THE PLANETARY SOCIETY

THE PLANETARY REPORT

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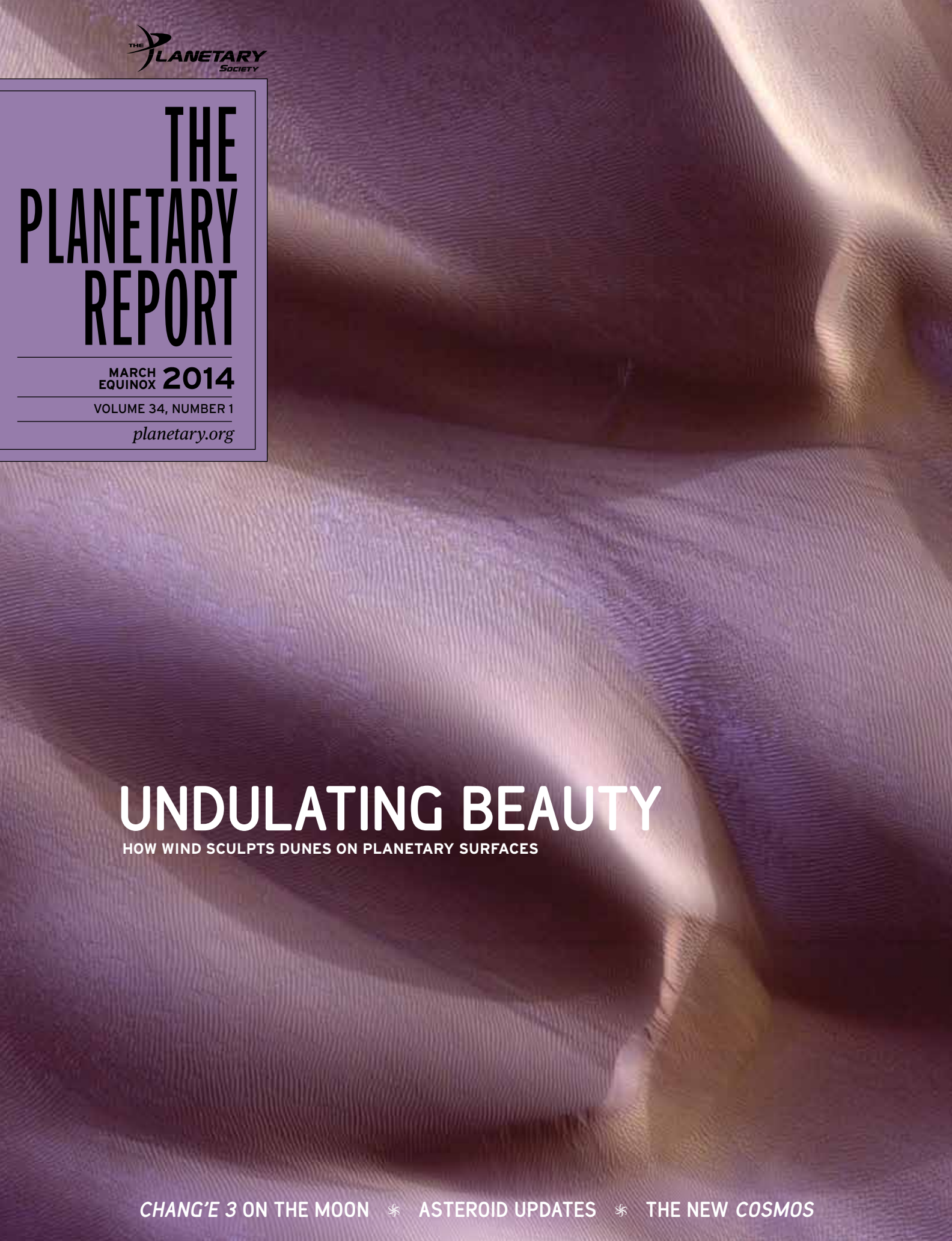

UNDULATING BEAUTY

HOW WIND SCULPTS DUNES ON PLANETARY SURFACES

CHANG'E 3 ON THE MOON ✻ ASTEROID UPDATES ✻ THE NEW *COSMOS*

EMILY STEWART LAKDAWALLA
blogs at planetary.org/blog.

Playing Light Games

LIGHT BOUNCES AROUND Saturn's system in mind-bending ways. In this unusual photo, taken when the Sun was nearly in front of *Cassini*, the spacecraft is looking at the night side of Saturn's moon Enceladus. Ordinarily, Enceladus is a bright, icy white, but here its nightside is lit by light that bounced off the yellow globe of Saturn, painting the moon a yellowish color. Meanwhile, ice crystals erupting out of Enceladus' south polar geysers are scattering sunlight toward *Cassini* like dust motes in a sunbeam, rendering their faint plumes brightly visible. Most of these ice crystals escape Enceladus' weak gravity to go into orbit around Saturn, forming its E ring. A faint dark region of the sky to the left of Enceladus is the shadow of the moon cast on the faintly light-scattering ice crystals of the E ring.

–Emily Stewart Lakdawalla

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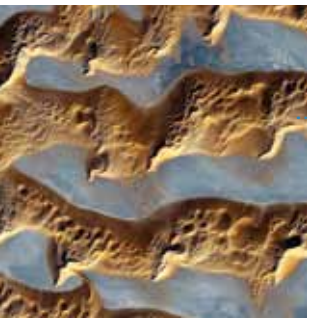
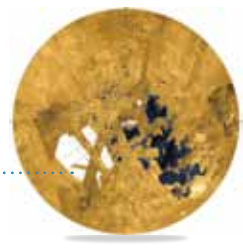
Image: NASA/JPL/SSI/Gordan Ugarkovic





ON THE COVER: Among nature's gifts, dunes exist in a class by themselves. Whatever form they take—from star- or crescent-shaped, to sharp-crested and linear, to sensuous and undulating—they are all fascinating and beautiful. It was late fall in the Aonia Terra region of Mars' southern hemisphere when the High Resolution Science Experiment (HiRISE) on *Mars Reconnaissance Orbiter* imaged these dunes. In this colorized view, carbon dioxide frost (bright lavender) is just beginning to accumulate on the dunes' pole-facing slopes and in the troughs between the meter-scale ripples. *Image: NASA/JPL/University of Arizona*

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BILL NYE *is chief executive officer of The Planetary Society.*

Extraordinary News

Exciting Times for Your Society

IN MARCH OF THIS YEAR, the Society received a spectacular gift of $4.2 million. It's from a Member who joined about a year ago. After several months of observation, this relatively new Member decided that we are literally a worthy cause. This gift will enable us to hire several new staffers. We will be able to do what we already do—but a great deal more of it. This is the most exciting time for us since we were formed 34 years ago.

As I've been saying, our Society's membership is growing for the first time since the mid-1990s. When The Planetary Society was first formed, we had about 100,000 members, including me. We hope to reach that level again and exceed it in the coming years. To do that, I'm asking for your advice.

I like to describe the Society as an organization that does three things well; in fact, better than any other space interest group:

- We educate. Just check out our blogs, where Emily Lakdawalla and Mat Kaplan lead the way.
- We create. No other membership organization is building its own spacecraft or sending member names and messages on round trips to asteroids in the solar system. We also create by funding researchers who are finding a much cheaper way to get samples from Mars. We fund searches for near-Earth asteroids, and we have found a great many of them, thanks to carefully targeted equipment and techniques developed by highly skilled Members. Our own Bruce Betts manages all of these remarkable projects.
- We advocate. We are the space interest group that is most closely engaged with members of the United States Congress, and we have the best thought-out policy recommendations, because we listen to how you all feel and what you all want in space policy. Casey Dreier organizes this effort.

These are the things the Society is working on now. What do you want our organization to be up to? What should we be focused on? Let me know.

THE COSMIC SHOOTING GALLERY

If you're a Member, your name will be on its way to asteroid Bennu; you will be part of a mission to one of the hundreds of thousands of comets and asteroids in our planetary neighborhood. Many of these objects are hurtling through space, and sooner or later, humankind will have to deflect one that's headed our way. Sooner or later, we will need to be ready to act, and I want our Society to be at the forefront of the research. Our first task is to find as many of these potential threats as possible. Next, we want to offer to the world a system that can give one of these objects a bump or a nudge—just a little delta-v—that will divert it from Earth. Right now, in the early twenty-first century, our unique Laser Bees research looks very promising. We're working hard so that when the need arises, we'll to be able to provide the science that informs the engineering needed to keep our planet intact. It's not just the stuff of science fiction, as the recent events in Chelyabinsk remind us of our place in the cosmic shooting gallery.

CHINA'S *YUTU*

I'm also proud to report that The Planetary Society became the most reliable source in the English-speaking world for news about the China National Space Agency's Moon rover, *Yutu*, or *"Jade Rabbit."* Most people I meet are hardly aware of China's accomplishments in space. The Chinese space agency is going to continue to explore, with

the goal always in mind to land people back on the Moon. This will drive interest in space and funding for exploration the world over.

Our new mission statement–to empower the world's citizens to advance space science and exploration–recommits us to engaging globally with as many people as possible in the adventure of space so that we can maintain adequate funding for planetary programs, devise ways to explore asteroids, and inspire the next generation of space scientists.

DEBATING KEN HAM

As you may have heard, I recently participated in an unusual debate with an avowed creationist named Ken Ham in Petersburg, Kentucky. He believes Earth is extraordinarily young–only 6,000 years old.

As a Member, and as a reader of this magazine, you might wonder what I thought I was doing getting involved in this seemingly peripheral matter, something far from the mission and vision of The Planetary Society. I felt it was appropriate to debate Mr. Ham in the same way that it was appropriate for Carl Sagan to debate Immanuel Velikovsky about his extraordinary and very wrong assumptions about the natural history of Venus and its environment. I remember well how Velikovsky confused carbohydrates with hydrocarbons. After all, desert dwelling nomads eating bread would be one thing; having them drink motor oil would be something else. I remember the Sagan-Velikovsky arguments as being part of a worldwide interest in space and in the planet Mars, especially. Just as we do now, people everywhere had a deep interest in what might be up there and out there in deep space. Velikovsky was wrong and Carl Sagan took the time to call him on it.

Thank you all again for your support.

A SELFIE WITH PRESIDENT OBAMA

From time to time, I get a message from the Office of Science and Technology Policy (OSTP) inviting me to attend certain events. I've been to two White House Science Fairs, and I attended a White House holiday party. It is an honor to speak with young people about science. Along this line, my fellow Board Member Neil deGrasse Tyson and I were invited to be presenters at the first edition of the White House Student Film Festival.

Neil and I, half-whispering, fantasized about getting a custom, selfie-style picture with President Obama. I admit this was a bit of a crazy thing to even imagine. I am pretty sure the president has a photographer with him almost all the time, someone with quite a few more megapixels and more compositional skill than we have with our iPhone cameras. Nevertheless, Neil took the chance. "Hey, Mr. President, can we get a selfie with you?" I immediately remarked, "Let's break the Internet!" For whatever reason, the president was charmed by our honesty and enthusiasm.

In those few moments, the president, Neil, and I spoke about science and space exploration. I offered that when we explore the cosmos, we come to believe and prove that we can solve problems that have never been solved. It brings out the best in us. Space exploration imbues everyone in the country with an optimistic view of the future. The president agreed. Here's hoping we planted a reminder, a thought that will stick with him as he negotiates the NASA budget. And, we hope he remembers that moment as a fun one.

Getting a selfie with the most powerful man on our planet was a thrill. Judging from the shot, he had a good time, too. It preserves a great moment for planetary science!

Bill Nye

ABOVE *Best selfie ever? At the first annual White House Student Film Festival, Bill Nye, President Obama, and Neil Tyson discussed planetary science–and had a little fun.*

Photo: Neil deGrasse Tyson

HAPPENING ON
PLANETARY RADIO
planetary.org/radio

THE MOST POWERFUL INSTRUMENT EVER FOR IMAGING EXOPLANETS
Principal Investigator and physicist Bruce Macintosh joins astronomer Franck Marchis to celebrate first light from the Gemini Planet Imager. bit.ly/planetary-2014-01-13

GETTING HUMANS TO MARS WITHOUT BREAKING THE BANK
NASA scientist Harley Thronson tells us about a new initiative that is figuring out how we will get men and women to the Red Planet at a reasonable price. bit.ly/planetary-2014-02-18

AN EXHILARATING ERA—THE *VOYAGER* YEARS
JPL's Blaine Baggett and former JPL director Ed Stone talk "The Stuff of Dreams," a documentary about an era in planetary exploration that was both exhilarating and exasperating. bit.ly/planetary-2014-02-25

EXPLORING BLACK HOLES AND SUPERNOVAE WITH NuSTAR
Caltech's Fiona Harrison provides a tour of some of the universe's most fascinating objects using the first high energy X-ray telescope in space. bit.ly/planetary-2014-03-11

ALASKAN AURORA ADVENTURE!
Planetary Radio host Mat Kaplan takes us on a trip to see the Northern Lights in Fairbanks, Alaska with fellow Planetary Society Members. bit.ly/planetary-2014-03-18

Find these shows and our entire archive of *Planetary Radio* at *planetary.org/radio*!

ON *PLANETARY.ORG*

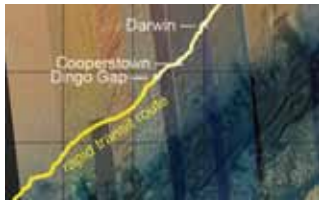
ADVOCACY
NEW U.S. BUDGET
The President's budget for 2015 has come out. See what it means for NASA and planetary science at planetary.org/sos

OPINION
WHAT IS NASA FOR?
Curiosity team member Craig Hardgrove suggests answers. bit.ly/planetary-2014-02-12

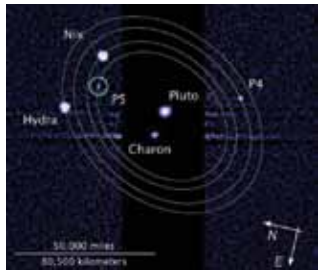
MEDIA
MOONWALKING
Images of the moon that you have never seen before . . . courtesy of *Lunar Reconnaissance Orbiter*. bit.ly/planetary-2014-03-17

MEDIA
SPINNING BODIES
Thousands of images means we can create animated movies of the planets spinning . . . cool! bit.ly/planetary-2014-02-24

FUTURE SPACECRAFT
Van Kane looks at the state of NASA's Discovery program, which builds "cheap" missions. bit.ly/planetary-2014-02-08

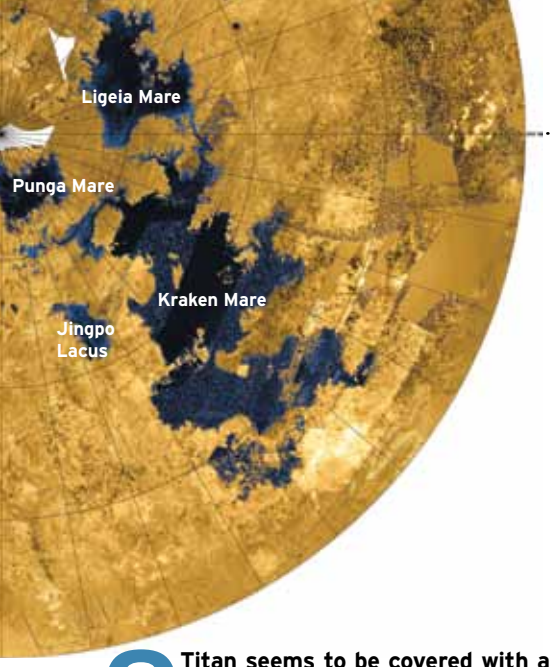


IMAGING
FINDING A ROUTE
How does the HiRISE camera on *Mars Reconnaissance Orbiter* help map *Curiosity*'s course on Mars? bit.ly/planetary-2014-02-10



PLUTO'S MOONS
Why did it take so long to find Pluto's other moons? bit.ly/planetary-2014-02-19

INTERNATIONAL
RUSSIA'S PLANS
After several lost missions, Russia has some ambitious planetary exploration goals. bit.ly/planetary-2014-01-22



Map: NASA/JPL-Caltech/ASU/USGS; Illustration: NASA/ESA/M. Kornmesser, ESO

Q **Titan seems to be covered with a lot of hydrocarbons. In her blog post on May 15, 2013 [bit.ly/planetary-2013-05-15], Sarah Hörst gives a nice explanation of how they may have formed from atmospheric components. Are we sure that the hydrocarbons on Earth didn't come from a similar process?** *–Kevin Albertson, Windsor, Colorado*

A Earth's hydrocarbons are pretty easy to connect to biological processes. Carbon has two main isotopes, carbon-12 and carbon-13, which are atoms that have the same number of protons but different numbers of neutrons. Biological processes use carbon-12 more efficiently than carbon-13. This means that living things, or things that were once living, have more carbon-12 than non-living things. When we look at Earth's hydrocarbons, we can see that they are enriched in carbon-12, and that tells us that the source of these hydrocarbons was once a live organism (or many, many, many organisms!).

We do think that the atmosphere of the early Earth (before life existed) had a haze layer similar to Titan's, and right now scientists, including me, are trying to figure out if we can find evidence of that haze layer somewhere in the rock record. We hope that the carbon isotopes will help us do this, since biological and non-biological processes create different carbon isotope signatures. First we have to understand what the isotope signature of haze would look like, and then we have to try to find it!

–Sarah Hörst, University of Colorado

FACTINOS

Hundreds of New Planets

IN LATE FEBRUARY, NASA's *Kepler* mission team announced the discovery of 715 new planets. These newly verified worlds orbit 305 stars and reveal multi-planet systems much like our own solar system.

Nearly 95 percent of these new worlds are smaller than Neptune (which is almost four times the size of Earth). These findings mark a significant increase in the number of known, small-sized planets that are more like Earth than previously identified exoplanets. Four of these new planets are less than 2.5 times the size of Earth and orbit in their sun's habitable zone.

To verify this bounty of newly discovered planets, a research team co-led by Jack Lissauer of Ames Research Center analyzed stars with more than one potential planet, all of which were detected in the first two years of *Kepler*'s observations–May 2009 to March 2011. The research team used a technique called "verification by multiplicity," which relies in part on the logic of probability. Through a careful study of sample stars, these 715 new planets were verified.

"Four years ago, *Kepler* began a string of announcements of first hundreds, then thousands, of planet candidates–but they were only candidate worlds," said Lissauer. "We've now developed a process to verify multiple planet candidates in bulk to deliver planets wholesale, and have used it to unveil a veritable bonanza of new worlds."

Listen to *Kepler* team member Jason Rowe discuss these findings at bit.ly/planetary-2014-03-04.

ABOVE *NASA's* Kepler *mission continues to detect evidence that the Milky Way is teeming with planets around other stars–recently confirming 715 new worlds in planetary systems much like our own. In this artist's impression, the planets, their orbits, and host stars are vastly magnified in terms of their actual distance from one another.*

ABOVE LEFT *Titan's northern hemisphere abounds with lakes of liquid hydrocarbons. For more information, visit* bit.ly/planetary-2014-03-15.

RALPH D. LORENZ *studies how planetary atmospheres and surfaces interact.*

The Dune Whisperers

Learning How Windblown Sand Shapes Planetary Landscapes

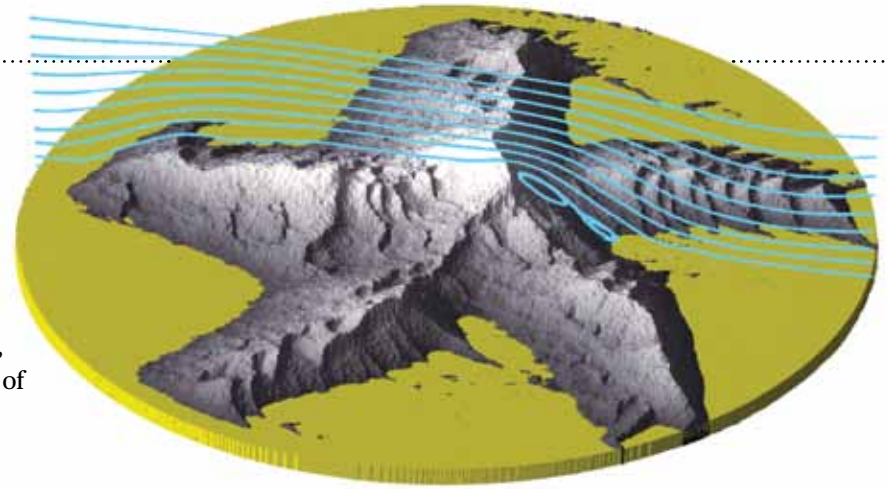
ABOVE *The Arabian Peninsula's Rub' al Khali (Empty Quarter) is the largest continuous sand desert on Earth and home to a variety of spectacular dune shapes. This towering star dune is formed by converging winds and will likely stay fixed in place for millennia. The dune modifies the wind around it, leading to the arrangement of smaller dunes that snake away from it. Similar dune geometry can be seen at Nevada's Sand Mountain.*

DUNES ARE NOT ONLY one of the most dynamic features of planetary landscapes; they also are among the most beautiful. The combination of their spectacular variety and comforting regularity appeals to something in the human brain—like snowflakes, no two dunes are exactly alike, yet there clearly is order in their formation. Our understanding of how dunes and ripples form and evolve has progressed dramatically in the last two decades, accompanied by breathtaking spacecraft views of dunes on Earth and Mars, and the discovery, through spaceborne radar observations, of dunes on Venus and Titan. This understanding now opens a new window into the recent history of the changing climates on Mars and Titan as well as our own world.

Conceptually, dunes are straightforward. Get dry sand that's fine enough, and winds that are strong enough, and the sand can move. But why should it pile up in organized patterns? How big can a dune grow? How does the shape of a dune relate to the winds that form it? On these seemingly simple yet profound questions there has been tremendous recent progress, made possible with advanced computer models and careful laboratory experiments. These scientific advances now coherently and quantitatively expose the relationships among the planetary environment, the interactive processes of airflow and sand movement, and the resulting landforms. We can now predict with

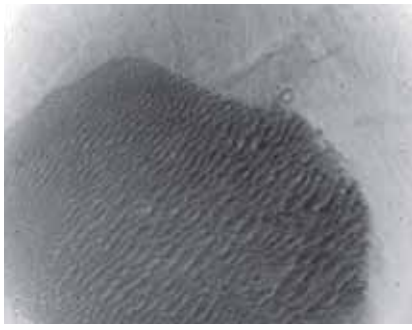
Photo: George Steinmetz

some confidence what kind of dune we will get, once we specify the environmental factors such as the grain size, the gravity, and the variation of wind speed and direction.



ABOVE *Modern computer studies can quantify how airflow moves sand, and how the resulting dune shape affects the airflow. This simulation of a 5-pointed star dune is composed of two computer models that reveal how streamlines of wind compress at the dune's crest and then separate, leaving a vortex in the lee of the dune.*

Star Dune model courtesy Clement Narteau; *Mariner 9* image: NASA/JPL



ABOVE *The first dunes recognized on another world. After the 1972 Martian dust storm cleared,* Mariner 9 *snapped this image showing what at the time was called a "suspected dune mass" in the Hellespontus region. At upper right is a small impact crater and (just barely visible here, and not recognized at the time) some faint dust devil tracks. The white dots across the dune field are transmission errors.*

MOVING SAND

The first major progress on these questions was made in the 1940s by the British soldier and scientist Ralph Bagnold, who made daring long-range desert raids into Libya during World War II. Bagnold used special wind tunnels and field measurements to understand sand transport, and his work remains the foundation for all that has followed.

Martian dust storms were known from telescope observations; dunes were seen first by spacecraft in 1972. In 1975 Planetary Society Cofounder Carl Sagan worked with Bagnold to understand how the thin Mars atmosphere might blow sand and dust–a thin atmosphere needs to move much faster to overcome the weight of a grain. This in fact has remained a puzzle until rather recently–it turns out there is a big difference between the high wind speed needed to get sand moving, and the rather lower wind needed to keep it moving once it starts. Despite the fact that Mars' atmosphere is about 50 times thinner than ours, Mars has dunes and ripples everywhere.

In contrast, the torrid Venus atmosphere is about 50 times denser than ours, so moving sand should take only very weak winds since there is more atmospheric momentum, or "push," for the same wind speed. Yet only a couple of dune fields were seen on Venus' surface by *Magellan*'s radar mapping in the early 1990s. The explanation for this paradox may be twofold–Venus' volcanically young surface just doesn't have much sand-sized material to blow around, and much of it may be sculpted into fields of "microdunes" too small to observe at the 100-meter scales that *Magellan* could observe.

It was natural to speculate that because Titan has a significant atmosphere, and weak gravity too, it would be very easy to move sand and form dunes. That speculation seemed too easy to me as I worked in the early 1990s to anticipate the findings from *Cassini* and *Huygens*, then under development. So far from the Sun, Titan might not have strong winds. Furthermore, we expected Titan to be wet: its hazy atmosphere was featureless and opaque in the images from the *Voyager 1* encounter in 1980 and contains methane, which (with ethane) could be present as liquid on the surface. Thus I published a paper in 1995 suggesting we would be unlikely to discover sand dunes on Titan.

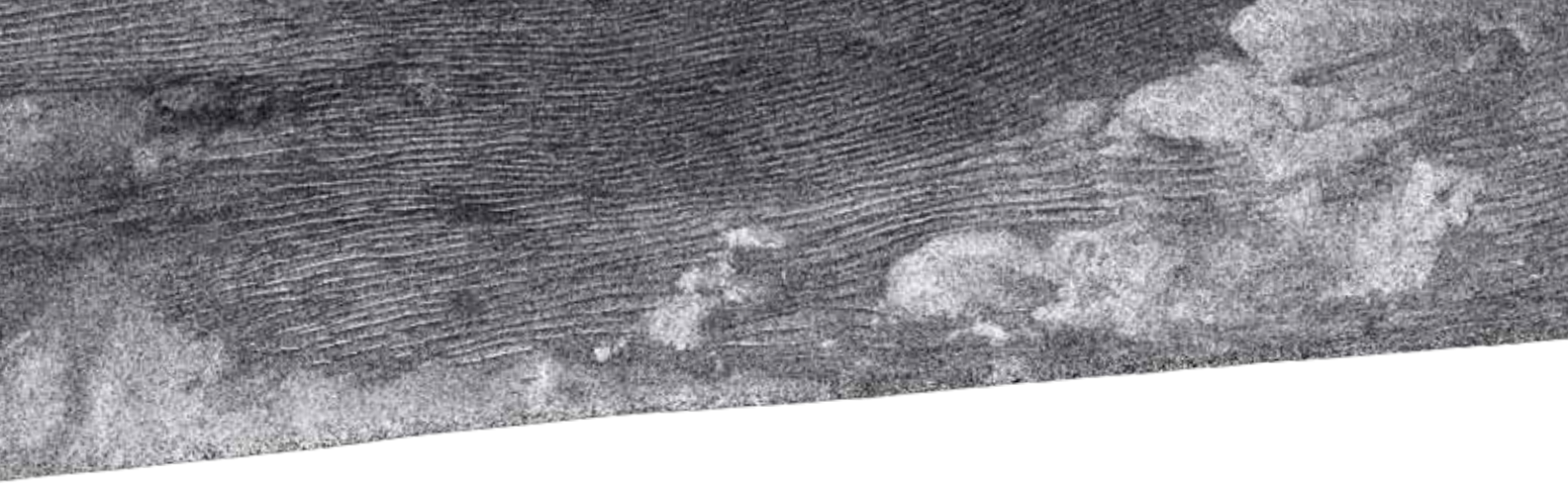
That, of course, proved to be one of the most spectacularly wrong predictions in planetary science! Unlike its uniform-looking atmosphere, Titan's surface proved to be tremendously variable–the liquids presently are concentrated in lakes and seas around the north pole, while the equatorial regions form a vast desert, covered with colossal linear dunes, much like the largest dunes on Earth. Just like deserts on Earth, it rains occasionally, so Titan has canyons and pebble-strewn riverbeds (in one of which *Huygens* happened to land), but the dunes dominate. In fact, dunes cover some 15 percent of

RALPH D. LORENZ *is a member of the Principal Professional Staff at the Johns Hopkins University Applied Physics Laboratory. He led the paper reporting the discovery of sand dunes on Titan by the* Cassini *RADAR team in 2006. His book,* Dune Worlds: How Windblown Sand Shapes Planetary Landscapes, *co-authored with Jim Zimbelman, will be published in April 2014.*

ABOVE *Apart from Olympia Undae, the vast dune field near Mars' north pole, many of the Red Planet's dunes are found inside impact craters. In this view of Victoria crater, imaged by the High Resolution Imaging Science Experiment (HiRISE) on* Mars Reconnaissance Orbiter, *a field of dunes ripples across the floor of the 800 meter-wide crater.*

BELOW *Fortuna is one of only two known dune fields on Venus. The direction of the wind that formed Fortuna's dunes shows in the white streaks of this* Magellan *radar view, but the dunes' shapes are difficult to assess. The dunes are the faint dark streaks that cross the white streaks at right angles.*

Images: NASA/JPL-Caltech/University of Arizona; NASA/JPL



Titan's surface, far more than the 1 to 2 percent on Mars and Earth (and only a little less than the fictional world Arrakis of the *Dune* novels).

It is of course by destroying theories with data that scientific progress is made. In the pre-*Cassini* era we had little reason to think Titan wasn't uniform, but we now know Titan's active hydrological cycle segregates the moisture away to high latitudes, freeing the sand to move, a process that computer models (global circulation models, or GCMs) suggest results from Titan's slow rotation. By contrast, on faster-rotating Earth, the drying occurs at mid-latitudes—most deserts are found about 20 to 30 degrees from the equator. Mars and Venus are dry everywhere.

FACTORS IN DUNE SIZE AND SHAPE

As ever in science, deeper questions result. For example, why on Titan—a world with gravity like that of our Moon, with air four times denser than ours, and sand likely made of organics like what you might scrape from the inside of your kitchen oven—should the dunes end up being exactly the same shape and size as those in the Namib or Arabian deserts on Earth?

In the last decade, it has become recognized that the size of a dune is eventually limited by the thickness of the planetary boundary layer (PBL), the region of the atmosphere closest to the surface that gets mixed up by heating from the ground. On Earth the height of this layer varies between about 300 meters and 3 kilometers (lower values near the coast, higher inland), and the largest dunes found are spaced by about these distances, with heights that are smaller by a factor of about 10. Similarly, Titan's dunes are 2 to 3 kilometers (about 1 to 2 miles) apart, consistent with *Huygens* measurements that show a 2- to 3-kilometer boundary layer.

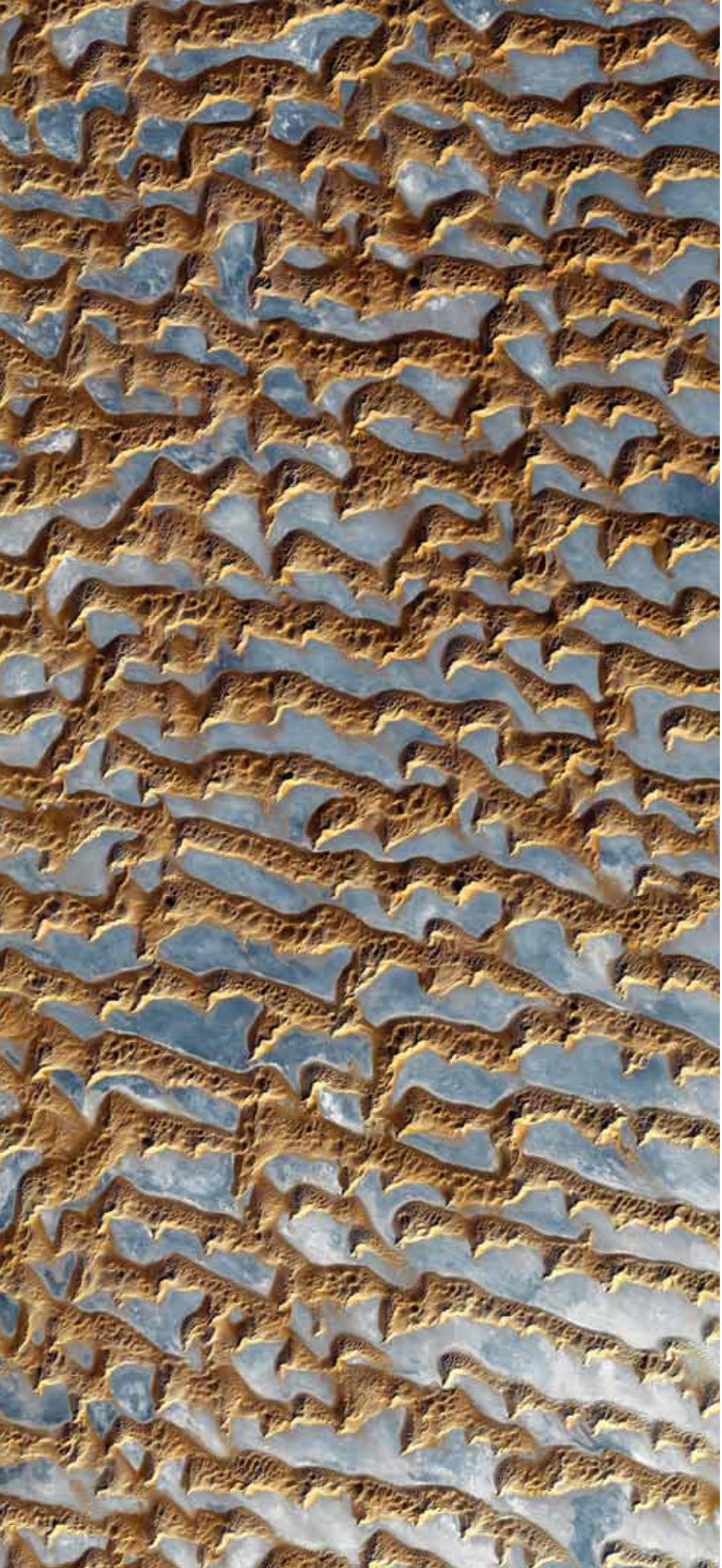
As for the shape, scientists struggled to make GCMs produce the converging winds that form giant linear dunes which *Cassini* observations suggest have a net sand transport from west to east. In fact, so far Titan has shown us few clouds to track, so dunes are one of our best clues as to how Titan's winds behave. One interpretation is that it is only at spring equinox on Titan that the equatorial winds are fast enough (about 1 meter per second) to move sand, so the dunes we see reflect only the exceptional (eastward) winds at equinox, not the average wind regime, which generally goes to the west near the equatorial surface.

This exceptionalism takes us back to Mars. There, the boundary layer can grow to great heights (as revealed by dust devils, which also tend to be capped by the PBL, sometimes reaching 20 kilometers, or about 12 miles), and dunes could in principle grow

ABOVE *This* Cassini *radar image of the Belet sand sea on Titan shows very regularly spaced dark features, with glints on their north faces, confirming their positive relief. This image covers an area 100 by 300 kilometers (62 by 186 miles). The dunes' length, height, spacing, and appearance overall are very similar to the linear dunes in Africa's Namib Desert.*

BELOW *This photo of White Sands National Monument in New Mexico was taken with a GoPro camera lofted by a small kite. The barchanoid (curved) dune shape seen here forms in winds that generally blow from one direction, and is a very common dune type on Mars. The author and his vehicle are just visible at lower left.*

Images: NASA/JPL/R. Lorenz/*Cassini* RADAR Team; R. Lorenz



to be very large. Mars' dunes may in places be bigger than those on Earth, but they aren't that much bigger. The reason seems to be that they haven't had time to grow.

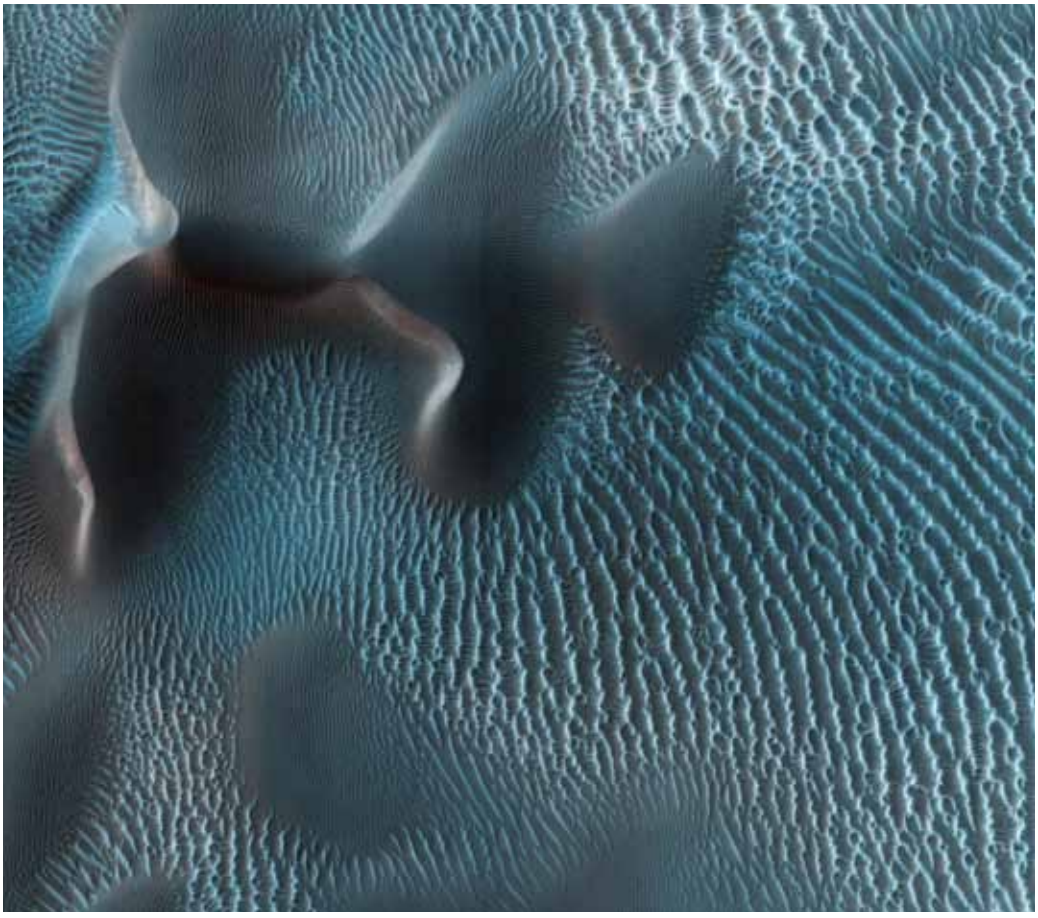
MEMORIES OF ANCIENT WINDS

Because Mars' equatorial tilt, and its relationship to the planet's slightly eccentric orbit around the Sun, both change over astronomical time (tens of thousands to millions of years), Mars' climate and wind patterns change dramatically. The same sorts of change, known as the Croll-Milankovich cycles, play a role in pacing the ice ages on Earth, and on Titan may be responsible for flipping the liquids from one pole to the other, also over some tens of thousands of years. A large dune might take tens of thousands of years or more to form under a given set of wind conditions. But if the wind regime has changed on a similar timescale, the dune orientation and shape will be "off balance"—out of equilibrium with the present climate.

Most locales on Mars see winds from just one direction, which leads to slowly migrating barchan (crescent) and barchanoid forms. Many dunes on Mars seem to be aligned in ways we wouldn't expect, given the wind predictions from GCMs. These models, which are used to assess wind hazards for landers and rovers, are based on more data than we have from Titan models (after all, there have been several—admittedly far too few—landers with meteorology stations on Mars) and the thin Mars atmosphere is more predictable than Titan's. So this misalignment seems to be real. Some terrestrial dunes—including those in the Arabian desert—similarly reflect past conditions, in this case the changing extent of monsoon winds since the last ice age.

Disentangling the convolved effects of the past and present winds, and the resulting mutant shapes and superposed generations of bedforms, was previously a matter of attempted qualitative explanations, but new computational tools let us quantitatively

Image: NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

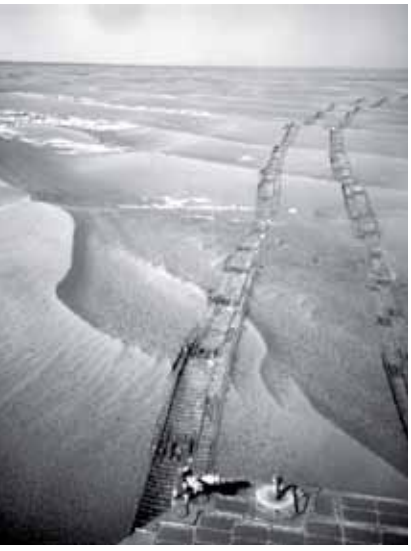


ABOVE *Classic barchan dunes on the coast of Peru. These are the fastest-moving type of dune. They are formed by sand blowing inland from the Pacific Ocean. Small dunes move faster than large ones, and computer models can reproduce how they interact with each other.*

BELOW *This HiRISE image of Mars' Olympia Undae shows three different types of aeolian features: a set of barchan and dome-like dunes, on which small, round ripples are superposed and, on the floor around the dunes, larger but sharper-crested ripples are visible.*

OPPOSITE PAGE *This satellite view of kilometer (.6 mile)-wide megabarchan dunes in the Rub' al Khali shows that they probably developed more like Titan's linear dunes. But since the end of the last Ice Age, winds there have become more unidirectional, tearing the dunes into a more barchanoid shape.*

Photo: George Steinmetz; image: NASA/JPL-Caltech/University of Arizona



LEFT Opportunity *captured this image of its tracks through Martian dunes near "Halfmoon" crater in February 2009. The tracks show where the wheels slipped as the rover negotiated wind-blown sand ripples. Some coarse granules can be seen on the flanks of the ripples, and, in some places, cracked white bedrock is exposed.*

RIGHT *This other-worldly view of and from a large linear dune at the eastern end of the Rub' al Khali shows the United Arab Emirates-Omani border (dark fence with observation tower). Two other linear dunes (similar to Titan's) are visible in the distance, whereas crescent-shaped barchans are migrating across the bright flat gravel floor in the foreground. The dunes have no respect for the border fence. In desert regions, dune interaction with human infrastructure is expensive and challenging to deal with.*

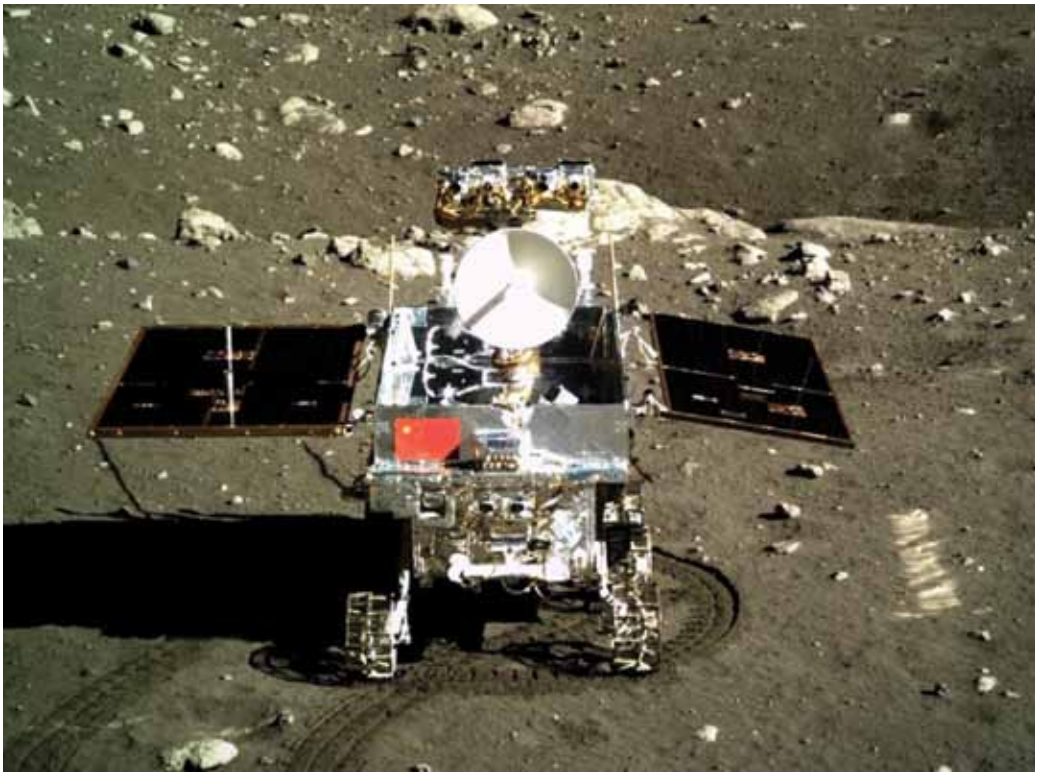
assess how long winds of a given strength and annual pattern must persist to produce the landscape we see. While small dunes and ripples form quickly and reflect today's conditions, large dunes may be Mars' memory of how the winds once were. Similarly, close study of Titan is starting to hint that while the dune pattern overall is very regular, reflecting a mature "end state," small features at the edge of some dune fields may indicate a changing climate.

Closer inspection always gives new insights. For many years it was a puzzle why no Mars dunes were observed to move, whereas small barchan dunes on Earth can move tens of meters per year. We knew since the *Viking* landers in 1975 that the sand moves—their robot arms made little piles of sand that blew away. More recently, the Mars Exploration Rovers, which have struggled across fields of ripples, have observed sand movements. It was speculated that perhaps the dunes were cemented in place, by ice or salts. Indeed, observations with ever-sharper cameras (notably, the 0.5-meter resolution of the HiRISE camera on *Mars Reconnaissance Orbiter*) have shown some dunes to be "crumbling," suggesting that they were cemented (hinting at the presence of moisture in the past). On the other hand, as we have observed for increasingly longer periods, dunes and ripples have now been seen in some places to move at a rate of a few meters per year.

Dunes and moving sand affect us on Earth in many ways, from cars getting stuck on field trips, to blocked roads and railways, to the loss of farmland. In fact, the science fiction novelist Frank Herbert dedicated his novel *Dune* to dryland ecologists fighting desertification. Our growing understanding of the processes involved has gone hand-in-hand with the exploration of other worlds where these same processes, under wildly different conditions, lead to exotic yet familiar landscapes and whispers of past climates.

Image: NASA/JPL; photo: R. Lorenz

EMILY STEWART LAKDAWALLA
blogs at planetary.org/blog.



China Is On the Moon

First Lunar Lander and Rover of the Digital Age

***CHANG'E 3* SOARED SKYWARD** from the mountainous Xichuan launch site atop a Long March 3B rocket on December 2, 2013. The powerful rocket delivered the spacecraft directly onto a lunar transfer trajectory. Just five days later, *Chang'e 3* entered orbit at the Moon, and landed at its first opportunity, on December 14.

Every step of the journey was broadcast live to the entire world over television and the Web. This degree of openness still boggles my mind every time I reflect upon it. In the past, it was common to hear of Chinese accomplishments in spaceflight only after they were over. This mission has been quite different. China provided live television—with expert commentary in English!—as the rocket lifted off, injected the spacecraft onto its transfer orbit, and separated from the lander. Video cameras attached to each rocket stage broadcast spectacular imagery, and the final spacecraft separation occurred against a cinematic backdrop of Earth's curved horizon.

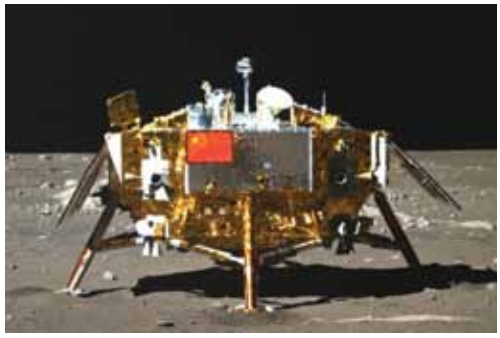
The landing, too, was broadcast live, as *Chang'e 3* sent still frames from a landing video camera back to Earth. Reminiscent of *Apollo*, the spacecraft angled as it deorbited, watching the curved lunar horizon approach before rotating into a more vertical descent attitude. Craters appeared in the field of view as the spacecraft dropped steadily to an altitude of 100 meters, where it hovered while assessing the safety of the landing site with camera and laser ranging. It made a small adjustment to its targeted landing site, then descended farther, cutting the engines at about 4 meters above the surface to drop the rest of the way to the surface. Just hours later, it deployed a six-wheeled rover, *Yutu*, onto the lunar soil.

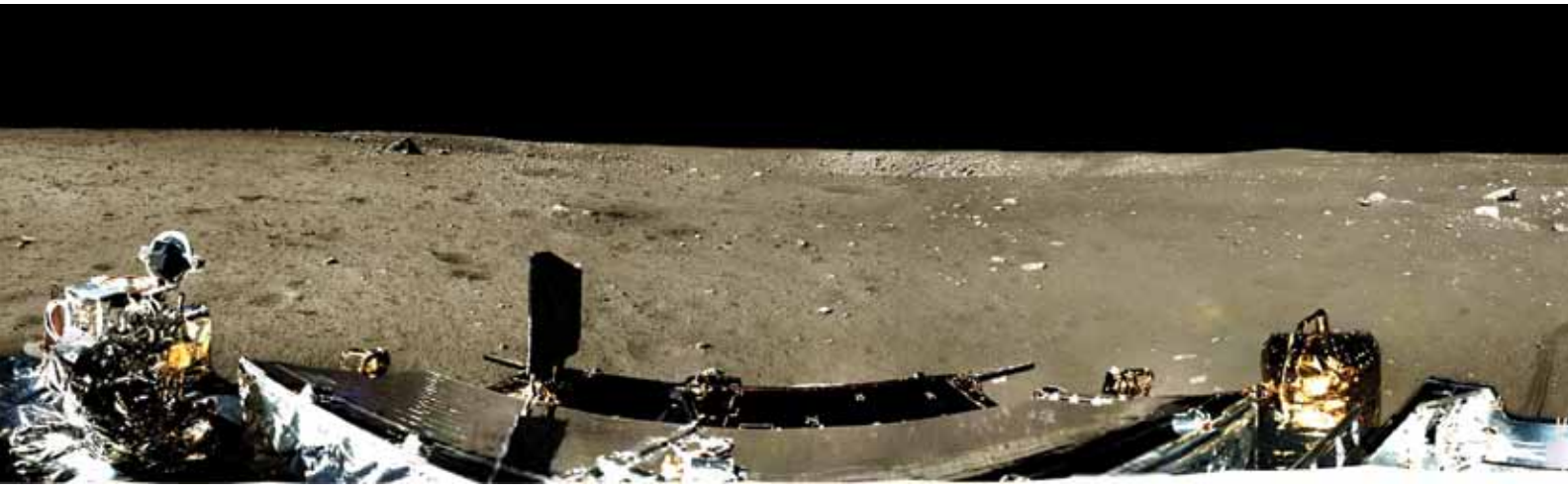
ABOVE Chang'e 3 *departed Earth for the Moon on December 2, 2013. This still frame is from China's live television coverage of the launch—from lift-off through third-stage separation. To watch the launch movie, go to* bit.ly/planetary-2013-12-01.

LEFT *On December 15, 2013, one day after landing, the* Chang'e 3 *lander took this image confirming the safe deploy of the* Yutu (Jade Rabbit) *rover on the lunar surface. China has shared every step of this mission with the world via television and the Web.*

Images: Chinese Academy of Sciences; CCTV

Chang'e 3 and *Yutu* spent their first lunar day checking out instruments–and each other. The lander took a 360-degree color panorama of a chocolate-brown lunar landscape, with bright white rocks poking through–colors that puzzled many observers. Most of the images initially shared on the Web came through a circuitous transmission path that negatively affected the quality of the photos: they were displayed on screens in Beijing-based mission control, recorded from those screens through a television camera, and broadcast to the Web as video. After the initial day, though, the Chinese Academy of Sciences began sharing selected digital (though still compressed and uncalibrated) image data directly from its website.





ABOVE RIGHT *By December 21,* Yutu *had completed a semicircular traverse around the lander and was able to view its "front" (south-facing) side.*

ABOVE *This panorama around the* Chang'e 3 *lander was captured on December 20. This version has been cleaned of vignetting and other artifacts to create a more seamless view.*

Both lander and rover hibernated successfully through their first long, cold lunar night. During that night, NASA's *Lunar Reconnaissance Orbiter* team published their first photo of lander and rover sitting on the lunar surface; they have continued taking photos of rover and lander at nearly every opportunity.

After waking up on the second lunar day, the lander found its color camera had failed, but that was as expected; the camera was intended only for initial reconnaissance of the landing site and had not been protected against the nighttime temperature drop. The lander moved into its science phase, gathering data with two ultraviolet instruments: one designed to look at stars, the other for observing Earth's plasmasphere. Ultraviolet light mostly doesn't penetrate Earth's atmosphere, so a lunar lander is a productive platform for ultraviolet observation. Meanwhile, the rover set off to explore the lunar surface with a ground-penetrating radar instrument and two spectrometers designed to study the composition of the lunar soil.

The mission seemed to meet with nothing but success until late in the second lunar day, when disaster struck. China National Space Agency has not been specific about the details, saying only that a "mechanical control abnormality" crippled *Yutu*. The anomaly, whatever it was, prevented mission controllers from properly preparing the rover to survive the second lunar night by tucking

Images: inset: Chinese Academy of Sciences; panorama: Chinese Academy of Sciences/Don Davis

its camera mast down and folding one solar panel over it, like a duck sleeping with its head under its wing. With delicate electronics unprotected from the drop in temperature, *Yutu* was not expected to survive.

Public response to the rover's peril was surprisingly emotional, thanks in large part to the work of an anonymous Chinese space enthusiast who writes a blog and maintains a social media presence in the imagined voice of *Yutu* on Weibo, a Twitter-like service in China. In a passionate farewell, the *Yutu* persona counseled her Earth-bound fans to not be discouraged, to take heart in the 42 days of success in the context of the difficult history of lunar exploration, and, most poignantly, to comfort the *Chang'e 3* lander when it discovered *Yutu*'s death.

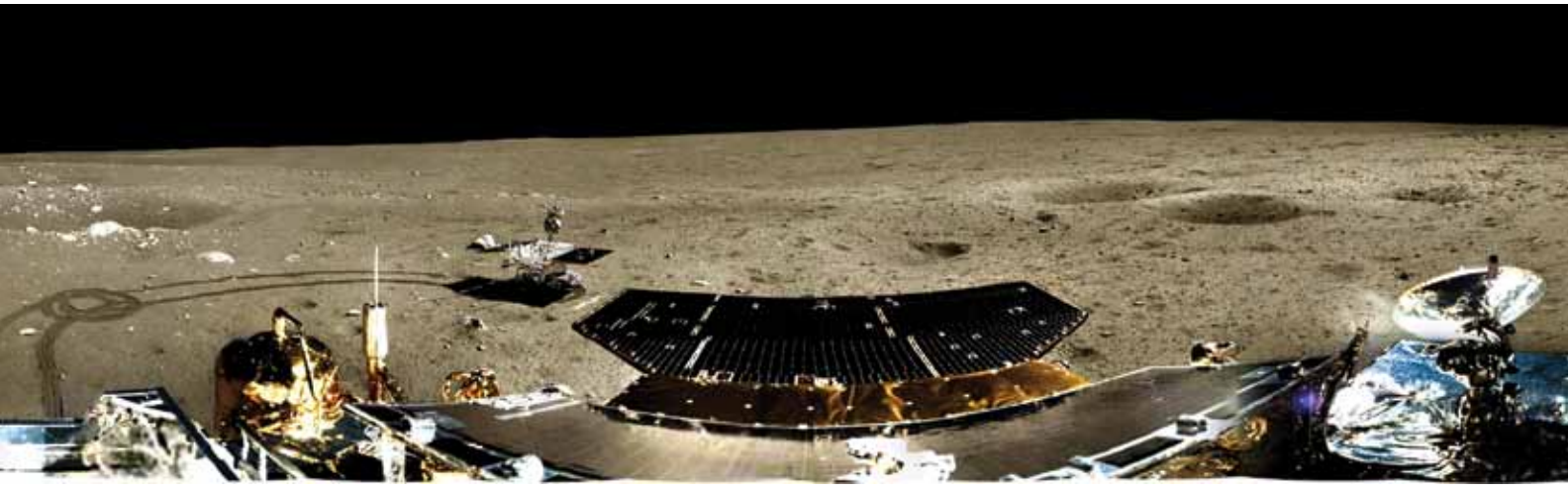
The farewell generated an outpouring of support for *Yutu* and for Chinese space exploration in general. Here in the United States, the news of *Yutu*'s plight even made it to a lengthy segment on *The Daily Show with Jon Stewart*, in which actor Patrick Stewart dramatically read some of *Yutu*'s final words.

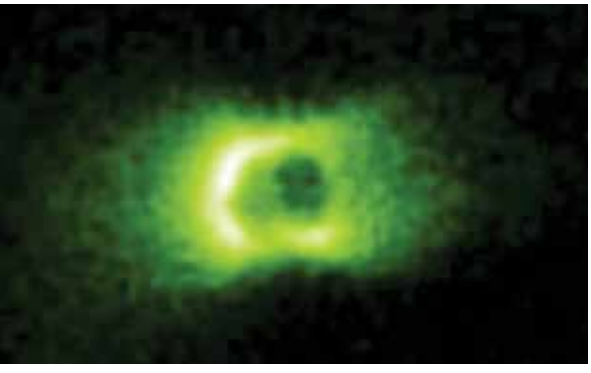
But the eulogies were premature. Against the odds, *Yutu* has survived the second and third lunar nights with functional instruments and radio communications capability. However, efforts to regain the rover's ability to move have been unsuccessful, rendering its experiments useless.

Yutu's failure is a setback, but the lander continues to operate, and the mission has been reorganized into a streamlined team that can support a year of operations. Back on Earth, China still has a duplicate of *Chang'e 3* and *Yutu* and is expected to launch a *Chang'e 4* lander in 2015. *Chang'e 4* may have a different complement of scientific instruments, and I hope lessons learned from *Yutu*'s failure will enable *Yutu*'s successor a longer life on the Moon.

For more information and to see some of Lunar Reconnaissance Orbiter*'s images of the lander and rover on the Moon, go to* bit.ly/planetary-2014-03-05.

Image: Chinese Academy of Sciences





LEFT *A couple of days after landing,* Chang'e 3*'s ultraviolet camera captured this view of Earth's plasma environment at a wavelength of 63 nanometers. Because ultraviolet light doesn't penetrate Earth's atmosphere easily, the Moon is a good place from which to make observations.*

ISON Rounds the Sun, as Seen from *STEREO*

PIERSON S.: Even though this is time-lapse imagery, I think people still don't realize the speed at which ISON is traveling. To get footage of it, in this fidelity, is nearly as exciting as the Meisser 82 supernova. This is just flat out stunning. **JOSEPH R.:** Time adds a third dimension. The movie of ISON circling the Sun helps one to understand still photos of other comets, and it shows the dynamics of the Sun's environment.

ABOVE *A still shot from an animation captured by the* Solar Terrestrial Relations Observatory (STEREO) *spacecraft. To see the full 96-frame movie, go to* **bit.ly/planetary-2013-12-06**.

These images—and thousands more—are available in The Planetary Society's Bruce Murray Image Library. Visit often because we're adding new pictures all the time. **planetary.org/multimedia/space-images/**

Winners!

Favorite Images from 2013

IN OUR DECEMBER SOLSTICE 2013 issue—as well as on *planetary.org*—we asked you to tell us which image from our "Year in Pictures" feature you liked best, and why. The "why" is especially important to us because it is yet another way to get insight into what our Members think and care about most when it comes to space science and exploration.

The view that received the most votes was the animation of comet ISON disappearing behind the Sun and surviving—sort of! A very close second place went to "Saturn Within Its Rings," (also called "Gazing on Northern Poles") courtesy of *Cassini* and amateur image processor Gordon Ugarkovic.

Thank you for sharing your thoughts with us. Here's a small sampling of your responses.

—Donna Stevens, Senior Editor, *The Planetary Report*

2013 YOUR COMMENTS

Saturn Within Its Rings

DAVID W.: Citizen Science! This is one of the most spectacular photos of Saturn I've ever laid eyes on and it's even more spectacular that a true enthusiast stitched this beauty together. **BILL AND COCO P.:** Images showing Saturn up close and personal through *Cassini*'s eyes always draw me into the marvel of seeing that gorgeous planet "in person."

Color View of *Curiosity*

ROBERT I.: To see the tracks and actual vehicle, sent by humans, operating on another world is incredible. An awe-inspiring juxtaposition: the majesty of the solar system and the ingenuity of Earth's people. A lot of perspective in a single image; that's why it gets my vote.

Yutu Begins Her Lunar Journey

LORI P.: Because this keeps the dream alive for everyone on Earth—that together we can succeed if we only try—for the good of the many, instead of the few.

Virgin Galactic *SpaceShipTwo*

LAURA M.: It illustrates with power and beauty the next phase of humankind's exploration in space.

Earth from JunoCam

AVI S.: The Earth looks alien yet familiar in this flyby photograph by *Juno*. The portion of the planet captured is unusual and the JunoCam push-frame imager gives it an odd aesthetic. **JULIA B.:** While all the images are great, this is our home. I vote Earth.

Chelyabinsk Meteor Explosion

ERICK G.: I think this was yet another eye-opening event that should remind us all of how easily incredible damage can fall from our solar neighborhood. We need to be wary and do what we can as a world to predict and thwart impact damage. **PHIL B.:** I believe this image woke up the whole planet to the fragility of life on our "pale blue dot."

Chelyabinsk Meteor Trail

LAURI H.: It is a nice looking and less-dramatic meeting of a meteor and the Earth. **MARJORIE S.:** It makes an especially visual connection between Earth and its "neighbors."

LADEE Heads to the Moon

EDWARD F.: Because it represents humanity's future: the exploration of the heavens, and it also shows the beautiful skyline and a small piece of what we have achieved here on our own beautiful planet.

ICELAND: LAND OF ICE AND FIRE

EXPLORE WITH THE PLANETARY SOCIETY AND BETCHART EXPEDITIONS

Iceland Total Solar Eclipse and Aurora Borealis
MARCH 15-23, 2015

Here is your chance to experience a total solar eclipse! You and your fellow Planetary Society Members will be in expert hands with long-time Betchart and Planetary Society expedition leader Bob Nansen and local Icelandic naturalist Siggi Tomasson. Get ready to:

- Go airborne to witness the total solar eclipse from the sky.
- Explore the land of fire and ice—the famous Geysir, after which all the world's geysers are named; the Blue Lagoon; Lake Myvatn's nature baths, and more.
- Marvel at the stunning night skies created by the Aurora Borealis.

You'll have front row seats for the experience of a lifetime—from watching the solar eclipse, to hearing talks on volcanism and glaciers, to enjoying Icelandic sagas, to learning about cutting edge research on the Aurora Borealis.

To get started on your adventure, go to planetary.org/expedition to download more information.

You can also contact Taunya at Betchart Expeditions to learn more: *Taunya@betchartexpeditions.com*
408-252-4910 (International)
800-252-4910 (USA only)
408-252-1444 (Fax)

Betchart Expeditions
17050 Montebello Rd., Cupertino, CA 95014 USA
info@betchartexpeditions.com
betchartexpeditions.com

Free Online College Introductory Astronomy Class

Come explore the solar system and the universe with Planetary Society Director of Projects Bruce Betts. His online college level class, Introduction to Planetary Science and Astronomy, runs through May 7, 2014 on Wednesdays at 15:00 Pacific time through California State University Dominguez Hills (CSUDH). The classes are broadcast live as well as archived on YouTube.

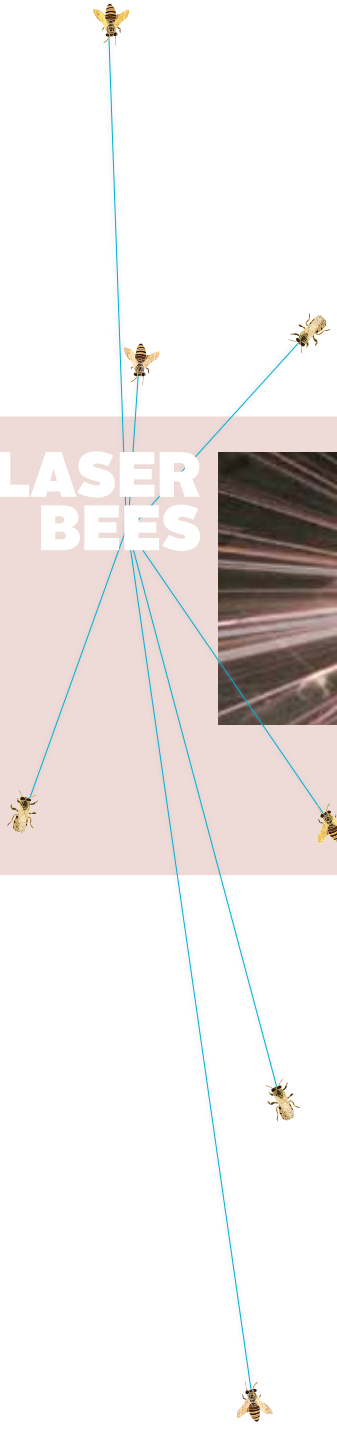
The CSUDH online system allows Dr. Betts to point out topics of interest directly on images of planets, moons, galaxies, and so much more. The course, while light on math, is designed to provide both a solid introduction to the solar system and increased understanding/enjoyment of future discoveries. Fundamental knowledge, as well as recent space discoveries, are discussed. The class focuses on our solar system, but also covers exoplanets, stars, galaxies, and the universe. Special guests will join discussions of their research and missions. Dr. Betts will also provide tips for personal sky observation.

Because this is a CSUDH Young Scholars Program class, only California high school and community college students can take the class for credit, but everyone can participate in the class and ask questions during the live classes. Everyone who watches the classes can also earn a certificate of achievement. Learn more, including information on how to watch the class, an archive of past lessons, the syllabus, schedule and reading assignments, and class assignments and tests (optional if you are not enrolled for college credit) on the class page at planetary.org/bettsclass.

BRUCE BETTS *is director of projects for The Planetary Society.*

Near-Earth Asteroids

Preparing to Laser Some, and Fly Your Name to One



LASER BEES UPDATE

Things are going well with the Planetary Society-sponsored Laser Bees project. The Laser Bees concept is to use a small "swarm" of spacecraft, each equipped with a powerful laser, to change the orbit of a potentially dangerous asteroid if one were to threaten the Earth. The lasers would vaporize (ablate) rock on the surface of the asteroid over weeks, months, or years, and that would create jets of material that would push the asteroid in the opposite direction, away from Earth. The Planetary Society is supporting laboratory experiments at the Universities of Strathclyde and Glasgow in Scotland to better understand the various aspects of this seemingly promising technique. Here is part of a recent update from project leader Massimiliano Vasile and graduate student Alison Gibbings:

Thanks to The Planetary Society we now have a new 130-watt fiber laser, an improved vacuum chamber, new diagnostic tools and new samples made of asteroid-analogous material, plus some meteorites. Using new measurements (in-situ mass balance, high speed camera, and a thermal camera), our new experiment campaign will examine the potential of laser ablation for the exploration, exploitation, and deflection of asteroids. It will enable us to measure the initial expansion and development of their gas and ejecta plume, and further improve the mathematical model to predict their thrust magnitude. We now have a better understanding of the physics behind the ablation of asteroids; in particular, the energy losses that can reduce the efficiency of the ablation process.

The results gathered from the work supported by The Planetary Society allowed us to push the boundaries of the research on asteroid deflection and to initiate larger research projects. The results gained from the experiments were instrumental to developing a mission study, supported by ESA, on a small technology demonstrator that could be used to test laser ablation on a small-scale asteroid. The results coming from the work supported by The Planetary Society also allowed us to initiate a large, four-year research program, called Stardust, supported by the European Commission. The overriding goal of Stardust is to train researchers to develop and master techniques for asteroid and space debris monitoring, removal/deflection, and exploitation, such that they can be applied in a real scenario.

We are very happy not only that progress is being made on Laser Bees, but also that

ABOVE *Zapping olivine rock with a laser, this shows the ablation response of the olivine in the left photo with ejecta (pieces) coming out, and on the right with a mini "rocket plume."*

Photos: University of Strathclyde

Thanks! Planetary Society Members have helped make these and other projects possible. Thank you.

our support of the project, in part, has led to other near-Earth asteroid related projects. For more details on the project, including papers published by Vasile and Gibbings and awards they have been winning, see bit.ly/laserbees.

SEND YOUR NAME TO AN ASTEROID

We have a new opportunity to send your name to space as part of our Messages from Earth program: NASA's OSIRIS-REx mission and The Planetary Society invite people worldwide to send their names on a round-trip ride to the target of the OSIRIS-REx mission, the asteroid Bennu.

In the Messages to Bennu! campaign, hundreds of thousands of names will hitch a ride to the asteroid, spend over two years there, and return to Earth in the mission's sample return capsule in 2023. A copy of the names will also be placed on the spacecraft, which will remain in space long after the sample return capsule is back on Earth.

As with every campaign in our Messages From Earth program, the names of all current Planetary Society Members will be automatically included in this mission. We encourage Members to submit names of family members and pass along to friends this opportunity to participate in space exploration.

Those who submit their names to this campaign will be able to download and print a certificate documenting their participation in the OSIRIS-REx mission. Names can be submitted until September 30, 2014 at planetary.org/bennu.

WHAT'S UP? *by Bruce Betts*

IN THE SKY

There is a total lunar eclipse on April 15 visible throughout most of North America, South America, and Australia. An annular solar eclipse visible in portions of Australia occurs on April 29. There is a possible meteor shower/storm on May 24 as Earth crosses through debris from the small comet P/209 LINEAR. Predictions of the shower's intensity are highly variable, ranging from tens of meteors per hour to many hundreds. Reddish Mars is at opposition (opposite side of the Earth from the Sun) on April 8, rising around sunset, setting around sunrise, and at its brightest for the next couple years. The evening sky also has bright Jupiter in the southwest, and yellowish Saturn following Mars across the sky. Mercury is low in the west in late May after sunset.

RANDOM SPACE FACT

If the Moon were the size of a tennis ball, then Mercury would be the size of a softball, Mars a little bigger than a shot put, Venus the size of a basketball, and Earth slightly bigger than a basketball.

TRIVIA CONTEST

Our September Equinox contest winner is Curtis McLendon of San Juan Capistrano, California. Congratulations! **THE QUESTION WAS:** What astronaut on a *Mercury* mission became the first to do a manual (as opposed to an automated) re-entry? **THE ANSWER:** Gordon Cooper on the last *Mercury* flight (launched May 15, 1963), due to electrical system failures.

Try to win a free year's Planetary Society membership and a Planetary Radio T-shirt by answering this question:

Which planet in our solar system has the shortest day/rotation period?

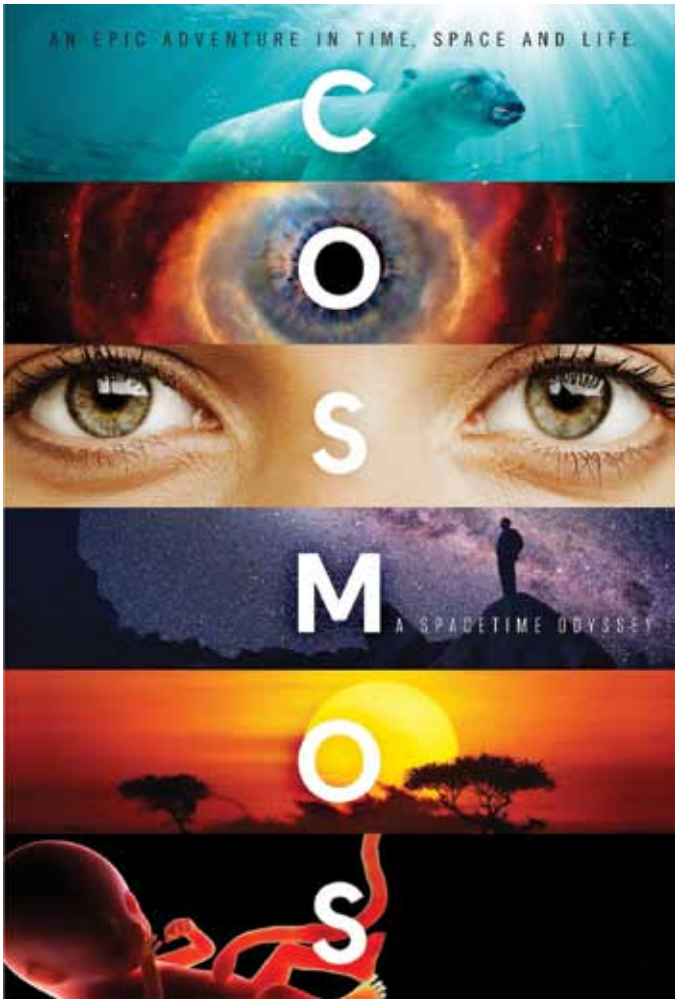
E-mail your answer to *planetaryreport@planetary.org* or mail your answer to *The Planetary Report*, 85 South Grand Avenue, Pasadena, CA 91105. Make sure you include the answer and your name, mailing address, and e-mail address (if you have one). By entering this contest, you are authorizing *The Planetary Report* to publish your name and hometown. Submissions must be received by June 1, 2014. The winner will be chosen by a random drawing from among all the correct entries received.

For a weekly dose of "What's Up?" complete with humor, a weekly trivia contest, and a range of significant space and science fiction guests, listen to *Planetary Radio* at *planetary.org/radio*.

CASEY DREIER *is director of advocacy for The Planetary Society.*

A Unifying *Cosmos*

Celebrating Science . . . and Connections



ABOVE Cosmos: A SpaceTime Odyssey *airs Sunday nights on Fox and Monday nights on the National Geographic Channel.*

THE PLANETARY SOCIETY was only a few months old when Carl Sagan's *Cosmos: A Personal Voyage* first aired on television in 1980. And even though the Society and *Cosmos* were never officially connected, I've always felt that this timing was particularly appropriate. We've aged together, experienced the same intervening years of ups and downs, changes to politics and to nations, the birth of the Web, and the decline of old media. We share an ethos derived from our common heritage: that the understanding of science is crucial to the body politic, that we should expect much of our audience, and that the public is not only fascinated by space exploration, but is moved to support it.

So it is fitting that 2014 finds both *Cosmos* and The Planetary Society in a period of rejuvenation. We are both reaching new audiences, embracing new forms of communication, and led by the most influential figures in science outreach, Bill Nye and Neil deGrasse Tyson. These are crucial adaptations in a world where science is celebrated in popular culture yet undermined in schools and government, where culture is self-segregating and increasingly divided against itself.

We seem to celebrate and revile science. The comedy show *Big Bang Theory* dominates television ratings while the real big bang theory is dismissed by large portions of the public (in the United States, anyway); tens of millions of people flock to a Facebook page to declare that they "[Expletive] Love Science" while a congressman on the House Science, Space, and Technology Committee declares that the theory of evolution is a lie "from the pit of hell;" the more overwhelming the evidence is for climate change, the more fervent are its deniers.

The groups behind these differing attitudes interact rarely, and when they do, they speak past each other. The recent fragmentation of media allows these divisions to exist with relative ease. The dizzying number of cable channels and micro-communities on the Web allow individuals to pick

and choose news sources based on ideological preferences, limiting the impact of scientific outreach. As the diversity of media increased, so did the cost of reaching a large audience. The Planetary Society has worked hard to reach as many people as possible, and we welcome the rebirth of *Cosmos* and its celebration of science.

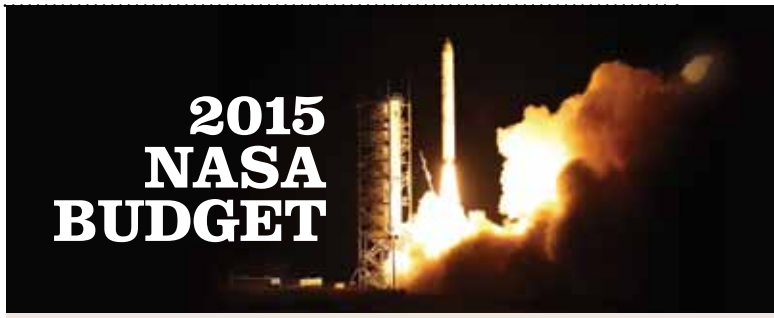
Ann Druyan and Neil deGrasse Tyson's *Cosmos: A SpaceTime Odyssey* airs on the Fox network, and while network television's reach is only a fraction of what it was in 1980, it is still substantial. Millions of viewers are tuning in to *Cosmos* every week; many of them are experiencing its lessons of science, history, and philosophy for the first time.

But it goes deeper than that. *Cosmos* is a celebration of universality—of our interconnectedness. The very show that's reaching beyond the fragmentation of society is telling us how connected we really are. The cold points of lights in the sky? Our progenitors. The DNA in our cells? The same in all living things on Earth. And so on. The show reflects the deep optimism of its creators: that greater understanding of science serves as a social good, that information presented clearly and in a compelling manner will resonate with the public.

Cosmos presents its science with a mixture of exposition and emotional appeal. A certain secular spirituality infuses the show, an open acceptance of wonder and reverence that betrays a deep sense of humanity, or at least acknowledgement of the human condition. People steeling themselves against the implications of modern science may be surprised to find themselves moved to wonder or excitement. *Cosmos* not only acknowledges this feeling, but validates it. This emotional connection is far more durable than any intellectual one. That *Cosmos* acknowledges this fundamental quality of human existence demonstrates the importance of its return.

As The Planetary Society grows again, we embrace the return of *Cosmos* and the generation of science devotees it will inspire. Our fates continue their strange entanglement—unconnected, but representative of each other. We both share a common reverence for the cosmos, for the mystery it represents, and for the small steps humanity makes in an attempt to figure it all out. All of us, particularly we Society members, must continue to find new ways to bridge the divisions and promote science and exploration. The world may feel fragmented, but *Cosmos* reminds us that our connections run deep.

Image: NASA Wallops/Chris Perry



2015 NASA BUDGET

There was a period, not long after the original *Cosmos* first aired, when NASA's planetary exploration program faced total cancellation. It inspired one of our first calls-to-action and was one of the defining moments for a nascent Planetary Society. The program survived, but barely.

Now, as the new Cosmos airs, NASA's planetary exploration program once again faces great challenges—but this time the Society is in a far stronger position. We're organized. We have more contacts and supporters in Washington, a unified scientific community, and the power of the Web to work with.

As this issue was close to going to press, we learned that the White House's 2015 NASA Budget Request threatens the *Opportunity* Mars rover, cuts planetary exploration funding, cuts NASA's top-line budget, and mothballs the Stratospheric Observatory for Infrared Astronomy (SOFIA) telescope. NASA does acknowledge the importance of Europa, but their commitment to a future mission there is tenuous at best. We need your help to change this.

Make a difference. Be an advocate for space.
Learn how at **planetary.org/SOS**.

WHAT DO YOU THINK?
Have you watched the new *Cosmos*? Write to Members' Dialogue to share your thoughts on the show at *planetaryreport@planetary.org*.

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Your Legacy—What Will It Be?

The legend of the Moon Goddess Chang'e (pictured here) has a legacy stretching from ancient times to the *Apollo* Moon landing in 1969 (Houston radioed the tale of Chang'e and her bunny companion to astronaut and Planetary Society Adviser Buzz Aldrin before his Moon walk) to today's *Yutu* ("*Jade Rabbit*") lunar rover.

Two gifts. Two stories.

Mary Evans was a Planetary Society Member for more than 25 years. Several years ago, she told us that she would leave a gift to the Society in her will.

When her gift of more than $600,000 arrived, her son, Mike, explained:

"Mom was kind and very strong. From her earliest days in the 1930s she was interested in the wonders of space. Her passion and commitment are being passed to you in the form of this monetary gift. Being a part of this organization was a highlight of her life."

Thanks to Mary, her passion for space and for the Society continues through her generous gift to the future.

According to his brother John, Don Ray LaGesse was "... born about two hundred years too early ... He spent hours drawing up ideas for such things as asteroid-capturing systems and systems to use methane on other planets for fuel and to help with water production."

Don left $2,500 to The Planetary Society. His generous gift arrived in the heart of the recession. He knew that people were struggling, cutting back, even from groups that gave them joy.

As Don wanted, we used his donation to aid longtime members who could not afford to renew their memberships in The Planetary Society. Their gratitude is immense.

Your gift, large or small, will make an impact.

Have you included us in your will? Do you have questions? We'd love to talk with you.

Thank you, Planetary Society Members!

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Illustration: Shi Yu/Wikipedia Commons