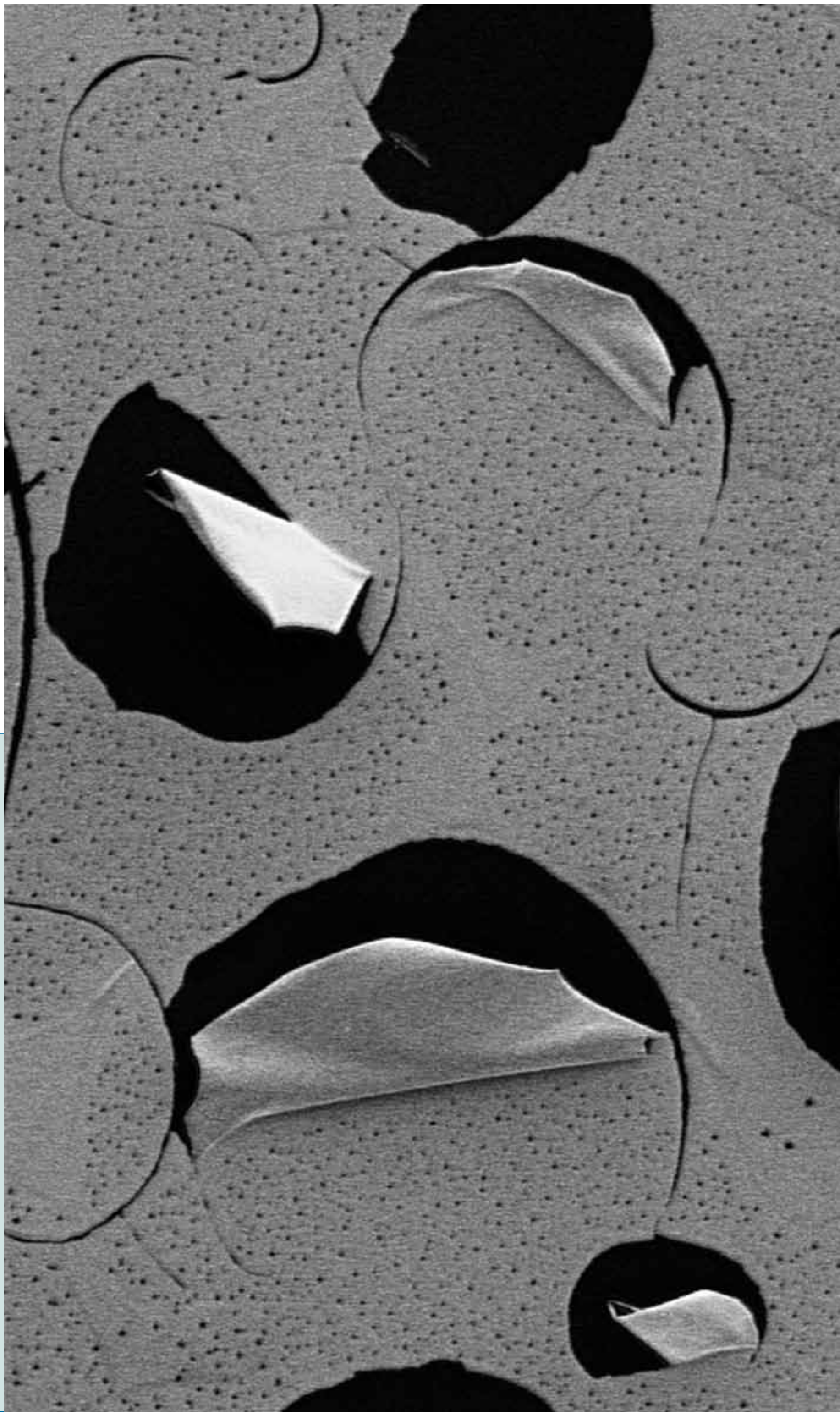
Random



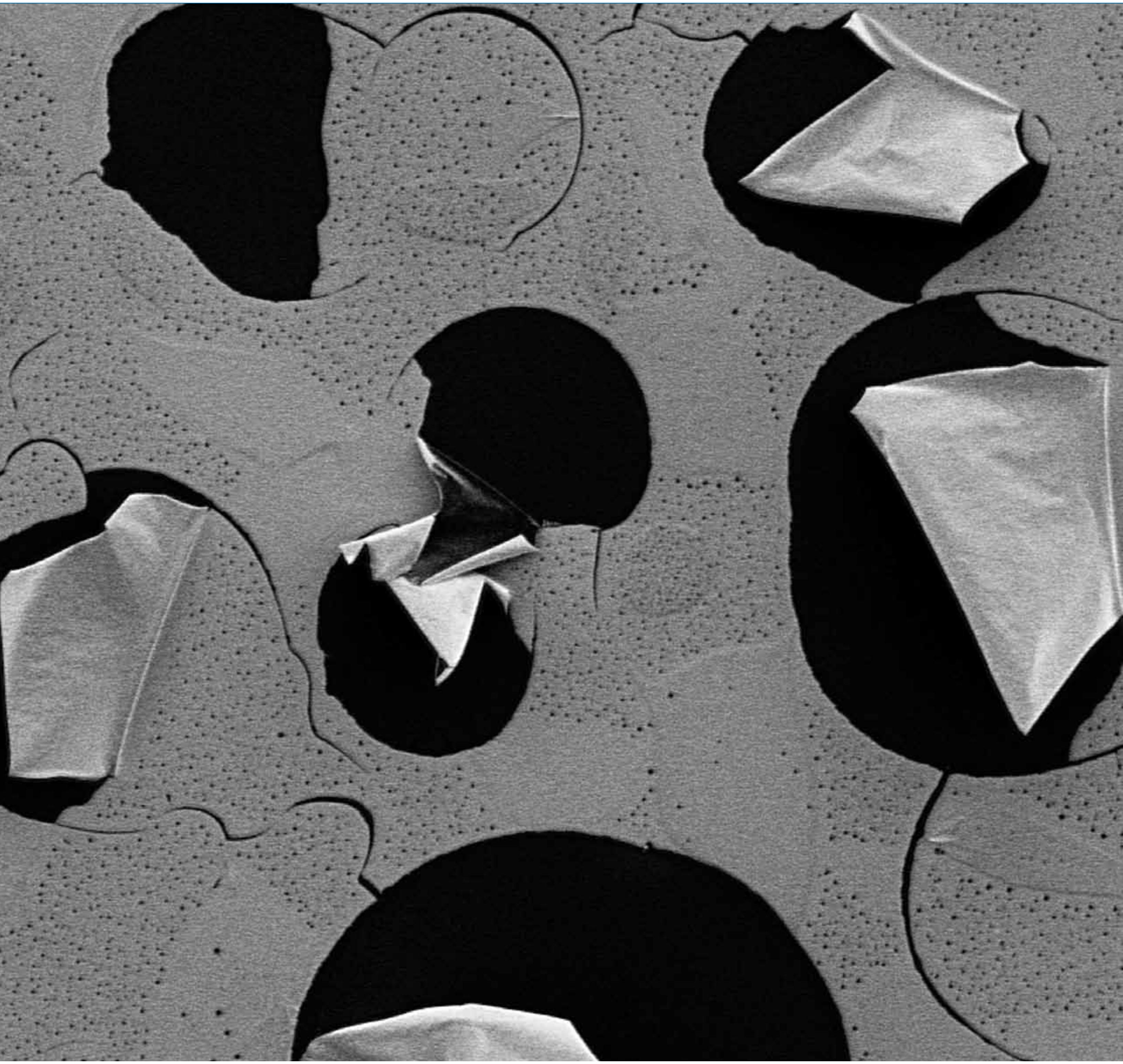
Art collector and author Gertrude Stein once remarked that "sculpture is made with two instruments and some supports and pretty air." The tiny sculpture shown here indeed relied on some pretty (hot) air to get its shapes. It is made from a thin film of gold, less than 100 nanometers thick, that was deposited onto Plexiglas and then heated. Due to differences in the thermal expansion of the two materials, this gold sample peeled up and twisted to form abstract art. This image, taken with a very powerful scanning electron microscope, was created by Dennis Callahan, a PhD candidate in materials science working in the lab of Howard Hughes Professor Harry Atwater.

For more of Callahan's artful images, check out his blog, Of Science and Art (ofscienceandart.blogspot.com).

If you have images you would like to share with us, go to eands.caltech.edu for more information.

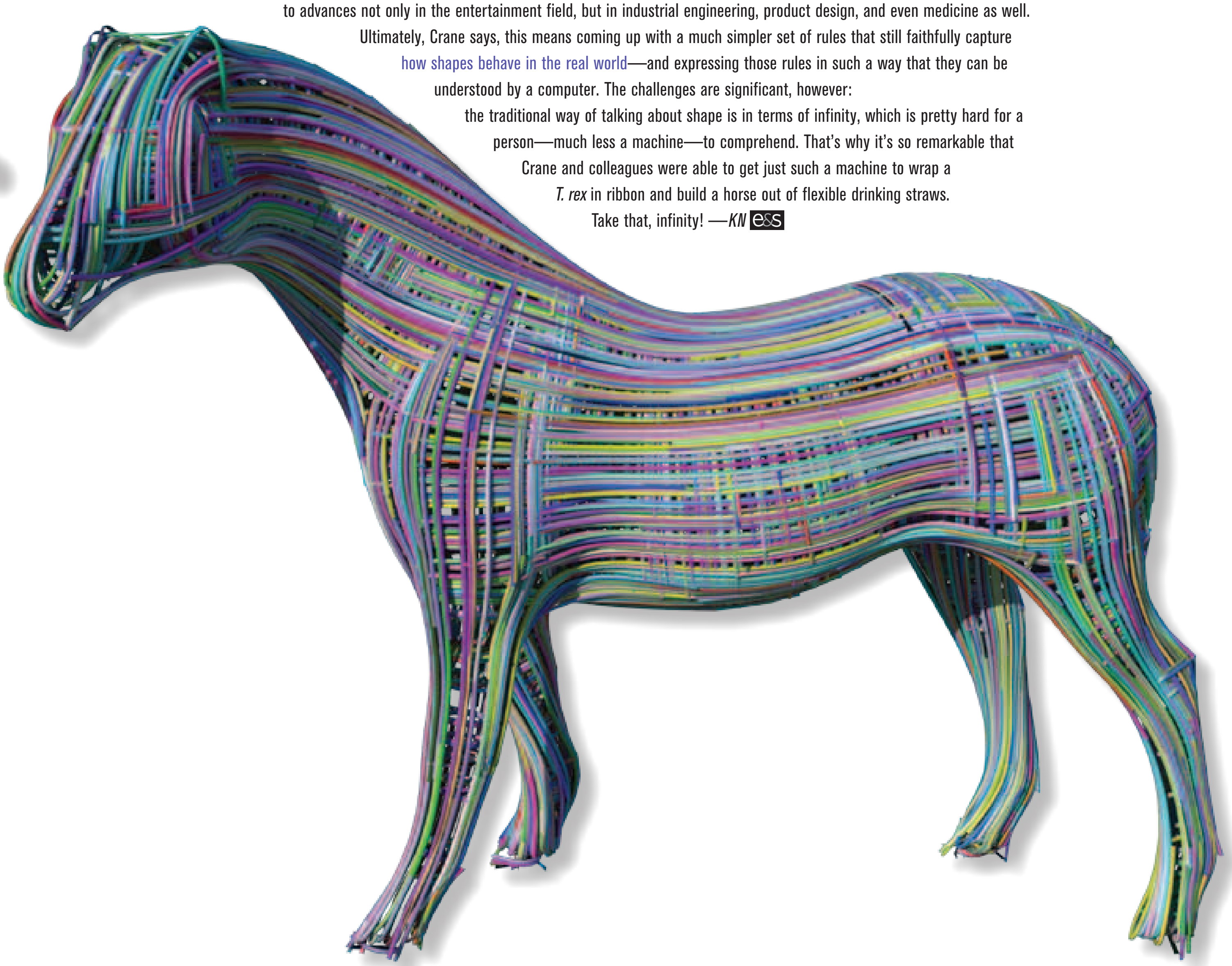
Walk

THINGS THAT CAUGHT OUR EYE . . .



CONQUERING SHAPES

Computer graphics have come a long way since early arcade games like Pong. But even from that seemingly simple beginning, the technology has been built upon an elaborate set of rules. Behind each computer-generated movie villain or video-game hero is a complex algorithm, or detailed list of instructions, that needs to be followed by the computer in order to create the intended image. Those lists are consistently being revised and revisited by people like Keenan Crane, a graduate student in computing and mathematical sciences, who designed the method that produced the *T. rex* and horse you see on these pages. His interest lies in knowing how computers represent and manipulate shapes—a line of inquiry called discrete differential geometry that could lead to advances not only in the entertainment field, but in industrial engineering, product design, and even medicine as well. Ultimately, Crane says, this means coming up with a much simpler set of rules that still faithfully capture how shapes behave in the real world—and expressing those rules in such a way that they can be understood by a computer. The challenges are significant, however: the traditional way of talking about shape is in terms of infinity, which is pretty hard for a person—much less a machine—to comprehend. That's why it's so remarkable that Crane and colleagues were able to get just such a machine to wrap a *T. rex* in ribbon and build a horse out of flexible drinking straws. Take that, infinity! —*KN* e&s



OCEANS OF WATER IN A PLANET-FORMING DISK

Water enough to fill Earth's oceans several *thousand* times over has been found in the planet-forming disk around a nearby star. The discovery, made by a team including Caltech's Geoff Blake (PhD '86) and Dariusz Lis and JPL's John Pearson, could help explain how Earth got its oceans. If other planet-building disks prove to be equally wet, "water-covered planets like Earth may be quite common," Lis says. The star, called TW Hydrae, is about four-fifths the mass of the sun and a mere 10 million years old.

While such disks are quite common, water vapor had never before been detected in the outer regions of one. The finding implies that the outer reaches of our own solar nebula could have been chock-full of ice as well. Such a large reservoir of water would have been crucial for the creation of Earth's seas, because the current theory of solar-system formation holds that water was scarce in the solar nebula's inner part, where our planet coalesced. "Water is essential to life as we know it," Blake says. "But the early Earth is predicted

to have been hot and dry." Earth's water, then, must have come from somewhere else. One likely source? Comets.

Comets, often called dirty snowballs, hoard most of our solar system's patrimony of water ice. A few million of them colliding with Earth in the early days could have brought in enough water to create our oceans. Such a scenario is not as implausible as it may sound—there was a tremendous amount of debris flying around back then, including as many as several trillion proto-comets. "These results beautifully confirm the notion that the critical reservoir of ice in forming planetary systems lies well outside the formation zone of Earthlike planets," Blake says.

The TW Hydrae measurements came on the heels of another discovery by Lis, Blake, postdoc Martin Emprechtinger, and others—that the deuterium-to-hydrogen ratio of comet Hartley 2's ice is similar to that of Earth's oceans, supporting the idea that the seas did come from the skies. (Deuterium is an isotope of hydrogen with an extra neutron in its nucleus.) In fact, the ratio suggests a very specific part of the sky: the Kuiper Belt, which begins just beyond Neptune's orbit and extends out to 50 astronomical units (AU) from the sun. (For comparison, Earth is one AU from the sun.) Previous measurements of comets from the Oort Cloud, a collection of trillions of icy bodies lying more than 5,000 AU from the sun, had shown a very different deuterium-to-hydrogen signature.

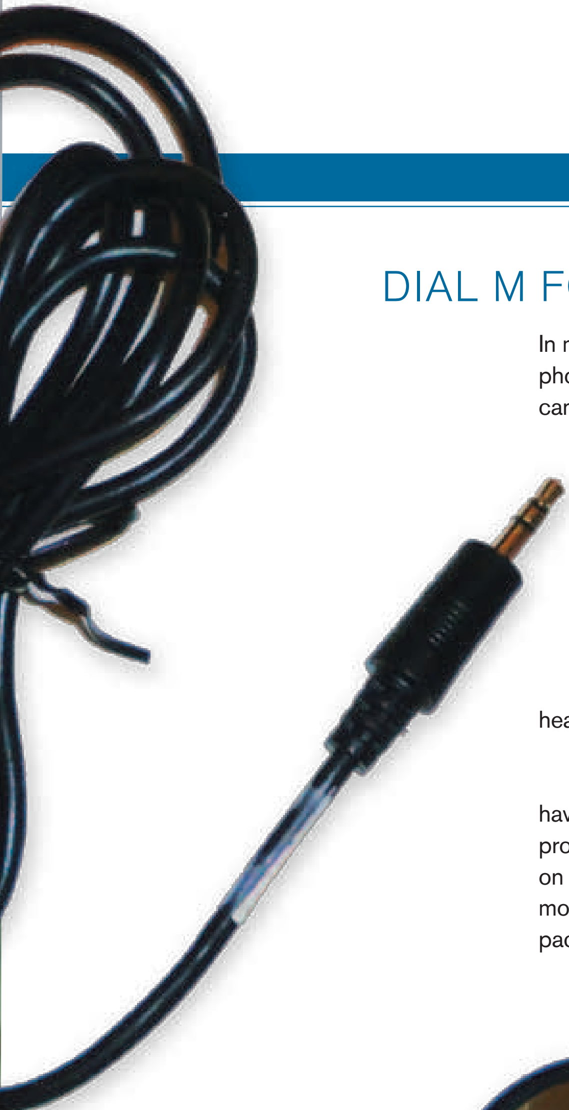
To make things even more interesting, the Oort Cloud's comets are believed to have been formed in the vicinity of the gas-giant planets Jupiter, Saturn, Uranus, and Neptune—that is, in the zone stretching from 5 to 30 AU—before being exiled into the very outermost precincts of the solar system by gravitational kicks from their bigger brethren. "The result . . . is consistent with the emerging picture of a complex dynamical evolution of the early solar system," says the paper.

Geoff Blake is professor of cosmochemistry and planetary sciences and professor of chemistry at Caltech. Dariusz Lis is a senior research associate in physics and the deputy director of the Caltech Submillimeter Observatory. The observations were made with the Herschel Space Observatory, a mission of the European Space Agency, using the HIFI instrument, to which JPL made significant contributions. Caltech's Infrared Processing and Analysis Center operates the NASA Herschel Science Center, which provides science and operational support for the mission. The Hartley 2 study was led by Paul Hartogh of the Max Planck Institute for Solar System Research in Katienberg-Lindau, Germany, and was published in the October 13 issue of *Nature*; the TW Hydrae work was led by Michiel Hogerheijde of Leiden University in the Netherlands and appeared in the October 21 issue of *Science*. —*MW* E&S

This artist's conception illustrates a storm of comets around a star near our own, called Eta Corvi. Evidence for this barrage comes from NASA's Spitzer Space Telescope, whose infrared detectors picked up indications that one or more comets were recently torn to shreds after colliding with a rocky body. In this artist's conception, one such giant comet is shown smashing into a rocky planet, flinging ice- and carbon-rich dust into space, while also smashing water and organics into the surface of the planet. A glowing red flash captures the moment of impact on the planet. Yellow-white Eta Corvi is shown to the left, with still more comets streaming toward it.

Spitzer detected spectral signatures of water ice, organics, and rock around Eta Corvi—key ingredients of comets. This is the first time that evidence for such a comet storm has been seen around another star. Eta Corvi is just about the right age, about one billion years old, to be experiencing a bombardment of comets akin to what occurred in our own solar system at 600 to 800 millions years of age, termed the Late Heavy Bombardment.

Scientists say the Late Heavy Bombardment was triggered in our solar system by the migration of our outer planets, which jostled icy comets about, sending some of them flying inward. The incoming comets scarred our moon and pummeled our inner planets. They may have even brought materials to Earth that helped kick-start life.



DIAL M FOR MEDICINE

In many rural areas across the globe, people are much more likely to have a cell phone than a local doctor. Clinics are scarce in such remote locations, travel can be tough, and many laborers cannot afford to take a single day off work—all of which makes medical visits nearly impossible.

To address this lack of adequate health care, a group headed by Julian Bunn, of Caltech's Center for Advanced Computing Research, and Mani Chandy, the Ramo Professor and professor of computer science, is working to make the "10-cent checkup" a reality by building low-cost diagnostic devices that can be plugged into cell phones.

"We want to exploit cell-phone technology and the Internet to provide inexpensive health-care tests for the poor in remote rural villages," says Chandy.

Various students in the Summer Undergraduate Research Fellowship program have been working on the project for three summers now. Last year, four students built prototypes of a plug-in stethoscope and an electrocardiogram recorder. Other devices on the drawing board include a blood-pressure meter, a thermometer, and a heart monitor. The cell phone will relay the data to an Internet cloud, where a software package that students are also designing will sort the results into "probably normal"

"We want to exploit cell-phone technology and the Internet to provide inexpensive health-care tests for the poor in remote rural villages," says Chandy.

or "refer to doctor." The "referred" results would upload to the cloud, where doctors from virtually anywhere could review the data and determine whether the patient needs to be seen at a clinic.

Theresa Juarez, a senior in mechanical engineering, says she enjoyed the project because it deals with a tangible product and can influence people outside her immediate field. "It's more practical and hands-on," she says. "You end up getting a result at the end that you can play with and work and use, and it has the potential to actually make a difference, bringing adequate health care to places in the world that don't have it." *—KF/KN* e&s

15,500 FEWER THINGS TO WORRY ABOUT

Here's some good news, for a change: drifting around in our part of the solar system there are some 15,500 fewer asteroids than we previously thought that are big enough to wipe out a city.

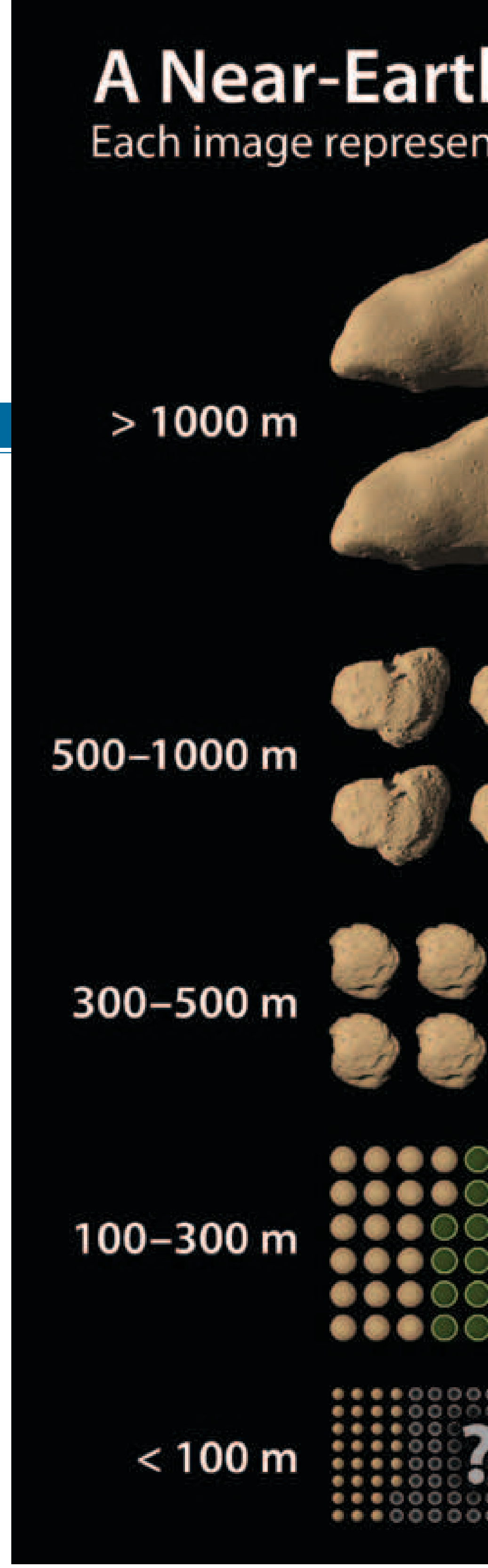
The Wide-field Infrared Survey Explorer (WISE) has just finished the best census yet of midsize and larger near-Earth asteroids, or NEOs—the space rocks that live well within Mars's orbit and occasionally come too close for comfort to Earth. This survey, called NEOWISE, "allows us to make a better estimate about the whole population," says JPL's Amy Mainzer (MS '01), NEOWISE's principal investigator and lead author of a paper describing the work in the December 20, 2011, issue of the *Astrophysical Journal*. "It's like a poll, where you ask a small group of people questions and use their answers to draw conclusions about an entire country."

The data, gathered from January 2010 through February 2011, provide far better estimates of asteroid diameters than previous visible-light surveys because infrared detectors sense heat rather than reflected sunlight. Many asteroids are quite dark—in fact, blacker than coal—but their temperatures depend primarily on their distance from the sun. The ones closest to us are thus relatively warm, averaging a balmy –73°C or so.

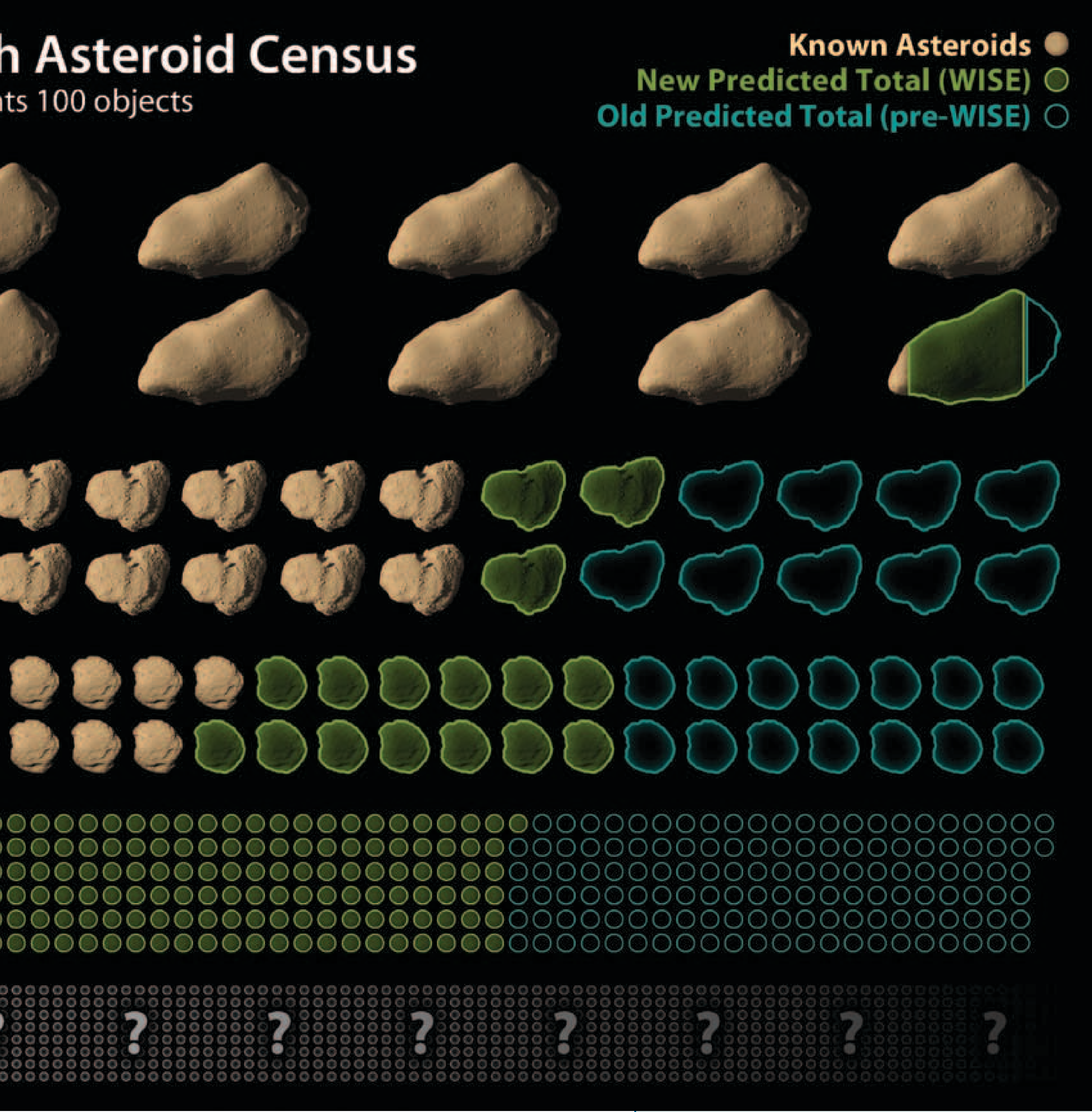
The NEOWISE survey suggests that all the NEOs in the 10-kilometer-diameter class—the dinosaur-killers—have been found. That's *really* good news, because most of the objects that we know of in this size range have had their orbits calculated to a high degree of precision for the next several centuries. None of the known ones are thought likely to draw a bead on us.

The analysis predicts that there are about 980 NEOs in the one-kilometer class—the size of a small mountain, and big enough to set civilization back quite a bit. NEOWISE's all-sky images allowed scientists to predict that about 910 of these have already been discovered, or 93 percent of the estimated number. None of the known ones are thought likely to draw a bead on us any time soon either. This finding fulfills a goal set in 1998 when Congress authorized NASA's Spaceguard program, whose mission was to be able to track at least 90 percent of the one-kilometer NEOs.

And finally, NEOWISE puts the number of midsize asteroids—those about 100 meters in diameter, or large enough to mean Game Over for any metropolitan area unlucky enough to suffer a direct hit—at roughly 19,500, which is about 15,500 fewer than the 35,000 previously estimated. About three-quarters of these remain undiscovered (or have not been spotted often enough to have their orbits accurately determined), so we're not out of the woods just yet. But identifying these asteroids as "near Earth" simply means that their orbital paths and ours are in the same general vicinity; the number of potentially hazardous ones that come *really* close to us remains unknown but is being investigated.



JPL operates the WISE spacecraft, which was built by Ball Aerospace and Technologies Corporation in Boulder, Colorado. WISE's telescope and camera



were built by the Space Dynamics Laboratory in Logan, Utah. WISE's principal investigator, Edward Wright, is at UCLA. Caltech's Infrared Processing and Analysis Center handles the spacecraft's science operations and data processing. *—DS* E&S

The NEOWISE survey looked at more than 500 objects larger than 100 meters in diameter. Each asteroid in this graphic represents about 100 space rocks. The known NEOs have been colored in; the outlines show how many NEOs were thought to exist before the survey, with the green outlines showing the new estimates based on the NEOWISE data. (Sizes of NEOs are not drawn to scale.)