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SCIENCE NEWS MAGAZINE
SOCIETY FOR SCIENCE & THE PUBLIC
DECEMBER 13, 2014

Sweet Dreams, Philae

Mind Control for Genes

Almost Empty Galaxies

Spider Sensors

FACING DISASTER

SPECIAL REPORT

In the Volcano's Shadow

Robot First Responders

How Kids Recover from Catastrophes

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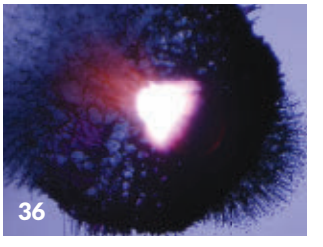

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Departments

COVER After Mount Nyiragongo's last eruption, Goma's citizens rushed to rebuild atop just-hardened lava flows. *GYSEMBERGH Benoit/Getty Images*

CLOCKWISE FROM TOP: COURTESY OF BOSTON DYNAMICS; COURTESY OF H. GELDERBLOM & A. KLEIN/UNIVERSITY OF TWENTE; MICHAEL ALLEN SMITH/FLICKR (CC BY-SA 2.0)

Preparing for disaster, celebrating success

It's not every day that you hear science stories on sports radio. But the Rosetta mission, which involved the impressive feat of landing a robot on a swiftly moving comet, provided an exception. Steve Czaban of ESPN Radio took a break from his usual obsessive football and basketball chatter, if only briefly, to voice his admiration for Rosetta and its slo-mo, balletic conveyance of the Philae lander onto 67P/Churyumov-Gerasimenko. In terms of public appreciation of science, the nod was gratifying. But it also reminded me why *Science News* is needed.

Czaban lauded the prowess and chutzpah of the engineers behind Rosetta, but he didn't say why the mission exists or what key scientific questions it hopes to answer. That deeper view, often missing from mainstream media reports about science, is what *Science News* offers every issue, on as many aspects of science as we are able — from the headline grabbers like Rosetta to the more arcane but still fascinating search for the genetic roots of tameness in felines (see Page 7).

Philae's landing didn't work out quite as planned (see Page 6). But it was by no means a disaster. By any reasonable measure, the Rosetta mission is already a triumph; it successfully acquired data from the surface of a comet, a heroic accomplishment requiring years of preparation and planning by the mission's scientists and engineers.

Preparing and planning for what might go wrong not only are key to success in risky space missions, but also are important for mitigating real disasters back here on Earth.

Three very different looks at disasters make up this special issue. Meghan Rosen reports on Page 16 about efforts to build a robotic first responder — a machine able to venture into rubble-strewn or radioactive sites to save lives or minimize damage. On Page 22, Laura Beil examines current understandings of how catastrophes affect children and who is most vulnerable. And on Page 26, Thomas Sumner describes the difficult job of studying an active volcano so a war-weary city can prepare for its hazards. Science cannot prevent all disasters or solve all the problems they spawn, of course, but it can point to the best ways to prepare, making disasters less damaging than they might otherwise be. — *Eva Emerson, Editor in Chief*

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Phone: (202) 785-2255
Customer service: member@societyforscience.org
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Excerpt from the December 5, 1964, issue of *Science News Letter*

50 YEARS AGO

Magnetism locates ruins

Archaeologists are mapping a 2,500-year-old Greek settlement that man may never see.... A group of scientists have located what is believed to be either the seaport of the half-legendary city of Sybaris, or Sybaris itself.... The ruins are covered by earth and lie 15 feet below the level of water in the ground.... However, the exploring instrument, a rubidium magnetometer, clearly defines their shape, size and location, enabling the archaeologists to map the ruins without physically having seen them.

UPDATE: Magnetometry and other noninvasive techniques are still used to explore sites. Variations in magnetism and electrical signals can reveal buried structures. Ground-penetrating radar, laser technology called lidar and other devices help scientists see through soil, foliage and water. Archaeologists can combine these technologies to make digital reconstructions of sites. Recently, such technologies have helped scientists locate long-lost sites such as a gladiator training school, ancient Khmer urban sprawl and a "super henge" near Stonehenge.

SCIENCE STATS

A look back at 2013's disasters

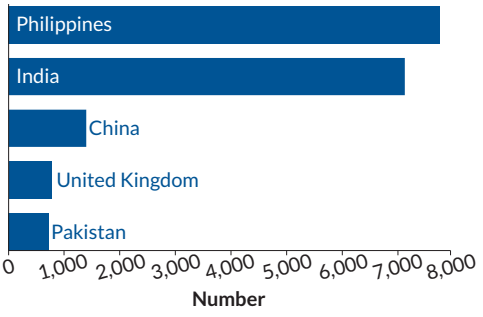
Last year was not so bad overall for natural disasters. With 330 disasters worldwide, 2013 fell well below the yearly average of the preceding decade, 388, according to a report from the Université Catholique de Louvain in Brussels.

But it was a terrible year for the Philippines, which experienced the world's most deadly disaster. Typhoon Haiyan struck in November, killing more than 7,300 people. June's monsoon floods in India killed more than 6,000 people.

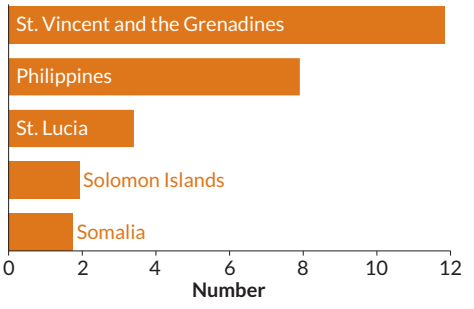
With 13 deaths, the tiny Caribbean nation St. Vincent and the Grenadines, home to around 103,000 people, was the only country to lose more than 0.01 percent of its population to disasters: It and St. Lucia experienced a flood in December.

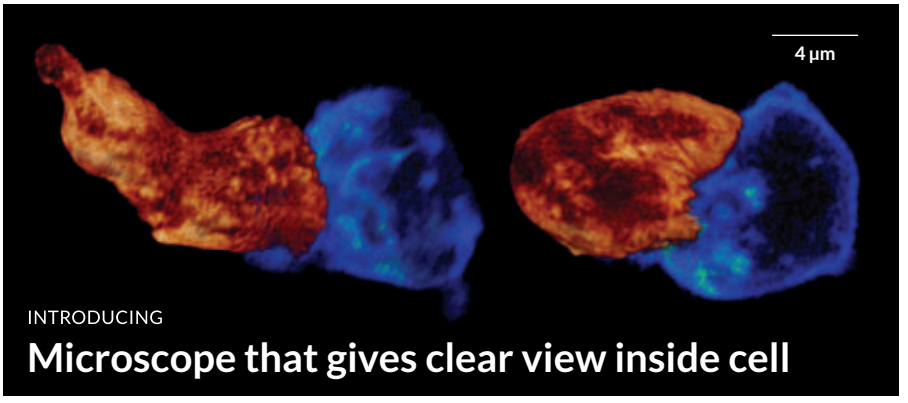
SOURCE: *ANNUAL DISASTER STATISTICAL REVIEW 2013*

Global deaths due to disasters, 2013



Deaths per 100,000 people, 2013





INTRODUCING

Microscope that gives clear view inside cell

A new microscope sweeps lattices of light over samples to give scientists sneak peeks inside living cells without hurting them.

Scientists have previously devised ways to glimpse the hidden machinery of cells, but spying the tiny nuts and bolts in action is tricky. Shining light on cells for too long can bleach their color and even kill them. So 2014 chemistry Nobel Prize–winner Eric Betzig of the Howard Hughes Medical Institute's Janelia Research Campus in Ashburn, Va., and colleagues tweaked a technique to see cells' innards (*SN Online: 10/8/14*). Instead of shooting a focused beam of light at a developing embryo or a virus infecting a cell, the scientists spread the beam out into a grid.

Breaking up the beam dials down the light's intensity and protects cells, the researchers report in the Oct. 24 *Science*. Using this lattice light-sheet microscope, the scientists were able to watch as a cancer cell navigated through a sticky thicket of protein and as an immune cell (shown in orange) stretched out and glommed on to another cell (blue-green). —*Meghan Rosen*

BETZIG LAB/HHMI

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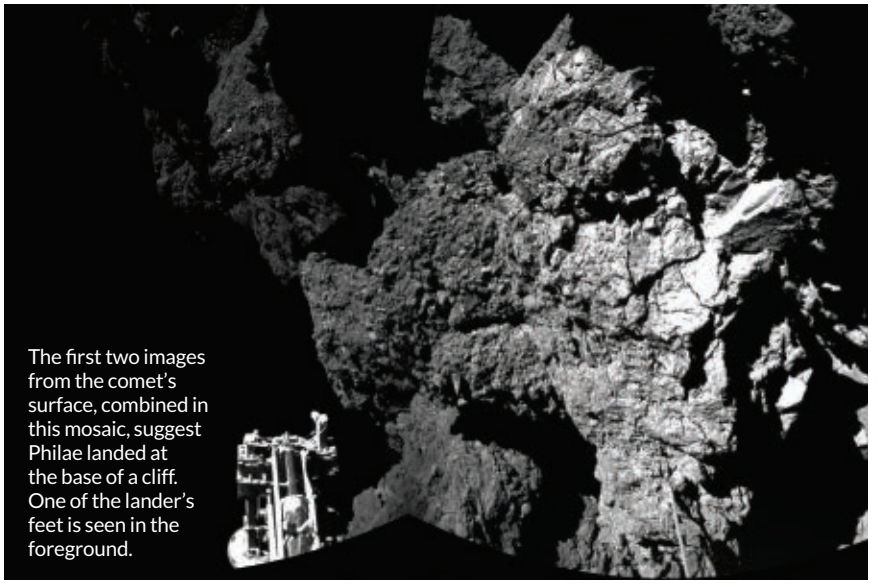
ATOM & COSMOS

Comet lander's exploration cut short

Despite rough touchdown, Philae able to collect some data



The first two images from the comet's surface, combined in this mosaic, suggest Philae landed at the base of a cliff. One of the lander's feet is seen in the foreground.

CIVA/PHILAE/ROSETTA/ESA

BY ASHLEY YEAGER

On November 12, a robot called Philae fell from its mother ship Rosetta onto comet 67P/Churyumov–Gerasimenko, touching down not once but three times. Philae's final resting place, however, put it in a tough spot — in a crevice, in the shadow of a cliff, with two legs on the ground and one in space.

The precarious position wasn't exactly what mission scientists from the European Space Agency had planned for with the first ever comet landing (*SN: 11/1/14, p. 22*). Resting on two legs, rather than three, raised concerns about whether all of Philae's instruments would work correctly. Worse, the cliff's shadow also blocked solar panels from harvesting enough sunlight to recharge Philae's batteries, leaving the lander with only about 50 hours of power to explore its new home. Mission scientists were left scrambling to wring as many details as possible about the comet before the lander and its 10 instruments went into hibernation on November 15.

One of Philae's instruments revealed that it had gotten a whiff of carbon- and hydrogen-rich organic compounds. Another instrument on the lander provided the first high-resolution image of the comet's surface, released within hours of Philae's settling onto 67P. Taken from a height of only 3 kilometers, the photo showed that the dusty surface is covered with steep cliffs, boulders and other debris.

In the final hours of Philae's battery life, the scientists took risks, programming the lander to hammer into the comet's surface. The hammer penetrated only 10 to 20 centimeters before hitting a hard wall of material, hinting that 67P's surface is a rigid, possibly icy, layer beneath just centimeters of dust.

Another instrument recorded the vibrations of Philae's initial landing, which scientists interpreted as a short, significant thud. The two-second sound clip, released November 20, along with Philae's bouncy landings, corroborates the discovery of a potentially icy layer under the comet's dusty coat, says Martin Knapmeyer, a planetary scientist at the German Aerospace Center in Cologne and the lead scientist on Philae's Cometary Acoustic Surface Sounding Experiment.

Philae drilled into 67P to collect surface samples and deliver them to the lander's ovens for chemical analysis. An X-ray spectrometer also took data to identify elements and molecules at Philae's landing spot. But there are questions about how well these instruments worked.

"A primary question was, Did we have enough data to complete some of the top questions we went there to address?" says Claudia Alexander, who works on the Rosetta mission at NASA's Jet Propulsion Laboratory in Pasadena, Calif. NASA contributed instruments and electronics to the mission.

Philae beamed back a lot of data that will change the way scientists think about comets, Alexander says. "But we're still sorting out the completeness of what we got." Mission scientists will need to combine even more data from other instruments before interpreting how the comet is structured and what kinds of layers it may have within its core.

> The team is confident that Philae will eventually receive enough sunlight to recharge its batteries.

Mission scientists are still hoping that Philae may provide data to answer these questions. In a last-ditch effort to extend its life, the team rotated Philae on November 14 to align a solar panel with the sun. That didn't recharge the robot's batteries. But the team is confident that as Philae rides on 67P into the inner solar system, the lander will eventually receive enough sunlight to recharge its batteries and possibly even restart its exploration. And the Rosetta orbiter is still studying 67P and will remain with the comet until December 2015. Already, according to one report, Rosetta has found unusual levels of heavy hydrogen, indicating that primordial comets didn't provide the Earth's oceans with water. ■

Read more about Philae at **sciencenews.org/rosetta**

GENES & CELLS

Genes tell tale of cat domestication

Traits differing in tame, wild felines linked to DNA variants

BY TINA HESMAN SAEY

A peek into cats' genetic makeup may help reveal how hissing wild felines became purring tabbies.

Genes involved with embryo development differ between wild and domesticated cats, researchers report November 10 in the *Proceedings of the National Academy of Sciences*. The new genetic data support a recent hypothesis about why domesticated animals often have a juvenile appearance.

In July, three scientists proposed that certain physical features shared by domestic animals, described as domestication syndrome, might all result from mild defects in the function of cells known as neural crest cells (*SN: 8/23/14, p. 7*). Neural crest cells migrate to different parts of an embryo and give rise to several tissues, including the bone and cartilage that shape faces, muscles, pigment cells and the adrenal glands, which control the flight-or-fight response.

Some of the genes identified in the new study are involved with neural crest cell development, supporting the idea that changes in the cells can lead to tameness, the researchers say. Genes involved in memory, fear and reward systems in the brain also differed between domestic and wild cats.

It's still too early to say how these genetic changes might affect brain development and lead to the evolution of tameness, says Greger Larson, an evolutionary biologist at the University of Oxford. Many genes contribute to domestication. The combination of the neural crest cell hypothesis and supporting genetic evidence, such as that provided by this study, give researchers clues about which genes or biological systems might be most important for domestication, he says.

Most scientists consider cats only semidomesticated, says geneticist and study coauthor Wesley Warren of Washington University School of Medicine in St. Louis. Pet cats are independent and breed freely with their wild cousins. So the researchers were surprised that they could find genetic signatures of domestication in the animals at all.

Comparison of DNA from Cinnamon, a female Abyssinian cat that lived at the University of Missouri, with DNA from other domestic and wild cats has revealed how domestication shaped cats' genes.

Warren and his colleagues first compiled the genome of a female Abyssinian cat named Cinnamon as a reference to compare with DNA of multiple cats and other species. To look for genetic variants associated with domestication, the researchers examined DNA from 22 cats from six domestic breeds (*Felis silvestris catus*), two European wildcats (*F. silvestris silvestris*) and two African wildcats (*F. silvestris lybica*).

The team looked for regions of the genome where domestic cats are genetically similar to each other but differ substantially from wildcats. The researchers concluded that the 13 genes in five genome regions that they found were associated with domestication. Five of those genes are involved in controlling survival and migration of neural crest cells in the embryo.

It may be that the researchers are overinterpreting their data, says Anna Kukekova, a geneticist at the University of Illinois at Urbana-Champaign who studies tame and aggressive silver foxes. "They cannot say that the changes they found are associated with tameness," she says.

Comparing the cat genome with those of other species, the researchers did discover some genetic variants that help explain some feline characteristics, such as cats' keen eyesight and hearing.

Genes may also reveal what it takes to be a real carnivore. Cats are obligate carnivores: Some nutrients they need are found only in meat. They also have trouble digesting plant-based foods. "No tofu for felids," says study coauthor Leslie Lyons, a comparative geneticist at the University of Missouri College of Veterinary Medicine in Columbia.

Researchers have wondered how cats avoid heart disease when they eat such protein- and fat-laden diets. A genetic analysis reveals that several genes involved in processing lipids have evolved rapidly in cats compared with other species. Those fat-processing genes help the animals stave off the artery-clogging effects of a high-fat diet. Polar bears also eat a lot of meat and have developed similar adaptations, suggesting that those genetic changes may be a signal of a carnivorous lifestyle. ■

FROM TOP: KRISTINA NARFSTROM/UNIVERSITY OF MISSOURI, COLUMBIA; JOACHIM S. MÜLLER/FLICKR (CC BY-NC-SA 2.0)

BODY & BRAIN

Brain regions link odors to words

Smell processing differs from vision, hearing, study finds

BY RACHEL EHRENBERG

The nose may know, but the brain still has a hard time making sense of smells.

Scientists have identified two brain regions that act as an interface between odor and language, helping guide word choices to describe what the nose smells. These regions receive crude olfactory information very early in the brain's smell processing pathways, a new study finds, which may explain why people have a hard time identifying odors.

"Smell is integrated at a very early stage," says cognitive psychologist Jonas Olofsson, who led the study, published November 5 in the *Journal of Neuroscience*. Unlike visual and auditory information, which travel through more circuitry to the brain's language network, smell data seem to come in rough and unedited.

Previous studies had implicated the two brain regions, and it has long been known that most people are pretty bad at naming smells or their components.

"Smell is very holistic. We're not very good at isolating multiple objects the way we are with visual objects," says Olofsson, of Stockholm University.

While people can often tell two smells apart, recognizing a single odor is difficult and often depends on context. "In one context a smell might be identified as a nice cheese, in another it might seem like the person standing next to us needs to wash their clothes," Olofsson says.

To get at what the brain is doing when someone tries to name a smell, the research team put electrodes on the heads of 15 people who then sniffed a particular odor, such as peanut butter or gasoline. The participants were then shown a word that either matched the smell, was related to the smell (as in the word "chocolate" after smelling peanut butter) or unrelated to the smell (the word "chocolate" after smelling gasoline).

When participants tried to figure out whether a smell matched a word, there was a spike in electrical activity toward the back of the brain. When researchers asked participants to view a picture instead of a smell along with the same word sets, electrical activity for unrelated words didn't come from the same area. That suggests that a different brain area was at work when processing an odor cue versus processing a visual one. Participants also made more mistakes

LIFE & EVOLUTION

Massive study maps out insect history

Analysis dates branches on family tree, rethinks relationships

BY SUSAN MILIUS

By analyzing a locust swarm of data — some 1,478 genes from each of 144 kinds of insects and their relatives — a worldwide research team has reconstructed the tale of how insects took over the Earth.

The first insects may have appeared as early as 479 million years ago, 101 members of the 1KITE (1,000 Insect Transcriptome Evolution) collaboration report in the Nov. 7 *Science*.

Insects eventually became the first animals to fly, taking off about 406 million years ago, the researchers calculate. Since then, branching and twigging of the genealogical tree of the six-legged creatures has produced today's wild diversity of form and lifestyle among 32 major groups, or orders: silverfish, beetles, termites, butterflies, glacier-prowling predators called ice crawlers, the enigmatic "twisted wing parasites" and so on.

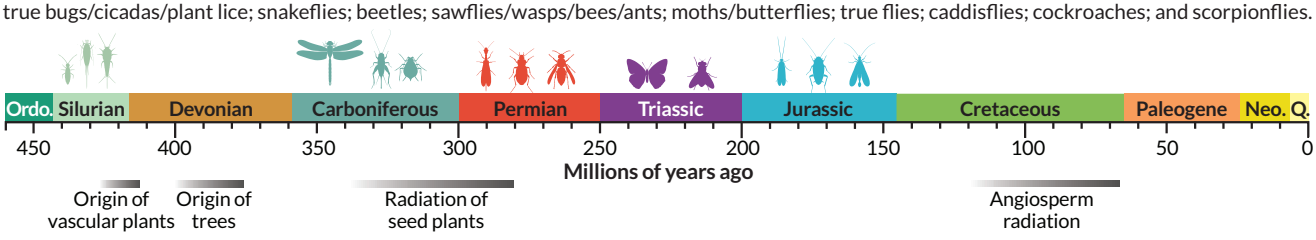
1KITE focused on getting the most possible genetic data out of representative insects from each order. Researchers captured as much as they could of the genetic templates (made from RNA) that genes produce for creating proteins. By working back from all these templates, researchers inferred what the genes were like, and then analyzed the subset of 1,478 genes shared by all insects in the study.

Previous evolutionary studies used at most a couple of hundred genes, and no other study with this technique has covered such a broad group of organisms, says study coauthor Bernhard Misof of the Zoological Research Museum Alexander Koenig in Bonn, Germany. Funds for the extensive lab work came from a Chinese genomics institute called BGI, says coauthor Karl Kjer of Rutgers University in New Brunswick, N.J.

The arrangement of branches of the new genealogical tree is reassuring, says Niels Kristensen of the University of Copenhagen, who was not involved in the study. The new data confirm much of what earlier research concluded about the tree's basic pattern. "Overall it fits my ideas about how things are," he says.

Details have changed, though. Among the tweaks, the collaboration shifted

Insect history A new ancestry tree dates origins of (from left) springtails; jumping bristletails; silverfish; dragonflies/damselflies; crickets/katydids; true bugs/cicadas/plant lice; snakeflies; beetles; sawflies/wasps/bees/ants; moths/butterflies; true flies; caddisflies; cockroaches; and scorpionflies.



1KITE, ADAPTED BY M. ATAROD

when cued with a smell compared with responses to pictures, indicating that the odor-language interface is relatively inefficient at making sense of smells.

A separate group of people underwent fMRI experiments, allowing the researchers to pinpoint the two brain areas deciding what each smell was. These regions, the anterior temporal lobe and orbitofrontal cortex, are closely linked to the olfactory cortex, the brain's primary headquarters for smell information. The findings suggest that these regions talk to brain areas directly involved in language.

Sensory information typically travels through the thalamus, a major brain switchboard, before it's relayed to the cortex, says Johan Lundström, a neuropsychologist at the Monell Chemical Senses Center in Philadelphia. It's intriguing that smell information doesn't seem to do that, he says. ■

the dragonfly order and the mayflies, beloved by fly fishermen, into one ancient lineage. It's a controversial pairing because, among other differences, mayflies molt as adults but dragonflies don't, says David Grimaldi of the American Museum of Natural History in New York. It's an idea that "entomologists have been volleying back and forth ... for decades," he says. Even the new data-rich paper, he notes, calls for more research on the topic.

The study also changes the timing for some landmark insect events. It concludes that modern parasitic lice diverged onto their own evolutionary path about 53 million years ago. That contradicts the scenario of lice going parasitic early enough to vex dinosaurs, as described by Vincent Smith of the Natural History Museum in London and colleagues. Smith says the lousy-dino idea came from less genetic information, but it had many more kinds of lice and more detailed timing calibration than the 1KITE study.

Grimaldi takes issue with dates for some branches in the new tree and calls for more effort to calibrate tree time based on fossils. ■

K. COOK ET AL, NASA, ESA

ATOM & COSMOS

Some galaxies are short on stars

Faint spheres could aid understanding of dark matter

BY CHRISTOPHER CROCKETT

Not all galaxies are filled with stars. Astronomers have discovered a horde of nearly starless galaxies, each about the size of the Milky Way. How they formed is a mystery, and they imply that there are more ways for a galaxy to evolve than previously imagined.

Pieter van Dokkum, an astronomer at Yale University, and colleagues stumbled across 47 galaxies that stopped forming stars long ago. The stars in each galaxy that remain — about 0.1 percent the number in the Milky Way — are spread throughout a sphere roughly the size of a typical spiral galaxy. A stargazer living in one of these galaxies might see only a few stars at night, says van Dokkum. "You need something unusual to create a galaxy like this."

A faint smudge of a galaxy, in the center of a Hubble Space Telescope image, is about the same size as the Milky Way but has relatively few stars.

The galaxies live in the Coma cluster, a cache of more than 1,000 galaxies about 300 million light-years away in the constellation Coma Berenices. Each of the dark galaxies is just a smudge of light found in images that the researchers acquired with the Dragonfly telescope's eight telephoto lenses all pointing at the same patch of sky. The team also found dark galaxies hiding in old pictures from the Canada-France-Hawaii Telescope and the Hubble Space Telescope. The discovery is described in a paper posted online October 30 at arXiv.org.

The galaxies are red, which means they are filled with cool, dim stars. Young galaxies are blue, dominated by light from hot, massive stars. But as those stars die off, the long-lasting red stars remain behind. These dark galaxies are therefore pretty old. "But what pretty old means is difficult to say," says van Dokkum. The galaxies seem to be at least 4 billion years old, but they could also be nearly as old as the universe, which exploded into existence 13.8 billion years ago.

"This is an oddball category of galaxies that have no natural place in our understanding of galaxy formation," says Chris Impey, an astronomer at the University of Arizona in Tucson who was part of a team that found a few similar galaxies in the 1980s lurking in the nearby Virgo cluster. "It's a sobering reminder that our knowledge of galaxies is still incomplete."

Astronomers believe that galaxies start out as dark lumps of matter whose gravity draws in clouds of hydrogen gas. Once the gas becomes dense enough, stars start to form. As the galaxy ages, fresh supplies of gas from deep space or passing smaller galaxies feed the star-building furnaces. As long as hydrogen is available, the galaxy can keep making new stars.

These newly found dark galaxies imply that either stars can form in galaxies that don't have much gas (not likely, van Dokkum says) or that something happened to the galaxies billions of years ago. Perhaps the cluster influenced them in some way, he says, as nearby galaxies stole star-forming ingredients, though that process would tend to reduce the size of the galaxy as well. "The simple answer is: I don't know," van Dokkum says.

These galaxies could be important laboratories for understanding dark matter — the elusive, exotic substance that binds galaxies and clusters together. To survive the gravitational tugs from the rest of the Coma cluster, these galaxies need to be 98 percent dark matter and just 2 percent the normal atoms that make up stars and planets. Impey says the motions of the stars could allow researchers to map how dark matter is spread out within each galaxy. ■

GENES & CELLS

Gut microbes less diverse in humans

Great apes harbor more varied bacterial populations

BY TINA HESMAN SAEY

Humans have evolved a less diverse mix of gut microbes than great apes have.

Compositions of gut microbial communities steadily changed as African apes evolved. But in humans such shifts have reached a frenzied pace with most alterations weeding out microbial diversity, Andrew Moeller, an evolutionary biologist at Yale University, and colleagues report in the Nov. 18 *Proceedings of the National Academy of Sciences*.

Great apes and humans share a common set of intestinal microbes, the researchers concluded after examining fecal samples from wild chimpanzees, bonobos and gorillas and from people living in the United States, Malawi, Tanzania, Venezuela and Europe.

Moeller and colleagues traced how each species' microbes changed as the human and ape branches of the primate family tree split from each other. In the time since the last human-African ape common ancestor, between 8 million and 19 million years ago, the relative microbial mix has undergone 35 major shifts. Nearly half of those have occurred in the human lineage, the researchers found. Those shifts left humans with a few types of bacteria dominating the gut as well as some rare varieties mixed in. Apes' guts contain a wider variety of bacterial types but with each type in fairly low abundance.

Bacteroides bacteria, which are associated with eating meat, increased in abundance in human guts to five times the level found in apes. A microorganism called *Methanobrevibacter*, which helps break down complex carbohydrates from plants, decreased by a similar amount in humans compared with apes.

Human microbiomes have continued to change rapidly. People living in rural Malawi have gut microbe communities more similar to those of bonobos than do people in the United States.

Many of the contrasts between humans and apes may be due to differences in environment and lifestyle. "Gorillas, chimps and bonobos spend a lot of time rolling around in the dirt and grooming each other," Moeller says. They probably encounter a wider array of microbes than do humans, who live indoors, use antibiotics and eat more meat and less fruit and leaves than apes do.

Cooking may have lessened humans' reliance on gut microbes, says Rebecca Stumpf, a biological anthropologist at the University of Illinois at Urbana-Champaign. Cooking breaks down nutrients into easily digestible forms, potentially taking jobs from microbes that would otherwise perform that duty. ■

MATTER & ENERGY

Graphene lets protons slip through

Finding material's loophole offers promise for better fuel cells

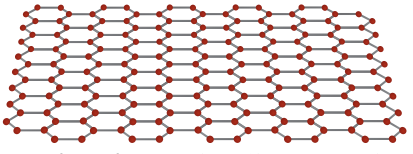
BY ANDREW GRANT

The world's thinnest material has a soft spot for protons.

Despite its impermeability to all atoms and molecules, the slim carbon film known as graphene allows protons to pass through it, new experiments reveal. The finding suggests that graphene and similar ultrathin materials can improve hydrogen fuel cells, which require a barrier that allows only protons to penetrate.

"It's great work and a very important result," says Vikas Berry, a chemical engineer at the University of Illinois at Chicago.

Discovered in 2004 by Andre Geim and Konstantin Novoselov of the University of Manchester in England, graphene consists of a single layer of carbon atoms in a honeycomb pattern. Such ultrathin materials behave very differently than their thicker cousins with the same chemical makeup. For example, graphene conducts electricity far better than its pure-carbon relative diamond.



A graphene sheet consists of just one atomic layer, illustrated here, but its structure prevents other atoms and molecules from penetrating.

One of graphene's most remarkable properties is its impermeability to gases and liquids. Despite its nanometer thickness, a sheet of graphene is a formidable barrier because of the dense swarm of electrons surrounding its carbon nuclei. Physicists had thought that it would take tens of years for a proton to pass through.

Ignoring the predictions, Geim and colleagues tested graphene's proton permeability. The researchers placed a sheet of graphene between electrodes made with Nafion, a polymer that conducts protons but not electrons, and measured whether a current of positive charge flowed between the electrodes. Surprisingly, the team detected a steady current, demonstrating that protons were migrating through the graphene. The current ceased when the team added a second sheet of graphene, suggesting that the additional layer sealed up proton-sized pores in the first sheet. The results were posted online October 31 at arXiv.org.

Geim's team also tested other ultrathin materials. Berry is excited by the high proton permeability of hexagonal boron nitride. He envisions nanometer-thick sheets of boron nitride in hydrogen fuel cells, which convert hydrogen fuel into electricity and harmless waste products such as water. These fuel cells require a membrane that allows protons to pass through but nothing else. Berry notes that graphene's high conductivity of electrons could be an impediment. But boron nitride is an electrical insulator, ensuring that only protons migrate through. ■

E. OTWELL

EARTH & ENVIRONMENT

Spiders enlisted as pollution sensors

Hunting arachnids give glimpse of chemical threats to food web

BY BETH MOLE

Dangling from riverfront webs, spiders may be watchdogs for waterway pollution.

By stockpiling toxic baggage carried by their waterborne prey, these eight-legged monitors can reveal the type, quantity, location and potential biological harm of certain chemicals lurking in water and riverbeds. Spiders may even be better surveyors than some chemical tests, researchers reported November 11.

Along the banks of three rivers around the Great Lakes, scientists collected two types of spiders: long-jawed spiders and orb weaving spiders. Both feast on aquatic insects such as midges that spend their youth in the water, often mucking around in river sediments, where they can pick up industrial chemicals. On the banks, the hungry spiders can build up high levels of chemicals and pass them on to bird predators.

Spiders lurking along riverbanks, such as the long-jawed spider (top), can act as sentinels for pollution, telling researchers the location, amount and source of the contaminants.

The three rivers tested in the study — the Ottawa, Manistique and Ashtabula —are known to harbor contaminants, mainly polychlorinated biphenyls, or PCBs. A family of more than 200 compounds, PCBs are neurotoxic and disrupt hormone systems in some animals and humans, but they are fairly harmless to the river insects and their arachnid predators. Though PCBs were banned in the United States in 1979, their previous use in hundreds of industrial applications, including production of plastics, electrical transformers and dyes, has left a legacy of pollution. Once sunk in riverbeds, the threat that PCBs pose to animals and humans is tricky to predict from water and sediment samples alone.

"That's the big challenge," says environmental engineer Upal Ghosh of the University of Maryland, Baltimore County. The chemicals could stay put in sediments, or some fraction could move into the food web. Using spiders to unravel that threat, he says, is intriguing.

From 2009 to 2013, researchers led by ecologist David Walters of the U.S. Geological Survey in Fort Collins, Colo., collected more than 10,000 spiders living within a meter of the three rivers. By measuring chemicals in five to 20 spiders at each section along contaminated stretches of the rivers, the researchers could gauge which PCBs were seeping out of the waters, what concentrations the pollutants hit, and how dangerous they might be to creatures on land.

"These do pose a risk to wildlife like birds," Walters said of the PCB levels found. Declines in numbers of songbirds such as swallows could be due in part to eating PCB-laden spiders. And, he said, the levels in spiders mimic those seen in fish, confirming the spiders' reliability as sensors. All three rivers have fish consumption advisories, he said.

The researchers could even use the spiders' specific collection of PCBs to pinpoint the source of pollution. For instance, spiders downstream of a paper recycling plant along the Manistique River collected the cocktail of PCBs that had been used in paper recycling.

Walters hopes that the spider monitoring, which is now being used by other researchers, could help keep tabs on polluted sites, track river cleanup methods that can cost millions and identify new hot spots of pollution. ■

RYAN OTTER

MEETING NOTES

Colorado deluge produced flood of drug-resistance genes

The historic 2013 flooding in Colorado left waterways awash in antibiotics and microbial drug-resistance genes, researchers reported November 12. In the months after the disaster, researchers detected record high levels of drugs in the South Platte River Basin, near the state's northern border. Scientists spotted drugs in the headwaters of the river, previously considered pristine. The researchers, led by Joshua Wallace of the University at Buffalo in New York, saw a spike in the genetic fragments that render microbes immune to particular drugs, compared with preflood levels. Microbes resistant to common antibiotics may cause infections that are difficult to treat. Whether the spike in resistance genes is due to a deluge of gene fragments or a surge in drug-resistant microbes remains unclear. — *Beth Mole*

DDT lingers in Michigan town

Decades after a chemical plant sent the now-banned insecticide DDT through St. Louis, Mich., the harmful chemical lingers at highly toxic levels in birds and their eggs, researchers reported November 13. Led by environmental toxicologist Matt Zwiernik of Michigan State University in East Lansing, researchers found that the town's birds suffer from seizures and lesions and have shortened lives. Of 29 dead birds collected between May and August 2013, 10 had gross organ abnormalities, including brain and liver lesions. Levels of DDT and its breakdown products were among the highest ever recorded in wild birds. Many eggs had such high concentrations that they had no chance of hatching. The U.S. Environmental Protection Agency is now working to clean up the town. — *Beth Mole*

BODY & BRAIN

‘Bath salts’ lower brain’s connectivity

Finding in rats may explain drug users’ depression, aggression

BY KATE BAGGALEY

The recreational drugs known as bath salts reduce communication between different areas of the brain, a new study in rats finds. This decline may be tied to the depression and aggressive behavior that some users feel after taking the drugs.

Compared with control animals, rats dosed with one illegal bath salt variant had less synchronized activity, or “functional connectivity,” among the 86 brain areas that researchers examined.

“The higher the dose, the less connectivity you get in the brain,” said neuroscientist Marcelo Febo, who presented the research November 15.

Bath salts are stimulants that boost levels of dopamine, a messenger molecule related to reward and pleasure, as well as norepinephrine and serotonin, which play roles in attentiveness and mood. The drugs are chemically similar to methamphetamine, cocaine and ecstasy, and take their name from their similar appearance to the Epsom salt sprinkled in baths.

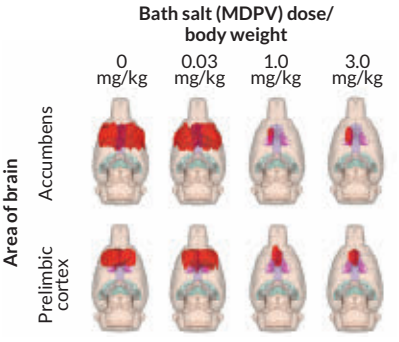
Initially marketed as “legal highs,” the two most common bath salt variants were banned in 2011. One of them, MDPV (3,4-methylenedioxypyrovalerone), is more potent than cocaine, said Michael Baumann of the National Institute on Drug Abuse in Baltimore. “For people experimenting with this drug, if they’re used to doing a line of cocaine and they do the same-sized line of this drug, it’s essentially like they just did 10 lines of cocaine.”

Low doses of bath salts can make users feel euphoric and alert. Within hours of taking MDPV, however, some people experience a powerful crash that can make them delirious, suicidal or violent.

To investigate bath salts, scientists gave 46 rats doses of MDPV or saline, waited an hour and took functional MRI scans of the rats’ brains. In rats dosed with MDPV, functional connectivity decreased widely.

The findings suggest that bath salts have effects that reach beyond the dopamine reward system. “It can happen with other drugs after chronic use,” said Febo, of the University of Florida in Gainesville. Longtime cocaine users can experience panic or anxiety after taking the drug. “But with bath salts it appears to be a much more rapid onset,” he said.

His team must still compare MDPV’s brain effects with those of other stimulants. Without a comparison, it’s unclear whether the results are unique to bath salts, Baumann said. ■



An hour after taking the bath salt MDPV, synchronized activity (shown in red) declined in a rat’s brain, as fMRI scans revealed.

M. FEBO *ET AL*

BODY & BRAIN

Breathing returns to paralyzed rats

Treatment boosts respiration long after spinal cord injury

BY MEGHAN ROSEN

Paralyzed rats can breathe a sigh of relief: A new treatment can restore lung function, even a year and a half after a spinal cord injury that takes it away.

When researchers injected a scar tissue–chewing enzyme into the rats’ spinal cords and then forced the animals to adjust to low oxygen, the rats could breathe easily again, neuroscientist Philippa Warren reported November 17.

Warren’s team is the first to show that respiratory recovery is possible long after a paralyzing injury. For people on respirators, “Even minor improvements in the ability to breathe would be huge,” said neuroscientist Oswald Steward of the University of California, Irvine. Being able to cough and clear one’s throat could help people recover from respiratory infections that might otherwise be fatal.

Spinal cord injuries that hit high in the neck can freeze chest muscles that help people breathe. Normally, the brain tells the body to inhale via nerves that stretch to the diaphragm. This muscle lies beneath the lungs like a rubber sheet, flexing and relaxing to pull and push air into and out of the body. When an injury severs certain nerves in the spinal cord, the diaphragm goes limp.

Though there’s no way to fix breathing ability in people with this type of paralysis, scientists have had some success in rats — but only if the rats receive treatment within weeks of a spinal cord injury. With a chronic injury, scar tissue stacks up, clogging the injury site with fibers that stop new nerves from sprouting.

“The scar tissue never goes away, which means nothing can recover,” Warren said.

To test a chronic-injury treatment, Warren sliced halfway through rats’ upper spinal cords, paralyzing one side of the diaphragm. With half the muscle pumping and half slumping, the animals could breathe but had trouble coping with exercise or changes in oxygen.

Building on a technique developed by her colleagues at Case Western Reserve University in Cleveland, Warren injected an enzyme called chondroitinase ABC into the rats’ spinal cords to clear out scar tissue a year and a half after the injury. Then she placed the rats in a low-oxygen chamber 10 times a day for five minutes. The oxygen cutback forced the animals to breathe deeper and faster, as if they lived at a high altitude, Warren said.

After three weeks of this lung workout, two-thirds of injured rats were breathing like healthy ones, Warren reported. ■

Read more news from the meeting at bit.ly/SN_neuroscience2014

ATOM & COSMOS

Objects with odd orbits return home

Two distant travelers shed light on solar system's formation

BY CHRISTOPHER CROCKETT

Two visitors from the edge of the solar system appear to be returning to their birthplace. One is made of rock, the other slathered in organic compounds. Despite their long journey from the Oort cloud, the icy debris field that envelops the solar system, neither object looks like other bodies from that region. Instead, the objects may be relics from the solar system's formative years, thrown to the Oort cloud while the planets were still forming over 4 billion years ago.

One body, designated C/2013 P2 Pan-STARRS, is making a rare appearance in the inner solar system as it loops around the sun once every 51 million years. Planetary scientist Karen Meech of the University of Hawaii at Manoa and colleagues discovered the object in August 2013, when it was about three times as far from the sun as Earth is.

The object's highly stretched orbit indicates that C/2013 P2 most likely came from the Oort cloud. But the lack of a tail immediately flagged P2 as an oddball. Comets from the Oort cloud, like the recent visitors ISON (*SN: 11/16/13, p. 14*) and Siding Spring (*SN Online: 10/20/14*), typically light up as they approach the sun. Heat from the sun generates long, bright tails of ice and dust. But P2 showed only a barely visible stream of particles trailing behind.

"This was not acting like anything we have seen," said Meech, who presented the discovery November 11.

While investigating P2, Meech and colleagues stumbled across another body passing through the asteroid belt that is also on a cometlike orbit but bearing little ice or dust. The second object, designated C/2014 S3 Pan-STARRS, loops around the sun once every 314,000 years along an orbit that takes it roughly 27 billion kilometers from the sun, or six times farther than Neptune.

Meech and colleagues took a closer look at both objects with the Canada-France-Hawaii Telescope on Mauna Kea in Hawaii. P2 is red, indicating it is covered in organic material; S3 appears to be made of rock. Since P2 looks like objects in the Kuiper belt, the ring of ice boulders just beyond Neptune, and S3 looks like asteroids, which mainly inhabit the inner solar system, both must have formed much closer to the sun than to the Oort cloud.

Scott Sheppard, a planetary scientist at the Carnegie Institution for Science in Washington, D.C., said the composition of S3, in particular, is surprising. Asteroids appear to form only inside the orbit of Jupiter. For a rock to arrive from the backwaters of the solar system, it must have been launched out there long ago. A gravitational nudge might have sent S3 falling back toward the sun after spending billions of years in the Oort cloud. A close encounter with Jupiter could then have redirected S3 into its current orbit.

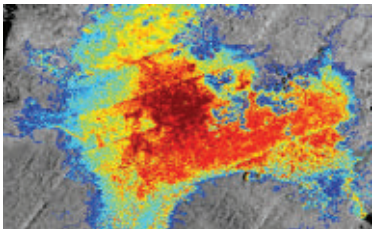
If that scenario is correct, S3 could be a remnant from the solar system's first few million years, when Jupiter is thought to have wandered toward the sun, into the current orbit of Mars, before heading back out. That theory, known as the "Grand Tack model," explains the surprisingly small size of Mars and the locations of objects within the asteroid belt (*SN: 5/5/12, p. 24*). But little direct evidence supports it.

If the Grand Tack model is correct, Meech said, then researchers can pinpoint the origin of Earth's water (*SN Online: 11/1/14*). As Jupiter plowed through the inner solar system, it should have dragged along icy asteroids from the outer solar system that eventually plowed into Earth. Or Earth may have formed entirely from local ingredients.

"This has major implications for forming habitable worlds," Meech said. If Earth needed Jupiter to lob water at it, that may mean that life on exoplanets depends on giant planets setting the stage. ■

A. HAYES *ET AL.*, CORNELL UNIV., JPL-CALTECH/NASA, ASI

MEETING NOTES



Some sections of Ligeia Mare, one of Titan's largest seas, extend 200 meters or more (dark red) below the surface.

Cassini maps Titan's seas

For the first time, scientists have mapped the depths of methane seas on Saturn's moon Titan. The Cassini spacecraft bounced radar off Titan's seas to see how choppy they are. A closer look at the data showed a second, weaker reflection after the first, indicating that the radar penetrated the seas and reflected off the bottoms. In some parts of Titan's second-largest sea, Ligeia Mare, Cassini didn't detect a second reflection, suggesting that the seafloor drops below Cassini's range of 200 meters, Alexander Hayes of Cornell University reported November 10. *— Christopher Crockett*

Unseen planets sweep up dust around young star

Observations of a young star show similarities to what the early solar system might have looked like. Kate Su and Sarah Morrison of the University of Arizona and colleagues found a roughly 10-billion-kilometer-wide gap in the dusty disk encircling HD 95086, a 20-million-year-old star about 295 light-years away. The gap divides the disk into two regions: an inner ring analogous to our asteroid belt and an outer ring similar to the Kuiper belt. Young planets can carve out gaps in disks, but the one known planet orbiting HD 95086 couldn't make one this big. Morrison said November 11 that several additional, not-yet-detected planets would be needed. *— Christopher Crockett*

GENES & CELLS

Human thoughts activate genes

Mind control device switched on protein production in mice

BY TINA HESMAN SAEY

Just by thinking, humans may be able to control gene activity in a mouse.

People's brain waves caused a gene to turn on in mice, researchers report November 11 in *Nature Communications*. The mind control trick isn't telepathy. It's a marriage of two technologies: one that uses bursts of light to turn on genes and one that enables people to control external devices, such as robot arms, with their minds using brain-computer interfaces.

Such mixed technologies may one day head off epileptic seizures before they start.

"It's conceptually interesting," says Brendan Allison, who works with brain-computer interfaces at the University of California, San Diego. But he and other neuroscientists say the study may be fatally flawed because it uses technology that cannot reliably distinguish one type of brain wave pattern from another. "This is certainly many years from human application," Allison says.

For years, Martin Fussenegger, a synthetic biologist at an ETH Zurich facility in Basel, and his colleagues have designed molecules that can tweak gene activity in response to light, a technique called optogenetics. A certain wavelength of light activates light-sensing proteins. Those proteins then perform a job such as turning gene activity on or off or causing nerve cells to send electrical signals to other cells. Other scientists have used such methods to tinker with mice's memories (*SN: 10/4/14, p. 6*).

Fussenegger got the bright idea to use brain waves to control a lightbulb, which would then switch on a gene in a mouse. He and colleagues engineered cells to contain a gene that would turn on in response to infrared light. The gene encodes the information needed to make a protein called secreted alkaline phosphatase, which has no biological activity in mice but can be measured in their blood. Cells containing the infrared-activated gene were sealed into a capsule that the team could implant under a mouse's skin. Along with the capsule, researchers implanted a near-infrared light-emitting diode, or LED.

When activated, a wireless LED implant (left) inserted under the skin of a mouse (right) turned on certain genes in the mouse. The LED was controlled by the brain activity of human volunteers.

Volunteers in the study wore a headset to measure electrical activity with an electroencephalograph, or EEG. Researchers asked the volunteers to relax, concentrate or do an exercise in which they learned to control their own brain waves.

"It was hard for most subjects to relax on demand," says Fussenegger, so participants did breathing exercises to unwind. To induce concentration, the volunteers played the computer game Minesweeper.

Wireless signals from the EEG headset flipped on the LED when volunteers reached the desired brain state. The light then turned on production of alkaline phosphatase.

Fussenegger hopes to create a device that could detect brain waves presaging a seizure in people with epilepsy and could trigger cells to pump out seizure-stopping proteins.

The problem for studying brain control in this case is that the technology was inadequate for the task, other scientists say. It is notoriously hard to identify brain states, such as relaxation, even with multiple indicators, let alone with a single brain wave measurement. "It's very unlikely that the [brain-computer interface] outputs accurately reflected the subjects' mental states," Allison says.

The brain wave signals in the study don't look like true EEG signals and could even have been produced by eye-blinks, says José Contreras-Vidal, a biomedical engineer at the University of Houston. "I'm not convinced that's what they say it is."

Still, Allison says that collaboration with researchers who are well versed in brain control might produce a viable system that could eventually help people with a wide variety of neurological and psychiatric disorders. ■

BODY & BRAIN

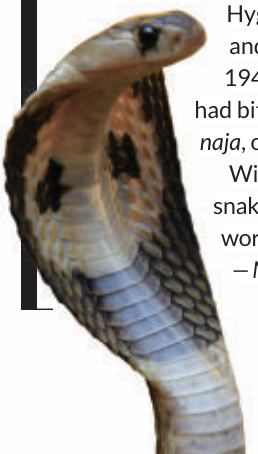
Snakebite test correctly IDs attackers

NEW ORLEANS — Swabbing for traces of snake DNA around bite marks on people can reveal the guilty serpent, a use of forensics that could change how people identify the culprits, a study in Nepal finds.

Snake identification can be lifesaving if it guides use of antivenom, said François Chappuis of Geneva University Hospital, who reported the findings November 4 at a meeting of the American Society of Tropical Medicine and Hygiene. His team used polymerase chain reaction to amplify and identify DNA from snake fluids left near bite marks in 194 patients. The team determined that 87 of the snakes that had bitten people were venomous, including 42 cobras (*Naja naja*, one shown) and 22 common kraits (*Bungarus caeruleus*).

With 21 people who had arrived at clinics with the venomous snake that had bitten them, the scientists double-checked their work and found that their test correctly identified every snake.

— Nathan Seppa



FROM TOP: M. FOLCHER *ET AL./NATURE COMMUNICATIONS* 2014 (CC BY 4.0); MICHAEL ALLEN SMITH/FLICKR (CC BY-SA 2.0)

R. MOTANI

LIFE & EVOLUTION

Extinct reptile took to land and sea

The fossils of a big-flippered sea creature may bridge the gap between landlubbing and water-dwelling reptiles of the Triassic period. The animal, a primitive relative of the dolphinlike reptile *Ichthyosaurus*, may have paddled flexible flippers over sand and used its heavy bones to stand up to waves crashing on shore. Ryosuke Motani of the University of California, Davis and colleagues describe the find November 5 in *Nature*. Scientists had guessed that ichthyosaurs' ancestors were land animals that made their way to the sea. The new skeleton (above) was found in China and belonged to a reptile that's the earliest to show signs of living both on land and in water, Motani says. Named *Cartorhynchus lenticarpus*, the reptile lived about 248 million years ago. — *Meghan Rosen*

EARTH & ENVIRONMENT

Lightning strikes will surge with climate change

Global warming could have an electrifying effect. Climate calculations suggest that U.S. lightning frequency will increase about 12 percent for every 1 degree Celsius in warming, researchers report in the Nov. 14 *Science*. David Romps of the University of California, Berkeley and colleagues considered two factors related to thunderstorm creation: precipitation rate and the amount of energy available to make air rise. The team created a formula that relates the product of these two climate conditions to the lightning flash rate. Comparing their calculations with U.S. climate data collected in 2011, the formula predicted 77 percent of the variability in the U.S. lightning strike rate over the year. The team applied the formula to 11 climate simulations. On average the simulations churned out about 50 percent more lightning strikes in the United States over the next century. — *Thomas Sumner*

MATTER & ENERGY

Milestone algorithm runs on quantum computer

An algorithm that demonstrated the benefit of using quantum mechanics to solve certain problems has been run on a quantum computer. Simon's algorithm, proposed by computer scientist Daniel Simon in 1994, provides instructions for a computer to determine whether a black box returns a distinct output for every possible input. It was the first example of problem-solving software that quantum computers should be able to execute exponentially faster than conventional computers as the problem gets harder. Mark Tame of the University of KwaZulu-Natal in South Africa and colleagues report in the Nov. 14 *Physical Review Letters* that they ran a version of Simon's algorithm on a computer with six quantum bits. The quantum computer ran the algorithm twice on average to solve the problem; a conventional computer would require nearly three tries. The gap in the amount of tries would rise exponentially as the number of possible inputs increased. The algorithm has no practical application, but Tame says the work is a step toward implementing quantum software such as Shor's algorithm (*SN Online: 4/10/14*), which has implications for data encryption. — *Andrew Grant*

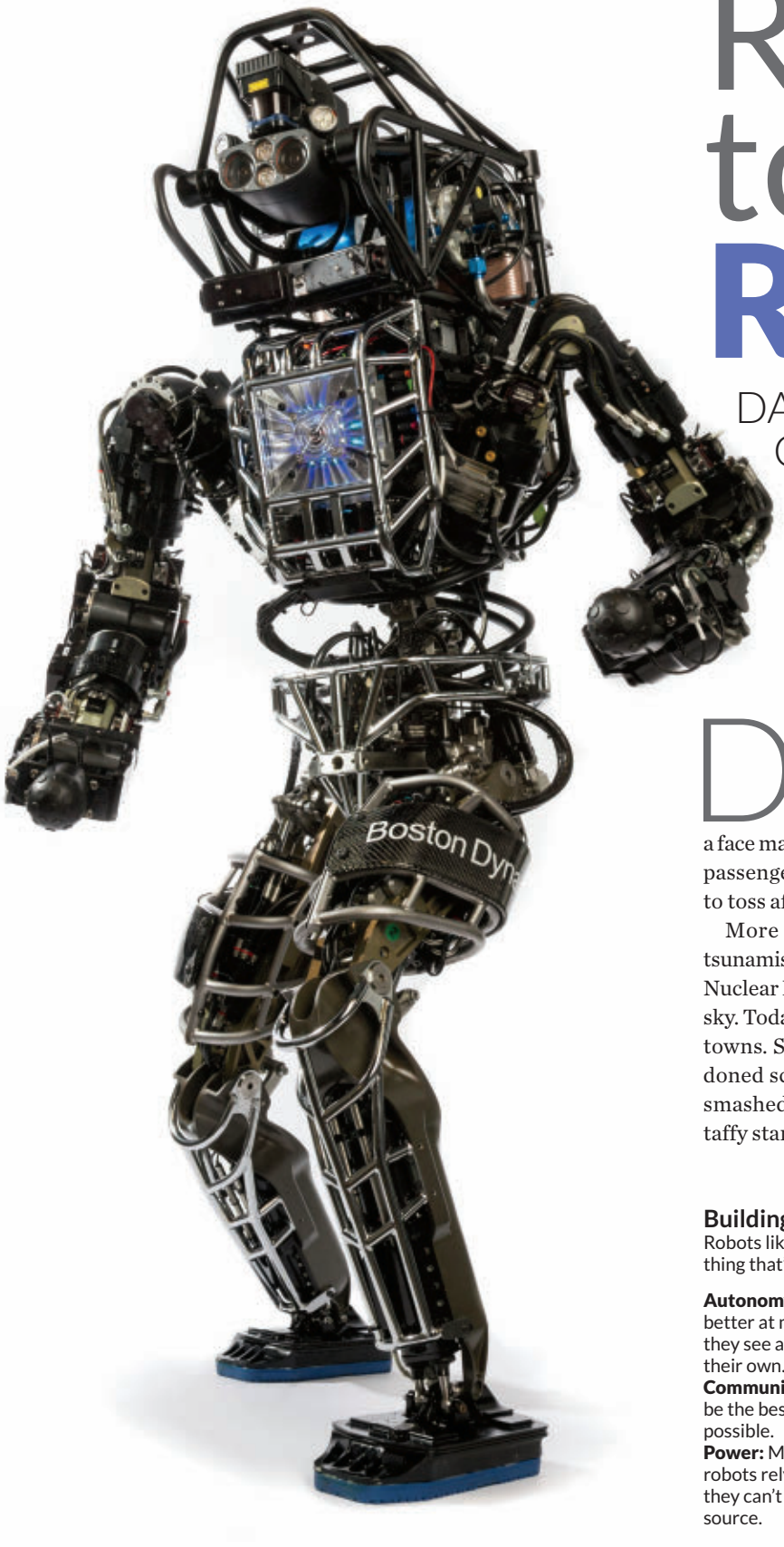
GENES & CELLS

Rare genetic mutations may protect against heart disease

Mutations that inhibit production of a protein involved in cholesterol absorption exist in about 1 in 650 people. These lucky few have substantial protection against heart disease, scientists report November 12 in the *New England Journal of Medicine*. The protein, Niemann-Pick C1-Like 1, facilitates movement of cholesterol from the small intestine into the blood. People with one of 15 mutations in the gene encoding this protein have lower levels of low-density lipoprotein. LDL delivers cholesterol to cells, but excess LDL contributes to plaque formation in arteries. Scientists at Washington University in St. Louis and colleagues looked for mutations in the Niemann-Pick gene in over 22,000 people. Thirty-four people carried a mutation that switches off the gene's protein production. Having only one working copy of the gene, their likelihood of heart disease was roughly halved. The carriers' LDL cholesterol levels also averaged 12 points lower than noncarriers'. A drug called ezetimibe, marketed as Zetia, lowers LDL by inhibiting activity of the same protein. — *Nathan Seppa*

Bacteria help norovirus grow in the lab

After decades of effort, scientists have figured out the dirty little secret to growing a common stomach bug in the lab. Bacteria found in feces help norovirus, a diarrhea-causing, vomit-triggering microbe, to infect human cells in plastic dishes, researchers report in the Nov. 7 *Science*. Adding these bacteria along with the virus to human cells could give researchers a way to test antiviral drugs and vaccines, says study coauthor Stephanie Karst , a virologist at the University of Florida in Gainesville. To collect norovirus, researchers strain stool samples to get rid of bacteria and other fecal tidbits. But Karst knew that bacteria help some viruses infect intestinal cells. She wiped out mice's gut microbes with antibiotics and then hit the animals with a mouse version of norovirus. In these mice, virus levels dropped. To see if gut bacteria boosted norovirus in humans, the team dosed human immune cells with unfiltered stool loaded with gut bacteria. The cells became viral factories, cranking out more copies of norovirus than did cells hit with cleaned samples. — *Meghan Rosen*



ROBOTS to the RESCUE

DARPA's Robotics Challenge inspires new disaster-relief technology

By Meghan Rosen

Dennis Hong first spied Japan's ruined nuclear power plant from a bus wrapped in plastic.

A hefty layer of protection guarded the seats, floors and handles from radioactive dust. Hong wore a face mask and gloves to limit his own exposure. Like the other passengers, he had dressed in old clothes that he was willing to toss after the trip.

More than three years earlier, after an earthquake and tsunamis battered Japan's eastern coast, the Fukushima Daiichi Nuclear Power Station blew, blasting radiation into the sea and sky. Today, villages outside the plant still lie as barren as ghost towns. Soccer balls and notebooks rest untouched in abandoned schools; hushed houses sit deserted. Along the coast, smashed buildings, flipped cars and train tracks twisted like taffy stand as reminders of the catastrophe.

Building a better bot

Robots like Atlas (left) can do some impressive things, but not everything that's needed to save lives in a disaster. Challenges include:

Autonomy: Robots have to be better at making sense of what they see and executing actions on their own.
Communication: Wireless may be the best option, but not always possible.
Power: Most disaster-relief robots rely on power cords, so they can't go far from their energy source.
Strength: It takes strength to turn a valve or push aside debris.
Driving: Robots can drive cars, but getting them in and out of a vehicle is tricky.
Manipulation: Humanlike fingers can grasp door knobs and pick up tools, but they can easily break.
Mobility: Staying balanced is a big challenge for a humanoid robot trying to walk on rough terrain.

COURTESY OF BOSTON DYNAMICS

"It's like a disaster site frozen in time," Hong says. "It's surreal."

Workers toiled day and night to save the plant, but they had to get out as radiation levels rose. Even in disaster areas not tainted with radiation, picking through the shambles of destroyed buildings is treacherous: People need to dodge shards of glass and metal and duck clouds of smoke and dust.

Ideally, robots could take over for human crews. But seemingly simple tasks, such as walking, communicating and staying powered up, still pose big challenges for machines.

Hong, a UCLA roboticist, is one of several engineers racing to make robots that can come to the rescue in disasters. He and others from academia, industry, NASA's Jet Propulsion Lab and the Department of Defense research agency known as DARPA traveled to Fukushima this spring to see what they were up against. "The take-home message was, 'Wow, it's damn difficult,'" Hong says.

Engineers have built impressive-looking humanlike bots that can play trumpet and even compete against each other in slow-moving soccer games. But machines that can actually do the work of humans in disaster zones — climbing over rubble, digging through debris for survivors, opening doors and valves — don't exist.

So DARPA kicked off a contest to create robots that someday could do the job. In 2012, the agency announced the DARPA Robotics Challenge, a competition designed to push disaster robotics technology miles past where it is today. A year ago, 17 robotic contenders, including Hong's man-shaped machine, THOR-OP, tackled a rugged obstacle course to try to gain a spot in the finals, to be held in June 2015.

Gill Pratt, a DARPA program manager, knows that researchers might take years to develop robots that could have saved the power plant. But he thinks the competition — with its motley crew of robotics engineers and their rowdy fans — is a good place to start.

On the scene

In the last decade or so, disaster-response robots haven't changed much. When the World Trade Center collapsed in 2001, engineers deployed a handful of lightweight bots to burrow through the rubble.

"These guys went into spaces where the first responders couldn't go," remembers Robin Murphy, a field roboticist at Texas A&M University in College Station. Because 110 floors of concrete and steel crumpled down into dense stacks of dust and debris, she says, ground-penetrating radar couldn't see through the rubble, and search-and-rescue dogs had trouble sniffing out survivors.

The robots, roughly shoebox-sized tanks, offered a new way for rescue teams to take a look. Murphy considers the roving machines a success: A few tunneled deep within the wreckage and withstood extreme heat to find 10 sets of human remains. But the robots didn't locate any survivors, and they ran into a slew of technical snags.

One robot slipped its tread and had to be pulled from the rubble and repaired. Another got wedged in a gap, stalled until rescuers could tug it out by its safety tether. A third robot lost communication, broke its tether, and was never seen again.

Machines at Fukushima faced similar problems. In the days following the earthquake, researchers from around the world sent ground-based and aerial robots to Japan to try to get to spots where humans couldn't safely travel. DARPA sent all it had, Pratt remembers. But training power plant personnel to use the robots took time. And once inside the plant, muddy stairs, tight stair landings and a severed communication cable thwarted the machines' progress.

"We did everything we could, and it still wasn't good enough," Pratt says.

The power plant survived the first hit: an earthquake that thundered beneath the Pacific Ocean on the afternoon of March 11, 2011. The magnitude 9.0 quake, one of the most powerful in Japan's history, hit about 180 kilometers from the Fukushima-Daiichi site — more than the distance from Philadelphia to Baltimore. And the power plant had been built to withstand vigorous shakes.

The quake cut off power, but the reactors shut down automatically as planned and backup generators kicked in to prevent overheating. Less than an hour after the earthquake struck, however, a series of tsunamis roared down upon the plant. One wave towered up to 15 meters high, about three times the height of the tsunamis that Fukushima's buildings had been designed to block.

Seawater flooded in, wrecking equipment and sparking electrical failures in the backup generators. With no power to chill the reactors, water in the cooling systems boiled away. Steam built up, temperatures ticked higher and hydrogen gas collected inside the reactor buildings. Plant workers tried to open valves to release pressure, but radiation levels had climbed too high for people

At 5 feet 2 inches tall and 400 pounds, this bot, called CHIMP, rolls on treads for extra stability. It can turn valves and operate power tools.

> "These guys went into spaces where the first responders couldn't go."
> **ROBIN MURPHY**

NATIONAL ROBOTICS ENGINEERING CENTER/CARNEGIE MELLON UNIVERSITY

to safely endure. They weren't able to vent the gas soon enough to stop the explosions. A day after the tsunamis, the plant's first reactor blew. Over the next three days, two other reactors exploded too.

Ideally, plant workers would have sent in robots to turn the valves and prevent the explosions, Pratt says. But the robots that made it to Japan didn't get inside the plant in time and probably weren't strong enough for the task.

A far cry from C-3PO

Years before, Japan — a country known for its advanced robotics — had actually developed robots to respond to nuclear emergencies. After a power plant accident in 1999, engineers created six huge, treaded robots to open doors, turn valves, carry heavy loads and even clean up radiation. But these bots weren't maintained well enough for use at Fukushima. Even if they had been oiled up and ready to go, at more than 200 kilograms, about the weight of a female polar bear, they may have been too big and heavy to be useful, engineer Keiji Nagatani and colleagues reported in the *Journal of Field Robotics* in 2013.

A smaller robot, designed for disposing of explosives, was the first to make it into Fukushima's reactors, about a month after the earthquake struck. Shin-height and light enough to be carried on a soldier's back, the robot, called the PackBot, uses treads to haul itself over bumpy turf. A skinny arm mounted with a gripper claw and a camera lets the robot grasp and see.

Thousands of these bots, developed more than a decade ago and used at the collapsed twin towers, have worked with military and police to suss out explosives. In the days following the Fukushima earthquake, iRobot, the company that produces the PackBot, rushed to add radiation and chemical sensors to the bots and send them overseas, says engineer Tim Trainer, a vice president of the company.

The sensors came in handy: Plant workers used them to point out places inside the plant where humans could safely explore. But maneuvering the robots through the darkened plant was at times impossible. Though the machines could open doors, the bots' operators had to use two PackBots to do so: one to turn the handle and the second to aim its camera at the first. What's more, the robots struggled to climb the plant's slick metal stairs.

After the PackBot failed to make it up a few flights, workers sent in Japan's version of the machine, a slightly less rugged-looking bot called Quince. But Quince couldn't adapt to stairway landings that were smaller than shown in the building's blueprints, Murphy explains, and the robot's bulky body got stuck. Quince also snapped its tether, leaving the bot stranded in a place where humans couldn't save it.

Given Japan's top spot in the robotics realm, the country's lack of versatile, usable rescue robots surprised people in the field, says University of Pennsylvania roboticist Mark Yim. Not only did Japan have simple ground-roving bots like Quince, but the country had more humanoid machines than anyone else on the planet, he says. Unfortunately, these fledgling gizmos weren't ready to leave the lab. For some humanoids, just making it across slightly uneven floors can be tricky.

"People see a humanoid robot and they think it can do anything a human can do," Yim says. "In reality, it can do very little."

Still, some type of limbed, human-ish machine might be the key to tackling disasters in urban areas, where stairs and doors have been designed for human legs to climb and human hands to open. Adopting a personlike shape could even let robots access tools, Hong says.

After the 2011 quake and tsunamis caused mass evacuations, hundreds of Japanese police and soldiers donned radiation protective gear to search for missing people.

FROM LEFT: © AFLO / MAINICHI NEWSPAPER/EPA/CORBIS; HIRO KOMAE/AP

DARPA Robotics Challenge tasks

During the 2015 finals, robotic contenders will navigate through a gauntlet of tricky tasks. DARPA hasn't finalized the course yet, but it could include a combination of the following obstacles:

1. Drive a vehicle

2. Get out of the vehicle

3. Open door and travel through opening

4. Move debris or climb over it

5. Use a tool to cut a hole in a wall

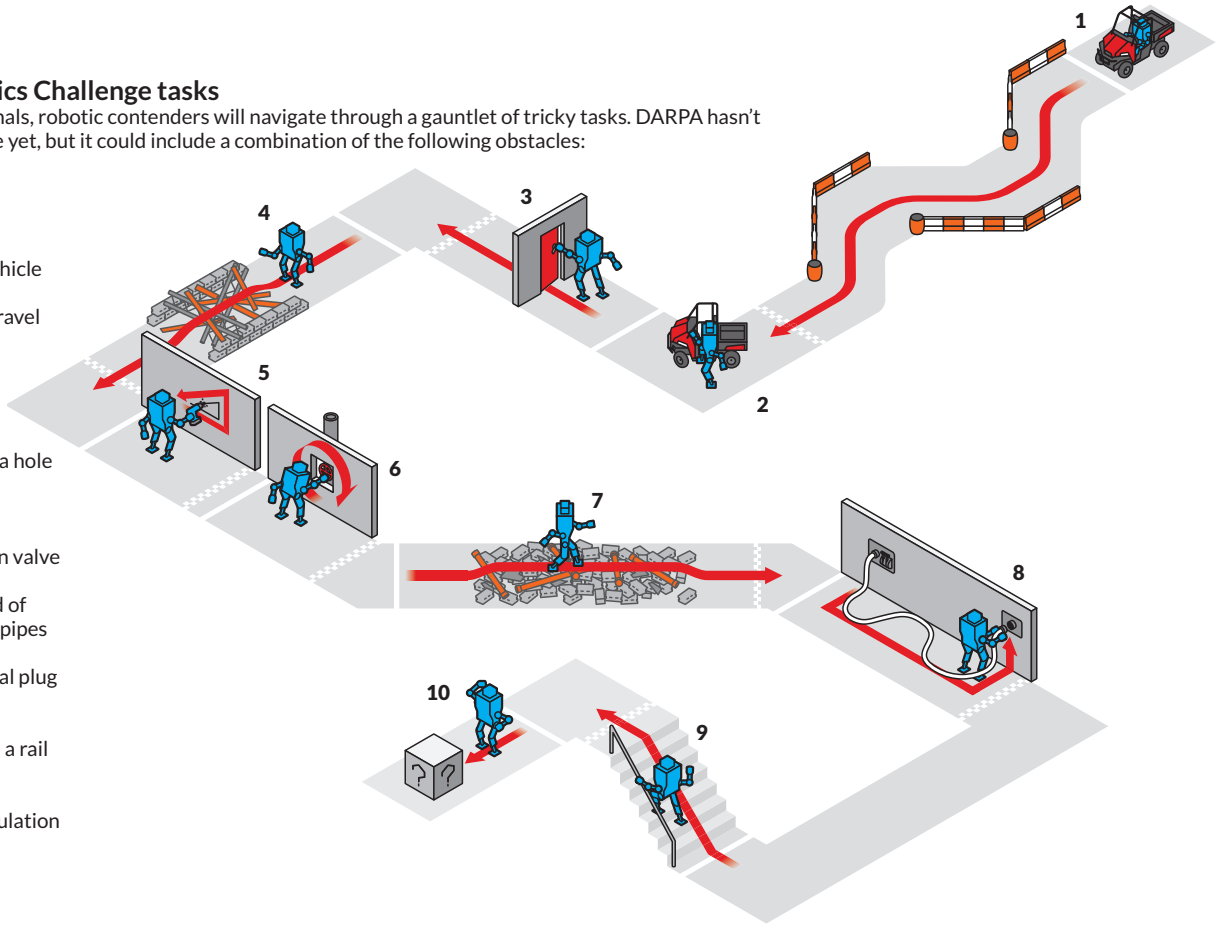
6. Reach through opening and open valve

7. Cross over a field of loose debris and pipes

8. Insert a cylindrical plug into a receptacle

9. Climb stairs with a rail on one side

10. Surprise manipulation task



"At a disaster site, there are bulldozers, excavators, power tools — all this great equipment that people use for rescue missions," Hong says. "So, naturally, a lot of people believe the robot needs to be in a human form."

And in the DARPA Robotics Challenge trials, most contenders were. But these robots aren't anywhere near the C-3PO- or Terminator-style machines of the movies. Today's state-of-the-art humanoids have just begun venturing out of the lab, and they're taking baby steps.

Clash of the bots

Watching disaster-relief robots triumph — or fizzle — at even the simplest tasks can be thrilling. Last December, thousands of cheering spectators flocked to a Florida racetrack to see a medley of high-tech machines in action at the trials. The robots lumbered and lurched through a series of tasks, including opening doors, walking over rubble and turning valves. Here was the future of disaster-relief robots, where the simple act of getting a bot to set a tool on a table is still considered showboating.

Each robot's team set up its equipment in garages used by pit crews during NASCAR events. Crowds gazed down from the stands, while engineers directed the robots through timed 30-minute tasks.

"A lot of these are tasks that a person could complete in a minute or less," says software engineer Doug Stephen of the Florida Institute for Human and Machine Cognition in Pensacola. "But things we take for granted are incredibly hard for a robot." And figuring out how to build a bot that can sail through all of these tasks, rather than designing a specialized door-opener or valve-turner, for example, is even harder.

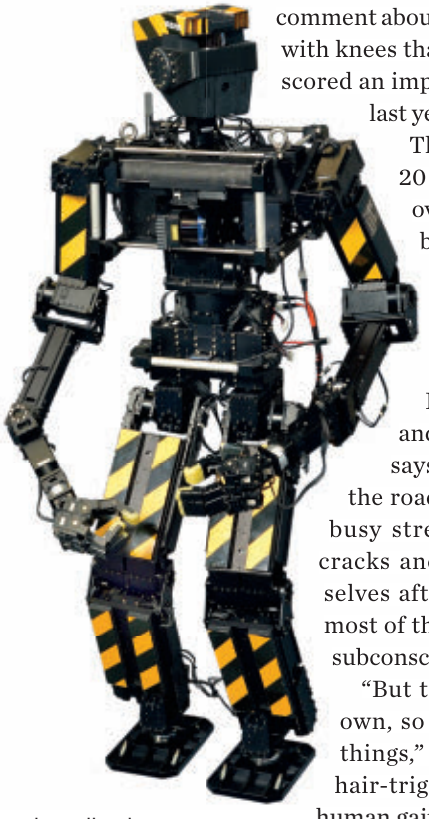
> "It would be really cool to have a robot that can ... burst through the door, save the baby, the whole nine yards."
>
> BRETT KENNEDY

The competition, however, may have already begun to pay off. Teams at the trials dived into the problems that plague humanoid robots — walking, power usage, handling tools. They've created a bevy of bots that could one day do some good in a disaster.

Google has already snapped up the Japanese company that built the first-place finisher, SCHAFT, and later withdrew it from the competition to focus on building its own product. Google declined to

Unlike two-legged bots in the DARPA trials, RoboSimian can crawl on four matching limbs or scoot around on wheels mounted to its rear.

FROM TOP: JAMES PROVOST; NASA/JPL-CALTECH



Though smaller than some of the other bots at the competition, THOR-OP, or Tactical Hazardous Operations Robot-Open Platform, is quick and nimble. It also excels at manipulation tasks.

comment about SCHAFT, a lanky-limbed bot with knees that can bend backwards, which scored an impressive 27 out of 32 points at last year's trials.

The second-place finisher, with 20 points, may be on its way to overcoming a huge challenge in bipedal robotics: locomotion. When it comes to humanoids, Murphy says, "Historically, a lot of focus has been on just walking and not falling over."

Humans don't simply pick up and set down their feet, Stephen says. People tailor their steps to the road on the fly, weaving through busy streets, striding over sidewalk cracks and swiftly rebalancing themselves after stumbles. And they make most of these on-the-spot adjustments subconsciously.

"But the robot has no brains of its own, so we have to tell it how to do things," Stephen says. Capturing the hair-trigger tweaks and easy grace of human gait "is a tough nut to crack." For the DARPA Robotics Challenge, he and colleagues designed software that helps robots "think" on their feet.

Working with a heavy-duty robotic hulk named Atlas, which was developed by Boston Dynamics, a company also recently acquired by Google, the Pensacola team cruised through the rough terrain task at the trials. The monster of a machine, bulging with black wires and a silvery skeleton, stands about as tall as Arnold Schwarzenegger and weighs more than the action hero did in his bodybuilding days. "Atlas is designed to take a beating," says Stephen. "It basically looks like a giant roll cage."

In the trials, their bot conquered a task that involved hiking up a ramp, climbing steps and navigating over jumbled cinder blocks. "It was our big event," Stephen says. A large crowd cheered as the robot picked its way through the course — step by ginger step — without falling.

Other teams handled the walking problem in a less humanlike way. Engineer Brett Kennedy and colleagues at NASA JPL in Pasadena, Calif., built and developed software for a bot they named RoboSimian. Short and sleek, with a headless body and four identical limbs, the lithe little robot is Atlas' opposite. Instead of walking on two legs, RoboSimian sits back on its haunches and scoots around on two wheels attached to its rear. Or it crawls on all fours.

Bypassing the need to balance on two feet saves RoboSimian power. In a disaster, the bot could potentially park itself on its limbs, set the brakes and subsist on tiny sips of energy from a battery while waiting for orders from humans. "It's a very patient robot," Kennedy says.

Patience is a virtue for rescue robots, which can't always rely on power cords when working at the scene of a disaster.

Finding nonhuman ways to tackle problems might even give humanoids the best of both worlds. Dennis Hong's robot, THOR-OP, which looks something like a leaner, friendlier Atlas, was able to turn a valve in one of the trials' tasks by spinning its wrist, rather than turning the wheel hand-over-hand like a human would. Hong presented his research at the IEEE/RSJ International Conference on Intelligent Robots and Systems in Chicago in September, along with work on a new, less-clunky bot with springy artificial muscles.

At the trials, Hong's team finished in ninth place, just one spot shy of advancing to the finals. Hong's team got lucky and made the cut when Google's SCHAFT dropped out of the competition. DARPA expects additional teams to compete in the finals, including some sponsored by the European Union, Japan and Korea.

Though the agency hasn't released many details about the June finals, the teams know that their bots will have to operate without a power cord, and the communication link between robots and team members will switch on and off, like a cellphone dropping a call, Pratt says. Instead of attempting (or opting out of) individual tasks, the bots must power through several tasks in just one hour. The best team receives a $2 million prize.

Engineers competing in the finals agree that even the best bots of the upcoming competition probably wouldn't be ready for another Fukushima. Though, Kennedy says, "I think that we would be able to do better." And the range of technology the competition inspires could lead to many different types of disaster-ready robots.

"Someday, it would be really cool to have a robot that does everything a fireman can do," Kennedy says "Burst through the door, save the baby, the whole nine yards." ■

Explore more

- DARPA Robotics Challenge website: www.theroboticschallenge.org

D. HONG, ROBOTICS & MECHANISMS LABORATORY/UCLA

For an interactive view of Atlas and video of the DARPA Challenge visit **bit.ly/SN_rescuebots**

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Emotional Wounds

Many children, like this young girl in Gulfport, Miss., lost a great deal during Hurricane Katrina. Some recovered more quickly than others.

OSCAR SOSA/BLOOMBERG NEWS/GETTY IMAGES

For some children, the effects of a disaster reach deeper than anticipated

By Laura Beil

On April 19, 1995, an unemployed security guard with an antigovernment vendetta detonated more than two tons of nitrogen fertilizer mixed with fuel at the Alfred P. Murrah Federal Building in Oklahoma City, killing 168 people. A photographer captured a firefighter emerging from the rubble, his thick arms cradling the broken body of an infant, one of 19 babies and toddlers who lost their lives at the building's day care center. The image became the emblem of the nation's horror, recording the bomb's visible toll on the young.

But terror attacks and natural disasters also take a more subtle toll on children: emotional scars that researchers are still working to understand. At the time of the bombing, most mental health experts assumed that sudden tragedy is a psychological lightning strike, a quick shock that dims over time. Few researchers had interviewed children to learn otherwise.

Scientists have now pieced together a story that is much more complex. And like youth itself, it does not adhere to any single narrative. How children fare, and in what way disaster affects a particular child, is an equation with a lengthy list of variables, including a child's mental health before the disaster, how directly he or she was affected by the events and even the emotional consistency of parents during and after the catastrophe. Most children work through the stress and move on. But for a disturbingly high number, a disaster changes the psychological trajectory of their lives, perhaps for years.

"We've learned that children have a variety of reactions, and they're not always mild like people once thought," says Robin Gurwitch, a child psychologist from Duke University Medical Center who was involved in studies in Oklahoma City.

A dose of danger

Just a generation ago, assessments of children who had been through a trauma were largely based on the opinions of adults. In the 1980s,

pioneering scientists began to take the unusual step of questioning children directly, and major themes emerged. High among them was the existence of a "dose-response effect," much like what occurs with medicines. In short, the closer children are to destruction or danger (the greater their "dose" of tragedy), the more likely they are to suffer serious psychological harm.

One of the first studies to demonstrate this followed a tragedy in 1984, when a sniper fired into a Los Angeles school yard, killing one girl and injuring 12 others. Following the attack, a research team led by UCLA psychiatrist Robert Pynoos interviewed 100 children at the school over time to gauge their reactions. More than a year after the shooting, children who were on the playground had persistent post-traumatic stress symptoms, while students who were in the building had recovered, Pynoos and colleagues reported in the *American Journal of Psychiatry*. Friends of the murdered girl continued to grieve, however, no matter where they had been when she died.

For natural disasters, the dose-response effect can apply across a wide swath of the population. Pynoos and colleagues studied children after an earthquake devastated northern Armenia in 1988. A year and a half after the earthquake, he led a study of 231 children in three cities at different distances from the epicenter: the site of the earthquake, 35 kilometers away and 75 kilometers away. Children closest to the damage experienced the greatest severity of PTSD, depression and separation anxiety, the researchers reported in 1993 in the *British Journal of Psychiatry*.

"If you're going to study who is vulnerable to what, you have to study by dose of exposure," says Pynoos, who is codirector of the National Center for Child Traumatic Stress. After large natural disasters, it's often estimated that 25 percent of victims experience persistent psychological disturbances, he says, but that number belies the fact that in some circles the effects reach deeper. After the 1994 Northridge earthquake in California, "there were children, parents and teachers in the epicenter that had actually been trapped; 85 percent of them showed severe levels of PTSD five months post-earthquake," he says.

Studies of other disasters have produced similar findings about the importance of proximity, even among children whose safety is never threatened. One study of more than 3,000 middle and high school students conducted seven weeks after the Oklahoma City bombing found that those who knew someone who was killed were more likely than their peers to experience post-traumatic stress reactions, especially those who had lost a parent or sibling.

Similarly, children who had relatives participating in the manhunt for the perpetrators of the 2013 Boston Marathon bombing were almost six times as likely to have symptoms of PTSD as peers whose relatives were not involved, according to a study published this year in the journal *Depression and Anxiety*.

While studies have found that kids closest to danger are more likely to suffer, the encouraging news is that for most, the effects tend to diminish over time, even when the damage is cataclysmic. Eight months after the 2011 earthquake and tsunami in Japan, researchers interviewed more than 10,000 child survivors in a hard-hit area called Ishinomaki City. Across all age groups, the children's scores on a post-traumatic stress questionnaire were better at 20 months than at 8 months after the disaster, the researchers reported last February in *PLOS ONE*.

Taking science by storm

While symptoms generally subside, a subset of children appear to struggle for years, particularly when they can't reclaim their normal routines. This point became clear in studies conducted after Hurricane Andrew slammed into Florida's southern coast on August 24, 1992, with top wind gusts exceeding 250 kilometers per hour. Andrew coalesced into a hurricane only two days before it made landfall, leaving residents little time to prepare. In the aftermath, more than 160,000 people were homeless.

One of the unexpected findings to emerge from Hurricane Andrew was the discovery of large numbers of silent sufferers — children who express their stress in ways adults don't often recognize, says Annette La Greca, a clinical child psychologist at the University of Miami in Florida. Three months after the storm, she and her colleagues surveyed 568 children at three South Florida elementary schools. Few students, if any, had shown outright distress to their teachers or parents, La Greca says. School officials were convinced that the kids were doing fine.

But when researchers asked the children to respond to a series of questions — such as, "Do you feel more alone inside or alone with your feelings?" or "Have you felt so scared, upset, or sad that you couldn't even talk or cry?" — they found that about 55 percent of the children were showing moderate to severe signs of post-traumatic

Reactions can differ by age

Symptoms of post-traumatic stress in children can sometimes go unnoticed, not easily recognized by adults.

Preschool

- Feelings of helplessness, uncertainty; renewed separation anxiety
- Fear may move into other aspects of life
- May regress developmentally
- Nightmares, fear of going to sleep

School age

- Guilt or shame over what they did or didn't do during the disaster
- Constant retelling of the traumatic event
- Sleep disturbances, fear of sleeping alone, nightmares
- Poor concentration at school
- Drop in school performance or attendance
- Headaches and stomachaches with no obvious cause
- Unusually reckless or aggressive behavior

Adolescents

- Feelings of fear, vulnerability and concern with being labeled "abnormal" or different from peers may cause withdrawal
- Shame and guilt about the event
- Fantasies of revenge and retribution
- May engage in self-destructive or accident-prone behavior

SOURCE: THE NATIONAL CHILD TRAUMATIC STRESS NETWORK

Gulf Coast disasters Families who live along the coast have experienced repeated disasters, both natural and human-made, since Hurricane Katrina. Multiple traumas can prolong stress symptoms among already vulnerable children.

AUGUST 29, 2005
Hurricane Katrina
Category 5
Alabama, Florida, Louisiana, Mississippi

SEPTEMBER 20, 2005
Hurricane Rita
Category 5
Florida, Louisiana, Texas

SEPTEMBER 1, 2008
Hurricane Gustav
Category 2
Arkansas, Louisiana, Texas

stress disorder.

"They clearly were not fine," La Greca says. "Some of them told us they hadn't told their parents because their parents were distressed. They didn't want to burden them."

A later study of the children at 10 months after the storm, published in 1996 in the *Journal of Consulting and Clinical Psychology*, found that those most likely to have persistent problems were those whose homes had not been repaired, or who were living with other stresses such as a parent out of work because of the storm.

"We were surprised how many kids were experiencing difficulty but didn't feel like they could talk to their parents about it," says Mitchell Prinstein, now a psychology professor at the University of North Carolina at Chapel Hill, who had started a graduate position in La Greca's lab a week before Hurricane Andrew.

Even uninjured children, or those whose homes were intact, were still disturbed that their lives were not the same. "They were going to school in portable trailers outside a pile of rubble that used to be their school," Prinstein says. That's one reason he and other researchers now say that rebuilding schools and playgrounds, as well as reestablishing connections to friends as quickly as possible, helps children recover.

A minority of children may endure symptoms for years. In the Miami team's studies of Hurricane Andrew, 18 percent of the children were still having problems 10 months after the storm. One of La Greca's graduate students found that among those kids still coping with symptoms of post-traumatic stress 10 months after the hurricane, 60 percent still had symptoms four years later. That result, she says, implies that those who do not recover quickly may be at higher risk for persistent struggles.

Similar smoldering effects for some children were found after Hurricane Katrina in New Orleans, which in 2005 replaced Andrew as the nation's most costly natural disaster. Once the storm retreated, levees protecting the low-lying city failed, flooding 80 percent of New Orleans and Saint Bernard Parish. Three years later, about 11.5 percent of children were still experiencing emotional disturbances from the storm, according to a study published in 2010 in the *Journal of the American Academy of Child & Adolescent Psychiatry*. In the normal population, prevalence of emotional disturbances among children is less than half that high.

"You see three distinct patterns," La Greca says, summarizing data she described in 2013 in *Child & Youth Care Forum*. "There are children who are doing fine across the board, maybe 40 to 45 percent. Another 30 to 35 percent started out distressed but bounce back. It was only 18 to 20 percent who had elevated distress long term. That's the group, from a clinical perspective, we'd like to be able to identify early on."

This remains a major goal: predicting which children are the most susceptible and in need of attention. Studies have found that a child's mental state before a disaster affects how he or she fares after. More than a year before Andrew hit, La Greca had by chance conducted a study of 92 elementary school children, grades 4 through 6, documenting their mental health.

After Hurricane Andrew, children who were more prone to anxiety before the hurricane were more likely to have symptoms of post-traumatic stress after the storm, according to findings that La Greca and her colleagues reported in the *Journal of Consulting and Clinical Psychology*.

Added stresses

Children also have slower recoveries when misfortune doesn't stop with the initial event. Stressed parents may start to argue or get divorced. Pets can die or disappear. Following Katrina, many businesses and homes sat as abandoned reminders, crime rates soared and many families were repeatedly displaced.

Researchers found that some children were transferred to a new school nine times in the course of a year. Four years after the storm, relocated kids whose families were unable to return were more likely to show symptoms of post-traumatic stress, depression and trauma than those who had returned to their zip code, according to a 2013 study of 795 children published in the *Journal of Traumatic Stress*. But the effect varied by age, with younger children seeming more adaptable to relocation.

55
percent
Fraction of children who had moderate to severe symptoms of post-traumatic stress three months after Hurricane Andrew

18
percent
Fraction of children who had moderate to severe symptoms of post-traumatic stress 10 months after Hurricane Andrew

60
percent
Fraction of children who were stressed at 10 months who had post-traumatic stress symptoms four years after Hurricane Andrew

E. OTWELL

SEPTEMBER 13, 2008
Hurricane Ike
Category 2
Arkansas, Louisiana, Texas

APRIL 20, 2010
Deepwater Horizon oil spill
Alabama, Florida, Louisiana, Mississippi

While most children are resilient, each renewed stress makes feelings of post-traumatic stress and depression harder to overcome, says Joy Osofsky, head of pediatric mental health at Louisiana State University School of Medicine in New Orleans.

"For the children who experienced Katrina, there's been a lot of disruption for a long period of time," she says. Louisiana's coast continues to be battered. Hurricane Rita made landfall a month after Katrina in 2005; then came Hurricane Gustav in 2008 and the Deepwater Horizon oil spill in 2010. Even though those disasters did not cause damage on the scale of Katrina, children who had lived through it were already vulnerable.

The effects of disasters can have unexpected physical consequences as well: a study published in May in the journal *Psychological Trauma: Theory, Research, Practice and Policy* found that eight months after Hurricane Ike hit Galveston, Texas, in 2008, children were more likely to become sedentary, especially those who reported the greatest struggles with post-traumatic stress reactions. Children who had lived through the hurricane reported an average of 41 sedentary after-school hours per week; the average is less than 30.

Even though subsequent disasters can't be anticipated, preparing for them can help ease the effects. How children react depends largely on the adults around them, according to several studies. When parents are prepared and are calm (or as calm as can be expected), children, who take their cues from adults, might be more relaxed themselves.

SUE OGROCKI/AP

A boy is helped out of the rubble of Plaza Towers Elementary school in Moore, Okla., after a massive tornado ripped through the town in 2013.

Researchers from the University of Queensland and colleagues in Brisbane, Australia, surveyed more than 800 elementary school children three months after a minicyclone hit in 2008 with winds up to 130 kilometers per hour. In February, they reported in the *Journal of Child and Adolescent Psychopharmacology* that, after accounting for other variables, children who perceived a change in their parents' behavior — such as becoming more protective or communicating a lingering sense of danger — were more likely to suffer post-traumatic stress.

UCLA's Pynoos acknowledges that it can be tough for parents to keep cool in the face of imminent danger, but after the disaster they can revisit those frightful moments and restore trust. The importance of parent stability also underscores the need to support families and to maintain a social fabric following the event. During the evacuation of a high school near the World Trade Center on 9/11, Pynoos says, the principal made sure the building was emptied smoothly and that children with disabilities were helped out of the building. She stood by the door, spoke to all students as they left and made sure no child walked away without a buddy for the journey home, he says. "That was very important."

Work like this will continue to gain importance, as an estimated 175 million children may be exposed to disasters by the end of the decade, according to the advocacy group Save the Children. As the planet warms, scientists are predicting that some hurricanes could become even fiercer, floods and severe weather more frequent. "With climate change, there will be likely over time an increase in extreme weather events," says Miami's La Greca. Images of distressed children will always be in the news, but how they respond is coming into better focus. ■

175
million
Number of children worldwide who could be exposed to disasters by the end of the decade

Explore more

- U.S. Department of Homeland Security. "Helping Children Cope." www.ready.gov/kids/parents/coping

War Zone VOLCANO

An uphill battle to reveal Mount Nyiragongo's fiery past and forecast its future

By Thomas Sumner

On clear nights a red glow radiates from the top of Mount Nyiragongo in the Democratic Republic of the Congo. On the mountain's summit the source of the light thrashes and boils: the largest and most active lava lake in the world.

Among volcanoes, Nyiragongo stands out. The magma that fuels its violent eruptions is incredibly fluid, capable of racing down the mountainside at highway speeds. The volcano would be a hotbed of research activity — if it weren't in the crossroads of war.

More than a million people live in the volcano's shadow, many of them refugees from years of civil war and the 1994 genocide in neighboring Rwanda. Eruptions in 1977 and 2002 poured fast-flowing lava into the booming city of Goma, killing hundreds and blackening the landscape. Yet after both eruptions, people returned to Goma before the lava hardened, and many others have found their way to its fertile land on the shore of Lake Kivu. The city's population has tripled since 2002.

"Nyiragongo is a humanitarian crisis waiting to happen," says Kenneth Sims, a geochemist at the University of Wyoming in Laramie. The white gas that constantly billows from the volcano's crater is a reminder that the question isn't if, but when, the volcano will kill again.

100
kilometers per hour
Speed of lava flow during Nyiragongo's 1977 eruption

Despite Nyiragongo's deadly potential, scientists know almost nothing about the volcano's eruptive history. Without knowledge of past eruptions as a guide, forecasting and preparing for the volcano's next violent outburst has become a dangerous game of assumptions and uncertainty.

The Congolese volcanologists who monitor the mountain struggle with insufficient funding and outdated equipment. Most foreign scientists are scared off by the conflicts that have rattled the region. Just a handful of researchers, including Sims, are braving the volcano's blistering heat and risking encounters with armed bandits to grab lava rock samples so they can study the isotopes of radioactive elements within. Such information should help in deciphering Nyiragongo's powerful past to offer at least a glimpse of its future. The results so far suggest that Goma's residents may be in more danger than once thought.

Rivers of fire

Nyiragongo rises more than 3 kilometers from the East African rift, a seam where tectonic forces slowly rip the African Plate apart. Molten rock from Earth's mantle wells up through the cracked crust, feeding chains of restless volcanoes and siring what will one day be new seafloor (*SN: 7/2/11, p. 22*).

OLIVIER GRUNEWALD

Unlike explosive volcanoes such as Mount St. Helens, Nyiragongo doesn't erupt with a bang. Instead, outward pressure from a magma blob rising from Earth's mantle can cause stockpiled lava to burst out of fractures in the mountainside or to overflow from the summit. Nyiragongo's core is a vertical magma-filled vent that fills the 260-meter-wide lava lake in the volcano's crater. That lava lake contains 9 billion liters of molten rock, volcanologists estimated in the *Journal of Geophysical Research: Solid Earth* in May. Offshoots of the main magma channel connect to the fractures as well as to defunct minivolcanoes referred to as parasitic cones.

"Nyiragongo is a humanitarian crisis waiting to happen."
KENNETH SIMS

The lava moves fast, "like water over honey," says Sims, because of the unusually low amount of lava-thickening silica found within this volcano. During the 1977 eruption, lava flows reached speeds of 100 kilometers per hour, the fastest recorded for any volcano.

The next eruption, in 2002, struck without warning. More than 14 million cubic meters of lava gushed down the volcano's southern flank toward nearby Goma. Two rivers of fast-flowing molten rock flooded into the city, cutting through the middle of the town. The eruption killed at least 170 people, destroyed about 15 percent of Goma and left 120,000 people homeless. The chaos ignited an exodus across the nearby Rwandan border as 300,000 people fled the destruction. A few days later, dozens more died when lingering lava triggered an explosion at a local gas station.

Despite the devastation, the eruption was relatively small and lasted only 12 hours, says volcanologist Dario Tedesco of the Second University of Naples in Italy. With no warning, however, the evacuation didn't start until after the eruption had already begun, says Tedesco, who spends half of each year working in Goma. Researchers in Goma noticed Nyiragongo belching gas and shaking the ground more than usual beforehand, but they didn't have the tools or data to confidently predict an eruption.

At the center of local volcanologists' work is the Goma Volcano Observatory. The small one-story building sits near a dirt soccer field on a hill-sized parasitic cone called Mount Goma, overlooking downtown. Around 14 researchers make do with old equipment and a limited budget. Since grants from European groups dried up a year and a half ago, the observatory has received no external funding. The Congolese government provides monthly salaries of $200 to $350 per person. Tedesco says those salaries are enough for a single person or a couple to eat for only 10 to 15 days, yet many of the researchers have large families.

"We're working at 25 percent capability," says observatory director general Katcho Karume. "We don't have enough, but we do what we can." Without funding and equipment, Karume says, properly monitoring Nyiragongo for potential eruptions is nearly impossible. Well-observed volcanoes elsewhere in the world are covered in a network of sensors, such as GPS trackers used to measure bulges on the mountainside caused by pent-up magma. In Goma, the researchers rely on about half a dozen remote posts that monitor the volcano's seismic rumblings, but those posts are often out of commission — their valuable batteries stolen.

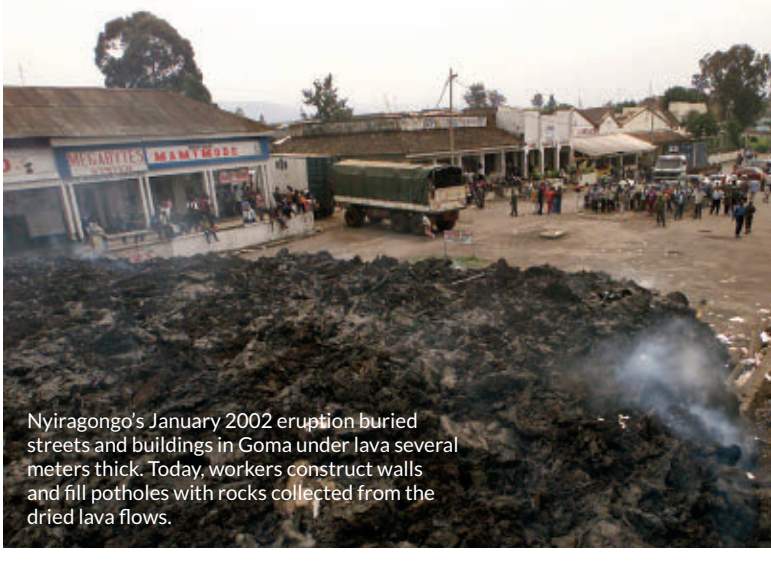
Goma's strategic importance on the Rwandan border and along the shores of Lake Kivu makes it a prime target for rebels. In November 2012, the M23 rebel group took control of the city, forcing out the Congolese army. The rebels withdrew from the city days later, but hung around in nearby Virunga National Park. For the last two years the group's movements around Nyiragongo put a stop to direct monitoring by scientists. Expeditions to the summit finally resumed in October.

As the observatory scientists struggle to keep tabs on the volcano, more is at stake today than in 2002, Karume says. Goma's population has boomed from 400,000 then to more than 1.1 million in 2013, nearly three times the population of Miami. Many of the new residents come from the war-torn countryside or neighboring Rwanda, seeking safety and opportunity in Goma, which is home to the United Nations regional headquarters. The sprawling city's edge now stretches to just 13 kilometers from the volcano's crater.

"If there is an eruption, it is going to come out quickly and people won't have enough time to escape," Karume warns.

Assessing the risk

Karume is revising the Nyiragongo hazard map, a report designed to help officials prepare for potential volcanic events. The work is problematic, he says, because scientists know for certain only about past eruptions in 2002, 1977 and another in 1300, dated by carbon-14 measurements. Many unmapped cooled lava flows stretch down the mountain. Since they have no vegetation, they appear at most a few centuries old. But those flows have never been dated. The nearly 100 parasitic cones that surround Nyiragongo seem young as well but lack specific age estimates. With so little to go on, Sims says,



Nyiragongo's January 2002 eruption buried streets and buildings in Goma under lava several meters thick. Today, workers construct walls and fill potholes with rocks collected from the dried lava flows.

REUTERS

Goma's population expanded as refugees flocked to the area around Nyiragongo (the smoky mountain in the distance). In 1994, nearly a million people crossed into Goma to escape the genocide in neighboring Rwanda.

FINBARR O'REILLY/REUTERS

researchers can't tell if existing parasitic cones are centuries old — from a previous stage in Nyiragongo's evolution — or if new minivolcanoes may emerge in busy, downtown Goma.

Having a complete eruptive history is like having a career criminal's record, he says. You might not know exactly when he'll strike next, but you at least have an idea of what to expect.

But the three dated eruptions simply aren't enough, says Mark Bebbington, a geostatistician at Massey University in Palmerston North, New Zealand. "A rule of thumb would be 20 to 30 dated eruptions to really get anywhere," he says.

Bebbington applies statistical analysis to volcanic histories to uncover patterns, such as how often a volcano erupts, what size outpouring it's capable of or whether it's becoming increasingly restless. In June, he reported in *Geophysical Journal International* the possibility of predicting the intensity of a volcano's next explosive eruption using volcanic histories.

These calculations can't predict exactly when an eruption will happen, he says, but they can help cities create evacuation plans and guide the placement of infrastructure. This would be particularly important in Goma, where the limited number of roads leading away from town could create a bottleneck during a disaster.

Volcanoes near large populations elsewhere in the world have much more complete histories than this mysterious volcano, Bebbington says. For example, written accounts chronicle the eruptions of Italy's Mount Vesuvius for thousands of years. But because Goma is a young city, established about 75 years ago, no such accounts exist for Nyiragongo's ancient eruptions.

For volcanoes without extensive eyewitness histories, researchers rely on several techniques, some more direct than others. With carbon-14 dating, scientists look for a plant or animal killed by the eruption. By measuring the levels of radioactive carbon in the fossilized remains, researchers can estimate how long ago the eruption responsible for its demise happened. This technique requires luck, however, because fossils buried under volcanic debris must first be found.

A new technique called cosmogenic dating uses rocks perched in plain sight. As cosmic rays bombard Earth, they can trigger formation of isotopes such as helium-3 in outer rock layers. Scientists can measure ratios of these isotopes to determine how long a rock has been exposed. Unfortunately, the method can't be applied to Nyiragongo because the weather causes too much erosion, making all the lava flows seem much younger than they actually are.

For Nyiragongo, Sims studies the radioactive elements locked inside the volcano's ancient lava flows. Over time, unstable thorium, potassium and uranium atoms in the rocks decay into other elements. By measuring the relative amounts of these daughter products — such as radium and lead — he can estimate how long ago the lava hardened.

To begin his dating project, Sims needed a baseline to compare his results against — zero-age lava fresh from the edge of the volcano's lava lake. He got his chance during a 2010 expedition.

400
thousand
Goma population in 2002

1.1
million
Goma population in 2013

Dollars and guns

Sims' mission for a fresh lava sample, his second since he began studying Nyiragongo in 2004, took more effort than a typical volcano ascent.

Goma has no ATMs and most shopkeepers won't accept African currency. To buy the climbing equipment, camping gear and food for the weeklong stay, Sims carries $5,000 to $6,000 in U.S. bills with him every time he prepares an

expedition. The locals are picky even when it comes to U.S. currency, Sims says. They accept only pristine bills printed after 2006 — no cuts, marks or too many folds. Carrying that amount of money, Sims says, makes him feel like "a walking target."

He recalls one year having a drink with a fellow scientist in a bar in Goma. "I had one drink and both of us were totally trashed, and we both think we got mickied [drugged]." They were lucky to stagger back to their hotel unharmed.

The 2010 trip required 150 porters — locals paid a month's wage for hauling equipment and supplies up the volcano. Ten scientists accompanied Sims, including Tedesco and researchers from the volcano observatory. Five armed park rangers came along for protection. On a previous expedition, Tedesco says, crooked soldiers robbed some of his friends, even taking their shoes, before a firefight broke out between the rangers and the robbers. "There are guns everywhere," Sims says. "It's always in the background."

Nyiragongo's crater descends in three tiers, with the lava lake occupying the crater floor 400 meters below the rim.

Thankfully, the team ascended the mountain without any run-ins, hiking through sweltering jungle and carefully traversing steep slopes leading to Nyiragongo's high, windy and frigid summit.

Hell on Earth

About a kilometer across, Nyiragongo's crater opens into a supersized natural amphitheater deeper than the Empire State Building. At center stage, the huge lava lake burns bright red and breathes a plume of sulfur dioxide into the sky at a rate of more than 1,300 kilotons per day, Tedesco and colleagues reported in November in the *Journal of Geophysical Research: Atmospheres*. "When you're up on the rim, it's like you're looking down into hell," Sims says.

The crater descends in three gigantic steps like tiers on an inverted wedding cake. Dead bugs scatter the ground, drawn in by the glowing light and killed by the blistering temperatures and noxious gases. Sims' experience as a mountain climber and wilderness guide came in handy in 2010 as the team rappelled down the unstable slope wearing gas masks.

Along the descent, Sims chiseled away layers of weather-beaten old lava flows with a sledgehammer to reach the rock's untarnished inner layers. Weathering alters the chemistry of the lava and makes the outer layer useless for analysis. The testing Sims does in his Wyoming lab requires only tiny fragments, but he broke off chunks the size of shopping bags. With so much effort needed to collect the samples, he didn't want to risk running out.

To get a fresh sample, Sims descended alone to the lowest tier, Nyiragongo's heart. The lava lake rises 15 meters above the crater bottom, encased in a bowl-shaped spatter cone built by overflows and spray from popped lava bubbles.

Donning a silver-colored, heat-resistant suit, Sims quickly scaled the steep spatter cone, making his way to the freshly deposited lava rocks along the lake's edge that had been molten just 30 minutes earlier. After breaking away a lava rock with his fist, he sprinted back to safer ground, his boots melting underfoot and the precious sample burning through his oven mitt–like gloves. At last Sims had a rock that he hoped would help pin down Nyiragongo's eruptive timetable.

Rock of ages

Back in his University of Wyoming lab, Sims and geologist Erin Phillips examine the lava samples freighted back from Nyiragongo in labeled cloth sacks. Each rock contains a geological birth certificate encoded in its chemistry. By measuring the ratios of radioactive elements in the rock, Sims and Phillips can estimate how long ago it spewed from the volcano.

The rocks that melt to form Nyiragongo's magma innards

Volcanologist Kenneth Sims and colleagues rappelled into the Nyiragongo crater in 2010 to collect a fresh lava sample.

Researchers need special heat-resistant suits to withstand the heat radiating from the 1,100° Celsius molten rock.

CLOCKWISE FROM TOP: OLIVIER GRUNEWALD; OLIVIER GRUNEWALD; CARSTEN PETER/NATIONAL GEOGRAPHIC CREATIVE

contain uranium-238 atoms. Over time uranium decays into radioactive thorium-234, which eventually decays into unstable protactinium-234 and so on. In total, the decay chain bridges 19 isotopes and culminates in a stable lead-206 atom. Scientists can approximate the age of a rock by comparing the relative number of atoms of each isotope embedded within.

If the rock remains solid, uranium's offspring stay trapped. However, when rock melts under the extreme temperatures and pressures inside Earth's mantle, much of the radioactive isotopes wash away or bubble up to the surface as gas. When the liquid rock solidifies as a lava flow on the surface, any new decay products are once again confined. The melting essentially resets the rock's age.

This rock reboot allows scientists to determine the ages of ancient lava flows, Phillips says. "We're putting it all together to get a story about the volcano."

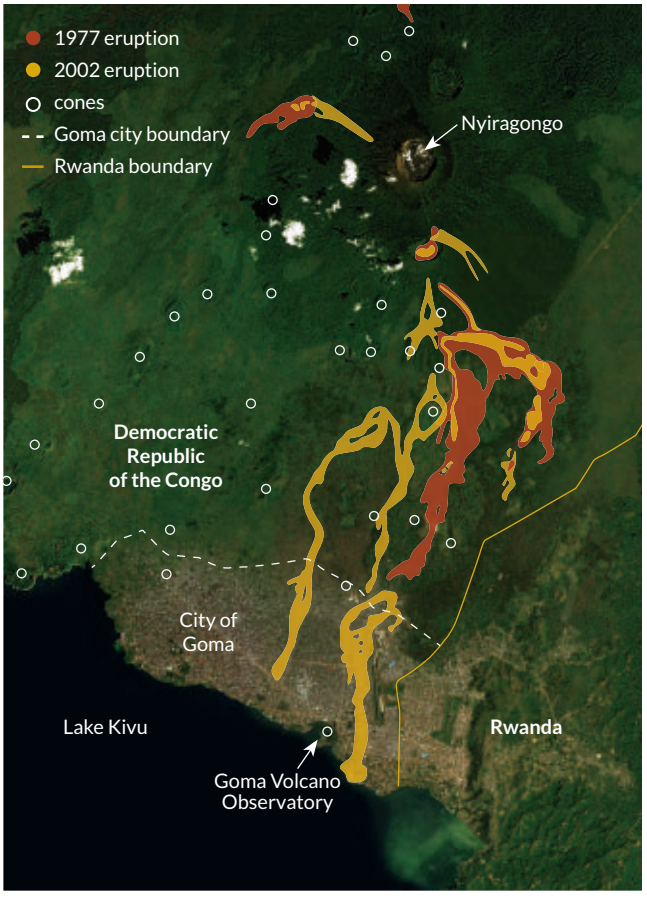
Phillips crushes rock chips from an undated lava flow near Nyiragongo's summit that is not from the 1977 or 2002 eruptions. She drops the pulverized rock into a swirling mix of water, hydrogen peroxide and hydrochloric acid. This acid bath breaks down rock and makes the isotopes entombed inside easier to find. After a long soak, she puts the processed sample inside a mass spectrometer to measure the types and quantities of atoms inside.

Sims and Phillips compare the levels of a pair of uranium decay products: lead-210 and radium-226. This isotopic duo is important, Sims says, because scientists know how long into a rock's life it takes for the elements to reach a stable ratio. Lead-210 and radium-226 take around 100 years to reach this equilibrium.

Using the newborn lava samples he collected in 2010 for calibration, Sims and Phillips discover that the undated sample contains more radium-226 than lead-210. The flow, it seems, formed less than 100 years ago. This unpublished finding is the first significant evidence of a third Nyiragongo eruption within the last century, Sims says. "It looks like Nyiragongo has been more active recently than had previously been known."

People in Goma rebuilt on top of the 2002 lava flows. Volcanologists must contend with rebel activity as they try to monitor the volcano. They worry that a future eruption could strike without warning.

Active area Lava from eruptions in 1977 and 2002 flowed from the volcano toward Lake Kivu. Goma's population has expanded to within 13 kilometers of the crater. Nearly 100 inactive minivolcanos, called parasitic cones, dot the area, hinting that new ones may form in the future.



A more active Nyiragongo is bad news for the people of Goma, Sims says. The newly dated eruption suggests the volcano's magma refills more quickly after each outburst than once thought. Still, four known eruptions aren't enough to fully understand a volcano's personality, he says. He plans to return in 2015 to date more lava flows around the mountain so he can establish a comprehensive eruptive history and help the city better prepare for the next big one.

Tedesco doesn't think that the news of increased danger will cause people to leave Goma. For many residents, he explains, Goma is their first real home after spending years as refugees.

For now, Tedesco says, he's staying too. "After so many years I think I belong more to Goma than to Italy," he says. "I love that place [Goma], although I also hate that place. Nothing changes, it's very difficult to work, there's too much corruption sometimes — but we have to work with what we have and believe we can make the difference." ■

Explore more

■ P.-Y. Burgi *et al.* "Dynamics of the Mount Nyiragongo lava lake." *Journal of Geophysical Research: Solid Earth.* May 2014.

FROM LEFT: KAREL PRINSLOO/ASSOCIATED PRESS; ERIC AUGENSTEIN, ADAPTED BY M. ATAROD

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EXHIBIT

‘Designing for Disaster’ explores hazard-resistant buildings

The National Building Museum examines methods used by engineers to make buildings resistant to wildfires and other natural hazards.

Earthquakes, hurricanes, tornadoes, floods, wildfires — no part of the United States is immune to natural disasters. While no one can prevent these hazards, people can prepare for them. “Designing for Disaster” at the National Building Museum in Washington, D.C., showcases how scientists, engineers and government officials work together to guard the country’s infrastructure against Mother Nature’s fury.

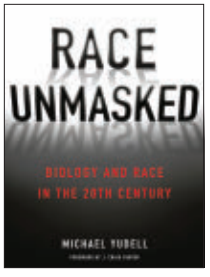
On entering the exhibit, visitors are immediately confronted with tangible reminders of the destruction that natural disasters can inflict: The door of a home drowned by Hurricane Katrina stands near the exhibit’s entrance; a few pieces of a Japanese dock lie on a table, having washed ashore in Washington state after the 2011 Tohoku earthquake; a battered tornado siren from Kansas hangs from the wall.

The rest of the exhibit focuses on how engineers design and build disaster-resistant structures. The University of California, Berkeley, for instance, recently retrofitted its nearly 90-year-old football stadium, which straddles the Hayward Fault. Parts of the stadium rest on large blocks that can slide independently of each other and move up and down and side to side as needed during an earthquake. When a museum visitor clicks a button, life-size stairs demonstrate how the system would work in a real earthquake.

Another highlight is a mini replica of Florida International University’s Wall of Wind, an array of 12 giant fans that can simulate the strongest hurricanes. It has helped engineers and manufacturers develop windproof materials and structures. With the exhibit’s replica, visitors can test how well roof designs stand up to hurricanes. Activating the fans is enjoyable, but some visitors may yearn for more explanation of why some designs do better than others. The Wall of Wind is one of several hands-on components in the exhibit. But overall, “Designing for Disaster” is quite text-heavy and clearly aimed at adults, who may at times grow tired of all the reading.

Still, the exhibit’s message is important. As the exhibit shows, it often takes a monumental disaster for officials to enact stringent building codes and laws. But with such advanced engineering know-how already available, why wait for disaster to strike? — *Erin Wayman*

Designing for Disaster
THROUGH AUGUST 2, 2015
National Building Museum
WASHINGTON, DC



BOOKSHELF

Race Unmasked

Michael Yudell

It’s 1921 and the American Museum of Natural History in New York City is packed with visitors eager to learn about the hot science of eugenics. Museum staff dubs its conference and exhibit “the most important scientific meeting ever held in the museum.” In his new book, Yudell, a historian of public health, argues that the complicated interaction of science and race visible in the eugenics movement is still playing out. “Thinking in the natural sciences has influenced the continued evolution of racist ideology in the United States,” he writes.

An inversion also holds true: Racist ideology has shaped — and continues to sway — the evolution of science. The result is a constant trade-off of influence between popular culture and science.

Yudell dissects key moments in innovation. For example, Mendelian genetics arose and was appropriated by eugenicists to falsely link complex personal attributes to heredity. In addition, by midcentury, leading anthropologists accepted Africa as the birthplace of the genus *Homo,* but then several researchers spun off theories positing that different races are *Homo sapiens* subspecies.

Today, science limits Mendelian genetics to the explanation of simple dominant-recessive schemes, acknowledging that genetic variation within a group may exceed variation between groups. And the year 2000 saw all people, in a sense, become 99.9 percent genetically identical. In the wake of completing the Human Genome Project’s first draft, lead scientist Francis Collins wrote, “Those who wish to draw precise racial boundaries around certain groups will not be able to use science as a legitimate justification.”

Unfortunately, in 2014 American science has no more claim to being post-racial than American culture does. *Race Unmasked* points to several discomfiting examples. Identifying genetic differences between races and ethnic groups is an interest far from tangential in 21st century research. And the National Institutes of Health, which Collins now leads, “reifies racial categories,” Yudell says, by requiring scientists to collect data on race in their work.

Perhaps most telling for Yudell is the amended thinking of Collins, who proclaimed a raceless science as we were leaving behind a racism-tinged century. Today he advocates disease research employing race despite having championed the technology that allows us to look beyond it. — *Bryan Bello*
Columbia Univ. Press, $40

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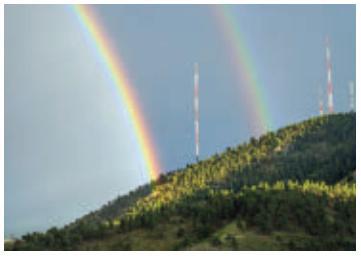
Anatomy of an illusion

Sunlight bouncing around inside of raindrops produces both the bright primary bow of a double rainbow and the fainter, reversed secondary bow. Drops falling between the two bows can't send light towards the viewer, creating a dim region called Alexander's dark band.



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Dark side of the rainbow

Christopher Crockett's *"When a rainbow goes full circle"* (SN: 11/1/14, p. 32) *showcased a spectacular photo of a double rainbow snapped from a helicopter over Western Australia.*

Sharp-eyed readers were quick to point out an interesting optical phenomenon in the image. "Not only does it show the full-circle double rainbow, the viewer can also discern that the outer bow has the spectrum colors reversed," wrote **Jean Parcher**. "In most photos the second bow is too dim to see the reversal."

Ray Rosich called attention to something else in the photo: "It seems to be very common for people to clearly observe the primary and the secondary rainbows but to not notice the dark band between them." This relatively dim patch of sky, known as Alexander's dark band, is created when water droplets between the colorful bows bend light away from the observer. He added that, so far, none of his family members share his enthusiasm for the physics behind the band. "Unfortunately, not being physicists, their eyes just glazed over during my explanatory monolog. I guess the beauty of physics only goes so far with nonphysicists!"

Puzzling out post-op recovery

Searching for certain immune cells in the blood may help doctors predict how long a patient will spend recuperating from an operation, **Nathan Seppa** *reported in "Test foretells surgery recovery time"* (SN: 11/1/14, p. 16).

The new test was able to sort out which patients were on the path to a good recovery only 40 to 60 percent of the time, which **Linda Ferrazzara** found perplexing. "Doesn't that mean that it couldn't predict good recoveries 40 to 60 percent of the time as well?" she wrote in an e-mail. "I'm not quite sure exactly what these tests were able to predict with enough of a chance of reasonable accuracy that it would be worth the time and effort (and expense) to even run them."

The test was intended to be more explanatory than predictive, **Seppa** says. Not everyone heals from surgery at the same speed, and scientists are still trying to figure out why. The new test reveals a component of the biology that drives recovery. The researchers who did the study found variations in protein activity inside immune cells called monocytes that show up in the first day after surgery in patients who mend rapidly. Differences in these cell signatures explained up to 60 percent of the variation in recovery rates between patients, says study coauthor **Martin Angst** of Stanford Medical School. What accounts for the rest of the variation is still unclear.

Bird news, good and bad

While some bird populations in the United States and Canada are booming, many aren't doing so well, according to a new report. **Susan Milius** *covered the ups and downs of avian populations in "North American bird update has a little good news"* (SN: 11/1/14, p. 4).

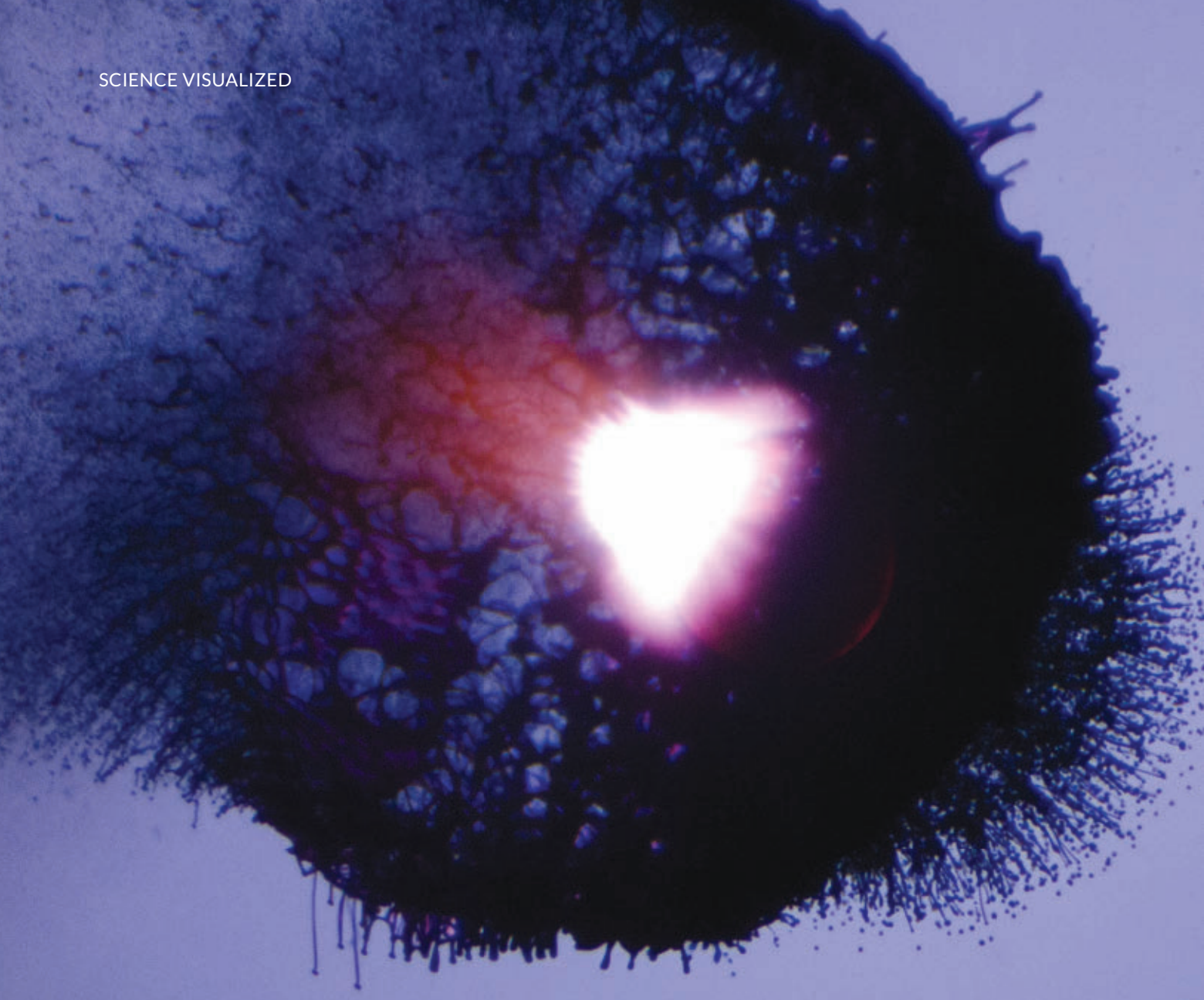
"It is an impressive increase of the wetland-inhabiting species, but the continuing decline of birds inhabiting the other habitats is worrying," wrote commenter **mudfooted**.

Birds that live in deserts and other arid areas are showing the steepest declines, with populations dropping by 46 percent since 1968. **Dan Midgett** wondered why: "It's not as if humans are competing for that habitat much." Reader **Daxx2513** had a potential answer: "Actually, the Southwest has the fastest growing population in the country. More than the actual space, it's the human hoarding and overuse of available water in those areas that is stressing the system."

Clarification

"Satellites expose mysteries of the deep ocean" (*SN: 11/15/14, p. 7*) identified the ocean-monitoring Jason-1 satellite as a NASA mission. **Edward A. Henry** correctly pointed out that the satellite is a joint venture between NASA and the National Centre for Space Studies in France.

WELCOMIA/ISTOCKPHOTO



Assaulting ink drops for science

This is what it looks like when a pulse of laser light obliterates a free-falling ink drop. The photograph is from an award-winning video in the American Physical Society's 2014 Gallery of Fluid Motion competition. The image and others like it may help engineers build the next generation of computer chips.

The carnage was documented by physicist Hanneke Gelderblom of the University of Twente in Enschede, Netherlands, and her team, who fire nanosecond-long pulses of green laser light at drops of ink. A strobe light illuminates the action, allowing two cameras in tandem to capture about 10 million frames a second. This photo was taken microseconds after the laser made contact with a drop.

The laser delivers so much energy so quickly that some liquid transforms into a superheated gas called a plasma. That transformation is of particular interest to Gelderblom and ASML, the Dutch company that supports her research.

ASML builds lithography machines, which are used to produce computer chips. One device works by shooting a laser at drops of molten tin to produce plasma. The plasma then emits extreme ultraviolet light, which can imprint features less than 13.5 nanometers across onto chips. A smaller feature size would enable engineers to pack more transistors onto a single chip.

Gelderblom's experiments provide insight into the first step of ASML's laser-driven process. Her team studies the shape and fragmentation of the disturbed drops and analyzes how those features change depending on the laser energy and focus. —*Andrew Grant*

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Watch the full video at **bit.ly/SN_laserdrop**

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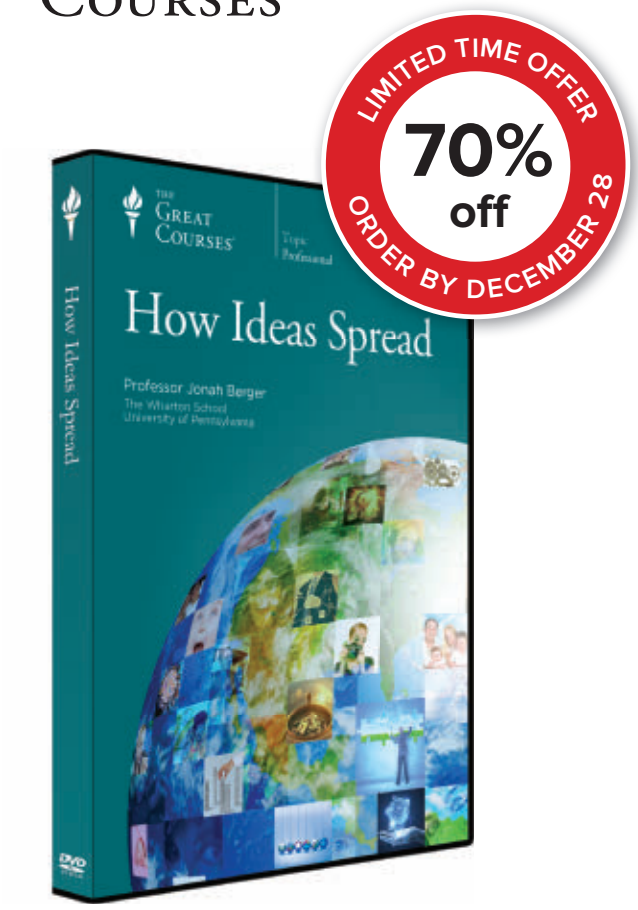

What Factors Make Something Go Viral?

Anyone who has something to sell, a cause to promote, or a message to spread knows that there are obstacles in creating a message that resonates, spreads, and sticks to make their product or idea the word on the street. Enormous sums of time and money have been spent trying to answer the question of why some ideas catch on while others fade.

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