures take advantage of plastic debris in the oceans

**By Chris Samoray**

Oceanfront property doesn't come cheap. Except, perhaps, for some seafaring microbes.

Steady streams of tiny plastic pieces making their way into the ocean give microbial squatters a place to take up residence. Each plastic home comes equipped with a solid surface to live on in an otherwise watery world. These floating synthetic dwellings and their microbial inhabitants have a name: the plastisphere.

Microplastics in the ocean run 5 millimeters across or less. Their hard surfaces make them floating oases for some ocean microbes.

Microbes of the plastisphere live in waters from Australia to Europe. They differ by location, are as varied as the plastic they live on and can be a tasty food option for other creatures. What impact — good or bad — the microbe-covered plastic has on the oceans is still in question. Early hints suggest that there may be climate effects and unexpected movement of harmful microbes or other creatures to new destinations. Each study sparks new ideas and new theories.

"This is an opportunity to learn about the ocean from a big experiment that has already been put in place by humans," says marine chemist Tracy Mincer of the Woods Hole Oceanographic Institution in Massachusetts.

### As the plastic multiplies

Plastic is everywhere. Finding it polluting the world's oceans has been a worrisome reality for years. But a discovery more than four decades ago shocked a pair of Woods Hole researchers.

In 1972, scientists were trawling the surface of the Sargasso Sea in the North Atlantic Ocean to collect *Sargassum*, a brown algae seaweed. The researchers' interest was diverted, however, by an unexpected catch: tiny plastic particles.

Repeated net tows caught more plastic. The researchers calculated an abundance of 3,500 small plastic pieces per square kilometer, and were left thinking about the future. "The increasing production of plastics ... will probably lead to greater concentrations on the sea surface," the researchers wrote in *Science*.

FROM TOP: E.R. ZETTLER/SEA EDUCATION ASSOC., FALSE COLOR BY E. OTWELL; S.L. WRIGHT *ET AL/CURRENT BIOLOGY* 2013

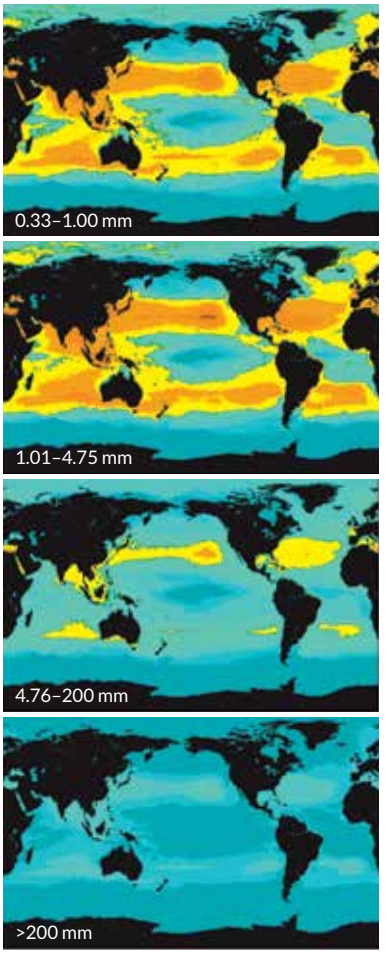
More recent estimates put the amount of plastic floating in the world's oceans at more than 5.25 trillion pieces, weighing more than 268,000 metric tons (*SN: 1/24/15, p. 4*). That translates to as much as 100,000 pieces per square kilometer in some areas of the ocean.

In a few places, the concentration of plastic and other trash has earned a nickname or two. In the North Pacific Ocean, for example, the expanse between Japan and the U.S. western coast is variously known as the "great Pacific garbage patch" or the "Pacific trash vortex."

These floating areas of debris aren't visible to satellites, however. The ocean still looks blue because most of the junk is barely visible tiny bits of plastic.

These microplastics are no bigger than 5 millimeters across and come from many sources. Some are broken bits of larger plastic pieces. Others, such as synthetic fibers from clothing and plastic beads from toothpastes and face washes, escape cleaning filters at wastewater treatment plants and end up in the ocean.

"We treat millions of gallons of wastewater per day in the United States," says Chelsea Rochman, a marine ecologist at the University of California, Davis. She describes the waste as "a concentrated stream" of debris going out into the ocean.




**Plastic waves** Oceans worldwide harbor lots of plastic, some places more than others. As seen in the top two maps, microplastics smaller than 5 millimeters in size make up most of the oceans' plastic. In some areas, concentrations reach 100,000 pieces per square kilometer.

## Diversity rules

During the 1972 expedition, the researchers found a handful of diatom species, single-celled algae, on the microplastics. It wasn't until much later that scientists began to uncover the diversity of microbial life on this plastic flotsam.

In 2013, Mincer and colleagues found an ensemble of microbes thriving on microplastics collected from the North Atlantic Ocean. Some of the microbes made food from sunlight, some ate microbes and some lived on top of other microbes. The colonies grew on two abundant plastics — polypropylene and polyethylene — and were different from microbe populations in the surrounding seawater, the researchers reported in *Environmental Science & Technology*.

Polypropylene, which is often used in packaging, hosted 799 distinct microbe species that weren't found on polyethylene or in the water. Likewise, 413 species were unique to polyethylene, the most common plastic produced worldwide. Seawater samples yielded 1,789 different microbes. Just 53 species populated both the water and the two types of plastic.

These numbers suggest that some microbes living on ocean plastic might not be found in the seawater otherwise. Or they may be present, but in amounts too low to detect. Another possibility is that the microbes hitchhiked on plastic from a different part of the ocean.

Beyond the Atlantic, microbes have been found populating plastics in Australian waters and the vast expanse of water between Hawaii and the continental United States. Coastal northern European countries have collected plastisphere microbes as well. Even the Great Lakes have microbes living on plastic, according to early work by Melissa Duhaime, a microbiologist at the University of Michigan in Ann Arbor.

In many cases, the microbe species differ depending on the water they occupy. There also seems to be a geographic footprint pointing to where the microbes originated, says Linda Amaral-Zettler, a marine microbial ecologist at the Marine Biological Laboratory in Woods Hole and a coauthor with Mincer on the 2013 paper.

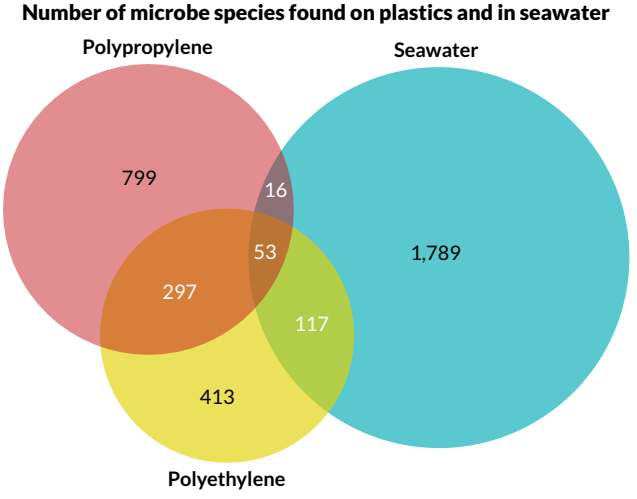
Microbes on microplastics in the North Pacific differed from those in the North Atlantic, Amaral-Zettler, Mincer and colleagues reported in the December *Frontiers in Ecology and the Environment*. Along with geographic variation, the number of microbe species on the plastic pieces also correlated with latitude. Possibly tied to temperature, latitudes closer to the equator had more species than latitudes nearer the poles.

Microbe populations might also change with the seasons, says Caroline De Tender, a marine microbiologist at the Institute for Agricultural and Fisheries Research in Merelbeke, Belgium. "It's something that we suspect is happening," says De Tender, who got a sense of seasonal variety while analyzing plastic pieces from the North Sea near Belgium collected in March and August of 2014. Those results appeared last August in *Environmental Science & Technology*.

Other research supports the idea. Clear differences emerged among microbe communities when researchers left plastic water bottles exposed in the North Sea for six weeks at a time during winter, spring and summer in a study reported in 2014 in *FEMS Microbiology Ecology*. Knowing the geography and environmental factors could help researchers get a better

M. ERIKSEN *ET AL*/*PLOS ONE* 2014, ADAPTED BY E. OTWELL

**Different neighborhoods** DNA fragments revealed that ocean plastic and seawater host their own kinds of microbes. Two common plastics, polypropylene and polyethylene, had hundreds of microbe species not common in seawater. Areas of overlap show microbes that occupy multiple habitats. SOURCE: E.R. ZETTLER *ET AL/ENVIRON. SCI. TECHNOL.* 2013




handle on the amount of plastic going into the ocean and where it's coming from.

## The food chain

To understand the plastisphere, scientists must figure out why microbes congregate on plastic.

For one thing, a hard piece of plastic offers a solid surface to latch on to and grow on in the open ocean. Better still, the plastic acts like a meal plate, serving up an all-day buffet.

"A surface in the open ocean is a real advantage for these guys because it concentrates nutrients that they're competing for," Mincer says.

In the open ocean, the main ingredients of many ocean microbes' diets, such as nitrogen and phosphorus, are often lacking. Like dust on a windowsill, nutrients suspended in seawater will collect on a hard surface. When a piece of floating plastic weighing about one gram is drenched in nutrients, it can grow a microbial community with more biomass than 1,000 liters of open seawater.

While plastic platters of nutrients keep microbes full, they also attract other critters that gobble the microbe-loaded plastic for dinner.

"They smell and taste like something that's good to eat," says Erik Zettler, a microbial ecologist at the Sea Education Association in Woods Hole, who has worked on projects with Amaral-Zettler (his spouse) and Mincer.

It seems that plastic has worked its way up the food chain. Observations of plastic in zooplankton, crabs (*SN: 8/9/14, p. 9*), fish, seabirds and turtles populate the scientific literature.

Rochman, of UC Davis, and colleagues looked for human-related debris such as plastic and textile fibers in fish being sold in Indonesian markets and from fish and oysters for sale in the United States. Out of 76 fish from Indonesia, 21 had plastic in their guts. In the United States, 15 of 64 fish and four of 12 oysters contained human-related debris, mostly fibers from textiles. At least six of the U.S.-sold fish carried plastics, the team reported in September in *Scientific Reports*.

Yet, Rochman says, there's not enough research to say that people shouldn't eat seafood, which is an important source of protein. "What we don't want to do is turn people off to seafood," she says. "I even eat oysters," which can take in a lot of plastic.

## Climate impact

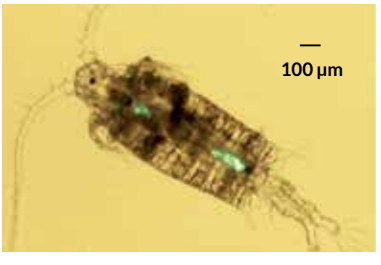
When animals eat plastic, they don't digest it, Rochman says. Any plastic that doesn't get stuck in the digestive tracts of sea critters is let out in the water again. Some scientists think that pooped-out plastic could influence Earth's carbon cycle by releasing climate-warming carbon dioxide back into the atmosphere.

The ocean acts as a big carbon dioxide sink. Normally, microscopic marine plants take up carbon dioxide from the atmosphere. When other organisms eat the plants, they digest what they can and excrete any leftovers as fecal matter that sinks to the ocean floor. That's a good thing, Mincer says, "a geological burial of carbon."

But plastic can destabilize fecal pellets, making them fall apart before they have a chance to sink to carbon-storage depths. When the plastic poop breaks up, it releases nutrients loaded with carbon and keeps carbon at shallow levels.

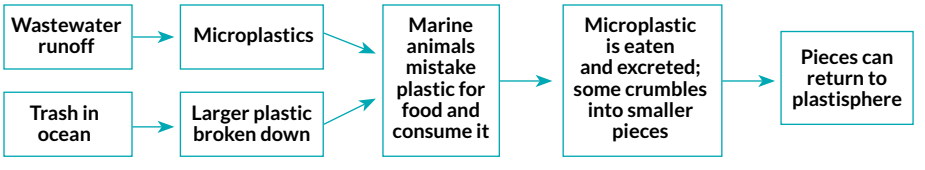
"What you get is a short-circuiting of [the carbon-storing] pump," Mincer says. "You're not getting effective sequestration and burial of that atmospheric carbon."

Some pooped plastic could make it back to the plastisphere, where it has potential to crumble into even smaller bits. A single 200-millimeter plastic piece, for instance, could potentially split into more than 62,000 pieces. Waves and sunlight can speed the breakdown. Microbes might be helping as well.




COPEPOD: REPRINTED WITH PERMISSION FROM M. COLE *ET AL/ENVIRON. SCI. TECHNOL.* 2013, AMERICAN CHEMICAL SOCIETY

**Land-to-sea journey** Ocean plastic comes from wastewater and trash. Hungry ocean critters, like the copepod to the left, sometimes ingest the plastic (shown in green). After the plastic is pooped out, it can rejoin the plastisphere. SOURCE: M. COLE *ET AL/ENVIRON. SCI. TECHNOL.* 2013



At least a few microbes make pits and grooves on plastic, which might trigger breakage. In the Zettler report from 2013, a few microbes in the North Atlantic made pits in plastics that conformed to their rounded shapes. Similar microbes were found making marks in plastic off the coast of Australia. Whether it's normal microbe wear and tear or a sign that the microbes are consuming the plastic is up for debate.

Even if they are munching on the plastic, microbes probably won't rid the ocean of plastic anytime soon. "Most of what we're finding is not on a timescale that is relevant to human existence," says Duhaime, the Great Lakes microbiologist.

The long life of ocean plastic doesn't just give microbes stable space and ready food. It also has the potential to move organisms outside of their native range, like an unanchored houseboat, ready to spread potentially harmful microbes.

"Ships only go port to port," says David Barnes, a marine ecologist at the British Antarctic Survey. "Plastic goes everywhere."

Ocean currents transport plastic, and anything on it, great distances; computer models show some plastics traveling more than 1,000 kilometers in less than 60 days. Barnes has studied washed-up plastic on islands around the world, and he found one piece that had been afloat for at least a year.

Ocean plastic may have helped spread a coral pathogen that causes skeletal eroding band disease from the South Pacific and Indian oceans to Hawaii and even the Caribbean, researchers reported in 2014 in *Marine Biology*. And that's not the first time a potentially harmful organism has been found on plastic.

Vibrio — a fast-growing group of microbes, some of which can cause disease in fish and humans — has been found living on plastics in a couple of studies. Nearly a quarter of the microbe community from one piece of plastic from the Zettler 2013 study was made of vibrio. Usually, vibrio doesn't make up much more than 1 percent of any microbe community.

Duhaime wonders whether some kind of microbe superbug could populate ocean plastics. In an extreme and entirely hypothetical scenario, such a microbe could embark on a transoceanic, transcontinental journey by traveling via ocean currents to different countries.

The plastisphere, created by human trash fouling the oceans, seems to offer a wealth of opportunity for microbes — a chance to eat well and, possibly, see the world. Scientists are just starting to uncover the complexities of this new ecosystem. With all the variables that can shape microbe communities on ocean plastics, says Amaral-Zettler, it's hard to say what to expect. ■

### Explore more


- Erik Zettler. "Life in the plastisphere: What do we know about plastics in the ocean?" COSEE Ocean Systems. April 30, 2014. bit.ly/plastisphere
- Nate Seltenrich. "New link in the food chain? Marine plastic pollution and seafood safety." *Environmental Health Perspectives*. February 2015.


## Cleaning the ocean

Since microbes won't be making a substantial dent in the oceans' plastic load anytime soon, creative types have come up with a few ideas to tackle the problem.

Young Dutch inventor Boyan Slat first caught international media attention in 2013 for his plan to clean up the ocean. Just out of high school, Slat proposed using a long V-shaped array of floating barriers to collect ocean plastic. With the help of ocean currents, plastic pieces concentrate in the center of the V and are scooped up by a conveyer belt driven by solar panels and dropped in a collecting station for recycling. A modified version of the 21-year-old's design will be deployed off the coast of Tsushima, Japan, this year.

A floating village called Seawer is an out-there concept that would strain trash from the ocean using a lineup of different-sized filters. Seawer could catch and store big junk, such as refrigerators and tin cans, as well as small plastic particles. To support human inhabitants living topside, the system would produce hydroelectric power and purify seawater for drinking and irrigation.

Other measures work closer to the source. Baltimore's Mr. Trash Wheel removed at least 213 tons of trash from the city's Inner Harbor last year, stopping plastic and other debris before it reached the ocean. Its 2015 roundup included 118,670 plastic bottles and 2.6 million cigarette butts. There's also an app called Marine Debris Tracker that gives beachgoers a chance to log litter finds in a database researchers use to study ocean trash. There soon may be fewer microbeads to tally. In December, President Barack Obama signed legislation banning plastic microbeads in cosmetics. — *Chris Samoray*

The water-powered Mr. Trash Wheel (top) pulls garbage from Baltimore's Inner Harbor. Boyan Slat's solar-powered design (rendering, bottom) uses ocean currents to gather plastics for recycling.

FROM TOP: WATERFRONT PARTNERSHIP OF BALTIMORE; THE OCEAN CLEANUP