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JANUARY/FEBRUARY 2017 $7

SKY ALMANAC 2017

THE UNIVERSITY OF TEXAS AT AUSTIN McDONALD OBSERVATORY

StarDate

JANUARY/FEBRUARY 2017 • Vol. 45, No. 1

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StarDate (ISSN 0889-3093) is published bimonthly by the McDonald Observatory Education and Outreach Office, The University of Texas at Austin, 2609 University Ave. A2100, Austin, TX 78712. © 2016 The University of Texas at Austin. Annual subscription rate is $26 in the United States. Subscriptions may be paid for using credit card or money orders. The University of Texas cannot accept checks drawn on foreign banks. Direct all correspondence to StarDate, The University of Texas at Austin, 2609 University Ave. A2100, Austin, TX 78712, or call 512-471-5285. POSTMASTER: Send change of address to StarDate, The University of Texas at Austin, 2609 University Ave. A2100, Austin, TX 78712. Periodicals Postage Paid at Austin, TX. StarDate is a registered trademark of the University of Texas McDonald Observatory.

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Features

Departments

This Page

The Sun sets over the Hobby-Eberly Telescope at McDonald Observatory. Among other projects, astronomers use the telescope to discover and study planets in other star systems.

Coming Up in March/April

In our next issue, we'll explain how studying sand dunes can teach us about winds and geology on Mars and Titan. And we'll keep you informed on what's happening in the night sky, present the latest astronomy news, and much more.

NASA/JPL

On the Cover

A NASA poster envisions trips to several exoplanets.

SKY ALMANAC 2017

A PLETHORA OF PLANETS

'Sometimes I think we're alone in the universe, and sometimes I think we're not. In either case the idea is quite staggering.'

– *Arthur C. Clarke*

Stars wobble. They also shift, fade, and exhibit other odd behaviors — caused not by the stars themselves, but by orbiting planets.

The first confirmed exoplanets (planets in star systems other than our own) were discovered 25 years ago, orbiting a dead star known as a pulsar. Since then, astronomers have racked up about 3,500 more exoplanets, orbiting young stars and old stars, big stars and little stars, stars like our own and stars that are wildly different. The planets themselves are known as hot giants, cold giants, super Earths, super Neptunes, and by a host of other descriptions.

All of these discoveries have required patient observations, often over periods of years or even decades. Some were made by watching a star's light "wobble" as the star was tugged by the gravity of an accompanying planets. Others were made by watching a star fade by a tiny bit as a planet passed across its face. And a handful were made by actually seeing the planet, although always as nothing more than a pinpoint of light in the glare of the parent star.

This plethora of worlds is the subject of our Sky Almanac, as we describe some of the planets, how they were found, how astronomers continue to add to their exoplanet totals, and how they are looking for evidence of life — including intelligent life — on these strange new worlds among the stars.

Text by Damond Benningfield

ETHAN TWEEDIE PHOTOGRAPHY

JANUARY

OVERVIEW

Some of the brightest stars in the sky decorate the long, cold nights of January. Beautiful Orion is in view almost all night, trailed by Sirius, the brightest star in the night sky. All five planets that are visible to the unaided eye are in view as well, adding to the beauty of winter nights.

HIGHLIGHTS

1 Venus, the Evening Star, is to the upper left of the Moon at nightfall.

2-3 The orange planet Mars is to the upper left of the Moon at nightfall on the 2nd, with much brighter Venus to the lower right of the Moon. By the following night, the Moon has moved past Mars.

3 The Quadrantid meteor shower should be at its peak tonight, with maximum rates of up to a few dozen meteors per hour.

4 Earth is at perihelion, its closest approach to the Sun for the year, at a distance of about 91.4 million miles (147 million km).

8-9 Aldebaran, the bright eye of Taurus, stands to the lower left of the Moon at nightfall on the 8th, and to the upper right on the 9th.

11-12 Venus is at its greatest distance from the Sun in the evening sky, so the Evening Star stands fairly high as night falls.

14 Regulus, the brightest star of Leo, poses just a whisker from the Moon as they climb into good view around 9 or 10 p.m.

19 Mercury is at its greatest distance from the Sun in the morning sky. It looks like a fairly bright star quite low in the southeast as dawn brightens.

FEATURED EVENT

19 The planet Jupiter and the star Spica snuggle close to the Moon.

23 Antares, at the heart of the scorpion, is to the lower right of the Moon at first light, with the planet Saturn about the same distance to the lower left of the Moon.

24 Saturn is very close to the right or lower right of the Moon at dawn.

26 Mercury is to the right or upper right of the Moon in early twilight. The planet looks like a fairly bright star, but it is so low in the sky that you might need binoculars to spot it.

31 Mars perches close to the upper right of the Moon at nightfall, with much brighter Venus a bit farther to the right of the Moon.

JANUARY

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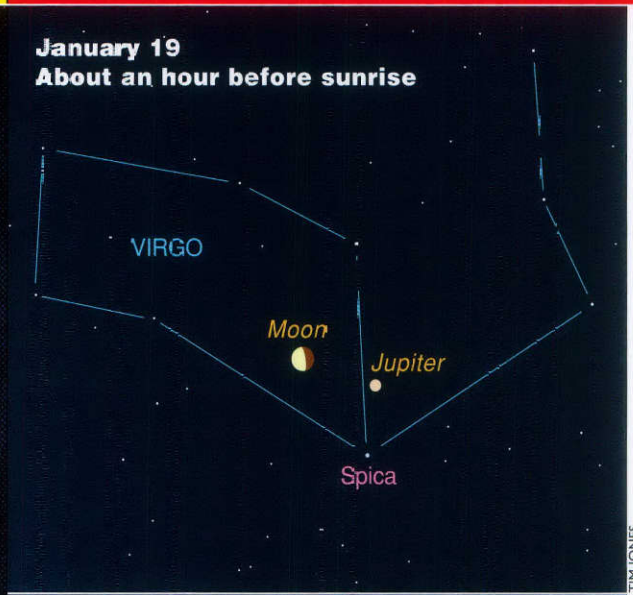


FEATURED EVENT

Double Giants

Some friendly giants pose with the Moon in the wee hours of January 19: the largest planet in the solar system and two of the largest stars in the galaxy.

Jupiter looks like a brilliant star quite close to the right of the Moon as they climb into view around 1 or 2 a.m., and stays close as they climb higher into the sky. The binary star Spica, the brightest star of the constellation Virgo is a bit to their lower right.

Jupiter is about 11 times Earth's diameter, and more than 300 times its mass. That great heft makes Jupiter the 900-pound gorilla of the planets. Its gravity influences the orbits of comets and asteroids, deflecting them into new paths whenever they get remotely close to it.

Jupiter exerted its influence most strongly when the solar system was young. It probably kicked billions of leftover planetary building blocks out into interstellar space, never to see their stellar home again. It also influenced the orbits of the other planets, and may even have pushed some small inner planets into the Sun. That would have cleared the way for the formation of today's inner planets, including Earth.

Spica looks like a single pinpoint of light. In reality, though, it consists of two big, heavy stars locked in a tight orbit around each other. One of the stars is about 10 times as massive as the Sun, while the other is relatively puny at only six times the Sun's mass. That puts both of them in the top one percent of the top one percent of all the stars in the galaxy.

The more massive star faces a brilliant demise. Within a few million years, it probably will explode as a supernova. For a few days, it may outshine all the other stars in the Milky Way galaxy combined, providing a giant going-away party for a giant star.

Planetary Pulsations

If any planets were born with the star known as PSR 1257+12, they've long since vanished. A billion years ago or longer, the star exploded as a supernova, turning any worlds around it into cosmic dust. The star got a second chance at planetary parenthood, though. Not long after the blast, gas and dust fell back toward the star's corpse — a superdense knot known as a neutron star. Some of this material coalesced to give birth to at least three new planets.

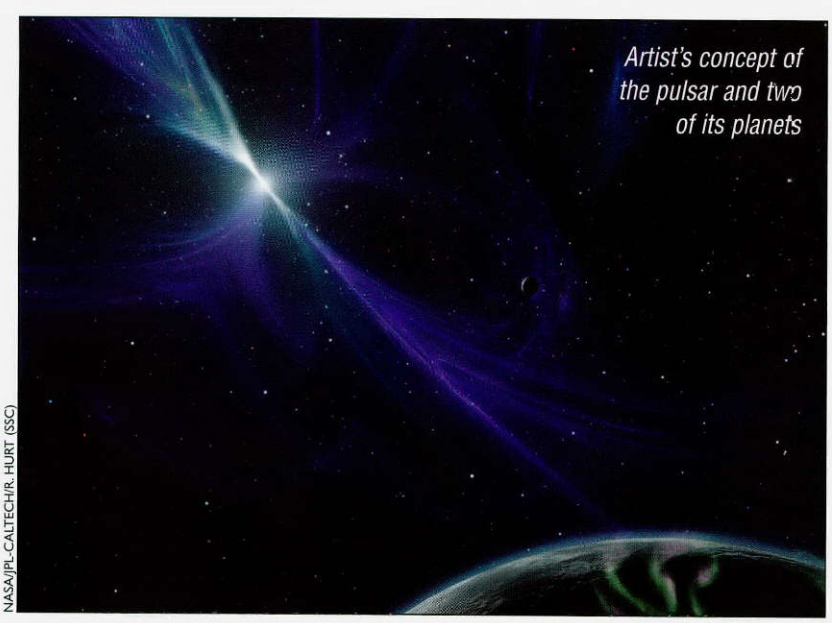
The second-generation worlds of PSR 1257+12 were the first exoplanets ever discovered. A team led by Alexander Wolszcan found the first of them 25 years ago.

Wolszcan and his colleagues were studying PSR 1257+12 with the giant Arecibo radio telescope in Puerto Rico. The neutron star, which is 1.4 times the mass of the Sun but no bigger than a small American city, spins almost 10,000 times per second, emitting pulses of radio waves with each turn (hence another name for this type of dead star: pulsar).

A pulsar's signals are as regular as the ticking of an atomic clock. Yet in January 1992, the astronomers discovered tiny changes in the timing of the pulses of PSR 1257+12. Those changes are caused by the planets. Their gravity tugs at the pulsar, causing it to wobble back and forth a tiny bit, changing the cadence of its pulses.

From those changes, the astronomers calculated that the planets range from about the mass of the Moon to about four times the mass of Earth. Each orbits the star in just a few weeks.

Today, these worlds are awash in radiation which may be peeling away their outer layers like cosmic onions. So while they may be the first exoplanets ever discovered, they may be the last place to look for signs of life beyond Earth.



Artist's concept of the pulsar and two of its planets

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

KEY DATES

Grissom, White, and Chaffee at the Florida launch pad.

NASA

January 27

The race to the Moon took a big step backward on this date in 1967 when three astronauts died in a launch pad fire. Virgil "Gus" Grissom, Ed White, and Roger Chaffee were rehearsing for the Apollo 1 flight, scheduled for just a month later, when a spark ignited in the spacecraft. The combination of a pure oxygen environment, flammable materials, and a hard-to-open hatch doomed the crew. It took 21 months to redesign the spacecraft and fly the first manned mission.

SKY WATCH

Meteor Showers

Shower	Peak	Moon
Quadrantids	Night of January 2	Sets around midnight
Lyrids	Night of April 21	Morning crescent
Eta Aquarids	Night of May 5	In view most of night
Perseids	Night of August 12	In view most of night
Orionids	Night of October 21	Evening crescent
Leonids	Night of November 16	New Moon
Geminids	Night of December 13	Morning crescent

- Actual times may vary.
- For most showers, the best view comes after local midnight.
- The glare of a bright Moon makes it harder to see the meteors.

Source: International Meteor Organization

Moon phases are Central Time.

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

PERIGEE January 10 | **APOGEE** January 21

FEBRUARY

OVERVIEW

Venus and Mars remain steady companions in the early evening sky this month. Venus, the Evening Star, is the brighter of the two, with orange Mars staying just above it. One of the first signs of spring, the constellation Leo, begins poking its nose into the eastern evening sky, and clears the horizon by around nightfall at month's end.

HIGHLIGHTS

1 Venus and Mars line up to the lower right of the Moon as evening twilight fades away.

5 Aldebaran, the bright orange eye of the bull, stands quite close to the Moon tonight.

FEATURED EVENT

7 Several bright, prominent stars surround the Moon tonight.

8 The Moon stands about halfway between Procyon and Pollux.

10 A penumbral eclipse will be visible from North America tonight, as the Moon passes through the Sun's outer shadow. The shadow is so faint, though, that most skywatchers won't notice it.

10-11 Regulus, the heart of Leo, crouches close to the lower left of the Moon at nightfall on the 10th, and farther to the upper right of the Moon on the 11th

15-16 The brilliant planet Jupiter and the star Spica stand below the Moon as they climb into good view in the wee hours of the 15th, and above the Moon on the 16th.

16-17 Venus is at its brightest for its current Evening Star appearance.

19 Antares, the leading light of Scorpius, stands below the Moon at first light.

20-21 The planet Saturn stands below the Moon at first light on the 20th, and to the right of the Moon on the 21st, with Antares to their right.

26 An annular solar eclipse will be visible across parts of the southern hemisphere.

28 Brilliant Venus shines to the upper right of the Moon at nightfall, with Mars above them.

FEBRUARY

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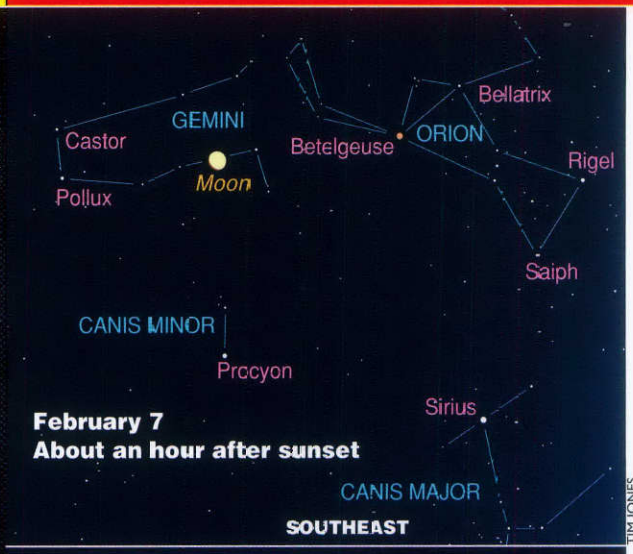


TIM JONES

FEATURED EVENT

Pointing the Way

If you keep promising to learn a few constellations and bright stars but never seem to find the time, the night of February 7 offers an easy way to check a few of each off the list. That's because several prominent stars will surround the gibbous Moon, making it easy to find the stars and their home constellations.

As twilight fades away, look for two bright stars that stand to the left of the Moon by less than twice the width of your fist held at arm's length. These are Pollux (the brighter one) and Castor (above it), the twins of Gemini. Pollux is a stellar giant that is nearing the end of its life, while Castor is a system of at least six stars.

Next, look about the same distance to the right of the Moon for Betelgeuse, the bright orange star that marks the shoulder of Orion. Betelgeuse is a supergiant — a type of star that is many times heavier than the Sun, hundreds of times wider, and tens of thousands of times brighter. Relatively soon (on the astronomical timescale), the star will explode as a supernova, briefly outshining all the other stars in the galaxy combined.

The same fate awaits most of the other bright stars of Orion, which stretch to the lower right of Betelgeuse. Three stars form a compact line known as Orion's Belt, with Rigel, the constellation's brightest star, on the opposite side of the belt from Betelgeuse.

Canis Minor, the little dog, stands below the Moon, marked by its single bright star, Procyon. The star's name means "before the dog," telling us that it rises slightly before the Dog Star, Sirius, from most northern latitudes. Sirius itself (in Canis Major, the big dog) stands down to the lower right of Procyon, twinkling fiercely through the winter night.

That gives you four constellations in a single quick glance, perhaps jump-starting those plans to learn more of the geography of the night sky.

A Big, Hot Surprise

The discovery of the planet 51 Pegasi b established a long list of "firsts." It was the first planet discovered orbiting a main-sequence star, which is a type of star that, like the Sun, is in the prime of life. It was the first planet discovered with a technique that measures a "wiggle" in the parent star's light. And it was the first of a new class of planets, dubbed "hot Jupiters."

University of Geneva astronomers Michel Mayor and Didier Queloz announced the discovery in October 1995. They found the planet using a technique called radial velocity. It measures a star's back-and-forth motion in response to the gravitational pull of the orbiting planet. It became the leading planet-discovery technique for more than a decade.

The planet itself was a big surprise. It orbits the star, 51 Pegasi, at a distance of just four million miles, which is much closer than Mercury, the solar system's inner planet, is to the Sun. Yet the planet is bigger than Jupiter, the giant of the solar system, but only about half as massive. (Because of its mass, the International Astronomical Union later named the planet Dimidium, Latin for "half.") Theories of planet formation, though, said that such worlds should not exist, because conditions so close to the star would be too hot to allow gas to accumulate to form a massive body.

Over the next few years, however, the radial velocity technique revealed many more hot Jupiters orbiting other stars. Such planets are relatively easy to find because they exert a stronger pull on their stars. That led astronomers to theorize that hot Jupiters actually formed farther from their stars, then spiraled inward as a result of gravitational interactions with other planets. That process may have shoved any close-in planets into their stars.

The planet is so close to 51 Pegasi that the top of its atmosphere may sizzle at 1,800 degrees Fahrenheit (1,000 C), inflating the planet's diameter — creating the first known hot Jupiter.

An artist's concept of 51 Pegasi b

ESO/M. KORNMESSER/NICK RISINGER

KEY DATES

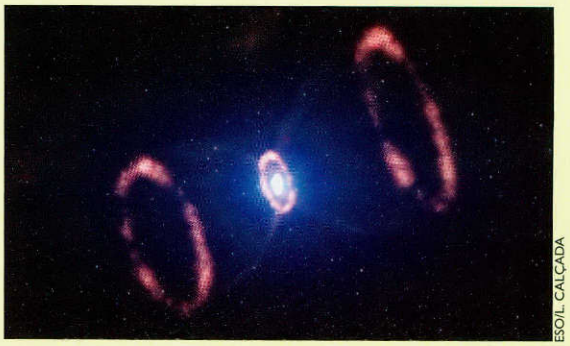
February 2

CALENDAR EVENT

Legend says that if a groundhog sees its shadow when it pokes its head out of its burrow on February 2, 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.

February 23

The brightest supernova seen in Earth's skies in several centuries flared to life in the Large Magellanic Cloud, a small companion galaxy to the Milky Way. From the southern hemisphere, Supernova 1987A was visible to the unaided eye. Astronomers continue to monitor the star today as the cloud of debris expands into interstellar space.

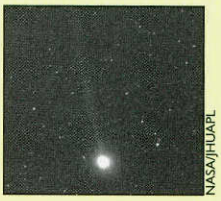


ESO/L. CALÇADA

An artist's concept shows the supernova today. The rings are caused by a shockwave ramming into material expelled by the star before it exploded.

STAR WATCH

One of the best chances to a see a comet this year comes in late February and early March, when Encke's Comet climbs into the western evening sky. It stands to the lower right of Venus, the Evening Star, on February 20, when it may be bright enough to detect with binoculars. It moves farther from Venus after that, but it also grows brighter. It will form a triangle with Venus and the Moon on February 28, then quickly disappear in the evening twilight as March begins.



NASA/JHUAPL

A view of Encke from a spacecraft orbiting Mercury

The comet was discovered in 1786, but was named for the astronomer who first plotted its orbit, Johann Franz Encke. It is about three miles (4.8 km) in diameter, and orbits the Sun once every 3.3 years. It will make its closest approach to the Sun on March 9, at a distance of about 32 million miles (51 million km).

Moon phases are Central Time.

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

PERIGEE February 6

APOGEE February 18

MARCH

OVERVIEW

Leo takes its rightful place as the lord of the skies on March nights. The lion is in good view in the east as darkness falls, and springs high across the sky during the night. The bright planet Jupiter trails far behind it, near Spica, the brightest star of Virgo. And the even brighter planet Venus changes addresses during the month. It is the brilliant Evening Star as the month begins, but switches to the morning sky by month's end.

HIGHLIGHTS

1 Mars poses close to the right of the Moon as night falls, with brighter Venus to their lower right.

2 Mars and Venus align to the lower right of the crescent Moon.

4 Aldebaran, the brightest star of Taurus, stands quite close to the upper left of the Moon at nightfall. As seen from the United States, the Moon will pass directly in front of the star a bit later, blocking it from view.

9-10 Regulus, the heart of the lion, stands to the lower left of the Moon at nightfall on the 9th, and closer above the Moon on the 10th.

12 Daylight Saving Time begins in the United States at 2 a.m. local time.

13-14 Bright Jupiter and the fainter star Spica rise below the Moon late on the evening of the 13th, and almost even with it on the 14th.

19 Antares, the heart of the scorpion, stands to the lower right of the Moon at first light, with the planet Saturn about the same distance to the lower left of the Moon.

FEATURED EVENT

20 Spring arrives in the northern hemisphere at 5:29 a.m. CDT.

20 Saturn lurks close to the lower right of the Moon at first light.

25 Venus crosses the line between Earth and the Sun today, and is lost in the Sun's glare. It soon will return to view as the Morning Star.

29 Mercury, the Sun's closest planet, is in good view to the lower right of the Moon as darkness falls, with Mars almost directly above the Moon.

30 Mars snuggles to the lower right of the Moon at nightfall.

31 Aldebaran stands to the upper left of the Moon this evening.

MARCH

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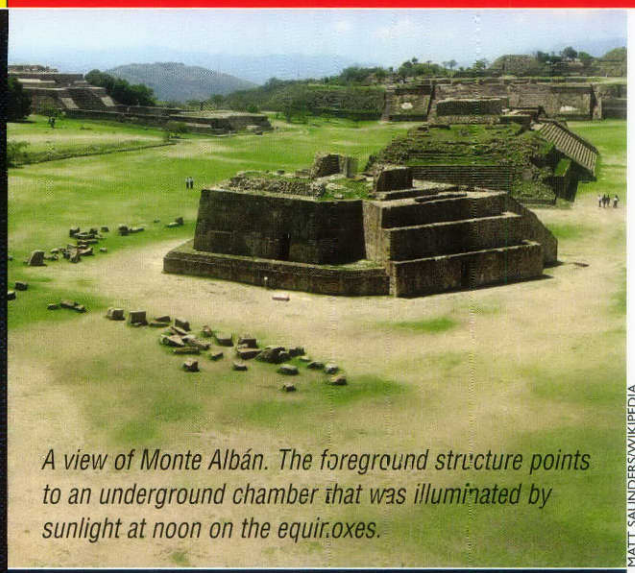


A view of Monte Albán. The foreground structure points to an underground chamber that was illuminated by sunlight at noon on the equinoxes.

MATT SAUNDERS/WIKIPEDIA

FEATURED EVENT

Springing a New Season

Spring arrives in the northern hemisphere at the vernal equinox, on March 20, which is the moment the Sun crosses the celestial equator from south to north.

If you stand on the equator on that date, you might notice something interesting at local noon (the moment when the Sun stands directly overhead). You would not cast a shadow. The same thing will happen for latitudes up to 23.5 degrees north sometime between the equinox and the summer solstice, in June.

Such an occurrence held deep significance for many cultures. The point directly overhead, called the zenith, was considered the pinnacle of heaven. Since the Sun often represented one of the most important gods, its passage through the zenith was a profound event.

In South America, for example, the Inca erected tall poles or columns to help them anticipate the Sun's passage through the zenith. According to an early Spanish settler, the Inca set up poles at sites both north and south of the equator. A large group of them was assembled near present-day Quito, Ecuador, which sits almost astride the equator. According to Inca tradition, when the shadows vanished, the Sun god descended to Earth.

The cultures of Mesoamerica paid close attention to the zenith as well. In the city of Monte Albán, built by the Zapotec of present-day southern Mexico, one building contains a small room with a 15-foot tube to the surface. When the Sun passed through the zenith, it shone straight down the tube, filling the room with light. A smaller tube illuminated a room at a Mayan city. These devices helped residents celebrate the Sun — and the sacred zenith.

From the continental United States, the Sun never climbs quite high enough to stand directly overhead, so we see our shadows every sunny day.

Looking for Dark Crossings

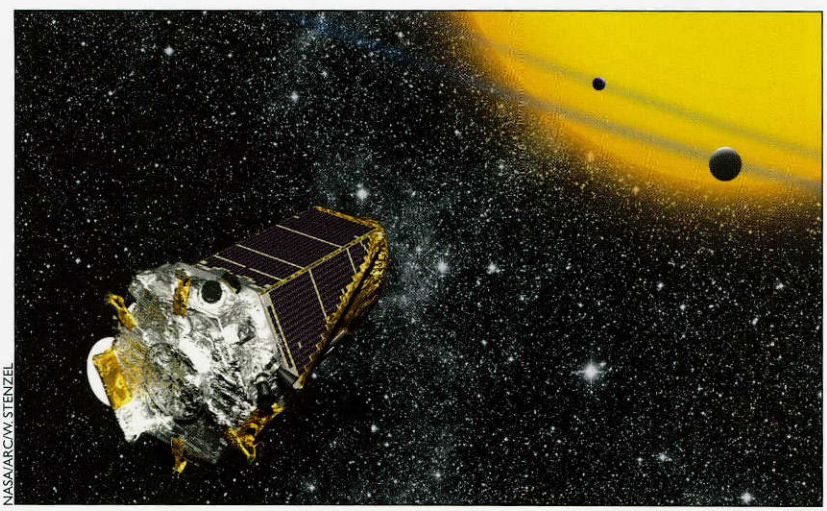
On a single day in May 2016, the number of confirmed exoplanets jumped by more than a third, when scientists with the Kepler mission announced the discovery of 1,284 new worlds. That solidified Kepler's spot as the champion of planet hunters.

The space telescope was launched in 2009, and spent the next four years staring at 150,000 stars in a small patch of the northern sky. It was designed to look for transits in which a planet passes directly in front of a star, briefly blocking a small fraction of its light. The combination of observations by Kepler and ground-based telescopes can reveal a planet's size, mass, and distance from its star.

The mission was a smashing success. As of late 2016, it had confirmed more than 2,300 planets, with astronomers trying to confirm the existence of thousands of additional candidate worlds. The list of discoveries includes a score of planets that are close to the size of Earth that orbit in the habitable zone, which is the distance from a star at which temperatures are just right for liquid water. Such worlds are considered the best possibilities for supporting Earth-like life.

Kepler's pointing system failed in 2013, but engineers worked out a new mission that allows the craft to watch separate patches of sky for almost three months at a time. Known as K2, this mission began in 2014 and has been extended through 2019. It has revealed more than 100 additional planets, mainly around the small, faint stars known as red dwarfs.

Ground-based transit searches, often using telescopes as small as a few inches in diameter, have detected more than 100 planets on their own, helping make transit detection the king of exoplanet discovery techniques.



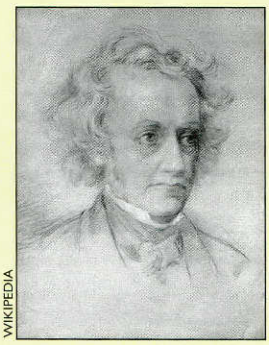
NASA/ARC/W. STENZEL

Kepler watches two exoplanets transit their star in this artist's concept.

KEY DATES

March 2

A small asteroid known as 2012 DR32 will pass about 650,000 miles (more than one million km) from Earth, which is less than three times the distance from Earth to the Moon. It is one of the closest known approaches of any asteroid this year.



WIKIPEDIA

A portrait of John Herschel by his daughter

March 7

John Herschel was born in Slough, England, 225 years ago. The son of William Herschel, who discovered the planet Uranus, John conducted an extensive survey of southern-hemisphere skies from South Africa. He also published a catalog of nebulae and star clusters, and was a founder of the Royal Astronomical Society.

THE BASICS

Tilting Toward Summer

The seasons are caused by Earth's tilt on its axis. As Earth orbits the Sun, the north pole appears to "nod" up and down as viewed from the Sun. It nods most directly toward the Sun at the June solstice, which is the beginning of summer and the longest day of the year in the northern hemisphere. Six months later, however, as Earth moves halfway around its orbit, the north pole nods away from the Sun, so it's winter (and the shortest day of the year) in the northern hemisphere and summer in the southern hemisphere. The equinoxes occur between the solstices, when the Sun crosses the equator.

Moon phases are Central Time.

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

PERIGEE
March 3, 30

APOGEE
March 18

APRIL

OVERVIEW

The brightest objects in the night sky other than the Moon bracket the mornings this month. Venus reigns as the brilliant Morning Star in the east, with next-brightest Jupiter on the opposite side of the sky. Venus is quite low as April begins, but climbs higher as the month progresses. Jupiter is well up in the sky in early April, but sets around dawn by the end of the month.

HIGHLIGHTS

1 Two orange stars stand close to the Moon as night falls. Betelgeuse is to the left of the Moon, with Aldebaran about the same distance to the lower right of the Moon.

6 Regulus, the heart of Leo, is the bright star quite close to the Moon tonight.

FEATURED EVENT

7 The giant planet Jupiter is at opposition.

9 Jupiter stands to the lower left of the Moon at nightfall, with the star Spica below Jupiter.

10 Jupiter lurks quite close to the Moon tonight, with Spica close by.

15 Antares, the brightest star of Scorpius, is below the Moon at dawn.

16 Saturn is close to the lower left of the Moon at dawn.

23 Venus, the Morning Star, rises to the upper left of the Moon in dawn's early twilight.

27 Orange Aldebaran and Mars perch to the upper left and upper right of the Moon, respectively, as evening twilight fades.

28 Aldebaran is close to the lower right of the Moon as twilight fades.

APRIL

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30						

The Great Red Spot and surrounding storms as seen from the Cassini spacecraft

NASA/JPL

FEATURED EVENT

Giant Storms on a Giant World

Jupiter is the behemoth of the solar system's planets. It is 11 times Earth's diameter, and more massive than all the other planets and moons combined. And its thick atmosphere may be the most turbulent, with storm systems that can be the size of continents or larger whirling away through its colorful clouds.

Jupiter rotates on its axis roughly every 10 hours, which stretches the clouds into wide bands. Some of the bands are higher than the others, with water vapor and other compounds climbing on powerful updrafts of warm air. These bands alternate with lower decks, where the cloud material cools and sinks back into the atmosphere.

The transition zones between these bands cause wind shear, which stirs up giant storms. The largest, the Great Red Spot, is big enough to swallow Earth. Its shield of reddish clouds extends high above the surrounding layers, and winds at its perimeter howl at up to several hundred miles per hour.

The Great Red Spot may have been around since at least the late 1600s. It has stayed at the same latitude (in the southern hemisphere), but has drifted in longitude. More intriguingly, it has changed size and color over the centuries. At its peak, it was about three times Earth's diameter. In recent years, though, it has shrunk considerably. At the same time, its color has faded from brilliant red to a pale pinkish-orange. Planetary scientists don't fully understand the dynamics that sculpt this powerful storm.

The Great Red Spot is easily visible through most telescopes. And this month presents an especially good opportunity to look for it, because Jupiter is at opposition. It lines up opposite the Sun, so it rises at sunset and is in the sky all night. It is closest to Earth as well, so it's at its brightest, outshining everything except the Moon and Venus. It appears larger than at any other time of year, making it especially easy to pick out its cloud bands.

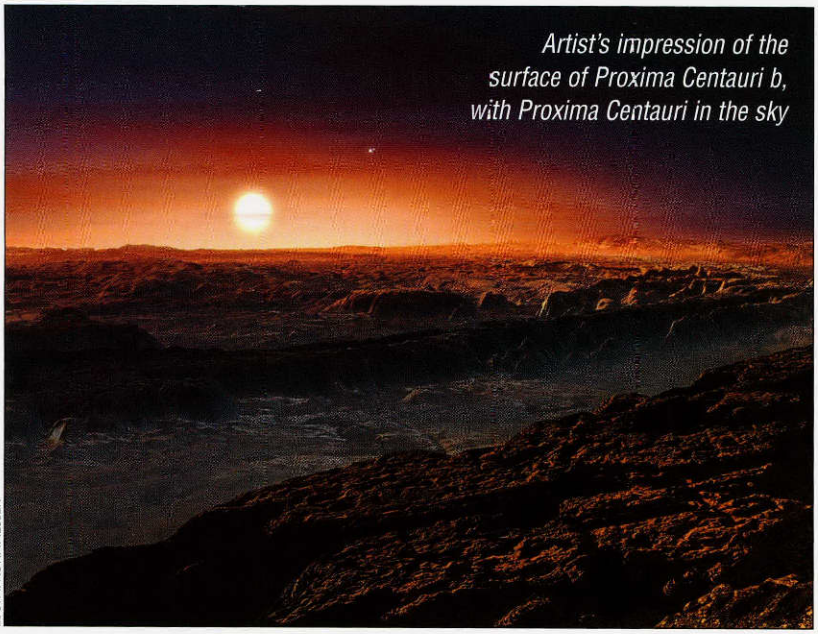
Closing in on Another Earth

When Russian billionaire Yuri Milner last year announced plans to develop a tiny starship to travel to our nearest stellar neighbor, Proxima Centauri, which is just 4.2 light-years away, no one knew whether there were any planets for the postage-stamp-size probe to explore. But just months after the birth of Breakthrough Starshot, astronomers announced the detection of the planetary equivalent of the Holy Grail there: an Earth-size planet orbiting in the habitable zone, which is the distance from the star where temperatures are just right for liquid water, a necessary ingredient for Earth-like life. In fact, Proxima Centauri b may be the most Earth-like planet yet discovered.

Astronomers have compiled a growing list of habitable-zone planets. Depending on how liberally you define such a zone, the list may include a couple of dozen worlds. Most of them are gas giants like Jupiter, the giant of our own solar system, so they are unlikely to harbor Earth-like life (although they could have habitable moons). Some, however, are rocky worlds up to a few times the mass of Earth, including a few that appear to have atmospheres.

Proxima Centauri b is the most intriguing of the bunch. It is only slightly larger and heavier than Earth. It orbits Proxima once every 11 days at just five percent of the distance from Earth to the Sun. Proxima Centauri is so small and faint, however, that the planet's surface is estimated to be slightly cooler than Earth's. The planet probably is locked so that the same hemisphere always faces the star, just as the same side of the Moon always faces Earth.

No one knows yet if the planet has water or an atmosphere. But if a probe ever visits Proxima Centauri, at least it'll have an interesting world to explore.



Artist's impression of the surface of Proxima Centauri b, with Proxima Centauri in the sky

ESO/M. KORNMESSER

KEY DATES

April 24

WIKIPEDIA

Just three months after the American Moon-landing program suffered a crushing setback with the death of three astronauts (see January), the Soviet program experienced its own catastrophe. The first flight of the new Soyuz spacecraft, launched on April 23, 1967, ended in disaster the following day when its parachute became tangled and it crashed, killing cosmonaut Vladimir Komarov. The flight was marred by many problems, suggesting that the Soyuz was not yet ready to fly. It didn't return to flight until October 1968. Today, however, a modified version of the Soyuz continues to ferry cosmonauts and American astronauts to orbit.

SKY WATCH

Viewing the Planets*

Venus
The brilliant morning or evening star starts 2017 in the evening sky, where it remains through mid-March. It then disappears in the Sun's glare, but returns to view in the morning sky by late March or early April.

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

Mars
The Red Planet shines brightest this year in January, when it's in the evening sky. It disappears in the Sun's glare in early June, then climbs into the morning sky in September.

Mercury
The Sun's closest planet is at its best this year in the dawn sky in mid-September, and in the evening sky in early April.

Saturn
The ringed planet shines brightest this year in June, as it moves through Ophiuchus, the serpent bearer.

Uranus
The seventh planet is at its brightest in October, in Pisces, when it barely reaches naked-eye visibility. You need very dark skies and good eyes to spot it.

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

Moon phases are Central Time.

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

APOGEE
April 15

PERIGEE
April 27

MAY

OVERVIEW

The bright lights of spring take over the night sky. Regulus leads Leo across the sky, with the lion's head and mane spreading above it in the evening hours, and its body and tail to the left and upper left. The tail ends at another bright star, Denebola. Spica, the leading light of Virgo, follows Leo, with the brilliant planet Jupiter close by.

HIGHLIGHTS

3-4 Regulus stands close to the left of the Moon at nightfall on the 3rd, and a bit farther to the upper right of the Moon on the 4th.

6 Bright Jupiter lines up to the lower left of the Moon at nightfall, with the star Spica below Jupiter.

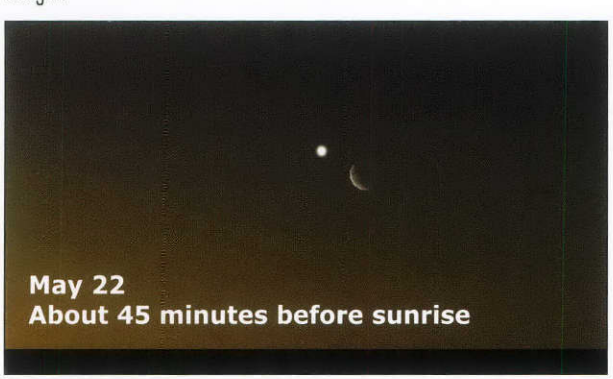
7 Jupiter is quite close to the Moon this evening, with Spica farther below the Moon.

8 Spica is close to the right of the Moon at nightfall.

11 Antares, the brightest star of Scorpius, is to the lower right of the Moon as they rise in late evening.

12 The planet Saturn poses to the lower left of the Moon as they climb into good view around midnight tonight, with Antares to their right.

13 Saturn is close to the right of the Moon as they climb into view late tonight.



May 22
About 45 minutes before sunrise

21-22 Brilliant Venus stands to the lower left of the Moon at first light on the 21st, and closer to the Moon on the 22nd.

31 The Moon sweeps past Regulus for the second time this month, in the western sky at nightfall.

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			

Venus rises above Earth's atmosphere in this view from the International Space Station.

NASA

FEATURED EVENT

Uniting Morning and Evening Stars

In modern times, it seems obvious that the Morning Star and Evening Star are the same object. They are the same brightness, they are in view for equal spans, and like Clark Kent and Superman, you never see both of them at the same time.

There's no secret to their twin identities, though. Both are the planet Venus, the brightest object in the night sky other than the Moon. Yet it took some cultures a while to figure that out. The Greeks, for example thought of them as two separate objects. The Morning Star was Phosphoros, while the Evening Star was Hesperos. The Greeks didn't unite the two until about 2,500 years ago.

One culture that wasn't fooled by Venus' dual identity was the Maya of Central America. Venus was the most important object in the night sky, playing key roles in everything from festivals to warfare. So the Maya carefully plotted Venus' motions across the sky. They developed tables that allowed them to predict just where Venus would be far in the future — morning or evening.

Venus shines so brightly for several reasons. First, it's Earth's closest planetary neighbor, passing as little as 27 million miles (45 million km) from us. Second, it's the second planet from the Sun, so it receives a lot of sunlight. And third, its atmosphere is topped by bright clouds, which reflect about two-thirds of the sunlight that strikes them.

Venus moves from morning sky to evening sky when it passes behind the Sun. At that distance, it remains out of view for more than two months. It moves back to the evening sky when it crosses between Earth and Sun, so it's hidden in the Sun's glare for only a few days.

Venus made the transition back in March, and is now entrenched as the Morning Star. It will remain in view until around Thanksgiving, when it will disappear in the Sun's glare, not to return until next year — as the Evening Star.

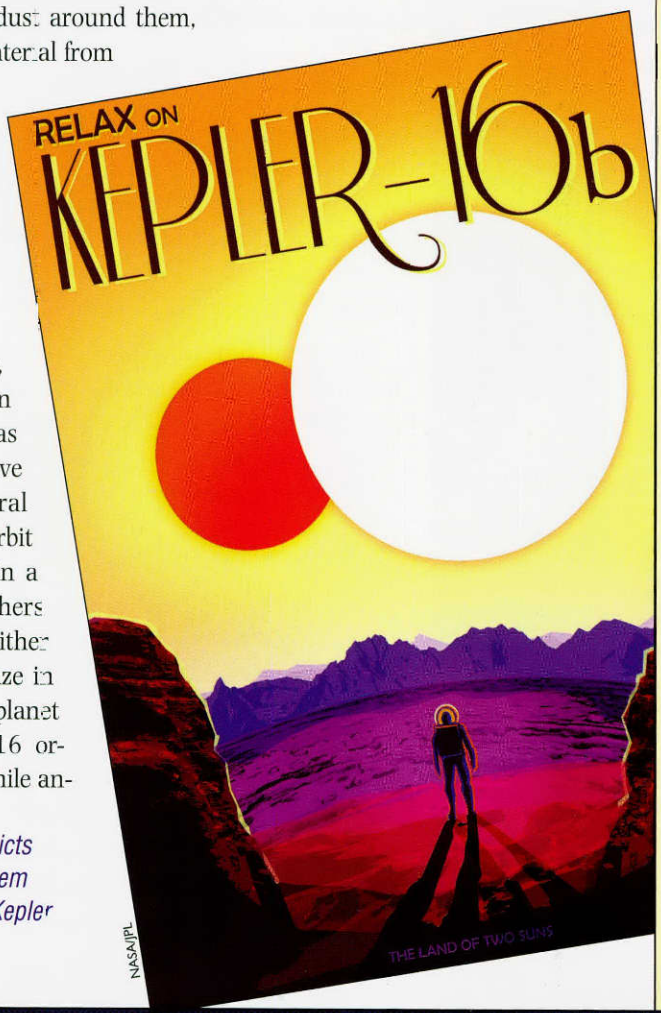
Two Sunsets are Better Than One

If real-life planet hunters could visit any fictional planet of their choosing, there might be a mad dash for Tatooine, the home world of Luke Skywalker. The first *Star Wars* movie, which premiered 40 years ago this month, features an iconic view of Luke watching as twin suns set over the desert. Today, any planet found to have two suns is instantly compared to that famous world.

At the time the first movie was released, many astronomers might have been skeptical of the configuration. They presumed that young binary star systems would stir up the disks of gas and dust around them, preventing the material from coalescing to form planets. And even if planets did form, it would be difficult for them to maintain stable orbits.

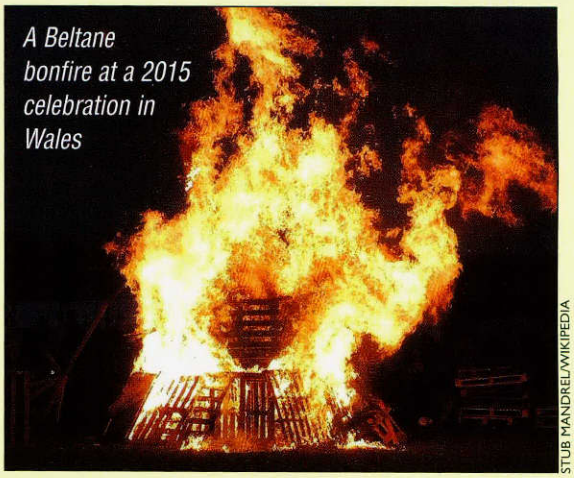
The reality, though, has been quite different, as astronomers have discovered several Tatooines. Some orbit one of the stars in a binary, while others orbit both stars. Either way, two suns blaze in their skies. (One planet discovered in 2016 orbits three stars, while another system, also found last year, has two planets orbiting one star in a binary, and a third planet orbiting the other star.)

The planets discovered in binary systems to date are either outside the habitable zone or they are giant worlds that are not likely homes for life. But a study in 2015 concluded that Earth-like worlds in Earth-like orbits could be relatively common in binary systems, increasing the odds that a real Tatooine could be whirling through the galaxy, with two stars illuminating any life on the planet.



A NASA poster depicts a Tatooine-like system discovered by the Kepler space telescope.

KEY DATES



A Beltane bonfire at a 2015 celebration in Wales

STUB MANDREL/WIKIPEDIA

May 1

CALENDAR EVENT

Today is the date of Beltane, an ancient Celtic festival that was celebrated with bonfires. The date is a cross-quarter day, which falls roughly halfway between a solstice and an equinox. In many cultures, these dates marked the beginning of the seasons, so May 1 was the first day of summer. Some of the traditions of Beltane are preserved as May Day.

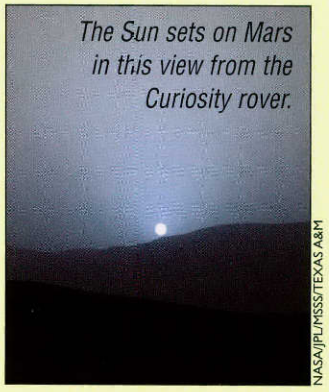
May 4

Fans around the world celebrate today as Star Wars Day. (The first movie in the series, known today as *Episode IV: A New Hope*, premiered 40 years ago this month.) May the fourth be with you!

www.starwars.com/may-the-4th

May 5

Spring begins in the northern hemisphere of Mars and autumn in its southern hemisphere today, as the Sun crosses the planet's equator from south to north.



The Sun sets on Mars in this view from the Curiosity rover.

NASA/JPL/MSSS/TEXAS A&M

Moon phases are Central Time.

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

APOGEE
May 12

PERIGEE
May 25

JUNE

OVERVIEW

June offers warm nights for watching the sky but a limited amount of time to enjoy the view, with the longest days and shortest nights of the year. Even so, there is plenty to look at, with Leo diving toward the western horizon in early evening and the Summer Triangle climbing into view in the east. The triangle's leading light, Vega, is the second-brightest star visible from most of the United States on summer evenings, only a fraction fainter than Arcturus, which is high in the south at nightfall.

HIGHLIGHTS

2-4 The Moon passes by the brilliant planet Jupiter and the fainter star Spica on these evenings. They line up to the left of the Moon on the 2nd, with Jupiter quite close to the Moon on the 3rd and Spica close to the lower right of the Moon on the 4th.

7-9 Antares and Saturn are next up for the Moon. Antares, the heart of Scorpius, stands directly below the Moon as darkness falls on the 7th. On the 8th, Antares is to the lower right of the Moon, with brighter Saturn to the lower left. And Saturn is quite close to the Moon on the 9th.

FEATURED EVENT

15 Saturn, the second-largest planet in the solar system, is at opposition.

20 Summer arrives in the northern hemisphere at 11:24 p.m. CDT, the moment of the June solstice. The Sun stands farthest north for the year today, which is the longest day of the year north of the equator.

20-21 Venus, the Morning Star, stands to the left of the Moon at first light on the 20th, and about the same distance to the upper right of the Moon on the 21st.

27 Regulus, the heart of the lion, stands just a whisker from the Moon as night falls.

30 Brilliant Jupiter perches close to the left of the Moon as night falls, with the star Spica to their left.

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
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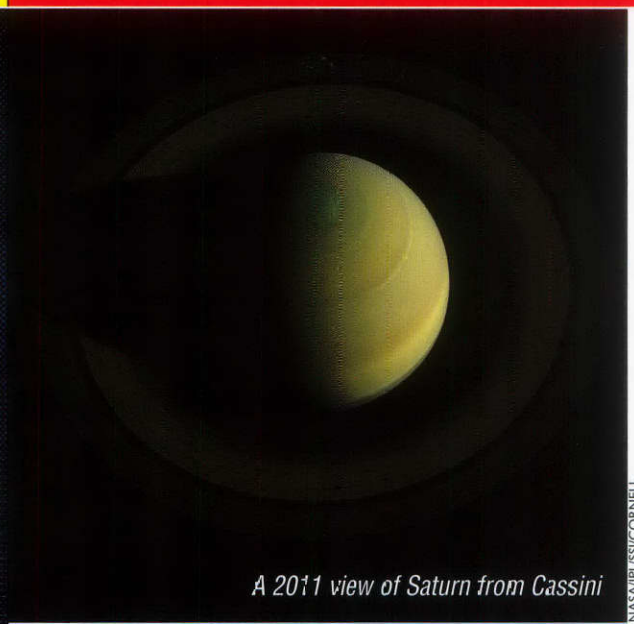


A 2011 view of Saturn from Cassini

NASA/JPL/SSI/CORNELL

FEATURED EVENT

A 'Superior' Planet

Saturn is a superior planet. That's not because it is bigger than Earth (about 9.5 times Earth's diameter), because it has more moons (60-plus), or because its rings make it the beauty of the solar system. Instead, it's because Saturn orbits outside Earth's orbit, which in astronomical jargon qualifies it as a "superior" planet.

The effect of that superiority is on display this month, as Saturn reaches opposition, when it lines up opposite the Sun in our sky. The planet remains in view all night, sliding about halfway up the southern sky after midnight. Saturn is also brightest for the year, shining like a brilliant golden star; only the Moon and a handful of planets and stars will outshine it.

Earth is the third planet from the Sun, so only two planets are inferior to it: Mercury and Venus. Since their orbits are inside Earth's, neither planet strays far from the Sun in our sky.

The other five major planets are superior, although only Saturn, Jupiter, and Mars are easily visible to the unaided eye. These planets can loop "behind" Earth, lining up opposite the Sun and remaining in view throughout the night. They are closest to Earth around the time of opposition as well, so they shine brightest then.

Saturn is so far from the Sun that it takes almost 30 years to complete a full circle through the background of stars. At that pace, it comes to opposition about every 12.5 months (compared to 13 months for Jupiter and 26 months for much closer Mars).

At opposition, Saturn is still about 800 million miles (1.3 million km) from Earth. Yet its great size, combined with its "superior" location, help make the giant planet one of the skywatching treats of late spring and early summer.

Planets by the Bunch

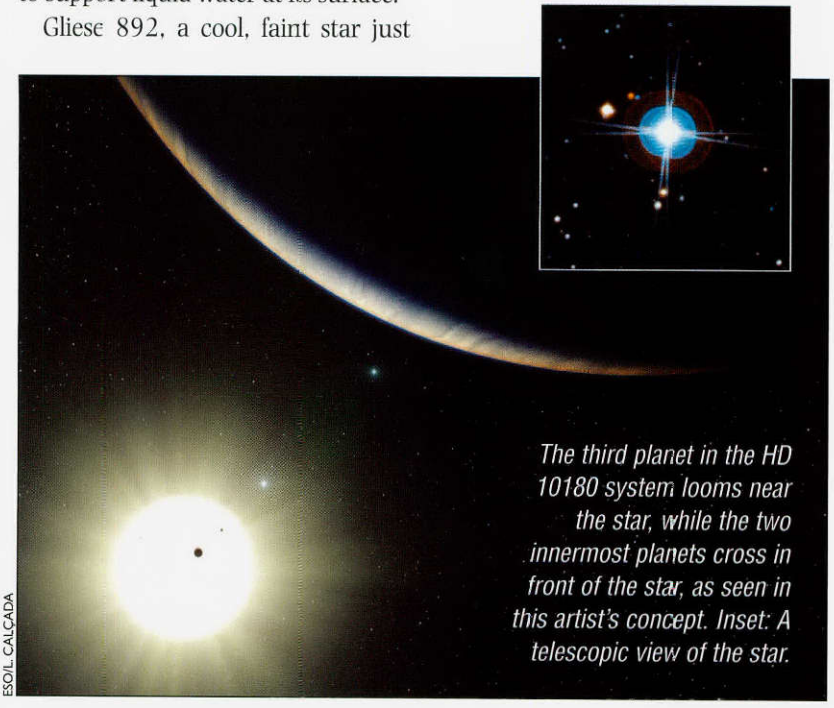
Like bananas and flowers, exoplanets sometimes come in bunches. Astronomers have discovered hundreds of systems with at least two planets, and a few that appear to have six or more.

Such systems are of particular interest because they most closely resemble our own solar system. Studying these planetary families may therefore reveal new details about the birth and evolution of Earth and its sibling worlds.

Kepler-90, a star that's a bit bigger and hotter than the Sun but only half as old, appears to host at least seven planets, none of which is farther out than Earth is from the Sun. Its closest planet, which is likely to be a dense chunk of rock, is only about seven million miles out, which means its surface is likely to be molten. Even the farthest planet is likely to be too hot to support liquid water at its surface.

Gliese 892, a cool, faint star just 21 light-years away, in Cassiopeia, appears to have at least six planets (several of which were confirmed by 27 years of observations at McDonald Observatory). Five of the planets are closer to the star than Mercury is to the Sun. Because the star is so faint, however, the outermost of these worlds may lie within Gliese 892's habitable zone.

Perhaps the most populous system yet discovered is HD 10180, which is about 127 light-years away. It hosts at least six planets, with one study suggesting as many as nine. The system's star is a near-twin to the Sun, with roughly the same size, mass, and age. One of its planets appears to remain inside the star's habitable zone. The planet itself is a giant, making it an unlikely home for life, but if it has any large moons, they might be more hospitable.

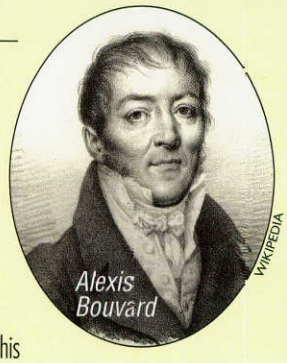


The third planet in the HD 10180 system looms near the star, while the two innermost planets cross in front of the star, as seen in this artist's concept. Inset: A telescopic view of the star.

ESO/L. CALÇADA

KEY DATES

June 27



Alexis Bouvard, the man who first suspected the existence of an eighth planet, was born 250 years ago, in France. He compiled detailed tables of the positions of the known giant outer planets, Jupiter, Saturn, and Uranus. His plots for Uranus didn't match up with later observations, so Bouvard suggested than the gravity of a more distant planet was tugging at it. After his death, two other astronomers used Bouvard's table to predict the location of the eighth planet, which was quickly discovered. The new world was named Neptune, and today it is the solar system's most remote major planet.

RESOURCES

ONLINE

StarDate Online
Daily skywatching tips, lunar phases, daily StarDate radio program, and other skywatching resources **stardate.org**

Publicly Accessible Telescope Viewing
State-by-state listings **telescopes.stardate.org/guide/public.html**

U.S. Naval Observatory
Custom sunrise/sunset and moonrise/moonset charts and much more
www.usno.navy.mil/USNO/astronomical-applications

SpaceWeather
Updates on solar flares, photo galleries, skywatching news, aurora-watching details **spaceweather.com**

Meteor Shower Calendar
International Meteor Organization **www.imo.net/calendar**

PUBLICATIONS

Observer's Handbook 2017, edited by James Edgar
rasc.ca/handbook

Moon phases are Central Time.

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

APOGEE June 8

PERIGEE June 23

JULY

OVERVIEW

With summer blazing across the northern hemisphere, the season's well-known celestial markers blaze low across the southern sky. Scorpius stands low in the south as night falls, marked by its bright orange "heart," the star Antares. Sagittarius follows it across with the sky. Its brightest stars form the outline of a teapot. And the three points of the Summer Triangle pose high in the east at nightfall and climb across the crown of the sky later on.

HIGHLIGHTS

1 The star Spica stands to the lower left of the Moon at nightfall, with the brighter planet Jupiter to the lower right of the Moon.

FEATURED EVENT

3 Earth is farthest from the Sun for the year today.

5 Antares, the heart of the scorpion, skitters to the lower right of the Moon at nightfall, with the planet Saturn to the lower left of the Moon.

6 Saturn perches close to the lower right of the Moon this evening, with Antares to their right.

11 Aldebaran stands directly below Venus, the Morning Star, at first light. Venus will slide to the lower left over the next few mornings, and will stand almost even with Aldebaran on the 16th and 17th.

19 Aldebaran is to the lower left of the Moon at first light, with Venus to the lower left of Aldebaran.

20 Venus is close to the upper left of the Moon this morning, with Aldebaran to their upper right.

26 Mars is in conjunction with the Sun, passing behind the Sun as seen from Earth, so it is lost in the Sun's glare. It will return to view in the dawn sky in September.

28 Brilliant Jupiter is below the Moon at nightfall, with Spica farther to the lower left of the Moon.

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					

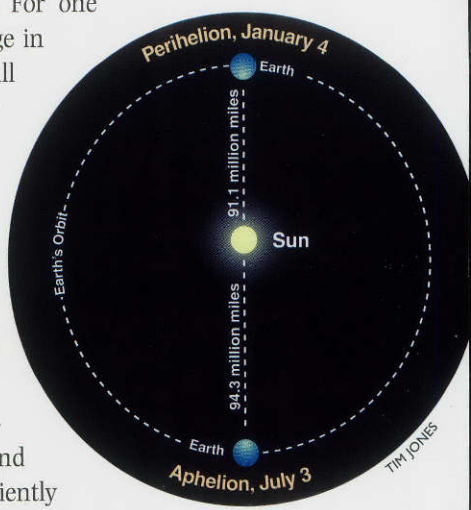
FEATURED EVENT

Hot, Distant Sun

The Sun blazes with all its fury as we head into the hottest part of the year in the northern hemisphere. But the Sun is actually farthest from Earth for the entire year on July 3, a point in Earth's orbit known as aphelion.

Earth's distance from the Sun varies because our planet's orbit isn't a circle. Instead, it's an ellipse, which looks like a stretched-out circle. On average, Earth is about 93 million miles (149 million km) from the Sun. But because of Earth's lopsided orbit, over the course of a year the distance varies by about three percent. So in early July, Earth is about 1.5 million miles (2.5 million km) farther than average, while it's a similar distance closer than average in early January.

If it seems unusual that the hottest days of the year come when we're farthest from the Sun, it's because the distance between Earth and Sun has little to do with Earth's seasons. For one thing, the change in distance isn't all that great, so the amount of sunlight that Earth receives at different times varies by only a few percent. More important, perhaps, the planet's oceans and atmosphere efficiently store and distribute heat around the globe.



The seasons are caused not by any change in distance to the Sun, then, but by Earth's tilt on its axis. During summer, the north polar axis aims more directly at the Sun, so the days are longer and hotter. During winter, the south polar axis points at the Sun, so it is cold in the northern hemisphere.

And since Earth travels slowest when it is farthest from the Sun, as it is this month, summer is the longest season in the northern hemisphere, stretching about four days longer than winter.

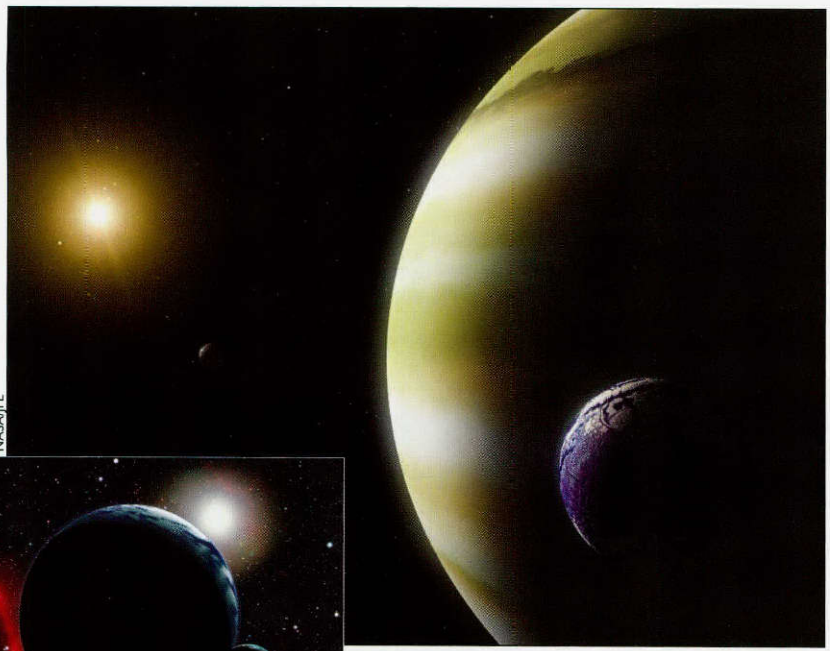
Looking for Moons in the Zone

The giant planets Jupiter and Saturn are unlikely homes for life. They don't have solid surfaces, and conditions in their atmospheres aren't good for the kind of life we have here on Earth. Yet both planets have moons that are considered much more likely abodes for life. The moons have liquid water below their icy crusts, along with sources of energy and the right chemistry for life. That has inspired astronomers to look for moons orbiting planets in other star systems.

They already have discovered several giant planets that are in the habitable zone, which is the distance from a star where temperatures are just right for liquid water on a planet's surface. The planets are too much like Jupiter and Saturn for Earth-like life. If they have big moons, however, those worlds could be good abodes for life — small, rocky worlds with abundant supplies of water.

Simulations have shown that such exomoons could grow to about twice the mass of Mars, which would be a good bit bigger than any moon in the solar system. Such a heavy world could potentially hold on to its water and atmosphere for billions of years, providing plenty of time for life to develop.

So far, no one has seen any exomoons. They are quite hard to detect with current technology. But new telescopes on the ground and in space should have the ability to pluck them from the observations of exoplanets — perhaps revealing some distant homes for life.



NASA/JPL

D. AGUILAR/CfA

Artists' concepts of moons orbiting giant exoplanets

KEY DATES

An artist's concept depicts jets of gamma rays shooting from an exploding star.

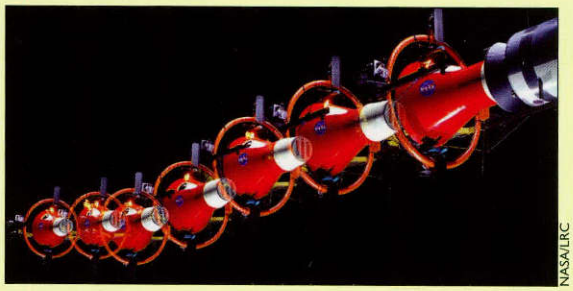
ESO/A. ROQUETTE

July 2

A military satellite designed to look for evidence of nuclear explosions on Earth instead found an even more impressive type of blast in the distant universe in 1967: the first gamma-ray burst. Because astronomers didn't analyze the satellite's readings until much later, however, the discovery wasn't revealed until 1973. Today, we know that such bursts are some of the most powerful events in the universe, emitting as much energy in one second as the Sun will produce in its entire 10-billion-year lifetime. The bursts probably are produced by exploding stars, although the details are still debated.

July 17

In 1917, the National Advisory Committee for Aeronautics broke ground on the first building at Langley Field, Virginia. The new research center there conducted pioneering aviation research, particularly with wind tunnels. In 1958, it was transferred to the newly formed NASA. Langley Research Center hosted the Space Task Group, which launched the first astronauts into space, and in the 1960s it built and operated the Lunar Orbiter series of spacecraft. Apollo astronauts trained there, and part of the Viking mission to Mars was developed at Langley.



NASA/LRC

This multiple-exposure image shows Gemini astronauts training for docking maneuvers at Langley in the 1960s.

Moon phases are Central Time.

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

APOGEE July 5

PERIGEE July 21

AUGUST

OVERVIEW

There's really only one skywatching event to talk about this month: a total solar eclipse. In one of nature's most spectacular light shows, the Moon will cover the solar disk on August 21, briefly plunging a narrow path across the United States into darkness. The rest of the country will see a partial eclipse.

HIGHLIGHTS

1 Antares, the orange supergiant star at the heart of the scorpion, is below the Moon at nightfall. The brighter planet Saturn stands to their left.

2 Saturn is close to the lower left of the Moon at nightfall, with Antares far to the lower right.

16 Aldebaran, the bright orange eye of the bull, stares down at the Moon at first light.

18-19 Venus, the brilliant Morning Star, stands to the lower left of the Moon at first light on the 18th, and closer above the Moon on the 19th.

FEATURED EVENT

21 A total solar eclipse will slice across the American heartland.

24 The bright planet Jupiter poses to the upper left of the Moon as darkness falls. The star Spica is quite close to the left of Jupiter.

25 Spica, the leading light of Virgo, is below the Moon at nightfall, with much brighter Jupiter to the lower right.

29 Saturn is close to the left or lower left of the Moon as evening twilight fades away, with Antares below the Moon.

ECLIPSE RESOURCES

NASA Eclipse Web Site
eclipse.gsfc.nasa.gov

Where to Watch the Eclipse
www.greatamericaneclipse.com/best-places-to-view

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

Disappearing Sun

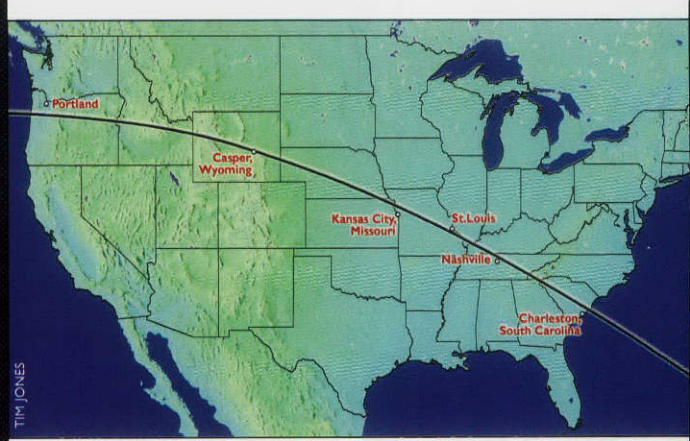
For about two minutes on the afternoon of August 21, the sky over Nashville will turn almost as dark as night. Ditto Casper, Wyoming; Columbia, South Carolina, and the southern suburbs of St. Louis. They will be darkened by one of nature's most spectacular events: a total solar eclipse.

The eclipse takes place as the new Moon passes directly between Earth and the Sun. By an astronomical coincidence, the Moon and Sun appear almost exactly the same size in Earth's sky, allowing the Moon to completely cover the Sun. The sky will turn dark, and the Sun's silvery outer atmosphere, the corona, will shine faintly around the intervening lunar disk.

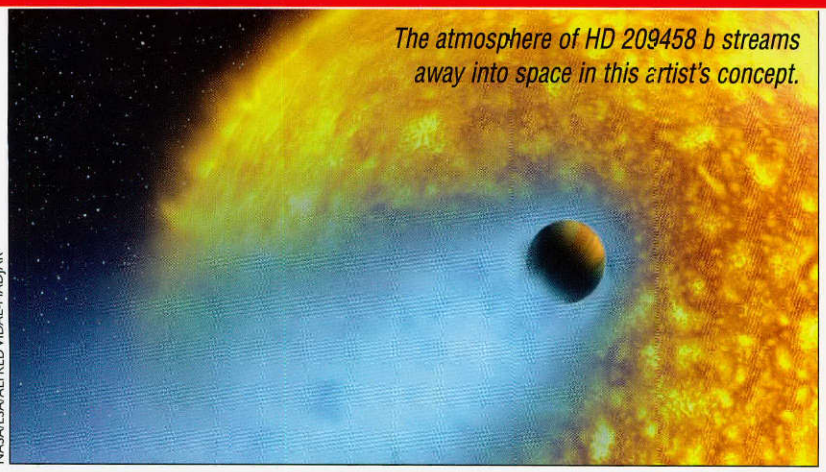
This eclipse begins over the Pacific Ocean, when the Moon's dark shadow first touches Earth. The shadow will reach the Oregon coastline at 10:16 a.m. PDT, and race southeastward before exiting over South Carolina at 2:49 p.m. EDT.

The eclipse will reach its maximum length of about 2 minutes, 40 seconds, over southern Missouri. The path of the eclipse will reach a maximum width of about 70 miles, although it lasts longest along the centerline of that path. Nashville is the largest city within the eclipse path, although parts of Kansas City and St. Louis will lie inside the shadow as well.

While the rest of the United States will miss out on the total phase of the eclipse, the entire country will experience a partial eclipse, where the Moon covers a part of the solar disk. From cities close to the eclipse path (such as Portland, Oregon, where the Moon will cover 99 percent of the Sun, or Atlanta, with 97 percent coverage), the sky will turn noticeably darker and the temperature will drop a bit. Even so, skywatchers will need eye protection to look at the eclipse.



The eclipse path (dark line) will approach several major cities.



The atmosphere of HD 209458 b streams away into space in this artist's concept.

NASA/ESA/ALFRED VIDAL-MADJAR

Something in the Air

HD 209458 b probably wouldn't be a good place for an afternoon picnic. It's a gas giant planet, like Jupiter, so there's no solid surface for a picnic blanket. It's so close to its parent star that temperatures in its thick atmosphere are hot enough to melt lead. Even worse, the atmosphere is being blown into space at a rate of up to 500,000 tons every second.

HD 209458 b was the first exoplanet known to possess an atmosphere. In 2001, astronomers used Hubble Space Telescope to take a spectrum while the planet was passing in front of its parent star. Starlight filtering through the atmosphere revealed its presence. The technique has since revealed hydrogen, carbon, and oxygen in the atmosphere, with one study claiming the detection of water vapor as well.

Astronomers have used the same technique to discover atmospheres surrounding more than a score of exoplanets. Most of those worlds are gas giants, so their thick atmospheres are relatively easy to detect. Observations have revealed that some contain water vapor, which is a key ingredient for Earth-like life. Astronomers have even detected clouds on a few planets, including Kepler 7 b, which has a heavy blanket of clouds on one hemisphere but clear skies on the other.

In 2016, astronomers announced the first detection of an atmosphere around a super-Earth (a world up to a few times the mass of Earth). They found hydrogen and helium around 55 Cancri e, a planet discovered at McDonald Observatory. The planet is about eight times as heavy as Earth, but only twice its diameter. Like many of the giant worlds, it is quite close to its parent star, so it is too hot to sustain Earth-like life.

No one has yet seen an atmosphere around an Earth-sized world, although that's largely because they haven't seen many such planets at all. Yet planet hunters hope that when they do find such planets, they will be able to detect the chemical fingerprints of life in their atmospheres — perhaps showing us worlds that would be comfortable spots for a picnic.

KEY DATES

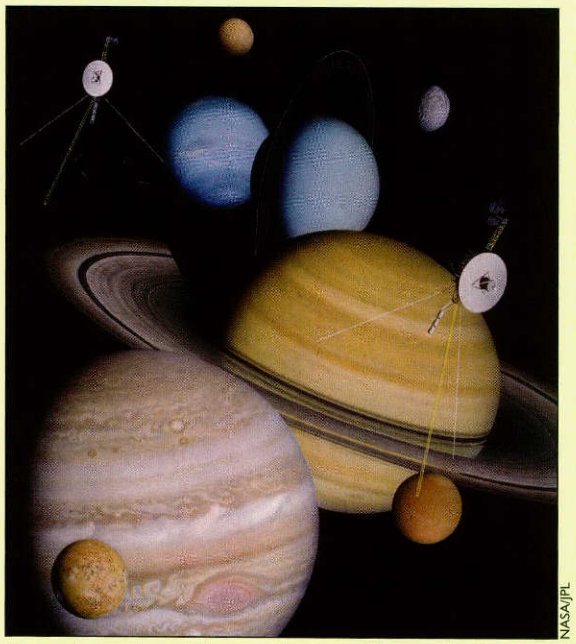
August 1

CALENDAR EVENT

Today is Lammas, a cross-quarter day, which falls about halfway between a solstice and an equinox, and was used in earlier eras to mark the beginning of a season. Lammas evolved from the Celtic celebration of the warrior god Lugh, whose name means "the Shining One."

August 20

Voyager 2 was launched 40 years ago, with its twin, Voyager 1, following a few days later. Both spacecraft explored Jupiter and Saturn, with Voyager 2 continuing to Uranus and Neptune. Both are still functioning, with their instruments measuring charged particles and magnetic fields at the edge of the solar system.



NASA/JPL

A montage shows Voyager images of four planets (from front, Jupiter, Saturn, Uranus, Neptune) and four large moons explored by the twin probes.

August 30

David Jewitt and Jane Luu expanded the boundaries of the solar system 25 years ago with the discovery of 1992 QB1, the first object found in the Kuiper Belt, a broad ring of material beyond the orbit of Neptune. It is roughly 100 miles in diameter, and orbits the Sun once every 290 years at an average of about 43 times the distance from Earth to the Sun. Astronomers have since discovered roughly 1,500 additional Kuiper Belt Objects, which are leftovers from the birth of the solar system.

Moon phases are Central Time.

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

APOGEE
August 2, 30

PERIGEE
August 18

SEPTEMBER

OVERVIEW

A traffic jam highlights the morning sky this month, as three planets line up near Regulus, the heart of Leo. The planets move through different configurations during the month, providing a different view each day. In the evening sky, some of the signature constellations of summer begin dropping from view, while some of the faint constellations of autumn climb skyward in the east and southeast.

HIGHLIGHTS

4 Neptune, the most distant of the Sun's major planets, is at opposition tonight. The giant planet lines up opposite the Sun, so it rises at sunset and is in view all night. It's also brightest for the year, although you still need a telescope to see it, in the constellation Aquarius. It is about one degree (less than the width of your finger held at arm's length) to the lower left of the naked-eye star Lambda Aquarii.

12 Aldebaran is quite close to the Moon at first light.

16 Mars and Mercury stand almost atop each other at dawn, quite low in the east. Mercury is the brighter of the two planets.

FEATURED EVENT

17-18 The Moon slides past Venus, Regulus, Mars, and Mercury.

19-20 Venus and Regulus are side by side at first light, with Venus by far the brighter object.

21 Jupiter stands to the left of the Moon not long after sunset, low in the evening twilight.

22 Jupiter is to the lower right of the Moon tonight.

22 Autumn arrives in the northern hemisphere at 3:02 p.m. CDT, the moment of the September equinox. The Sun crosses the celestial equator, which is the projection of Earth's equator on the sky, from north to south.

25 Antares, the heart of the scorpion, is below the Moon this evening, with the planet Saturn about the same distance to the left of the Moon.

26 Saturn is just a bit below the Moon this evening.

SEPTEMBER

Su	M	T	W	Th	F	Sa
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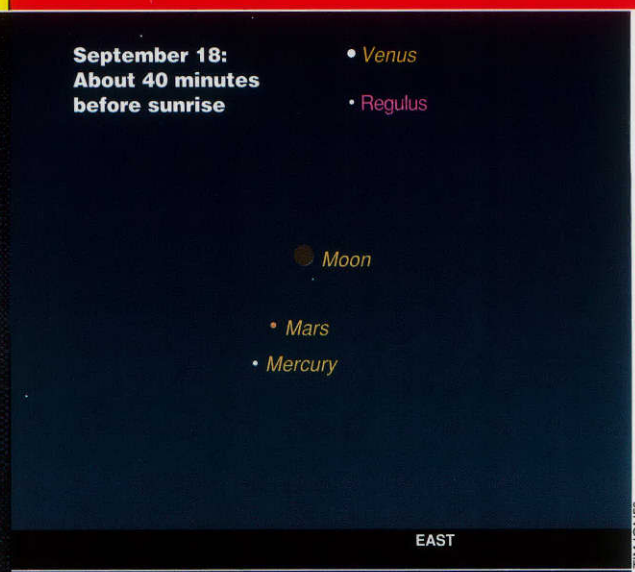


TIM JONES

FEATURED EVENT

Dawn Lineup

A constantly shifting array of bright objects highlights the dawn sky during the latter half of September. Regulus, the brightest star of Leo, anchors the group, maintaining its position relative to the other stars even as it rises four minutes earlier each day. The other objects — the Moon and three planets — slide back and forth with respect to Regulus.

Venus, the brightest of the planets, shines as the brilliant Morning Star. It stands above Regulus on the morning of September 15, but quickly slides down past the star. Venus is closest to Regulus on the 20th, when they are separated by less than the width of a finger held at arm's length.

The next-brightest planet is Mercury. It is the closest planet to the Sun, so it never strays far from the Sun in Earth's sky. At best, it is visible for a short while before sunrise or after sunset. This month it climbs fairly far away from the Sun, which makes it easier to spot. It is farthest from the Sun on the 12th, then almost overlaps Mars on September 16 as it quickly drops toward the eastern horizon. Mercury will shine brightest in late September and early October, although it will be so low in the sky by then that it will be difficult or impossible to spot through the Sun's glare.

Mars is the faintest of the three planets, shining less than one percent as bright as Venus, and its immersion in the morning twilight makes it even more difficult to see. But Mercury and the other bodies will help point the way.

The most prominent of those other bodies is the crescent Moon, which joins the show on the mornings of September 17 and 18. It stands to the upper right of Venus on the 17th, and between the close Venus-Regulus and Mars-Mercury pairings on the 18th, completing a beautiful tableau in the dawn sky.

Planetary Aliases

Zombie fans, take note: If you need more of the living dead, look toward a dead star in the constellation Virgo. It's encircled by a "living dead" planet, along with a poltergeist and the god of nightmares. If you are of a more literary bent, however, then a star system in Ara, the altar, offers the characters from *Don Quixote*.

A recent contest sponsored by the International Astronomical Union (IAU), which bestows names on all astronomical objects and features, produced names for 31 planets in 19 star systems.

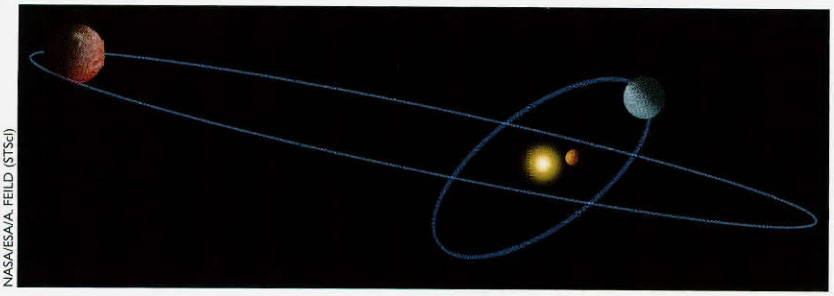
Prior to the contest, exoplanets were designated only by the name of the star followed by a lower-case letter of the alphabet. That is an efficient way for the astronomers who study exoplanets to keep track of things, but it lacks the cool factor of such fictional planetary names as Vulcan, Gallifrey, Arrakis, or Abydos.

Under the old naming scheme, Mu Arae included the planets Mu Arae b, c, d, and e. Those designations remain, but they have been supplemented by the names Quixote, Dulcinea, Rocinante, and Sancho from *Don Quixote*. The star itself was named Cervantes, after the book's author.

The star 18 Delphini was designated Musica, the Latin word for music, and its only known planet was named Arion, after a Greek musician and poet.

The planets of 55 Cancri (page 15) were named for people who played important roles in the early days of the telescope, including Galileo, the first scientist to study the heavens through a telescope, and Hans Lippershey who is credited with inventing the telescope. Fittingly enough, 55 Cancri itself was named for Copernicus, who demonstrated that the Sun, not Earth, is at the center of the solar system.

And the pulsar PSR 1257+12 (page 5) was named Lich, after an undead Norse god who could control the living dead. Its three known planets, which were reborn from the ashes of the explosion, were named Draugr (the undead in Norse mythology), Poltergeist, and Phobetor (the Greek god of nightmares).



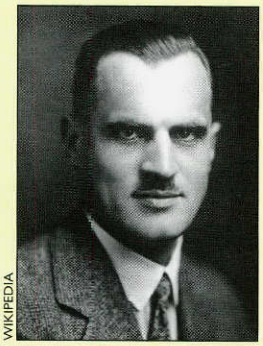
NASA/ESA/A. FEILD (STScI)

Three recently named planets orbit Upsilon Andromedae, as shown in this artist's depiction. The planets (in order of their distance from the star) were named Saffar, Samh, and Majriti, after 10th- and 11th-century astronomers from Andalusia (modern-day Spain). The system has an unusual configuration, with one planet orbiting in a different plane from the others.

KEY DATES

September 9

American astronomer Edward Emerson Barnard discovered Amalthea, a moon of Jupiter, 125 years ago, in 1892. It was the final moon of any planet to be discovered simply by looking through the telescope; later discoveries were made on photographic plates or other media.



WIKIPEDIA

Arthur Compton in 1927

September 10

Physicist Arthur Compton was born in 1892. In 1927, he won the Nobel Prize for Physics for his discovery of the Compton effect, which showed that electromagnetic radiation behaves as particles as well as waves. The discovery was important to developing telescopes for studying X-rays and gamma rays. NASA named a large gamma-ray space telescope in his honor.

September 15

The Cassini mission to Saturn will end when the spacecraft plunges into Saturn's atmosphere. Cassini has been orbiting Saturn since 2004, and has studied the planet, its rings, and its amazing moons. It has depleted most of its fuel, and to avoid risking possible contamination to Enceladus, which has the ingredients for life, or to other moons, Cassini is being intentionally flown into Saturn, where it will be destroyed. Before the fatal plunge, it will make several passages between Saturn and its inner rings.

NASA/JPL

An artist's concept shows Cassini diving between Saturn and its rings.

Moon phases are Central Time.

The full Moon of September is known as the Fruit Moon or Corn Moon.

PERIGEE September 13 | **APOGEE** September 27

OCTOBER

OVERVIEW

October offers some of the best skywatching conditions of the year. The nights are getting longer, while the weather is cooler but not frigid. The evening sky offers such treats as Andromeda and her famous galaxy, M31, as well as several other constellations associated with her mythological story. Other highlights include the two most prominent star clusters in the sky, the dipper-shaped Pleiades and nearby V-shaped Hyades, both in Taurus.

HIGHLIGHTS

FEATURED EVENT

5 The Moon is full today. It is known as the Harvest Moon.

5-6 Venus, the Morning Star, slips past Mars in the pre-dawn sky. Much fainter Mars is quite close to the lower right of Venus on the 5th, and a little farther to the upper right on the 6th.

8-9 Aldebaran stands to the lower left of the Moon as they climb into view in late evening on the 8th, and about the same distance to the upper right of the Moon on the 9th.

15 The Moon passes in front of Regulus, the brightest star of Leo, in the hours before dawn, briefly blocking the star from view.

17 Mars poses close to the right of the Moon at first light, with much brighter Venus below them.

18 Venus stands to the upper right of the Moon this morning, with Mars well above them.

19 Uranus, the third-largest planet in the solar system, is at opposition. It lines up opposite the Sun, so it rises at sunset and is in view all night. The giant planet is also brightest for the year, although you still need binoculars to see it (unless you have exceptionally dark skies and great eyesight), in the southwestern corner of the constellation Pisces.

23-24 The planet Saturn shines like a bright star to the left of the Moon at nightfall on the 23rd, and to the lower right of the Moon on the following evening.

OCTOBER

Su	M	T	W	Th	F	Sa
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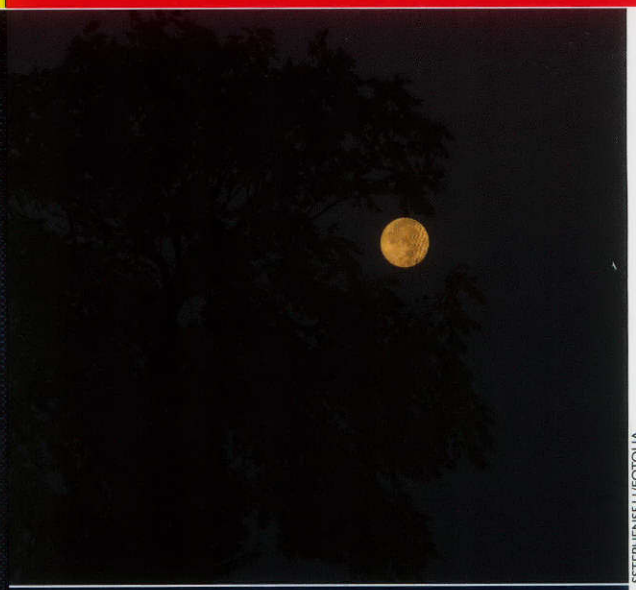


SSTEPHENSS11/FOTOLIA

FEATURED EVENT

Catching the Harvest Moon

With the Major League Baseball playoffs cranking up in early October, perhaps it's not surprising that Mother Nature tosses out her own curveball. The Harvest Moon, which usually graces the skies of mid to late September, this year slides into early October.

The Harvest Moon is the full Moon closest to the autumnal equinox, which marks the beginning of fall. This year, the equinox took place on September 22. September's full Moon occurred on the 6th, or 16 days and 13 hours before the equinox. This month's full Moon, on the other hand, comes on October 5, about 12 days and 23 hours after the equinox, giving October the Harvest Moon honors.

The Harvest Moon moniker seems to have been bestowed by farmers in northern Europe, who relied on its light to help them complete the harvest.

On average, the Moon rises and sets about 50 minutes later each day. At this time of year, though, the Moon's path across the sky is such that, from high northern latitudes, the full Moon rises only about 30 minutes later on succeeding nights. So when the Sun sets, the rising full Moon lights up the fields, allowing farmers to continue harvesting their crops without a break.

The full Moon after the Harvest Moon traditionally is known as the Hunter's Moon. It illuminates the now-denuded fields, making it easier for hunters to track game. Although that's not especially important for most people today, in bygone centuries it was a big help to hunters who were trying to store food for the long, dark, cold northern winter.

Since the Harvest Moon moved into October, the Hunter's Moon slides into early November, which should be just about the time the World Series wraps up.

Exoplanetary Snapshots

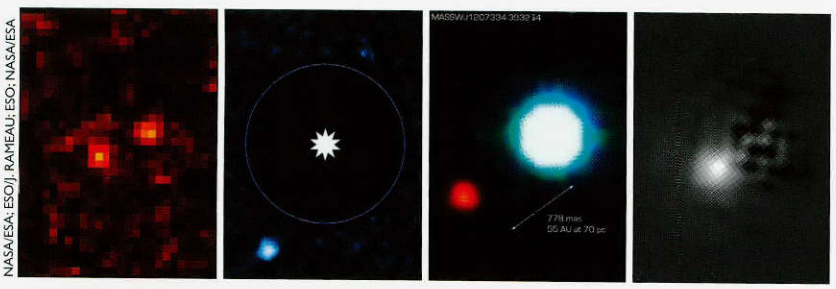
Autumn's evening skies lay claim to only one bright star of their own: Fomalhaut, the leading light of Piscis Austrinus, the southern fish. It scoots low across the south, but the "autumn star" is easy to pick out because it is surrounded by relatively barren skies.

Fomalhaut also is surrounded by a wide disk of dusty debris. An exoplanet orbits near the inner edge of the disk, billions of miles from the star. It is one of the few planets that astronomers have seen directly. In fact, they discovered the planet in a series of images snapped by Hubble Space Telescope.

Seeing an exoplanet directly is difficult because it is so small, faint, and close to its star that it is overpowered by the star's glare, like a firefly hidden in the blaze of a searchlight. As a result, astronomers have photographed only a few exoplanets. And most of those show up not at visible wavelengths, but in the infrared. Such planets are so young that their gravity is still causing them to contract, heating them and making them glow brightly in the infrared.

Fomalhaut b was seen by Hubble's visible-light detectors. The planet may be up to twice the mass of Jupiter, the giant of our own solar system. It also could be much smaller, but surrounded by a cloud of dust or space rocks.

Future generations of ground- and space-based telescopes may provide much better views of exoplanets. James Webb Space Telescope, which is scheduled for launch next year, will collect 10 times as much light as Hubble, and it is optimized for infrared observations. The Giant Magellan Telescope, under construction in Chile, will provide a much sharper, deeper view than any current telescope, raising the possibility that it could see many more exoplanets, and perhaps even begin to see details on their surfaces.



NASA/ESA; ESO/J. RAMEAU; ESO; NASA/ESA

ESO

From top left: Two images of Fomalhaut b, snapped two years apart, show the planet's orbital motion; HD 95086 b (lower left) with its star blocked out; 2M1207 b (red) glows brightly in the infrared, with the scale bar showing a distance of 55 times the Earth-Sun distance; a planet orbiting a brown dwarf, which has been blacked out; the planet CVSO 30 c (small dot) orbits about 660 times the Earth-Sun distance from its parent star.

KEY DATES

October 4

Today marks the start of World Space Week, a celebration of the six decades of space exploration. **worldspaceweek.org**

October 18

The Soviet Union notched its first successful planetary encounter in 1967, when Venera 4 parachuted through the atmosphere of Venus. During its descent, the probe found that the atmosphere consists primarily of carbon dioxide, and confirmed the findings of earlier flyby missions that the atmosphere is extremely hot.

October 24

Walter Adams unknowingly recorded the first known evidence of exoplanets 100 years ago. Adams recorded a spectrum of van Maanen's star with a telescope at Mount Wilson Observatory in California. The spectrum showed an abundance of calcium, magnesium, iron, and other elements. Van Maanen's star, however, is a white dwarf, which is the dead core of a once-normal star, so its surface should show none of these elements. Another astronomer discovered the spectrum in 2015 and realized that the star's surface was "polluted" with rocky debris from dead planets.

October 28

NASA/GSFC

Tonight is International Observe the Moon Night, a celebration established in 2010 to enhance public interest in the Moon and support for lunar exploration. It features hundreds of hosted Moon-watching events across the country. **observethemoonnight.org**

October 31

CALENDAR EVENT

Today is Halloween, a cross-quarter day. In many cultures, such dates represented the start of a new season, not its mid-point. In northern Europe, this was a dreaded time of year, with the long, cold nights of winter ahead. Many thought it was a time when lost souls roamed the land.

Moon phases are Central Time.

The full Moon of October is known as the Harvest Moon or Dying Grass Moon.

PERIGEE October 9

APOGEE October 24

NOVEMBER

OVERVIEW

One of the most popular stories from ancient mythology is told in a group of constellations that highlight November's sky. Cassiopeia, the vain queen of Ethiopia, claimed that she was the most beautiful woman of all, angering the sea nymphs. They convinced the sea god Neptune to send Cetus, a nasty sea monster, to destroy the kingdom. To appease the gods, King Cepheus ordered his daughter, the princess Andromeda, chained at the edge of the sea as a sacrifice. But she was rescued by Perseus, who flashed the monstrous head of Medusa at Cetus, turning him to stone. Five of these characters stretch from north to southeast in the evening sky.

HIGHLIGHTS

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

FEATURED EVENT

5 The Moon occults Aldebaran as seen from much of the United States this evening.

11 Regulus, the bright heart of the lion, stands close to the lower left of the Moon at first light. From some parts of the world, the Moon will actually occult the star, briefly blocking it from view. Unfortunately for those of us in the United States, the occultation will take place after daylight, so we won't be able to witness the disappearing act.

15 The orange planet Mars perches to the upper right of the Moon at first light. Spica, the leading light of the constellation Virgo, is to the lower right of the Moon.

16 The bright planets Jupiter and Venus stand below the Moon in the early morning twilight. Venus is the brighter of the two, but it is lower in the sky, making it more difficult to spot if you don't have a clear horizon.

20 Golden Saturn, the solar system's second-largest planet, snuggles close to the left or lower left of the Moon as night falls.

NOVEMBER

Su	M	T	W	Th	F	Sa
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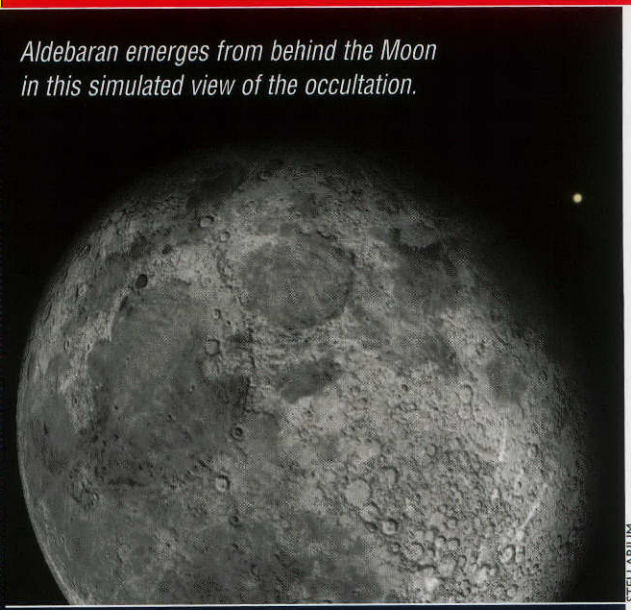
Aldebaran emerges from behind the Moon in this simulated view of the occultation.



STELLARIUM

FEATURED EVENT

Patient Search

Tracking down a planet in another star system can take some patience. Consider Aldebaran, the bright orange star that represents the eye of Taurus, the bull. It stands close to the upper right of the Moon as they climb into good view in late evening.

In 1993, McDonald Observatory astronomers Artie Hatzes and William Cochran reported the discovery of a possible planet in orbit around Aldebaran. Their work showed that if they were seeing a planet, it was much heavier than Jupiter, the giant of our own solar system.

Inspired by earlier work by Canadian astronomers Gordon Walker and Bruce Campbell, the Texas astronomers measured Aldebaran's radial velocity — its motion toward or away from Earth. Tiny changes in that velocity can be caused by the tug of an orbiting planet. They also can be caused by changes on the surface of the star itself — by magnetic storms that are similar to sunspots, for example.

After their initial study, Hatzes and Cochran kept watching Aldebaran with telescopes at McDonald and elsewhere. They also looked at observations made by others as far back as 1980. So based on more than 30 years of data, they recently confirmed their earlier finding: Aldebaran does appear to have a planet.

The planet is at least six and a half times as massive as Jupiter. It orbits Aldebaran once every 21 months, and it's as far out as Mars is from the Sun — a big but hard-to-confirm planet orbiting the eye of the bull.

Stranger Than Fiction

Kepler space telescope has revealed an amazing array of exoplanets. Perhaps its most intriguing discovery, though, isn't a planet at all. In fact, by late 2016 scientists still weren't certain just what it is. One remote but intriguing possibility, though, is that Kepler saw artifacts of an extraterrestrial civilization around a distant star, known as Tabby's Star for Tabetha Boyajian, the leader of the team that discovered it.

One of the reasons to seek out strange new worlds, of course, is to determine whether other life exists in the universe, particularly intelligent life. Over the last half-century, astronomers have pursued the search for extraterrestrial intelligence (SETI) primarily with radio telescopes, which listen for messages beamed our way or radiation from high-powered radar or other technology leaking into space.

So far, the searches have turned up empty. That could mean that we're alone in the universe, but it also could mean we haven't searched long enough and deeply enough, or that other civilizations are at different levels of technology from our own, so they aren't beaming any radio waves into the galaxy.

The radio searches continue, but SETI is expanding to look for laser beams and other types of signals. And Kepler and other planet-searching tools are helping as well.

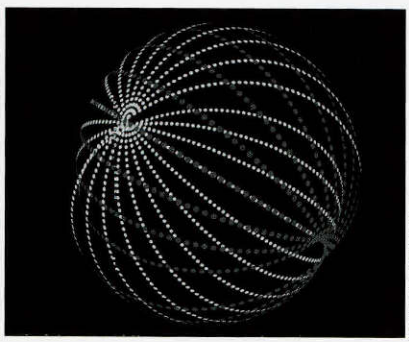
Kepler discovers a planet by watching it pass in front of its star, blocking a small fraction of the star's light — usually no more than one percent — but the light from Tabby's Star dipped by as much as 22 percent. And there were many other drops that weren't as deep, but that lasted for days instead of the hours required for most planet transits. Boyajian's team wrote that the dips could be produced by a swarm of dusty comets in a lopsided orbit around the star.

One other possible explanation, though, is massive structures built by a super-civilization. Such structures could be designed to capture the star's light to power the civilization.

Observations by other telescopes have found nothing to support that idea. There's no infrared glow, which would be generated as the structures heated up, and no evidence of radio transmissions from the system.

But the comet idea doesn't work especially well, either. So the nature of Tabby's Star is still a mystery.

NASA/JPL



VEDEXENT/WIKIPEDIA

Possible explanations for Tabby's Star include a swarm of dusty comets (left) and rings of giant light-gathering panels around the star.

KEY DATES

November 2

The 100-inch telescope at Mount Wilson Observatory in California, then the largest telescope in the world, first looked at the stars in 1917. Edwin Hubble used the telescope to confirm that there are other galaxies beyond our own galaxy, the Milky Way, and to discover that the universe is expanding as a result of the Big Bang.

November 11 *CALENDAR EVENT*

A second celebration tied to the start-of-winter cross-quarter day (after Halloween), Martinmas commemorates Saint Martin of Tours, who was executed on that date in the year 397. In Scotland, landlords collected rent on Martinmas.

November 24

In 1967, Thomas Brock published "Life at High Temperatures," a scientific article describing microscopic organisms he and a colleague discovered living in hot springs in Yellowstone National Park. These organisms were the first "extremophiles," which live in environments once thought to be uninhabitable. The discovery of these and other extremophiles may mean that life can take hold and survive in the extreme environments of other planets and moons in our solar system and beyond.

JIM PEACO/NPS

Bacteria and other extremophiles create the orange and yellow mats around Grand Prismatic Spring in Yellowstone.

November 28

Jocelyn Bell, a graduate student at Cambridge University in England, recorded the first pulsar, in 1967. She was using a radio telescope to study quasars when she found something that produced pulses of energy every 1.3 seconds. Bell and her adviser, Antony Hewish, eliminated orbiting satellites, Little Green Men, and other possible explanations before determining that the signal came from a dense, rapidly rotating object. Today, pulsars are known to be the ultra-dense corpses of once-massive stars. Hewish and Martin Ryle shared the 1974 Nobel Prize in Physics for the discovery, but Bell was left out.

Moon phases are Central Time.

The full Moon of November is known as the Hunter's Moon, Frost Moon, or Snow Moon.

PERIGEE November 5

APOGEE November 21

DECEMBER

OVERVIEW

The year ends as it began, with the brilliant stars of winter climbing into the evening sky. By the end of December, dazzling Orion will be in good view by the time the sky gets dark. Sirius, the brightest star in the night sky, will rise below Orion a bit later. The twins of Gemini stand to the left of the hunter, with Taurus, the celestial bull, above, continuing the never-ending cycle of stars and planets across the night sky.

HIGHLIGHTS

2-3 Aldebaran, the brightest star of Taurus, stands to the lower left of the Moon at nightfall on the 2nd, and to the upper right of the Moon on the following evening.

3 The planet Mars and the star Spica stand side by side in the eastern sky before dawn, above the much brighter planet Jupiter.

8-9 Regulus, the heart of Leo, crouches to the left of the Moon at first light on the 8th, and about the same distance to the right of the Moon on the following morning.

13 Mars stands below the Moon at first light, with Spica farther to the right of the Moon.

14 The brilliant planet Jupiter huddles close to the lower right of the Moon at dawn, with Mars and Spica to the upper right.

15 The Moon, Jupiter, Mars, and Spica (from lower left to upper right) form a diagonal line in the southeast at dawn.

21 Winter arrives in the northern hemisphere at 10:28 a.m., the moment of the December solstice. The Sun stands farthest south for the year, bringing the shortest days and longest nights north of the equator.

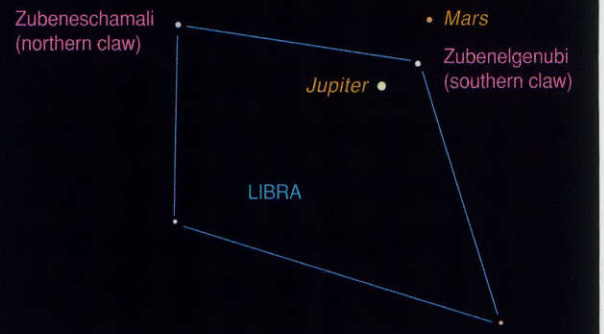
30 Aldebaran is quite close to the Moon tonight. From much of the country, the Moon will occult the bright star.

FEATURED EVENT

31 Jupiter and Mars flank Zubenelgenubi, one of the brightest stars of Libra, the balance scales.

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						



December 31, looking southeast before dawn

FEATURED EVENT

Clawing Past a Star

The planets Mars and Jupiter execute a pincer maneuver in the pre-dawn sky as 2017 comes to an end: They bracket one of the ancient claws of Scorpius, the celestial scorpion. Jupiter looks like a brilliant star in the southeast at dawn, with fainter orange Mars to its upper right. Zubenelgenubi stands almost directly between them.

Zubenelgenubi is the brightest star of present-day Libra, which represents a set of balance scales. But its intriguing name comes from an Arabic phrase that means "the southern claw," which tells us that when Scorpius was first drawn, thousands of years ago, the star represented one of its claws.

Centuries later, though, the claws were severed from the scorpion and given to the new constellation Libra. That may have been because the Sun appeared against those stars at the time of the fall equinox, which is a time of equal daylight and darkness — a time of balance in the sky.

Zubenelgenubi consists of two widely separated components, both of which are visible through binoculars. There is more to Zubenelgenubi than even binoculars can reveal, though. Each of the two visible stars is in fact a pair of stars on its own, for a total of four stars in all.

The stars in each pair are quite close together. But the two pairs are separated by more than 5,000 times the distance from Earth to the Sun. At that range, it takes more than 200,000 years for the two pairs to complete a single orbit around each other.

There's evidence that Zubenelgenubi has one more member: a star known as KU Librae. It is three light-years away from the others, so it might not be bound to them. But it appears to be the same age and composition, it's about the same distance from Earth, and it moves along with the others, perhaps extending the reach of the scorpion's claw.

The Search Goes On

A quarter of a century ago, astronomers had not yet discovered a single planet in a star system beyond our own. By the time 2017 draws to a close, though, the number of confirmed exoplanets is likely to top 5,000, and possibly thousands more than that. With those numbers, astronomers can begin to tell us how planets form, how planetary systems evolve, how many planets reside in the habitable zone, and much more.

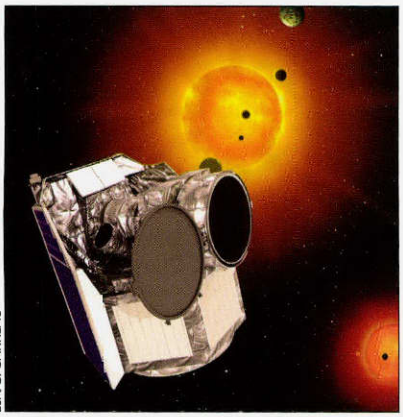
Yet the search is just beginning. Scientists continue to hunt for planets with telescopes on the ground and in space, and they are planning even bigger searches with new telescopes and instruments.

One of the new space telescopes is tentatively planned for launch this month, and a second could be ready to go as well.

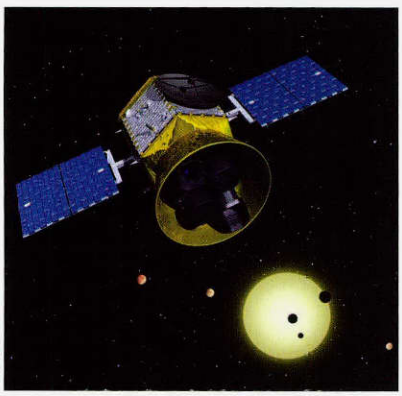
NASA plans to launch TESS (Transiting Exoplanet Survey Satellite), a small mission that will use the same technique as Kepler space telescope to scan several hundred thousand stars for exoplanets. While Kepler surveyed relatively faint stars in a small region of the sky, TESS will study brighter stars and will scan the entire sky, one patch at a time. Mission scientists expect the satellite to discover more than 2,000 exoplanets, including hundreds that are small, rocky worlds like Earth.

At the same time, the European Space Agency is preparing CHEOPS (Characterising Exoplanets Satellite), a space telescope that will study star systems that are already known to host transiting planets. It will watch transits in detail, helping astronomers determine the size of the planets. Combined with observations by other telescopes, that will help scientists determine the composition of the planets. CHEOPS also will study the atmospheres of the close, giant planets known as hot Jupiters.

Even more powerful searches are either under development or in the planning stages, preparing to add thousands more entries to the list of known exoplanets.



ESA/C. CARREAU



NASA/MIT

Artist's concepts of TESS (bottom) and CHEOPS, looking for transiting planets.

KEY DATES

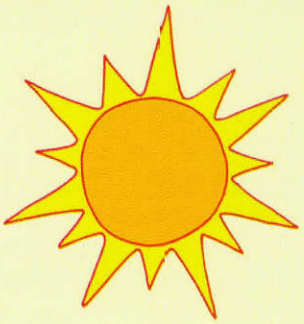
December 13 — CALENDAR EVENT

In Scandinavia, today is known as Saint Lucy's Day, a celebration of the year's longest nights. In Sweden, girls dressed in white and served pastries, and people sang songs to celebrate the return of light in the weeks ahead.

December 17 — CALENDAR EVENT

Today is Saturnalia, one of several ancient festival days that were tied to the winter solstice. This Roman event honored Saturn, the god of the harvest. People decorated trees with sweets and ornaments, performed acts of charity, exchanged small gifts, and decorated their houses with candles and lamps to cheer up the long winter nights. Many of Saturnalia's customs survive in the celebration of Christmas.

THE BASICS



Saturnalia, Saint Lucy's Day, and other December celebrations were timed to coincide roughly with the winter solstice, which is the shortest day of the year. The word solstice means "Sun stands still." For most of the year, the Sun's rising and setting points move northward or southward along the horizon from day to day. Around the solstices, though, that motion appears to stop, with the Sun rising and setting at almost exactly the same spot along the horizon for several days. The total amount of daylight remains almost exactly the same for several days as well, adding to the idea that the Sun is standing still.

Moon phases are Central Time.

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

PERIGEE December 4

APOGEE December 18

SKY CALENDAR

by Alan MacRobert

Bright stars and planets light up winter's night skies. Betelgeuse and Rigel stand out in Orion, but it's the hunter's faithful canine companion, Canis Major, that bears the brightest star of all: Sirius, the Dog Star. In February, Mars and Venus make a beautiful pair in early evening skies, with the Red Planet above brighter Venus.

JANUARY 1 - 15

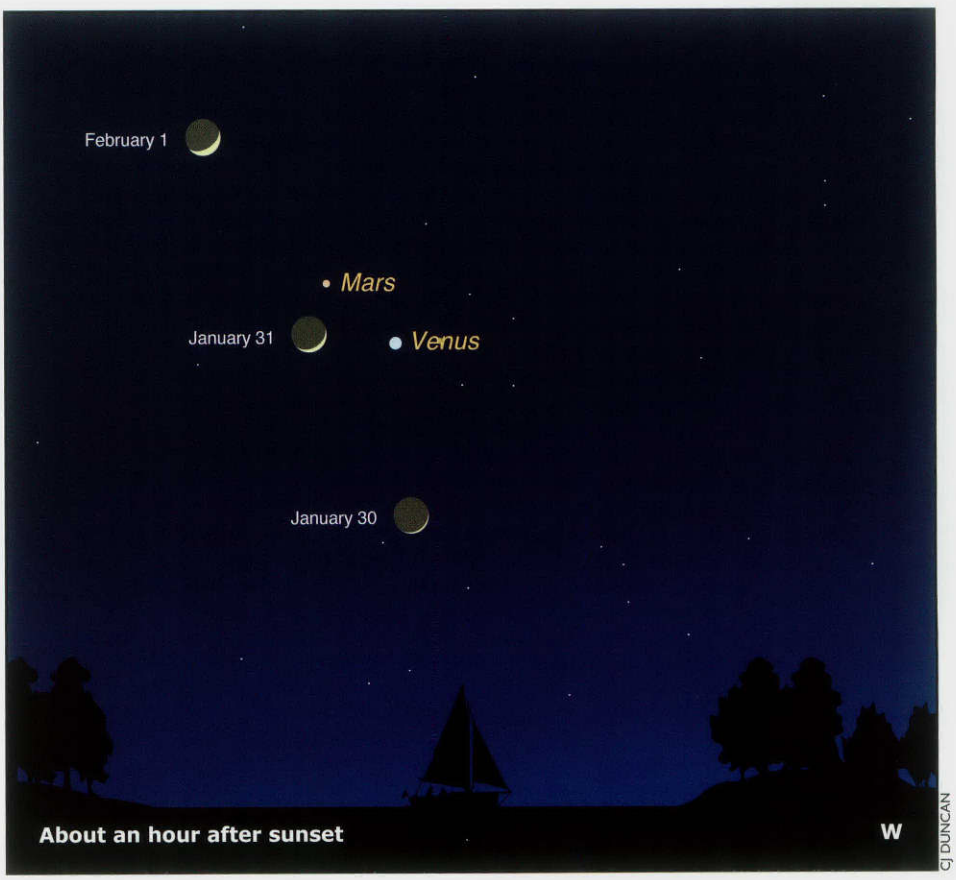
Venus emblazons the southwest wall of the sky in the clear cold twilights of January. Start looking for it around sunset, high up. How soon can you spot it?

When you do, mark its location by moving around to place it just over a treetop or building corner. Mark the place where you're standing. Come back here *before* sunset within the next few days, and see if you can pick out Venus now. It will be a little to the upper left of where you placed it last time. Knowing where it is, you'll probably spot it fairly easily. Binoculars can help.

In fact, Venus is more visible in daylight than you probably realize — at least when it's positioned higher than the Sun, as it is these winter afternoons. In a blue sky, you'll look and look and not see anything — and then suddenly there it is. In order to see such a tiny speck of light on a bright background, your eye has to land precisely on it, and this takes a bit of time and luck, unless you've already marked the spot.

You do need sharp vision for this, so put on your distance glasses if you have them.

As twilight deepens, watch for Mars to come into view near Venus. It's 12 degrees to the upper left of the bright planet on New Year's Day, about the width of your fist at arm's length or a bit more. The gap shrinks to 8 degrees by January 15: a fist or a bit less.



Mars is such a faint little thing compared to Venus! They shine at magnitudes –4.4 and +0.9, respectively, which works out to be a 130-times difference in brightness. Mars, god of war, struts all big and manly when he's on the opposite side of the sky around opposition, but he dwindles down to this meek little speck whenever he nears Venus.

Why so? We always see Venus on approximately the same side of the sky as the Sun. When we see Mars in this direction, Mars is far away, on the opposite side of its orbit from us.

The crescent Moon hangs with the two of them on the evenings of January 1, 2, and 3.

By the time Mars is plainly visible in the oncoming dusk, so are the brightest stars of Orion, Taurus, and Auriga over in the southeast and east. The full grandeur of these brilliant winter constellations becomes apparent right after dark, now that it's January and they're high early.

JANUARY 16 - 31

The gap between Venus and Mars, both still high in the southwestern twilight, shrinks only a bit in the second half of January: from 8 degrees to 6 degrees. After dark, they look quite bright in comparison to when you first saw them! They don't set until about 9 p.m. The waxing crescent Moon makes a compact triangle with them on the evening of the 31st.

Look in the southeast at nightfall for Sirius twinkling brilliantly (rather low); Orion up above it, with his three-star belt almost vertical; Aldebaran above Orion; and the Pleiades above Aldebaran.

How closely have you examined the Pleiades? The little cluster is about the size of a fingertip at arm's length. Believe it or not, it's more than twice the size of the full Moon. An optical illusion is what makes this hard to believe. Our eyes and brains unconsciously interpret *bright* things as *big* things, whether they are or not.

Still don't believe it? Measure the Pleiades with your fingertip, then do the same with the Moon when it comes

back into the evening sky.

Similarly, people have a hard time believing the Sun is no bigger in apparent size (angular diameter) than the Moon.

I have pretty sharp vision when I wear my distance glasses. I can almost always count six Pleiades stars even in a moonlit or light-polluted sky. In a dark sky, I sometimes make out eight when I spend enough time waiting for the next two to glimmer forth. Some people can see nine. Binoculars show dozens.

FEBRUARY 1 - 15

The Venus-Mars pair keeps hanging there in the western twilight. The planets remain 6 degrees apart through the first half of February, then widen back to 12 degrees and counting by month's end. Never this winter do they have an actual conjunction.

Venus, meanwhile, is brightening. A little in January, and a little more in February. The change is barely detectable by eye, but if you've become a dedicated Venus-watcher, you'll notice.

Sirius, the Dog Star, shines higher in the southeast now after dark. Another bright star of Canis Major shines to Sirius' right, by about three finger-widths at arm's length. This is Mirzam, "the Announcer." It moves ahead of Sirius across the sky like a herald before the king. Mirzam would be considered an impressive star in its own right if it weren't playing subordinate to such a brilliant follower.

So would the three stars that make a nice, neat triangle about a fist-width below: Wezen, Adhara, and Aludra, forming the Big Dog's rump, hind leg, and tail, respectively.

Orion now tilts to the right of straight up from Sirius (depending on your latitude). Look far to the left of Sirius and probably a bit higher (again depending on latitude) for Procyon, the "little dog star," in dim Canis Minor. The Dog Star and the "little dog star" are slightly more than two fists at arm's length apart.

Look higher to Procyon's upper left for Pollux and (above it) Castor, the heads of Gemini.

Go back to Orion and look high above it. The brightest star there is orange Aldebaran — a match in color for Betelgeuse, but not quite as bright. Aldebaran lies on the lower left edge of the big Hyades cluster in Taurus. The main Hyades group is loose, rather dim, and shaped like a letter V lying on its side. It's bigger but much less eye-catching than the Pleiades.

And Capella, one of the brightest stars after Sirius, now shines nearly straight up in early evening. Around it and east of it (near Gemini) are other stars of its constellation, Auriga, the charioteer.

One of these, the one a fist-width east of Capella, is Menkalinan, another case of a fine star that would be better known if its brighter neighbor didn't take all the attention.

Look well below these two and you're back to Castor and Pollux.

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

Morning 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 set by the wee hours of the morning, giving skywatchers some time to appreciate the shower.

We haven't said anything yet about the third bright planet of these winter nights. It's Jupiter, and it still doesn't rise until 11 p.m. or midnight. After it comes up (watch the east-southeast), you'll see that it's near Spica. The star is some 3 degrees to Jupiter's lower right.

Far to the upper left of this pair (straight left if you're as far south as Florida) will be Arcturus, brighter than Spica but no match for Jupiter. These two are archetypical spring stars, but there's nothing springlike about the early-February world after midnight, if you're up late enough to offer them a preseason hello.

FEBRUARY 16 - 28

The autumn months are long gone, and finally leaving, too, is autumn's signature Great Square of Pegasus. This year its departure in the west comes with a bright marker. As soon as twilight fades, look to the right of Venus by less than one fist. The not-so-bright star there (second magnitude) is the left-hand corner of the Great Square. The Square is now oriented as a diamond, standing on one corner. It takes this pose whenever it's low, whether sinking in the west or rising in the east.

Running almost straight up from the Great Square's top corner is a big line of second- and third-magnitude stars forming the back and bright leg and foot of the constellation Andromeda. She's now standing on her head, the star Alpheratz, which does double duty as the Great Square's top star.

Orion remains the shining centerpiece of other bright winter groups. Look under his feet for Lepus, the hare, dim but surprisingly big compared to the striding hunter. A rabbit that large, proportionally, would feed Orion's whole tribe.

Turn northwest and look high for Cassiopeia, a zigzag constellation that alternates from being a wide W when low to a wide M when nearly overhead. Early these evenings, Cassiopeia is in its M stage, with its right side (the fainter side) canted upward. And already the Big Dipper is gaining height in the southeast, standing on its handle.

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

Bright Stars of Winter

Name	Magnitude*	Distance**	Constellation	Notes
Sirius	–1.46	8.6	Canis Major	Binary star
Arcturus	–0.04	37	Boötes	Red giant
Capella	0.08	43	Auriga	Quadruple star
Rigel	0.12	860	Orion	Blue supergiant
Procyon	0.34	11.5	Canis Minor	Binary star
Betelgeuse	0.3-1.2	570	Orion	Red giant
Aldebaran	0.85	67	Taurus	Orange giant
Spica	1.04	250	Virgo	Close binary star
Pollux	1.14	34	Gemini	Has giant planet
Regulus	1.35	79	Leo	Fast rotation

* Apparent magnitude (brightness as seen from Earth); the lower the number, the brighter the star ** In light-years

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.**

MAGNITUDES

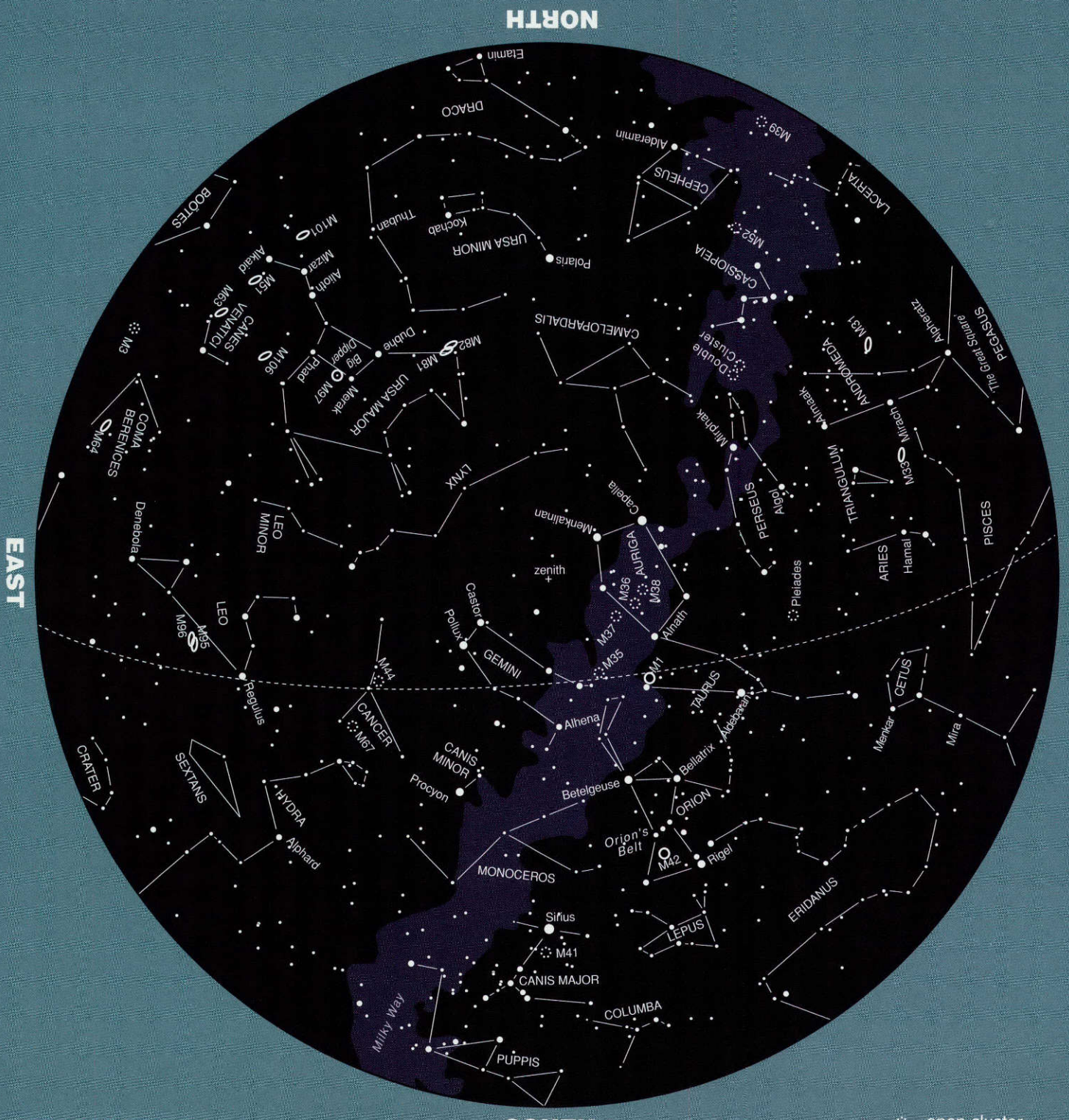
- 0 and brighter
- 1
- 2
- 3
- 4 and fainter

- open cluster
- globular cluster
- nebula
- planetary nebula
- galaxy

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.**



MAGNITUDES

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