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OUR GOLDEN ANNIVERSARY YEAR

JANUARY/FEBRUARY 2023 $6

SKY ALMANAC 2023

THE UNIVERSITY OF TEXAS AT AUSTIN McDONALD OBSERVATORY

StarDate

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Features

Departments

On the Cover

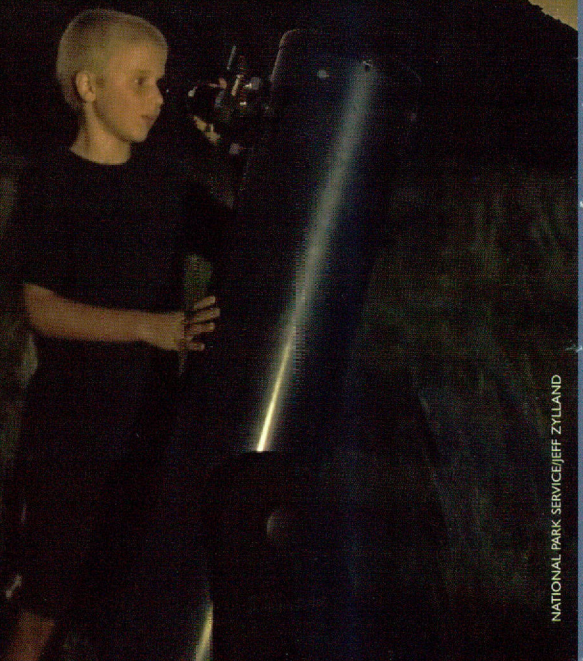
An array of covers from 1973 to 2023 highlights 50 years of StarDate.

This Page

A boy peers at the night sky from Theodore Roosevelt National Park.

Coming Up in March/April

We'll face cosmic gales in our next issue, and tell you how scientists are preserving the observations of decades-old space missions.



NATIONAL PARK SERVICE/JEFF ZYLLAND

GOLDEN YEARS

In the summer of 1973, the U.S. Senate was conducting hearings into the Watergate affair, which would lead to the resignation of President Richard Nixon. Arab nations imposed an oil embargo, creating long lines at American gas stations. A dozen eggs cost 45 cents. And there were no Internet, social media, electric cars, celebrity Kardashians, or smartphones; people relied on printed newspapers, face-to-face conversations, and even rotary telephones for information and human contact.

The world's largest telescope was a quarter-century old and still recorded the universe on glass plates. Astronomers had never heard of dark energy, had only scant evidence of black holes, and had discovered exactly zero planets beyond our own solar system. NASA had just wrapped up its final Apollo missions to the Moon, and it launched a second crew to the Skylab space station in July.

The first Mars orbiter, Mariner 9, had completed its mission less than a year earlier. Its accomplishments were among the items recorded in a new skywatching newsletter from McDonald Observatory, which published its first issue in July. The nameless newsletter was two pages long and told readers how to find the bright planets and follow the phases of the Moon.

The newsletter soon was named *McDonald Observatory News*, which then became *StarDate*. Over the past half-century, we've reported on many remarkable advances in astronomy. Today, for example, astronomers know that about 96 percent of the universe is missing; they've discovered more than 5,000 exoplanets, which orbit stars other than the Sun; the number of known asteroids has increased from a few thousand to more than one million; and astronomers have even photographed two supermassive black holes.

We catalog some of the highlights of the past 50 years of astronomy in this issue, while telling you about a few of our own. It's been a golden 50 years for both astronomy and *StarDate*, and we can only imagine what we'll be able to tell you when we reach our centennial, in 2073. To the stars!

Text by Damond Benningfield

JANUARY

OVERVIEW

This month is all about the planets. Venus, the Evening Star, climbs higher into the sky night by night. It passes Saturn, which is headed in the opposite direction, late in the month. Jupiter is high and bright during the evening, outshining every other pinpoint of light except Venus. After its spectacular opposition in December, Mars remains a bright orange beacon that's visible most of the night. Finally, little Mercury puts in a decent morning appearance in the second half of January.

HIGHLIGHTS

3 Mars stands just above the Moon at nightfall. Aldebaran, the bright eye of Taurus, is farther to the lower right of the Moon.

3 The Quadrantid meteor shower is at its best tonight. Moonlight will overpower all but the brightest meteors, however.

4 Earth is closest to the Sun today for the year, at a distance of 91.4 million miles (147.1 million km).

12 Mars is stationary (see The Basics, page 5).

18 Antares, the bright orange heart of the scorpion, is quite close to the Moon at first light.

19 Mercury stands well to the lower left of the Moon, quite low above the horizon, during dawn twilight.

20-23 Venus, the brilliant Evening Star, passes the fainter planet Saturn. The Moon is below them on the 22nd, then to their upper left on the 23rd.

25 Jupiter, the solar system's largest planet, is the brilliant point of light above the Moon at nightfall.

30 Mercury stands farthest from the Sun for its current morning appearance. It's bright, but it's so low in the morning twilight that you need a clear southeastern horizon to spot it.

FEATURED EVENT

30 The Moon will cover the planet Mars tonight for skywatchers in the southern United States.

31 Mars sits to the upper right of the Moon at nightfall, with Aldebaran, the brightest star of Taurus, a little farther to the right of the Moon.

JANUARY

Su	M	T	W	Th	F	Sa
1	2	3	4	5	6	7
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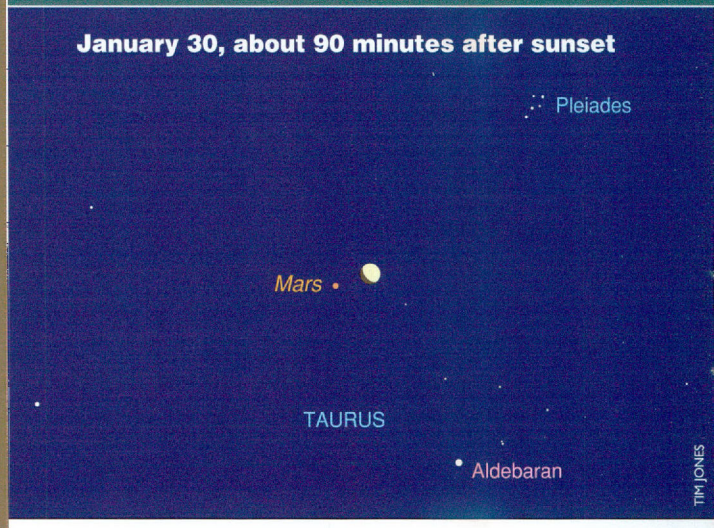
FEATURED EVENT



Hiding the Red Planet

Mars and the Moon will play hide-and-seek for much of 2023. The Moon will pass in front of the Red Planet five times, briefly hiding it from view. And while you don't need tickets to watch these events, you do need the right seat assignments. The first one, on January 3, is visible only from southern Africa and adjacent regions, for example, while the one on February 27 is visible only from north polar regions.

For those with assigned seats in the United States, the best one comes on the night of January 30, when Mars will disappear from Florida across Texas to southern California.

Such an event is known as an occultation, from a Latin word that means "to hide." Occultations are possible because the orbits of both Mars and the Moon lie near the ecliptic, which is the Sun's path across the sky. Both bodies stray from the ecliptic a little, though, so most months the Moon passes within a few degrees of Mars but doesn't cover it up.

Even when the two bodies do align, it's visible from limited regions. In part, that's because an occultation lasts only an hour or two, so for many parts of Earth it happens when Mars and the Moon are below the horizon. The view also is limited by the fact that the Moon is much closer than Mars, so most regions see the Moon pass "above" or "below" Mars—with no occultation at all.

On the night of January 30, though, the geometry will be just right for skywatchers in the southern U.S., Mexico, Central America, and a few Pacific islands. Mars will disappear before midnight and remain out of view for up to a couple of hours.

The rest of the country will still see a beautiful sight. Mars is quite bright after its opposition in early December, so it looks like a brilliant orange star quite near the gibbous Moon throughout the night.

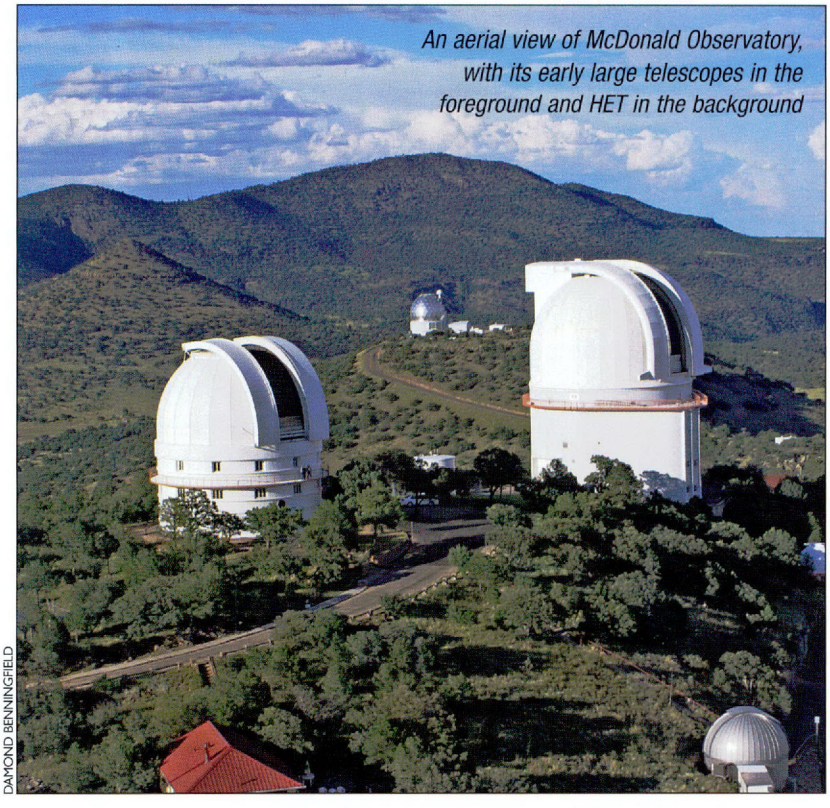
From the Dark Age to Dark Energy

McDonald Observatory had just emerged from its own Dark Age. In the late 1950s and early '60s it suffered through a lack of maintenance and upgrades, so it had fallen behind other observatories. Under the leadership of a new director, Harlan Smith, and with commitments from both the University of Texas and NASA, McDonald upgraded its original 82-inch (2.1-meter) telescope and built a new 107-inch (2.7-meter) one—the third largest in the world at the time.

By 1973, those telescopes, along with a couple of smaller ones, were busy every clear night of the year, observing the universe at a breathtaking pace. Yet much more was to come.

Today, the Observatory is home to many small telescopes that are operated remotely by institutions across the country and the world. Most important, it's home to the Hobby-Eberly Telescope (HET), one of the largest in the world. With an effective size of almost 10 meters (400 inches), it gathers the faint light of galaxies billions of light-years away.

HET was conceived by astronomers at Pennsylvania State University. They approached McDonald Director Frank Bash about placing the telescope at the Observatory, and he enthusiastically agreed. It was dedicated in 1997 and has been upgraded and improved in two major projects. Today, HET is one of the leading tools in the search for dark energy—helping keep McDonald out of the Dark Ages for decades to come.



An aerial view of McDonald Observatory, with its early large telescopes in the foreground and HET in the background

DAMOND BENNINGFIELD

THE BASICS

Standing Still at High Speed

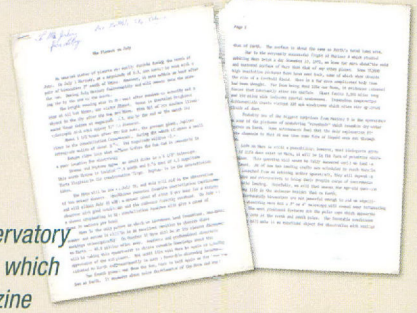
January is a big month for Mars. Not only does the Moon occult it twice (page 4), but the planet switches directions on January 12, when it will appear to stand still against the background of stars.

It's an optical illusion caused by the relative motions of Mars and Earth. Earth is closer to the Sun, so it moves faster. As it starts to catch up to Mars, the planet stops its normal eastward progression, stands still for a while, then begins moving westward. As Earth pulls away from Mars, the process reverses: Mars stands still, then heads eastward again.

To envision how it works, imagine that you're driving down the highway at 70 miles per hour. You pass a car that's creeping along at 55. While you're behind the slowpoke, it appears to move forward against the background of buildings, trees, or mountains. Once you get close enough, though, it looks like it's going backward against that background. It's not, of course, it's just that your perspective has changed. As you leave it behind, it appears to start moving forward again—just like Mars spinning around the Sun.

StarDate 50

The first issue of the precursor of today's *StarDate* was published in July 1973. The two-page newsletter offered skywatching tips (Venus was the Evening Star, two meteor showers were visible late in the month, and Mars was approaching opposition, so it was especially bright). It included news of the recently concluded Mariner 9 mission, which was the first to orbit Mars, and its discoveries of giant volcanoes and canyons on the Red Planet.



The first McDonald Observatory skywatching newsletter, which became StarDate *magazine*

Moon phases are Central Time.

The full Moon of January is known as the Old Moon, Moon After Yule, or Wolf Moon.

APOGEE
January 8

PERIGEE
January 21

FEBRUARY

OVERVIEW

The cold February evenings offer some of the brightest stars in the entire night sky. Sirius, the brightest of them all, climbs across the south, trailing below and behind beautiful Orion. Taurus, the bull, looks down on them. From the southern United States the second-brightest star, Canopus, huddles below Sirius. The brilliant planets Venus and Jupiter creep toward each other throughout the month, and appear to almost touch by the last night of February. Mars continues its fading act; it will shine just half as bright at the end of the month as at the beginning, and will set a good bit earlier.

HIGHLIGHTS

3 Pollux, the brightest star of Gemini, perches close above the Moon at nightfall. Castor, Gemini's other twin, is farther along the same line.

5-6 Regulus, the heart of the lion, stands below/to the upper right of the Moon on these evenings, respectively.

10 Spica, the brightest star of Virgo, stands close to the right of the Moon as they climb into view in late evening. It is to the lower right of the Moon at first light on the 11th.

14 Antares, the bright orange heart of Scorpius, is quite close to the lower left of the Moon at first light. Antares is one of the bigger and brighter stars in our region of the galaxy.

16-17 The Moon glides across the Teapot—the figure formed by eight bright stars in Sagittarius—at dawn on these mornings. The Moon will stand at the intersection of the lid and spout on the 16th, and to the lower left of the handle on the 17th.

FEATURED EVENT

21-23 The Moon sweeps past Venus and Jupiter, forming a brilliant trio in the evening sky.

27 Mars and the Moon barely miss each other tonight. From most of the U.S., bright orange Mars poses quite close to the left of the Moon at nightfall. They'll scoot closer as the evening progresses.

28 Jupiter stands just above Venus in the evening sky. They are the two brightest objects in the night sky after the Moon. They will align side by side on the following night.

FEBRUARY

Su	M	T	W	Th	F	Sa
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26	27	28				

FEATURED EVENT

Brilliant Triumvirate

Venus and Jupiter inch toward each other throughout February, just about catching up on the final night of the month. To make the encounter even more spectacular, the Moon swings past them on the evenings of the 21st through the 23rd—a conjunction of the three brightest objects in the night sky.

Venus is the brighter planet, shining as the Evening Star. It appears so bright because it's close to Earth, it's covered by highly reflective clouds, and it's close to the Sun, so it reflects a lot of sunlight into space.

Thanks to our always-changing viewing angle, the gap between Venus and the Sun will widen over the next few months, so the planet will stand a little higher in the sky each evening until late June. The distance between Venus and Earth will be closing until August, when Venus will pass between us and the Sun.

Jupiter, on the other hand, is dropping toward the Sun, so it will disappear in the evening twilight next month. Jupiter shines brightly because it's the biggest planet in the solar system—roughly 11 times the diameter of Earth—and because it, too, is covered by clouds. Its brightness is limited by its great distance—an average of about 485 million miles (780 million km), which is more than five times Earth's distance from the Sun.

The Moon will sweep up from below the two planets. It will stand a little below Venus at nightfall on the 21st, breathtakingly close to Jupiter on the 22nd, and well to the upper left of the two planets on the 23rd. Venus and Jupiter then head toward an amazing side-by-side appearance on March 1.

Astronomy Goes Digital

Modern observatories are packed with the latest technology. Computers point the telescopes and compile data, CCDs observe the sky, and high-speed lines transmit observations around the world. And in many cases, the telescopes are operated robotically; astronomers submit observing requests, then wait for the computer to make the observations and send them along.

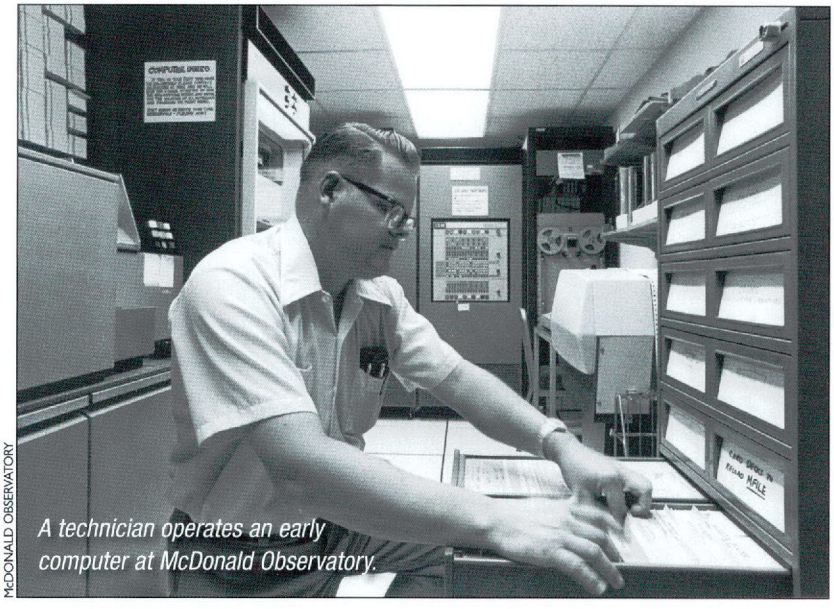
Astronomy has adopted the latest technologies for centuries. For much of its history, the technology moved slowly. In the past half-century, though, that's changed.

In 1973, most observations were still recorded on photographic plates, which were developed in a chemical laboratory. Astronomers spent hours or days poring over the glass plates with magnifying lenses to measure the positions of stars or other objects, or to look at their spectra—individual wavelengths of light spread out into a pattern of bright and dark lines.

In addition, an astronomer or observing assistant physically pointed the telescope at a target; only a few observatories were beginning to use computers for the job. An observer used small finder scopes or images on a TV screen to keep the target centered in the telescope, requiring constant attention and many hours at the telescope itself, often in cold conditions.

Analyzing the data required hours of work with special calculating machines or by hand (the original astronomical "computers" were people—often women—who worked with pencil and paper). Charts, graphs, and other documents were created by hand as well.

Most observatories switched to more modern methods as computers (the electronic kind) became faster, cheaper, and more reliable during the 1970s, beginning a technological revolution in the field that continues today.



McDONALD OBSERVATORY

A technician operates an early computer at McDonald Observatory.

KEY DATES

February 2 — ***GROUNDHOG DAY***

Legend says that if a groundhog sees its shadow when it leaves its burrow, winter will last another six weeks; if not, expect an early spring. In ancient Britain, February 2 was known as Candlemas, and it represented the end of winter and the beginning of spring.

SKY WATCH

Celebrating the Seasons

Candelmas celebrated one of four cross-quarter days, which occur halfway between a solstice and an equinox. These dates marked the changing of the seasons, and people celebrated them with feasts and religious ceremonies. Several modern celebrations evolved from those commemorations.

BELTANE, MAY 1

An ancient Celtic festival honored the newly arrived summer with big bonfires. Some of the traditions are preserved today as May Day.

LAMMAS, AUGUST 1

This festival evolved from a celebration known as "loaf-mass." But it had an even older ancestor: the Celtic celebration of Lugh, "the Shining One." Lugh was a great warrior, a sorcerer, and a master of arts and crafts, which earned him a spot among the gods and an annual feast day.

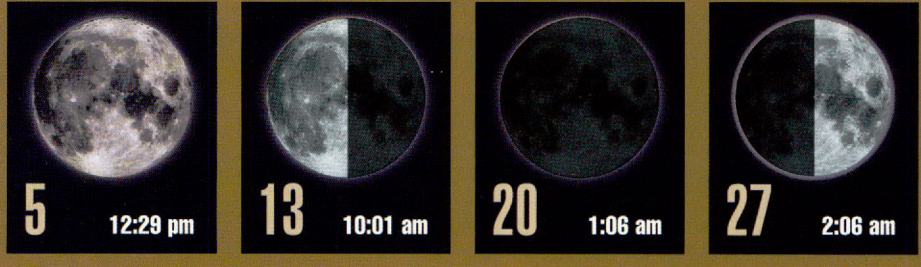
HALLOWEEN, OCTOBER 31

Northern Europeans dreaded this time of year because of the looming winter. Many thought souls roamed freely, looking for new bodies to inhabit. On November 1, All Saint's Day, the Celts put out their hearthfires and dressed as goblins or witches, made noises, and played pranks to convince the spirits they were already possessed. Immigrants brought these traditions to the United States in the 1800s.

StarDate 50

In December 1973, the newly named *McDonald Observatory News* told readers about highly anticipated Comet Kohoutek, which was forecast to be the brightest comet in years. The *News* warned readers, however, that the comet "probably will not be as bright as some early predictions indicated." It was right: Kohoutek was a public flop, remaining invisible to the unaided eye.

Moon phases are Central Time.



The full Moon of February is known as the Snow Moon, Wolf Moon, or Hunger Moon.

APOGEE February 4

PERIGEE February 19

MARCH

OVERVIEW

After a few months of spectacular planet viewing, things start to calm down. The month starts with Venus and Jupiter forming a dazzling pair in the west at nightfall, but they quickly separate, with Jupiter dropping lower into the sunset. Mars drops to just a fraction of the brilliance it displayed in December, with Saturn and Mercury out of sight. In the stars, Leo begins its climb to spring prominence, with Virgo following the lion a few hours later.

HIGHLIGHTS

1 Venus and Jupiter appear to almost touch each other, low in the west as evening twilight fades, with Venus the brighter of the two planets. Venus will move away from Jupiter over the following nights.

2 Pollux, the brighter of Gemini's twin stars, is quite close to the Moon tonight. Castor, the other twin, is farther from the Moon.

5 Regulus, the heart of Leo, is close to the right of the Moon at nightfall.

9 Spica rises below the Moon late this evening.

13-14 Antares, the orange heart of the scorpion, stands to the lower left/right of the Moon at first light, respectively.

13 Mars and El Nath, the star at the tip of one of the horns of Taurus, stand side by side this evening. Mars is brighter, with El Nath to the right.

20 Today is the vernal equinox, marking the beginning of spring in the northern hemisphere.

FEATURED EVENT

21 The Moon is new today, which makes this a good time to look for the zodiacal light.

23-24 The Moon will move past Venus, the Evening Star.

25 The Pleiades star cluster poses to the upper right of the Moon at nightfall. Binoculars will help you see the cluster's stars through the glare.

27 El Nath is close to the right of the Moon as night falls, with Mars a little farther to the upper left of the Moon.

28 Mars is below the Moon this evening.

MARCH

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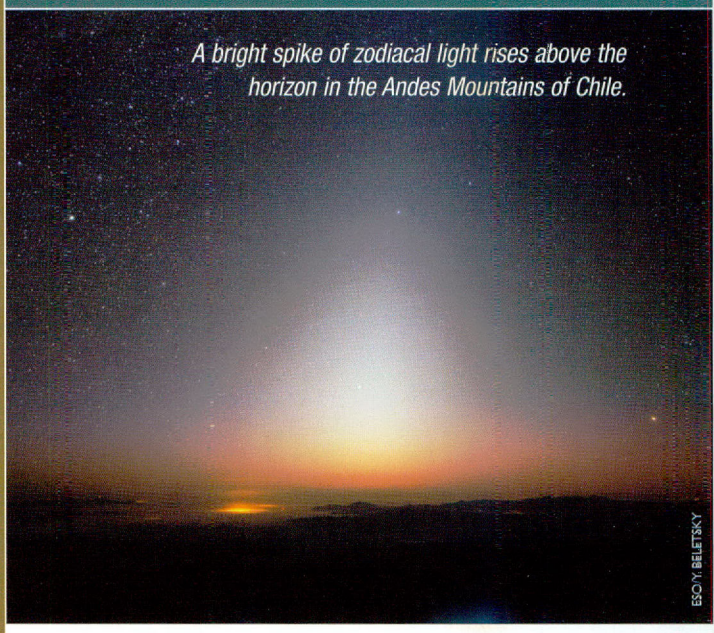
FEATURED EVENT



A bright spike of zodiacal light rises above the horizon in the Andes Mountains of Chile.

ESO/Y. BELETSKY

Ghostly Pyramid for Dark Nights

The "dark of the Moon"—the time around new Moon, when the Moon crosses between Earth and the Sun—is the favorite time of the month for many astronomers. With no moonlight to brighten the sky, they can peer deeper into the universe, allowing them to see fainter and more distant stars and galaxies.

It's also a good time of month for casual skywatchers. Away from the glow of city lights, they can catch the subtle but breathtaking glow of the Milky Way, glimpse faint meteors, and see star clusters and even a remote galaxy or two.

One other faint treasure is the zodiacal light—a ghostly pyramid of light extending from the horizon. It's easiest to see after evening twilight ends in spring or before morning twilight begins in autumn. Because the Moon is new on March 21, the evenings before through a few days after that offer a good chance to see the phenomenon.

Zodiacal light is sunlight reflecting off of tiny grains of dust in the plane of the solar system. Most of the dust is supplied by comets, which lose some of their material when they pass close to the Sun, or by collisions between asteroids. A study a few years ago suggested that much of the dust in the inner solar system comes from Mars. The tiniest dust grains are blown out of the solar system by the solar wind, while larger grains spiral into the Sun.

The dust actually spreads out across the entire sky, along the zodiac, but the grains closer to the Sun receive more sunlight, so that part of the band of dust shines brightest—providing a skywatching bonus on spring evenings.

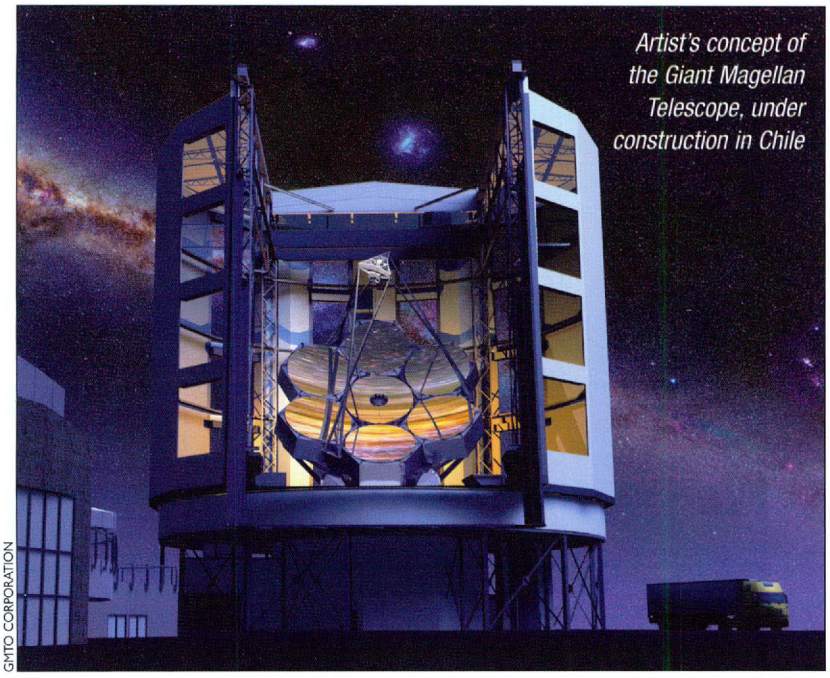
Giants Grow Bigger

The 200-inch (5.1-meter) Hale Telescope at California's Palomar Observatory reigned as the world's largest telescope for three decades, and the largest effective one for years after. Today, though, it barely ranks in the top 20. New techniques have made it possible to produce bigger mirrors at lower cost. And the escalation in giant telescopes isn't over yet.

In the 1980s, University of Arizona astronomer Roger Angel developed a way to produce single-glass mirrors up to 8.2 meters (27 feet) in diameter. Such mirrors have honeycomb-like structures that make them tons lighter than solid-disk mirrors, so they're less expensive to produce, mount, and operate. Today, such mirrors form the heart of eight telescopes around the world, with four more of roughly 6.5 meters (21 feet)—all bigger than the world's largest in 1973.

Even bigger mirrors are made from smaller segments that fit together like tiles on a floor. Small motors align the segments to produce the proper shape for bringing the universe into focus. The Hobby-Eberly Telescope at McDonald Obseratory, for example, consists of 91 hexagonal segments that form an overall mirror with an effective diameter of about 10 meters. The world's largest optical telescope, the 36-segment Gran Telescopio Canarias, spans 10.4 meters (34 feet).

Today, astronomers are developing new telescopes that would dwarf even those giants. The collecting areas of the Giant Magellan Telescope, Thirty-Meter Telescope, and Extremely Large Telescope all will be larger than a basketball court. All three are scheduled for completion sometime in the next decade, greatly extending our view of the distant universe.



Artist's concept of the Giant Magellan Telescope, under construction in Chile

GMTO CORPORATION

SKY WATCH

The Planets in 2023

VENUS

The brilliant planet starts the year as the Evening Star and remains in the evening sky until early August. It will return, as the Morning Star, a couple of weeks later and remain in the morning sky through the end of the year.

JUPITER

The largest planet in the solar system, and usually the brightest object in the night sky after the Moon and Venus, shines at its best in late October and early November, when it is brightest and is in the sky all night.

MARS

For the first part of the year, orange Mars will be visible for most of the night. As the year progresses it will set earlier and earlier, disappearing in the Sun's glare for the final three months. By the time it vanishes it will shine only a few percent as bright as in January.

MERCURY

The Sun's closest planet is in the morning sky in late January through February, late May into late June, and late September into early October (its best apparition). It appears in the evening sky in April (its best showing), July and August, and November through mid-December.

SATURN

The ringed planet shines brightest this year in late August and early September as it moves through Aquarius.

URANUS

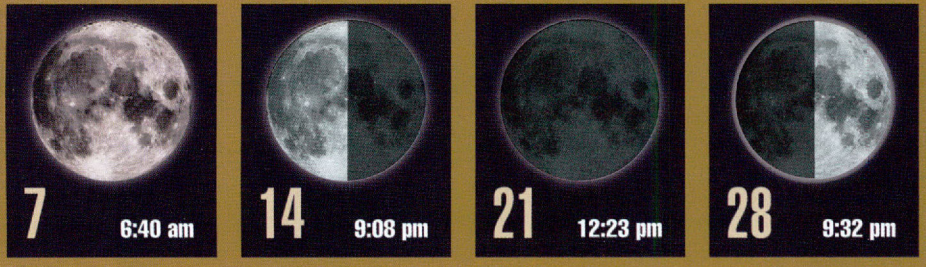
The seventh planet is at its brightest in November, when it barely reaches naked-eye visibility, although most skywatchers will need binoculars or a telescope to spot it.

Ranked in order of maximum brightness when not too near the Sun

StarDate 50

In March 1979, the *News* was expanded and given a new format that allowed it to publish short feature articles. Another redesign, which added a jot more color, followed in 1983. The name was changed to *StarDate* in 1986.

Moon phases are Central Time.



The full Moon of March is known as the Sap Moon, Worm Moon, or Lenten Moon.

APOGEE
March 3, 31

PERIGEE
March 19

APRIL

OVERVIEW

Taurus is especially prominent this month thanks to the Moon and the planet Venus. The bull is dropping toward the horizon and soon will disappear from view. But Venus, the Evening Star, slides close to its shoulder, marked by the Pleiades star cluster, a third of the way through the month. The Moon teams up with Venus and the bull's orange eye, the star Aldebaran, later on. By month's end, Venus and the Moon both pay calls on El Nath, the star at the tip of one of the bull's horns.

HIGHLIGHTS

FEATURED EVENT

1-15 The planet Mercury stages a pretty good showing in the western evening sky.

1-2 Regulus is below/to the upper right of the Moon at nightfall on these dates, respectively.

5-6 Spica stands below/close to the upper right of the Moon, respectively, as they climb into view by 9 or 10 p.m.

10 The Moon and Antares, the bright heart of the scorpion, appear to almost touch each other as they rise into view in the wee hours of the morning. They open a little separation by dawn.

15-16 Saturn is to the left of/above the Moon at dawn, respectively.

20 A solar eclipse will be visible from the Indian Ocean to Antarctica and into the western Pacific Ocean. It will be a total eclipse along some of that path, but annular along other parts, with the Sun encircling the Moon with a ring of fire.

22 Venus, the Evening Star, stands to the upper left of the Moon at nightfall, with Aldebaran, the orange eye of the bull, a little farther to the left of the Moon.

22 The Lyrid meteor shower is at its best late tonight.

23 Venus is to the lower right of the Moon at nightfall.

25 Orange Mars is close to the lower left of the Moon at nightfall.

28-29 Regulus stands to the lower left of the Moon at nightfall on the 28th, and to the right of the Moon on the 29th.

APRIL

Su	M	T	W	Th	F	Sa
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23	24	25	26	27	28	29
30						

FEATURED EVENT

NoDoz, Anyone?

When you have one of those days that seems to last forever, just be grateful you're not on the planet Mercury, where a single day lasts for two years.

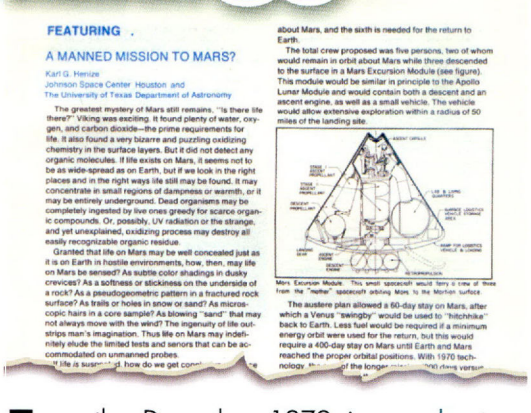
Mercury is the closest planet to the Sun. It spins on its axis three times for every two orbits it makes around the Sun. Because of the Sun's changing position in Mercury's sky, that means a "day" on Mercury—the time from one noon to the next—lasts for two full Mercury years, which is about 176 Earth days.

That doesn't necessarily mean that sunsets or sunrises are 176 days apart, however. Mercury's orbit is lopsided, so the planet's orbital speed varies by quite a bit. Combined with its slow rotation, that creates some odd effects. From some locations, during parts of its orbit, the Sun can rise, reverse direction and set, then rise again. There are double sunsets as well.

Mercury puts in a good showing as the Sun sets in our own sky during the first half of April. It begins the month quite low in the west at sunset, although it shines brightly. It then climbs away from the Sun, reaching its greatest separation on April 11, so it stands highest in the sky then.

Mercury fades as it moves higher, although it should still be easy to pick out, well below much brighter Venus. It then drops back toward the Sun and disappears in the evening twilight during the latter half of the month, with the exact date depending on your viewing circumstances.

StarDate 50



FEATURING .

A MANNED MISSION TO MARS?

Karl G. Henize
Johnson Space Center Houston and
The University of Texas Department of Astronomy

The greatest mystery of Mars still remains. "Is there life there?" Viking was exciting. It found plenty of water, oxygen, and carbon dioxide—the prime requirements for life. It also found a very bizarre and puzzling oxidizing chemistry in the surface layers. But it did not detect any organic molecules. If life exists on Mars, it seems not to be as wide-spread as on Earth, but if we look in the right places and in the right ways life still may be found. It may concentrate in small regions of dampness or warmth, or it may be entirely underground. Dead organisms may be completely ingested by live ones greedy for scarce organic compounds. Or, possibly, UV radiation or the strange, and yet unexplained, oxidizing process may destroy all easily recognizable organic residue.

Granted that life on Mars may be well concealed just as it is on Earth in hostile environments, how, then, may life on Mars be sensed? As subtle color shadings in dusky crevices? As a softness or stickiness on the underside of a rock? As a pseudogeometric pattern in a fractured rock surface? As trails or holes in snow or sand? As microscopic hairs in a core sample? As blowing "sand" that may not always move with the wind? The ingenuity of life outstrips man's imagination. Thus life on Mars may indefinitely elude the limited tests and sensors that can be accommodated on unmanned probes.

about Mars, and the sixth is needed for the return to Earth.

The total crew proposed was five persons, two of whom would remain in orbit about Mars while three descended to the surface in a Mars Excursion Module (see figure). This module would be similar in principle to the Apollo Lunar Module and would contain both a descent and an ascent engine, as well as a small vehicle. The vehicle would allow extensive exploration within a radius of 50 miles of the landing site.

Mars Excursion Module. This small spacecraft would ferry a crew of three from the "mother" spacecraft orbiting Mars, to the Martian surface.

The austere plan allowed a 60-day stay on Mars, after which a Venus "swingby" would be used to "hitchhike" back to Earth. Less fuel would be required if a minimum energy orbit were used for the return, but this would require a 400-day stay on Mars until Earth and Mars reached the proper orbital positions. With 1970 tech-

From the December 1979 issue, about possible plans for a manned trip to Mars, written by NASA scientist-astronaut and University of Texas adjunct astronomy professor Karl Henize:

The concept that a Mars research station might be established in our lifetime is not so fanastic as it may seem. ... Regardless of the length of mission desired, it is clear that the time has come when a manned expedition to Mars is feasible.

Moonrush, Round Two

The final Apollo mission left the Moon at the end of 1972, wrapping up the first great era of lunar exploration. The Soviet Union sent a few robotic rovers and sample-return missions in the 1970s, but the United States left our satellite world in peace. As of late 2022, it hadn't sent a lander in almost half a century, although a few orbiters have mapped the lunar surface in great detail and found evidence of water ice at the poles.

NASA plans for that to change. It has scheduled a spate of robotic orbiters, landers, rovers, and sample-return missions (most of which have been delayed by years). Many of them will concentrate their efforts on finding resources, such as ice, for human explorers. Astronauts are scheduled to orbit the Moon as early as 2024, and land perhaps three years later.

During the decades since the final Apollo mission, however, the Moon has become a much more international destination. China has landed rovers and brought back samples, including the first from the lunar farside. Europe, Japan, India, South Korea, and Israel have dispatched probes as well, with varying degrees of success. More countries are planning to aim for the Moon in the next few years as well.

Over the coming decades, we could see permanent human settlements, large radio telescopes, and other additions to the lunar surface, extending a new era of lunar exploration.

Astronauts arrive on the Moon aboard the SpaceX Starship, which will deliver the first crews, in this artist's concept.

SPACEX

KEY DATES

April 5

Europe plans to launch Jupiter Icy Moons Explorer (JUICE) to study the largest jovian moons, Ganymede, Callisto, and Europa. All three may have deep oceans of liquid water below their icy crusts. JUICE will try to not only confirm the oceans, but provide details on their depth, layers, and other characteristics. The craft is scheduled to arrive at Jupiter in 2031.

ESA

Artist's concept of JUICE with Jupiter and the moons it will explore, (from top) Callisto, Europa, and Ganymede

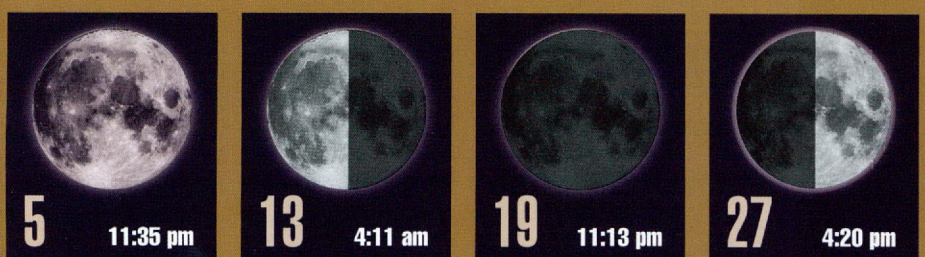
EXPLORATIONS

Back to the Moon?

NASA and other space agencies plan to dispatch several robotic spacecraft to the Moon. Each mission has been delayed by years, so these launch dates are uncertain.

MISSION	COUNTRY	LAUNCH
SLIM	**Japan**	**First Quarter**
A small lander will demonstrate the technology to conduct precision landings in scientifically interesting locations.		
Chandrayaan-3	**India**	**First Quarter**
The successor to the failed Chandrayaan-2 mission will consist of a lander and a small rover.		
IM-1	**USA**	**Late March**
Scheduled to land in the Ocean of Storms, it will measure the nearby environment. It will share a ride with a small orbiter, Lunar Flashlight, which will look for ice at the south pole.		
IM-2	**USA**	**Mid-Year**
Scheduled to land near the south pole, it will drill into the surface to hunt for water ice. It will carry a small "hopper" to enter dark craters. Several missions will share the ride, including Lunar Trailblazer, an ice-hunting orbiter; and M1/MAPP, a test rover.		

Moon phases are Central Time.



The full Moon of April is known as the Egg Moon or Grass Moon.

PERIGEE April 15

APOGEE April 28

MAY

OVERVIEW

The Moon stages some especially close encounters with several stars and one planet this month, snuggling as close as a couple of degrees from them. The stars include Regulus and Spica, the leading lights of Leo and Virgo, which are in view almost all night. The constellations Hydra, Crater, and Corvus, which have a shared myth, are in great view as well, scooting low across the south during the evening.

HIGHLIGHTS

3 Spica, the brightest star of Virgo, snuggles quite close to the lower right of the Moon at nightfall.

5 A weak lunar eclipse will sweep across the eastern hemisphere. The Moon will pass through Earth's faint outer shadow, so skywatchers will have to concentrate to notice much difference in the Moon's appearance.

6 Antares, the orange heart of the scorpion, is close below the Moon as they climb into view before midnight, and closer to the left of the Moon at first light on the 7th.

13 Saturn perches close to the upper left of the Moon at first light. It looks like a bright star.

17 The Moon and the brilliant planet Jupiter appear to almost touch one another in the dawn twilight. They are quite low in the sky, however, so you need a clear horizon to see them.

17 Mars aligns to the left of Pollux and Castor, the twins of Gemini, for several evenings. They are almost equally spaced, and both Mars and Pollux show a bit of an orange color.

FEATURED EVENT

22-24 The Moon sweeps past Venus, Mars, and the twins of Gemini on these evenings.

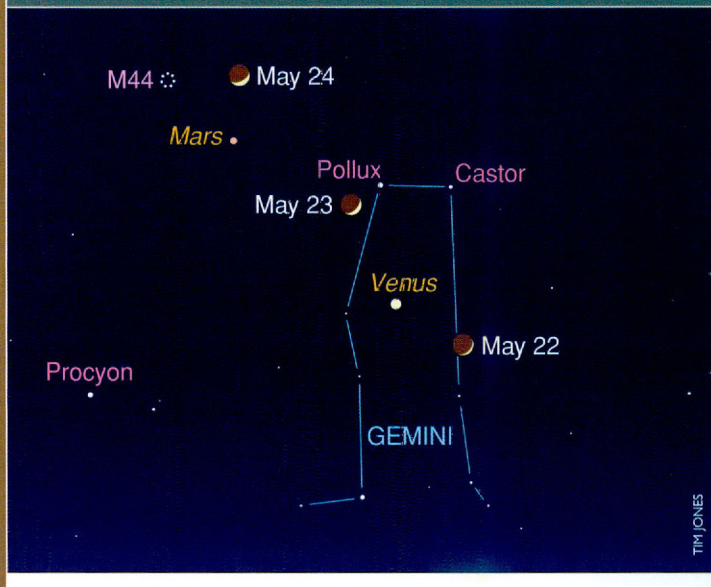
26 Regulus is the bright star near the Moon at nightfall.

30-31 The Moon returns to Spica, with the bright star to its lower left at nightfall on the 30th and to its upper right on the 31st.

MAY

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			

FEATURED EVENT



Block Party

The Moon and four other bright celestial objects look like they're having a block party on the evenings of May 22-24. The Moon looks up at its companions on the 22nd, stands in the middle of them on the 23rd, and waves goodbye on the 24th, as it climbs higher across the sky.

The brightest member of the neighborhood quartet is the planet Venus, the brilliant Evening Star. It far outshines everything else in the night sky other than the Moon, so you can't miss it. It's also by far the closest member of the quartet now, at a distance of about 75 million miles (120 million km). The planet is moving toward us and will be closest in August, when it crosses between Earth and the Sun. It will reach a minimum distance of just 27 million miles (43 million km), which is closer than any other planet.

Mars, on the other hand, is moving away from us in a hurry. It was at its closest and brightest in December, but is growing fainter as it retreats. This month it looks like a modest orange star, standing well to the upper left of Venus.

The other members of the quartet are Pollux and Castor, the brightest stars of Gemini. Each twin maintains the same brightness all the time because they are so far away that any change in distance is insignificant. Pollux is about 34 light-years off, while Castor is about 50 percent farther, at 51 light-years. That's the main reason Castor looks fainter than Pollux.

Venus will line up with the twins in late May and early June, while Mars will leave them behind as it slides eastward against the background of stars.

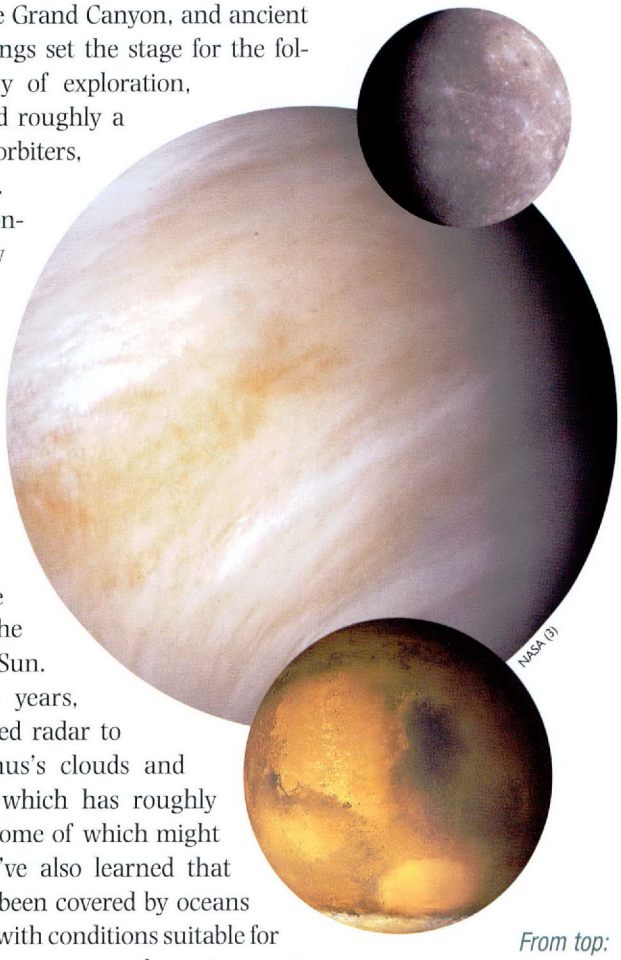
Visiting the Neighbors

The first successful visitors to Mars had some bad luck. They flew past some of the least interesting parts of the planet, so their crude images showed dull landscapes. In 1971, though, Mariner 9 transformed our concepts of the Red Planet, showing giant volcanoes, a canyon system that dwarfs the Grand Canyon, and ancient river beds. Its findings set the stage for the following half-century of exploration, which has included roughly a score of successful orbiters, landers, and rovers.

It took a while longer to get to know Venus and Mercury, the two planets that are closer to the Sun than Earth is. Venus is enwrapped in a thick atmosphere topped by a blanket of clouds, while Mercury broils in the heat of the nearby Sun.

In the past 50 years, spacecraft have used radar to peek through Venus's clouds and map the surface, which has roughly 1,600 volcanoes, some of which might still be active. We've also learned that Venus might have been covered by oceans in the distant past, with conditions suitable for life. Some readings even suggest that microscopic organisms could inhabit the clouds.

We got our first good look at Mercury in 1974. Even today, only two spacecraft have studied the planet. Radar observations from Earth, however, along with data from the second Mercury mission, found water ice at the poles. A European mission that's en route to Mercury will add greatly to our knowledge of the little planet in the years ahead.



From top: Mercury, Venus, and Mars, shown roughly to scale

SKY WATCH

Meteor Showers

SHOWER	PEAK*	MOON
Quadrantids	Night of January 3	In view almost all night
Lyrids	Night of April 22	Sets early, so won't interfere
Perseids	Night of August 12	Thin crescent, rises late
Draconids	Night of October 8	Crescent, rises during peak
Orionids	Night of October 21	Sets before peak hours
Leonids	Night of November 17	Not in view in peak hours
Geminids	Nights of December 13/14	Not in view in peak hours

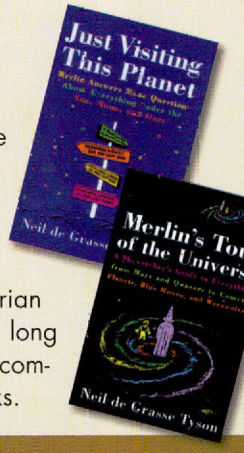
** Actual times may vary*

THE BASICS

Keeping the Moon in Phase

People are sometimes confused by the terminology used to describe the phases of the Moon, especially first quarter and third quarter. In both cases, half of the lunar hemisphere that faces Earth is in sunlight, so people wonder why it's not called a "half" Moon. In fact, as a description of the Moon's appearance, that works just fine. But "first" and "third" quarter refer to the Moon's position in its month-long cycle of phases. At first quarter, the Moon has completed one-fourth of that cycle, and at third quarter it's three-fourths of the way through the cycle. Simple, what?

StarDate 50



Celebrity astronomer Neil de Grasse Tyson made his public outreach debut in 1983 when he took over writing the "Merlin" question-and-answer column. He gave Merlin the voice of the Arthurian wizard, which the column has kept long after Tyson's departure. Tyson later compiled his Merlin work into two books.

Moon phases are Central Time.

The full Moon of May is known as the Milk Moon, Flower Moon, or Corn Moon.

PERIGEE May 11 | **APOGEE** May 25

JUNE

OVERVIEW

Venus and Mars highlight the early evening sky as they draw closer together throughout the month. Both pay a call on M44, the sparkly Beehive Cluster, although you really need binoculars to see many of its stars buzzing around the brighter planets. Scorpius clatters into full view in the south-southeast at twilight's end by the end of the month, with Sagittarius following it into view a little later.

HIGHLIGHTS

1 Zubenelgenubi, the star that marks the southern claw of the scorpion, perches quite close to the Moon at nightfall.

FEATURED EVENT

1-3 Mars passes in front of the star cluster M44, the Beehive. Binoculars reveal the cluster's "swarm" of stars.

2 Venus, the Evening Star, tonight is in its best alignment with Castor and Pollux, the twin stars of Gemini.

3 Antares, the heart of the scorpion, is close to the full Moon tonight. This full Moon is in view for less time than any other, so it's known as the Short-Night Moon.

9-10 The bright planet Saturn stands to the upper left/upper right of the Moon at dawn, respectively.

FEATURED EVENT

11-13 Venus takes its turn crossing in front of the Beehive.

20 Venus is well to the upper left of the Moon at nightfall. Mars is a little farther along the same line. Castor and Pollux pose to the lower right of the Moon.

21 Summer arrives in the northern hemisphere at 9:58 a.m. CDT, which is the moment of the June solstice.

21 Venus, Mars, and the Moon form a tight trio low in the west as evening twilight fades away.

22 Regulus, the heart of Leo, stands to the left of the Moon at nightfall, with Mars and Venus farther to the lower right of the Moon.

27 Spica, the brightest star of Virgo, is close to the Moon at nightfall.

30 Antares snuggles close to the Moon for the second time this month.

JUNE

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	

FEATURED EVENT

Multi-colored stars sparkle in this view of the core of M44, the Beehive Cluster.

FRED LAUTERBACH/WIKIPEDIA

Bees in the Crib?

Mars and Venus will pass near a star cluster with many aliases this month. Perhaps its best-known name is the Beehive Cluster, although it's also well known as Praesepe (Latin for "crib" or "manger"), Messier 44, and NGC 2632. Astronomers have more than a dozen other names for it as well.

The cluster is in the middle of Cancer, the crab. From its distance of at least 600 light-years, it looks like a hazy smudge of light. Binoculars reveal a swarm of stars like bees surrounding their hive.

Astronomers have identified roughly 1,000 members of the cluster. Most of them are cosmic embers much smaller and fainter than the Sun. A few are brighter and more massive than the Sun. They congregate near the cluster's core, with the less-massive stars straggling up to a few dozen light-years away. Those stars won't hang around forever, though. They're being tugged by the gravity of the galaxy's other stars and gas clouds, so eventually they'll be stripped away and head off on their own, leaving far fewer bees in this busy hive.

Mars will pass directly across the cluster on June 2 and will line up just outside it on the nights before and after. Venus will scoot by later in the month, passing closest on the 12th. It will stay just outside the cluster's dense core.

StarDate 50

In 1977, McDonald Observatory launched a telephone message service offering short blurbs about what to see in the night sky. It proved so popular that on June 13 it went on the air on Austin station KLBJ-FM as "Have You Seen the Stars Tonight?" The following year the daily program began national distribution under a new name: Star Date.

Outward Bound

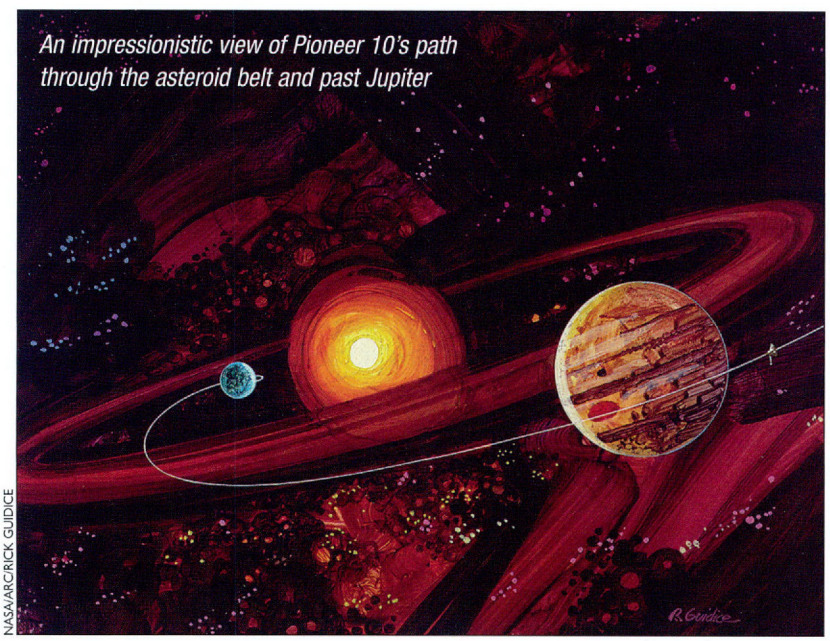
Humanity made its first foray into the outer solar system in 1973, when Pioneer 10 zipped through the asteroid belt (unscathed, by the way) and flew just 82,000 miles (132,000 km) above the cloudtops of Jupiter, the fifth planet from the Sun and largest planet in the solar system.

That initial journey beyond the orbit of Mars opened the exploration floodgates. In the half-century since, a dozen American spacecraft have pushed into the asteroid belt or farther. They've explored Saturn, Uranus, and Neptune; Ceres, the largest object in the asteroid belt; Pluto, the largest member of the Kuiper Belt, beyond the orbit of Neptune; and several smaller bodies.

The missions have revolutionized our view of the outer solar system. They've revealed that several large moons of the outer planets hide oceans of liquid water beneath their icy crusts, and at least two of the oceans could provide conditions comfortable for life. A European mission scheduled for launch this year will study three of the ocean worlds that orbit Jupiter, while an American mission the following year will concentrate on Europa, one of the moons considered most likely to harbor life.

Spacecraft have also revealed that the interiors of the giant planets are different than expected, and their findings have helped scientists develop new models of early solar system evolution.

In the next couple of decades, a small helicopter is scheduled to buzz through the cold skies of Titan, the largest moon of Saturn, and the first missions to Uranus and Neptune since the 1980s are under development, continuing a push into the outer solar system that began 50 years ago.



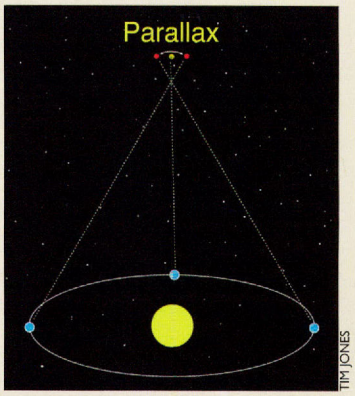
An impressionistic view of Pioneer 10's path through the asteroid belt and past Jupiter

NASA/ARC/RICK GUIDICE

THE BASICS

Get Out Your Calculator

The universe is vast. Really vast. Really, *really* vast—so expansive that the units of measurement we use here on Earth just don't work. The closest star beyond the Sun, Proxima Centauri, is 25 trillion miles away—25 followed by 12 zeroes—while the closest major galaxy, M31, is roughly 15 followed by 18 zeroes. As you try to record objects that are even farther, you soon run out of fingers and toes.



TIM JONES

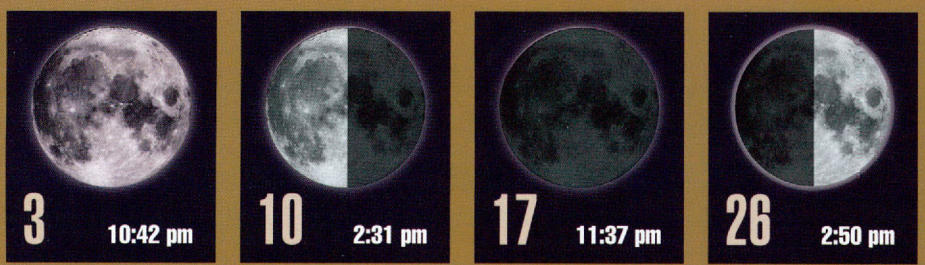
This illustration depicts parallax, with a nearby star appearing to shift position against the distant background as viewed from different positions in Earth's orbit.

To handle those distances, astronomers have devised their own units of measurement, including the light-year (the distance light travels in one year—roughly 5.9 trillion miles), and the parsec (short for parallax-second).

Astronomers measure the direction to a star when Earth is on opposite sides of its orbit. The target appears to shift a bit against the background of more-distant stars. The size of that shift is the star's parallax. (To visualize how it works, hold your finger in front of your face and look at it with one eye, then the other. The finger appears to shift against the background.)

Astronomers then convert the parallax to a distance. If the star shows a parallax of one second of arc (there are 1,296,000 arcseconds in the full circle of the sky), it is one parsec away—about 3.26 light-years. So Proxima Centauri is 1.3 parsecs (4.2 light-years) from us, while M31 is about 780,000 parsecs (2.5 million light-years). For distances with lots of zeroes, astronomers use kiloparsecs (thousands of parsecs), megaparsecs (millions), or gigaparsecs (billions) to describe the full vastness of the universe.

Moon phases are Central Time.



The full Moon of June is known as the Flower Moon, Strawberry Moon, Rose Moon, or Honey Moon.

PERIGEE June 6

APOGEE June 22

JULY

OVERVIEW

Venus, Mars, and Regulus congregate low in the west during early evening for much of the month. Venus is the brilliant Evening Star. The other two are less than one percent as bright, but their proximity to Venus will help them stand out. The Moon crosses by them on the 19th and 20th, and Mercury joins the show by July's end. In the meantime, Scorpius and Sagittarius continue to dominate the southern sky, with the scorpion's curving body and tail to the right and the archer's "teapot" to the left.

HIGHLIGHTS

1 Venus, Mars, and Regulus are in the west at nightfall, with Mars and Regulus to the upper left of the Evening Star, in that order.

6 Earth is at aphelion, its farthest point from the Sun for the year.

7 Saturn, which looks like a bright star, is close to the Moon at first light.

7 Venus is at its brightest for its current evening appearance.

7-11 Mars and Regulus pass especially close to each other. Fainter Mars passes to the right of Regulus, then above it. They are closest on the evenings of the 8th and 9th.

11-12 Brilliant Jupiter is to the lower left/upper right of the Moon at first light on these dates, respectively.

13-14 Aldebaran aligns below/to the right or lower right of the Moon at first light, respectively.

19 Venus stands to the left of the Moon in the early evening, with Regulus above Venus and Mars to the upper left.

20 Mars is close to the left of the Moon, with Venus and Regulus farther below it or to the lower right.

22 Venus and Mercury align low in the west in evening twilight, with fainter Mercury to the right of Venus.

FEATURED EVENT

28 Mercury stands almost directly atop Regulus, quite low in the west in the fading twilight.

JULY

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					

FEATURED EVENT

About 30 minutes after sunset

TIM JONES

Close But Hard to See

Pull out your binoculars and make sure you have a clear western horizon shortly after sunset on July 28 for a breathtakingly close conjunction between the planet Mercury and the star Regulus, the heart of Leo, the lion. They will pass just one-tenth of a degree from each other, which is less than the width of a pencil held at arm's length (see page 17).

Regulus has frequent close encounters with solar system bodies because it lies almost astride the ecliptic, which is the Sun's path across the sky (the Sun will skim past the star on August 22 and 23).

The Moon and planets stay close to the ecliptic as well, so they periodically pass close to Regulus. Just this month, the list of close visitors will include Mars, from the 8th through the 11th, with a closest approach of about one degree; Venus, about 3.5 degrees away from the 14th through the 18th; and the Moon, five degrees away on the 20th. (The Moon can even pass directly in front of Regulus, blocking the star from view.)

Mercury is the least frequent caller. It is the closest planet to the Sun, so it never appears far from the Sun in our sky. That means it has to wait for Regulus to come to it, shortly before sunrise or shortly after sunset.

Mercury will creep up on Regulus for a few nights before passing the star, then remain close for a few more nights as it pulls away. Look for them beginning about a half-hour after sunset, almost due west. Mercury and Regulus are so low that any obstructions along the horizon will hide them. Binoculars will help you hone in. Mercury is the brighter of the two targets. The view is better from southern latitudes because the ecliptic stands at a slightly more favorable angle.

Getting to Know the Little Guys

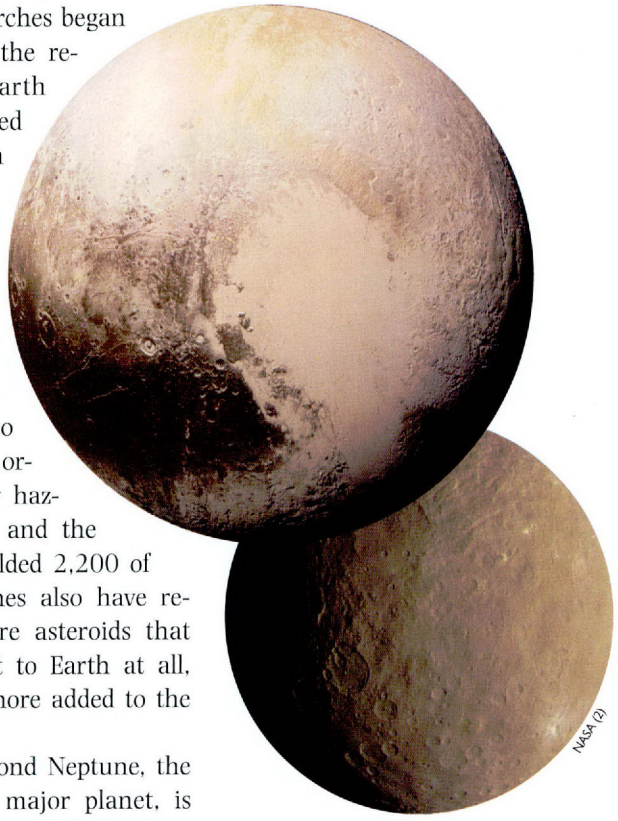
The number of known tiny bodies in the solar system is staggering: more than 3,500 objects beyond the orbit of Neptune, more than 30,000 that come close to Earth's orbit, and more than 1.2 million in the asteroid belt, between Mars and Jupiter. By 1973, however, astronomers had cataloged a total of only about 2,000 small bodies in all, including only one beyond Neptune—Pluto.

The explosion has been fueled by bigger telescopes (see page 9), improved technology (page 7), and automated searches, which scan large swaths of sky every night.

Most of the searches began as a reaction to the realization that Earth has been pounded by big asteroids in the distant past, causing local or even global catastrophes, and that we could be hit again in the future. Congress required NASA to find and plot the orbits of potentially hazardous asteroids, and the searches have yielded 2,200 of them. The searches also have revealed many more asteroids that present no threat to Earth at all, with thousands more added to the list every month.

The region beyond Neptune, the Sun's outermost major planet, is known as the Kuiper Belt. In those remote precincts, even the largest bodies are faint. Pluto, the best-known member of the belt, wasn't discovered until 1930. We saw it as no more than a pinpoint of light until the New Horizons spacecraft flew past Pluto in 2015.

Some astronomers have suggested that a body much larger and heavier than Earth, Planet Nine, could lie billions of miles beyond Neptune. Other astronomers have questioned that idea. Regardless of whether Planet Nine exists, we're likely to find many more tiny solar system bodies in the next 50 years.



True color views of Pluto (top) and Ceres, the largest resident of the asteroid belt

THE BASICS

Measuring the Night Sky

Step out into a dark sky some night and look at the stars. After you give your eyes a few minutes to adapt to the darkness, hold your finger at arm's length and scan until you find two stars that just flank it. Congratulations! You've just measured their separation—about two degrees.

In this issue and others, we frequently describe apparent distances between the Moon, planets, stars, and other objects in degrees. A full circle around the sky is 360 degrees, so one degree is a small fraction of that.

But it can be difficult to judge separations with the eye alone, so seasoned skywatchers use a few easy markers:

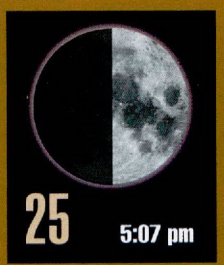
- An extended palm, fingers wide-spread, spans about 20 degrees; that's slightly larger than the span from Orion's shoulder star, Betelgeuse, to his foot star, Rigel.
- A closed fist spans about 10 degrees, or roughly the width of the teapot formed by the stars of Sagittarius.
- A finger is roughly two degrees wide; the gap between the twins of Gemini is about two fingers.
- A pencil is about one degree wide, or twice the width of the Moon.

This system works well for everyone because people with longer arms generally have bigger hands and fingers than those with shorter arms. So start taking the measure of the night sky!

StarDate 50

StarDate hasn't been limited to just the regular monthly magazine. Over the past 30 years we've published several editions of our *Teacher Guide* and *Guide to the Solar System*, as well as one edition of *Beyond the Solar System*.

Moon phases are Central Time.



The full Moon of July is known as the Hay Moon, Thunder Moon, or Apollo Moon.

PERIGEE July 4

APOGEE July 20

AUGUST

OVERVIEW

The Moon continues its run of close encounters, staging amazing conjunctions with Jupiter and Mars and actually covering the giant star Antares. Venus switches titles during the month. And some of the constellations associated with autumn climb into view in early evening, including Capricornus, Aquarius, and Pegasus.

HIGHLIGHTS

8 The Moon and the giant planet Jupiter appear to almost touch one another at first light. Jupiter looks like a brilliant star.

9 Jupiter stands to the upper right of the Moon at first light, with Aldebaran, the eye of the bull, about the same distance below the Moon.

10 Aldebaran is to the lower right of the Moon this morning.

12 The Perseid meteor shower should be at its best tonight, with little moonlight to interfere with the show.

13 The Moon forms a roughly equilateral triangle with the twins of Gemini this morning. Pollux, the brighter twin, is to the lower left of the Moon, with Castor to the upper left.

13 Venus, which has reigned as the Evening Star for months, passes between Earth and the Sun today, so it's hidden in the Sun's glare. It will return to view later in the month, however, as the Morning Star, quite low in the east during dawn twilight.

14 The twins are above the thin crescent Moon this morning.

18 Mars and the Moon almost touch other in the evening twilight.

20 The star Spica stands to the left of the Moon at nightfall.

24 The Moon will occult Antares, passing in front of the star for skywatchers across all of the United States except Alaska. The occultation takes place around 9 p.m. CDT, with the exact timing varying by location.

29-30 Saturn is to the left/upper right of the Moon at nightfall on these days, respectively.

FEATURED EVENT

30 The Moon is full tonight. As the second full Moon of the month, it's known as a Blue Moon.

AUGUST

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		

FEATURED EVENT

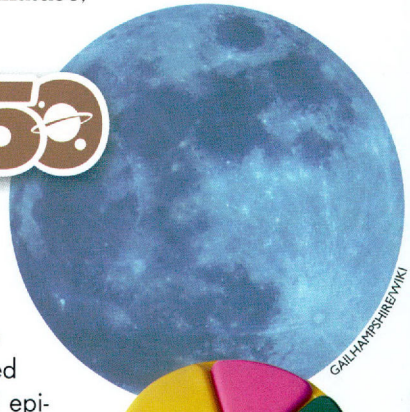
A Case of the Lunar Blues

The Moon gets a case of the blues on August 30—it's known as a Blue Moon.

There's a whole passel of Blue Moon definitions. The old phrase "once in a blue moon" is applied to something that happens rarely. Astronomically, a Blue Moon can be the 13th full Moon in a year or the third full Moon in a season with four full Moons (with the next one due in August 2024). And today, Blue Moon most commonly refers to a second full Moon in a calendar month.

The Moon's cycle of phases roughly corresponds to the length of a month. In fact, the word "month" comes from "Moon." But there's a slight difference. A lunar cycle averages 29.53 days, so as the months roll by the calendar and the lunar cycle fall out of sync. That means the full Moon occurs a little earlier in the month as the months pass. In a month with 30 days, a full Moon on the 1st can be followed by another on the 30th, while months with 31 days can have full Moons on the 1st or 2nd and 30th or 31st.

The rarest of all blue Moons is when the Moon actually looks blue. This happens when a major volcanic eruption spews tiny ash particles high into the atmosphere. The particles scatter red light and allow bluer wavelengths to shine through, giving us a truly blue Moon. After the massive eruption of Krakatoa in the late 19th century, for example, a blue Moon was reported as far away as Europe. Other blue Moons were seen after the eruptions of Mount Saint Helens, in 1980, and Mount Pinatubo, in 1991.



StarDate 50

If you wonder how the modern definition of Blue Moon came about, you can thank StarDate radio, which reported it in a January 1980 episode. Writer/producer Deborah Byrd discovered the definition in a 1946 article in *Sky & Telescope* magazine. It turns out the article was mistaken, but Byrd found no evidence of that at the time. The definition later was used in the board game Trivial Pursuit, which helped ingrain it in popular culture. You're welcome.

NASA

An artist's concept depicts possible Earth-like exoplanets.

Planets Everywhere

Few advances of the past half-century are more astonishing than the discovery of exoplanets—planets orbiting stars other than the Sun. Even more astonishing are the numbers: more than 5,000 planets and counting.

Most of the discoveries were made with two techniques, and most came from a single spacecraft, the Kepler space telescope.

The initial discoveries, made with ground-based telescopes, looked for a tiny "wiggle" in a star's light waves caused by the gravitational pull of an orbiting planet. Many of the planets discovered with that technique are huge and close to the star, so they've been classified as "hot Jupiters," after the largest planet in our solar system.

The second technique looks for the light of a star to dip slightly as a planet passes in front of it. It requires a precise alignment with Earth, so only a fraction of stars will reveal their planets this way. Even so, the technique has yielded thousands of planets—most of them from Kepler, which was designed specifically to hunt such worlds.

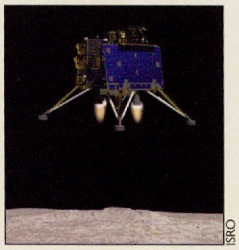
The population of known exoplanets is quite diverse. They range from the mass of the Moon to dozens of times the mass of Jupiter. Some are close to their parent star; some are far away. Some are dense balls of rock, others are big balls of gas, and some may be covered by oceans of liquid water.

Most intriguingly, some lie inside their star's Goldilocks zone—the distance from the star where conditions are most comfortable for life as we know it. We haven't yet seen any evidence of life on any of these worlds, but astronomers are searching. Giant new telescopes on the ground and in space could photograph the surfaces of some worlds and discover the tell-tale signs of life—perhaps an astonishing discovery for the next half-century.

KEY DATE

August TBD

India plans to launch Chandrayaan-3, a rover that will land near the Moon's south pole. It is a repeat of Chandrayaan-2, whose rover crashed during its landing attempt in September 2019. The Indian space agency has strengthened the lander's structure and improved its landing software to enhance the chances of a successful touchdown.



ISRO

Chandrayaan-3 on final approach to the lunar surface

THE BASICS

Twinkle, twinkle, little star—or not

Twinkling stars are a favorite of poets and lovers, but the bane of astronomers. Twinkling transforms a star or other astronomical object into a fuzzy blob.

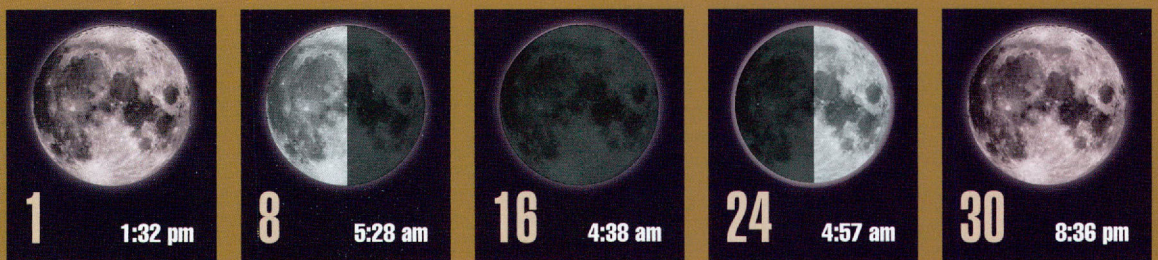
Stars twinkle as their light passes through layers of the atmosphere of different density and temperature. Each layer "bends" the lightwaves, causing them to follow a jagged path toward the surface, which spreads them out. It's the same effect that makes the bottom of a swimming pool appear to shimmer and vibrate.

AKIRA FUJI

Different colors are bent at slightly different angles, so sometimes a star appears to flash rapidly from white to blue to red. Twinkling is most obvious when a star is low in the sky because its light must pass through a thicker layer of air to reach the observer.

To beat the effect, astronomers place their telescopes above as much of the atmosphere as possible: on mountaintops, in balloons and aircraft, and, best of all, in space. In addition, they can compensate for the blurring by rapidly changing the shape of small mirrors that bring the view of stars and galaxies into focus. It's a complex and expensive technique, but it defeats the beautiful yet messy twinkling of the stars.

Moon phases are Central Time.



The full Moon of August is known as the Grain Moon or Green Corn Moon.

PERIGEE August 2, 30

APOGEE August 16

SEPTEMBER

OVERVIEW

The stars of autumn begin to push those of summer out of the way as the nights grow longer and cooler. Pegasus is in view in the east as night falls, with several related constellations following the flying horse into the sky over the next few hours.

HIGHLIGHTS

4-5 Jupiter is close to the left of the Moon at first light on the 4th, and farther to the lower right of the Moon on the 5th. Jupiter is the largest planet in the solar system and the third-brightest object in the night sky.

6 Aldebaran, the eye of the bull, stands below the Moon at first light.

7 El Nath, the tip of one of the horns of Taurus, is close to the left of the Moon at first light.

10 The twins of Gemini align above the Moon at first light.

11-12 Venus, the Morning Star, stands to the lower right/upper right of the Moon at first light on these dates, respectively.

16 The Moon once again occults Mars, although it occurs during daylight as seen from the United States.

19 Neptune, the Sun's most remote major planet, is at opposition. It is in view all night and is closest to Earth, so it shines brightest for the year. You still need strong binoculars or a telescope to see it, however.

19-20 Venus shines brightest for its current Morning Star appearance.

20 Antares, the orange heart of the scorpion, is close to the left of the Moon at nightfall.

23 Autumn arrives in the northern hemisphere at 1:50 a.m. CDT, the moment of the equinox.

26 Saturn looms just above the Moon at nightfall.

FEATURED EVENT

28 The Moon is full tonight. As the full Moon closest to the autumnal equinox, it's the Harvest Moon.

30 The Moon loops back to Jupiter. The giant planet rises to the lower left of the Moon in midevening, and is closer to the upper left of the Moon at dawn.

SEPTEMBER

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

FEATURED EVENT

George Inness, Harvest Moon*; oil on canvas, 1891*

Fields of Moonbeams

Full Moons have a poetic roll call of names, from Wolf Moon to Rose Moon to Honey Moon. None is more evocative, however, than September's full Moon, which is known as the Harvest Moon—the full Moon closest to the autumnal equinox. This year, the Moon is full early on September 29 as clocked from the United States, so the nights of the 28th and 29th will double as Harvest Moon nights.

For the farmers of yore, no full Moon was more welcome than this one. Its brilliant glow lit up the fields, allowing farmers to gather their crops well into the night.

It was especially helpful at high latitudes because it rises at about the same time each night for several nights in a row.

Over the course of a year, the Moon rises an average of about 48 minutes later each night. Depending on the precise geometry, however, the interval can range from a few minutes to much more than an hour.

At this time of year, as you go farther north, the interval between rising times gets smaller and smaller. From the latitude of Seattle, for example, the Moon rises only about 20 minutes later for each of the few nights around the full Moon. That provides a lot of extra moonlight to illuminate the fields.

The Moon makes up the time around new Moon, when it rises more than an hour later each night, balancing the books on the amount of moonlight.

Lunar Lycanthropy

Even a man who is pure at heart
and says his prayers by night,
may become a wolf when the
wolfbane blooms,
and the autumn moon is bright.
—Maleva, *The Wolf Man*, 1941

Werewolf legends have been around for centuries, but their association with the full Moon probably was introduced in the 1941 Universal horror classic *The Wolf Man*. The movie also threw in autumn, suggesting a connection to the Harvest Moon.

Seeing the Darkness

Not long after Albert Einstein published his theory of gravity, General Relativity, German scientist Karl Schwarzschild found something amazing in its equations: If the matter in a star was packed tightly enough, its gravity would cause the star to collapse to a single point, which would surround itself with a zone of darkness: a black hole.

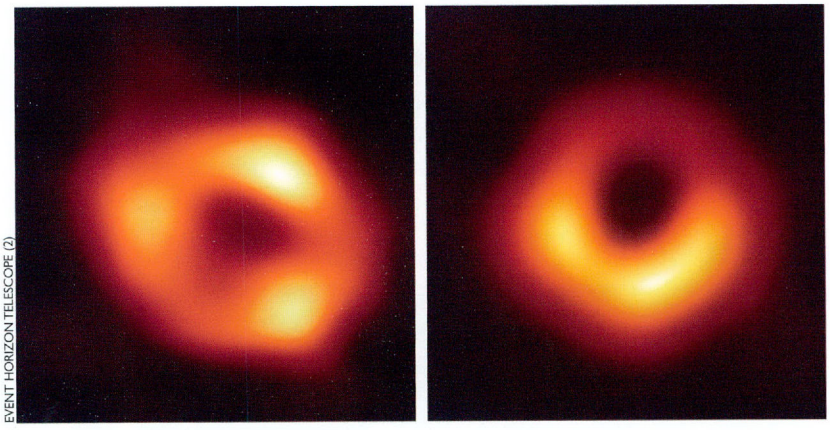
Einstein himself didn't believe that such an object could exist, and for decades, no one could prove otherwise. That began to change in 1971, when an orbiting satellite discovered an odd source of X-rays, Cygnus X-1. Mathematical models suggested the X-rays were produced by hot gas spiraling around a black hole.

In the 50 years since, the evidence has piled up, including gravitational waves—ripples in spacetime that also were predicted by General Relativity—produced by the mergers of black holes, and direct images of two black holes in the hearts of galaxies.

Today, there is little doubt not only that black holes exist, but also that they are common.

Most black holes are a few times the mass of the Sun. They are the collapsed cores of massive stars, or the products of mergers between two less-dense stellar corpses. The other common variety, supermassive black holes, inhabit the cores of many galaxies. They are millions to billions of times the mass of the Sun. Some, known as quasars, are encircled by disks of gas that can outshine an entire galaxy of stars.

Although we know that black holes exist, they remain mysterious: How do they form, what is their relationship to their host galaxies, and, most important, what happens inside their boundaries? Astronomers and other scientists continue to study those mysteries and more as we drive deeper into the 21st century.



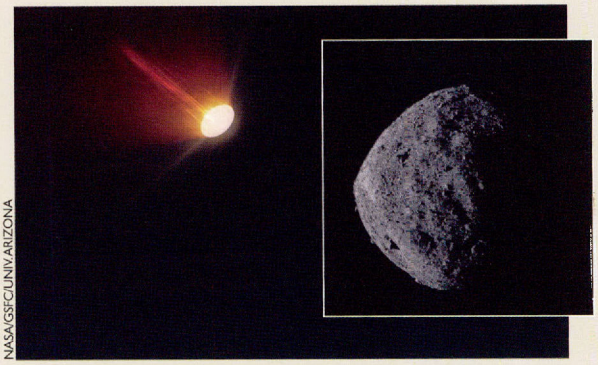
EVENT HORIZON TELESCOPE (2)

The only direct images to date show a black hole in the core of the Milky Way Galaxy (left) and the giant galaxy Messier 87. The images show rings of light focused and amplified by the gravity of the black holes.

KEY DATES

September 24

A spacecraft that left Earth seven years ago will drop off a package today: a couple of ounces of an asteroid. Osiris-Rex spent two and a half years orbiting Bennu, an asteroid a third of a mile (500 meters) wide that could someday threaten Earth. The probe briefly touched down, stirring up dust and pebbles that it snagged for return to Earth. The spacecraft will eject the sample return capsule, which will land in Utah, then head toward the asteroid Apophis, which will pass just 20,000 miles (32,000 km) from Earth in 2029. The craft will orbit Apophis and study how its encounter with Earth altered the asteroid.



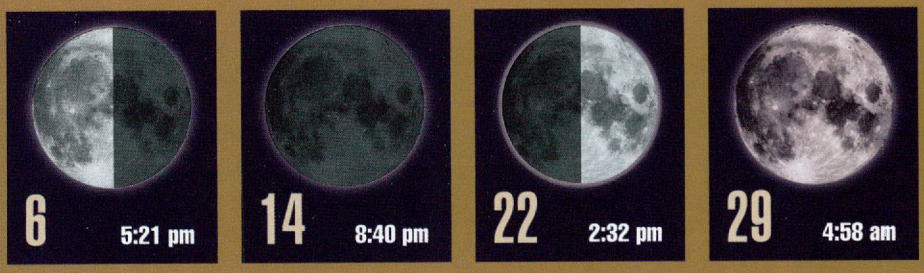
NASA/GSFC/UNIV ARIZONA

The sample capsule plunges to Earth in an artist's concept. Inset: Osiris-Rex view of Bennu

StarDate 50

In 1988, *StarDate* switched from a newsletter format to a full-fledged magazine, with slick paper stock, full color, and other changes. The design changed as well, as did its artistic approach: Most of the magazine was illustrated with works of fine art instead of pictures of the universe. The design changed to roughly its current format in 1996, although we continually tweak it to improve the magazine's appearance.

Moon phases are Central Time.



The full Moon of September is the Fruit Moon or Green Corn Moon. This year it's also the Harvest Moon.

APOGEE September 12

PERIGEE September 27

OCTOBER

OVERVIEW

As a warm-up for next year's total eclipse, the Moon and Sun will stage an annular eclipse this month, visible across parts of the western United States. Venus puts on an especially striking show of its own, highlighting the early morning sky all month. And the stalwart constellations of autumn rise to prominence, with several in view all night.

HIGHLIGHTS

1 Jupiter and the Moon appear to almost touch each other as they climb into good view by 10 p.m.

2-3 Aldebaran stands below/to the right of the Moon, respectively, as they rise in late evening.

7 Pollux, Gemini's brighter twin, is close to the Moon at first light.

8-11 The Moon, Venus, and Regulus form a shifting lineup at first light. Venus, the Morning Star, lines up side by side with Regulus on the 8th, then slowly moves away. The Moon will stand above Venus and Regulus on the 9th, form a tight line with them on the 10th, and slide below them on the 11th.

FEATURED EVENT

14 The Moon passes between Earth and the Sun today, creating an annular solar eclipse.

18 Antares stands to the lower right of the Moon, very low in the late evening twilight.

21 The Orionid meteor shower should be at its best late tonight.

23-24 The Moon forms a wide-spread triangle with Saturn and Fomalhaut, the brightest star of Piscis Austrinus, the southern fish, on these evenings. Saturn is to the upper left/upper right of the Moon at nightfall, with Fomalhaut farther to the lower left/lower right, respectively.

23-24 Venus stands farthest from the Sun for its current Morning Star appearance. It's visible for up to about three hours.

28 The Moon is full today. It's known as the Hunter's Moon.

28 Jupiter and the Moon are almost touching each other as they climb into good view in early evening.

30 Aldebaran stands to the lower right of the Moon as they heave into good view by 9 or 10 p.m.

OCTOBER

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				

FEATURED EVENT

A Ring of Fire

The Sun and Moon will combine to create a ring of fire in the sky as seen from a narrow strip of the western United States on October 14. The event is an annular solar eclipse, which occurs when the full Moon passes between Earth and the Sun. The Moon is a little farther than its average distance, so it can't quite completely cover the Sun. Instead, it leaves a thin ring of sunlight.

This eclipse sweeps ashore on the coast of Oregon at about 9:15 a.m. PDT. It then slices southwestward, passing over Eugene, Oregon; Albuquerque and Santa Fe, New Mexico; and Midland/Odessa, San Antonio, and Corpus Christi, Texas. It then heads into the Gulf of Mexico around noon CDT before crossing over much of Central America and parts of South America.

Annularity—the period when the Moon is fully encircled by sunlight—will last only three or four minutes across the United States. At the point of maximum eclipse, the Moon will cover roughly 91 percent of the Sun's total disk. **The remaining sunlight is still too bright to look at directly, though.** Watch it through special eclipse glasses or dark welder's glass, or check in online.

Almost all of the United States outside the path of totality will see a partial eclipse, with the Moon blocking a smaller fraction of the Sun's disk. The closer to the path of totality, the greater the eclipse.

Mother Nature provides her own lens for viewing the eclipse: tree leaves. As sunlight passes between the leaves, it projects small images of the eclipse on the ground. They're a fun and safe way to enjoy a special alignment of the Sun, Moon, and Earth.

National Eclipse
nationaleclipse.com/maps_2023.html

Time and Date
www.timeanddate.com/eclipse/solar/2023-october-14

NASA Feature Page
solarsystem.nasa.gov/eclipses/2023/oct-14-annular/overview/

Solar Eclipse Across America
eclipse.aas.org

A May 2012 annular eclipse

BILL DUNFORD/NASA

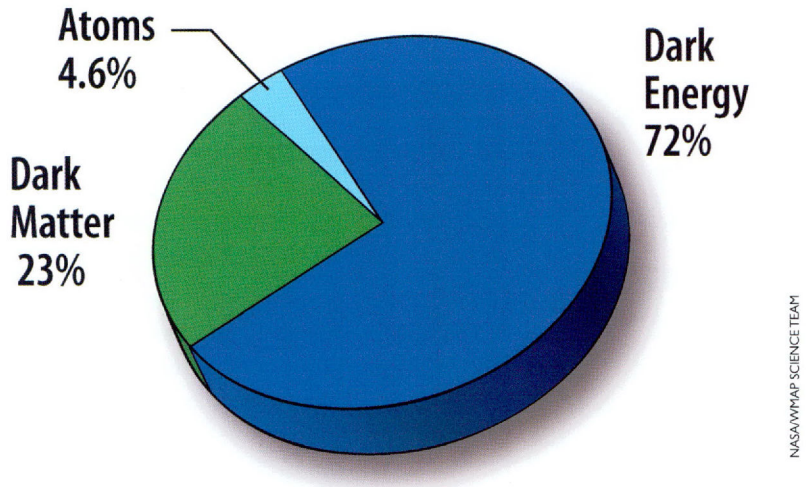
The Universe Goes Dark

Most of the universe is missing—or at least misunderstood. All of the stars, planets, galaxies, gas clouds, radiation, and everything else we can see and touch accounts for about five percent of the total mass and energy in the universe. Scientists have been searching for the rest for decades, but they haven't found it.

A half-century ago, astronomers already knew about some of the missing stuff. Known as dark matter, it accounts for roughly 85 percent of all the matter in the universe. We know it's there because it exerts a gravitational pull on the visible matter around it. It was first postulated by brilliant but acerbic physicist Fritz Zwicky, who surmised that it served as a gravitational "glue" that kept clusters of galaxies from flying apart. In the early 1970s, Vera Rubin and Doug Ford suggested that dark matter surrounded galaxies, causing stars in their outer regions to move much faster than they would under the pull of the visible matter alone.

The leading idea says that dark matter is a form of subatomic particle that seldom interacts with normal matter. Physicists have built many detectors to search for the particles, with no confirmed discoveries. That suggests they may have to look for a new explanation.

In the late 1990s, astronomers discovered that most of the universe appears to consist not of dark matter but of dark energy. (Two teams later shared a Nobel Prize in Physics for the discovery.) They found that the universe is expanding faster as it ages. They had expected the gravity of all the visible and dark matter to slow the expansion, and perhaps even cause the universe to begin collapsing in on itself. That suggests that some mysterious force is causing the universe to speed up. Many experiments are looking for an explanation, but, as with dark matter, the results remain dark.

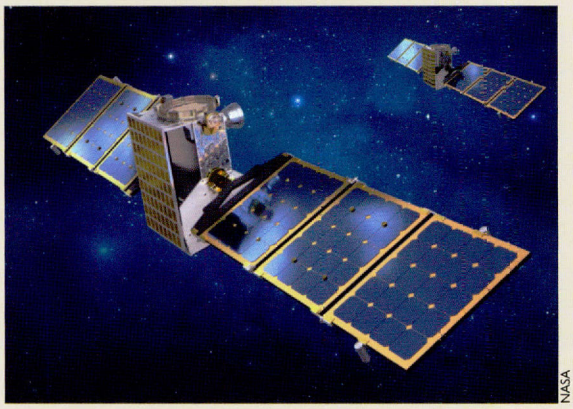


NASA/WMAP SCIENCE TEAM

Everything we know is contained in the thin wedge at upper left.

KEY DATES

October 10



NASA

Artist's concept of the twin Janus spacecraft

NASA plans to launch Psyche, a mission to explore an asteroid of the same name. The asteroid appears to be made primarily of metals, suggesting it could be a fragment of the core of a larger world that was smashed apart in a giant collision. Delays in software development and other problems scuttled a planned launch attempt in 2022, so the spacecraft will take an additional two years to reach Psyche. Two smaller satellites, which make up the Janus mission, will launch on the same rocket. The year-long delay means Janus's original targets won't be in the proper position, so scientists are looking for new asteroids for the probes to explore.

October 21

This is International Observe the Moon Night, which was established to commemorate achievements in lunar exploration.

moon.nasa.gov/observe-the-moon-night
www.facebook.com/observethemoon

StarDate 50

StarDate radio made its national debut on October 1, 1978. Funded by the National Science Foundation, it was narrated by Joel Block and written and produced by Deborah Byrd. Today, the program airs on more than 350 stations—both public and commercial—across the United States. It is the longest-running science feature on national radio.

Moon phases are Central Time.

The full Moon of October is known as the Dying Grass Moon or Hunter's Moon.

APOGEE
October 9

PERIGEE
October 25

NOVEMBER

OVERVIEW

Taurus reaches its highpoint around midnight on late November nights, so it's in view all night, marked by Aldebaran, its bright orange eye. Jupiter, the largest planet in the solar system, is at its best as well, shining from near the head of Cetus, the whale or sea monster. Auriga the charioteer is in view all night, too, led into the sky by its brightest star, Capella.

HIGHLIGHTS

1 El Nath, which marks the tip of one of the bull's horns, is quite close to the Moon at first light.

FEATURED EVENT

2 Jupiter is at opposition, shining at its best for the year.

5 Daylight Saving Time ends at 2 a.m. local time.

6-7 Regulus, the brightest star of Leo, is below/to the upper right of the Moon at first light, respectively.

8 Venus, the Morning Star, is below the Moon at first light.

9 Venus and the Moon are almost touching.

10 Venus is above the Moon at first light, with Spica, the brightest star of Virgo, about the same distance below the Moon.

11 Spica is quite close to the Moon at first light.

18 Mars is in conjunction, passing behind the Sun and hidden from view.

19-20 Saturn is to the upper left/closer to the right of the Moon at nightfall, respectively.

24-25 Jupiter stands to the lower left/upper right of the Moon at nightfall, respectively.

27 Aldebaran, the orange eye of the bull, is to the right or lower right of the Moon at nightfall.

30 Pollux, the brighter twin of Gemini, is very close to the Moon as they climb into good view by about 9 p.m.

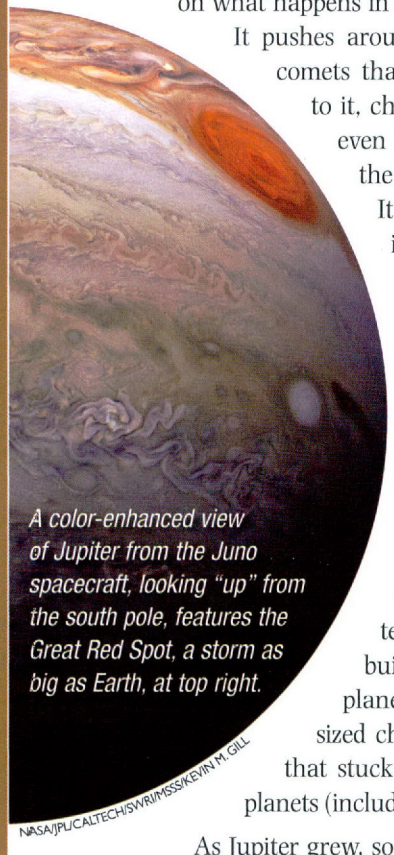
NOVEMBER

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		

FEATURED EVENT

A Planetary 'Monster'

Jupiter is the monster of the solar system. It is twice as massive as all the other planets, moons, asteroids, and comets combined. That gives it a giant influence on what happens in our planetary system. It pushes around the asteroids and comets that pass remotely close to it, changing their orbits or even flinging them out of the solar system entirely. It even has a long-term influence on the orbits of Earth and the other planets.



A color-enhanced view of Jupiter from the Juno spacecraft, looking "up" from the south pole, features the Great Red Spot, a storm as big as Earth, at top right.

NASA/JPL-CALTECH/SWRI/MSSS/KEVIN M. GILL

Jupiter's influence was even greater when the solar system was younger and more crowded. As the planets were taking shape, the solar system was packed with the building blocks known as planetesimals—mountain-sized chunks of rock and ice that stuck together to build the planets (including Jupiter).

As Jupiter grew, so did its gravity. Over a few million years, it flung millions of planetesimals in all directions. Some of them slammed into the Sun, while others bombarded the other embryonic planets. Others flew into the Oort Cloud—a shell of small bodies that extends up to a light-year from the Sun—while still others were hurled into interstellar space.

This influential planet stages its best showing of the year this month. It reaches opposition on the night of November 3, when it lines up opposite the Sun. It's in view all night and it shines brightest for the year, outranked only by the Moon and Venus, the Morning Star. It will line up close to the Moon on November 24 and 25.

JUPITER FACT FILE

- Gas giant
- 11.2 times Earth's diameter
- 318 times Earth's mass
- Year: 11.9 Earth years
- Day: 9 hours, 56 minutes
- 5.1 times Earth's distance from the Sun
- 80 known moons

NASA/ESA

A true-color view of Jupiter from Hubble Space Telescope, 2019

Leaving Orbit (Again)

In 1973, NASA had just completed its first grand era of manned space flight with the final Apollo lunar-landing mission, in December 1972. Since then, it has launched astronauts on more than 140 additional trips to Earth orbit, and it's preparing rides to the Moon for later in this decade, and perhaps to Mars a decade or two later.

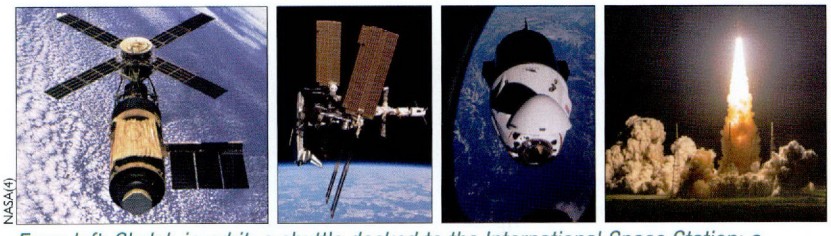
Apollo hardware carried three crews of astronauts to Skylab, the first American space station, in 1973 and 1974, for stays of up to 84 days. In 1975, astronauts rode an Apollo spacecraft to orbit for a link-up with a Soviet Soyuz capsule.

The space shuttle made its debut in 1981, and launched 135 times. Its crews deployed and upgraded Hubble Space Telescope, conducted thousands of scientific experiments, deployed classified military payloads, and did most of the assembly work for the International Space Station. But the shuttle was expensive to fly, and never came close to NASA's promises of offering routine trips to orbit. The loss of the Challenger and Columbia shuttles and their crews convinced the space agency to retire the fleet.

American astronauts hitched rides to orbit aboard Soyuz capsules for years, then switched to the SpaceX Dragon capsule.

Today, NASA is prepping for new trips to the Moon. It launched Artemis I, the first test flight of its new Orion capsule and giant Space Launch System rocket, in November 2022. Artemis II is planned to send astronauts into lunar orbit as early as 2024, and Artemis III will send a crew to land on the Moon a few years later.

Eventually, NASA plans to build a permanent outpost near the Moon's south pole. After that, Artemis hardware may send astronauts to Mars, greatly expanding the human presence across the solar system.



NASA(4)

From left: Skylab in orbit; a shuttle docked to the International Space Station; a Dragon capsule approaches the space station; Artemis I heads for the Moon.

Neither Gone nor Forgotten

The American spacecraft that carried astronauts to orbit over the past 50 years are on display at museums across the country.

Skylab command modules: Skylab 2, Naval Air Museum, Pensacola; Skylab 3, Great Lakes Science Center, Cleveland; Skylab 4, Oklahoma History Center, Oklahoma City.

Apollo-Soyuz command module: National Air & Space Museum, Washington, D.C.

Space shuttles: Atlantis, Kennedy Space Center, Florida; Discovery, Steven F. Udvar-Hazy Center, Virginia; Endeavour, California Science Center, Los Angeles; Enterprise (didn't fly in space), Intrepid Sea, Air & Space Museum, New York City.

THE BASICS

Binocular Vision

The human eye is a pretty good astronomical instrument. It can detect tiny differences in brightness and color, see features on the Moon, and even sense the faint glow of remote star clusters and galaxies.

Eventually, though, many skywatchers yearn to see more. And that's when many of them foul things up. They buy a telescope, plop it on the deck, and expect to see Hubble-like views of the universe. But when the telescope proves to be more difficult to use than expected, or the views aren't magazine-cover quality, they chuck the thing in the garage and give up.

Fortunately, there's an intermediate solution: binoculars.

The performance of a pair of binoculars is indicated by two numbers, expressed as "7x35" or "10x50." The first number is magnification, which tells you how much closer an object will look, while the second is the diameter, in millimeters, of the glass lenses at the front of the twin tubes. Larger lenses let in more light, so they provide a brighter view of the sky.

Most experts recommend 7x50 or 10x50 binoculars because they provide a good blend of light-gathering power, light weight, and a wide field of view.

Binoculars should allow you to see objects that are two or three magnitudes fainter than you can see with the unaided eye—a factor of 10 or so. With that boost, the hazy band of the Milky Way becomes a speckled field of individual stars, and some star clusters transform from fuzzy blobs to dense balls of twinkling lights.

StarDate 50

Over the past 50 years, we've featured the work of hundreds of writers, including several successful authors of fiction and nonfiction books. Some of our former editors are published authors as well. Jeff Kanipe, who edited the magazine in the early 1990s, has written more than 10 books on skywatching and other astronomy topics, while David S.F. Portree, who succeeded him, has authored several books on space history.

Moon phases are Central Time.

The full Moon of November is known as the Frost Moon or Snow Moon.

APOGEE November 6

PERIGEE November 25

DECEMBER

OVERVIEW

The panoply of the winter sky begins to take over the evening hours. Orion, perhaps the most beautiful constellation, is in full view at nightfall by the middle of the month, highlighted by its three-star belt and the stars Betelgeuse, in the hunter's shoulder, and Rigel, at his foot. Sirius, the brightest star in the night sky, trails below the belt, followed by the other stars of his constellation, Canis Major, the big dog.

HIGHLIGHTS

1 Venus, the Morning Star, stands side by side with Spica, the brightest star of Virgo, at first light.

1 Pollux and Castor, the twin stars of Gemini, align to the right of the Moon at first light.

3-4 Regulus, the heart of the lion, stands to the lower left/closer to the right of the Moon at first light, respectively.

4 Mercury stands farthest from the Sun for its current evening appearance. It is quite low in the southwest during twilight.

8 Spica is close below the Moon at dawn, with Venus farther to the lower left of the Moon.

9-10 Venus is quite close to/directly above the Moon at first light.

17 The giant planet Saturn is close above the Moon at nightfall.

21 Winter arrives in the northern hemisphere at 9:27 p.m. CST, the moment of the December solstice. It is the shortest day of the year in the northern hemisphere, and the Sun stands farthest south in the sky.

FEATURED EVENT

21 The asteroid Vesta is at opposition.

21-22 Bright Jupiter, the solar system's largest planet, poses close to the lower left/to the right of the Moon at nightfall on these dates, respectively.

24 Aldebaran is to the lower left of the Moon at nightfall.

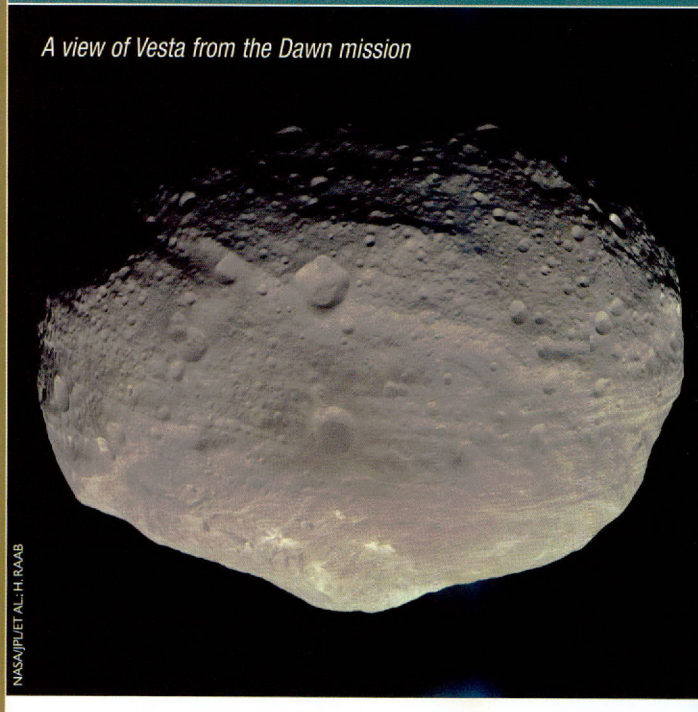
27 Pollux is to the lower left of the Moon, and Castor to the upper left, as they climb into good view in early evening.

30-31 Regulus is to the lower right/upper right of the Moon as they move into good view by about 10 p.m., respectively.

DECEMBER

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						

FEATURED EVENT



A view of Vesta from the Dawn mission

NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA/H. RAAB

A Bright Solar System 'Leftover'

When you build a house or a highway or any other major structure, there are always leftovers—wood chips, scraps of wallpaper, bits of rebar, grains of asphalt. That rule applies when you build a planetary system as well. In our own system, many of the leftovers inhabit the asteroid belt—a wide band of debris between the orbits of Mars and Jupiter.

The gravity of nearby Jupiter prevented these leftovers from coalescing to form a planet. Astronomers have discovered more than one million members of the belt (see page 17).

The brightest of those leftovers, Vesta, puts in its best showing of the year in December. It's at opposition, so it aligns opposite the Sun in our sky. It rises around sunset, is in view all night, and shines at its brightest. Even so, you need binoculars to pick it out, between the feet of Gemini and the tip of Orion's upraised club.

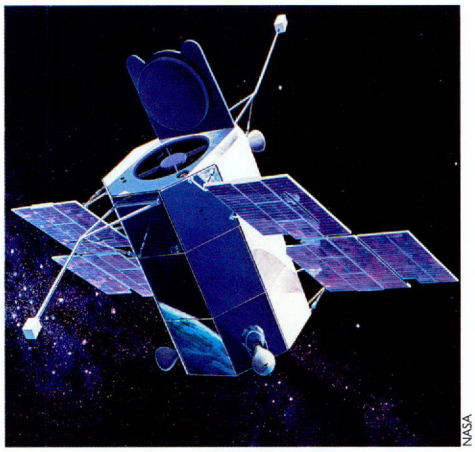
Vesta is the second-largest and second-most-massive member of the belt. It's roughly half the diameter of Ceres. Vesta appears brighter, though, because its surface is more reflective and because it is a little closer.

Its surface has been battered by countless collisions, including several giant ones. One of those big ones blasted several large chips into their own orbits; today, those fragments are known as Vesta-family asteroids. The collisions also sent some bits of material all the way to Earth. They form a special class of meteorites.

The Dawn spacecraft orbited Vesta for 14 months, beginning in July 2011. Its observations, combined with studies of the meteorites, have given us our most detailed profile of any of the leftovers in the asteroid belt.

Space, the Final Frontier

In the early days of space exploration, both scientists and science-fiction writers dreamed of operating telescopes from space stations, with astronauts conducting around-the-clock observations. Few dreamed that technology would allow them to place untended telescopes in space. In the past half-century, however, the world's space agencies have launched scores of space telescopes, with grand ambitions for even more.


NASA

An artist's concept depicts the first successful space telescope, Orbiting Astronomical Observatory 2, which was launched in 1968.

Because they're above Earth's atmosphere, space telescopes offer many advantages over ground-based instruments. The atmosphere blurs the light of astronomical objects (even when the sky is clear, it's nighttime, and there is no pesky moonlight). The atmosphere also absorbs most forms of energy, from the infrared to ultraviolet, X-rays, and gamma rays. Telescopes on the ground are blind (or almost so) to these wavelengths, which reveal important details about black holes, newly forming stars, galactic mergers, and much more.

The first space telescopes were launched in the late 1960s and early '70s. The field experienced a grand era a couple of decades later when NASA launched its four Great Observatories: Hubble Space Telescope, to study visible wavelengths; Spitzer Space Telescope, to study the infrared; Compton Gamma-Ray Observatory; and Chandra X-Ray Observatory. As of late 2022, Hubble was still operating. The largest telescope to date, James Webb Space Telescope, which observes the infrared sky, launched in 2021.

As technology improves, astronomers are developing even-more-capable telescopes. Euclid, a European mission scheduled for launch as early as this year, will study dark energy and dark matter (see page 23). The Nancy Grace Roman telescope will study dark energy and explore exoplanets (with a goal of photographing the surfaces of some). And LISA, scheduled for launch in the late 2030s, will combine the observations of three widely separated spacecraft to measure the gravitational waves produced by the mergers of supermassive black holes and other objects.

These missions and many more will bring the universe closer, answering many questions while raising many others.

KEY DATE

December 17 *CALENDAR EVENT*

Today is Saturnalia, an ancient Roman festival tied to the winter solstice. It honored Saturn, the god of the harvest. People decorated trees, performed acts of charity, exchanged gifts, and decorated their houses with candles. Many of those customs survive in the celebration of Christmas.

RESOURCES

ONLINE

StarDate Online
Daily skywatching tips, lunar phases, daily StarDate radio program
stardate.org

U.S. Naval Observatory
Custom sunrise/sunset and moonrise/moonset charts and much more
aa.usno.navy.mil

SpaceWeather
Updates on solar flares and auroras, photo galleries, skywatching news
spaceweather.com

Meteor Shower Calendar
International Meteor Organization
www.imo.net/resources/calendar/2023

Mr. Eclipse
Details on eclipses for 2023 and beyond, plus historical eclipses
www.mreclipse.com/main/preview.html

PUBLICATIONS

Observer's Handbook 2023, edited by James S. Edgar
rasc.ca/handbook

Astronomical Calendar 2023, by Guy Ottewell
universalworkshop.com/astronomical-calendar-2023

StarDate 50

StarDate has gone through many changes over the past 50 years, but one thing has remained constant: the support of our loyal readers. Thousands have subscribed, and we look forward to bringing you astronomy news and features, skywatching tips, and much more for decades to come. Thank you!

Moon phases are Central Time.

The full Moon of December is known as the Long Night Moon or Moon Before Yule.

APOGEE December 4

PERIGEE December 16

by Alan MacRobert

Planets in the Evening, Planets in the Morning

All five of the planets that are visible to the unaided eye put in good appearances during winter's long, cold nights. Venus is the prominent Evening Star, Saturn and Jupiter arc high across the sky, and Mars brings up the rear, remaining in view until the wee hours of the morning. Mercury adds a nice dawn appearance in late January and early February. Orion, perhaps the most beautiful of all constellations, is in its prime, followed by faithful Sirius, the Dog Star. And the subtle band of the Milky Way steams high overhead.

JANUARY 1-15

Now that winter has taken hold, it's officially Orion season. The Jupiter and Mars seasons are still in progress, but waning. Venus season is just beginning, while Saturn is about to sink away.

Look for Venus, the Evening Star, rather low in twilight in the west-southwest. It seems tiny and faint at first, then looks ever brighter as twilight darkens. Of course, this is an optical illusion—a contrast effect. Venus sends us the same amount of light no matter how bright or dark the sky around it.

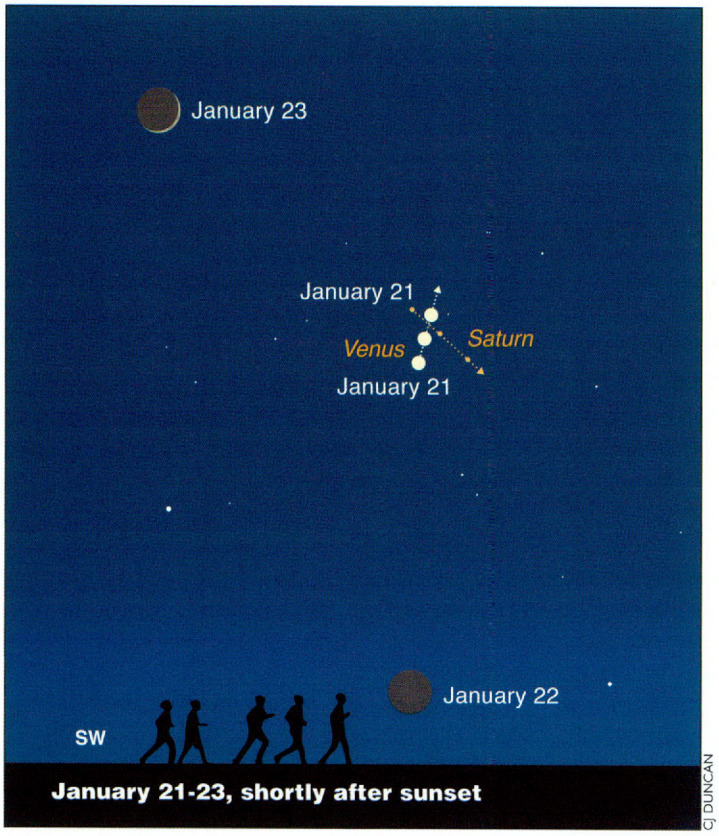
Where I live, Venus is the thing that doesn't move. I'm 20 miles west of a major airport, under the glide path for airplanes with their bright landing lights on. As they approach, I sometimes see as many as five false Venuses in the west at once. Our ancestors would have been stupefied. I've learned not to be annoyed.

The real Venus is purer white to my eyes. In a telescope it's currently a dazzling little ball only 11 arcseconds in diameter (the Moon is about 1,800 arcseconds) and slightly gibbous, shimmering in the low-altitude seeing.

Next up along the ecliptic is Saturn. Look for it to the upper left of Venus by about one or two fists at arm's length, with the gap closing every day. Saturn is only about one percent as bright, so twilight has to deepen before it comes into view.

Nevertheless, in a telescope Saturn's apparent disk reveals itself as larger than that of Venus. So why is Saturn so dim? Because of its much lower surface brightness. Saturn is 13 times farther from the Sun than Venus is, so the sunlight illuminating Saturn's cloud tops is 13 squared, or roughly 169, times dimmer than the sunlight on Venus's clouds. A telescope at medium power reveals this dramatically.

Next east along the ecliptic: big Jupiter! It's the brightest point in the sky after Venus. It stands high in the south as darkness falls, roughly five or six fists to Venus's upper left.



Next up is Mars, still big and bright a month after opposition. Mars is no match for Jupiter, but it's still the brightest thing high in the east to southeast these evenings. Its fiery yellow-orange tint gives it extra pizzazz.

Not far below Mars is fainter, Mars-colored Aldebaran, the eye of Taurus.

Orion sparkles below Mars and Aldebaran. After dark in early winter, Orion's three-star belt is nearly vertical. About a fist to the left of the belt, Mars-colored Betelgeuse shines in Orion's shoulder.

Can you see any difference in the colors of Mars, Aldebaran, and Betelgeuse? Mars will probably look a bit paler: less orange-red. But that's mostly an illusion from Mars simply being brighter at present. Yes, human color perception is tricky.

On January 3, look for Mars shining close to the bright white Moon. The Moon, too, plays tricks with our eyes and brain. Its surface material is not white at all but dark gray, almost black, as you can see in museum samples of lunar rocks and dust. The Moon looks white only because we view this dark material, which is dazzlingly sunlit, against a dark night sky.

And sorry to disappoint, but the deserts of Mars are not shiny fire-orange but dull, dark brown. In a dark sky we perceive brightly sunlit brown as orange. Believe it or not, a tangerine and a chocolate bar have the same hue, just different brightnesses. Your color vision evolved for everyday usefulness, not scientific accuracy.

JANUARY 16-31

Week by week, Venus works its way higher into the west-

ern twilight, while dimmer Saturn sinks lower, toward it. On January 22, they pass each other a mere third of a degree apart. That's about the width of a chopstick held at arm's length. They'll even fit together in a telescope's low- to medium-power view, giving a vivid comparison of the different sunlight intensities they receive.

Orion climbs higher in the southeast now, which means brilliant white Sirius twinkles below him as he follows the hunter into the sky. Sirius, the Dog Star, highlights Canis Major, the great dog, forever trotting behind Orion's feet. Orion's Belt points almost straight toward Sirius.

Look to the left of Sirius and a bit higher for Procyon, the Little Dog Star, in Canis Minor. Sirius and Procyon form a nearly equilateral triangle with Betelgeuse above them: the Winter Triangle.

The constellation to the left of Orion is Gemini. The stick-figure twins are lying on their sides with their feet toward Orion's dim, upraised club. Their two bright heads, Pollux and Castor, shine farther left. Pollux is the lower one. It's slightly the brighter of the two, and it shines pale orange; Castor is white. Can you see the color difference with your eyes alone? As always, binoculars or a telescope make star colors much more obvious.

Mars now shines high overhead in early evening. It forms the peak of a wide, flattish triangle with Aldebaran and the Pleiades on either side of it. Binoculars help show the dim, widely scattered Hyades star cluster next to Aldebaran. In binoculars, the tiny dipper shape of the Pleiades is a delight. And good binoculars, held steady, often show craters on the Moon.

Mark your calendar for January 30, when the gibbous Moon again shines very close to Mars (see page 4). But this time, the Moon actually occults (covers) Mars for several minutes—if you live south of a line from Florida's northernmost coast to the coast of central California. That includes Texas. Seen from north of there, Mars and the Moon just miss each other.

Meteor Watch

The Shower

Quadrantids

Named for the extinct constellation Quadrans Muralis, the wall quadrant, an early astronomical instrument. Today, that region is part of Boötes, the herdsman.

Peak

Night of January 3

Notes

The Quadrantids produce a large number of meteors at their peak, but the peak lasts only a few hours, providing a short viewing window. The Moon will be in view during the peak, however, blunting the shower's majesty.

FEBRUARY 1-14

Now it's Jupiter's turn to approach Venus from above. These two brightest planets are 29 degrees apart as February begins, closing in to 14 degrees by the 15th. They will have a spectacular conjunction on March 1, one-half degree apart.

February is when Orion stands upright, at his highest in the south at a convenient hour. That's where he is in mid- to late evening as February opens, and right after the end of twilight by month's end.

Here's another skywatching illusion: Orion may look smaller than when it was low in the sky, just above the eastern horizon. This is a case of the "Moon illusion"—never mind that Orion looks nothing like the Moon. Due to a quirk of human distance assumptions, any celestial object seems bigger when we see it in the same view as distant scenery on Earth.

The season is definitely turning. When Orion stands on the meridian, you'll find the Big Dipper standing upright on its handle in the northeast, already on its way toward its springtime heights. And Leo, lion of spring, is walking steeply up from his eastern-horizon lair, sporting first-magnitude Regulus in his forefoot.

In early dawn, look low in the east-southeast about 60 to 45 minutes before sunrise, and there's Mercury showing off quite plainly. Most of the time, the Sun's closest and smallest planet acts notoriously shy.

FEBRUARY 15-28

The big celestial event of late February is Venus and Jupiter closing in on each other in the western twilight, leading up to their tight conjunction on March 1; think photo opportunity! Find some nice foreground scenery for them, put your camera or phone on a tripod or other support, zoom in, and see what you get. Try taking a shot every clear night at the same time and place, with the same aim and zoom, to capture the developing planetary drama.

Much more subtly, late February is when, on moonless nights, the winter Milky Way arches straight overhead not long after dark. It spans the sky, running straight up from the south-southeastern horizon through the Winter Triangle of Sirius, Procyon, and Aldebaran, then between Orion and Gemini. It runs behind bright Capella, which is high overhead, then down through Perseus, the W of Cassiopeia (now standing on end), and on to the west-northwestern horizon. If you don't have too much light pollution, you can trace it out before moonlight starts to interfere around February 24.

The winter Milky Way is weaker and thinner than the glorious section that arches over our summer sky. In summer we face more toward our galaxy's rich central regions, while now we're looking out toward its rim.

And on the night of February 27, the Moon yet again passes close by Mars. There's no occultation this time, however, unless you're in Iceland or northern Scandinavia.

Hot, Puffy, and Orange

Betelgeuse has lived a short but spectacular life, and it's almost over. Within the next 100,000 years, it should blast itself to bits as a supernova.

Betelgeuse marks the shoulder of Orion the hunter, which is in the east and southeast at nightfall in January, and in the southeast to south in February. Betelgeuse shines bright orange, indicating that its surface is thousands of degrees cooler than the Sun's.

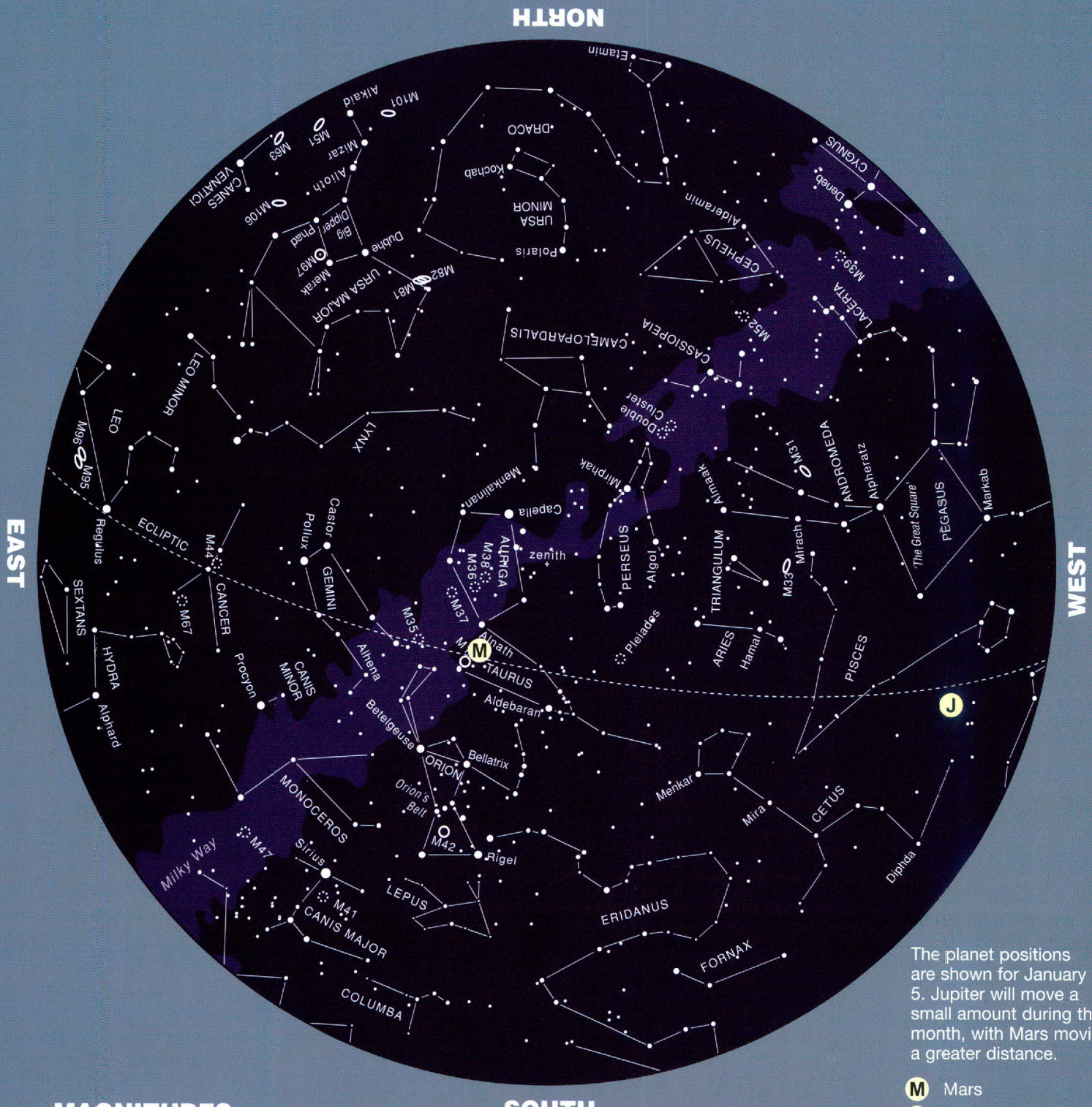
That "coolness" is only skin deep. Deep in its core, Betelgeuse is tens of millions of degrees hotter than the Sun. The core probably is fusing helium atoms to make carbon. That process produces tremendous amounts of radiation, which inflates the star's outer layers like a giant balloon. If Betelgeuse took the Sun's place, it would engulf the four inner planets, including Earth, and push toward the next planet, Jupiter.

Alan MacRobert is a senior editor of Sky & Telescope.

JANUARY

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

December 20	**11 p.m.**
January 5	**10 p.m.**
January 20	**9 p.m.**



The planet positions are shown for January 5. Jupiter will move a small amount during the month, with Mars moving a greater distance.

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

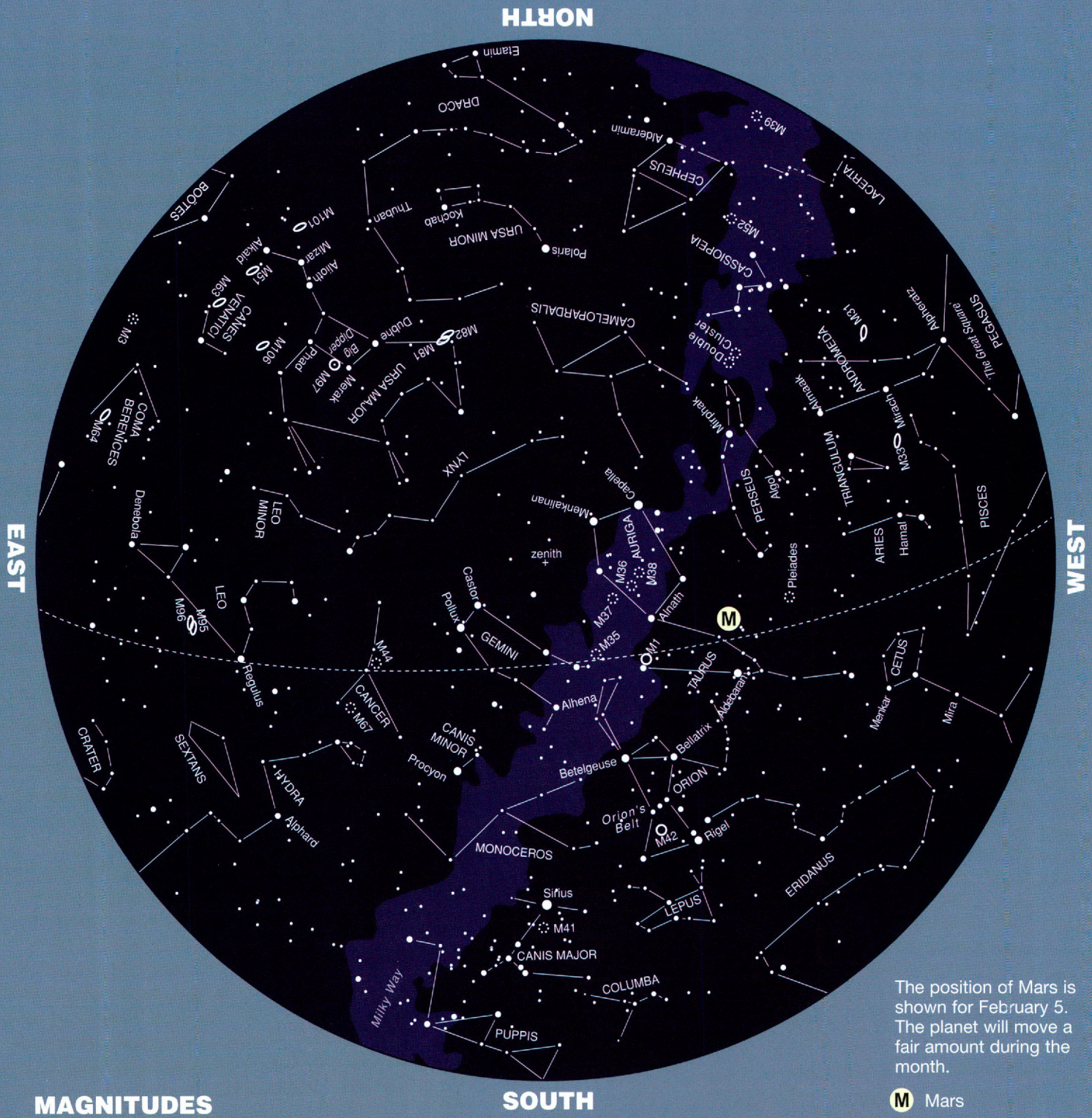
MAGNITUDES

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

FEBRUARY

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

January 20	**11 p.m.**
February 5	**10 p.m.**
February 20	**9 p.m.**



The position of Mars is shown for February 5. The planet will move a fair amount during the month.

MAGNITUDES

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

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

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