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SETTLING ON MARS
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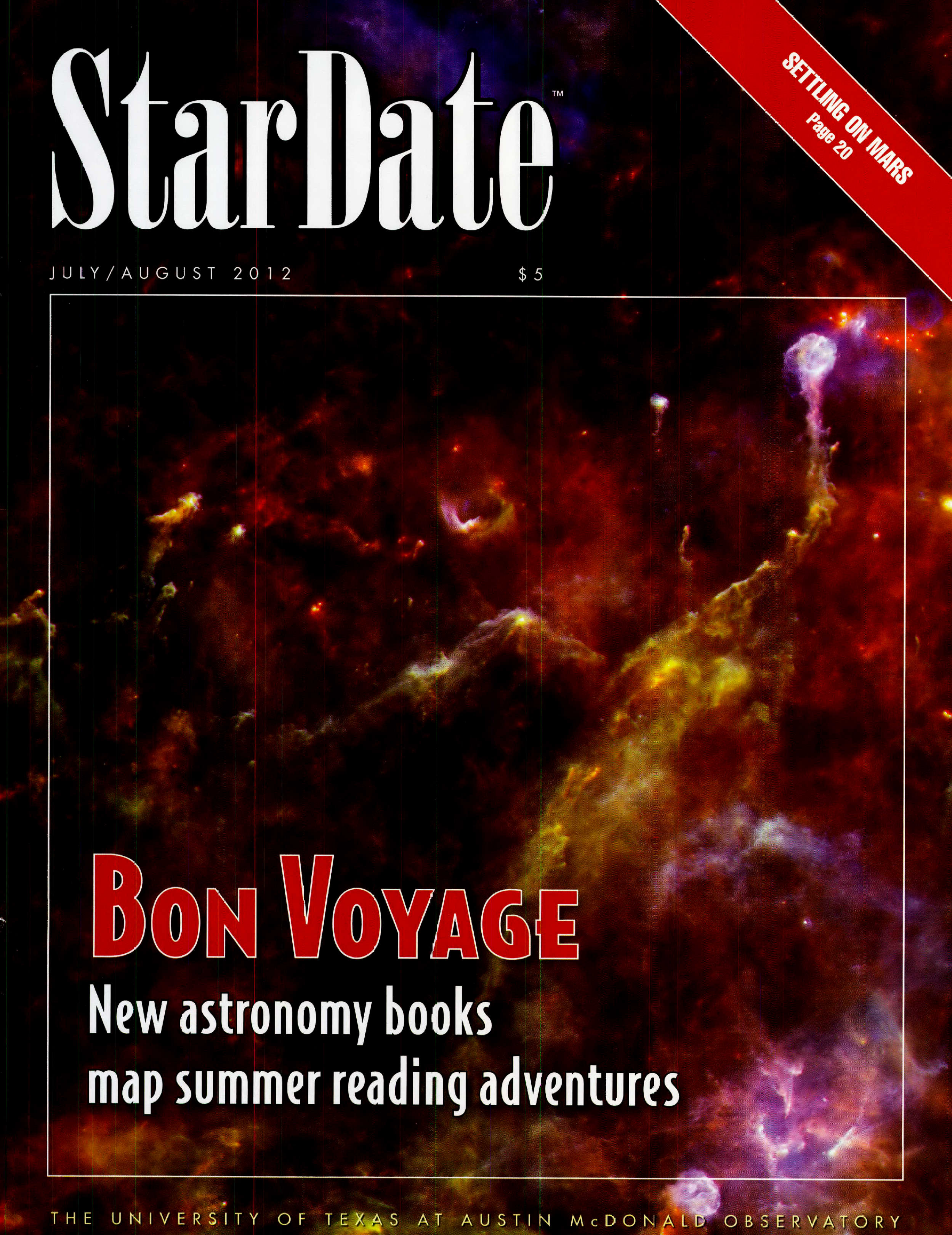

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StarDate

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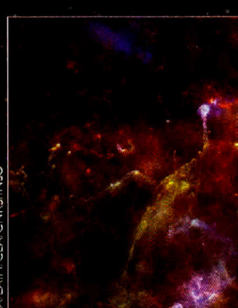

ESA/LAIM/CEA/CNRS/INSU

On The Cover
The chaotic interplay of gas and dust indicate birth sites of massive young stars in this view of the Cygnus-X region from Europe's Herschel infrared space telescope.

This Page
The background stars on this page are part of dwarf galaxy NGC 2366, a near neighbor of the Milky Way, as seen by Hubble Space Telescope. A bright blue star-forming nebula glows at top right; a distant golden spiral galaxy shines through at top left.

Coming Up in September/October
In the next issue of StarDate, *author Bradford Behr updates us on the bounty brought in by WISE, the Wide-field Infrared Survey Explorer. And we'll look back on efforts to communicate with inhabitants of other planets in the early days of radio.*

NASA & ESA

MERLIN

Dear Merlin,

Are the constellations in the Milky Way?

Rita Howard
Seattle

Yes. And no.

Although it is election season, Merlin is not flip-flopping on the issues. Instead, he is using this opportunity to point out that there is more than one definition for "constellation."

The classical constellations are connect-the-dot pictures of animals, people, and objects. The dots are individual stars, all of which lie within the confines of the Milky Way galaxy. In fact, most of them are within a few hundred light-years of Earth, so they are close neighbors. So in this definition, the answer is "Yes."

Here's the hanging chad, though. In the 1930s, the International Astronomical Union drew boundaries for 88 constellations. In this system, each constellation is a small patch of sky that borders on others, like a patchwork quilt. These patches are three-dimensional projections that extend as far as the telescope can see, so they incorporate stars inside the Milky Way plus galaxies that are far beyond the Milky Way. So in this definition, the answer is "Yes and No."

Merlin hopes this answer is sufficiently helpful to gain your vote for Chief Wizard in the next election.

Dear Merlin,

What makes so many stars, such as Sirius, twinkle in so many different colors?

Jack Harris
Volcano, Hawaii

An ocean of air.

Like the oceans, Earth's atmosphere comprises layers, streamers, and blobs of different temperature and density. As starlight encounters these structures, it is refracted, or bent. Each color of light is bent at a slightly different angle, so sometimes the reds are angled away from you, which makes a star briefly look pure blue; at others, the blues are angled away from you, making the star look red.

The effect is more pronounced for stars that appear low in the sky because their light must traverse a thicker layer of atmosphere before reaching your eye, providing more opportunity to distort the light.

LAYNE LUNDSTROM

Dear Merlin,

Mars looks reddish from Earth because of the surface material. What color is Earth as seen from Mars? Bluish because of the oceans?

Philip Groody
Alameda, California

Absolutely. Spacecraft have photographed Earth from orbit around Mars and seen the blue color.

When the separation between Earth and Moon is wide enough as seen from Mars, both bodies are visible at the same time, with Earth shining about 50 times brighter than its satellite.

Through a telescope, both Earth and Moon would show phases. Just before or after they pass between the Sun and Mars, both would be thin crescents. Just before or after they pass behind the Sun as seen from Mars, however, both would be almost full.

Dear Merlin,

Many books, articles, and papers have been written about the theory of relativity. Invariably the writers focus on light and the strange things that happen as an observer moves at a velocity approaching that of light. How does relativity relate to the remainder of the electromagnetic spectrum? What strange things happen to radio waves, X-rays, and gamma rays, for example?

Ron Giffin
Cincinnati

The same as visible light. All electromagnetic radiation is a form of "light." An observer traveling at close to lightspeed would see a strong redshift in the light from the objects ahead as their light waves were compressed. That would shift wavelengths of optical light (the wavelengths that are normally visible to the eye) to the ultraviolet, which has a shorter wavelength. At the same time, normally invisible long-wavelength infrared waves would be shifted to optical wavelengths. In essence, you would "see" the infrared universe, not the optical universe.

For objects behind the observer, the effect would be just the opposite — the ultraviolet would be stretched to optical wavelengths, and optical wavelengths would be shifted to the infrared.

At speeds just short of lightspeed, the distortions would become even weirder, with the light from all the objects ahead of you compressed to a single point. And if you had telescopes that could view the universe at many different wavelengths, they would see the same thing. The key is that to the universe, all electromagnetic energy is "light."

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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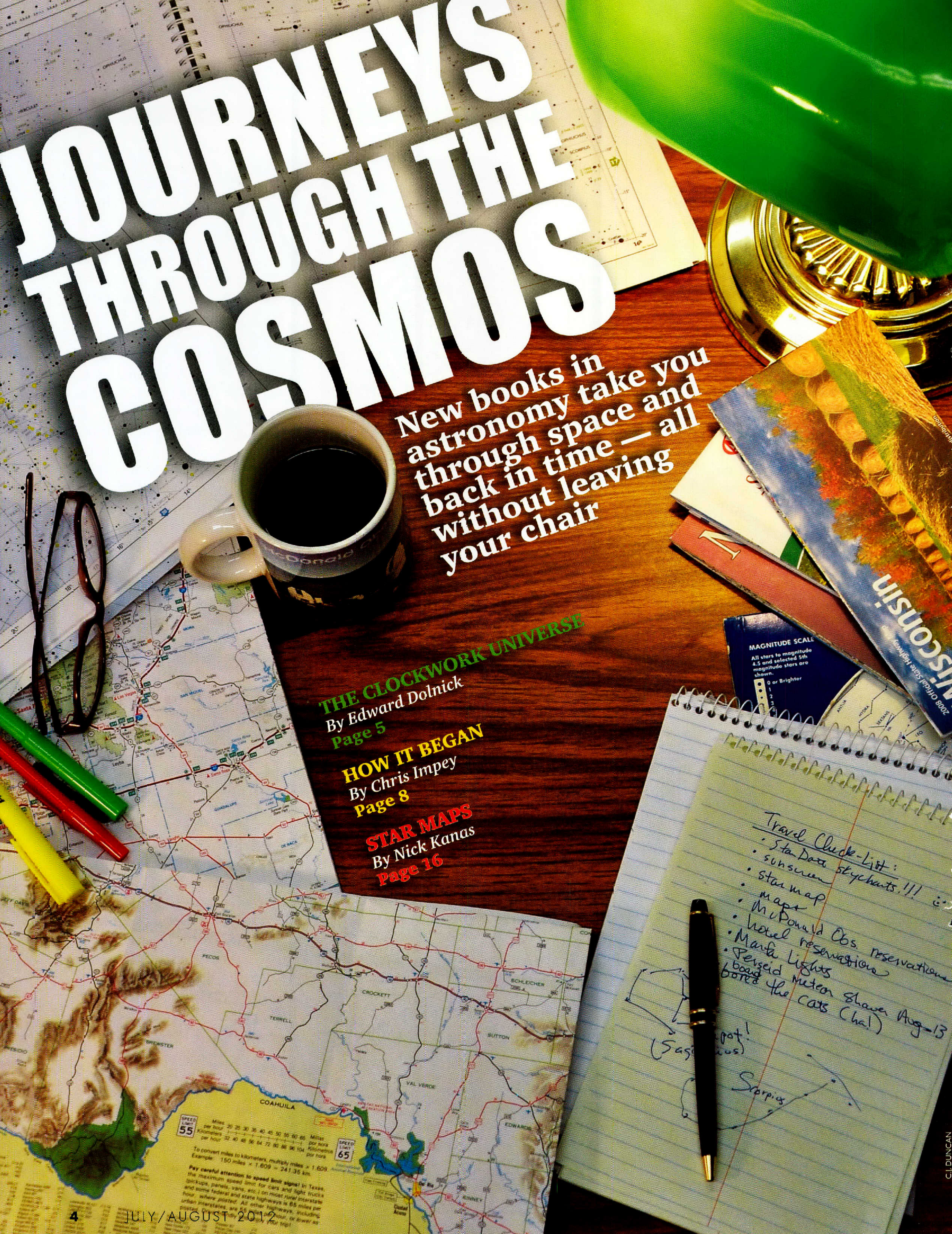

JOURNEYS THROUGH THE COSMOS

New books in astronomy take you through space and back in time — all without leaving your chair

THE CLOCKWORK UNIVERSE
By Edward Dolnick
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HOW IT BEGAN
By Chris Impey
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STAR MAPS
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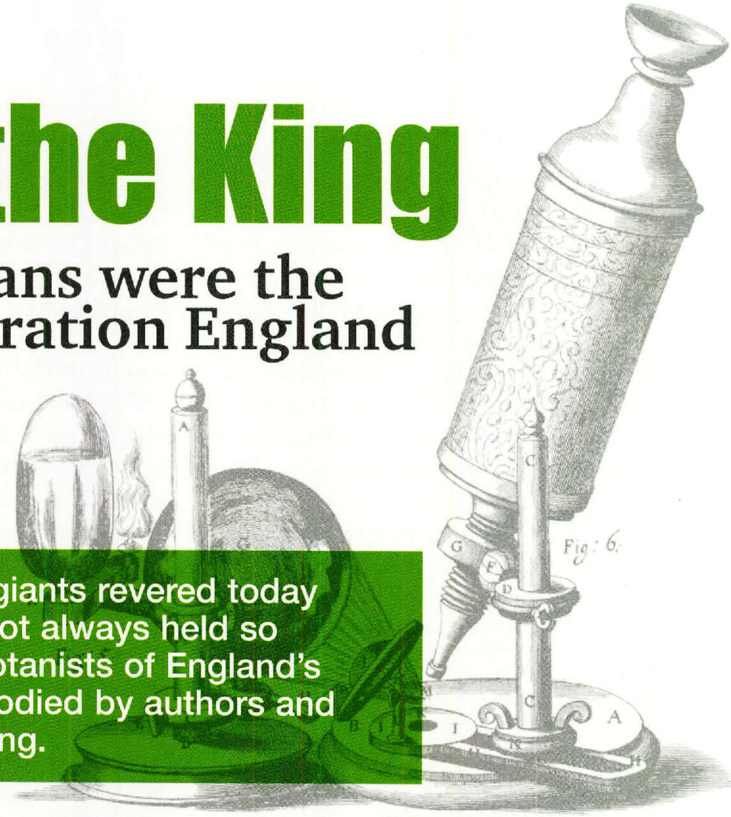
C.J. DUNCAN

Dancing for the King

Scientists and mathematicians were the butt of many a joke in restoration England



Robert Hooke's microscope

THE SETUP

Edward Dolnick explains that the intellectual giants revered today as founders of the scientific revolution were not always held so reverently. The astronomers, chemists, and botanists of England's fledgling Royal Society were mocked and parodied by authors and playwrights of their own time, and even the king.

THE EXCERPT

Science today is a grand and formal enterprise, but the modern age of science began as a free-for-all. The idea was to see for yourself rather than to rely on anyone else's authority. The Royal Society's motto was "Nullius in Verba," Latin for, roughly, "Don't take anyone's word for it," and early investigators embraced that freedom with something akin to giddiness.

The meetings of the Royal Society in its young days sound like gatherings of a group of very smart, very reckless Cub Scouts. Society members gathered in a large room with a bare table and a roaring fire. In a group portrait, the men—the company was all male—would have looked more or less alike, but that was largely because everyone wore wigs. (In England and France, fashion followed the court. When Charles II began to go gray, and when the Sun King's hairs began to clog the royal hairbrush, the monarchs donned wigs, and soon no gentleman in Europe would venture out in public in his own hair.) ...

The highlights, most weeks, were "demonstrations," the livelier the better. [Robert] Hooke and [Robert] Boyle carried out a long series of experiments to explore "the expansive forces of congelation"—they put water in a glass tube and froze it—and then everyone settled in to watch the tubes break "with a considerable noise and violence." Noise was always a great selling point. The members of the Royal Society were forever studying giant hailstones, for instance, in the hope that they would explode with a deafening crack when thrown in the fire. As a bonus, some hailstones had a strange shape or color. In those cases, the scientists' descriptions took on the tone of a "Ripley's Believe it or Not" item about a potato in the shape of a donkey. ...

Science was destined to remake the world, but in its early days it inspired laughter more often than reverence. [Famed seventeenth-century diarist Samuel] Pepys was genuinely fascinated with science—he set up a borrowed telescope on his roof and peered at the moon and Jupiter, he raced out to buy a microscope as soon as they came on the market, he struggled through Boyle's *Hydrostatical Paradoxes* ("a most excellent book as ever I read, and I will take much pains to understand him through if I can"), and in the 1680s, he served as president of the Royal Society—but his amusement was genuine, too. All these intellectuals studying spiders and tinkering with pumps. It *was* a bit ludicrous.

The king certainly thought so. He, too, was an aficionado of science. He had, after all, chartered the Royal Society, and he liked to putter about in his own laboratory. But he referred to the Society's savants as his "jesters," and once he burst out laughing at the Royal Society "for spending time only in weighing of ayre, and doing nothing else since they sat."

Weighing the air—which plainly weighed nothing at all—seemed less like a groundbreaking advance than a return to such medieval pastimes as debating whether Adam had a navel. Skeptics never tired of satirizing scientists for their impracticality. One critic conceded that the members of the Royal Society were "Ingenious men and have found out A great Many Secrets in Nature." Still, he noted, the public had gained "Little Advantage" from such discoveries. Perhaps the learned scientists could turn their attention to "the Nature of butter and cheese."

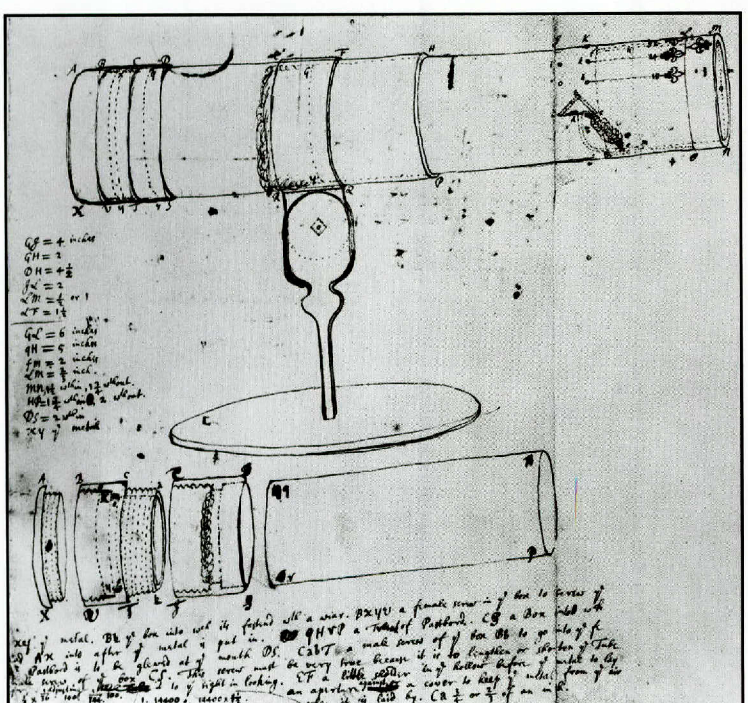
In fact, they had given considerable thought to cheese, and also finding better ways to make candles, pump water, tan leather, and dye cloth. From the start, Boyle had taken the lead in speaking out against any attempts to separate science and technology. "I shall not dare to think myself a true naturalist 'til my skill can make my garden yield better herbs and flowers, or my orchard better fruit, or my field better corn, or my dairy better cheese" than the old ways produced.

To hear the scientists and their allies tell it, unimaginable bounty lay just around the corner. Joseph Glanvill, a member of the Royal Society but not a scientist himself, shouted the loudest. "Should those Heroes go on, as they have happily begun," Glanvill exclaimed, "they'll fill the world with *wonders*." In the future, "a voyage to Southern unknown Tracts, yea possibly the Moon, will not be more strange than one to America. To them that come after us, it may be as ordinary to buy *a pair of wings* to fly to the remotest Regions, as now a pair of Boots to ride a Journey."

Such forecasts served mainly to inspire the mockers. By 1676 the Royal Society found itself the subject of a hit London comedy, the seventeenth-century counterpart of a running gag on *Saturday Night Live*. The play was called *The Virtuoso*, which could mean either "far-ranging scholar" or "dilettante." Thomas Shadwell, the playwright, lifted much of his dialogue straight from the scientists' own accounts of their work.

Playgoers first encountered the evening's hero, Sir Nicholas Gimcrack, sprawled on his belly on a table in his laboratory. Sir Nicholas has one end of a string clenched in his teeth; the other end is tied to a frog in a bowl of water. The virtuoso's plan is to learn to swim by copying the frog's motions. A visitor asks whether he has tested the technique in water. Not necessary, says Sir Nicholas, who explains that he hates getting wet. "I content myself with the speculative part of swimming. I care not for the practical. I seldom bring anything to use. ... Knowledge is my ultimate end."

Sir Nicholas's family is not pleased. A niece complains that he has "spent £2000 in Microscopes, to find out the nature of Eels in vinegar, Mites in Cheese, and the blue of Plums." A second niece worries that her uncle has "broken his Brains about the nature of Maggots and studied these twenty Years to find out the several sorts of Spiders."



Isaac Newton's sketch for a reflecting telescope

All the favorite Royal Society pastimes came in for ridicule. Gimcrack studied the moon through a telescope, as Hooke had done, and his description of its "Mountainous Parts and Valleys and Seas and Lakes," as well as "Elephants and Camels," spoofs Hooke's account. (Hooke went to see the play and complained that the audience, which took for granted that he was the inspiration for Gimcrack, "almost pointed" at him in derision.)

Sir Nicholas experimented on dogs, too, and boasted about a blood transfusion in which "the *Spaniel* became a *Bull-Dog*, and the *Bull-Dog* a *Spaniel*." He had even tried a blood transfusion between a sheep and a madman. The sheep died, but the madman survived and thrived, except that "he bleated perpetually, and chew'd the Cud, and had Wool growing on him in great Quantities."

Like his king, Shadwell found much to satirize in the virtuoso's fascination with the properties of air. Sir Nicholas keeps a kind of wine cellar with bottles holding air collected from all over. His assistants have crossed the globe "bottling up Air, and weighing it in all Places, sealing the Bottles Hermetically." Air from Tenerife is the lightest, that from the Isle of Dogs heaviest. Shadwell had great fun with the notion that air is a substance, with properties, rather than a mere absence. "Let me tell you, Gentlemen," Sir Nicholas assures his visitors, "Air is but a thinner sort of Liquor, and drinks much the better for being bottled."

Shadwell had a good number of allies among the satirists of his day, many of them eminent. Samuel Butler lampooned men who spent their time staring into microscopes at fleas and drops of pond water and contemplating such mysteries as "How many different Species / Of Maggots breed in rotten Cheeses."

But no one brought as much talent to ridiculing science as Jonathan Swift. Even writing more than half a century after the founding of the Royal Society, in *Gulliver's Travels*, Swift quivered with indignation at scientists for their pretension and impracticality. (Swift visited the Royal Society in 1710, squeezing in his visit between a trip to the insane asylum at Bedlam and a visit to a puppet show.)

Gulliver observes one ludicrous project after another. He sees men working on "softening Marble for Pillows and Pincushions" and an inventor engaged in "an Operation to reduce human Excrement to its original Food." In many places, the satire targets actual Royal Society experiments. Real scientists had struggled in vain, for instance, to sort out the mysterious process that would later be called photosynthesis. How do plants manage to grow by "eating" sunlight? Gulliver meets a man who "had been Eight Years upon a project for extracting Sun-Beams out of Cucumbers, which were to be put into Vials hermetically sealed, and let out to warm the Air in raw inclement Summers."

Swift's sages live in the expectation that soon "one Man shall do the Work of Ten and a Palace may be built in a Week," but none of the high hopes ever pans out. "In the mean time, the whole Country lies miserably waste, the Houses in Ruins, and the People without Food or Cloaths."

Mathematicians, the very emblem of head-in-the-clouds uselessness, come in for extra ridicule. So absentminded are they that they need to be rapped on the mouth by their servants to remember to speak. Lost in thought, they fall down the stairs and walk into doors. They can think of nothing but mathematics and music. Even meals feature such mathematical courses as "a Shoulder of Mutton, cut into an Equilateral Triangle; a Piece of Beef into a Rhomboides; and a Pudding into a Cycloid."

In hardheaded England, where "practicality" and "common sense" were celebrated as among the highest virtues, Swift's disdain for mathematics was widely shared by his fellow intellectuals. In that sense, Swift's mockery of absentminded professors was standard issue. But, more than he could have known, Swift was right to direct his sharpest thrusts at mathematicians. These dreamers truly were, as Swift intuited, the most dangerous scientists of all. Microscopes and telescopes were the glamorous innovations that drew all eyes—*Gulliver's Travels* testifies to Swift's fascination with their power to reveal new worlds—but new instruments were only part of the story of the age. The insights that would soon transform the world required no tools more sophisticated than a fountain pen.

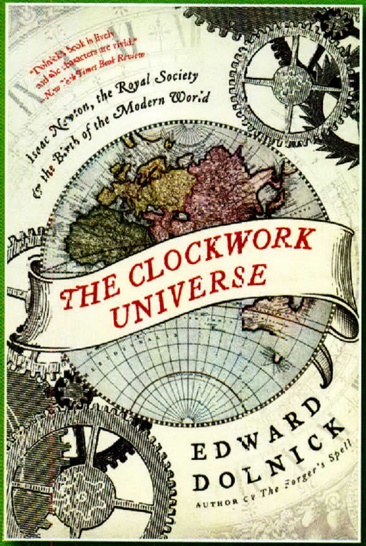
For it was mathematicians who invented the engine that powered the scientific revolution. Centuries later, the story would find an echo. In 1931, with great hoopla, Albert Einstein and his wife, Elsa, were toured around the observatory at California's Mount Wilson, home to the world's biggest telescope. Someone told Elsa that astronomers had used this magnificent telescope to determine the shape of the universe. "Well," she said, "my husband does that on the back of an old envelope."

Those outsiders who did take science seriously tended to dislike what they saw. The scientists themselves viewed their work as a way of paying homage to God, but their critics were not so sure. Astronomy stirred the most fear. Who needed it, when we already know the story of the heavens and the Earth, and on the best possible authority? To probe further was to treat the Bible as just another source of information, to be tested and questioned like any other. A popular bit of seventeenth-century doggerel purportedly captured the scientists' view: "All of the books of Moses / Were nothing but supposes."

The devout had another objection. Science diverted its practitioners from deep questions to silly ones. "Is there anything more Absurd and Impertinent," one minister snapped, "than to find a Man, who has so great a Concern upon his Hands as the preparing for Eternity, all busy and taken up with *Quadrants*, and *Telescopes*, *Furnaces*, *Syphons*, and *Air Pumps?*"

So science irritated those who found it pompous and ridiculous. It offended those who found it subversive. Just as important, it bewildered almost everyone.

THE BOOK



The Clockwork Universe
Isaac Newton, the Royal Society & the Birth of the Modern World
By Edward Dolnick

Softcover, 2012
Harper Perennial
$16.99
$9.99 Nook, Kindle, iTunes

Waiter, There's An Eyelash in My Salsa

The origin of all that we are from the hot hearts of stars

THE SETUP

One of the first lessons in astronomy classes is that we are "children of the stars" — not because our parents have their own stars on Hollywood Boulevard, but because the atoms that make up our bodies were forged in the hearts of stars. Author Chris Impey explains celestial alchemy — the process by which stars create the elements.

THE EXCERPT

With stars, there's much more than meets the eye. Hidden from our gaze, their cores are conjuring up all the ingredients of the material world. Simple and spherical in form perhaps, but stars are protean in their ability to create new elements.

The story of the birth of elements is framed by the simple question, what is the universe made of? Let's start with ourselves. In terms of number of atoms, we're roughly 65 percent hydrogen, 25 percent oxygen, 10 percent carbon, 1.3 percent nitrogen, and trace amounts of all other elements like calcium and phosphorous. Most of our mass is in the form of water. If you reach down and pick up a rock, the chemical composition is quite different. The most common elements in Earth's crust are oxygen, silicon, aluminum, sodium, hydrogen, iron, calcium, potassium, and magnesium. But chemical processes in the geologically active Earth have altered the proportions of elements, so a fairer sample of the material that makes up planets and moons comes by looking at the composition of primitive meteorites. That's combined with chemical analysis of the atmosphere of the Sun, which has 99 percent of the Solar System's mass. The universe is made of mostly "star stuff," and the best version of cosmic abundance comes from an average across a larger region of the Milky Way galaxy.

Imagine atoms in the universe scattered like playing cards. Instead of the normal suits and numbers, these cards are labeled as elements of the periodic table. The dominant elements are hydrogen and helium; everything else is amazingly rare. In terms of number of atoms, the universe is made up of 88 percent hydrogen, 12 percent helium, 0.060 percent oxygen, 0.026 percent carbon, 0.025 percent neon, and less than 1 part in 10,000 of all other elements. In the analogy of playing cards it's as if we marked all aces and two of the kings as helium atoms and the rest as hydrogen. We'd have to search through 32 decks of cards to find anything other than those two elements. If we had the patience to search 240 decks, or 12,500 cards, we'd find one nitrogen card, three neon cards, three carbon cards, and five oxygen cards. Everything else is hydrogen or helium. To find a single iron card, you'd need to sift through 190,000 cards or 3600 decks. Precious metals like gold, silver, and platinum are incredibly rare, cosmically speaking. Just 1 in 10 billion atoms, so gold at the current price is a steal. Imagine a huge Walmart store, emptied of goods and filled from floor to ceiling with decks of cards. You'd have to go through all of them to be sure of finding one gold atom ...

As biological creatures, we're partial to carbon. Some esoteric nuclear physics explains why carbon is as rare as it is, and why it isn't so rare that life couldn't exist. Two helium nuclei can fuse to make a beryllium nucleus, but it's radioactive with a half-life of a hundred-trillionth of a second. A star needs a central temperature of 100 million degrees to fuse the two nuclei together faster than they fall apart naturally. Only stars more massive than the Sun ever reach central temperatures this high. In the 1950s, astrophysicist Fred Hoyle realized that a special nuclear resonance greatly increased the probability of a third helium nucleus fusing with beryllium, and so forming carbon. The fact that carbon exists at all is essentially a coincidence of nuclear physics!

To make even heavier elements, higher temperatures and higher mass stars are needed, and they're rare… Fusion gets harder and harder because it has to overcome the increasing electrical repulsion between protons in the steadily growing atomic nuclei … In the most massive stars, carbon fuses with helium to make oxygen. But the star doesn't stop to breathe; it fuses oxygen with helium to make neon. And still it doesn't stop to advertise the fact; it fuses neon with helium to make magnesium. Larger units can combine too. Carbon fuses with oxygen to make silicon, two oxygens fuse to make sulfur, and two silicons fuse to make iron. …

For a massive star, this all must end in tears. The frenzy of alchemy takes place in a crescendo, with successive stages taking less time—carbon fusion takes about a millennium, oxygen fusion takes a year, and the final stage of silicon fusion takes only a day! The star ends with an "onion" structure, where raw hydrogen and helium are on the outside and layers of heavier and heavier elements are on the inside, nestled around an iron core. The core is a bizarre state of matter; its iron is hundreds of times denser than solid iron, yet it's a 3-billion-degree gas. Iron is a bottleneck because energy is no longer made by fusing toward heavier elements. With no energy to keep the star puffed up, it collapses.

All the heavy elements beyond iron in the periodic table are created by massive stars. About half of those atoms are made in the atmospheres of those stars by stealth as neutrons are captured by the heavy nuclei. This process only goes up to bismuth, the heaviest stable element. The other half are created in the paroxysm of the star's death. Collapse is followed by an explosion called a supernova, and elements as massive as radioactive uranium and plutonium can be created in seconds in the billion-degree blast wave. Those heavy elements include gold. …

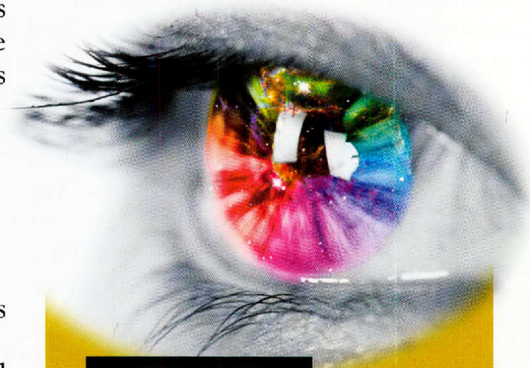
Stars are engaged in a vast recycling program. The universe would be a dull place if stars created elements and held on to them for eternity. Luckily, all large stars return a substantial fraction of their mass to the interstellar medium where it can become part of a new generation of stars and planets. Many atoms are removed from circulation in various stellar corpses: white dwarfs, neutron stars, and black holes. But a lot are sent back into space to be part of a new set of stories. …

It must have been the salsa. I woke up one night in a cold sweat. I'd lectured my class that day on the cosmic abundance of elements, and then gone out for Mexican food with some friends. As always, I'd explained to the students how almost every atom in their bodies had once been part of a different star, their stories stretching back in time to long before the Earth formed. I was probably on autopilot, since the information was so familiar, telling them a fantasic story without really considering it deeply myself.

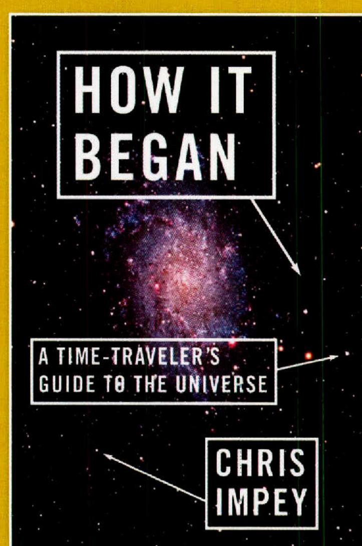
As I broke the surface of consciousness by tossing and turning I had been dreaming of atoms. I lay still and through one lidded eye saw a single blurry lash. My attention focused on the tip of the eyelash and suddenly I was down among the atoms, an incredible shrinking man.

Keratin. A protein that's the main structural element of hair and skin. Half of the atoms are carbon. The one nearest me was cooked up in a Sun-like star 6 billion years ago and blown off in a smoke ring where it languished in interstellar space before being swept up in the forming Earth. The next one over had a tumultuous history, churning through half a dozen stars before being interred on the planet to become food that would one day become part of me. There's a hydrogen atom. It's been unaltered since the birth of the universe 13.7 billion years ago. That's sulfur, forged inside a massive star and delivered to me by a titanic explosion 5 billion years ago.

And on and on. A trillion stories in one eyelash alone, a billion billion billion in my whole body. As Whitman once said: "I am large. I contain multitudes." My mind reeling, I submerged again into fitful sleep.



THE BOOK



How It Began
A Time-Traveler's Guide to the Universe
By Chris Impey

W.W. Norton & Company
$27.95
$14.99 iTunes, Kindle

Sky Calendar

by Alan MacRobert

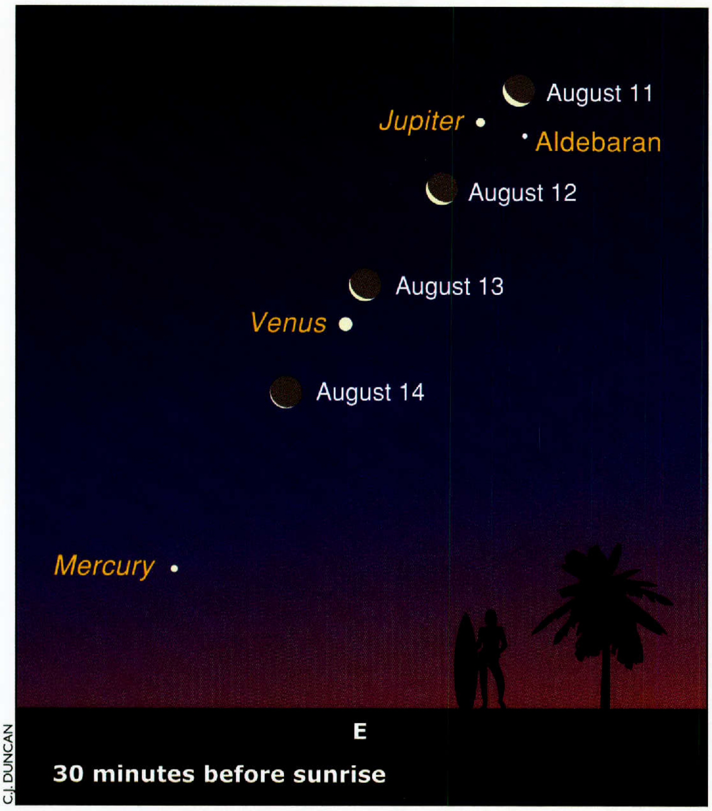
The dog days of summer bring a Summer Triangle doppelganger, a teapot in the sky, and early-morning planets. Take some time to watch the heavens before dawn and after dusk, and you won't be disappointed.

JULY 1 - 15

A temporary new "summer triangle" hangs in the southwestern sky after nightfall this year. Its top point is bright Arcturus, high in the southwest. Well below Arcturus and perhaps a bit to its left, a pair of dots marks another corner. These are diamond-like Spica and yellow-tinged Saturn. They're five degrees apart (about three finger-widths at arm's length). The triangle's third corner is dimmer Mars, to the lower right of Saturn and Spica.

Meanwhile, the actual, eternal Summer Triangle of stars floats high in the east. Bright Vega is its topmost point. Look to the lower left of Vega by about two fist-widths at arm's length for Deneb. Altair shines about three fist-widths to Vega's lower right.

Look south shortly after nightfall for orange-red Antares. It's the brightest star in the area to the far left of Saturn, Spica, and Mars. Antares is the heart of distinctive Scorpius — a pattern marked by two lesser, blue-white stars on either side of Antares, three more forming a nearly vertical line to its right and upper right, and more snaking far off to its lower left.



Meanwhile, brighter planetary action highlights the early July dawn — if you can get up before daybreak to take a look. Remember how Venus and Jupiter paired up spectacularly in the dusk last March? Now they're at it again in the morning sky. Venus and Jupiter are the two brightest celestial objects after the Sun and Moon. Look for them rather low in the east as dawn begins, and higher as the sky grows bright.

Venus is the brighter one, on the bottom. They stay four to six degrees apart (about three or four finger-widths) during the first half of July.

There's more here. Look for much fainter (but still first-magnitude) Aldebaran near or between them. And before the sky gets too light, look for the scattered stars of the Hyades Cluster in their background. To top it off, the waning crescent Moon shines above Venus, Jupiter, and Aldebaran on the morning of July 14, then right in their midst on the 15th.

JULY 16 - 31

The tall triangle of Arcturus, Mars, and the Saturn-Spica pair has been narrowing at its base. That's because Mars is speeding eastward against the background stars toward Saturn and Spica, on its way to passing between them in mid-August. The waxing Moon marches below them on July 24 and 25.

As the southwest triangle narrows from week to week, it moves lower and westward with respect to your twilight backyard scenery. Meanwhile the Summer Triangle of Vega, Deneb, and Altair ascends even higher in the east.

The Summer Triangle's top corner, Vega, passes nearly straight overhead in the middle of the night now, if you live in the mid- or northern latitudes of the United States or southern Canada. Every year, Vega crowns summer nights.

Below Vega, Cygnus, the swan, flies inside the Summer Triangle. The swan's brightest stars form the Northern Cross; Deneb on the left is the head of the cross and the tail of the swan. The Northern Cross (larger but dimmer than the more famous Southern Cross) currently lies more or less horizontal in early evening. Its foot, and the swan's beak, is rather faint Albireo. Look for it about two fist-widths to Deneb's right. Albireo is barely inside the Summer Triangle, less than halfway from Vega to Altair.

Cygnus lies along one of the brightest portions of the summer Milky Way. But only in a dark, moonless sky can you really appreciate this fact.

Before and during dawn, the luminous white lamps of Venus and Jupiter continue shining in the east, but now they're pulling apart. Venus remains at about the same height at dawn for the rest of July and August. Jupiter pulls farther away to Venus' upper right, with Aldebaran accompanying it. Capella shines to the left of this group.

AUGUST 1 - 15

Keep a nightly watch on Saturn, Spica and Mars! This friendly star-and-two-planets triad is moving lower in the west-southwest in late twilight just as it's getting really interesting. It begins August as a narrow triangle eight degrees long with Mars (the dimmest) as the long point on the right. Each evening Mars moves closer to Saturn and Spica (watch the triangle changing shape!) and then passes directly between them on August 13 and 14.

On the northern side of the sky after dark, look for two important starry landmarks. You can't miss the Big Dipper high in the northwest, with its bowl to the lower right and handle to the upper left. Look northeast, somewhat lower at dusk, for the flattened W of Cassiopeia, slightly smaller. The W is currently tilted with its right side higher.

The dipper is lowering and Cassiopeia is rising. They pose about equally high as evening grows late.

Look midway between the Big Dipper and Cassiopeia, and just a bit higher, for the rather dim North Star, Polaris. The North Star, of course, always marks true north — to an accuracy of better than one degree.

Before dawn, the Venus-Jupiter show in the east continues to enthrall. Venus still blazes fairly high. Jupiter, second brightest, is pulling ever higher to Venus' upper right. Orange Aldebaran sparkles to Jupiter's lower right, and (if the sky isn't too bright yet) the Pleiades float higher above.

See the bright star to the far left of Jupiter? That's Capella. To the right or lower right of Venus, Orion is on the rise, a distant early warning of winter. The waning Moon walks through this scene August 11-14.

As dawn brightens, look for little Mercury just above the east-northeast horizon. Jupiter and Venus point down almost directly at it.

Meteor Watch

The Shower
Perseids

Named for the constellation Perseus, the hero, which climbs into view in the early morning hours.

Peak
Night of August 11

Notes
The Moon is a thin crescent that rises about three hours before the Sun, so it will provide little interference. At the shower's peak you might see a few dozen meteors per hour.

AUGUST 16 - 31

The Saturn-Spica-Mars partnership continues to evolve day by day as it moves lower in the west-southwestern twilight. The three objects shift from a nearly straight line on August 13 and 14 to an equilateral triangle on the 21st — right when the waxing crescent Moon stops in to say hello. By the end of the month, the triangle is long again — this time with Mars as its left point. By now they are dropping quite low.

When dusk falls in late August, bright Vega is already close to the zenith, approaching from the east. Lower in the south-southwest, ruddy Antares is beginning its seasonal departure, sinking a little farther down and westward each week.

Due south, well to Antares' left, another sky landmark reaches its height right after dark: Sagittarius. No bright star marks this important group, but eight somewhat lesser stars form a unique pattern: the Sagittarius teapot. The teapot is a little larger than your fist at arm's length. Its triangular spout is on the right and its handle is on the left. It's currently tilted as if pouring.

Just above the teapot's spout is, appropriately, a big puff of steam — the Large Sagittarius Star Cloud, one of the brightest patches of the summer Milky Way.

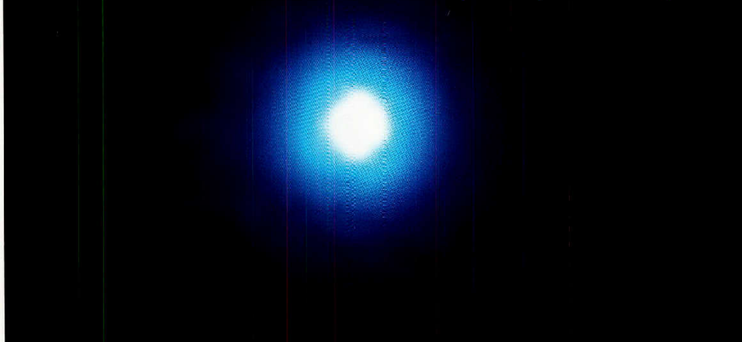
From this spot, if you have a dark enough sky, follow the Milky Way's band of light upward. The first really bright star it leads you to is Altair, high in the southeast. From there, the Milky Way passes just under brilliant Vega, which is high overhead. It continues across and down the sky to the northeast, growing narrower and dimmer, crossing the tilted W of Cassiopeia and finally merging with the patchy stars of the fall-and-winter constellation Perseus, which are beginning to rise out of the north-northeast.

The dawn planet show continues, with Venus performing admirably in its role as the most brilliant "Morning Star." Jupiter and fainter Aldebaran move increasingly high to Venus' upper right. Far below them, Mercury is sinking back to the sunrise horizon, barely to the left of where Jupiter and Venus point. Don't confuse Mercury with twinkly Procyon, which is more directly below Venus or, late in the month, to Venus' lower right.

And of course, don't fail to admire Orion striding up below Jupiter in early dawn.

Alan MacRobert is a senior editor of Sky & Telescope *in Cambridge, Massachusetts.*

The dusty disk surrounding Vega shows up well in infrared light in this view from Spitzer Space Telescope.



NASA/JPL-CALTECH/K. SU (UNIVERSITY OF ARIZONA)

The Star of Summer

In late summer, one of the brightest stars in the sky lords high overhead as darkness falls. Vega, the "summer star," is the leading light of Lyra, the harp, and the brightest member of the Summer Triangle (see skymaps on pages 12 and 13). It's the third-brightest star visible from most of the U.S., and at just 25 light-years away, a near neighbor of the Sun.

Hotter and brighter than the Sun, Vega is also heavier and is burning through its store of hydrogen faster. Though the Sun is billions of years older than Vega, its younger neighbor will die first.

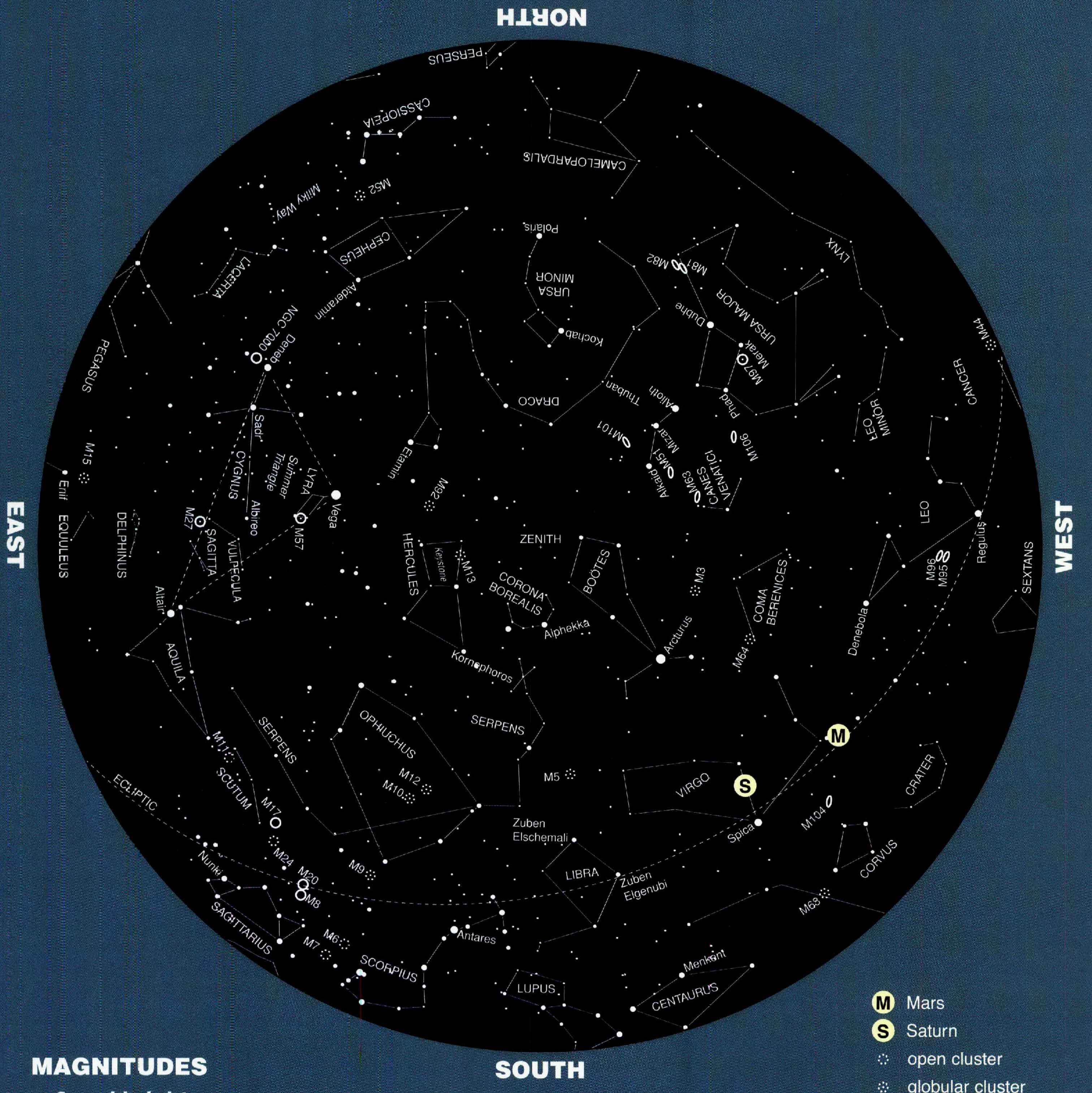
For decades, astronomers have known that a dust disk surrounds Vega, the kind from which planets are made. Vega's disk is lumpy and irregular, a shape possibly carved out by the gravity of unseen planets.

In the book (and movie) *Contact*, astronomers detect a signal sent from a civilization on a planet orbiting Vega. In reality, at 350 million years Vega probably isn't old enough for life to have arisen. And at thousands of degrees hotter than the Sun, it would be unfriendly to life as we know it.

JULY

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

June 20	**11 p.m.**
July 5	**10 p.m.**
July 20	**9 p.m.**



- **M** Mars
- **S** Saturn
- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy

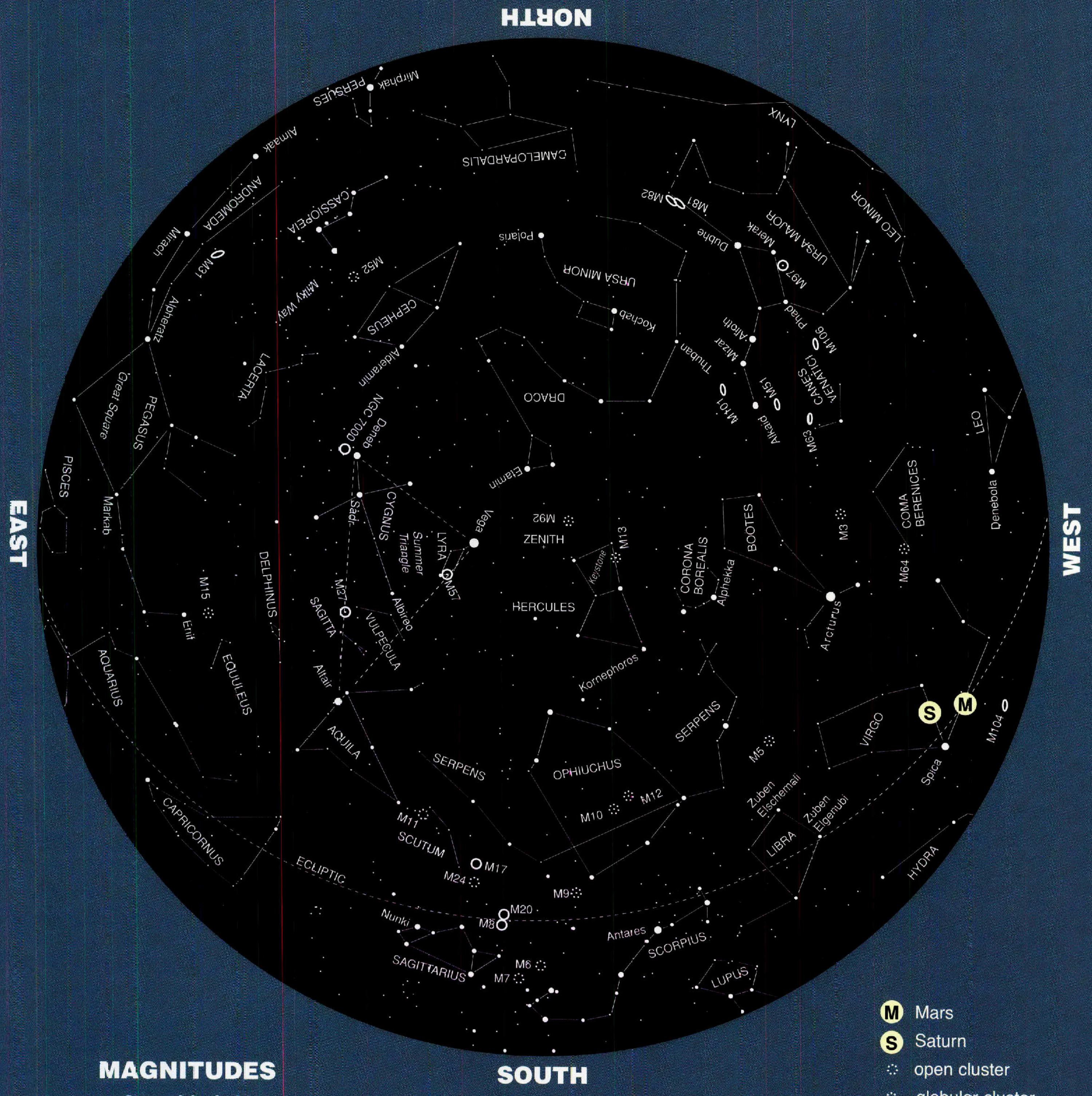
MAGNITUDES

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

AUGUST

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

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



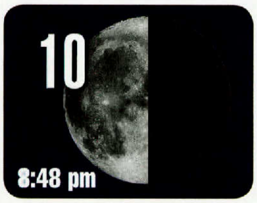
MAGNITUDES
- 0 and brighter
- 1
- 2
- 3
- 4 and fainter

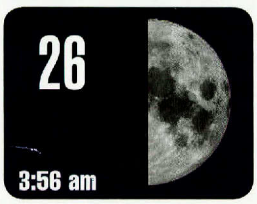
- M Mars
- S Saturn
- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy

SKY HIGHLIGHTS

by Damond Benningfield

JULY





Moon phase times are for the Central Time Zone.

1 The planet Mercury stands farthest from the Sun for its current evening appearance. It is low in the west at nightfall, with the true star Regulus to its upper left. Although Mercury looks like a bright star, it is so low in the sky that you need a clear horizon to see it, and binoculars will help you pluck it from the early evening twilight.

4 Earth is at aphelion, its farthest point from the Sun for the year, about 1.5 million miles (2.4 million km) farther than the average distance of 93 million miles (150 million km). We receive slightly less solar energy at this time of year, but Earth's oceans and atmosphere efficiently distribute heat around the globe, keeping temperatures in balance year 'round.

9 Aldebaran, the brightest star of Taurus, stands less than a degree to the lower right of brilliant Venus in the dawn sky. Jupiter looms above them.

12 Venus is at its brightest for its current "morning-star" appearance.

14/15 The crescent Moon teams up with Venus, Jupiter, and Aldebaran in the dawn sky.

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				

24/25 The Moon passes by two planets and a bright star in the western evening sky. On the 24th, Mars is to the upper right of the Moon with Spica and Saturn to the upper left. Spica is lower in the sky than Saturn. On the 25th, the Moon is to the left of the trio of bright pinpoints.

27/28 Antares, the bright orange "heart" of Scorpius, stands to the lower left of the Moon at nightfall on the 27th, and closer to the lower right of the Moon on the 28th. The scorpion's body and stinger curve to the lower left of Antares.

AUGUST

2 Aldebaran, the eye of Taurus, the bull, snuggles close to the lower right of the brilliant planet Jupiter at first light.

11 Jupiter stands close to the lower left of the Moon at first light today, with Aldebaran farther to the lower right of the Moon.

11 The Perseid meteor shower peaks tonight. At its best, under dark skies, you might see a score or so "shooting stars" per hour.

13 Venus, the brilliant "morning star," stands just a few degrees below the crescent Moon at first light. The bright orange star to their right is Betelgeuse, at the shoulder of Orion, the hunter. Venus is nearing its highest point for its current morning appearance.

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	

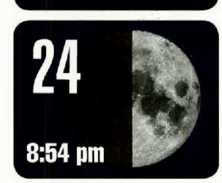
13/14 Mars shoots the narrow gap between the planet Saturn and the star Spica, low in the west-southwest. From bottom to top, they line up Spica-Mars-Saturn. Spica shines white or blue-white, Mars is orange, and Saturn looks golden.

15 The planet Mercury is to the lower left of the Moon during early morning twilight and looks like a fairly bright star.

21 The Moon teams up with the tight bunching of Mars, Saturn, and Spica. Spica is close to the upper right of the Moon, with Saturn above Spica and Mars to the upper left of the Moon.

24 Antares, the heart of Scorpius, is just below the Moon at nightfall.

31 The Moon is full tonight. It is the second full Moon of the calendar month, making it a "blue" Moon.



AstroMiscellany

FINAL FLIGHTS

NASA's four remaining space shuttles are beginning their final missions, as displays at three museums on the East Coast and one in California. Two are available for public viewing this summer, with the other two scheduled to go on display by year's end.

Discovery

APRIL 18

Kennedy Space Center to Washington, DC

Discovery, which flew 39 missions, is on display now at the National Air & Space Museum's Steven F. Udvar-Hazy Center at Dulles International Airport. Admission is free. The center is open daily, 10 a.m.-7:30 p.m. through September 3.

airandspace.si.edu/collections/discovery

Enterprise

APRIL 27

Washington, DC to New York

Enterprise, which flew several test flights from the back of a Boeing 747 but never went into space, will go on display July 19 at the Intrepid Sea, Air & Space Museum. Ticket prices vary. The museum opens at 10 a.m. daily.

www.intrepidmuseum.org/shuttle

Endeavour

SEPTEMBER

Kennedy Space Center to Los Angeles

Endeavour will make the final ferry flight of any shuttle when it jets to California in September, where it will go on display at the California Science Center. Admission will be free.

www.californiasciencecenter.org

Atlantis

NOVEMBER

Kennedy Space Center

A new $100 million exhibit featuring Atlantis, which flew the shuttle fleet's final flight, will open at the Kennedy Space Center next summer. Admission fees vary.

www.kennedyspacecenter.com

NASA (4)

Targeting Asteroids for the Pros

NASA is looking for a few good amateur astronomers to find and study near-Earth objects (NEOs). The "Target Asteroids!" project will support scientists working toward the 2016 launch of the probe OSIRIS-Rex on a sample-return mission to an asteroid.

Amateur astronomers will use their telescopes to note the position, motion, rotation, and light-output of NEOs to help the pros get a better idea of the overall NEO population. The hope is that by the time OSIRIS-Rex reaches asteroid 1999 RQ36 in 2019, the mounds of data gathered by amateurs will help the professional astronomers better understand what they find.

OSIRIS-Rex will map the asteroid and study its chemical makeup. The probe should return at least two ounces of asteroid material to Earth in 2023.

osiris-rex.lpl.arizona.edu/targetasteroids

Cosmic Cartography

Though today's skymaps are more practical, the beautiful celestial maps of past centures are worth a look

THE SETUP

European star and constellation maps were elaborate and varied widely in content and design. Nick Kanas explains that each reflects the cosmological beliefs and accepted constellations of its time, so that these maps are not only scientific, but also bearers of cultural cues from history.

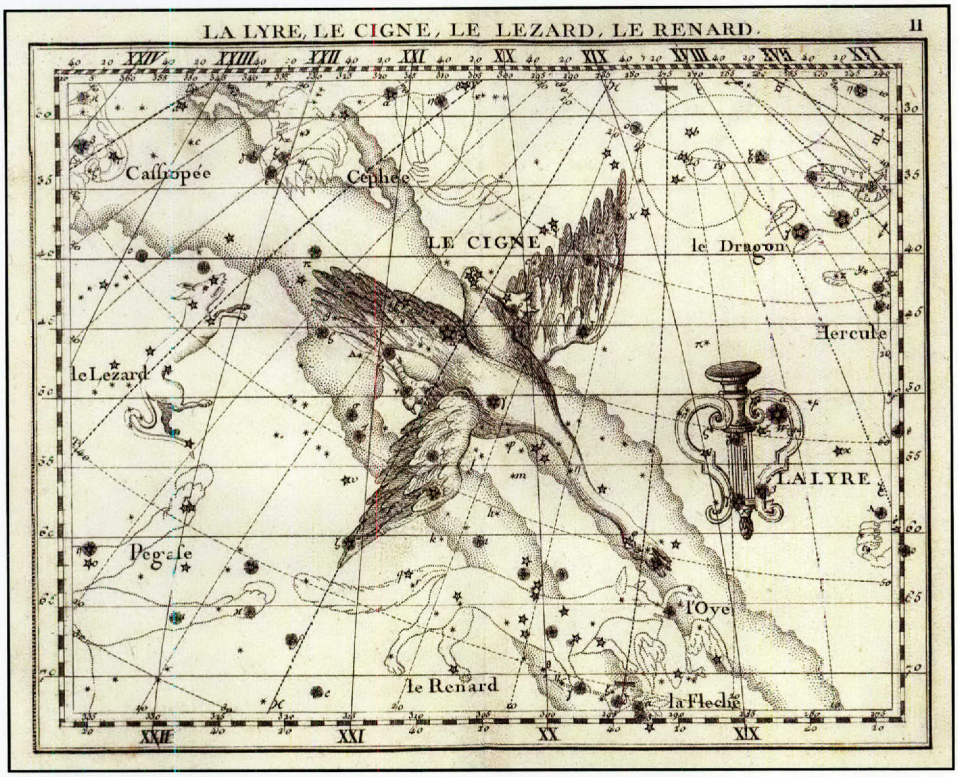
THE EXCERPT

From 1600 to 1800, a number of beautiful star atlases were printed that depicted the constellations according to ancient myths and tales. In Europe, where the quality of celestial atlases was unmatched, classical Greek traditions prevailed, and the constellations were given allegorical visual representations that consisted of heroes and heroines, real and imaginary animals, scientific instruments, and artistic tools. These images were placed in celestial coordinate systems that allowed the positions of the stars to be mapped in the sky and formed the backdrop for predictions of the location of the planets and other heavenly bodies throughout the year. But there was a second kind of image that was found in these celestial atlases as well. These images consisted of diagrams of heavenly bodies or of the entire solar system that reflected both contemporary and ancient cosmological systems. The components of these systems were shown with reference to each other in the sky and in some cases to the background stars. Let's look at these two types of star map in more detail.

An example of a constellation type of star map is shown [at the top of page 17]. This plate is from a celestial atlas first published by Fortin in 1776 and shows the sky around the central constellation of Cygnus the swan. ... Further perusal of this plate reveals that the names of the constellations are in the French language, indicative of the French origins of the atlas from which the plate comes. According to the title, four constellations are featured: la Lyre (Lyra the lyre), le Cygne (Cygnus the swan), le Lezard (Lacerta the lizard, looking here more mammalian that reptilian), and le Renard (Vulpecula the fox). Clenched in the jaws of Vulpecula is a separate constellation, l'Oye (Anser the goose). Lyra and Cygnus are among the 48 traditional constellations that have been with us for some 2,000 years, since ancient Greek times. In contrast, Lacerta and Vulpecula are "new" constellations that were introduced by the famous Polish astronomer Johannes Hevelius in 1687. Although these two constellations are still with us today, Anser is not, being a victim of the actions of the International Astronomical Union in 1922 when it purged the sky of many constellations in an effort to standardize their number and to discourage the actions of astronomers eager to honor patrons or celebrate events by inventing constellations for their star atlases (the I.A.U. settled on 88 constellations, which are now considered official). So, throughout history, constellations have come and gone, and what one sees in a given star atlas reflects what was current in the mind of its creator.

But [this map] shows more than constellations. Note the presence of two grid-like coordinate patterns, one using dotted lines and one solid lines. The first was based on an imaginary line in the sky representing the path of the Sun called the ecliptic. The second was based on an imaginary line in the sky that was a projection of the Earth's equator called the celestial equator. ... These two systems allowed any object in the sky to be "mapped" according to the coordinate system being used. This was a major advance over pre-Renaissance systems, where the location of heavenly bodies was in reference to their location in a constellation (e.g., "the star at the end of the right foreleg" or "the planet at the tip of the tail").

Plates such as this one were often used to accompany a star catalog, which gave detailed information

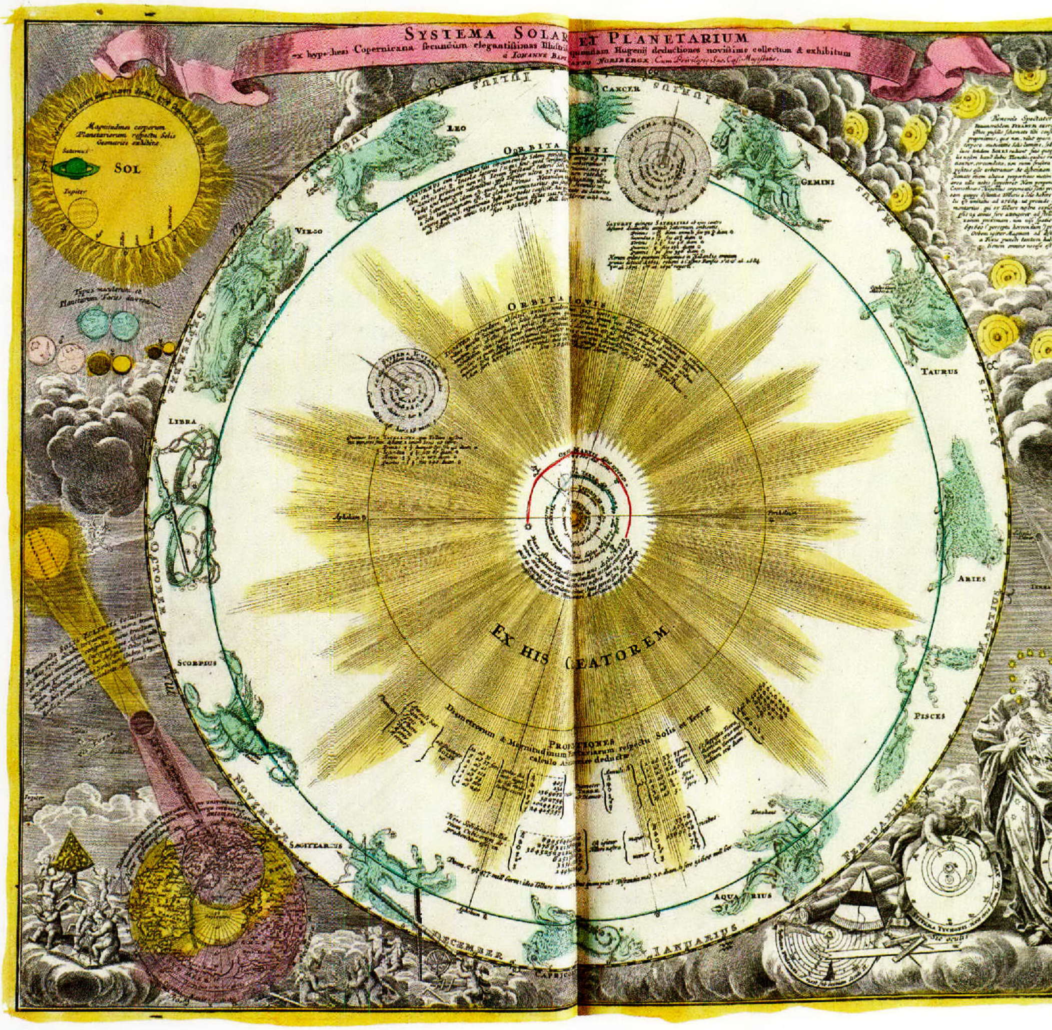


about stars such as their location in the sky, brightness (or magnitude), etc. Some of this information could be incorporated in the constellation map. For example, note that according to the scale at the bottom, Vega is a magnitude 1 star since it is indicated on the plate by a large gold symbol. In contrast, the star near the tip of Lacerta's nose is much dimmer at magnitude 5. Also shown in the plate are the locations of various nebulae, the supernova of 1670 (near Vulpecula's upraised ear), and the cloud-like Milky Way running diagonally from upper left to lower right.

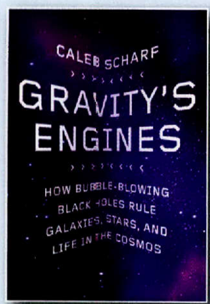
A particularly rich example of a cosmological star map is shown [at right], which was produced by Johann Doppelmayr and appeared in an atlas from the famous Homann publishing house around 1720. In a sense, this beautiful plate depicts the state of astronomical knowledge in the early 1700s. In the center is a spectacular representation of the Sun-centered heliocentric world introduced by the great Polish astronomer, Nicholas Copernicus (1473–1543 A.D.). The view here includes descriptions from the Dutch astronomer Christiaan Huygens (1629–1695 A.D.), complete with sunburst and showing the orbits of the planets and their moons revolving concentrically around the Sun. Throughout, there is written and numerical information on the proportionate diameters of the planets, and the rest of the universe surrounding our solar system is shown in the form of the twelve constellations of the zodiac.

In the upper left corner, we see representations of the then-known planets along with the Sun. There is an attempt to show these heavenly objects to scale in terms of diameter, and some surface features are indicated on some of the planets. In the upper right corner, we see heavenly clouds and diagrams of other solar systems that were thought to exist around the stars. In the lower left corner we see a depiction of the solar eclipse of May 12, 1706. On the miniature map of the Earth, the state of California was represented as an island, which was thought to be the case throughout much of the 17th Century and early 18th Century.

In the lower right corner below the illustration of a lunar eclipse, we see



Even More Books!



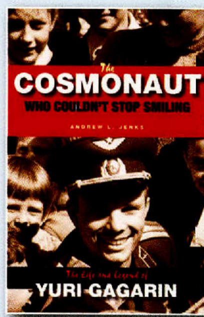
Gravity's Engines

How Bubble-Blowing Black Holes Rule Galaxies, Stars, and Life in the Cosmos

By Caleb Scharf

Farrar, Straus and Giroux; available August 7; $26

Black holes are not just engines of destruction — they also play a key role in the creation of stars and galaxies. A black hole's gravity pulls in great quantities of gas and dust, which form dense clouds that collapse to form stars. Later, though, the radiation from superhot gas falling into the black hole blows away the remaining clouds, shutting down starbirth. Author Caleb Scharf, director of Columbia University's Astrobiology Center, details this process and explains much more about the role of black holes in shaping the universe and life itself.



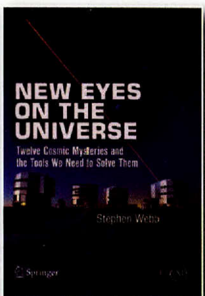
The Cosmonaut Who Couldn't Stop Smiling

The Life and Legend of Yuri Gagarin

By Andrew L. Jenks

Northern Illinois University Press; 2012; $35

April 2011 marked half a century since Yuri Gagarin's landmark flight into space aboard Vostok 1. Since then, his name and life story have become legend in post-Soviet Russia and around the world. This new biography by history professor Andrew Jenks of Cal State Long Beach seeks to tell the real story of Gagarin's life (and tragic death), simultaneously exploring how the popular tales that grew up around Gagarin say more about the Russian culture and how it has changed over time than about the first cosmonaut himself.



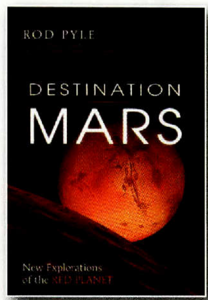
New Eyes on the Universe

Twelve Cosmic Mysteries and the Tools We Need to Solve Them

By Stephen Webb

Springer Praxis; available July 1; $39.95

Physicist Stephen Webb's third book details the biggest challenges facing astronomers today, from "catching" gravitational waves and understanding the nature of dark energy to finding more planets and listening for ET. He explains that the tools scientists need to probe a dozen of today's thorniest cosmic mysteries are not always the traditional reflecting telescopes with which we are familiar. The book also contains extensive glossaries of astronomy terms and science projects from around the world.



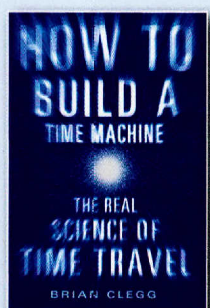
Destination Mars

New Explorations of the Red Planet

By Rod Pyle

Prometheus Books; 2012; $19

If you're looking for a complete overview of mankind's exploration of the Red Planet, this is it. From the Mariner fly-bys of the 1960s, to the Viking landers of the 1970s, straight through to the rovers and orbiters of today, Rod Pyle interviews the scientists from NASA centers and universities across the country who made these missions happen (or not — he also details the failures). Through exploration of the missions, and the culture in which they took place, he brings into sharp focus his thesis that science is an intensely human endeavor.



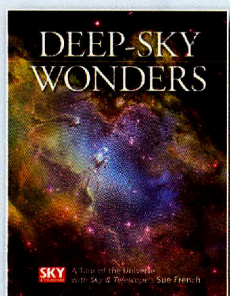
How to Build a Time Machine

The Real Science of Time Travel

By Brian Clegg

St. Martin's Press; 2011; $25.99

There's no physical law that prevents time travel, according to Brian Clegg. He explores the nature of time and how scientists might go about manipulating it. The book discusses faster-than-light travel, wormholes, neutron stars, quantum physics, and time paradoxes. Along the way, Clegg explains what separates science fiction from the possible science fact, showing what fiction authors (and movie and television makers) of the past got wrong about time travel — and what they got right.



Deep-Sky Wonders

By Sue French

Firefly Books Ltd.; 2011; $39.95

This hefty volume offers detailed tours of the night sky by season and area of the sky, illustrated with detailed charts and beautiful images from ground- and space-based telescopes. Although the book is aimed at those who use a telescope, many of the charts provide an overview of what's visible to the naked eye and the text describes objects that are wonderful to ponder whether you can see them or not. Combined with the images, they make the book a good guide to the night sky for just about any level of expertise.

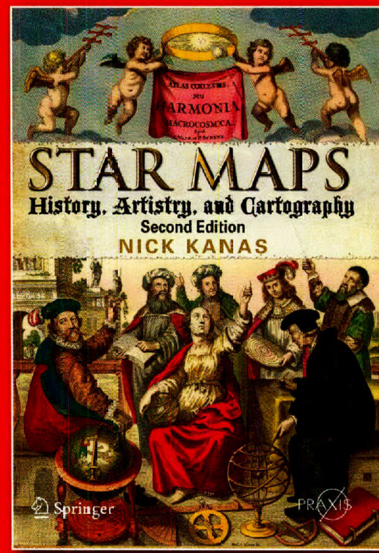
representations of three cosmological systems that are being introduced to us by Urania, the goddess of astronomy. Going left to right, we first see the system of the ancient Greek astronomer, Claudius Ptolemy (ca. 100–ca. 178 A.D.), which is partially obliterated by contemporary astronomical instruments (allegorically implying that modern science has dispatched this view). In this system, the Earth is in the center, followed by the orbits of our Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the fixed stars. A hybrid system developed by the Danish astronomer Tycho Brahe (1546–1601 A.D.) is next. In this model, the Earth is in the center and is orbited by the Moon and the Sun. However, Mercury, Venus, Mars, Jupiter, and Saturn orbit the Sun, whereas the fixed stars continue to surround the central Earth. The final model is labeled sic ratione (i.e., according to reason) and is the Copernican system. This labeling and the central dominance of Copernicus' ideas in this print clearly indicate the opinions of Doppelmayr and Homann, even though alternative models are included in the corner for historical purposes.

Images such as these were found in atlases devoted exclusively to the heavens. But celestial images also found their way into geographical atlases, which often included a plate or two of the constellations or of the solar system to accompany the terrestrial maps that were the focus of the book. This led credence to the notion that these celestial representations were a type of map. This notion was supported by the fact that celestial globes depicting the constellations had been known since classical Greek times, and beginning with the Renaissance, celestial globes often were paired with terrestrial globes for sale to people interested in geography and exploration. More recently, celestial images have been included in standard texts of cartography.

But is it accurate to call these celestial representations maps, or is the juxtaposition of celestial images with terrestrial images simply "guilt by association"? To gain some perspective on this question, let's consider one definition of a map: "A (flat) representation of the earth's surface or a part of it, showing physical, geographical, or political features ... a similar representation of the sky showing the relative positions of stars etc., or of the surface of a planet etc . . . A diagram representing the spatial distribution of anything or the relative positions of its components ...". Professor Norman Thrower, the distinguished geographer from the University of California, Los Angeles, further characterizes maps as follows: "Viewed in its development through time, the map details the changing thought of the human race, and few works seem to be such an excellent indicator of culture and civilization." For example, in terrestrial maps, different countries appear and disappear over time depending on politics and world events. From the above quotes, it would seem that to be called a map a celestial image needs to illustrate the physical location of something in space, to accurately show the relative position of its components, and to reflect the assumptions and ideas of the times. How well do celestial maps do this?

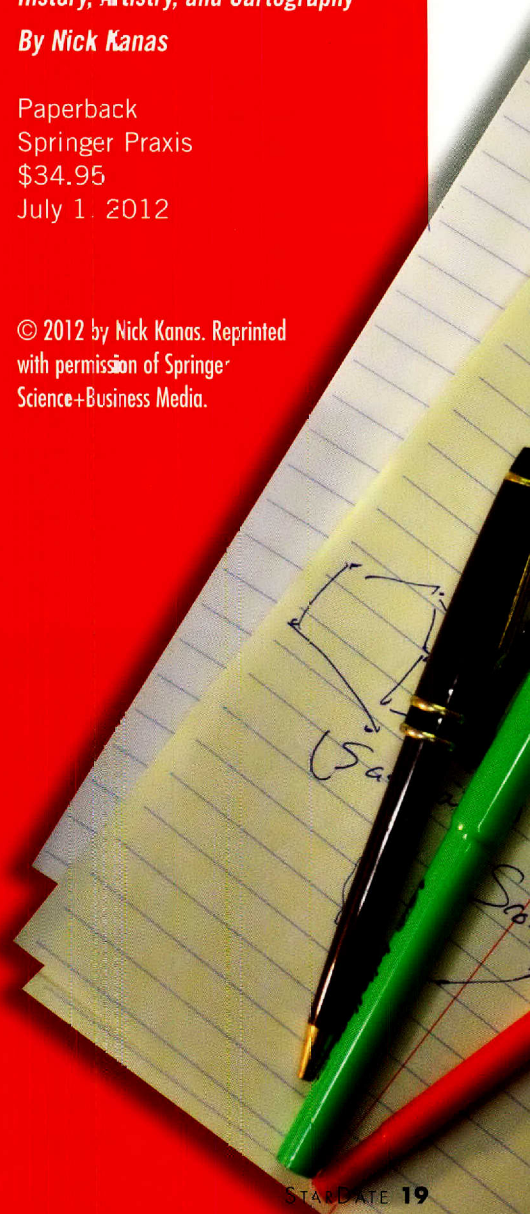
Based on the examples shown above, pretty well. The images give us information regarding the location of heavenly bodies and the relative position of their component parts. The stars and constellations are accurately plotted in a coordinate system referenced to the ecliptic or celestial equator. The surfaces of heavenly bodies such as the planets may be represented by showing important physical features. Finally, the images reflect the state of knowledge and the politics of the times in which they were created. Thus, star maps such as these meet the essential criteria of being true maps, albeit maps that are truly out of this world.

THE BOOK



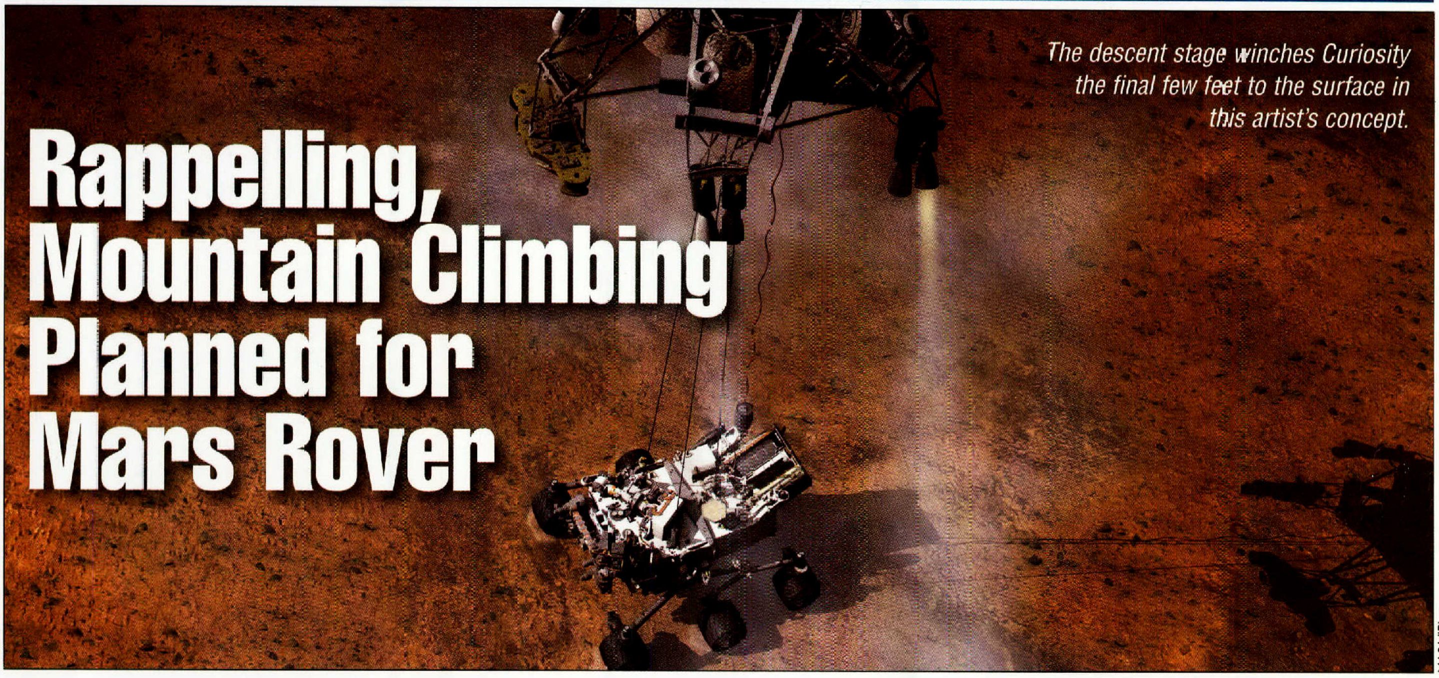
Star Maps
History, Artistry, and Cartography
By Nick Kanas

Paperback
Springer Praxis
$34.95
July 1, 2012



by Rebecca Johnson and Damond Benningfield

Rappelling, Mountain Climbing Planned for Mars Rover



The descent stage winches Curiosity the final few feet to the surface in this artist's concept.

NASA/JPL

The plan for landing the Curiosity rover on Mars sounds like something from an episode of "Mythbusters": Use a heat shield, a parachute, retrorockets, and a "sky crane" — a hovering platform that will winch the one-ton rover the final few feet to its destination. Oh, and you've got seven minutes for the entire sequence.

If it all works as planned, Curiosity will touch down on the night of August 5 in Gale Crater, a basin with a mountain towering three miles above its center. The crater shows evidence that it once contained liquid water. That earlier epoch should be recorded in rock layers at the base of the mountain.

During its one Mars-year (23 Earth-month) primary mission, the nuclear-powered rover, which is the size of a minivan, will probe the mountain and sediments in the surrounding crater for evidence of ancient water. Its measurements will help scientists determine whether the region was habitable in the distant past.

Curiosity's arsenal of instruments includes a microscope, a laser for vaporizing the surfaces of rocks to measure their composition, and on-board chemical laboratories to look for signs of carbon-based elements and other compounds needed to support life.

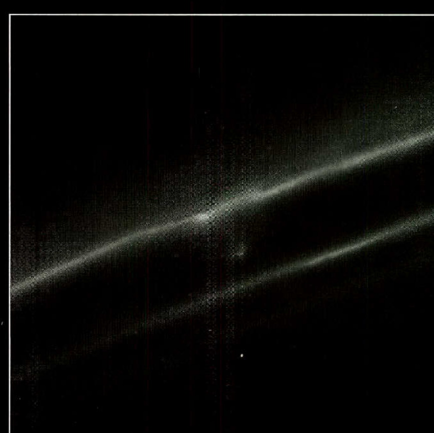
Its science mission depends on a successful landing, which is the most complicated of any Mars rover to date. A precisely controlled entry into the Martian atmosphere is expected to place Curiosity inside an elliptical target area just 12 miles (20 km) long, which is smaller than the landing zones for earlier rovers.

Previous rovers have used airbags to cushion their final drop onto the surface, but Curiosity is too heavy for that technique. Instead, a rocket-powered descent stage will hover just 65 feet (20 meters) above the surface and use the sky crane to winch the rover down, providing a touchdown speed of just 1.7 miles per hour (0.8 meters per second). The descent stage will then boost itself to a safe distance before crashing to the surface. **DB**

Saturn Snippets

Saturn's moon Phoebe wasn't always a moon. Scientists say that images from the Cassini orbiter reveal it was a planet-to-be, or planetesimal, that never fully formed. They also suggest Phoebe was born as a round, hot object beyond Neptune, in the vast Kuiper Belt. Heavy matter sank to its center, giving it the internal strata of a planet. Later collisions produced its current irregular shape. With about the same density as Pluto, Phoebe was probably ejected out of the Kuiper Belt and trapped by Saturn's gravity. It orbits in the opposite direction of Saturn's dozens of other moons.

Cassini astronomers have discovered the debris trails of about 500 one-mile-wide boulders passing through Saturn's F ring (see photo, right). Scientists call the trails "mini-jets." Saturn's moon Prometheus, at about 100 miles wide, was already a major culprit for creating chaos in the structure of the F ring. Studies of the changing structure of Saturn's rings should help astronomers better understand how planet-forming disks evolve around other stars, said Cassini project scientist Linda Spiker of NASA's Jet Propulsion Laboratory.



NASA/JPL-CALTECH/SSI/QMUL

A false-color Dawn image shows 'the snowman,' a set of three overlapping craters on Vesta.

NASA/JPL/UCLA/MPS/DLR/IDA

Bon Voyage!

Asteroid orbiter ready to depart Vesta, head toward Ceres

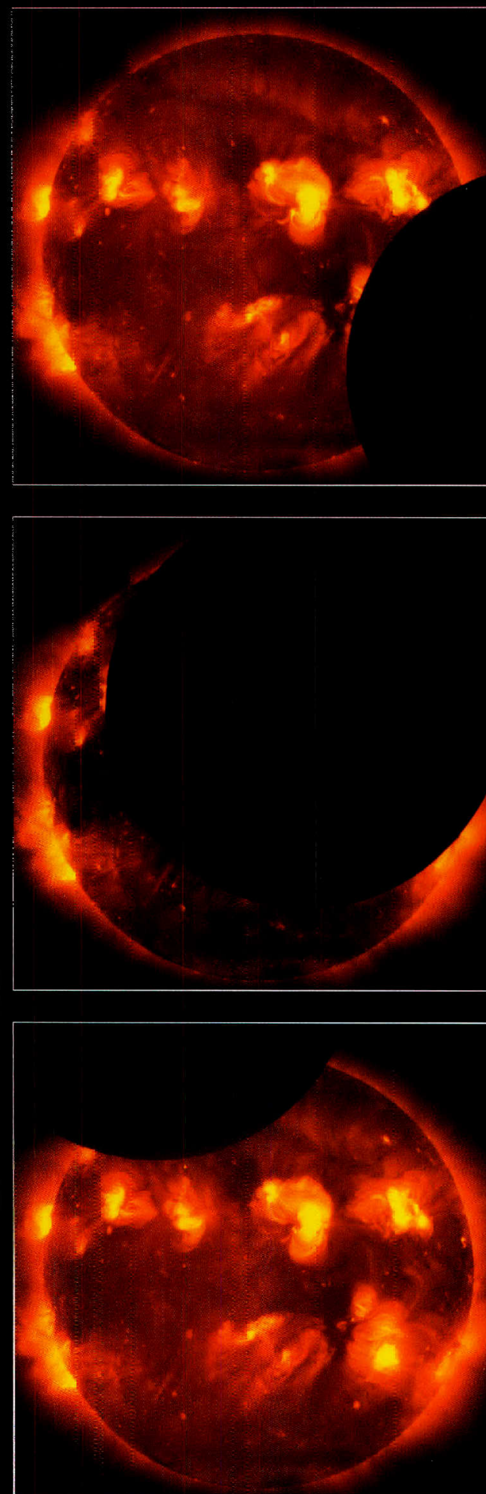
After spending 13 months studying Vesta, the Dawn spacecraft will bid the asteroid belt's second-heaviest member adieu on August 26 and begin a lengthy journey to Ceres, the belt's largest member.

Dawn found that Vesta is more like a mini-planet than an asteroid, with a layered structure similar to that of Mercury, Mars, and the Moon. It has an iron core that is about 140 miles (220 km) in diameter, surrounded by a mantle of silicon-rich minerals and topped by a crust of lighter volcanic materials. The layered structure tells planetary scientists that Vesta completely melted when it was young, allowing heavier elements to sink to the middle and lighter ones to float to the surface, which also happened to Earth and the other rocky inner planets.

The asteroid's composition revealed that it formed before the inner planets — about two million years after the first small solid chunks of matter coalesced, according to Carol Raymond, the mission's deputy principal investigator. "Vesta is the only intact layerered building block surviving from the very earliest days of the solar system," she said in a May 10 press briefing. "Vesta is special because it survived the intense collisional environment of the main asteroid belt for billions of years, allowing us to interrogate a key witness to the events at the very beginning of the solar system. We believe that Vesta is the only intact member of a family of similar bodies that has since perished."

Dawn's observations also confirmed that a class of meteorites on Earth are chips of Vesta. The meteorites, which account for about six percent of all meteorites, match the mineral and chemical composition of the rocks on part of Vesta's surface, which has undergone an almost continual bombardment by other space rocks throughout its 4.56-billion-year history. Some of those impacts blasted out the fragments that fell to Earth as meteorites.

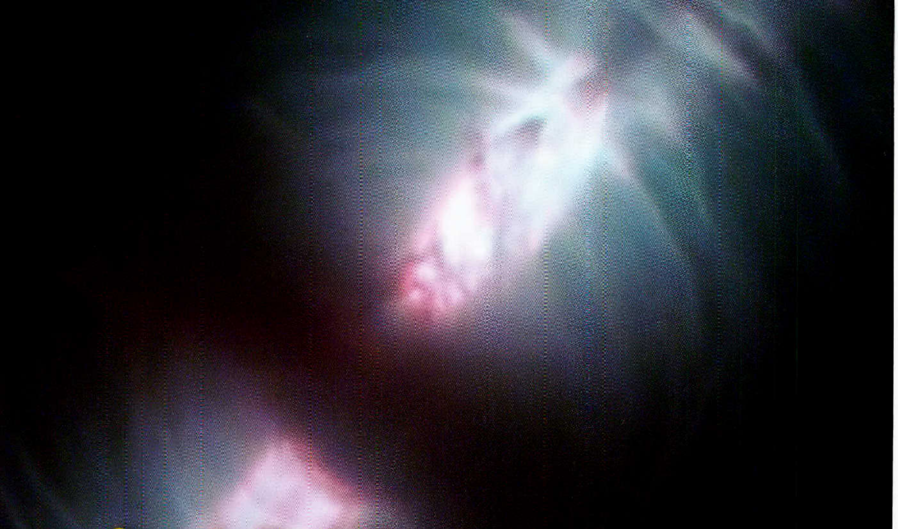
Vesta is the second most-massive asteroid in the main belt between Mars and Jupiter, and, at about 326 miles (525 km) in diameter, is either the second- or third-largest (the size of the asteroid Pallas is uncertain). Dawn's ion engines will propel the craft to a rendezvous with Ceres, the largest and most-massive asteroid, in February 2015. **DB**



JAXA/HINODE (3)

Solar Intruder

Japan's Hinode Sun-watching satellite recorded these views of the May 20 solar eclipse. The sequence goes from early eclipse at top, to maximum eclipse at center, to late eclipse at bottom. The spacecraft views wavelengths that are invisible to the eye, producing detailed views of sunspots (the bright spots on these images) and other features.



ESA/HUBBLE, NASA

Cosmic Egg's Beauty Rivals Faberge

This Hubble Space Telescope view of the Egg Nebula shows a brief period in the lives of stars like the Sun. Such objects are called planetary nebulae, because when the first were discovered centuries ago, astronomers thought they looked like planets. In reality, the object is a dying star. After burning though all of its nuclear fuel, a star of about the Sun's mass begins to puff off layers of gas into space, creating a beautiful cocoon around itself. In the case of the Egg, four jets shooting from its dark heart fuel suspicions that a binary star lies inside, with each star giving off jets at its poles. Once the outer cocoon of gas dissipates, the star or stars within will grow dimmer with time, cooling over the coming eons.

Fast Punches Scar Moon's Surface

A rearrangement in the distances of the giant outer planets from the Sun may have triggered a rearrangement in the face of the Moon, according to a recent study by researchers at the NASA Lunar Science Institute.

The researchers used observations from a laser altimeter aboard Lunar Reconnaissance Orbiter to measure the contours of 4-billion-year-old craters around the Nectaris Basin, a large volcanic plain.

The observations suggest the craters were formed by asteroids that were moving much fastern than those that created older or younger craters, which in turn suggests that the Moon (as well as Earth) underwent an unusually heavy bombardment about four billion years ago.

The bombardment may have been triggered by changes in the orbits of the giant planets Jupiter and Saturn. As their distance from the Sun changed, the gravity of the two planets — particularly Jupiter — kicked a group of large asteroids toward the inner solar system. Some of the asteroids then splatted into the surfaces of the Moon and Earth, creating new craters and blasting debris across both worlds. Wind, rain, and the motions of the crust have erased any traces of this bombardment on Earth, but it is preserved in the lunar craters.

What we Know About Fomalhaut

Half-finished telescope array probes planets orbiting nearby star

Astronomers using the half-completed Atacama Large Millimeter/Submillimeter Array (ALMA) in the Chilean desert say a pair of planets orbiting the nearby bright star Fomalhaut must be a tad larger than Mars, or perhaps up to a few times the size of Earth — much smaller than previous estimates.

These early-science observations used just a quarter of the array's planned 66 antennas. "This is just the beginning of an exciting new era in the study of discs and planet formation around other stars," said ALMA team member Bill Dent of the European Southern Observatory (ESO).

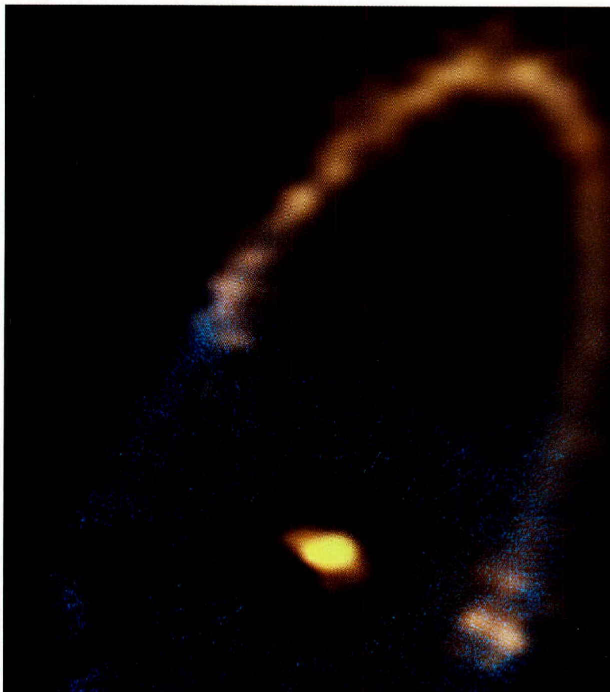
Aaron Boley of the University of Florida observed the cool, dusty disk surrounding Fomalhaut, which radiates light in the millimeter wavelengths the telescope can "see." The observations show that both the inner and outer edges of this dust disk are sharply defined.

This suggests that the disk is defined by the gravity of a pair of planets — one orbiting the star interior to the dust ring and the other exterior. Each planet shepherds the ring particles just as the "shepherd moons" of Saturn corral the particles that make up that planet's numerous rings.

"Combining ALMA observations of the ring's shape with computer models, we can place very tight limits on the mass and orbit of any planet near the ring," Boley said. "The masses of these planets must be small; otherwise the planets would destroy the ring."

Additionally, "the ring is even more narrow and thinner than previously thought," said team member Matthew Payne, also of the University of Florida. The team found that the ring is about 16 times wider than the Earth-Sun distance, and is seven times wider than it is thick.

ALMA should be completed next year. **RJ**



This combined image shows ALMA's millimeter-wave view of the disk around Fomalhaut (yellow), and an earlier visible-light view from Hubble Space Telescope (blue).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Vigorous star factories glow orange in this composite image of the region around Messier 78, a vast stellar nursery near Orion's Belt. A new telescope in Chile, which detects energy at submillimeter wavelengths, imaged the dense regions where new stars are born, which are overlaid on a view of the nebula in optical wavelengths. To the eye alone, the star-forming regions look black, because they contain dust that absorbs visible light. But the compressed gas and dust inside the clumps produce infrared energy that penetrates the nebula.

ESO/APEX (MPIfR/ESO/OSO)/T.STANKE ET AL./IGOR CHEKALIN/DIGITIZED SKY SURVEY 2