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JANUARY–DECEMBER 2020 $5

2020 SKY ALMANAC

THE UNIVERSITY OF TEXAS AT AUSTIN McDONALD OBSERVATORY

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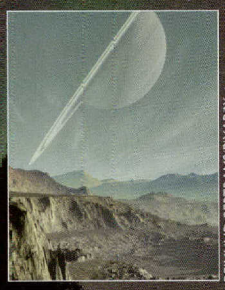
Features

Departments

This Page
A beautiful aurora shimmers over Denali National Park and Preserve in Alaska.

Coming Up in March/April
We'll delve into the mystery of the cosmic web, a structure of gas filaments underpinning the universe, along which galaxies are strung like beads on a string. We'll also bring you tips for spring skywatching, the latest astronomy news, and more.



REIMUND BERTRAMS PIXABAY

On the Cover
A lone astronaut gazes toward a Saturn-like planet from one of its moons in this artist's concept.

StarDate

2020 SKY ALMANAC

Here's a pop quiz for you. Which of the following ideas come from science fiction and which from science fact?

- *Particle beams and laser beams combining to propel interstellar probes*
- *Surfing on the solar wind*
- *Statis pods to carry astronauts to Mars*
- *A shape-shifting probe to fly, walk, and swim across the surface of Titan*
- *A web for catching asteroids and stopping their rotation*

It's a trick question. All of the ideas were proposed by scientists and have been investigated as part of a NASA program. Truth may not be stranger than fiction, but it can be just as much fun.

That's not to say, though, that the scientists who proposed these studies weren't inspired by fiction. Many astronomers, planetary scientists, rocket engineers, and others in the field started reading (or watching) science fiction as children or young adults, and entered their fields because they wanted to help transform the astounding ideas they encountered to science fact.

Science fiction continues to astound and inspire. Sometimes it does so with scientific accuracy — or at least plausability. At other times, though, it's just flat wrong. We highlight some of the rights and wrongs of science fiction and point out what astronomers are doing in several areas to turn fiction to fact — research projects that are just as interesting and inspiring as anything on the big screen.

Text by Damond Benningfield

JANUARY

OVERVIEW

Venus begins the year as the Evening Star, the brightest object in the night sky other than the Moon, standing well up in the west as night falls. The next-brightest object, the planet Jupiter, climbs into view in the eastern dawn sky during the month, and is in good view by month's end. Mars is pulling away from the Sun as well, teaming up with the similarly colored star Antares in the early morning sky.

HIGHLIGHTS

FEATURED EVENT

5 Earth is closest to the Sun for the year today.

7 Aldebaran, the orange eye of Taurus, the bull, stands close to the right of the Moon at nightfall.

10 A pale partial lunar eclipse will be visible today across northwestern North America and much of the Pacific Ocean. It is known as a penumbral eclipse because the Moon will dip into the faint outer portion of Earth's shadow, known as the penumbra.

10 Mercury is at superior conjunction, as it passes behind the Sun and is lost from sight. It will pop into view in the western evening sky late in the month.

11 Mars stands above the star Antares at first light, low in the southeast. Both are orange, but Antares is brighter.

12 Regulus, the heart of the lion, is below the Moon as they rise in mid-evening.

13 Saturn is at conjunction as it passes behind the Sun. It will return to view, in the dawn sky, in a few weeks.

17 Spica, the leading light of Virgo, poses to the lower right of the Moon at first light.

20 Mars will huddle close below the Moon at first light, with brighter Antares farther to the lower right of the Moon.

22 Jupiter, the solar system's largest planet, will stand to the lower left of the Moon during dawn twilight. Jupiter is so low in the sky that it may be difficult to spot.

27-28 Venus, the dazzling Evening Star, stands above the Moon at nightfall on the 27th and to the lower right of the Moon on the 28th.

JANUARY

Su	M	T	W	Th	F	Sa
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19	20	21	22	23	24	25
26	27	28	29	30	31	

FEATURED EVENT

Earth's 'Imperfect' Orbit

Nicolaus Copernicus revolutionized our understanding of the universe. He demonstrated that Earth and the other planets orbit the Sun. He also proposed that their orbits were perfect circles.

Decades later, German astronomer Johannes Kepler tried to prove those ideas mathematically. He used observations made by his mentor, Tycho Brahe, to try to plot the orbit of Mars, but he found that Copernicus was off a bit. To explain what's happening, he devised what are now known as Kepler's laws of planetary motion.

The first law says the orbits of the planets aren't circles. Instead, they're ellipses — like circles that have been flattened slightly. So the distance between a planet and the Sun changes throughout the year.

The second law says that a planet moves fastest when it's closest to the Sun, and slowest when it's farthest.

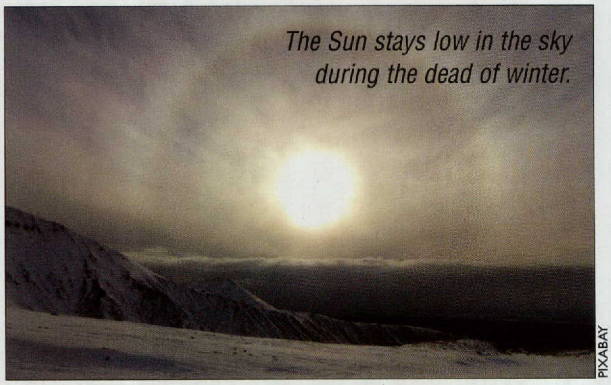
For a demonstration of those laws, consider an event that takes place January 5: Earth will be closest to the Sun for the year, about 1.7 percent closer than the average distance of 93 million miles (149 million km). After that, we'll move farther from the Sun until July.

Because of the close approach, known as perihelion, Earth will move at its fastest early this month, which has an impact on the seasons. Winter in the northern hemisphere is the shortest season — about five days shorter than summer.

The change in the Earth-Sun distance doesn't make much difference in the temperature, though, because Earth's oceans and atmosphere distribute heat around the globe.

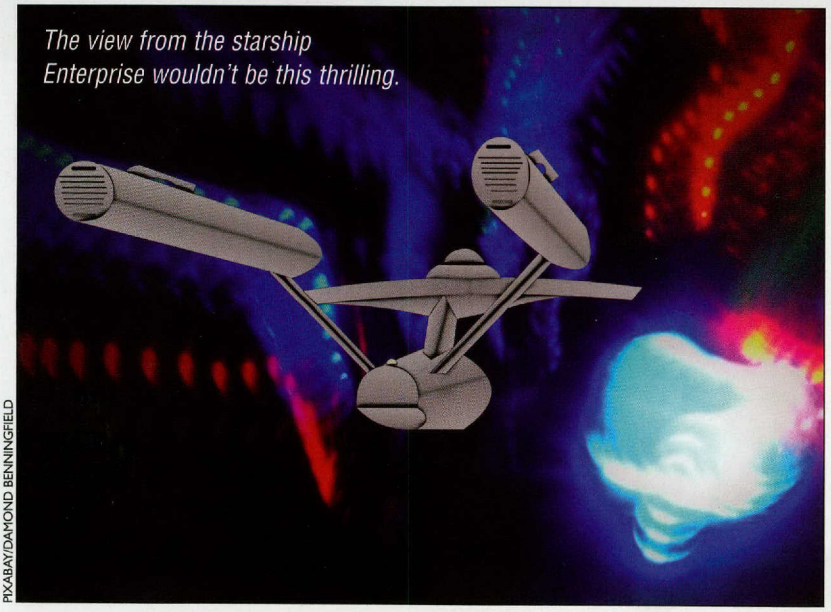
Instead, the seasons are caused by Earth's tilt on its axis. At this time of year the south pole tips toward the Sun, so the southern hemisphere sees longer days and the Sun climbs higher in the sky, warming things up. It's the reverse of that north of the equator: The north pole tilts away from the Sun, so the days are short and the Sun stays low in the sky.

The Sun is moving northward, though, so the northern hemisphere will get its turn in the Sun this summer.



The Sun stays low in the sky during the dead of winter.

PIXABAY



The view from the starship Enterprise wouldn't be this thrilling.

PIXABAY/DAMOND BENNINGFIELD

The Universe Vanishes

One of the big thrills for viewers of the original *Star Wars*, in 1977, was the first time the Millennium Falcon jumped to hyperspace, with the stars suddenly forming bright streaks ahead of the ship. That's become the go-to image for many sci-fi movies and television shows, but it's not right.

We don't know what it would look like to go faster than light, since such speeds are all but ruled out by the laws of physics (there may be some exceptions, but all would require absurd amounts of energy or exotic forms of matter). At close to the speed of light, though, the view would get downright weird.

Calculations show that as a ship neared lightspeed, the view of the surrounding universe would become compressed. At first, that would make passing planets and stars look squeezed from front to back.

Objects behind and to the sides of the ship would be projected in front of it. At 90 percent of the speed of light, thanks to an effect known as aberration, a passenger in the ship would see a tunnel of light, perhaps 10 degrees wide, straight ahead. As the ship nudged closer to lightspeed, the tunnel would get squeezed tighter and tighter. And at just short of lightspeed, the light would be compressed into a single point.

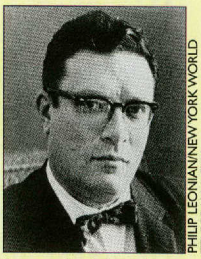
While the view was collapsing, light from stars and galaxies — and even the glow of the radiation left over from shortly after the Big Bang — would be shifted to shorter wavelengths. Red light would turn blue, blue would be shifted to ultraviolet, and ultraviolet to X-rays. And at the last tiny step short of lightspeed, everything would be shifted to X-rays and gamma rays, so passengers wouldn't see a thing.

So while traveling at almost the speed of light might be thrilling, the view wouldn't.

KEY DATES

January 2

Isaac Asimov, one of the most popular and prolific of all science-fiction writers, was born 100 years ago. He is best known for his three laws of robotics and for his galaxy-spanning Foundation series. Asimov also wrote hundreds of non-fiction articles and books, mainly about science, as well as fiction stories and novels in non-sci-fi genres.



PHILIP LEONIAN/NEW YORK WORLD TELEGRAM & SUN

Isaac Asimov in the 1950s

January 12

A stamp issued for the RAS's 150th anniversary, in 1970

The Royal Astronomical Society, one of the world's oldest and most prestigious astronomy groups, was born 200 years ago, during a meeting in a London tavern. It began as the Astronomical Society of London but obtained a royal charter a few years later. It remains busy, hosting conferences, publishing academic journals, and awarding its Gold Medal to distinguished astronomers and physicists.

January 13

In 1920, the *New York Times* criticized rocket pioneer Robert Goddard for a paper he'd written about the potential for rockets to travel in space. Among other things, Goddard suggested that a rocket could carry a small explosive charge to the Moon, with telescopes on Earth observing the blast. "That Professor Goddard with his 'chair' in Clark College and the countenancing of the Smithsonian Institution, does not know the relation of action and reaction, and of the need to have something better than a vacuum against which to react — to say that would be absurd," the *Times* opined. "Of course he only seems to lack the knowledge ladled out daily in high schools." The newspaper retracted the editorial in 1969, as Apollo 11 headed for the Moon.

January 25 *CALENDAR EVENT*

Today is the Chinese New Year. The Chinese calendar is based on the motions of the Moon, not the Sun. Extra months are periodically added, however, to keep the new year roughly aligned with the seasons.

Moon phases are Central Time.

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

APOGEE January 1, 29

PERIGEE January 13

FEBRUARY

OVERVIEW

Venus, the dazzling Evening Star, commands the evening sky this month. It rises almost straight up from the horizon, so it stands fairly high as darkness falls. Mars is beginning its climb across the morning sky, so it gets brighter and stands higher as the month progresses. It's trailed by Jupiter, the brightest star-like point of light in the sky other than Venus. Among the stars, brilliant Capella shines high overhead during mid-evening. The brightest light of Auriga the charioteer, it shines yellow-orange.

HIGHLIGHTS

3 Aldebaran, the baleful eye of Taurus, the bull, stares up at the Moon at nightfall.

7 Pollux and Castor, the twins of Gemini, line up almost directly above the Moon at nightfall, with Pollux closer to the Moon.

9 Regulus, Leo's blue-white heart, perches close to the right of the Moon as they climb into good view in early evening.

10 Mercury, the Sun's closest planet, stands low in the west as night begins to fall. The little world looks like a bright star, but you need a clear horizon to spot it.

13-14 Spica, the leading light of the constellation Virgo, the virgin, stands below the Moon at first light on the 13th, and farther to the lower right of the Moon on the 14th.

FEATURED EVENT

18 The crescent Moon will occult the planet Mars before dawn.

19 Brilliant Jupiter, the solar system's largest planet, stands to the left of the Moon at first light.

20 Saturn, the second-largest planet, is the bright "star" to the upper left of the Moon at first light.

26-27 Venus stands high above the crescent Moon on the evening of the 26th and to the right of the Moon on the 27th.

FEBRUARY

Su	M	T	W	Th	F	Sa
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FEATURED EVENT

Planetary Hide-and-Seek

The Moon and the planet Mars team up for a bit of stage magic on the morning of February 18. As seen from parts of the United States, Mars will disappear from view — hidden by the crescent Moon.

Such an event is called an occultation, from a Latin word that means "to hide." The Moon and planets all stay close to the ecliptic, which is the Sun's path across the sky. Their exact paths diverge from the ecliptic by a few degrees, though. And since the Moon is only one-half of a degree wide, the geometry has to be just right for it to pass in front of a planet and block its light, so such encounters don't happen often. The Moon last occulted Mars, for example, on July 4, 2019, with the event visible from parts of Asia.

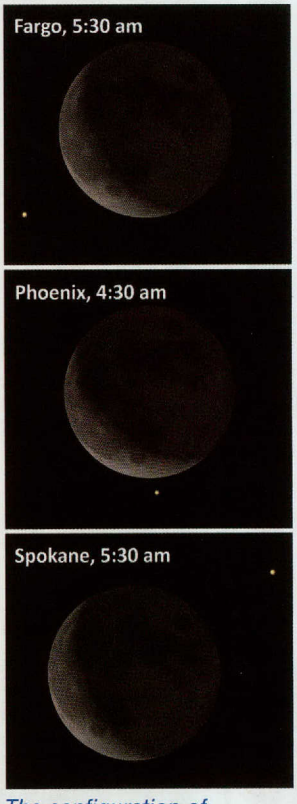
In the past, occultations of Mars were important ways for astronomers to learn about the Red Planet. Precise timing of its disappearance and reappearance helped them measure the planet's diameter, for example, and refine models of its orbit around the Sun.

Today, of course, fleets of spacecraft have provided much better measurements of Mars' size, orbit, mass, and many other parameters, so occultations are less important scientifically.

Occultations are still interesting to watch, though, and this one will be visible across much of the western half of the United States. The view will be best from the Mountain Time zone, where the Moon will cover Mars by around 4:45 a.m. local time (the exact time depends on your location). By then, the two worlds will be high enough in the sky for you to watch as the Moon passes between Earth and Mars (though still quite low).

Parts of the Central and Pacific zones will see at least some of the occultation as well, although the Eastern zone will miss out because the Sun will be rising by the time Mars vanishes.

Those who miss the occultation, though, will still see a beautiful conjunction of the Moon and Mars.



The configuration of Moon and Mars from several cities, shown in local time

GERALT/PIXABAY

Time dilation would allow you to travel into the future

A One-Way Ticket to the Future

Based on the number of novels, movies, and TV shows about it, you might assume that traveling through time is as easy as sitting in front of the fireplace on a brisk winter day: Just build a TARDIS or jazz up your Delorean and off you go on adventures in time and space.

The arrow of time, however, moves in only one direction. It allows you to travel *into* the future, but not *back* to the future. The laws of physics seem to make it impossible (or nearly so) to travel through time in anything like the modern concept of a time machine — something that allows you to move through the centuries at will. Wormholes, for example, seem to allow travel to other times (past or future), but a wormhole collapses as soon as anything enters it.

As many sci-fi stories and programs tell us, though, you can travel into the future, although it's a one-way trip. And you don't even need a time machine — a starship will do just fine.

The concept is known as time dilation. It says that as you travel faster, your clock ticks more slowly compared to the clocks of those you left behind. That concept has been proven by putting atomic clocks in airplanes and aboard GPS satellites. In fact, if GPS clocks weren't adjusted to account for time dilation, the entire system would fail.

At the orbital speed of a satellite, the difference is just a few millionths of a second per day. As velocity increases, though, the effect becomes more significant. If you could travel at 90 percent of the speed of light for one year as measured by the clock on your ship, more than 2.2 years would pass back on Earth. At 99 percent of lightspeed, it's more than seven years per ship year. And at 99.99 percent, the ratio is 70 Earth years per ship year.

Of course, there is the problem of finding a fast starship to carry you. But so far, that's the only known way to beat time — and travel into the future.

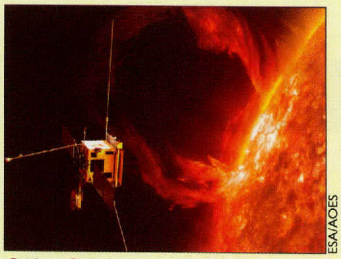
KEY DATES

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 5

Solar Orbiter is scheduled for launch. After reaching its science orbit two years later, the European mission will study the flow of charged particles known as the solar wind and how the wind carves out a magnetic bubble around the Sun.



ESA/AOES

Solar Orbiter

February 25

German astronomer Maria Margaretha Kirch was born 350 years ago. She was one of the few women astronomers of her day. She discovered a comet and wrote several popular pamphlets about celestial events, which made her one of Europe's best-known astronomers.

February 29

Lewis Swift, one of the most prolific comet hunters of his era, was born 200 years ago. The American astronomer discovered 13 comets and 1,248 nebulae, which included stellar nurseries, star clusters, and other objects. In the 1890s he became director of Mount Lowell Observatory in California.

February 29 — CALENDAR EVENT

Today is Leap Day, which leaps onto the calendar once every four years. Julius Caesar introduced Leap Day when he reformed the calendar in 46 B.C., producing the basic calendar we use today (a minor reform in the 16th century tinkered with Leap Day). During Caesar's time, however, Leap Day was a repeat of February 23. Without Leap Day, the calendar would drift with respect to the seasons. Under the current Leap Day rules, though, it will take thousands of years for the calendar to move out of alignment with the seasons by even one day.

Moon phases are Central Time.

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

PERIGEE February 10

APOGEE February 26

MARCH

OVERVIEW

Mars slides past two of its planetary siblings in the early morning sky this month. The Red Planet passes Jupiter on the morning of the 20th and Saturn on the 31st. The Moon joins the trio shortly after mid-month. As that plays out in the dawn sky, Regulus, one of the astronomical symbols of spring, climbs higher into the evening sky.

HIGHLIGHTS

1-2 Aldebaran stands to the upper left/lower right of the Moon, respectively, at nightfall on these dates.

7 Regulus is the bright star close to the Moon at nightfall.

8 Daylight Saving Time begins at 2 a.m. local time.

11 Spica rises to the right of the Moon in late evening.

15 Antares perches to the lower right of the Moon at first light.

FEATURED EVENT

18 The Moon, Jupiter, and Mars form a tight triangle before dawn, with Saturn close by.

19 The vernal equinox arrives at 10:50 p.m. CDT, ushering in spring in the northern hemisphere.

20 Jupiter and Mars are at their closest in the dawn sky, with Jupiter the brighter planet.

23-24 Mercury is at its farthest from the Sun in the dawn sky, although it is still a tough target to find.

23-24 Venus is at its farthest from the Sun in the evening sky. It shines well into the night as the Evening Star.

27-28 Venus stands high above the Moon on the evening of the 27th, and closer to the right of the Moon on the 28th.

29 Aldebaran is close to the lower left of the Moon at nightfall.

31 Saturn and Mars are quite close together in the early morning sky, with Saturn slightly higher than Mars.

MARCH

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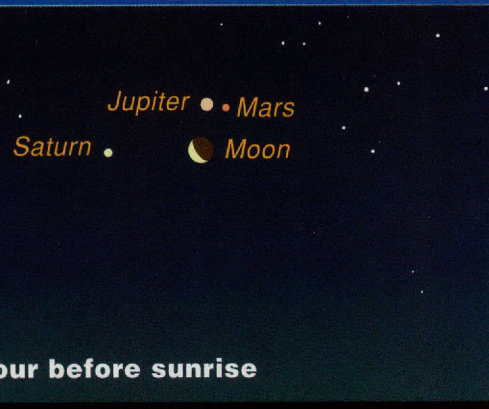


FEATURED EVENT

Dawn Traffic Jam

The pre-dawn sky will be especially busy this month. Mars will slide past Jupiter and Saturn, the largest planets in the solar system, with the crescent Moon joining them on the mornings of March 18 and 19.

The most impressive view comes on the 18th, when the paired Jupiter and Mars will stand close above the Moon. Jupiter is the brightest object in the night sky after the Moon and Venus, so it's impossible to miss. Mars will stand to the right of Jupiter. Although it's only a few percent as bright as Jupiter now, it's still an easy target.

The Moon will have moved a good distance by the following morning, so Saturn will stand to the upper right of the Moon, with the other planets to the upper right of Saturn.

Because Mars is closer to Earth than the other two dawn planets, it moves across the sky much faster. It will stand closest to Jupiter on the morning of the 20th, just below the giant planet. After that, it will take aim at Saturn, which is to the lower left of Jupiter. It will stand closest to Saturn at month's end, when they will be separated by about one degree, which is less than the width of your finger held at arm's length.

A fourth planet, Mercury, lurks well to the lower left the others, but it is so low in the sky that it is easily blocked by buildings or trees along the horizon. It doesn't climb away from the horizon until twilight is beginning to brighten the sky, either, so it can be tough to spot through the glow. Mercury will stand farthest from the Sun on the mornings of March 23 and 24, in the east-southeast. It will be easier to see from the southern latitudes of the United States than the north because its path across the sky stands at a slightly better angle at this time of year.

Dodging Meteors (or Not)

In the 1950 movie *Rocketship X-M*, intrepid explorers on their way to the Moon are almost done in by a "meteor shower" — a barrage of space rocks that look like giant pieces of popcorn. The ship manages to dodge the hailstorm, but thanks to other big problems it ends up headed toward Mars instead of the Moon.

Dangerous meteors (or meteoroids, as they should be called), often ablaze, were a common theme in '50s rocket movies and still pop up in more-modern flicks. Yet they all overstate the danger from showers of space rocks.

The meteor showers that periodically pelt Earth (see chart at right) consist of small particles shed by comets. Most of the bits of comet dust are the size of grains of sand or pebbles. They hit Earth's atmosphere at tens of thousands of miles per hour, creating friction that causes them to vaporize, forming the streaks of light known as meteors.

Most meteor showers are so diffuse that they're no threat to spacecraft, whether in Earth orbit or beyond. Because the grains of comet dust are moving so fast, however, the larger ones could cause some damage. So astronauts aboard the International Space Station have waited out especially dense storms in their return capsules, and in 1993, NASA delayed the launch of a space shuttle to avoid a possible "storm" of Perseid meteors. Operators of unmanned satellites sometimes close coverings over sensitive instruments and maneuver their craft to present the smallest possible profile to incoming showers.

Even crossing the asteroid belt is no big deal. This band between the orbits of Mars and Jupiter contains millions of small chunks of rock and metal, yet they're so widely spread that they are little hazard to spacecraft. A dozen probes have traveled into or through the belt, including several that rendezvoused with some of the belt's larger objects, with no problems.

So if you find yourself flying through the solar system, being bombarded by big, flaming space rocks is one thing you won't have to worry about.

An astronaut aboard the International Space Station photographed a meteor entering the atmosphere.

NASA

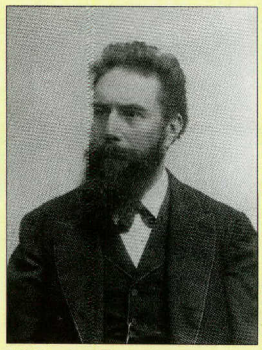
KEY DATES

March 14

Today is Pi Day (selected for the date's numerical designation: 3rd month, 14th day, or day 3.14, the first three digits of pi). It honors the mathematical constant that expresses the ratio between the circumference and diameter of a circle. ***www.piday.org***

March 27

German physicist Wilhelm Roentgen was born 175 years ago today. In 1895, he discovered X-rays, which eventually led to the study of the X-rays emitted by astronomical objects. The discovery earned Roentgen the first Nobel Prize in Physics, in 1901.



Wilhelm Roentgen

SKY WATCH

Meteor Showers

Shower	Peak	Moon
Quadrantids	Night of January 3	Sets after midnight
Lyrids	Night of April 21	New
Eta Aquarids	Nights of May 4/5	Sets in the early morning
Perseids	Night of August 11	In view after midnight
Draconids	Night of October 7	Out of view in evening
Orionids	Nights of October 20/21	Sets before midnight
Leonids	Night of November 17	Just after new
Geminids	Night of December 13	New

- 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.

Moon phases are Central Time.

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

PERIGEE March 10

APOGEE March 24

APRIL

OVERVIEW

The stars of winter are marching toward the end of their annual evening run. Orion is in the southwest at nightfall as April begins, for example, but is quite low in the west as the Sun begins to set by month's end. Sirius, the Dog Star, trots along behind Orion, with Procyon, the "little dog star," high above it. And Taurus, the bull, dives face-first toward the western horizon. Venus, the Evening Star, pushes through the constellation during the month.

HIGHLIGHTS

1 Saturn stands directly above Mars at first light by less than the width of your finger held at arm's length. Brighter Jupiter is close by.

FEATURED EVENT

3 Venus crosses the outskirts of the Pleiades.

4 Regulus, the heart of the lion, stands close to the upper right of the Moon at nightfall.

7-8 Spica is to the lower right of the Moon on the evening of the 7th and to the upper right of the Moon on the 8th.

9 Venus and Aldebaran line up at the same altitude in the west at nightfall. Aldebaran, the eye of the bull, is to the left of Venus by a little more than the width of your fist at arm's length.

11 Antares, the leading light of Scorpius, perches below the Moon at first light.

14-15 The Moon joins Jupiter and Saturn before dawn. The two bright planets stand well to the left of the Moon on the 14th, but closer above the Moon on the 15th.

16 Little orange Mars stands close above the Moon at daybreak.

21 The Lyrid meteor shower should reach its peak tonight.

25 Aldebaran is close to the left of the Moon during evening twilight, with brilliant Venus above them.

26 Venus lines up to the right of the Moon at sunset.

APRIL

Su	M	T	W	Th	F	Sa
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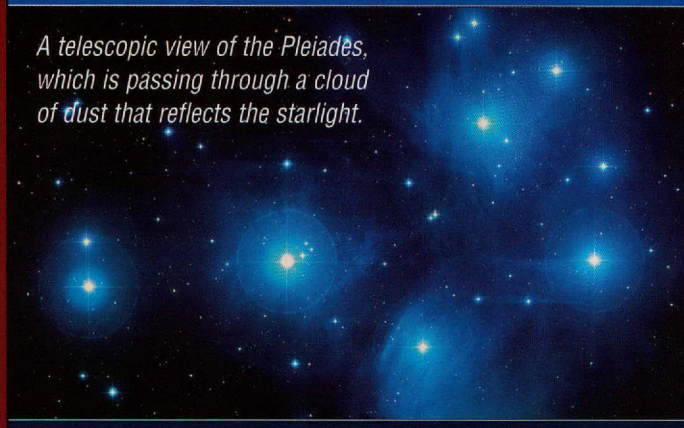


A telescopic view of the Pleiades, which is passing through a cloud of dust that reflects the starlight.

FEATURED EVENT

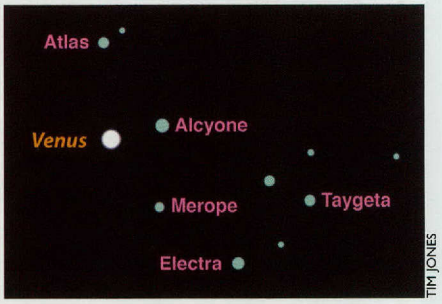
Venus Visits the Seven Sisters

Two of the night sky's most beloved objects stage a beautiful encounter early this month as Venus, the Evening Star, slides past the Pleiades star cluster.

Like most astronomical encounters, though, this one is an optical illusion. Venus and the Pleiades are separated by hundreds of light-years, but they happen to line up in the same direction in the sky.

Venus is a planet of our own solar system, so it's a close neighbor. In early April, in fact, it will be roughly 58 million miles from Earth, which is a baby step on the astronomical distance scale. At that distance, it takes light a little more than five minutes to travel from Venus to Earth.

By comparison, it takes about 445 years for light from the Pleaides, a cluster of several thousand stars, to reach Earth, which means the cluster is 445 light-years away. That places it at roughly 45 million times the distance to Venus.



TIM JONES

The cluster is nicknamed the Seven Sisters, after the daughters of Atlas from European mythology. Most skywatchers, though, see only five or six stars. Under especially dark skies, however, those with especially sharp eyesight have reported seeing a dozen or more. And with binoculars, the number of visible stars reaches several dozen.

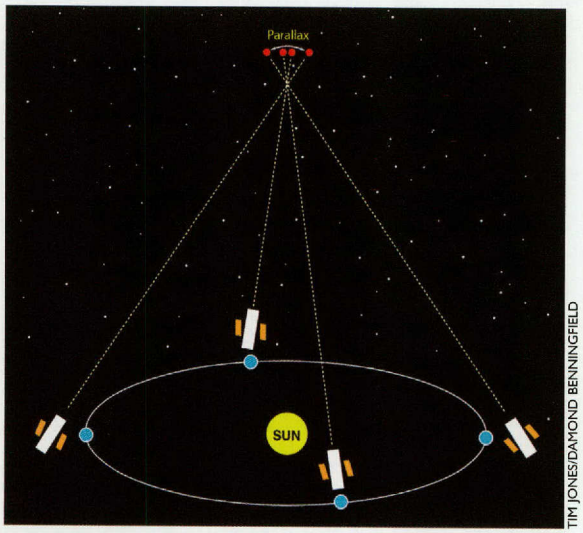
Venus' proximity to the Pleiades makes the cluster an especially appealing target this month. Venus will stand a little below the dipper-shaped cluster on April 1, pass through its left edge on April 3 (see chart), then climb away from it on succeeding nights. They will stay close together for a few nights, though, making it easy to spot the beautiful little cluster.

Chopping Off the Parsecs

In the original *Star Wars*, Han Solo brags that the Millennium Falcon can make the Kessel Run in less than 12 parsecs. Since a parsec is a unit of distance, not time, that didn't seem to make any sense. But in *Solo*, a more recent movie, it's explained that the Kessel Run isn't a straight path. Instead, it deviates around several objects along the way. A good ship and a good pilot, though, can take a dangerous shortcut, thereby cutting the distance to about 12 parsecs.

While the Kessel Run is fictional, the parsec is not. In fact, it's the most commonly used unit of distance in modern astronomy. It measures the distances to objects beyond the solar system — stars, galaxies, and others. It's equal to 3.26 light-years. (The light-year, which is used more in popular culture than professional astronomy, is the distance light covers in one year, which is about 5.9 trillion miles (9.4 trillion km).)

The word "parsec" is short for "parallax second." It's based on the apparent motion of an object as Earth moves from one side of the Sun to the other. As a result of that shift, the viewing angle to an object changes over the course of a year. How much it changes reveals the object's distance. The angles are so tiny, though, that the technique works best for targets that are within a few thousand parsecs — primarily stars in the Milky Way Galaxy — although even then there can be big uncertainties in the measurements. (For more-distant objects, astronomers rely on the brightness of pulsating stars or a certain class of exploding stars, among other techniques.)

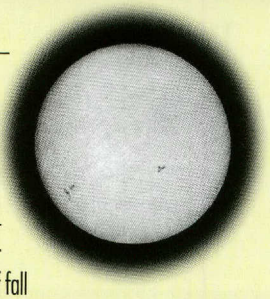


TIM JONES/DAMOND BENNINGFIELD

This diagram shows Hubble Space Telescope measuring the parallax of a star by determining its position against the background of more-distant stars at three-month intervals. The tiny shift in the viewing angle reveals the star's distance.

Among the bright stars and star clusters in view in this month's evening sky, brilliant Sirius (in the southwest) is just 2.6 parsecs away, Aldebaran (in the west) is 20, the Pleiades cluster (to the right of Aldebaran) is 136, and the Beehive cluster (which passes high overhead) is 177. The most-distant object easily visible to the unaided eye is M31, the Andromeda Galaxy, at a whopping 778,000 parsecs — with no shortcuts.

KEY DATES



April 2

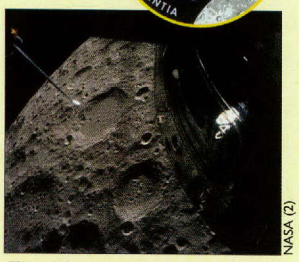
Physicists Leon Foucault and Louis Fizeau snapped the first photograph of the Sun 175 years ago today.

April 8

Today is the autumnal equinox in the northern hemisphere of Mars, marking the start of fall in the north and spring in the south.

April 13

The phrase "Houston, we have a problem" entered the lexicon in 1970, when an oxygen tank explosion crippled the Apollo 13 spacecraft en route to the Moon. Astronauts Jim Lovell, Fred Haise, and Jack Swigert, guided by flight controllers in Houston, converted their lunar lander, Aquarius, into a lifeboat, using its engine, power, and life support to return safely to Earth. (Incidentally, the astronauts actually said, "Houston, we've had a problem," but the phrase was quickly altered in the public forum.)

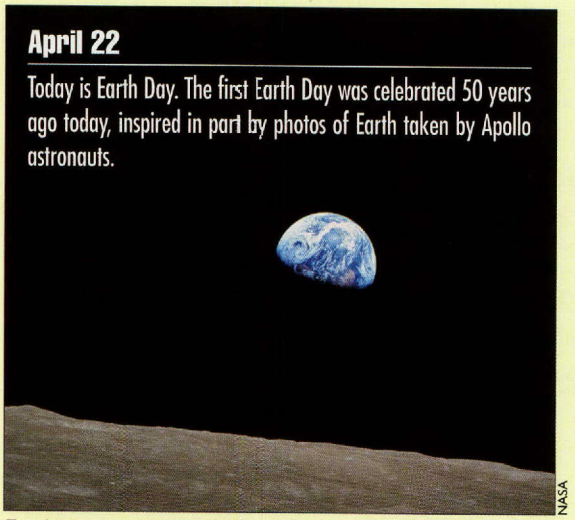


NASA (2)

The Moon slips below Odyssey, Apollo 13's crippled mothership.

April 22

Today is Earth Day. The first Earth Day was celebrated 50 years ago today, inspired in part by photos of Earth taken by Apollo astronauts.



NASA

Earth rises over the limb of the Moon during the Apollo 8 mission in 1968.

Moon phases are Central Time.

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

PERIGEE April 7

APOGEE April 20

MAY

OVERVIEW

The five easily visible planets really show off this month. Jupiter and Saturn, the solar system's giants, are close together in the dawn sky, with orange Mars lurking not far away. Venus continues its reign as the brilliant Evening Star, with fainter Mercury joining it for a few evenings after mid-month.

HIGHLIGHTS

1 Regulus stands close below the Moon at nightfall.

4 Mercury is in superior conjunction, passing behind the Sun as seen from Earth.

4 The Eta Aquariid meteor shower will reach its peak on the nights of May 4 and 5.

5 Spica is the bright star to the right of the Moon at nightfall.

7-8 Antares is below the Moon as they climb into good view on the night of the 7th, and closer to the right of the Moon on the 8th.

11-12 Jupiter and Saturn are to the left of the Moon at first light on the 11th, and form a tight triangle with the Moon on the 12th. Jupiter is the brighter of the two planets. Saturn is "stationary" on the 11th, standing still against the background of stars.

13 Jupiter and Saturn align to the upper right of the Moon at first light, with Mars farther to the left of the Moon. Jupiter will be stationary on the 14th, standing still against the starry background.

14-15 Mars stands to the upper left of the Moon at dawn on May 14, and above the Moon on May 15.

FEATURED EVENT

21-24 Venus and Mercury congregate in the west-northwest not long after sunset, with the Moon joining them on the 23rd and 24th.

26 Pollux and Castor, the twins of Gemini, align to the right of the Moon at nightfall. Pollux is closer to the Moon.

28 Regulus lurks to the left of the Moon at nightfall.

MAY

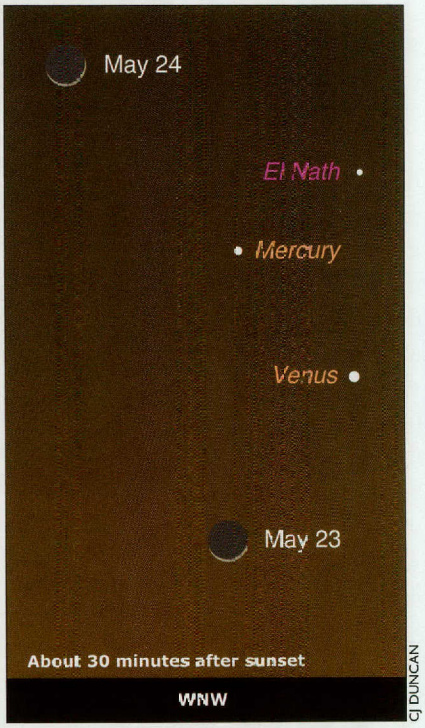
Su	M	T	W	Th	F	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

FEATURED EVENT

Crossing Paths

Three small but bright solar-system objects cross paths in the early evening sky this month. One of them is dropping toward the Sun as seen from Earth while the other two are moving away from it. All three will set in early evening.

Venus and Mercury will huddle close together for a few nights. Venus is the brilliant Evening Star. Mercury will climb past it on the nights of May 21 and 22, with their closest approach on the 21st.

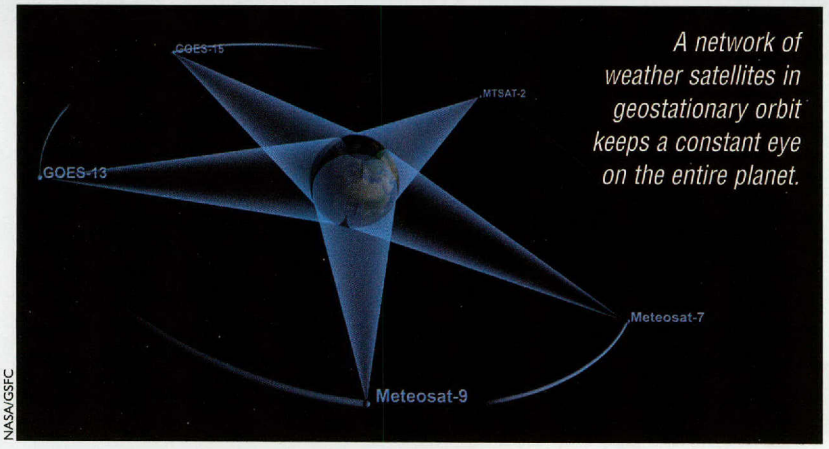


Mercury is the closest planet to the Sun while Venus is the second-closest, so both planets remain inside Earth's orbit. As a result, we have limited viewing windows for both worlds.

Mercury is never visible more than a couple of hours before sunrise or after sunset, and most of the time appears too near the Sun to see at all. It passes behind the Sun early this month. Thanks to the orbital motions of Mercury and Earth, it then climbs into view in the early evening sky. The Sun's smallest planet will continue to climb higher until it reaches its greatest extension from the Sun, in early June.

Because Venus orbits farther from the Sun than Mercury does, we have more time to view it. It can stay in sight for several hours before sunrise or after sunset. Now, though, it's dropping toward the Sun and will cross between Earth and Sun on June 3. Venus will disappear in the Sun's glare late in the month, then return to view as the Morning Star a couple of weeks later.

The Moon joins the planets on May 23 and 24. Since the Moon circles Earth, it can appear at any time of day or night, depending on its position in its orbit. It passes between Earth and the Sun on May 22 and climbs away from the Sun the following couple of evenings, when it will appear as a thin crescent.



NASA/GSFC

A network of weather satellites in geostationary orbit keeps a constant eye on the entire planet.

Just Hanging Around

In *Lifeforce*, a 1985 cult favorite about naked space vampires, an artichoke-shaped spacecraft assumes a "stationary" position over London — the better to gather the life force from human victims. That's not possible, though. (Well, we can't be sure about the space vampires, so we'll focus on the ship.)

It is possible for a spacecraft to assume a stationary position, but only if it's above the equator. Such a spot is known as a geostationary orbit. It's achieved at an altitude of about 22,300 miles. At that distance, a craft's orbital speed carries it around Earth in exactly one day. So the craft appears to stand still above a single spot on the equator.

The concept of geostationary satellites was popularized by science-fiction writer Arthur C. Clarke 75 years ago this month, long before engineers began launching them. In a 1945 issue of *Wireless World* magazine, Clarke speculated that such satellites could relay radio transmissions around the globe.

And they do. Most of the hundreds of craft placed in such orbits are communications satellites. A geostationary orbit allows them to stay in constant range of the same tracking stations, so they provide unbroken service. Others are weather satellites, which can keep a constant eye on the same patch of the surface.

A spacecraft can't remain stationary away from the equator because it always orbits the center of Earth's mass, which is the center of the planet itself. As a result, the craft's orbit carries it equal distances north and south of the equator.

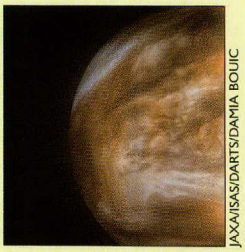
So if you tried to anchor a satellite above London, at a latitude of about 50 degrees north, its orbit would carry it just as far south of the equator as well. The craft would return to the same spot in the sky at the same time every day, but between those moments it would drop southward for 12 hours, then return north. (Such an orbit is known as geosynchronous: It's synchronized with Earth's rotation, but a craft doesn't remain stationary above a particular point.)

So neither London nor any other city has to worry about alien spaceships keeping a constant watch from high overhead.

KEY DATES

May 25

Japan launched its first successful interplanetary mission 10 years ago today. Akatsuki was aimed at Venus. A malfunction caused it to miss the planet on its first attempt, in late 2010. However, engineers worked out an alternate plan and the craft reached Venus in 2015. It was still operating in late 2019.



JAXA/ISAS/DARTS/DAMIA BOUIC

An infrared view of the nightside of Venus snapped by Akatsuki.

SKY WATCH

Viewing the Planets*

Venus The brilliant planet starts 2020 as the Evening Star, shining during and after evening twilight until late May. It then disappears from view as it passes between Earth and the Sun. It returns to view as the Morning Star in early to mid June and remains in the evening sky through the end of the year.

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

Mars Orange Mars begins the year in the morning sky, low in the dawn twilight. It slowly brightens and moves farther from the Sun until it reaches opposition in October, when it shines brightest and is in view all night. For a few weeks, it will outshine Jupiter.

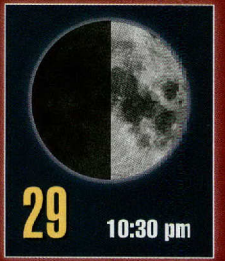
Mercury The Sun's closest planet is at its best this year in the dawn sky in late November, and in the evening sky in early February. It puts in lesser morning appearances from mid-March through mid-April and in late July, and evening appearances from mid-May to mid-June and September through the middle of October.

Saturn The ringed planet shines brightest this year in July, as it moves through Sagittarius.

Uranus The seventh planet is at its brightest in late October and early November, when it barely reaches naked-eye visibility. Most skywatchers will need optical aid to spot it, though.

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

Moon phases are Central Time.



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

PERIGEE May 5

APOGEE May 18

JUNE

OVERVIEW

The shortest nights of the year provide little time to view the wonders of the universe. Still, all five bright planets put in an appearance during the month, and the constellations of summer are creeping into view. Scorpius clears the horizon by nightfall at month's end, with the teapot of Sagittarius following behind it.

HIGHLIGHTS

3 Venus is at inferior conjunction today, passing between Earth and the Sun. It will return to view in a week or so as the Morning Star.

4 The planet Mercury is farthest from the Sun for its current evening appearance. It is low in the west-northwest as night begins to fall, about half-way between the stars Procyon, to the left of Mercury, and Capella.

8 Jupiter and Saturn stand to the upper left of the Moon at first light. Jupiter is the brighter of the two giant planets.

9 The Moon has moved past Jupiter and Saturn, so they stand to the Moon's right, with Saturn closer to the Moon.

12-13 Mars is to the left/upper right of the Moon at daybreak on these dates, respectively.

19 The Moon and Venus, the Morning Star, are close together about 30 minutes before sunrise. They are low in the sky, though, so they will be difficult to spot. From some parts of the world, the Moon will pass in front of Venus, blocking it from view.

FEATURED EVENT

20 Summer arrives in the northern hemisphere at 4:44 p.m. CDT, which is the moment of the June solstice.

21 An annular solar eclipse will be visible for much of the eastern hemisphere, but not the Americas.

23 The Beehive star cluster buzzes quite close to the lower left of the Moon in early evening.

24-25 Regulus, the heart of the lion, stands to the upper left of the Moon at nightfall on the 24th, and to the lower right of the Moon the following night.

28-29 Spica is the bright star to the lower left/lower right of the Moon as darkness falls on these nights, respectively.

JUNE

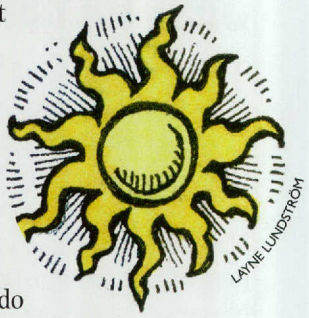
Su	M	T	W	Th	F	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

FEATURED EVENT

Nodding at the Sun

If we could watch Earth from the Sun, our planet would appear to "nod" up and down over the course of a year, with the north and south poles taking turns in the sunlight.

In June it's the north pole's turn. The pole nods farthest toward the Sun on June 20, the date of the solstice, marking the beginning of summer in the northern hemisphere and winter in the southern hemisphere.



The solstice is the longest day of the year in the north, ranging from a bit more than 12 hours of sunshine just north of the equator to a full 24 hours at the pole.

Earth doesn't actually nod, of course. It only appears to do so because the planet is tilted on its axis at an angle of about 23 degrees.

As Earth moves around the Sun, the axis always aims at the same point in space — toward Polaris, the North Star. At the June solstice, Polaris appears above the Sun as seen from the northern hemisphere. But six months later, at the December solstice, Earth has moved half way around the Sun. As a result, Polaris is in the opposite direction from the Sun. Essentially, that means that the north pole faces the Sun in June and turns its back on the Sun in December.

Between the solstices, the poles slowly nod up and down as each prepares to take its place in the sunlight.

THE BASICS

Framing the Seasons

The astronomical seasons are framed by four dates: the June and December solstices and March and September equinoxes. The solstices mark the Sun's farthest progression north or south and the start of either summer or winter, depending on the hemisphere. The equinoxes mark the moments the Sun changes celestial hemispheres as it crosses the equator. These herald the arrival of spring or fall. Day and night are roughly equal at the equinoxes, and the Sun rises due east and sets due west for the entire planet.

DON DAVIS/NASA

An artist's concept shows a giant asteroid slamming into Earth.

Saving the Nukes for Last

When astronomers discovered an asteroid in 2004, it looked like a job for Hollywood screenwriters. Early calculations gave the asteroid a 2.7 percent chance of hitting Earth in 2029. At an estimated diameter of about a fifth of a mile (340 meters), the asteroid could devastate thousands of square miles of Earth's surface and affect the environment around the globe.

Astronomers named the fearsome space rock Apophis, after an Egyptian god of chaos and darkness. Fortunately, though, additional tracking of its orbit eliminated the chance of a 2029 collision. Instead, it will pass about 19,000 miles above Earth's surface — close enough to be visible as it streaks across the sky.

NASA and others have been scanning for dangerous asteroids since the 1990s. They have discovered and plotted the orbits of thousands of Near-Earth Asteroids, whose orbits cross or come close to Earth's. Scientists estimate the haul includes all of the likely planet killers — asteroids at least one kilometer (0.6 miles) in diameter, which is large enough to cause global devastation. Now, the searches are looking for asteroids that could be city killers, like Apophis.

Scientists and engineers have studied several ways to deflect an asteroid. The effectiveness of each technique depends on the size of the asteroid and the length of time before the impact.

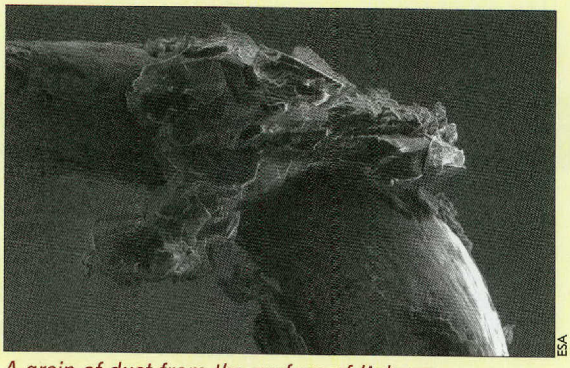
One technique calls for "painting" the surface in patterns of black and white. That would change the way the asteroid absorbs sunlight and radiates the heat back into space, creating a mild thrust to change the asteroid's speed and path. Another would use a spacecraft flying in formation with the asteroid to act as a gravitational "tractor," tugging it onto a new course. Both techniques would require years of lead time.

Deep Impact- and *Armageddon*-style solutions — nuke 'em — would be a last resort. Scientists would need to know an asteroid's composition and structure to make nuclear explosions most effective. Even then, chunks of debris would survive, some of which could still hit Earth. If there's no alternative, though, it would be time to bring in Bruce Willis and Robert Duvall to try to save Earth from mortal peril.

KEY DATES

June 13

Hayabusa, a Japanese spacecraft, brought pieces of asteroid Itokawa to Earth in 2010. The craft had gently touched the surface of Itokawa, collecting a few grains of cometary material. It then sealed the samples in a capsule that plunged through Earth's atmosphere and parachuted to a safe landing in Australia.

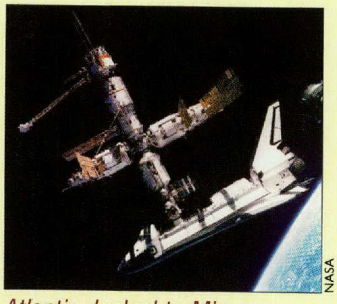


ESA

A grain of dust from the surface of Itokawa.

June 29

A new era in American-Russian space flight began when shuttle Atlantis docked to Mir, the first link-up between a shuttle and the space station, 25 years ago. Two Russian cosmonauts who launched aboard the shuttle remained on Mir, while three others returned to Earth on Atlantis. Eight other shuttle missions eventually docked with the station before it was deorbited, in 2001.



NASA

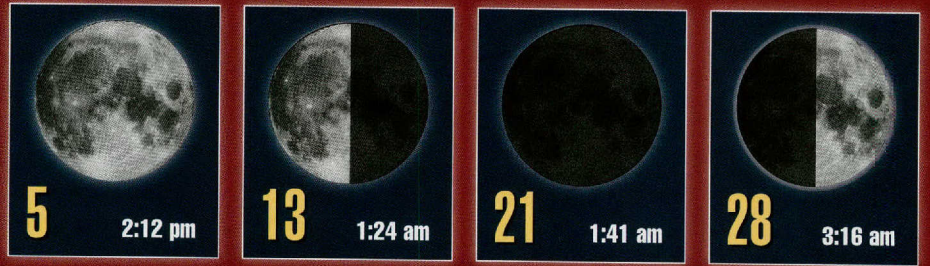
Atlantis docked to Mir, viewed from a nearby Soyuz spacecraft.

June 30

Today is Asteroid Day, part of a campaign to increase public awareness of the giant space rocks. It was created in part as a reaction to the discovery of Apophis, which will pass close to Earth in 2029 (left). More than 2,500 events were hosted as part of last year's Asteroid Day.

asteroidday.org

Moon phases are Central Time.



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

PERIGEE
June 2, 29

APOGEE
June 14

JULY

OVERVIEW

While the Summer Triangle and the other signature star patterns of the season continue their climb across the night sky, the solar system's giants stage a dazzling show. Both are at opposition, so they shine at their brightest for the year. Mars shines brightly, too, while Venus dazzles as the Morning Star.

HIGHLIGHTS

2 Antares, the orange heart of the scorpion, stands to the right of the Moon at nightfall.

4 Jupiter and Saturn align to the lower left of the Moon at nightfall, and closer to the upper left of the Moon at first light on the 5th. Jupiter is the brighter planet.

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

5 Saturn is quite close to the left of the Moon as they climb into good view in late evening, with brighter Jupiter to the upper right of the Moon.

11-12 Bright orange Mars stands to the upper left/upper right of the Moon at first light on these mornings, respectively.

11-14 Venus, the Morning Star, sweeps down past Aldebaran, the eye of the bull, at first light on these mornings.

FEATURED EVENTS

14 Jupiter, the solar system's largest planet, is at opposition.

16-17 Venus and Aldebaran perch to the lower left/close to the right of the Moon on these mornings, respectively.

FEATURED EVENTS

20 Saturn, the solar system's second-largest planet, is at opposition.

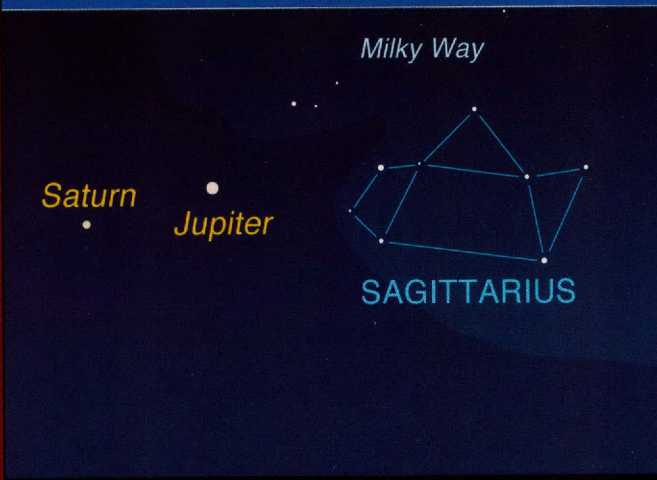
22 Mercury will shine at its best in the dawn sky the next few days. The little planet will look like a bright star quite low in the east-northeast about 30 to 45 minutes before sunrise. The view will be better from more southerly latitudes.

25-26 Spica is the bright star near the Moon on these evenings.

29 Antares stands below the Moon at nightfall.

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	



SE About 90 minutes after sunset

FEATURED EVENTS

A Time for Giants

July is a time for giants. The solar system's largest planets, Jupiter and Saturn, will stage their best appearances of the year, shining like brilliant stars. Best of all, they will stand within a lob-wedge of each other, separated by less than the width of your fist held at arm's length.

A planet is at its best for the year when it aligns opposite the Sun in our sky — a moment known as opposition. The planet rises at sunset, remains in view all night, and shines brightest for the year. Both Jupiter and Saturn reach that point this month.

Jupiter goes first, on July 14. It will easily outshine every other planet and star in the night sky other than Venus, the Morning Star. Saturn, to the left of Jupiter, reaches opposition on July 20. It's only a fraction as bright as Jupiter.

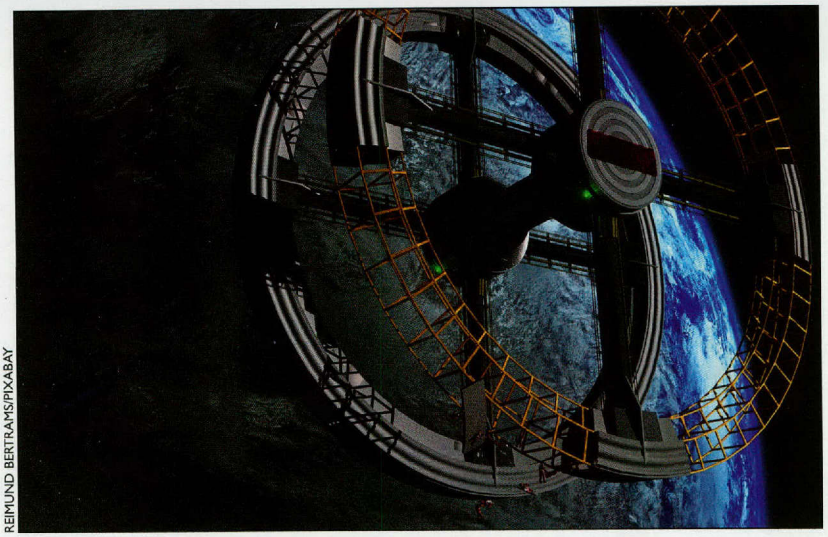
The two planets have appeared close together all year and will remain close through the end of 2020 and beyond.

That closeness is an illusion. Jupiter will be about 385 million miles (620 million km) from Earth when it reaches opposition, with Saturn about 450 million miles (725 million km) farther.

NASA (2)

Jupiter (top) and Saturn

At that great distance, both planets move slowly against the background of distant stars. Jupiter completes one circuit in roughly 12 years, while Saturn takes almost 30 years. As a result, both planets spend a long time inside the borders of each constellation they cross. Both have spent all of 2020 in Sagittarius and they will stay within the archer's boundaries until their close encounter in December.



REIMUND BERTRAMS/PIXABAY

Astronauts build a wheel-shaped space station in Earth orbit.

Taking a Spin

Everything comes with a price. Astronauts say that floating weightlessly around a spaceship, for example, is as fun as it looks. The price, though, includes loss of bone and muscle mass, reduced heart and lung function, and perhaps a suppressed immune system and other problems.

Artificial gravity like that depicted in *Star Trek*, *Star Wars*, and other Hollywood sci-fi is far beyond modern science.

There are a couple of ways to simulate gravity, though. One is for a craft to keep firing its rockets; the acceleration pushes anything inside the craft "downward," simulating gravity's pull. The other is to spin a cylindrical or wheel-shaped craft, which pushes outward, also creating simulated gravity. The "floor" of such a craft would be the inner edge of the cylinder or wheel.

Wernher von Braun, the German rocket scientist who was brought to the United States at the end of World War II, 75 years ago, popularized the concept of wheel-shaped space stations in the 1950s. He envisioned spinning structures holding dozens of inhabitants. They would watch Earth's weather, operate astronomical telescopes, and handle other chores.

Many Hollywood productions have correctly depicted spinning space stations. The most famous is *2001: A Space Odyssey*, in which a Pan Am space shuttle docked at an orbiting Hilton hotel. Other examples include *Babylon 5* and the recent *Expanse* TV series and the 2014 movie Interstellar.

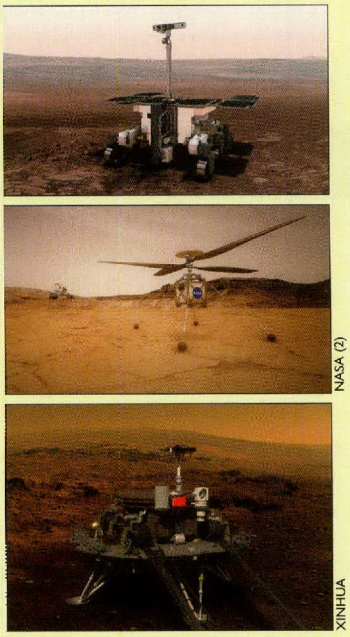
Others, though, have been a little off base. In the James Bond thriller *Moonraker*, for example, the inhabitants of a spinning space station are pushed perpendicular to the station's rotation. That would be like those of us on Earth walking on the walls instead of the floor. So when you see a production that features a rotating station, remember that the astronauts have to keep both feet on the "ground," just like they do at home.

KEY DATES

Mars will get a lot more crowded next year after four new missions arrive at the Red Planet. All are scheduled for launch this month. They are clumped together because the best time to launch a Mars mission is a few months before Earth and Mars are at their closest for the year (see October). That provides the shortest flight path for a Mars-bound spacecraft, requiring the minimum fuel for the maximum amount of payload. The listed dates are the opening of the launch window, which lasts about two weeks.

July 17, Mars 2020 Rover

This NASA mission, based on the successful Curiosity rover, will be the first to look for direct evidence of life on Mars, using an on-board laboratory to analyze samples of the dirt and rock. The rover will stash selected samples in a container for possible return to Earth by a future mission, and will help prepare for human exploration by trying to extract oxygen from the atmosphere. And it will carry a small robotic helicopter to scout the landscape.



NASA (2)

XINHUA

From top: ESA's Rosalind Franklin rover; NASA's helicopter; China's lander

July 23, HX-1

China's first independent Mars mission will consist of both an orbiter and a rover. They will carry a total of 13 scientific instruments to study the Martian surface and atmosphere.

July 25, ExoMars Rover Rosalind Franklin

A joint European-Russian rover will search for evidence of life on Mars. It will drill below the surface, where microbes might have survived the harsh Martian climate. Its instruments will search for organic molecules, determine the chemical and mineral composition of the rocks and dirt, and make other observations.

Date TBD, Hope Mars Mission

The United Arab Emirates hopes to launch its first interplanetary mission, an orbiter designed to study the Martian atmosphere.

Moon phases are Central Time.

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

APOGEE July 12

PERIGEE July 24

AUGUST

OVERVIEW

August nights are the province of two prominent constellations and an asterism. The constellations are Sagittarius, Scorpius, and the Summer Triangle. The brightest stars of Sagittarius form a teapot, with the Milky Way billowing as "steam" above the spout. Hook-shaped Scorpius really resembles its namesake, the scorpion. The Summer Triangle consists of three stars — Vega, Altair, and Deneb — that form a pattern that's not a constellation. Such a pattern is known as an asterism.

HIGHLIGHTS

1 Jupiter, the solar system's largest planet, aligns close above the Moon at nightfall. The second-largest planet, Saturn, stands farther to the left of the almost-full Moon.

2 Saturn and Jupiter line up to the upper right of the Moon at nightfall.

8 Mars is quite close to the Moon as they climb into view shortly before midnight, and closer to the Moon at first light on the 9th. From parts of the southern hemisphere, the Moon will occult Mars, blocking it from view.

12 Venus stands farthest from the Sun for its current morning appearance. It is in view for several hours, and is still high in the sky at first light.

13 Aldebaran, the eye of Taurus, stands close to the lower right of the Moon at first light.

15 Venus is close to the lower right of the Moon at first light.

15 The giant planet Uranus is at opposition.

22 Spica, the brightest star of Virgo, stands below the Moon at nightfall.

25 Antares, the heart of the scorpion, is close to the lower left of the Moon at nightfall.

27-29 The Moon sweeps past Jupiter and Saturn on these evenings. The planets are to the left of the Moon on the 27th. The Moon and Jupiter almost touch on the 28th, and the planets are to the upper right of the Moon on the 29th.

FEATURED EVENT

28 Ceres, the largest member of the asteroid belt, is at opposition.

AUGUST

Su	M	T	W	Th	F	Sa
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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

Biggest of the Small

Ceres is the biggest "have" in a realm of "have-nots."

It resides in the asteroid belt, a wide zone between the orbits of Mars and Jupiter populated by countless chunks of rock, metal, and ice. These bits of flotsam are "have-nots" because the gravitational pull of Jupiter kept them from coming together to form a planet. Ceres, though, is almost 600 miles (more than 950 km) in diameter and contains perhaps a third of the belt's total mass. That gives it some of the characteristics of a planet, including a round shape, a layered structure, and a thin atmosphere. Because of that it's classified as a dwarf planet, making it the asteroid belt's major "have."

One of the most intriguing things about Ceres is that up to 25 percent of its total mass may consist of water and water ice.

Dawn, a spacecraft that studied Ceres from orbit for three years, found that the surface consists of water ice mixed with water-rich minerals, such as clays. It also found that the largest mountain on Ceres, Ahuna Mons, may be an extinct ice volcano.

Dawn also spotted white spots on the surface that inspired speculation about alien colonies. Instead, though, the spots are vast deposits of salts (though chemically different from table salt). Scientists suggest that brine in a layer below the crust squirted to the surface. The water evaporated into space, leaving the bright salts.

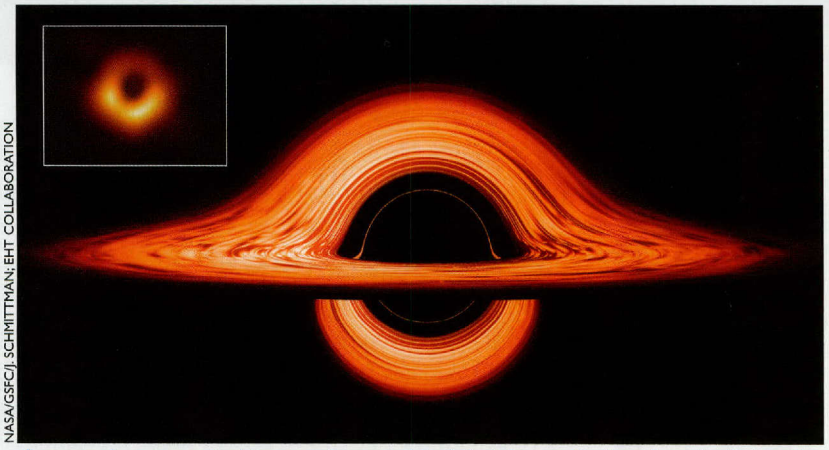
A Dawn view of Ceres, including bright white salt deposits in a crater at center.

NASA/JPL/UCLA/MPS/DLR/IDA

Dawn and Hubble Space Telescope detected evidence of water vapor in Ceres' thin atmosphere. It may have been expelled into space by ice volcanoes, or evaporated from the surface ice.

Models of Ceres suggest the layer of brine could be many miles deep, sandwiched between the icy crust and a mantle of ice mixed with watery minerals.

The presence of so much water, including some in liquid form, suggests that conditions on the young Ceres could have been right for the formation of life. That could make Ceres one of the biggest "haves" in the solar system: a life-bearing world.



NASA/GSFC/J. SCHMITTMAN; EHT COLLABORATION

A computer-generated image shows a black hole's gravity bending the light of a disk of hot gas (which passes in front of it) to form what looks like a maelstrom around the black hole. Inset: The first image of a real black hole, in M87.

Physics Meets Art in a Black Hole

Movie producers often hire scientists and engineers as technical consultants for sci-fi extravaganzas. Then, of course, they ignore them.

With *Interstellar,* a film by Chris Nolan in which Matthew McConaughey tries to save humanity with a little help from wormholes and black holes, things were different. The technical consultant, Kip Thorne, was also an executive producer. He crafted pages of equations that the movie's effects designers transformed into images, providing what probably is the most accurate depiction of a black hole to date.

The depiction was so accurate, in fact, that it surprised even Thorne, a leading expert in black-hole theory. The complex animations, which required hours to render a single frame of film, showed the black hole bending the light of a surrounding disk of gas, forming what looked like a swirling maelstrom around the black hole, which was unexpected. Thorne and the effects team turned the revelation into a set of scientific papers.

Black holes are naturally tempting targets for film and television producers. Any object that can bend light, swallow stars, and affect the passage of time is bound to draw attention. And scriptwriters have devised some creative uses for black holes, some of which might be possible, while others are no more than speculation: powering starships, destroying planets from within, serving as passageways to other times and dimensions.

Many black-hole depictions are just plain wrong, though: time randomly speeds up and slows down around a black hole (it wouldn't), spaceships escape through "cracks" in a black hole's surface (there are no cracks and no surface), or a black hole pulls in stuff from far outside its sphere of gravitational influence (which is no greater than that of an ordinary star of the same mass).

Right or wrong, though, Hollywood isn't likely to abandon black holes as plot points — or do a better job of getting it right than with *Interstellar.*

KEY DATES

August 3

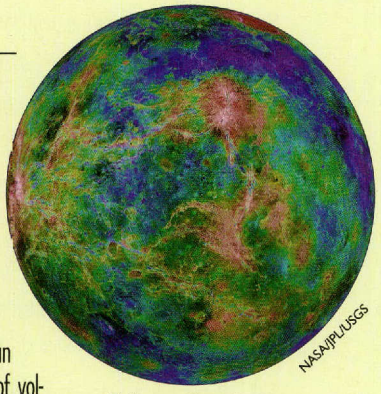
Mars will reach its closest point to the Sun for its current orbit. This happens during summer in the southern hemisphere, so the polar ice cap will begin to disappear as it's warmed by the Sun. Massive dust storms sometimes stir to life at this time, with some of them covering most or all of the planet (see page 23). A storm in 2018 blocked so much sunlight that it killed the solar-powered Opportunity rover, which had been creeping across Mars since 2004.

August 3

Asteroid 2018 BD will pass just 1.8 million miles (2.8 million km) from Earth today. The asteroid was discovered in January 2018, just seven hours before it passed 22,000 miles (35,000 km) from Earth. It is only 7-20 feet (2-6 meters) in diameter, so even if it hit Earth it probably would burn up in the upper atmosphere.

August 10

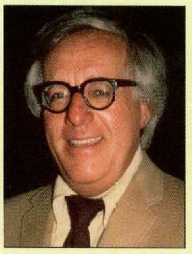
The most prolific Venus mapper in history entered orbit around the planet in 1990. Its radar peered through the planet's unbroken cloud layer, mapping almost the entire surface at scales of less than roughly 300 feet (100 meters). The maps revealed that the Venusian surface consists almost entirely of volcanic rock deposited within the last few hundred million years.



NASA/JPL/USGS

False-color view of Venus compiled from Magellan data

August 22



AI AN LIGHT

Ray Bradbury, 1975

Science-fiction author Ray Bradbury was born 100 years ago today. His most famous works include *Fahrenheit 451* and *The Martian Chronicles,* a series of stories about attempts to colonize the Red Planet. He received numerous awards, and his stories have been adapted for many other media, including radio, television, and movies.

Moon phases are Central Time.

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

APOGEE
August 9

PERIGEE
August 21

SEPTEMBER

OVERVIEW

The Celestial Sea wheels into the east and southeast during September evenings. This group of constellations all relate to water. Capricornus, the sea goat; Aquarius, the water bearer; Piscis Austrinus, the southern fish; and Pisces, the fishes are in view as darkness falls. Cetus, the sea monster, and Eridanus, the river, follow behind them. They may share an aquatic theme because autumn was a rainy season in the ancient Mediterranean, where the constellations were named.

HIGHLIGHTS

4 Mars stands to the lower left of the Moon as they rise tonight.

5 Mars and the Moon appear to almost touch as they climb into view in late evening. They'll be farther apart at first light on the 6th.

9 Aldebaran, the baleful eye of Taurus, the bull, perches close to the Moon at first light.

11 Neptune, the most distant of the Sun's major planets, is at opposition. It rises around sunset and is in the sky all night. It's brightest for the year, too, although still so faint that you need optical aid to spot it.

13 Pollux and Castor, the twins of Gemini, line up to the upper left of the Moon at dawn. Brilliant Venus is farther below the Moon.

14 Venus aligns close to the right of the Moon at first light.

15 Regulus, the heart of Leo, is to the lower right of the Moon at first light, quite low in the east.

21-22 Antares, the brightest star of Scorpius, is to the lower left/lower right of the Moon at nightfall on these dates, respectively.

22 Autumn arrives in the northern hemisphere at 8:31 a.m. CDT, the moment of the equinox. The Sun crosses the celestial equator, which is the projection of Earth's equator on the sky, from north to south.

24 Bright Jupiter is to the upper left of the Moon at nightfall.

25 Golden Saturn stands above the Moon as night falls, with brighter Jupiter to their right.

FEATURED EVENT

27 The Sextantid meteor shower should be at its peak.

SEPTEMBER

Su	M	T	W	Th	F	Sa
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FEATURED EVENT

Hiding in the Light

When the Sun rises, the rest of the universe vanishes. Scattered sunlight turns the sky bright blue, erasing the view of the stars and planets. Yet they haven't gone anywhere. They're still hanging above us, hidden in our star's brilliant glare.

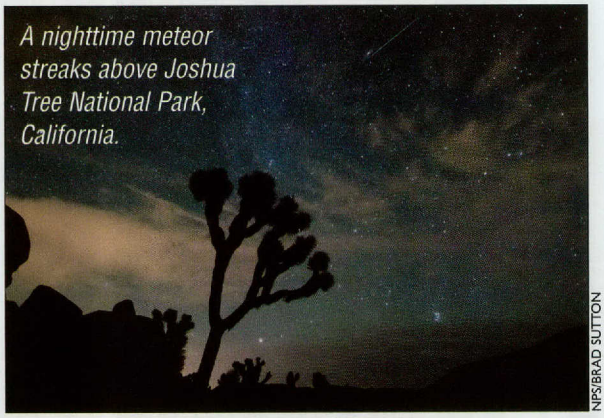
The curtain of blue also hides meteors — the streaks of light formed by bits of space rock burning up as they plunge into Earth's atmosphere. Just as many meteors flash through the daytime sky as the nighttime, including those spawned by several meteor showers. One of the most intense peaks in late September.

The Daytime Sextantids, as the shower is formally known, are spawned by asteroid 2005 UD. It may have split from the parent body of December's nighttime Geminids, which is one of the year's best showers. When Earth crosses 2005 UD's path, though, the dayside of our planet is facing into the stream of debris, so the meteors are washed out.

Astronomers track the meteors with radar. The meteors leave electrically charged trails in the upper atmosphere that reflect radio waves. Astronomers use those observations to trace the paths of the meteors, which tells them the orbit of the debris stream that feeds the shower. It also helped them track down the shower's parent asteroid.

There are two ways for the rest of us to observe the Daytime Sextantids. A few of them are visible in the hour or so before dawn, concentrated low in the eastern sky. The shower peaks on September 27.

The other way is to "listen" for them. The charged trail left in a meteor's wake reflects FM radio waves. If you still have an FM radio, tune to a weak, distant station at the low end of the band. When a meteor passes close by, the station's signal should become louder and clearer for anywhere from a fraction of a second to several seconds. So instead of music or a podcast, you might spend some time listening to the demise of space rocks that are hiding in the sunlight.



A nighttime meteor streaks above Joshua Tree National Park, California.

NPS/BRAD SUTTON

More Bang for the Buck

If you have a few hundred million dollars in your pocket, you could finance an effects-heavy cinematic trip to Mars. Or, for about the same amount of money, you could build a spacecraft to explore the Red Planet.

Astronomer Chris Impey has noted that the average Hollywood spectacular now costs more than the average space mission. *John Carter*, a 2012 flop about an earthling magically transported to Mars, for example, cost about the same as the failed Schiaparelli lander, part of Europe's ExoMars 2016 project (roughly $250 million each). And 2017's *Star Wars: The Last Jedi*, which was a huge success, cost about the same as the other half of the ExoMars project, Trace Gas Orbiter, another success (about $315 million each).

And when you consider the amount of money many science-fiction and action movies earn at the box office, the comparisons are even more staggering. The $630 million brought in worldwide by *The Martian* could almost have covered the construction, launch, and operations budget of MAVEN, a Mars orbiter ($671 million). And the proceeds from 2012's *The Avengers* ($1.5 billion) could have paid for the most recent Mars mission, InSight, with half a billion dollars left over.

Movie budgets continue to climb, and so do costs for most spacecraft. But more miniaturization of spacecraft components, allowing the creation of smaller probes, and the emergence of several commercial space operations could reduce the costs of missions to the Moon, Mars, and beyond in the years ahead. And improved technology should make it possible to provide better views from solar system explorers. So a high-definition livestream from the surface of Mars itself might cost less than a fictional view in the theater.

KEY DATES

September 1

Asteroid 2011 ES4 is predicted to pass about 40,000 miles above Earth today. As of late 2019, however, the asteroid hadn't been tracked since shortly after its discovery in 2011. That leaves a good bit of uncertainty about the timing, so the distance of closest approach could range from 35,000 to more than 10 million miles. The asteroid's estimated diameter is roughly 80 feet (25 meters), so even if it hits Earth the potential for damage is small.

September 2

Winter arrives in the northern hemisphere of Mars today (and summer in the southern hemisphere). It is the planet's shortest season, lasting just 158 Earth days, versus 183 days for northern summer.

September 24

Luna 16, the first automated probe to return samples of the Moon, touched down in the Soviet Union 50 years ago. The craft landed on the Sea of Fertility on September 20, 1970. About an hour after landing it drilled a 14-inch (35-cm) core into the surface, extracted about 3.6 ounces of rocks and dirt, and deposited them in a capsule. A few grains of the samples were given to the widow of Sergei Korolev, the principal architect of the Soviet space program. They have since been auctioned several times, most recently in 2018 for $855,000.

A set of postage stamps commemorating Luna 16.

September 26

Tonight is International Observe the Moon Night, designed to foster a better understanding of our satellite world. Last year, more than 2,000 events were hosted by museums, schools, planetariums, and other venues.

moon.nasa.gov/observe-the-moon/annual-event/overview

Moon phases are Central Time.

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

APOGEE September 6

PERIGEE September 18

OCTOBER

OVERVIEW

October is packed with amazing stargazing this year. It begins with the Harvest Moon, ends with the Hunter's Moon, and features Mars' best appearance of the year. The stars of summer continue to fade in the evening twilight, while those of autumn climb higher into the longer, cooler nights.

HIGHLIGHTS

1 The Moon is full today. As the full Moon closest to the autumnal equinox, it's known as the Harvest Moon.

1-3 Mars and the Moon will stage a beautiful encounter. The bright orange planet will stand to the left of the Moon on the evening of the 1st, quite close to it on the 2nd, and to the upper right of the Moon on the 3rd.

1-4 Venus sweeps past Regulus, the brightest star of Leo, before dawn. They will stand closest together on the 2nd and 3rd.

6 Aldebaran, the eye of Taurus, stands to the right of the Moon as they climb into view late this evening.

12 Regulus is below the Moon this morning.

13 Regulus is close to the upper right of the Moon at dawn, with brilliant Venus below them.

FEATURED EVENT

13 Mars is at opposition.

14 Venus stands to the upper right of the Moon at dawn.

19 Antares looks up at the Moon during early evening twilight.

21-23 The Moon passes by the planets Jupiter and Saturn. Jupiter is quite bright, with fainter Saturn not far to its left or upper left as night falls.

28-29 Mars and the Moon are close once again, with the planet continuing to shine like a bright orange star.

31 Uranus is at opposition. The giant planet rises at sunset and is in view all night. It's closest to Earth for the year as well, so it shines at its brightest, although you still need binoculars to spot it.

31 The Moon is full for the second time this month, so it's known as a Blue Moon. As the first full Moon after the Harvest Moon, it's also known as the Hunter's Moon.

OCTOBER

Su	M	T	W	Th	F	Sa
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FEATURED EVENT

A Dominating Performance

Mars dominates the night sky this month. It won't produce a showier display until 2035.

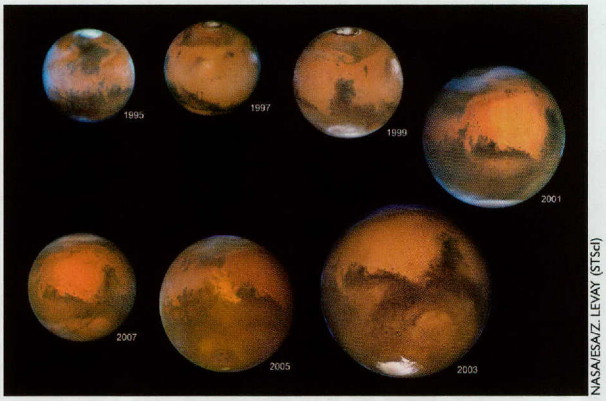
The planet is at opposition, where it lines up opposite the Sun. It reaches that point roughly every 26 months, but no two oppositions are alike because Mars follows an elongated orbit around the Sun. If Earth passes Mars when the Red Planet is near its closest point to the Sun, then it's an especially large target, so it shines especially bright, which is the case this month. For most of October, Mars will outshine everything in the night sky except the Moon and Venus, the Morning Star.

Mars reached its closest point to the Sun on August 2, and although it's now moving farther, it's still closer to the Sun than average. At the same time, Earth is a bit farther from the Sun than its average distance. The combination means that Earth will pass just 38.6 million miles from Mars on October 6 (which, thanks to some quirks in geometry, is one week before opposition, on October 13). That's a little farther than at the last opposition, in 2018, but much closer than any succeeding opposition until September 15, 2035.

Because Mars is closest to Earth at opposition, it's the best time to launch a spacecraft toward it. And during closer oppositions, space agencies can send heavier and more-capable probes without needing more powerful booster rockets. This year, a record four craft were scheduled for launch in July, with all four set to arrive at Mars early next year.

At its peak brightness, Mars will reach a magnitude of –2.62, so it will outshine Jupiter, normally the brightest pinpoint of light after Venus. Mars' orange color will be especially obvious, so the combination of brightness and color will make it an unforgettable sight.

Mars will begin to fade after mid-October as the distance to Earth increases. It will reach its next opposition on December 8, 2022 — more than 12 million miles farther than this year's stunning appearance.



NASA/ESA/Z. LEVAY (STScI)

This composite of Hubble Space Telescope views shows the relative size of Mars at several oppositions.

A Martian dust storm approaches astronauts and their lander in this artist's concept.

REN WICKS/NASA

Blowing Across Mars

Mars is windy. The InSight lander has recorded average wind speeds of about 10 miles per hour, with daily maximums, around noon, of 40 to 50 mph. And during a global dust storm in the 1970s, one of the Viking landers recorded top speeds of about 70 mph, which is just below hurricane force.

Science fiction often exaggerates the Martian winds, though. In 2015's *The Martian*, based on the novel by Andy Weir, astronaut Matt Damon gets stranded on the Red Planet by a powerful windstorm. It damages a habitat and topples one of two landers. Damon's crewmates, thinking he is dead, narrowly escape in the other craft.

That's unlikely to happen, though, because, at the equivalent of "sea level," the Martian atmosphere is only 0.7 percent as dense as Earth's. Even when the winds are blowing at gale force, they're not exerting a lot of pressure, so they would present little threat to landers.

The wind does carry a serious threat, though: dust. The Martian dust has a mild electric charge, so it clings to everything. And it's gritty, so it could easily jam up gears and wheels, damaging mechanical systems. It also coats solar panels, reducing their ability to convert sunlight to electricity (a problem that was well depicted in *The Martian*.)

Wind currents also stir up dust devils, which are small, twisting columns of air like those seen in the American southwest, and larger dust storms. The largest, which happen about every three Mars years (5½ Earth years), can blanket the entire planet. That turns the skies dark, silencing solar-powered landers (the Opportunity rover succumbed to a giant dust storm in 2018).

So while the Martian wind probably won't knock over any landers, it certainly could knock them out of commission.

KEY DATES

October 8

Author Frank Herbert was born 100 years ago. He is best known for the novel *Dune*, which describes the struggle to control Arrakis, a planet that produces a substance that space navigators must take to allow them to guide interstellar ships.

Covers from a few of the many printings of Dune

October 17

French astronomer Edouard Roche was born 200 years ago today. He proposed that the rings of Saturn formed when a small moon was pulled apart by the planet's gravity, and he calculated the distance from a star or planet at which any solid body would be distorted, known as the Roche limit. He also determined how the gravity of a star could pull gas off the surface of a companion.

SKY WATCH

Bookend Moons

Full Moons bookend October's night skies, and they're among the best-known full Moons of the year.

NASA/JOEL KOWSKY

A jet flies in front of a Blue Moon in July 2015.

The Harvest Moon lights up the sky on October 1. It is the full Moon closest to the autumnal equinox, which took place on September 22. Most years the Harvest Moon is in September. This year, however, October's first full Moon comes only eight days after the equinox, while September's full Moon took place a full three weeks before the equinox.

In centuries past, the Harvest Moon provided extra light to help farmers reap their crops at the end of the summer growing season. The next full Moon helped hunters track game through the denuded fields, so it became known as the Hunter's Moon. And this year, as the second full Moon in a calendar month, it's also known as a Blue Moon — bringing October to a close with a doubly famous full Moon.

Moon phases are Central Time.

The full Moon of October this year is the Harvest Moon. The second is the Hunter's Moon. As the second full Moon of the month, it's also a Blue Moon.

APOGEE
October 3, 30

PERIGEE
October 16

NOVEMBER

OVERVIEW

The bull climbs high across the sky on November nights, with his sparkly shoulder, the Pleiades star cluster, passing almost directly overhead around midnight. Yellow-orange Capella, one of the night sky's brightest stars, climbs along with it. And other autumn constellations, including Perseus and Andromeda, precede them.

HIGHLIGHTS

2 Aldebaran stands close to the lower right of the Moon as they climb into view shortly after darkness falls.

9 Regulus, the heart of the lion, is to the lower right of the Moon at first light.

10 The planet Mercury stands farthest from the Sun for its current morning appearance. It looks like a moderately bright star, low in the east-southeast, in early dawn. It is well below Venus, the Morning Star. Spica, the brightest star of Virgo, is to the upper right of Mercury.

TIM JONES

12 Venus stands below the Moon at first light, with the star Spica to its lower right. Mercury is below the trio.

13 Venus is to the upper right of the Moon, and Mercury below the Moon, at first light.

15 Mars is stationary today, appearing to stand still against the background of stars.

18-19 Jupiter and Saturn align to the upper left of the Moon on the evening of the 18th, and to the right of the Moon on the 19th. Jupiter is the brighter planet.

25 Bright orange Mars is close above the Moon at nightfall.

29-30 Aldebaran is close to the lower left/right of the Moon at nightfall on these evenings, respectively.

FEATURED EVENT

30 The Moon passes through the faint outer portion of Earth's shadow before dawn, creating a penumbral eclipse. It is so subtle that most skywatchers might not even notice it.

NOVEMBER

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FEATURED EVENT

Washed-Out Eclipses

For skywatchers in the United States, the Sun and Moon are a bit stingy this year. There are no total or even partial eclipses of either body. Instead, the best they have to offer are two penumbral eclipses of the Moon. Such eclipses are so pale and feeble that most skywatchers won't notice the difference in the light of the full Moon. The last of this year's penumbral eclipses takes place before dawn on November 30.

Lunar eclipses occur when the Moon passes through Earth's shadow. If the dark inner shadow obscures the entire lunar disk it creates a total eclipse, and the Moon turns dark red. If the inner shadow obscures only part of the Moon, it creates a partial eclipse, so the Moon looks as though something has taken a bite out of it.

During a penumbral eclipse, though, the Moon passes through the faint outer portion of Earth's shadow, known as the penumbra. Experienced observers may notice a slight darkening of the Moon's disk, but the effect is so obscure that most skywatchers see nothing.

Every eclipse belongs to a cycle known as a Saros. The circumstances of the eclipse repeat every 18 years, with the Moon and Earth's shadow in almost identical alignment. There's a slight drift between eclipses, though, so a cycle begins with a series of penumbral eclipses, then partial eclipses, then total eclipses as the Moon moves deeper into Earth's shadow. The cycle then reverses itself, with partial eclipses and penumbral eclipses, as the Moon slides out of the shadow.

The November 30 eclipse is part of a cycle that began on March 11, 993, and ends on May 14, 2291. The next eclipse in the cycle, also penumbral, takes place on December 11, 2038. Multiple cycles are always under way, though, so there are multiple eclipses each year.

This month's eclipse begins at 1:30 a.m. CST, when the penumbra first touches the Moon, and ends 4 hours, 26 minutes later. Except for eastern Maine, where the Moon sets shortly before the eclipse ends, the full cycle will be visible across the entire United States.

2020 ECLIPSES

DATE	TYPE	VISIBILITY FROM U.S.
January 10	Penumbral Lunar Eclipse	Alaska only
June 5	Penumbral Lunar Eclipse	None
June 21	Annular Solar Eclipse	None
July 5	Penumbral Lunar Eclipse	All except Alaska
November 30	Penumbral Lunar Eclipse	Entire country
December 14	Total Solar Eclipse	None

Exoplanets in fact and fiction

Planets, Planets, Planets

Science fiction has created an impressive variety of planets in star systems other than our own. Since they're the site of much of the action, which usually includes humans, most of these exoplanets are habitable (although some just barely).

Star Trek's Vulcan, for example, is a desert world. So are Tatooine, Luke Skywalker's home in the *Star Wars* universe, and Arrakis, center of action in the novel *Dune*. Hydros, a world from a Robert Silverberg novel, is completely covered by water; Hoth, also from *Star Wars*, is an ice world; and Dagobah, home of Yoda, is a jungle. And a couple of sci-fi moons, Endor from *Star Wars* and Pandora from *Avatar*, are covered by forests.

Astronomers haven't found a world to match any of those (yet), although they have found an astonishing variety among the thousands of exoplanets confirmed so far. The planets range from the mass of the Moon to many times the mass of Jupiter, the giant of our own solar system. Some have atmospheres, some have rings, some orbit more than one star, some orbit dead stars, and one or two appear to have moons.

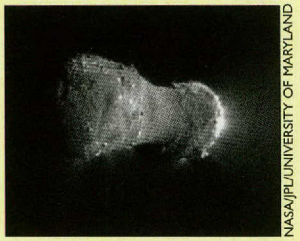
The list of known exoplanets includes dozens that orbit in the habitable zone — the distance from a star where temperatures are just right for liquid water. Since water is a key ingredient for Earth-like life, that makes these worlds the most likely places to look for life.

Habitability, though, depends on more than just a planet's distance from its star. The planet's composition, the radiation from its star, the number of impacts by comets and asteroids, and many other factors figure into the odds of a planet being able to support life. And so far, astronomers just don't know enough about the planets they've discovered to declare any of them "habitable."

Even so, they are looking for signs of life on some worlds. Such efforts probably will require bigger telescopes and better instruments to succeed, providing the first proof of a Vulcan or Hoth in another star system.

KEY DATES

November 4



NASA/JPL/UNIVERSITY OF MARYLAND

An EPOXI view of Hartley 2

EPOXI, a NASA mission, flew past Comet Hartley 2 10 years ago today. The mission, originally named Deep Impact, had fired a projectile at another comet and measured the debris blasted into space. After that, NASA retargeted the craft at Comet Boethin. When astronomers couldn't find the comet, though, the renamed EPOXI mission headed for Hartley 2. It flew within 431 miles (694 km) of the comet, and discovered that it was pumping vast amounts of water and carbon dioxide into space.

RESOURCES

ONLINE

StarDate Online
Daily skywatching tips, lunar phases, daily StarDate radio program, astronomy event listings **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 (the website will be offline until spring)
www.usno.navy.mil/USNO/astronomical-applications

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

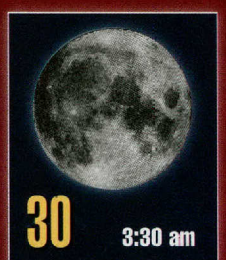
Meteor Shower Calendar
International Meteor Organization **www.imo.net/calendar/2020**

PUBLICATIONS

Observer's Handbook 2020, edited by Patrick Kelly
rasc.ca/handbook

Yearbook of Astronomy 2020, edited by Brian Jones
www.casemateipm.com

Moon phases are Central Time.



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

Daylight Saving Time ends November 1.

PERIGEE November 14 | **APOGEE** November 26

DECEMBER

OVERVIEW

As fall gives way to winter, some of the most spectacular stars and constellations in the night sky wheel into prime viewing hours. Orion the hunter is in view for most of the night as the month begins, and all night as it ends. A rectangle of four bright stars outlines his body, with his three-star belt at the rectangle's center. The belt points toward Sirius, the brightest star in the night sky. Other bright sights include the twins of Gemini, yellow-orange Capella high overhead, and the V-shaped face and orange eye of Taurus.

HIGHLIGHTS

5-6 Regulus, the heart of Leo, stands to the lower right of the Moon as they climb into good view shortly before midnight on December 5, and to the upper right of the Moon the following night.

10 Spica, the brightest star of the constellation Virgo, is to the lower right of the Moon at first light.

12-13 Venus is just below/to the upper right of the Moon in early twilight on these mornings, respectively. The planet is the Morning Star.

14 A total solar eclipse will be visible across a narrow strip of the southern hemisphere, from the Pacific Ocean, across southern South America, and into the Atlantic. Regions flanking that path will see a partial eclipse. North America is shut out of this eclipse.

FEATURED EVENT

16-17 The Moon passes by the planets Jupiter and Saturn in the early evening sky.

21 Winter arrives in the northern hemisphere at 4:02 a.m. CST, the moment of the December solstice. It is the shortest day and longest night of the year in the northern hemisphere, and the Sun stands farthest south in the sky.

FEATURED EVENT

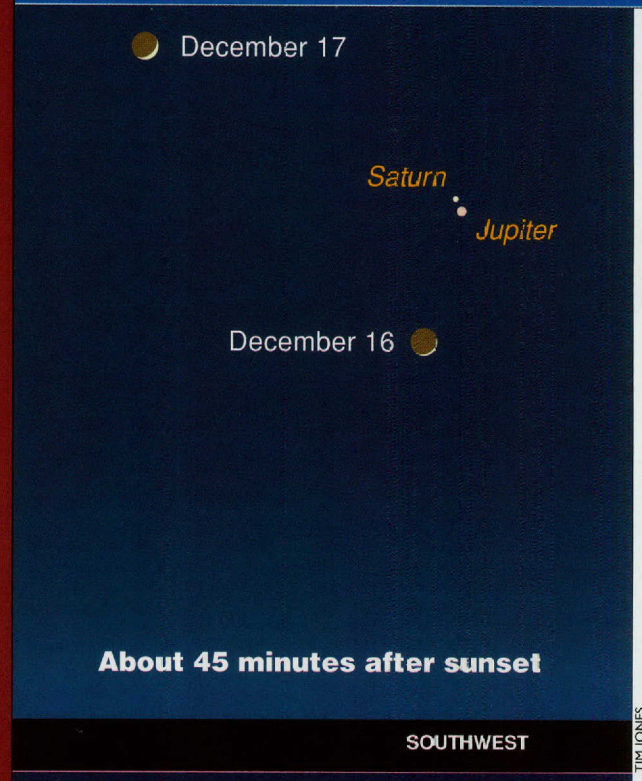
21 Jupiter and Saturn appear to almost touch each other.

23 Orange Mars stands above the Moon at nightfall.

27 Aldebaran is close to the right of the Moon at nightfall.

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		



TIM JONES

FEATURED EVENTS

Close-Together Giants

Jupiter and Saturn never pass closer than about 350 million miles from each other. Judging by their appearance in this month's western evening sky, though, you might think they were about to crash into each other. At their closest, on December 21, the giant planets will be separated by just one-tenth of a degree, which is roughly the width of a pencil lead held at arm's length. It will be their closest approach since July 16, 1623.

Such an encounter is known as a conjunction. It's possible because Jupiter and Saturn follow almost identical paths across the sky. They both stay quite close to the ecliptic, which is the Sun's path across the sky.

Jupiter follows a smaller, faster orbit around the Sun, so it catches up to Saturn every 20 years or so. Both move slowly across the sky, so they stay close together for months during each conjunction. They have been fairly close together all this year, and will be less than one degree apart (less than the width of your finger at arm's length) from December 12 to December 30.

Jupiter is by far the brighter of the two planets. It is the third-brightest object in the night sky, following only the Moon and Venus. Saturn is only about one-tenth as bright. Saturn will stand to the upper left of Jupiter at the start of the month but the larger planet will sweep past Saturn, so their positions will be reversed at the end of the month.

Adding to the beautiful conjunction, the crescent Moon will line up quite close to them on the evenings of December 16 and 17, creating one of the most beautiful sky shows of the entire year.

The Search Continues

Science fiction's first aliens were giant, fast-growing Moon creatures described by Johannes Kepler, a German astronomer who deduced the laws that govern planetary motions, in *Somnium*, a book published in 1634. The creatures spent the hot lunar days at the bottom of the ocean or inside caves, and if they got caught in the sunlight their spongy skin turned bark-like and fell off.

Writers have been crafting alien life ever since. They've envisioned deadly viruses (*The Andromeda Strain*), fast-growing blobs (*The Blob*), and beings made of pure energy (*Star Trek*). Most alien life, though, looks pretty familiar: two arms, two legs, two ears (with or without points), and two eyes (give or take). That's not surprising since the inhabitants of the only known civilization are the people of Earth.

So far, of course, we haven't found a shred of evidence of any life anywhere else in the universe, intelligent or otherwise. Astronomers are looking, though, from the planets and moons of the solar system to the hearts of nearby galaxies.

Astronomers are planning to use the Giant Magellan Telescope, James Webb Space Telescope, and other new instruments to search for "biomarkers" in exoplanet atmospheres — oxygen, methane, and other substances that can be produced by living organisms.

The search for extraterrestrial intelligence is using radio telescopes across the globe to listen for signals from civilizations near and far — from nearby stars to other galaxies. It's also using optical telescopes to look for laser flashes, which might power interstellar craft or serve as communications stations for multiplanet civilizations.

The next Mars missions, scheduled for launch this year (see page 17), include rovers designed to look for past or current life on the Red Planet. Future missions may drop a small submarine into the ice-covered ocean of Europa, sample a salty spray from a subsurface ocean on Saturn's moon Enceladus, or look for microbes in the sulfuric-acid clouds of Venus.

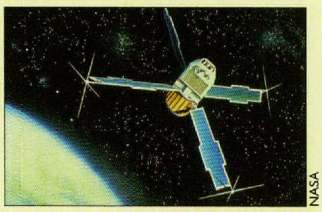
We don't know if we'll ever discover life beyond Earth, even if such life exists. We do know that authors will keep crafting exotic new races to entertain audiences, while scientists keep looking for the real thing.

MARTIN STR/PIXABAY

Until an alien spacecraft drops by, the search for ET will continue.

KEY DATES

December 12



NASA

Artist's concept of Uhuru in orbit

The first dedicated X-ray space telescope was launched on this date in 1970. Originally known as Explorer 42, it was renamed Uhuru after it entered orbit. It was launched from a platform off the coast of Kenya, and its name is the Swahili word for freedom. Uhuru studied Cygnus X-1, the first suspected black hole; discovered other black holes and neutron stars; and examined X-rays from other galaxies. It operated until 1973.

December 13

ALHAVE O'GORMAN/E KERVELLA

Betelgeuse as seen by a present-day telescope

Astronomers Albert Michelson and Francis Pease made the first direct measurement of the size of a star, in 1920: Betelgeuse, the bright orange shoulder of Orion. Using a complicated device known as an interferometer, they measured Betelgeuse's angular diameter, which they combined with the star's distance to reveal its true size, about 240 million miles. (Present-day measurements place Betelgeuse at a greater distance, making the star even larger.)

December 15

Venera 7, a Soviet probe, made the first transmission from the surface of Venus, in 1970. Although its parachute ripped, leaving it to fall a great distance before impact, its instruments survived for about 20 minutes on the surface. They transmitted the planet's surface temperature, which scientists used to calculate the atmospheric pressure. They also used those readings to estimate the wind speed. The readings confirmed that Venus is inhospitable to life. A sister craft also was launched toward Venus but failed to leave Earth orbit.

December 17 — CALENDAR EVENT

Today is Saturnalia, one of several ancient festivals 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 gifts, and decorated their houses with candles and lamps. Many of Saturnalia's customs survive in the celebration of Christmas.

Moon phases are Central Time.

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

PERIGEE December 12

APOGEE December 24

SKY CALENDAR

by Alan MacRobert

Venus reigns over the first part of this year as the Evening Star. Look for it high in the west at dusk. At dawn, look for the king of the planets, Jupiter, second in brightness only to Venus in the east. The Red Planet Mars will precede Jupiter up the firmament in early morning.

JANUARY 1 - 15

As the clear winter twilight fades, Venus pierces through as the Evening Star in the southwestern sunset afterglow.

As twilight deepens more toward the frigid night, you'll see that bright Venus is not the only notable point of light on that side of the sky. Way off to Venus' left, by two or three fists at arm's length, watch for 1st-magnitude Fomalhaut to glimmer into view. And three or four fists to Venus' right, watch for Altair.

Which will you see first? Altair is slightly brighter. But which one is higher or lower will depend on your latitude, and the lower a celestial object appears, the more it's dimmed by atmospheric extinction: the absorption of light by the thicker atmosphere the lower you look. (Think of the setting Sun.)

And which of the two appears first to you also will depend on pure, fluky chance. To see a tiny star that's just becoming visible in a fading sky, your exact center of vision has to land on its exact spot. That usually involves looking and looking before *bingo*, suddenly there it is.

As dusk deepens, Fomalhaut and Altair both become obvious, assuming you have an open view across from the west to the south-southwest. Over what landscape will you seek them?

This wide array of three gradually changes from night to night. On New Year's Day, you'll find one or both stars a little higher than Venus, depending on your latitude. Each night the stars sink a little lower while Venus creeps a little higher. By mid-January, Venus is quite a bit higher than either.

Unlike many stars that look similar, Fomalhaut and Altair really *are* fairly alike. Both are white type-A stars twice the size of the Sun, and hotter. They're just 25 and 17 light-years away, respectively, and they pour out 17 and 11 times as much light as our Sun.

Altair, however, is spinning so fast that it has an oblong shape: It's 25 percent wider than tall. Fomalhaut is nearly round.

Behind you by now, Orion and his winter constellation family are begging for attention in the east to southeast.

Orion is walking diagonally toward the upper right. His three-star belt is nearly vertical. Look above him for Taurus, highlighted by orange Aldebaran and, above that, the fingertip-sized Pleiades.

Gemini lies to the left of Orion, with Castor and Pollux marking the twins' heads on the left. Castor is the one on top.

Capella shines high above Gemini. It's the brilliant eye in the big, blocky, connect-the-dots head of Auriga, the charioteer. He's seen in profile, and takes a bit of imagination to make out. More prosaically, his five leading stars form a large squashed and tilted pentagon.

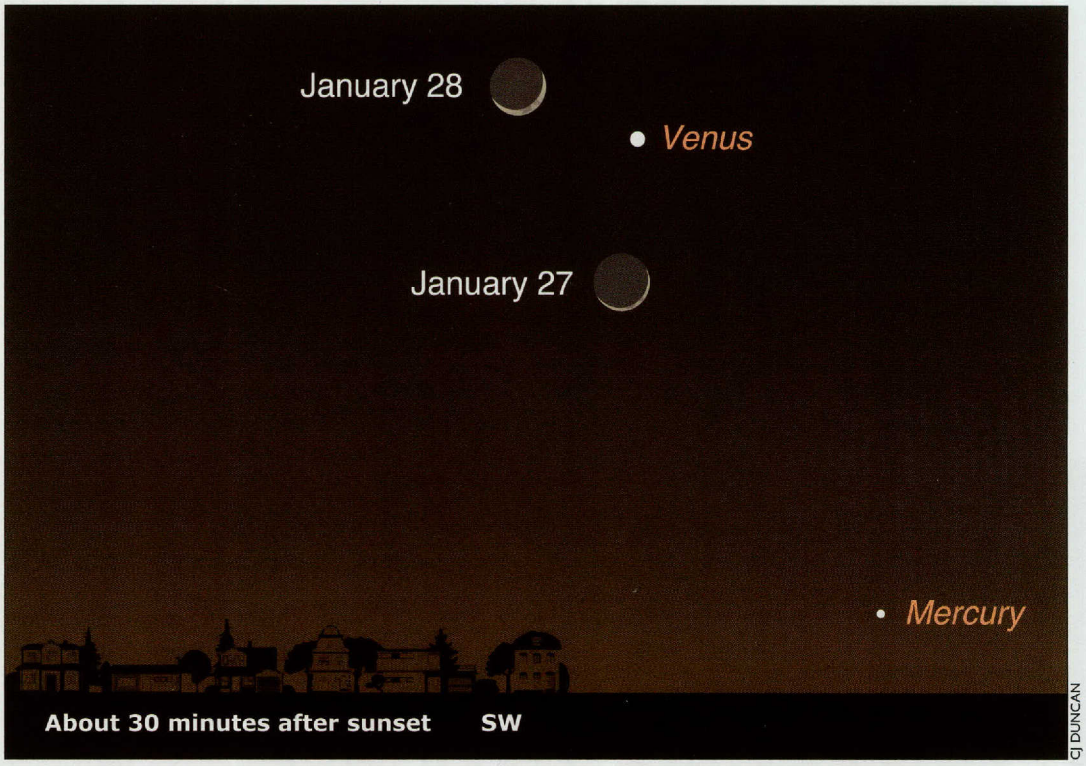
As evening advances, watch for brilliant Sirius to clear the horizon under Orion.

JANUARY 16 - 31

Venus, in the southwest, is both brightening and climbing higher as the weeks go by. It doesn't set now until a good hour and a half after complete darkness. It will continue to climb through the rest of winter.

Venus has lost any obvious neighbors — it's crossing dim Aquarius now — but the Great Square of Pegasus awaits you well to its upper right. As always in mid-winter, the Great Square is tipped up onto one corner in the west. The waxing crescent Moon poses enchantingly below Venus on the evening of January 27 and to the upper left of Venus on the 28th.

Orion and his neighbors



CJ DUNCAN

move toward the southeast and south as winter advances. Orion himself tilts more upright, and his belt turns from vertical to diagonal. The belt points toward Sirius to the lower left, and to the upper right toward orange Aldebaran, the eye of Taurus, the bull. Past Aldebaran, as always, you hit the frosty Pleiades.

Sirius is the bright dog tag on the chest of the stick figure of Canis Major, the big dog. Down below it, the triangle of stars marking the dog's tail and hindquarters is just rising.

Castor and Pollux are about four fists to the left of Orion and higher now. They're not exactly twins; Pollux is slightly brighter. And it's tinted pale yellow-orange, while Castor is white. Star colors are mostly subtle. But with scrutiny you can tell Castor and Pollux apart by Pollux's hue. It's an orange giant: a star that has bloated and cooled as it enters old age. They are, respectively, 51 and 34 light-years away.

Mars and Antares are another, temporary pair of not-quite-twins right now. They rise together in the early-morning hours. By the beginning of dawn (about an hour and a half before your local sunrise) you'll find them decently well up in the southeast. Both are orange-red; Mars is the one on the left. Mars is still so far from us, around on the far side of the Sun, that it's actually a little fainter than its rival, the red supergiant star Antares. In fact, the Red Planet is so small in apparent diameter that it may even twinkle a bit. Mars, however, is beginning a trek that will bring it to an excellent close and bright opposition in October.

As dawn grows bright, look about three fists at arm's length to the pair's lower left for Jupiter, just rising.

The waning crescent Moon poses above Mars and Antares on the morning of January 20, to their left on the 21st, and to the upper right of Jupiter on the 22nd.

The remaining two naked-eye planets, Mercury and Saturn, are lost in the glare of the Sun.

Meteor Watch

The Shower

Quadrantids

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

Peak

Night of January 3

Notes

The Quadrantids produce a large number of meteors at their peak, but the peak lasts only a few hours, providing a short viewing window. The Moon will be almost new, so it won't be around to spoil the show.

FEBRUARY 1 - 15

Venus is still the only naked-eye planet of the evening. It's now crossing dim Pisces. The Great Square of Pegasus is to its right.

Orion walks high across the meridian by midevening now, as upright and high as he gets. Sirius is to the lower left of him. Look more directly to his left for Procyon. These two dog stars, big and little, form the equilateral Winter Triangle with Betelgeuse, Orion's orange-supergiant shoulder.

The waxing gibbous Moon shines high over Orion on February 4 and 5.

Capella, the fifth brightest star in the sky (after the Sun), stands almost straight overhead around 7 p.m., depending on where you live. It goes exactly through your zenith if you're as far north as latitude 46 degrees (Portland, Oregon; Minneapolis; Montreal; Portland, Maine). Factoid of the night: Whenever Capella passes your zenith, Rigel — Orion's bright, leading foot — is also at its highest, marking true south over your landscape.

Look high in the northwest for W-shaped Cassiopeia. The W is turned way around, with its bottom oriented toward the upper left. Its lower three stars are its brightest.

Cassiopeia lies along the winter Milky Way, which now arches across the sky up from the northwest, across the zenith, and down to the southeast. Light pollution in your sky will dim the Milky Way or wash it out completely. But if your sky is unspoiled and your eyes are dark-adapted, the winter Milky Way is one of the most impressive glories of the night.

FEBRUARY 16 - 29

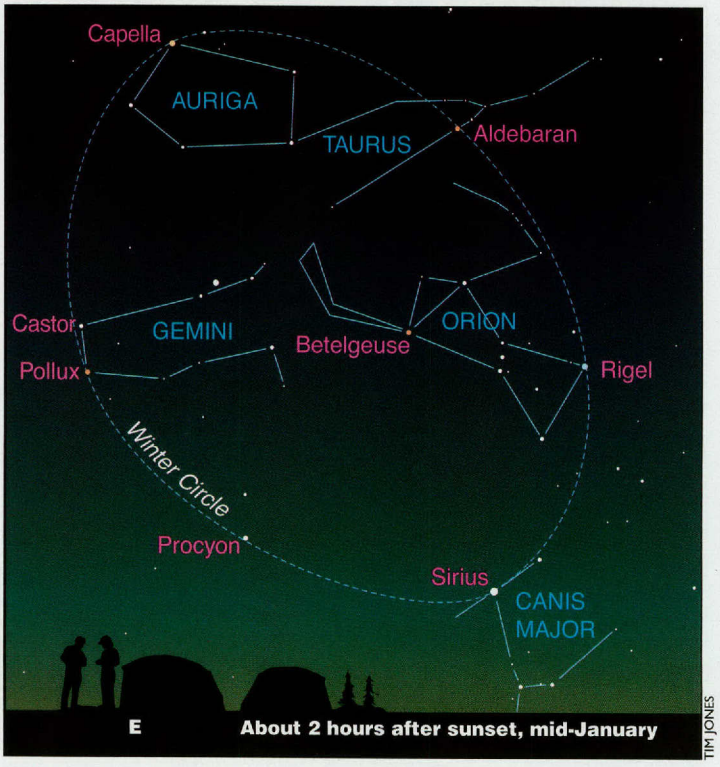
As winter proceeds toward its sloppy, muddy dog-end, the dog stars Sirius and Procyon shine their highest after dinnertime, clear and clean above it all.

And with spring approaching, the Big Dipper is already standing straight upright on its handle as it climbs the northeast. The handle is bent. Take a look with binoculars at the star at the bend. This is Mizar, with its tiny, close sidekick Alcor. If you have reasonably good vision you can resolve Alcor with your unaided eyes (it's currently to Mizar's lower left). But binoculars give you superhuman vision and render Alcor just as plain as day.

Also, make a point to set your alarm and look low in the southeast about an hour and 15 minutes before sunrise for Jupiter shining brightly. To its upper right, by a bit more than a fist at arm's length, will be little orange Mars. Two-thirds that far on the opposite side of Jupiter will be Saturn, still very low.

The waning crescent Moon pairs with Mars on the morning of February 18, Jupiter on the 19th, and Saturn on the 20th.

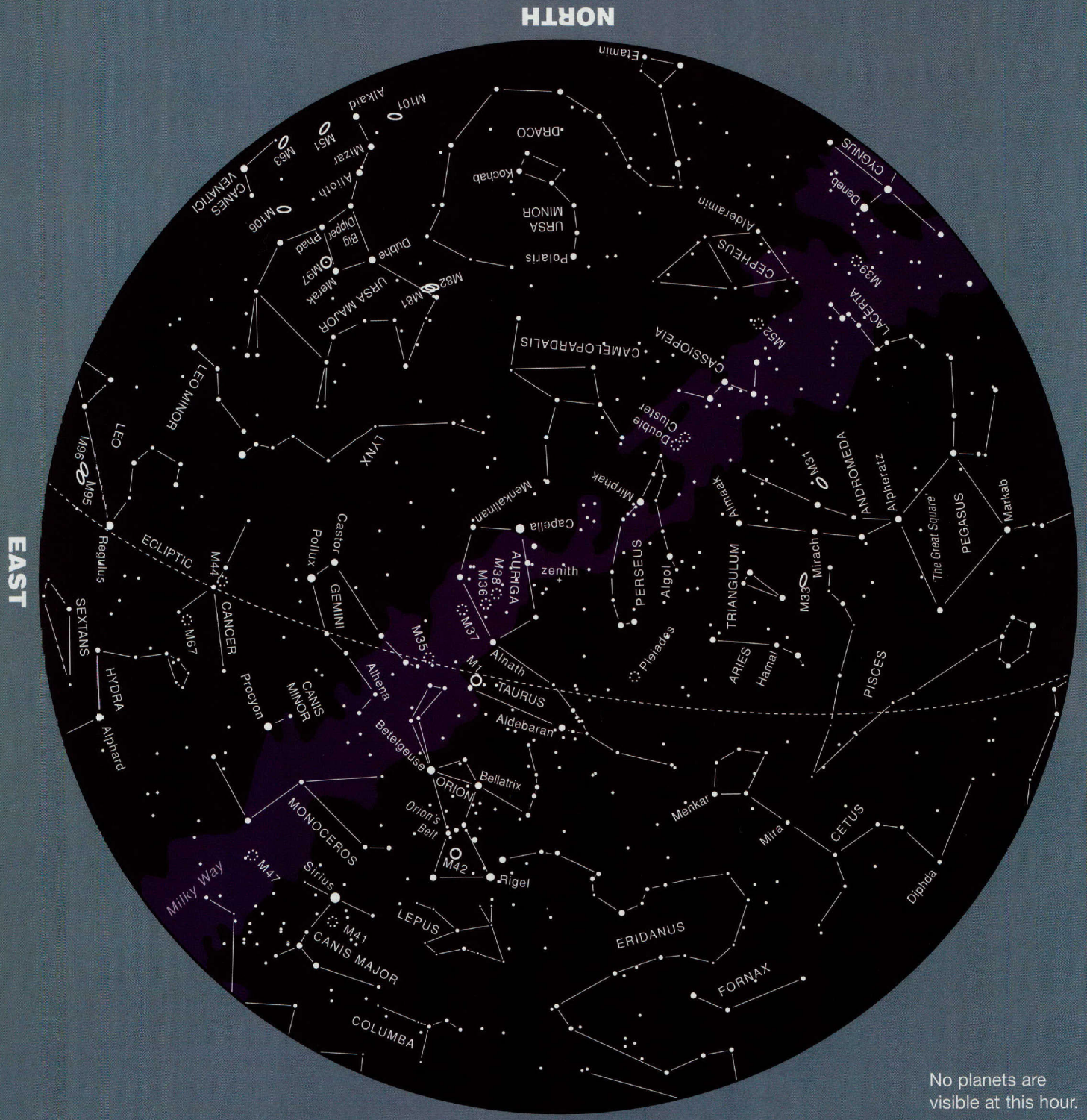
Alan MacRobert is a senior editor of Sky & Telescope.



JANUARY

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

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



MAGNITUDES

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

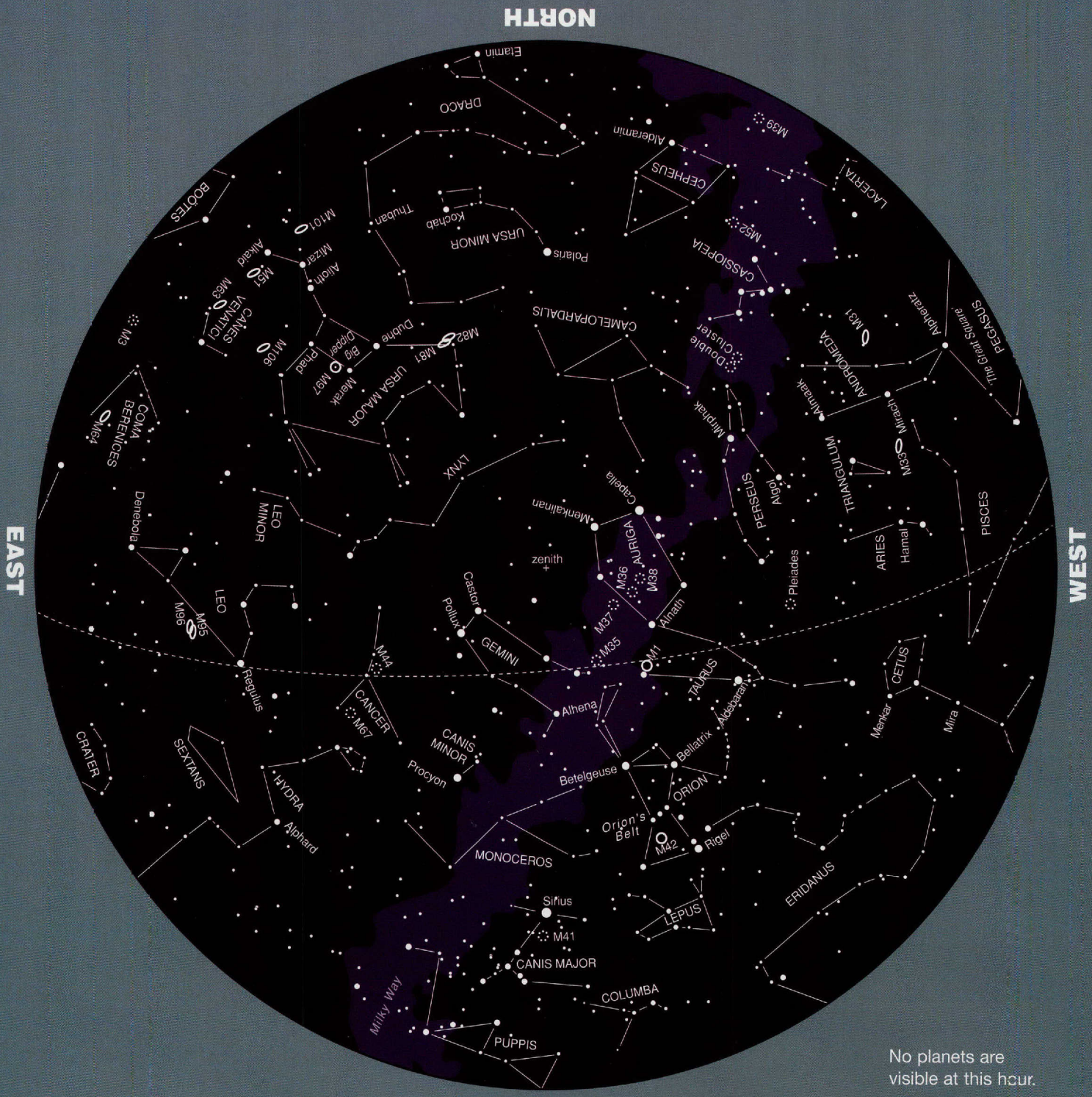
No planets are visible at this hour.

- 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.**



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