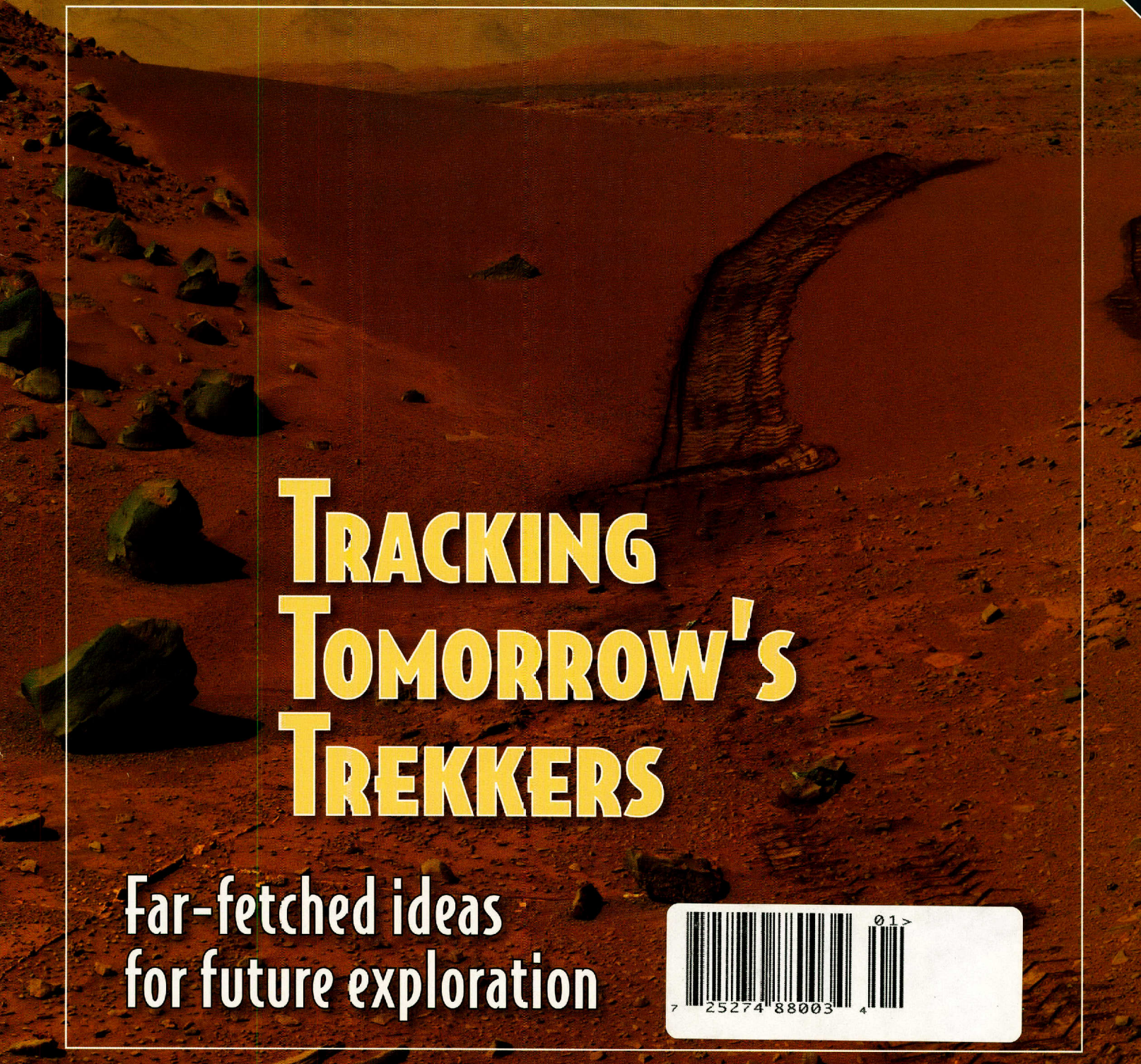
StarDate™

ON THE WINGS OF STARS
Page 16

SEPTEMBER/OCTOBER 2014 $7



TRACKING TOMORROW'S TREKKERS

Far-fetched ideas for future exploration

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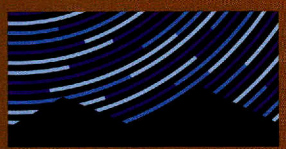

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Features

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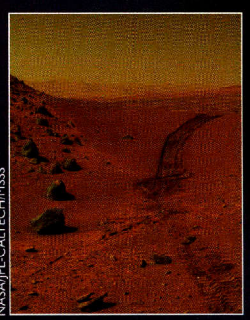


NASA/JPL-CALTECH/MSSS

On The Cover

The Curiosity rover shot this view of its tracks across Mars earlier this year. A NASA program to spur space technology innovation will fund studies for growing food on Mars, catching dangerous asteroids, hitching a ride on a comet, and more. For details, see Page 4.

This Page

This artist's concept shows the two stars in the binary system HK Tauri; each is surrounded by a disk of planet-forming material. The disks are not in the same plane. Astronomers say this misalignment may explain why some planets found around other stars have strange orbits compared to the planets in our solar system.

R. HURT (NASA/JPL-CALTECH/IPAC)

Coming Up

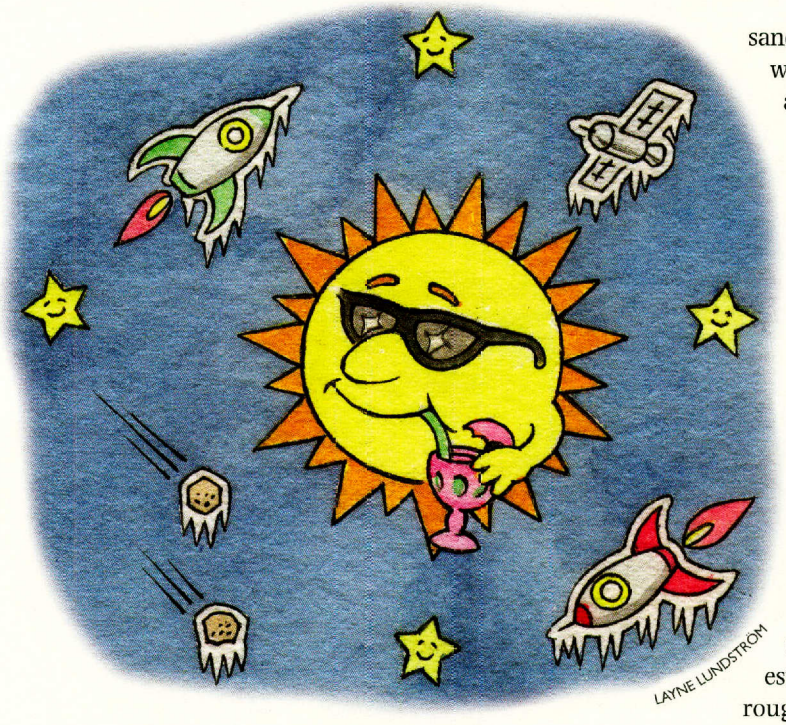
In our November/December issue, get caught up on the list of dwarf planets in our solar system, and learn how it may grow in the future. Plus we'll have end-of-the-year skywatching tips and charts and the latest astronomy news.

MERLIN

Dear Merlin,

If space is so cold (as you said in Merlin's Tour of the Universe*), why doesn't it extinguish the Sun? Also, is the Sun's gravitational pull strong enough that it would pull us in if we got close enough?*

Mr. Moss's Fourth Period
Robert E. Aylor Middle School
Stephens City, Virginia


LAYNE LUNDSTROM

It takes more than just cold to put out a fire — you need to get rid of its fuel as well. Fortunately for Earthlings, the Sun won't exhaust its fuel for a long time.

The minimum temperature in space is roughly 455 degrees below zero Fahrenheit, or about five degrees above absolute zero. This minute amount of heat comes from the afterglow of the Big Bang, known as the cosmic microwave background. Clearly, you'll want to wear some extra layers if you go galavanting through deep space.

That background temperature has nothing to do with what makes the Sun hot and bright, though.

The Sun "burns" through nuclear fusion, in which the nuclei of hydrogen atoms ram together to make helium. A tiny bit of the hydrogen is converted to energy, which is what makes the Sun shine. And although the Sun converts about four million tons of hydrogen to energy every second, it is so heavy that it will continue to shine for several billion years.

Concerning your second question, the Sun is pulling Earth toward it even now but Earth is moving just fast enough to maintain its distance and not fall in. If that balance were changed, then it would be possible for Earth to dip closer to the Sun or even fall into it. But like the Sun going cold, that's not likely to happen for a very long time.

Dear Merlin,

What would the night sky look like from a planet inside M13?

Cherie Hart
West Bend, Wisconsin

Bountiful, beautiful, and breathtaking. Merlin strongly recommends a visit to see it for yourself. Yes, it's 25,000 light-years away, but at least you'll log lots of frequent-flier miles.

M13 is a globular cluster, a family of several hundred thousand stars that are packed into a ball that is less than 200 light-years across, which is hundreds of times more stars than are found in a similar volume of space around the Sun.

With so many close neighbors, a planet in the heart of M13, which is also known as the Hercules Cluster for its location in the constellation Hercules, would never see the dark of night.


The sparkly heart of M13
NASA/STScI

While the Sun's nearest neighbors, the three stars of Alpha Centauri, are a bit more than four light-years away, a star in M13 would have thousands of stellar neighbors that were much closer. In such a cramped neighborhood, a planet's night sky most likely would burn with the light of hundreds of stars brighter than Sirius, the brightest star in Earth's night sky. Many of those would outshine even Venus, the dazzling morning and evening star, which is the brightest object in Earth's night sky other than the Moon.

Most of the cluster's stars are red and faint, though, which is a strong indication that they are among the galaxy's oldest stars. In fact, they're all roughly 12 billion years old, compared to 4.5 billion years for the Sun, so they formed when the universe was young. All of the cluster's hot, massive stars have long since expired, leaving only their dead cores. Most of the remaining stars are less massive than the Sun, so they are relatively faint.

Occasionally, however, one of them reaches the end of its life, puffing up to gigantic proportions and shining hundreds of times brighter than the cluster's other stars. When it dies, it expels its outer layers into space, creating a glowing bubble of hot gas that shines for tens of thousands of years, briefly adding a colorful decoration to the cluster's skies.

M13 is one of more than 150 globulars in the Milky Way, each of which would offer a similar view to its surviving planets.

Merlin is unable to send personal replies. Answers to many astronomy questions are available through our web site:

stardate.org/astro-guide

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I SPY

Giant bodies of liquid natural gas cover Titan's northern hemisphere, seen here by the Cassini orbiter. A proposed Titan submarine (artist's concept, opposite page) may explore Titan's largest northern lake, Kraken Mare, in the decades to come.

NASA/JPL-CALTECH/ASI/USGS

Around the country, scientists and engineers are hatching new ideas for exploring the universe in the coming decades

THE FUTURE

Today, orbiters are sending pictures back from Mars, more orbiters are en route to the Red Planet, and rovers trek slowly across its surface. A probe is nearly to Pluto, and another orbits Mercury. And space telescopes send back amazing views in X-rays and visible and infrared light. Thousands of scientists and engineers back up these missions, and they use the data the craft provide to learn more about the universe, near and far.

Another group, though, is focused less on what's happening out there now and more on what kinds of technology will be needed to reach even deeper into the universe.

S. OLESON/NASA/GRC

By Rebecca Johnson

Their far-fetched ideas are not things industry can build today — the necessary technologies don't always exist, and the research and development are unlikely to be profitable soon. But NASA does want these ideas. Each year, the agency selects futuristic projects to fund via its NASA Innovative Advanced Concepts (NIAC) program.

"NIAC accepts concepts based on wild ideas that could be incorrect — which has happened," says three-time NIAC awardee Webster Cash of The University of Colorado, Boulder. "Most of them turn out to be correct."

The $100,000 Phase I NIAC awards fund nine-month studies of technologies that should have broad applications for different kinds of future missions. "Phase I concepts are very early in development — years from implementation," Cash says. Fellow current awardee Eugene Boland agrees. "NIAC is not interested in if you can get it done in the next 10 years."

NIAC has funded studies of dozens of these ideas, including a space elevator, laser-propelled spacecraft, fusion-powered rockets, asteroid-mining robots, infrastructure for settling the Moon, a landsailing rover for Venus, printable spacecraft, and radiation shields to protect future astronauts on long-term flights.

This summer, NASA awarded phase I grants to a dozen projects selected from proposals submitted by scientists and engineers at NASA centers, colleges and universities, and industry. The projects span a wide array of topics, including new ways to explore the solar system and cheaper ways to build large space telescopes.

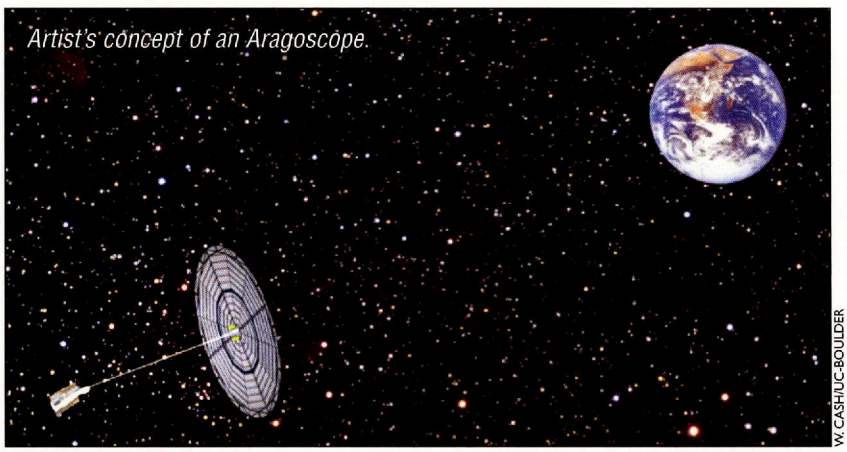
If the phase I studies go well, the projects may be chosen to receive a phase II award. The $500,000 grant would fund a two-year development study. In these, a project has to come up with one or two hardware designs.

Cash's current NIAC project is a new type of space telescope he has dubbed the Aragoscope. His own research centers around the search for Earth-like planets and methods of X-ray spectroscopy, but the Aragoscope could be optimized for most types of astronomical studies, he says.

The telescope is named after French scientist and politician Francois Arago, who in the early nineteenth century helped to prove that light is made up of waves. He did so via his discovery of diffraction, the bending of light around objects in its path. The Aragoscope takes advantage of diffraction to create what Cash calls an "ultra-high-resolution space telescope at low cost."

"What we're trying to do is get much better, clearer pictures of more-distant objects. You need a larger mirror for that," he says. But "in astronomy, we have an issue with gigantism. We always want larger telescopes, but the bigger they are, the more expensive they are."

An Aragoscope would be made of three pieces: a spacecraft containing the telescope, a large disk in front of it, and a high-tech rope called a tether connecting the two.


Artist's concept of an Aragoscope.

W. CASH/UC-BOULDER

Light coming from distant cosmic objects would diffract, or bend, around the disk's edge such that the light would come to a focus at the telescope. One design possibility is a 200-meter disk connected to a telescope by a tether about one kilometer long, Cash says.

The disk could be made of concentric rings to provide more diffracting edges and focus more light into the telescope. "We believe that concentric rings will increase the collecting area and will make the telescope more powerful," Cash explains. His team will investigate several possible designs.

The Aragoscope concept could be optimized for telescopes studying objects in various wavelengths of light, Cash says. "We're hoping if you could make the ring ... 500 meters, potentially you could image the event horizons of black holes in the X-ray," he says.

In the optical range, Cash says an Aragoscope would have 100 to 1,000 times the resolution of Hubble Space Telescope. Such an instrument would allow astronomers to study the disks of stars, which look like little more than pinpoints to today's largest telescopes. An optical Aragoscope could also separate the light from extrasolar planets and their parent stars more easily, and allow astronomers to peer into the disks of matter swirling around black holes, he says.

In addition to funding a fundamentally new space telescope design, this year's NIAC phase I projects include several potential planetary missions.

The Mars Ecopoiesis Testbed is one of them. "Ecopoiesis" means starting life in a new place, says team leader

TECHSHOT, INC. (2); NASA/JPL-CALTECH/CORNELL/ASU

The proposed Mars Ecopoiesis Testbed (right) could include a semi-porous dome housing microbes atop a cylinder that screws into the soil, as well as a solar power array and a dish for communicating with an orbiting satellite. Microbes first will be tested in Techshot's planetary simulator (above), which can reproduce conditions on the Red Planet.

Eugene Boland, a biomedical engineer and chief scientist at Techshot, Inc., in Greenville, Indiana. The company has built experiments for the International Space Station and the space shuttle program. This is its second NIAC-funded Mars project.

"Previously, we built a planetary simulator," Vice President Rich Boling says. "It can reproduce the temperature range, light range, atmospheric pressure, and other conditions you get on Mars. Researchers come in and see what will grow in it, using fake Mars soil that NASA provides."

Techshot's current NIAC project seeks to create a testbed that will try to see if organisms can grow on the Red Planet. "If we're going to colonize Mars, food is going to have to be produced," Boland says. He says that creating the testbed — a prototype that will help mission planners learn if growing plants or food on Mars is even possible — will require a host of new technologies.

The testbed currently envisioned looks like a tall cylinder, the bottom of which is shaped like a giant screw so that it can drill down into the Martian soil, called the regolith.

The testbed will need a way to corral and manipulate microorganisms in what Boland calls a semi-porous environment. Inside it, the organisms would be "exposed to the environment but not able to escape into the environment," he explains.

The testbed also will need sensors to monitor the microorganisms. Mission scientists will want to know what the organisms are doing. "Are they producing oxygen, water?" Boland asks. One of the project's goals is to record evidence of biological processes taking place inside the testbed.

Finally, the system must have a communications system to transmit that information to a satellite orbiting Mars, and from there back to Earth.

Boland says the testbed potentially could be deployed fairly soon compared to some NIAC projects. "The cutoff for [getting a project onto] the Mars 2020 rover was last December; it would have to be after that," Boland says. "Typically there are rover missions every four to six years. Our guess is 2024 to 2026" would be the first opportunity for this testbed to be launched to Mars.

Boland acknowledges that there is a moral debate about whether we should try to change Mars to be more like Earth to accommodate visiting astronauts or even future colonies, a process Carl Sagan called "terraforming." "What we're proposing to do is, before we answer the moral question, answer the scientific question first," Boland says. "Don't put the cart before the horse." The testbed project will help provide the "necessary data to make an informed decision," he says.

Several of this year's NIAC award-winning project ideas come from NASA centers. One of these is the Titan submarine project, led by Steven Oleson at NASA's Glenn Research Center in Cleveland. The submarine will be designed to explore one of the vast lakes on Titan, Saturn's largest moon.

The target is Kraken Mare, which is about the size of the Great Lakes. The submarine could find clues on Titan to aid our understanding of our own planet.

"In our solar system, there really are only two bodies that have liquid exposed to an atmosphere," Oleson says, "Earth and Titan." But on Titan, the liquid is not water, but hydrocarbons

Pocket Full of Wild Ideas

Here are a few more of the projects recently funded for study by NASA's Innovative Advanced Concepts program.

Titan Aerial Daughtercraft

This study proposes a small aircraft to be launched from a balloon or lander on Saturn's moon Titan. It would take images and map the surface from the air, land and take close-up images and microscopic samples, and return to its mothership to recharge before launching again. Larry Matthies of NASA's Jet Propulsion Laboratory heads the project.

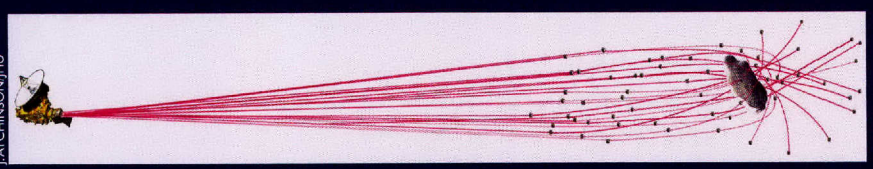
TETHERS UNLIMITED, INC.

WRANGLER

Can a small satellite capture giant asteroids and space debris that might threaten Earth, and stop them from spinning? Robert Hoyt of Tethers Unlimited, Inc. plans to study the problem using a pair of technologies the company created: a deployable net to catch the object, and a tether/winch apparatus.

Comet Hitchhiker

The project seeks to show that a small spacecraft can hitch a fast and cheap ride to the outer solar system by attaching itself to a comet using a tether. Masahiro Ono of NASA's Jet Propulsion Laboratory will lead this study.



J.ATCHINSON/JHU

Swarm Flyby Gravimetry

Justin Atchison of Johns Hopkins University wants to find out if a swarm of nano-satellites released from a larger mothership can accurately and cheaply map the interior structure of small bodies like comets or asteroids.

PRIDE

Another Johns Hopkins researcher, Timothy Miller, wants to map the icy shells of some moons in the outer solar system by detecting the neutrinos that pass through the ice from across the universe. These maps could help scientists decide the best places to look for life under the ice on Europa, Ganymede, and Enceladus.

PERISCOPE

In 2009, the Lunar Reconnaissance Orbiter discovered that the Moon has caves. Jeffrey Nosanov of the Jet Propulsion Laboratory wants to build a satellite that can map these caves, using a system that can literally see around corners underground — from orbit.

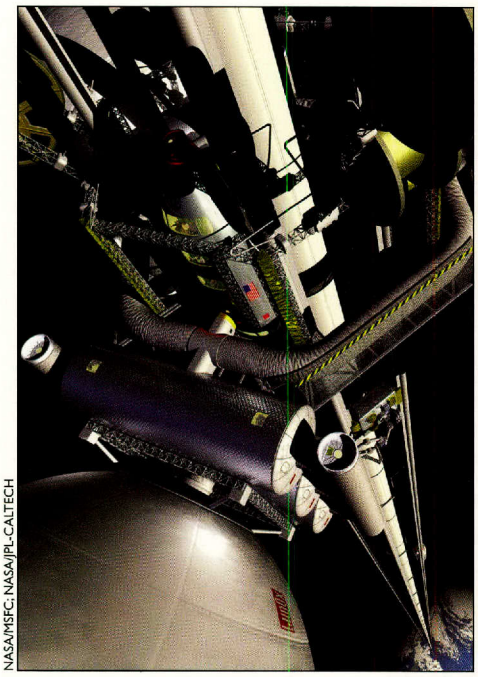
— liquid natural gas. "On Earth, life started here because we have hydrocarbons and water," Oleson says. "This [project] gives a snapshot into the past of how life started in our solar system, because Earth was very, very cold. There is no life there [on Titan], because it's too cold, 163 degrees below zero."

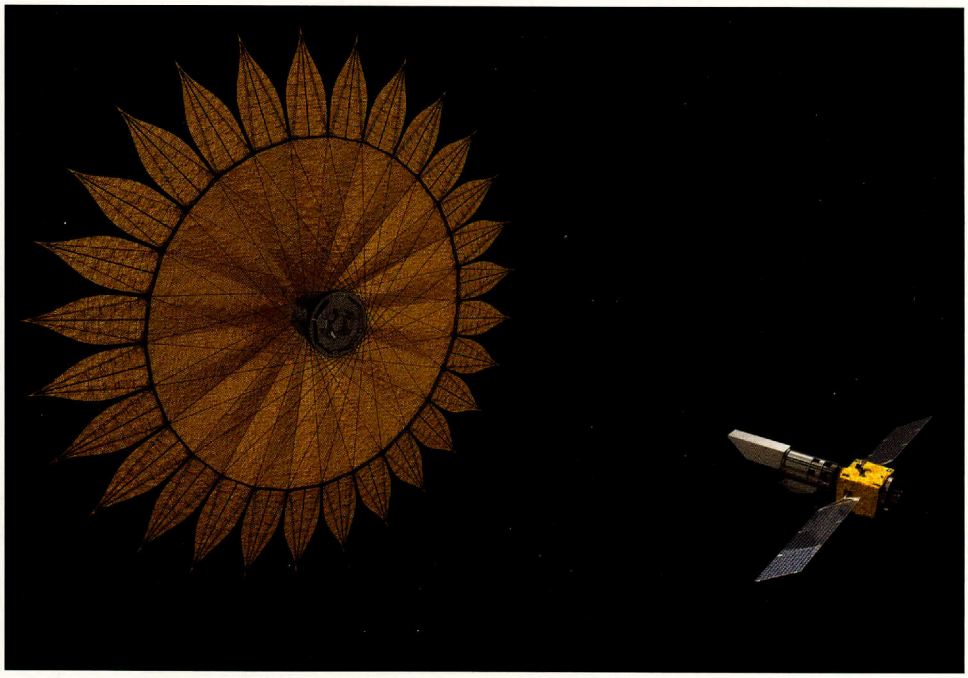
Creating a submarine to explore one of Titan's natural-gas-filled lakes is "extremely challenging on quite a few levels," Oleson says. The biggest challenge is how to power the submarine. Because Saturn is more than nine times farther from the Sun than Earth is, solar power isn't a feasible energy source. Instead, the submarine will most likely be powered by plutonium. "We could probably use a very small reactor; Navy subs use them all the time," Oleson says.

Other challenges include a communication system that can make contact with Earth through the lake, and the entire mission, which will probably include an orbiter as well as the submarine, must be autonomous, he says. That's because it takes hours for commands from Earth to reach Saturn, and hours more to receive an answer.

"The orbiter has to be very autonomous and very smart, and not tell the submarine to dive into the bottom or crash into the side" of the lake, Oleson says. The orbiter will give the submarine commands, like "you go off and get this sample. When you do, wait, come back and talk to me. Then we'll get some pictures," he says.

Oleson's background is in mission design and propulsion. During the Cold War, he was an Air Force analyst. His job was predicting what the Soviets would put into space in the future, he says. At the Glenn Research Center he heads an engineering team that specializes in planning future space missions. It's tackled more than 100 such projects, Oleson says. Yet to plan and execute the submarine mis-





NASA/MSFC; NASA/JPL-CALTECH

Two prior NIAC-funded studies. Left: A space elevator would allow vehicles to ascend to Earth orbit without a rocket. Several international competitions, similar to the Ansari X Prize, have been held to spur development. At right, the starshade is a free-floating plastic shade that would block the light from a star so its planets would be easier to study. A prototype is in development at NASA's Jet Propulsion Laboratory.

sion, "we need a scientist in there — they think totally differently," Oleson explains.

Ralph Lorenz of Johns Hopkins' Applied Physics Lab is the team's lead scientist. Lorenz was involved with the Huygens probe, which landed on Titan in 2005. He also is co-author of the popular-level book *Titan Unveiled*.

Planning for any kind of planetary science mission "starts with scientists saying, 'I want to go here, here, and here, and do this,'" Oleson says. Once they know the objectives, engineers can start working out how to make it happen. The team probably will spend a month on this NIAC study before moving on to another project.

In addition to potentially providing a new window into the early Earth, the Titan submarine will be a precursor to exploring other bodies in the solar system, Oleson says, noting that Jupiter's moon Europa has an ocean a few miles below the surface, and that Saturn's moon Enceladus also has subsurface water. "Once we get this submarine done, we'll translate it to these," he says.

All of the phase I project teams hope their studies eventually win them a phase II award from NIAC. After that, however, their futures are uncertain. Many earlier advanced concepts projects have languished. "After a NIAC study has been done, there's no mechanism to take it to the next level," Webster Cash says. "NIAC has been lobbying for a phase III and phase IV, to get technology through the valley of death," though, he says.

The question of how long it will take these ideas to reach implementation is "a very sore point," Cash says. Starshade is one of Cash's earlier NIAC-funded projects: a free-floating plastic shade that would be used in conjunction with a space telescope. The shade would block light from a star so that the telescope could more easily study its planets. "The Starshade could be done right now," Cash says, but the missing ingredient is funding. "If we could move forward in a technology-limited way rather than a funding-limited way, we could be flying a test in three to four years and a telescope in 10 years," he says of his new project, the Aragoscope. "Because of the way it works now, it could take decades. My guess is 30 years."

Rebecca Johnson is editor of StarDate.

Resources

Internet

NASA Innovative Advanced Concepts
nasa.gov/directorates/spacetech/niac

The Future of Space Telescopes
thespacereview.com/article/2232/1

Terraforming Mars
pbs.org/exploringspace/mars/terraforming

Techshot, Inc.
techshot.com

Titan Overview
solarsystem.nasa.gov/planets/profile.cfm?Object=Sat_Titan

Glenn Research Center
nasa.gov/centers/glenn

Sky Calendar

by Alan MacRobert

Summer is turning into fall, and the season's signature constellations, Pegasus and Andromeda, dominate the night sky. The giant planet Jupiter lights up the pre-dawn hours, while Mars and Saturn still shine in the evenings.

SEPTEMBER 1 - 15

A big planet, a little planet, and a supergiant star shine in a line in the afterglow of the late-summer sunset. Look southwest as twilight fades.

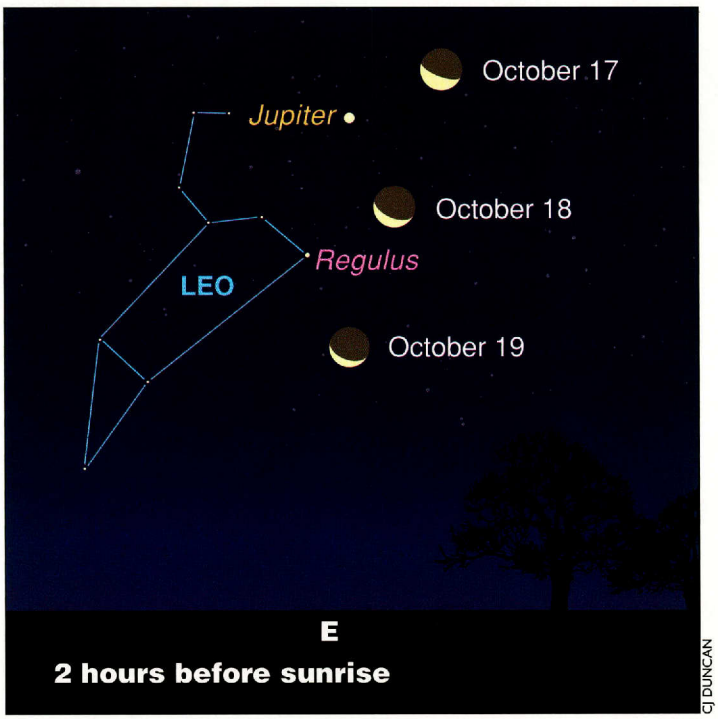
Very different they may be, but they *look* rather similar. Antares, the star, is the one on the left. Saturn, the giant planet, is on the right. Mars, the little planet, is between them, moving daily. They currently shine at magnitudes 1.0, 0.6, and 0.7, respectively. Mars and Antares even have almost exactly the same orange color.

Watch Mars find a new position for itself each day. It begins September just to the left of Saturn, then runs eastward with respect to the background stars toward Antares. It will pass above Antares in the last few days of the month.

The waxing crescent Moon passes through here at the beginning of September. On August 31, the Moon forms a tight triangle with Saturn and Mars. On September 1, it shines over Antares.

Some constellations have an obvious *lucida*, or brightest star. Antares in Scorpius is an example. Other constellations don't: for instance Sagittarius, the next constellation east of Scorpius. Its eight leading stars form the Teapot asterism, which in early September is still at its highest after dusk just to the right of due south. You have to look carefully to figure out which of the Teapot's stars is the brightest. (It's Nunki, the one forming the top of the Teapot's handle).

Ancient eyes saw Sagittarius as a centaur aiming an arrow at Scorpius. If you have as dark a sky as they did with lots of stars, it's indeed possible to connect the dots to form a figure drawing a bow with the arrow pointed in the right direction.



But the Teapot is much easier to spot, especially after you've recognized it once. Its handle is on the left and its triangular spout is on the lower right. The whole thing is a bit larger than your fist at arm's length.

As always, Sagittarius in the south means bright Vega is highest overhead. Arcturus dominates the west. The Big Dipper is swinging low in the northwest. And in the northeast, the tilted W of Cassiopeia has now achieved a greater altitude than the Big Dipper. This is an eternal sign that summer vacation is over and fall is hard upon us.

SEPTEMBER 16 - 30

Antares, Mars, and Saturn remain lined up in the southwest in twilight, more or less horizontally and a little lower now. On September 17, Mars passes a mere one-half degree above the second-magnitude star Delta Scorpii — that's about the width of a pencil at arm's length. Delta Scorpii is an unusual long-term variable star that, since 2000, has become the brightest star in upper Scorpius after Antares.

The official change from summer to fall at the equinox (on September 22 this year) coincides with the turnover of which bright star shines straight overhead in the evening. Vega holds this post in late summer (assuming you're in the mid-northern latitudes). But now Vega is shifting westward, away from the zenith, while lesser Deneb arrives from the east to take its place. If you look shortly after nightfall, the zenith balance shifts from one star to the other right at the time of the September equinox.

Vega and Deneb are two corners of the big Summer Triangle. The third is Altair, farther from both of them. At this time of the year, Altair is the brightest star shining high in the south.

Up before dawn? Jupiter shines in the east as day begins to break. It's by far the brightest thing there. The waning crescent Moon hangs to the upper right of it on the morning of September 19, then to its lower right on the 20th.

Jupiter will rise about two hours earlier each month, to light the evening sky this winter and spring.

OCTOBER 1 - 15

The lineup of stars and planets in the southwestern twilight is now lengthening and bending. Mars and Antares begin October still close together. Antares is the twinklier one, on the bottom. As October advances, Saturn and Antares move down and away to the lower right. But Mars will stay almost fixed at the same height (as viewed at the same stage of twilight) all month, all fall, and nearly all winter!

Every season has its signature constellations. Orion symbolizes winter, Virgo means it's spring, and Scorpius signifies the hot nights of summer. The Great Square of Pegasus, currently shining dimly in the eastern evening sky, tells of autumn leaves blowing on chill night winds — at least where I live in New England.

Meteor Watch

The Shower

Orionids

Named for the constellation Orion, the hunter, which is notable for its three-star belt and for the Orion Nebula, which is visible below the belt as a hazy smudge of light. At its best, this shower produces perhaps 15-20 meteors per hour.

Peak

Nights of October 20, 21

Notes

The Moon is almost new, so it will be thin and too near the Sun to interfere with the shower.

Granted, you can see these constellations at other times of year if you go out in the early morning hours. And thousands of years from now, they'll drift out of season due to the slow precession of the equinoxes. But in our era, the changing constellations are the most reliable natural sign of the turning seasons.

Look for the Great Square of Pegasus about halfway up the eastern sky after dark — halfway from the horizon to the zenith. It is currently balancing on one corner. Your fist at arm's length fits inside it.

The stars of the rest of Pegasus are scattered to the upper right of the Great Square. Look to the lower left from the Square's left-hand corner for the trailing, sparse row of stars marking the main line of the constellation Andromeda. The whole huge Andromeda-Pegasus complex rises higher in the east as October evenings grow late.

Follow where the Andromeda line points down toward the northeast, and there's Perseus on the rise. Perseus is reaching up to grab Andromeda by the foot — and again, it's possible to connect the dots in just such a way. Perseus lies in a particularly starry area astride the Milky Way.

Continue farther down in the same direction, practically to the north-northeastern horizon to spy Capella, one of the sky's brightest stars, beginning its long seasonal ascent. (Maybe. The farther south you live, the later into the night you'll have to wait for Capella to clear the horizon.)

Once Capella is up in good view (maybe by 9:30 or 10 p.m.), look off to its right in the east-northeast and you'll spot a unique little star bunch that's sometimes mistaken for the Little Dipper. These are the Pleiades, a star cluster the size of your fingertip at arm's length. Its six brightest stars form a tiny dipper shape.

Stay up really late and you'll see Jupiter rise around 1 a.m. It shines high in the east by dawn.

OCTOBER 16 - 31

With nights growing longer but Daylight Saving Time still in effect, sunrise comes nearly as late these mornings as it ever will. That means you've got an easy shot at the sky of pre-dawn. Jupiter catches your eye fairly high in the east. Look below it by about a fist-width at arm's length for Regulus, in Leo. The waning crescent Moon again poses in the vicinity on the mornings of October 17 and 18.

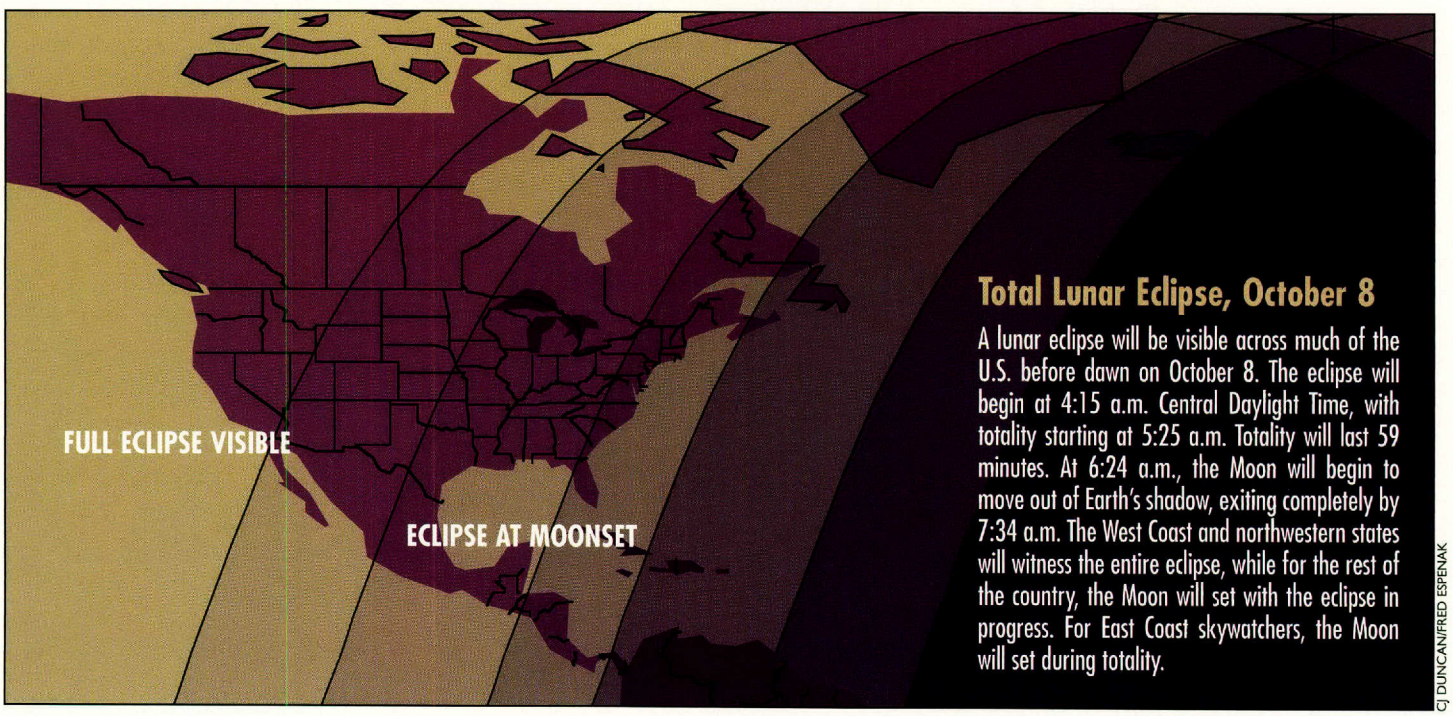
After dusk in late October, Deneb continues to rule the zenith while brighter Vega shines to its west. Deneb passes precisely overhead for all of you living at latitude 45 degrees north — a line running across northern Oregon, Wisconsin, northern New England, southern France, and northern Italy. The farther north or south of this line you live, the more widely Deneb misses your zenith point.

Deneb marks both the tail of Cygnus, the swan, and the head of the Northern Cross, which is made of the swan's brightest parts. To see the Northern Cross almost vertical just now, face west-southwest and look almost straight up.

The foot of the cross is the second-magnitude star Albireo, not far to the left of Vega. Look at Albireo with a small telescope and you'll see that it's a gorgeous double star, yellow and blue.

Deneb and the shaft of the Northern Cross lie in the middle of the summer Milky Way, which arches over the zenith right after dark now. The Milky Way runs up from Perseus low in the northeast, through the W of Cassiopeia standing on end above Perseus, up overhead and all the way down to Sagittarius sinking low in the southwest.

Alan MacRobert is a senior editor of Sky & Telescope *magazine.*



Total Lunar Eclipse, October 8

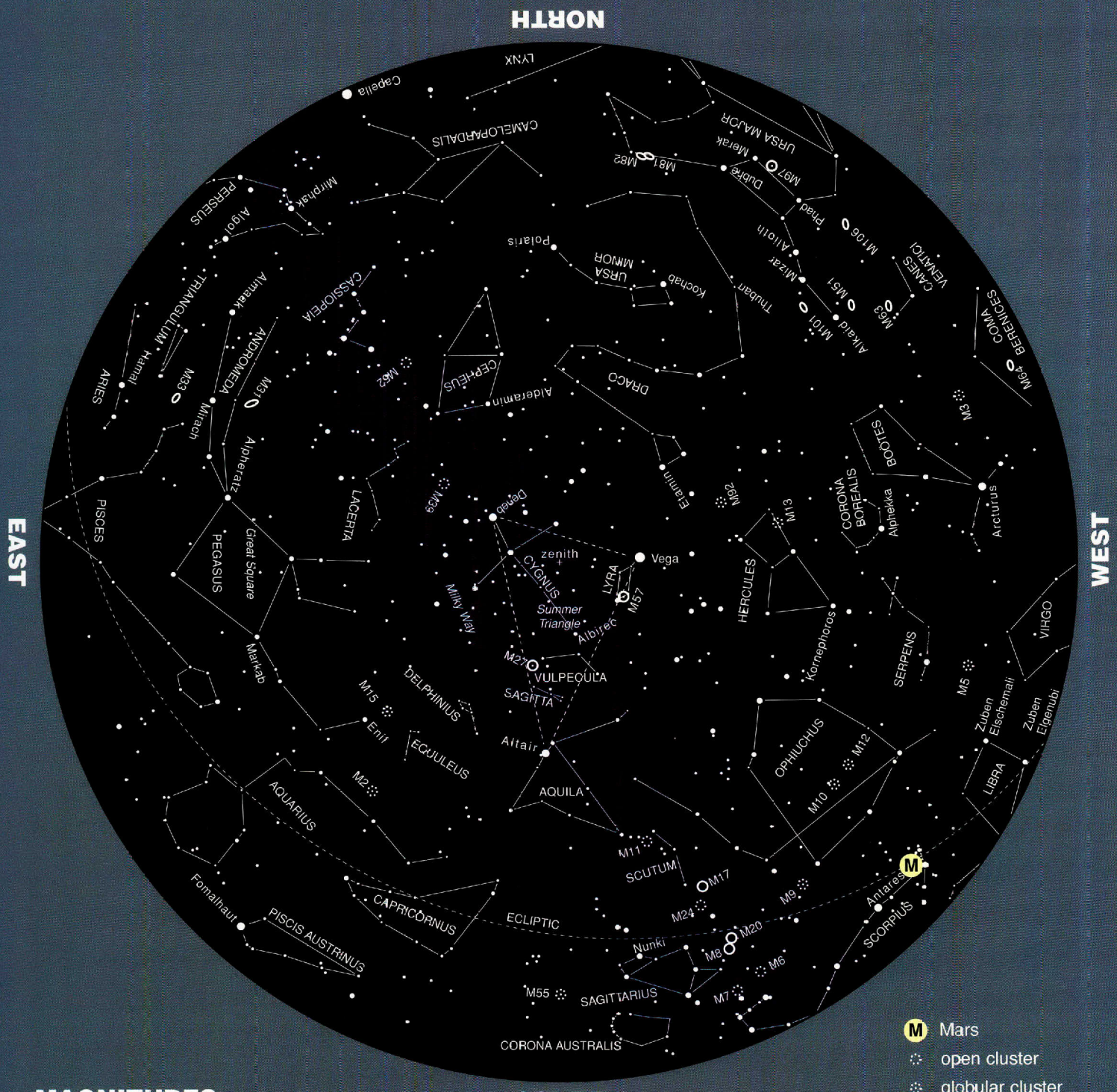
A lunar eclipse will be visible across much of the U.S. before dawn on October 8. The eclipse will begin at 4:15 a.m. Central Daylight Time, with totality starting at 5:25 a.m. Totality will last 59 minutes. At 6:24 a.m., the Moon will begin to move out of Earth's shadow, exiting completely by 7:34 a.m. The West Coast and northwestern states will witness the entire eclipse, while for the rest of the country, the Moon will set with the eclipse in progress. For East Coast skywatchers, the Moon will set during totality.

CJ DUNCAN/FRED ESPENAK

SEPTEMBER

How to use these charts:
1. Determine the direction you are facing.
2. Turn the chart until that direction is at the bottom.

August 20	**11 p.m.**
September 5	**10 p.m.**
September 20	**9 p.m.**



MAGNITUDES

- 0 and brighter
- 1
- 2
- 3
- 4 and fainter

- M Mars
- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy

OCTOBER

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September 20	**11 p.m.**
October 5	**10 p.m.**
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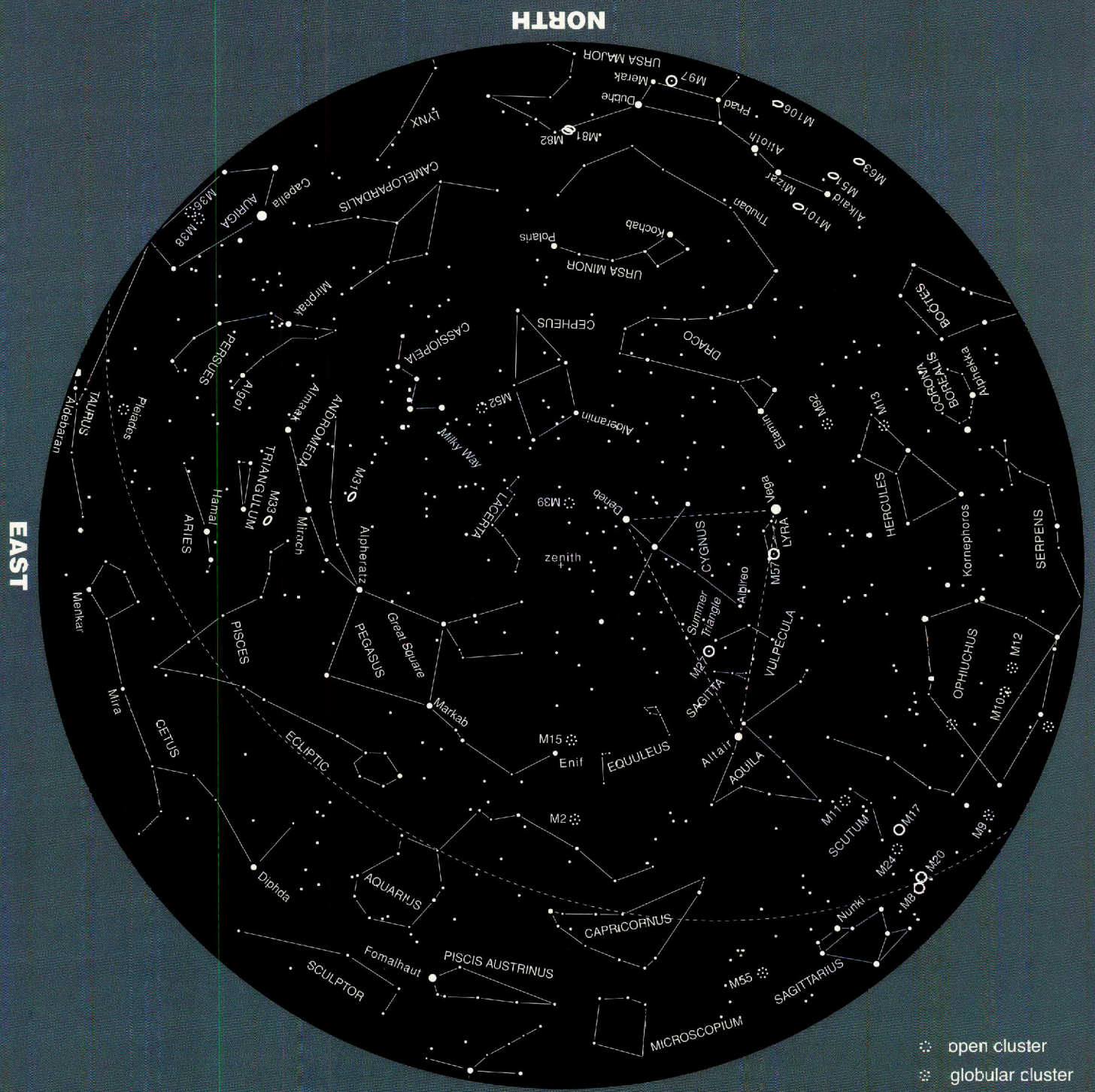

MAGNITUDES

- 0 and brighter
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- planetary nebula
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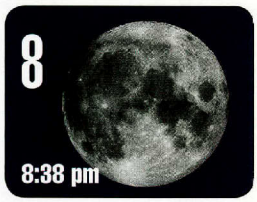
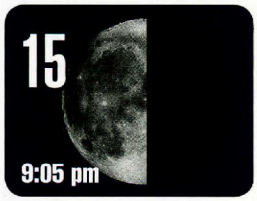
Sky Highlights

by Damond Benningfield





Moon phase times are for the Central Time Zone.

SEPTEMBER

1 Antares, the bright orange heart of Scorpius, stands to the lower left of the Moon at nightfall. The bright planets Mars and Saturn are farther to the Moon's lower right.

8 The Moon is full tonight. As the full Moon closest to the autumnal equinox, it is the Harvest Moon.

14 Aldebaran, the eye of the bull, is to the left of the Moon at first light, with the bull's shoulder, the Pleiades star cluster, to the upper right of the Moon.

15 Aldebaran is now to the right of the Moon at dawn.

19 The brilliant planet Jupiter is to the lower left of the Moon at first light, with the star Procyon farther to the right of the Moon.

20 Jupiter now stands to the upper left of the Moon at first light, with much fainter Regulus farther to the lower left of the Moon.

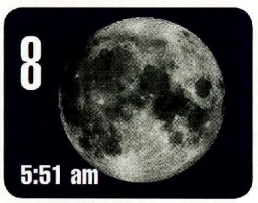
21 Regulus, the brightest star of Leo, crouches to the left of the Moon in the dawn sky.

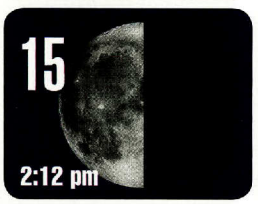
22 The autumnal equinox is at 9:29 p.m. CDT, marking the beginning of autumn in the northern hemisphere.

Su	M	T	W	Th	F	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

27 The planet Saturn perches close to the upper left of the Moon at nightfall.

27-29 Mars and Antares, two bright orange points of light, are separated by about three degrees, roughly the width of two fingers held at arm's length, in the southwest as night falls. The Moon moves past them on the 28th and 29th.





OCTOBER

7 Uranus, the seventh planet from the Sun, lines up opposite the Sun and shines brightest for the year. The giant planet stands close to the lower left of the full Moon tonight. It will be in better view in a few nights, when the Moon rises later. All but the most experienced skywatchers need a star chart and binoculars or a telescope to see it.

8 A total lunar eclipse will be visible across much of the United States before dawn this morning.

11 Aldebaran, the eye of Taurus, stands close below the Moon as they climb into good view in late evening. They will move closer together during the night, and stage an especially close encounter at dawn on the 12th.

17 Jupiter, which looks like a dazzling star, stands to the lower left of the Moon at first light.

18 Regulus, the brightest star of Leo, stands to the lower left of the Moon at first light, with brighter Jupiter above them.

23 A partial solar eclipse will be visible across the United States this afternoon. The eclipse peaks at 4:45 p.m. CDT. The Moon will cover more of the Sun's disk from northern latitudes than southern ones.

27/28 Mars perches to the left or lower left of the Moon at nightfall on the 27th, and to the lower right of the Moon on the 28th. Mars is above the "spout" of teapot-shaped Sagittarius, near the spot that marks the center of the Milky Way galaxy.

31 The planet Mercury shines low in the east during early twilight. It looks like a fairly bright star, but you need a clear horizon to see it.

Su	M	T	W	Th	F	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

by Rebecca Johnson and Damond Benningfield

Misfire

Neil Armstrong biography slightly off target

As the Apollo 11 lunar module soared toward the first Moon landing on July 20, 1969, its computer was having a hard time keeping up. Just a few minutes before touchdown, it flashed an alarm at astronauts Neil Armstrong and Buzz Aldrin, who reported it to the ground. In *Neil Armstrong: A Life of Flight*, Jay Barbree writes that an impatient Armstrong snaps at Houston to provide a reading on the alarm "right now." The flight controller responsible for the guidance systems "didn't know why," Barbree says, but he gave the go-ahead to continue.

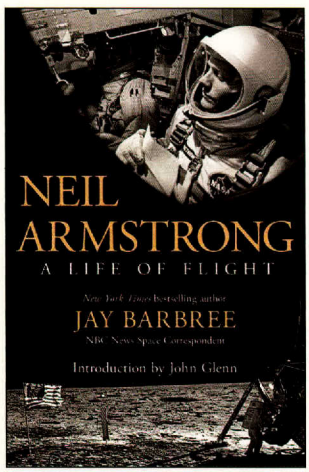
NASA

Neil Armstrong, 1969

This episode illustrates both the strength and the weakness of Barbree's book: It provides a detailed look at Armstrong's life and his mission to the Moon, but it overdoes the drama. In this case, while there was a computer alarm that required a quick decision, and Armstrong did ask for a response from mission control, he didn't snap out the "right now." And the flight controller, Steve Bales, had already been discussing the problem with a support engineer who confirmed the alarm was no show stopper, so Bales knew exactly why Apollo 11 was good to continue its landing.

The dramatic additions detract from what should be a first-rate biography of Armstrong, the first person to walk on the Moon. Barbree is a veteran NBC News reporter who has covered every American manned space mission, and became close to Armstrong over the years, so his book includes some behind-the-scenes looks at the astronaut and his work. Unfortunately, Barbree's tone is so awestruck that it's difficult to enjoy the story, and several embellishments pull it down even more.

So while *Neil Armstrong* provides a decent overview, the definitive biography of Armstrong's life has yet to be written.



Neil Armstrong
A Life of Flight
By Jay Barbree, $27.99

Help Name a Planet

The International Astronomical Union (IAU) is sponsoring the "NameExoWorlds" contest to give common names to some extrasolar planets and their host stars. Involving both the general public and astronomy clubs, anyone interested can sign up now at the project's website.

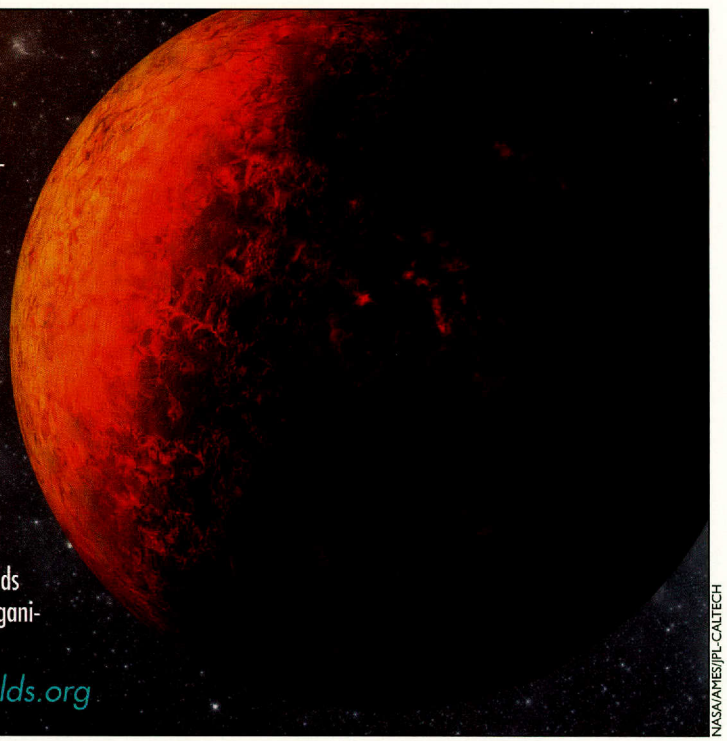
The planet names will be chosen through a three-step process. In October, registered astronomy clubs will select 20 to 30 exoplanets from a pool of 305. (An IAU working group of astronomers chose these; all were discovered before 2008 and have been extensively studied.)

Starting in December, the registered clubs will begin submitting potential names for the 20 to 30 worlds.

In March 2015, the public will vote for their favorite names at the project's website. The new common names will be announced at the IAU's General Assembly in Honolulu next August.

The IAU is the worldwide organization for professional astronomers, and holds the authority to approve names for celestial objects. This is the first time the organization has involved the public in naming objects outside of our solar system.

nameexoworlds.org



NASA/AMES/JPL-CALTECH

FLYING BY THE STARS

Some birds migrate by night using star patterns to guide their way across vast distances

By Bruce Dorminey

Opposite page, left: Navy personnel train to use a sextant for celestial navigation aboard the aircraft carrier USS Carl Vinson in the Pacific Ocean in 2010. Right: Studies of indigo buntings like this male have shown they orient themselves using the stars when migrating.

KUSHNIROV AVRAHAM

From a darkened airplane cabin on a cloudless night, I've often found myself wedged against the window, futilely searching for some familiar constellation. Not so the pilots, though, who rely on sophisticated instrumentation to guide their flight. In the era before global positioning systems, navigators routinely climbed up into aircraft astrodomes, sextants in hand, to "shoot" their celestial targets. For us, those days live on only in celluloid. But many species of birds still favor the art of celestial navigation.

Most birdwatchers know that migratory birds like the bobolink, garden warbler, and indigo bunting orient themselves using Sun angles and Earth's magnetic field lines. Most don't realize, though, that scientists think a significant number of species use the stars as a migration aid.

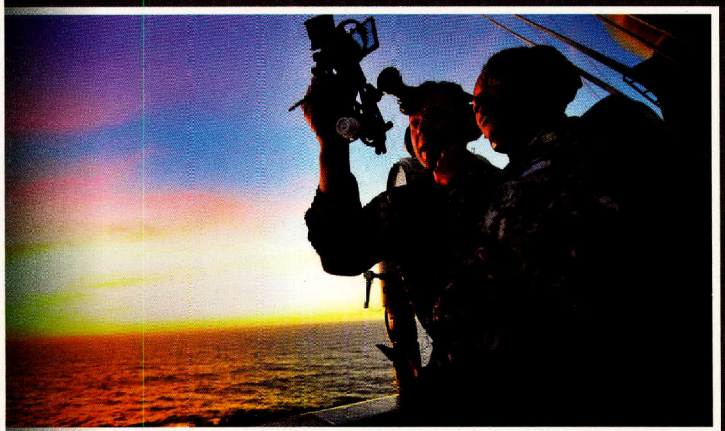
Just how these species developed such abilities remains a subject of contention among evolutionary biologists. Of an estimated 10,000 species of birds, scientists believe 85 percent migrate by night. And most appear to use some form of night-sky orientation. Only a tiny fraction of these species has been studied to understand their use of stellar cues.

Using satellite telemetry, scientists tracked the shorebirds called bar-tailed godwits flying nonstop from southwest Alaska to the North Island of New Zealand. The birds flew more than 7,250 miles in eight days. Researchers say it's hard not to imagine that over such a long flight, the godwits don't rely on the heavens for direction.

Birds migrate by night for various reasons. For songbirds like the indigo bunting, night provides some cover from aerial predators and protection from overheating when airborne. And given the length of their journeys — when crossing large bodies of water, for example — night migration is inevitable.

Anecdotal evidence bears this out. "Everyone who has gotten out of the city and seen the night sky seems to be able to relate to the fact that on a good night with a tail wind, millions of birds are passing overhead," says behavioral ecologist Stephen Emlen, a Cornell University professor emeritus.

But beyond this, many scientists, including Emlen, have studied night migration. For more than 60 years, experiments with various species of birds under artificial night skies — planetariums — have shown that birds are able to orient themselves in a



TRAVIS K. MEDOZA/US NAVY; KEVIN BOLTON

manner "appropriate to the season." In the 1960s and 1970s, Emlen conducted several experiments with indigo buntings and artificial planetarium skies. His most famous used groups of the birds raised from nestlings.

"You take these young guys out of the nest when their eyes are still closed and put them under a rotating planetarium sky," he says. "I took a planetarium apart and reconfigured Betelgeuse [in Orion] as the pole star."

Emlen found that birds exposed to a normal northern night sky with the axis of rotation centered around Polaris, the North Star, oriented themselves south. And birds exposed to an altered planetarium sky, with Betelgeuse as the axis of rotation, oriented themselves away from Betelgeuse.

But just how do the birds determine when to head north or south? It's not from studying seasonal changes in the night sky. Rather, it's thought to be determined by physiological reactions to seasonal changes in the length of day. Emlen's research supports the idea that as the days lengthen in spring or shorten in autumn, birds are physiologically induced into an "anticipatory" state. Come spring and autumn, Emlen says, the indigo buntings start jumping at night simply because they are in a motivational state to migrate.

Even so, Emlen says there is no genetic star-map-encoding of celestial navigational beacons in birds. "What's instinctual," he says, "is that they preferentially learn configurations of stars in the pole of the sky — the axis of rotation."

Emlen says that as long as the indigo buntings could view star configurations within 35 degrees of Polaris, they were able to properly orient themselves, regardless of whether they were heading north or south, in spring or fall. Trick them experimentally, however, and they would behave just as though Betelgeuse were the pole star. As a result, Emlen says he never could have risked releasing his hand-raised birds into the wild: When faced with the real sky, they might have migrated in the wrong direction.

Indigo buntings are seed eaters. In summer, they breed between forests and grasslands on the Atlantic seaboard and as far south as the Gulf coast. As autumn encroaches, they flee to southern Mexico, Central America, and northern South America. Like most species, in autumn they migrate to escape frigid weather and dwindling food sources, and in spring they migrate to find ample breeding ground and room to stretch.

Clearly, migration is necessary to the birds' survival. They must be able to determine the right course to their next food source, as well as to their breeding grounds.

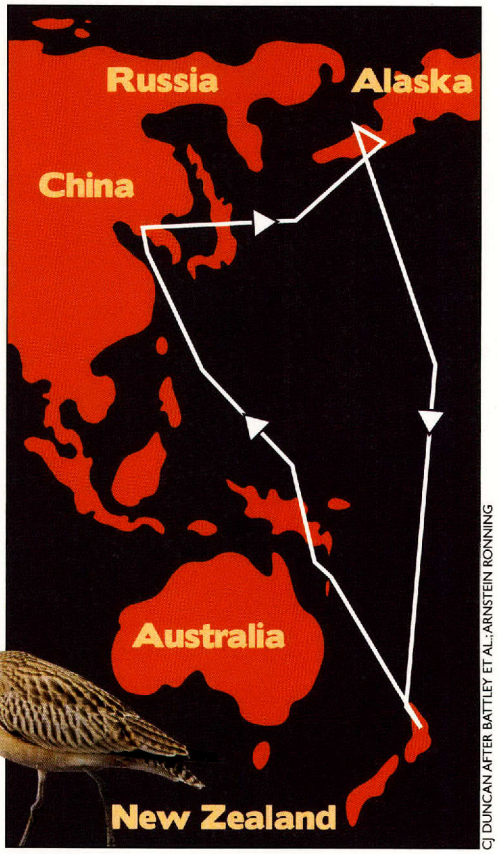
"When your life is at stake," Emlen says, "there will be all sorts of selective pressures to take advantage of anything that gives directional information. If I'm a night migrant and I'm taking off on a 600-mile trip across the Gulf of Mexico, that's pretty high risk."

To counter such risks, birds use multiple migration cues. Ornithologist Sidney Gauthreaux, a professor emeritus at Clemson University, notes that it's almost as if birds have several fail-safe systems so that when they can't see the stars, they are still able to migrate.

"For a songbird taking off around sunset," says biologist Mark Deustchlander of Hobart and William Smith Colleges, "the stars might not be visible quite yet. But it still has polarized light and a magnetic inclination compass" that it can read for navigational cues. Although humans are incapable of detecting polarized light with the unaided eye, Deutschlander says, to birds, such light effectively resembles a large sky arrow pointing north and south. The birds are also sensitive to Earth's magnetic field.

Calibrating those cues as they take off, birds begin their flight. As night falls and the stars become clear, they might prioritize stellar information over their own innate magnetic compasses.

The real test of such speculation comes in tracking how wind and weather affect birds during actual migrations. As luck would have it, Gauthreaux now lives in South Carolina's Lowcountry — a bizarre but beautiful mix of swamp, marsh, scrub forest, and intermittent open water near the Atlantic coast. It's a prime spot from which to monitor migrating birds.



CJ DUNCAN AFTER BATTLEY ET AL.; ARNSTEIN RONNING

Bar-tailed godwits make the longest-known migratory flights. Researchers from the US Geological Survey's Alaska Science Center tracked an individual from New Zealand to China (6,381 miles in 7 days), on to Alaska (4,045 miles over 5 days), and finally back to New Zealand (7,264 miles over 8 days). Such long flights over open water without landmarks probably mean the birds use cues from the stars to help find their way, scientists say.

Around noon on an early autumn day in the town of Beaufort, a dozen sailing yachts lie just beyond the last tufts of marsh in the clear channel of Beaufort River. A breeze signaling an approaching cold front stirs the tops of a stand of palms. Each year, thousands of birds pass through this vibrant coastal area en route to their winter homes. And

in a few hours, hundreds if not thousands of nocturnal avian migrants will use the Lowcountry as a way station for points farther south.

The last couple of days have been hazy, but when clear, Beaufort and the surrounding tidal marshland remain free of much of the light pollution that afflicts the northeastern United States. Those with the skill could even venture out into the open ocean, ignore the GPS and try a bit of celestial navigation.

During World War II, my own father was navigator aboard the flagship of a flotilla of some 15 naval vessels en route from Pearl Harbor to Guam. With only a compass, chronometer, and sextant, in April 1945, Lt. Arthur Dorminy [sic] led the tank landing ship USS LST-702 to a routine rest stop at Eniwetok Atoll. That's an uninterrupted open Pacific journey of some 2,100 nautical miles.

"I used a compass for steering course directions," says my dad, now a retired veterinarian in southern Georgia. "But our latitude and longitude were determined solely by celestial navigation." In three years of service, he never missed a landfall.

Nearly 70 years hence, celestial navigation, among humans at least, is a dying art. Perhaps that's part of the fascination with understanding how birds can migrate successfully. It's at least part of what makes Gauthreaux and colleagues continue to keep such long hours analyzing migratory radar data.

About an hour north of Beaufort, Gauthreaux and his wife Carroll Belser recently moved to Edisto Island and a spacious old plantation house abutting a quiet saltwater creek.

Near dusk on this October evening, I find Gauthreaux, Belser, and three visiting researchers at the end of a tiny peninsula in the house's oversized kitchen. When not checking a steaming pot of freshly caught crab, they're hovering around a laptop computer checking local NOAA weather radar images for an early surge of nocturnal migrators.

After dinner, their night's work entails manning two mobile radar stations inside utility trailers. At one station, Gauthreaux is equipped with both a thermal imager and an off-the-shelf marine radar equipped with a rotating parabolic dish. Pointed straight up, they can spot birds up to about 4,000 feet. The companion radar tracks virtually the same targets at an angle of 45 degrees, providing additional data on the migrators' flight speeds and trajectories.

One of the visiting researchers, retired zoologist Robert Beason, formerly with the USDA's National Wildlife Research Center in Sandusky, Ohio, suspects that tonight the birds migrating overhead are predominantly warblers, vireos, and small flycatchers.

"Along the Carolina coast in the past," Beason says, "in one hour, we've gotten migration rates of 10,000 individuals crossing a line one mile long. Tonight, some of these birds are heading out over the Atlantic and will not see land until they hit Venezuela."

Behind the plantation house, a path leads down to a boat dock at the edge of Store Creek. A couple of hours after dusk, the only sounds are those of water lapping gently in the marsh and the distant bark of someone's dog. The night sky, however, is screaming with information overload.

There is no scientific consensus on just how well birds actually see on their grand tours of the night sky. But Beason believes that most birds should be able to make out major stellar patterns even if they don't see quite as well as humans.

They may actually benefit from not viewing any more acutely than humans. Paradoxically, the old familiar constellations are arguably easier to identify under skies tainted by a bit of light pollution. Under the darkest skies, such patterns tend to be drowned out by stellar background noise. That may be one reason celestial navigation is looked upon by the general public as an almost magical way to navigate. How did it come to be second nature to most birds?

'What's instinctual is that they preferentially learn configurations of stars in the pole of the sky — the axis of rotation.'

— Stephen Emlen, behavioral ecologist

Ornithologist and evolutionary biologist Alan Feduccia, a professor emeritus at the University of North Carolina in Chapel Hill, says that as a matter of self-preservation, certain species evolved through natural selection to use the sky for orientation and migration. As for humans? "We evolved in the tropics," Feduccia says, "so there was no real selection for migration. We may have never had any natural orientation ability."

And unlike the indigo bunting, our existence never depended upon the hormonal urge to migrate.

Bruce Dorminey is a freelance science writer in Valdosta, Georgia.

Resources

Internet

Bird Navigation
birds.cornell.edu/AllAboutBirds/studying/migration/navigation

Celestial Navigation
aa.usno.navy.mil/faq/docs/celnav.php

Books

Nature's Compass: The Mystery of Animal Navigation, by James L. Gould and Carol Grant Gould, 2012

Celestial Navigation in the GPS Age, by John Karl, 2007

by Rebecca Johnson and Damond Benningfield

NASA/LOCKHEED MARTIN

NASA/ESA/J.-Y. LI

MAVEN swoops above the Martian atmosphere. Inset: Hubble Space Telescope view of Comet Siding Spring.

Mars Receives Visitors

Two probes will enter orbit just in time to view a spectacular comet

Mars is set to receive a wave of visitors in September and October. Two of them will stick around, while the third will zip by the planet after putting on a spectacular display in its night sky.

Spacecraft from the United States and India are scheduled to enter orbit around Mars in September. Both missions are designed to study how Mars lost its water and most of its atmosphere over the past few billion years.

And four weeks later, Comet Siding Spring, a relative of the objects that may have supplied the planet's water in the distant past, will sweep about 85,000 miles (137,000 km) above the Martian surface. The newly arrived orbiters, as well as other Mars orbiters and rovers, will observe the comet as its surrounding cloud of gas and dust interacts with the Martian atmosphere.

MAVEN (Mars Atmosphere and Volatile Evolution mission) will enter orbit on the evening of September 21. It's designed to learn more about the evolution of the Red Planet.

In its early days, Mars was warm and wet, with rivers coursing over the surface and perhaps an ocean covering almost an entire continent. Over the eons, however, Mars lost most of its atmosphere, with its water lost to space, frozen in the ice caps or below the surface, or hidden in underground reservoirs.

MAVEN will study the planet's upper atmosphere and its interaction with solar radiation and the solar wind to provide a better understanding of how this happened. The Sun's ultraviolet radiation should split apart molecules of water, carbon dioxide, and other compounds, allowing the solar wind — a steady stream of charged particles — to whisk them into space.

While NASA is an old hand at exploring the planet, India is a Mars neophyte. It sent a successful mission to the Moon, but the country is trying to expand its exploration of the solar system. The Mars Orbiter Mission, which will arrive on September 24, is a first step.

The mission's main goal is to demonstrate the technologies needed for further exploration, from the spacecraft and its instruments to tracking systems on Earth, but Mars Orbiter will conduct research while it's there as well. Like MAVEN, it will study how Mars is losing water to space. In addition, it will map minerals on the Martian surface and look for traces of methane in the upper atmosphere, which could be a marker of microscopic life.

The instruments on both Mars Orbiter and MAVEN are well suited for studying the comet, which will pass closest to Mars on October 19. Gas and dust in the coma, which extends far from the comet's tiny nucleus, should hit Mars' upper atmosphere, warming the atmosphere and perhaps triggering a meteor shower.

Mission managers may direct the orbiters away from the comet around the time of closest approach to protect them from the dust grains, which travel fast enough to cause significant damage. All of the spacecraft are likely to watch the comet before and after that approach, however. The Curiosity and Opportunity rovers on the surface may see a beautiful display as Siding Spring streaks across the Martian sky.

The comet will pass closest to Earth six days after its Mars encounter, but at a range of 130 million miles (209 million km). It may be bright enough to view with binoculars, low in the southwest in early evening. **DB**

Sun Calms Down After Weak Cycle

The Sun may be nearing the end of the peak of its current magnetic cycle, which has been one of the weakest since astronomers began monitoring solar activity more than 250 years ago. Even so, the downward side of such a peak can produce powerful outbursts that could disrupt communications and power grids on Earth.

The Sun goes through a cycle of magnetic activity that reaches its highest level every 11 years, on average. At its peak, known as solar maximum, this cycle produces many of the dark magnetic storms known as sunspots, as well as powerful solar flares and big outbursts of electrically charged particles. When such outbursts hit Earth they can damage orbiting satellites, knock out power grids, and disrupt some forms of radio, among other effects.

The current cycle produced a weak peak in 2011, entered a quiet phase, then produced a slightly stronger peak late last year and into this year. Yet it's been the quietest peak since 1906, with far fewer sunspots than average. On July 17, in fact, no sunspots marred the Sun's surface at all. (In June 2012, however, the Sun did produce its most powerful outburst yet recorded, although its fury was directed away from Earth.)

If this cycle follows the usual pattern, the peak should begin weakening later this year and into 2015. Solar scientists warn, however, that some of the most intense activity often comes after the peak, so the next year or two could produce some big fireworks on the Sun's surface.

This 2012 outburst was the most powerful in the current solar cycle.

Artist's concept shows Cassini passing by Titan.

NASA/JPL

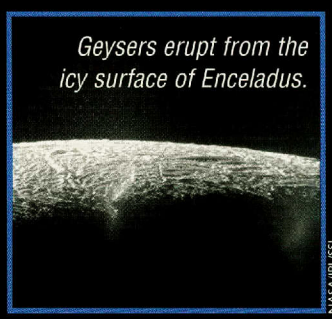
Dead Sea

Underground ocean on Titan may be too salty for life

Titan's underground ocean is the outer solar system equivalent of the Dead Sea, according to observations by the Cassini spacecraft, which has been studying Saturn and its moons for more than a decade.

Like many other large moons, Titan appears to have a large ocean of liquid water beneath its icy crust. The oceans on several moons, particularly Jupiter's Europa, are considered possible homes for life.

Cassini's careful measurements of Titan's surface contours and its gravitational field, however, suggest that Titan's ocean could be as salty as the Dead Sea, which has salinity levels roughly 10 times greater than those of Earth's oceans. Such heavy concentrations of dissolved minerals should preclude the possibility of Earth-like marine life.



Geysers erupt from the icy surface of Enceladus.

NASA/JPL/SSI

The Cassini observations also show that Titan's icy crust varies in thickness, suggesting that it is a rigid shell; a less-rigid layer of ice would spread out to produce a more uniform thickness. The rigid structure, however, would make it more difficult for methane to escape into Titan's cold atmosphere. Methane quickly breaks down in sunlight, yet there is a large concentration in the atmosphere, so something must be replenishing it. Methane may be escaping through volcanic hotspots scattered across Titan, although they are difficult to detect with Cassini's instruments.

Scientists also reported that Cassini has mapped 101 geysers of water and ice shooting into space from the south pole of Enceladus, another of Saturn's moons. The geysers are fed by an underground ocean. The warm water pokes holes in the overlying ice, allowing the water to escape into space, where it freezes. Some of this fresh ice supplies one of Saturn's outermost rings.

NASA/CXC/WESLEYAN UNIV/R.KILGARD, ET AL/STScI

A Whirlpool Sparkling with X-Rays

In this composite image of M51, the Whirlpool galaxy, X-rays seen by the Chandra Observatory appear in purple, and optical light from Hubble Space Telescope is shown in red, green, and blue. The purple highlights 500 sources of X-rays in the image; most are X-ray binary star systems inside M51. In an X-ray binary, a normal star is in a binary orbit with a neutron star or black hole. The neutron star or black hole is pulling matter off of its companion star. The matter is heated as it falls into the black hole, causing it to glow in X-rays.

Milky Way Star from Swallowed Galaxy Has Pair o' Planets

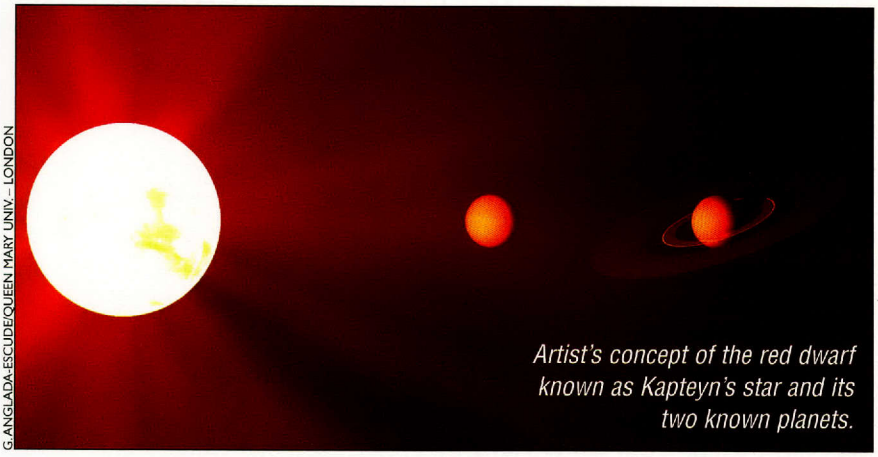
British astronomers have discovered two planets orbiting Kapteyn's star, a relatively nearby red-dwarf star. These planets are of potential interest due to their supposed age and, for one of them, the potential to support life.

The inner planet, Kapteyn b, is five times Earth's mass and orbits the star every 48 days at a distance where liquid water could exist (called the habitable zone). The outer planet, Kapteyn c, is a more massive super-Earth with a 121-day orbit. The team says this planet is too cold to have liquid water.

Kapteyn's star lies 13 light-years away in the southern-hemisphere constellation Pictor. The star has been identified as coming from a dwarf galaxy absorbed by the Milky Way in the distant past. That dwarf galaxy has mostly been ripped apart by gravitational tides, but astronomers believe its nucleus remains intact as the globular star cluster Omega Centauri, which contains hundreds of thousands of elderly stars similar to Kapteyn's star.

Omega Centauri and Kapteyn's star (and, by association, its newly discovered planets) are 11.5 billion years old. That makes these planets 2.5 times older than Earth. Thus, if Kapteyn b does support life, it has had much longer to evolve than life on Earth.

Guillem Anglada-Escude of London's Queen Mary University headed the study. **RJ**



G.ANGLADA-ESCUDE/QUEEN MARY UNIV.–LONDON

Artist's concept of the red dwarf known as Kapteyn's star and its two known planets.

New Evidence Challenges Earth-Moon Formation Scenario

At a recent meeting of geoscientists in Sacramento, a group led by Harvard's Sujoy Mukhopadhyay announced that the leading theory of Earth and the Moon's formations could be in for an update.

The prevailing theory says that the ancient Earth was struck by a planet-sized body around 4.5 billion years ago, melting the planet and flinging massive amounts of material into space. As the debris cooled, some of it separated and formed the Moon.

The new findings suggest that one part of the young Earth was affected more heavily than the rest.

"The energy released by the impact ... would have been huge, certainly enough to melt the whole planet," Mukhopadhyay said. "But we believe that the impact energy was not evenly distributed throughout the ancient Earth. This means that a major part of the impacted hemisphere would have been partly shielded, and would not have undergone complete melting."

The evidence comes from a ratio of chemical elements deep underground. The team studied the relative amounts of helium-3 to neon-22 in shallow parts of Earth's mantle compared to the deep mantle. They found that the former is much higher than the latter.

"This implies that the last giant impact did not completely mix the mantle and there was not a whole magma ocean," Mukhopadhyay said. This idea "challenges some of our notions on planet formation and the energetics of giant impacts," he said. "If the theory is proven correct, then we may be seeing echoes of the ancient Earth, from a time before the collision." **RJ**

Newborn stars sparkle against a background of glowing hydrogen gas in this view of NGC 3293, a star cluster in the southern constellation Carina, the keel. The cluster's 50 or so stars all formed in a single event less than 10 million years ago. Even so, one of its most massive stars is already nearing the end of its life. The bright orange star to the lower right of the cluster's center is a bloated red giant. It must be extremely massive to expire so quickly, and may be destined to explode as a supernova. The wisps of gas around the cluster are left over from the stars' formation.

ESO/G. BACCANI