

## Sky Calendar extra content pages, May, June, and July 2021

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**Predawn in May through July 2021:  
A great time for closeup views of the two  
giant planets!**

**Jupiter and Saturn, reaching opposition in August  
2021, are well placed for observation in predawn in  
May, June, and July 2021.**

**Jupiter**, shining at mag.  $-2.2$  to  $-2.4$  in May, rises ahead of the Sun by nearly three hours on May 1, and by more than four hours on May 31. An hour before sunup, it's the prominent “morning star” in SE, while **Saturn**, three mags fainter at  $+0.7$  to  $+0.6$ , is  $15^\circ$ - $18^\circ$  to Jupiter's upper right

in May. **In coming months, use binoculars to notice the 4th-mag. stars near each planet.** On May 6, **Jupiter** passes  $1.3^\circ$  N of Iota Aquarii and will begin retrograde  $3.4^\circ$  ENE of Iota on June 20, returning to pass it twice more, on Aug. 5 and Dec. 23, completing a *triple conjunction*. On May 23, **Saturn** appears just over  $0.6^\circ$  WSW of Theta in Capricornus and begins retrograde, backing to  $7.3^\circ$  WSW of Theta by Oct. 10.

A telescope gives impressive views of both these giant planets. **Saturn with its rings tipped  $17^\circ$  from edge-on takes on an especially 3-D aspect during May 2021**, as the planet's shadow is projected on the ring. Using an eyepiece providing high magnification, look for a “gap” where the ring goes behind the planet's NW limb.

**Jupiter's four bright Galilean moons now present their orbits nearly edgewise to Sun and Earth.** This once-in-6-year event results in Jupiter's moons appearing in a nearly perfect straight line and frequently occulting and eclipsing one another. **Here is a sampling of events involving one of Jupiter's moons casting a shadow on another, on May 11, 25, and 28:**

On **Tuesday, May 11**, observe Ganymede, the largest and brightest of Jupiter's moons, fade and re-brighten from 5:06:13 until 5:14:48 a.m. EDT (4:06:13 until 4:14:48 a.m. CDT) as it undergoes partial eclipse by Europa's shadow. That morning, both Europa and Ganymede appear on the east side of Jupiter. Ganymede is on the far side of its orbit and moving outward, away from Jupiter. Europa, on the near side of its orbit, is moving closer to Jupiter.

The other two Galilean satellites, Io and Callisto, appear on the west side of Jupiter that morning. Io is very close in on the near side of its orbit, having ended a transit at 4:20 a.m. EDT. Callisto, the faintest and outermost of the Galilean moons, happens to lie near greatest elongation, farthest west of Jupiter that morning.

In a similar event on **Tuesday, May 25** from 4:23:26 a.m. until 4:30:20 a.m. EDT (3:23:26 a.m. until 3:30:20 a.m. CDT), watch Ganymede fade and re-brighten as it undergoes partial eclipse by Io's shadow. But this time, Ganymede also undergoes a much longer, 3h 40m total eclipse, by Jupiter's shadow, ending just as it begins to undergo the partial eclipse by Io's shadow. Ganymede's emergence from Jupiter's shadow takes about 8 minutes, centered on 4:23 a.m. EDT (3:23 a.m. CDT), which means it hasn't yet reached full brightness when it starts to be dimmed by Io's shadow. So Ganymede fades again until deepest partial eclipse at 4:26:53 a.m. EDT (3:26:53 a.m. CDT), and finally reaches full brightness at 4:30:26 a.m. EDT (3:30:26 a.m. CDT).

On that morning, start watching around 4:15 a.m. EDT (3:15 a.m. CDT), and you'll see just three satellites of Jupiter: On the east side are Io, close in, and Europa, farther out, a few hours past greatest elongation. Both are on the near side of their orbits, so are moving westward, closer to Jupiter. Callisto at that time is the only satellite visible on the west side of Jupiter. Like Io and Europa, on the near side of its orbit, Callisto is also moving westward, but that's taking it farther away from Jupiter. Keep watch for the reappearance of Ganymede from Jupiter's shadow close in on the west side of

Jupiter. Ganymede is hidden by Jupiter's shadow, but will be halfway emerged by 4:23 a.m. EDT (3:23 a.m. CDT), when its partial eclipse by Io's shadow will be just about to get underway, at 4:23:26 a.m. EDT (3:23:26 a.m. CDT), as mentioned above. Ganymede will finally shine at full brightness as its eclipse by Io's shadow ends at 4:30:20 a.m. EDT (3:30:20 a.m. CDT). Note that Io and Ganymede appear on opposite sides of Jupiter. Visualize in three dimensions Io, in the foreground east of Jupiter, casting its shadow extending past the east limb of Jupiter, then behind the planet, to Ganymede in the background just off the west limb of Jupiter.

A few minutes later, at 4:31 a.m. EDT (3:31 a.m. CDT), Io's shadow will be entering upon the east limb of Jupiter. The shadow takes 2.3 hours to cross the disk of Jupiter, so observers farther west will be in a good position to see the later stages of the shadow transit, ending on Jupiter's west limb at 3:48 a.m. PDT. Io itself begins a 2.3-hour transit on the east limb of Jupiter at 2:52 a.m. PDT (3:52 a.m. MDT), but the light-colored satellite against the light-colored background of Jupiter will be difficult to observe.

Ganymede is occulted by Jupiter beginning at 3:14 a.m. PDT (4:14 a.m. MDT), as the satellite disappears behind the west limb of Jupiter.

**On the morning of Wednesday, May 26, view the portion of the lunar eclipse visible in your area.** In the U.S., a total eclipse of the Moon is visible west of a line from SW corner of Louisiana to NE corner of Montana. (Details in the next section, on the total eclipse of the “Supermoon”, below.) **None of Jupiter’s moons undergo eclipse by another of its moons this morning.** Europa and Callisto are west of Jupiter, on the near side of their orbits and moving outward, away from Jupiter. Ganymede, the brightest satellite, is alone on the east side, until Io emerges from behind the east limb of the planet at 2:29 a.m. PDT (3:29 a.m. MDT, 4:29 a.m. CDT). Both Io and Ganymede are on the far side of their orbits, and moving outward, away from Jupiter.

**On the morning of Friday, May 28, from 2:50:21-3:02:17 a.m. PDT (3:50:21-4:02:17 a.m. MDT), Ganymede’s shadow will fall on Io,** resulting in a brief total eclipse in the middle portion of the 11.9-minute eclipse. Set up your telescope at least ten minutes before the start of the event to allow enough time to identify the satellites. Have a variety of eyepieces handy, including a high-power eyepiece allowing you to split Ganymede and Europa, which will appear very close together.

Satellite #4, Callisto, is alone on the west side of Jupiter, very far out, near greatest elongation.

Satellite #3 Ganymede is the largest and brightest moon of Jupiter. It’s east of Jupiter and on the near side of its orbit, so it’s moving inbound, toward inferior conjunction and transit of Jupiter, later in the day.

Satellite # 2, Europa, appears very close to Ganymede, but it’s on the far side of its orbit, so is moving outbound, away from Jupiter. As minutes pass, it will be easy to notice changes in the relative positions of Ganymede and Europa, moving in opposite directions.

Satellite #1, Io, appears as the innermost moon on the east side of Jupiter. It’s on the far side of its orbit, so it’s also moving outbound, away from Jupiter. Observe Io before 2:50 a.m. PDT, while it is still at full brightness before its passage through Ganymede’s shadow. Normally, Io is the second brightest of Jupiter’s four Galilean moons, next after Ganymede.

The partial and total phases of the eclipse of Io by Ganymede’s shadow last a total of 11.9 minutes, centered on 2:56:19 a.m. PDT (3:56:19 a.m. PDT). For some time around then, Io is invisible, in total eclipse. Watch Io recover to full brightness by 3:02:17 a.m. PDT (4:02:17 a.m. MDT).

Note that Europa does not participate in the eclipse, even though it appears very close to Ganymede during the event. Nor will an occultation take place. During the course of the 11.9-minute eclipse, the angular separation between Europa and Ganymede closes from 8.3” (arcseconds) to 5.8”. Several minutes later, at 3:15:11 a.m. PDT (4:15:11 a.m. MDT), Europa and Ganymede reach their minimum distance apart, 4.5”, with fainter, outbound Europa passing north of bright, inbound Ganymede.

For an interactive observing tool for plotting the moons of Jupiter, visit:

<https://skyandtelescope.org/observing/jupiters-moons-javascript-utility/>

For a listing of mutual eclipses and occultations of Jupiter's satellites during 2021, visit:

<http://nsdb.imcce.fr/cgi-bin/nss-eph3.cgi>

Note that the *Sky and Telescope* tool portrays eclipses of the Galilean moons by Jupiter's shadow, but does not portray the eclipses of the satellites by each other.

## **Total Eclipse of "Supermoon" on Wednesday morning, May 26, 2021**

The Moon passing through Earth's shadow produces a **total eclipse of the Moon on the morning of Wednesday, May 26**. We give times in PDT because western states offer the best views within the continental U.S., including the brief stage of total eclipse. To determine the visibility of the eclipse from your location, first convert the times of the eclipse stages to your own time zone (adding one hour for MDT, or 2 hours for CDT, or 3 hours for EDT), and compare with your local moonset time, which is within a few minutes after sunrise. Or use the web resources below to obtain maps of eclipse visibility, and data giving Moon's location in the sky for your city at each stage of the eclipse.

Here is a description of the various stages of the event:

(1) Moon unusually bright at 1:48 a.m. PDT, when it lies just outside Earth's penumbra and reflects maximum sunlight back toward Earth. Look up the *opposition effect*.

(2) Moon begins to enter umbra, the dark central core of Earth's shadow, at 2:45 a.m. PDT, and partial eclipse begins. Soon after that, the circular edge of the encroaching shadow becomes noticeable.

The Moon will reach halfway across the Moon's disk by 3:18 a.m. PDT.

(3) Total eclipse is forecast to last only 14.5 minutes, from 4:11.5 to 4:26.0 a.m. PDT, when the Moon's entire disk is calculated to lie within the somewhat uncertain limits of the umbra. Even at deepest eclipse at 4:18.7 a.m. PDT, the Moon's northern edge will lie barely within the umbra, so will be perhaps bluish or yellowish in color, and noticeably brighter than the rest of Moon's disk, which should appear a deep rusty color. As totality ends at 4:26 a.m. PDT, the Moon begins to emerge from the umbra.

At 5:19 a.m., the umbra still reaches halfway across the Moon's disk.

(4) Partial eclipse ends at 5:52 a.m. PDT as the Moon completely leaves the umbra.

**Unfortunately for folks in eastern U.S. and Canada, east of a line from Delmarva (DE-MD-VA) Peninsula across Lake Ontario through Toronto and northwestward into Canada, the Moon sets before**

**umbral eclipse gets underway.** The farther west of that line, you are located, the more of the eclipse you'll see. **From a narrow band centered on a line from SW corner of Louisiana through NE corner of Montana,** the dim, setting totally eclipsed Moon is unlikely to be seen because of daytime sky brightness -- the Sun rises a few minutes before the totally eclipsed Moon sets. **You'll need to be west of that band to view the Moon in total eclipse!**

**Within the contiguous 48 states, California offers the best view of totality,** but even there, morning twilight has gotten underway. **Hawaii offers a much better view, with the totally eclipsed Moon and the spectacular Sagittarius-Scorpius-Ophiuchus central Milky Way high in a dark sky.** Hawaii time is three hours earlier than PDT, so deepest total eclipse occurs there near 1:19 a.m. HST.

**\*\*\* Resources for viewing lunar eclipses \*\*\***

**Lunar eclipses for beginners:**

<https://mreclipse.com/Special/LEprimer.html>

**Find Solar & Lunar Eclipses in Your City:**

<https://www.timeanddate.com/eclipse/>

**Total lunar eclipse of Wednesday morning, May 26, 2021:**

<http://www.eclipsewise.com/lunar/LEprime/2001-2100/LE2021May26Tprime.html>

**Total lunar eclipse of Wednesday morning, May 26, 2021, with detailed illustration and map of visibility:**

<http://www.eclipsewise.com/lunar/LEdisk/2001-2100/LE2021May26T.pdf>

**Annular or partial eclipse of Sun on June 10, 2021**

**At all stages of this eclipse, eye safety is very important! Follow the links to information on safe solar viewing, below.**

**Annular eclipse of the Sun on Thursday, June 10.** The track where an *annulus*, or bright ring of sunlight, or "ring of fire" can be seen, begins at sunrise in Canada just N and NW of Lake Superior. This is an *annular* eclipse, *rather than total*, because the Moon is too distant from Earth for its conical umbral shadow to reach the Earth. The extension of the umbra's cone beyond its apex, the Moon's *antumbra*, does reach Earth's surface and defines the area where an annular eclipse can be seen. After touching down in Canada N and NW of Lake Superior, the antumbra races northeastward, crossing the provinces of Ontario, Quebec, and Nunavut; then it next goes across northwest Greenland. **Greatest eclipse, mag. 94 percent, with annular phase lasting 3m 51s, occurs just off Greenland's NW coast at 6:42**

**a.m. EDT.** The antumbra continues across the Arctic, including the North Pole, and finally lifts off the Earth at sunset in NE Siberia.

**In N America, a partial solar eclipse** can be seen everywhere north of a line through SC-GA (near their common border); TN, KY, extreme SW corner of IN; IL, IA, SW corner of MN; SD, ND to NW corner; then through Canada's SK, AB, BC, YT, and U.S.'s AK. South or southwest of that line, the eclipse ends before sunrise and isn't visible. Closely north or northeast of that line, the eclipse is very slight and brief, with Moon leaving the Sun's disk and ending the event just after sunrise.

**Locations still farther north provide deeper and longer views of the eclipse!** For more information about this eclipse, including maps and local circumstances of visibility, check the web resources below.

**\*\*\* Resources for viewing solar eclipses \*\*\***

**Safe solar viewing:**

<https://eclipse.aas.org/eye-safety>

<https://skyandtelescope.org/observing/celestial-objects-to-watch/safe-solar-observing/>

<https://eclipse.aas.org/resources/solar-filters>

**Solar and lunar eclipses:**

<https://mreclipse.com/>

**Find Solar & Lunar Eclipses in Your City:**

<https://www.timeanddate.com/eclipse/>

**Solar eclipses for beginners:**

<http://www.mreclipse.com/Special/SEprimer.html>

**Solar eclipse of Thursday, June 10, 2021:**

<https://eclipsophile.com/ase-2021/>

<https://www.timeanddate.com/eclipse/solar/2021-june-10>

<http://www.eclipsewise.com/solar/SEprime/2001-2100/SE2021Jun10Aprime.html>

<http://www.eclipsewise.com/solar/SEcirc/2001-2100/SE2021Jun10Acirc.html>

**Visibility from cities in U.S.:**

<http://www.eclipsewise.com/solar/SEcirc/2001-2100/SE2021Jun10Acirc.html#section3>