Galactic Observer
John J. McCarthy Observatory

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Calibration target for the cameras and laser that are part of SHERLOC (Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals), one of the instruments aboard NASA's Perseverance Mars rover. The instrument, designed to search for organic compounds and minerals in rocks, was returned to service in June. A lens cover designed to protect the instrument's spectrometer and one of its cameras from dust had become frozen in January likely due to a malfunction of a small motor used to move the cover. Engineers were able to free the cover by testing potential solutions on a duplicate SHERLOC instrument at the Jet Propulsion Laboratory in Pasadena, California.
Image Credit: NASA/JPL-Caltech

September Astronomy Calendar and Space Exploration Almanac

International Observe the Moon Night 2024 – September 14th

Moon Mosaic: Bill Cloutier

In This Issue

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McCarthy Observatory
New Milford, CT

Celebrate the Moon

International Observe the Moon Night (InOMN) is being celebrated on September 14th this year. The event was first inspired by public outreach activities sponsored by the Lunar Reconnaissance Orbiter (LRO) and Lunar CRater Observation and Sensing Satellite (LCROSS) educational teams at the Goddard Space Flight Center in Greenbelt, Maryland and at the Ames Research Center in Moffett Field, California, in August 2009. In 2010, the Lunar and Planetary Institute and Marshall Space Flight Center joined Goddard and Ames in a world-wide event to raise public awareness of lunar science and exploration.

The Moon will rise at 5:30 p.m. (EDT) on the 14th and set after midnight at 3:05 a.m. on the 15th. At approximately 228,650 miles (368,000 km) from the Earth, 87% of the near-side lunar surface will be illuminated as the Sun sets and twilight deepens. Unfortunately, the Moon will be quite low in the sky, never climbing above 26°, even at its greatest altitude shortly after 10 p.m. However, with clear skies and a good horizon to the south, it’s an excellent opportunity to explore Oceanus Procellarum and the Aristarchus Plateau along the northern terminator and Mare Humorum and the polar region in the south.

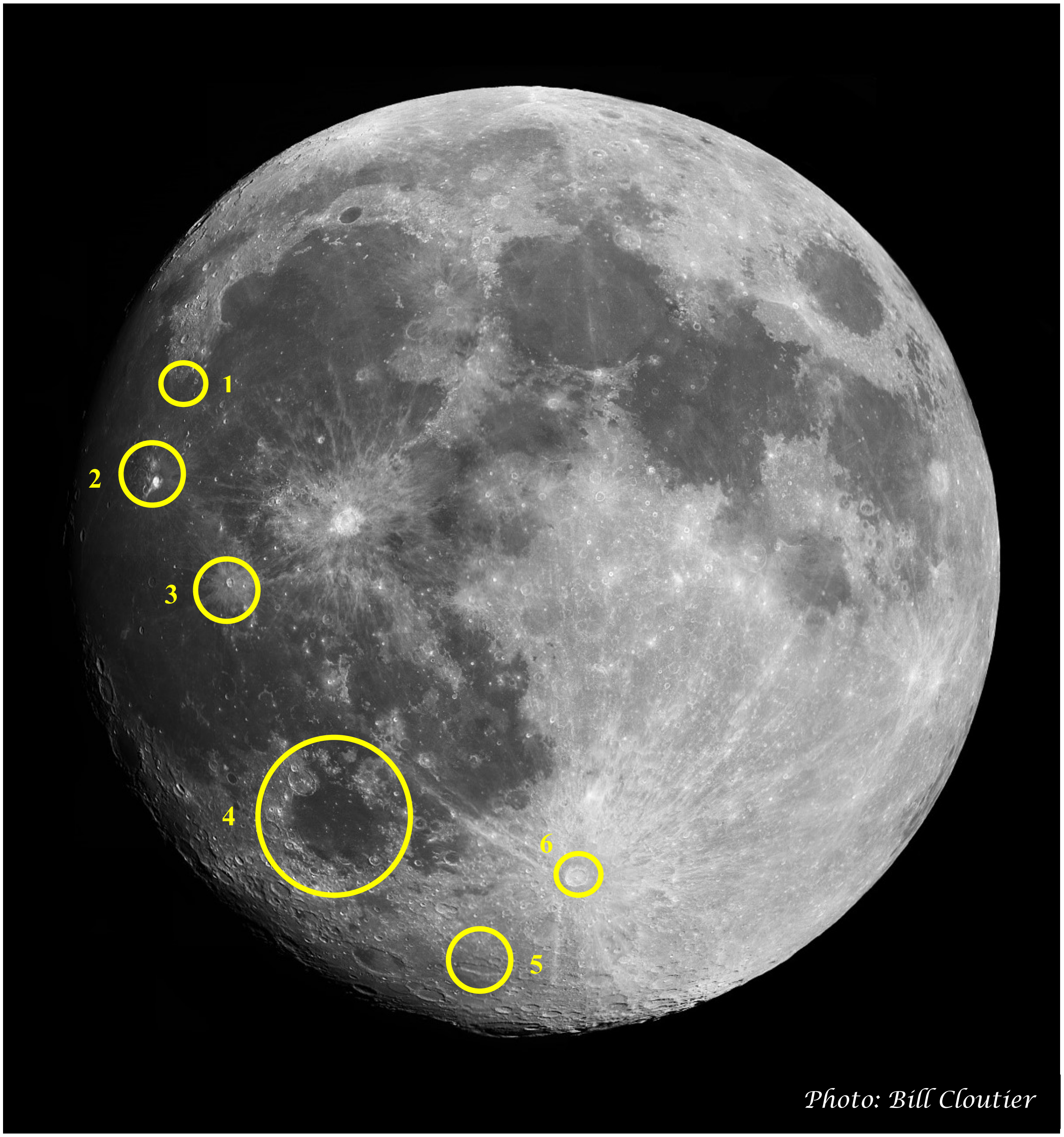
Start out your night in the north with a geologic enigma. Two volcanic domes, located along the western rim of the Imbrium Basin, southwest of Sinus Iridum and Promontorium Heraclides, are identified as Gruithuisen Gamma (γ) and Delta (δ). The composition of the domes is unlike the surrounding terrain in that they were likely formed by silicic lavas, as opposed to the basaltic lavas that filled the basin cavity. On Earth, water and plate tectonics play a role in the formation of silicic volcanoes – the Moon has neither. The creation process may remain a mystery until the domes can be visited and sampled.

Just to the south of the domes is the Aristarchus plateau, an uplifted slab of ancient crust, easily identified by the young and extraordinarily bright Aristarchus crater. Tucked between the craters Aristarchus and Herodotus is “Cobra Head,” a volcanic vent at the head of Vallis Schröteri, the largest sinuous valley or rille on the Moon. Cobra Head is believed to be the source of the lava that carved the 96 mile-long (155 km) primary rille and a 149 mile-long (240-km) inner rille that flow to the northwest. The primary rille is up to 7 miles wide (11 km) and 3,300 feet (1 km) deep. The nested secondary rille is indicative of multiple eruptive events over time.

Mare Humorum (Sea of Moisture) is the conspicuous feature along the southern terminator. The basaltic lava that fills this ancient impact basin forms a roughly circular plain over 260 miles (420 km) in diameter and is estimated to be several miles (km) in depth. As the lava cooled and contracted, the mass of material at the center of the basin induced stress fractures along the edges. On the eastern side of the mare are three rilles, concentric to the center of the basin, created by the subsidence (identified as Rimae Hippalus after a nearby crater). Interrupting the basin’s northern rim is the crater Gassendi with its double central peaks. Although its rim appears complete, the floor of this 69 mile (111 km) diameter impact feature exhibits extensive flooding, likely from widespread volcanism in the area. An impressive array of fracture lines crisscross the crater floor, while a smaller crater breeches its northern rim.

Wrap up the terminator tour with the crater Schiller, another lunar enigma. Its elongated shape (112 by 44 miles or 180 by 70 km) may have been created by a grazing impact (2° or 3°) or possibly the result of multiple overlapping impact craters.

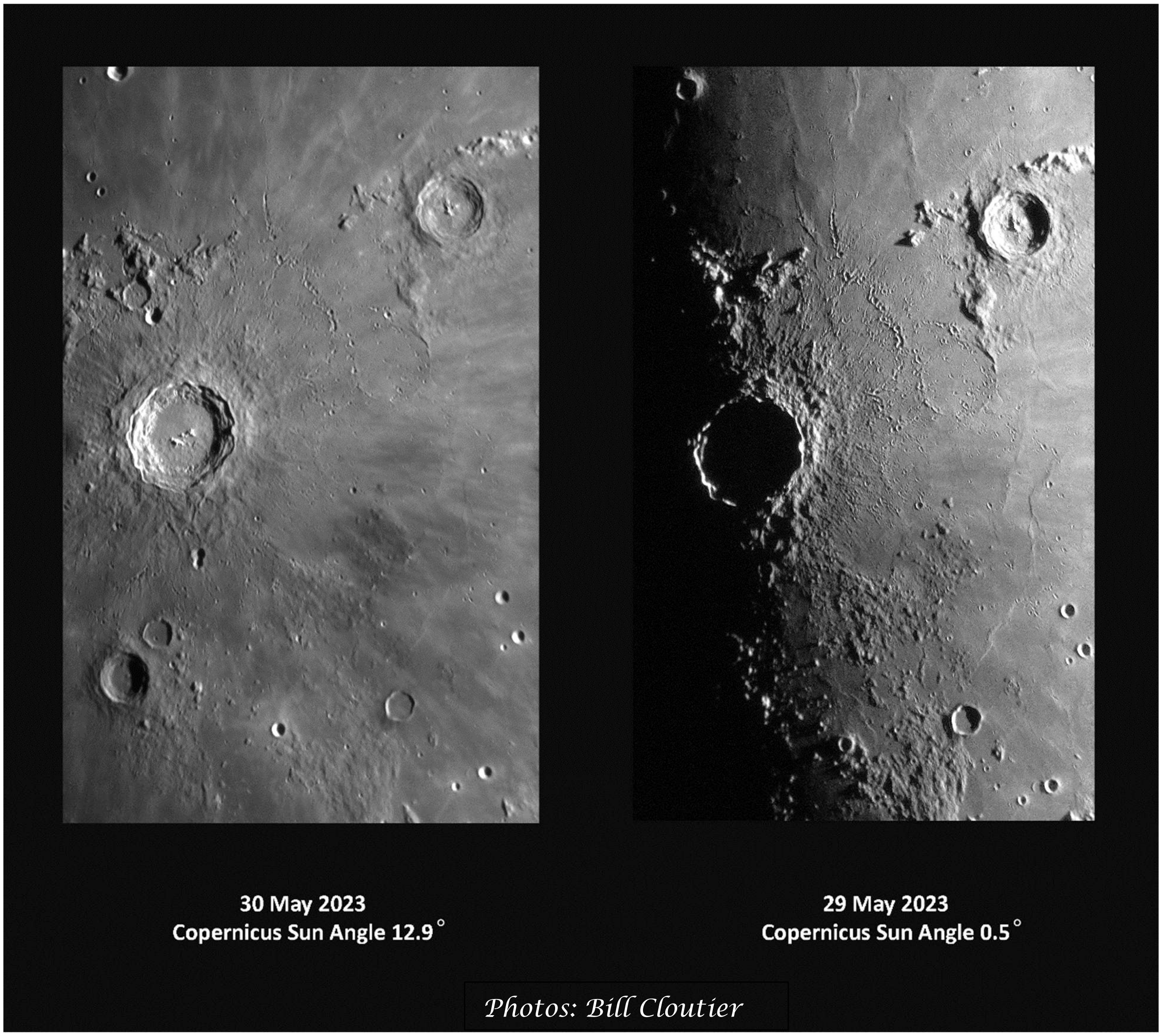
InOMN Highlights



1. Gruithuisen Domes: shield volcanoes Gamma (γ) and Delta (δ)
2. Aristarchus Plateau: uplifted section of ancient crust containing the bright crater Aristarchus and the largest sinuous rille on the Moon, Vallis Schröteri
3. Kepler: bright, young crater with distinctive impact rays splashing across the lava plains
4. Mare Humorum: flooded impact basin
5. Shiller: extremely elongated impact feature
6. Tycho's Rays: far reaching streaks of high-albedo material ejected during the formation of this very young impact feature (estimated at 108 million years old) – best seen under a high sun

Mare Humorum

Sun Angle



With the Moon's slow rotation rate, the time it takes for the Sun to return to the same position in the lunar sky is approximately 29.5 days. While half of the lunar surface is always illuminated, any specific location (excluding the polar regions) spends roughly two weeks of the lunation in complete darkness while sunlight plays across the ancient surface during the other half.

The terminator, or sunrise/sunset demarcation line, creeps across the lunar surface at a rate just shy of 10 miles per hour (16 kph). Optimal viewing of lunar features is best experienced along this line as deep shadows provide a dimension not seen when the Sun is higher in the sky.

One of the considerations in determining the launch windows for the Apollo missions was the illumination of the landing site (the acceptable range for the Sun elevation angle was from 5° to 14°). This would permit the recognition of topographical features without the "washout" effect experienced when the Sun is overhead (eliminating shadows and contrast). This restriction limited landing attempts to a 16-hour period every 29.5 days.

Starliner to Return without Crew

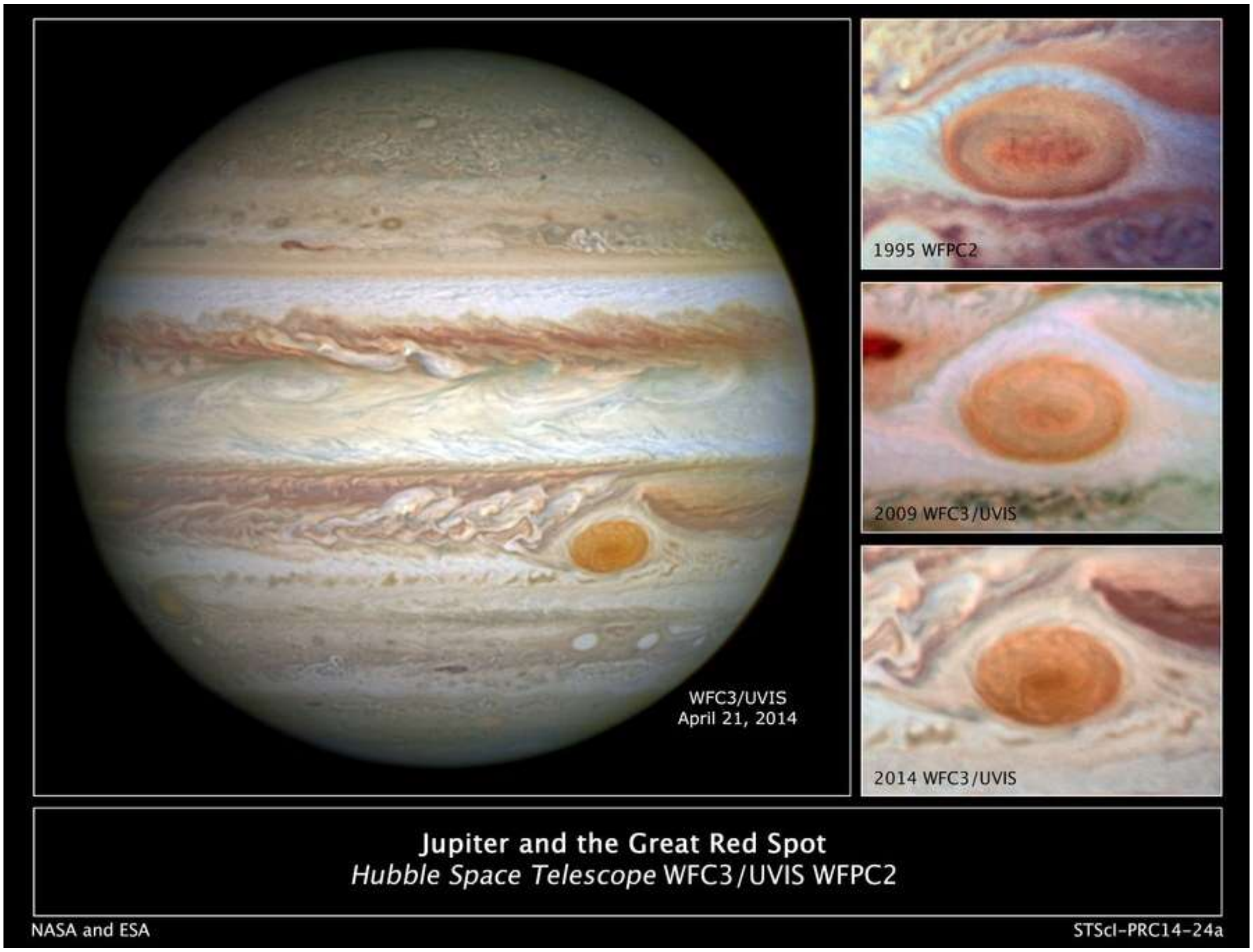
Starliner astronauts
Wilmore and Williams
Credit: NASA

NASA has decided to keep the crew of the Boeing Starliner, Butch Wilmore and Suni Williams, at the International Space Station (ISS) while the spacecraft returns to Earth on autopilot. Despite the company's assurances that the spacecraft is safe, based upon ground tests of its troubled thrusters, NASA elected to err on the side of astronaut safety. Wilmore and Williams will likely come back in February aboard a SpaceX spacecraft. NASA will need to bump two of the four astronauts scheduled to fly in September to the ISS in order to accommodate the Starliner crew.

Boeing Starliner
parked at the ISS
Credit: NASA

Red Spot Longevity

Recent observations suggest that Jupiter's Great Red Spot is contracting by almost 600 miles each year (it's still larger than the Earth in size). Historic observations, going back to the late 19th century, estimated the then-oval-shaped anti-cyclone to span 25,500 miles on its long axis. When the NASA's Voyager spacecraft passed by the gas giant in 1979, the storm was measured to be 14,500 miles across. Hubble Space Telescope images in 1995, and again in 2009, measured the width of the Great Red Spot at 13,020 miles and 11,130 miles, respectively. The persistent high-pressure region is now approximately 10,250 miles across and more circular in form.



Hubble Space Telescope images showing the progressive change in the size of the solar system's largest storm system from 1995 to 2014
Credits: NASA, ESA and A. Simon (Goddard Space Flight Center);
Acknowledgment: C. Go, H. Hammel (Space Science Institute, Boulder, and AURA), and R. Beebe (New Mexico State University)

Researchers have mapped the storm's internal structure with NASA's Juno spacecraft. Microwave observations indicate that the vortex extends at least 150 miles (240 km) below the cloud tops, while gravity measurements suggest that its roots could be twice as deep. The cause of the contraction, and whether it will continue, is unknown, but one theory is that the Great Red Spot is energized by the assimilation of smaller storms. The absence of feeder storms in the region could starve this behemoth and eventually lead to its unraveling.

Pillars of Creation Under New Light

Greg Bacon, Ralf Crawford, Joseph DePasquale, Leah Hustak, Christian Nieves, Joseph Olmsted, Alyssa Pagan, and Frank Summers (STScI), NASA's Universe of Learning

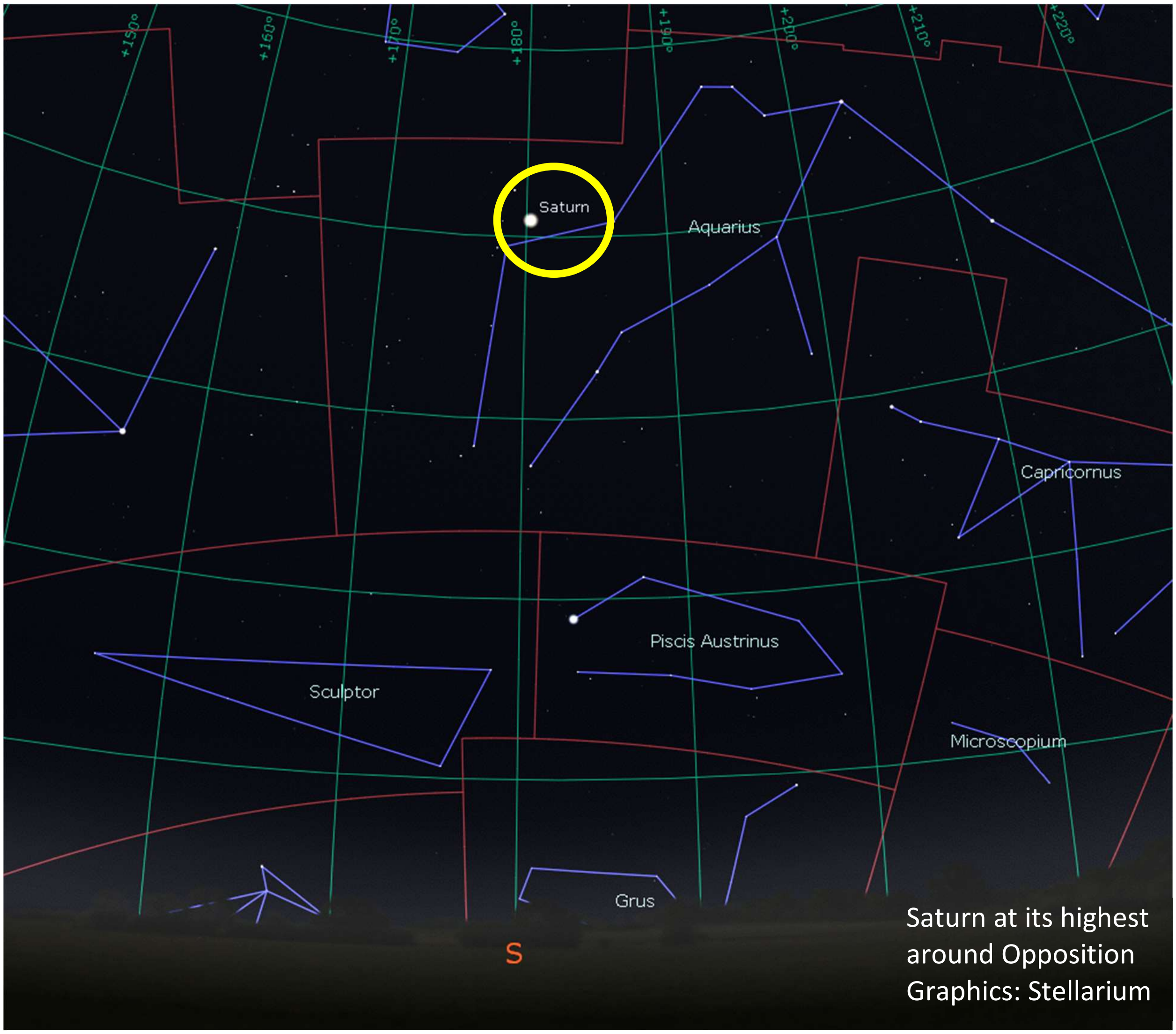
The "Pillars of Creation" are three tendrils comprised of cool molecular hydrogen and dust, embedded in the much larger Eagle Nebula (M16). The nebula, which spans 70 by 55 light-years, is located approximately 6,500 light-years (2,000 parsecs) from Earth in the constellation Serpens.

Within the pillars, which stretch three to four light years in length, are embryonic stars. Ultraviolet light from a nearby cluster of hot, young stars energizes the nebula and their fierce winds erode and sculpt the tenuous and dusty formation. While the nebula was first discovered 1745 by the Swiss astronomer Jean-Philippe Loys de Chéseaux, the "pillars" achieved recognition after they were first imaged by the Hubble Space Telescope in 1995.

Thanks to Hubble's longevity, and the launch of the Webb Space Telescope in 2021, star-forming regions like the one found in the Eagle Nebula can be explored at multiple wavelengths, revealing details not discernable with just one instrument. The mosaic (above) illustrates how the two telescope complement one another, with Hubble showcasing the opaque cocoons of dust and Webb providing a glimpse of the stars forming within (from the infrared light that can pass through the dust clouds). At the end of one of the "fingers" of the left pillar in the Webb image is a brand-new star, dazzling bright in the infrared.

Saturn at Opposition

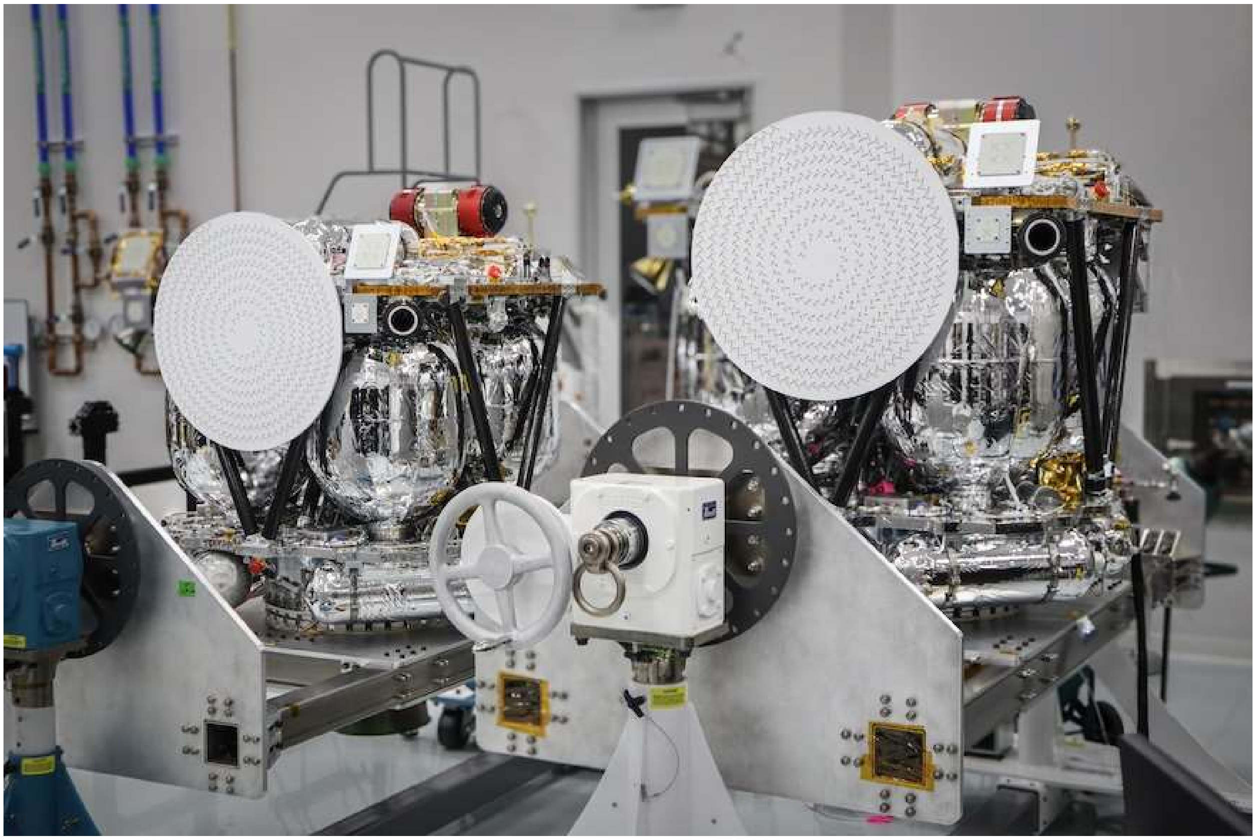
The solar system's most pictographic gas giant, Saturn, reappears in the evening sky in September, rising shortly after sunset on the 1st and at its highest (about 40°) almost 90 minutes after midnight. It will rise two hours earlier by the end of the month. Saturn can be found in the constellation Aquarius.



Saturn will reach Opposition on September 8th, when its lies directly opposite the Sun. On that date, the ringed-world will be 806 million miles (1,295 million km) from Earth or about 72 light minutes (time for light to travel from Saturn to Earth). Saturn will rise at 7:19 pm EDT from New Milford on the 8th and will be at its highest about an hour after midnight.

Saturn's north pole is currently oriented towards Earth and its rings inclined less than 4° to our line of sight. The tilt angle of the planet's rings can range from 0° (edge-on) to ± 27°, as seen from Earth, and we are currently approaching "ring crossing," which will occur in March 2025. At that time, the rings will seem to disappear from our sight. The rings will then begin to "reappear," revealing their underside, along with a view of the southern polar region.

New Glenn to Launch Mars Satellites on Initial Flight



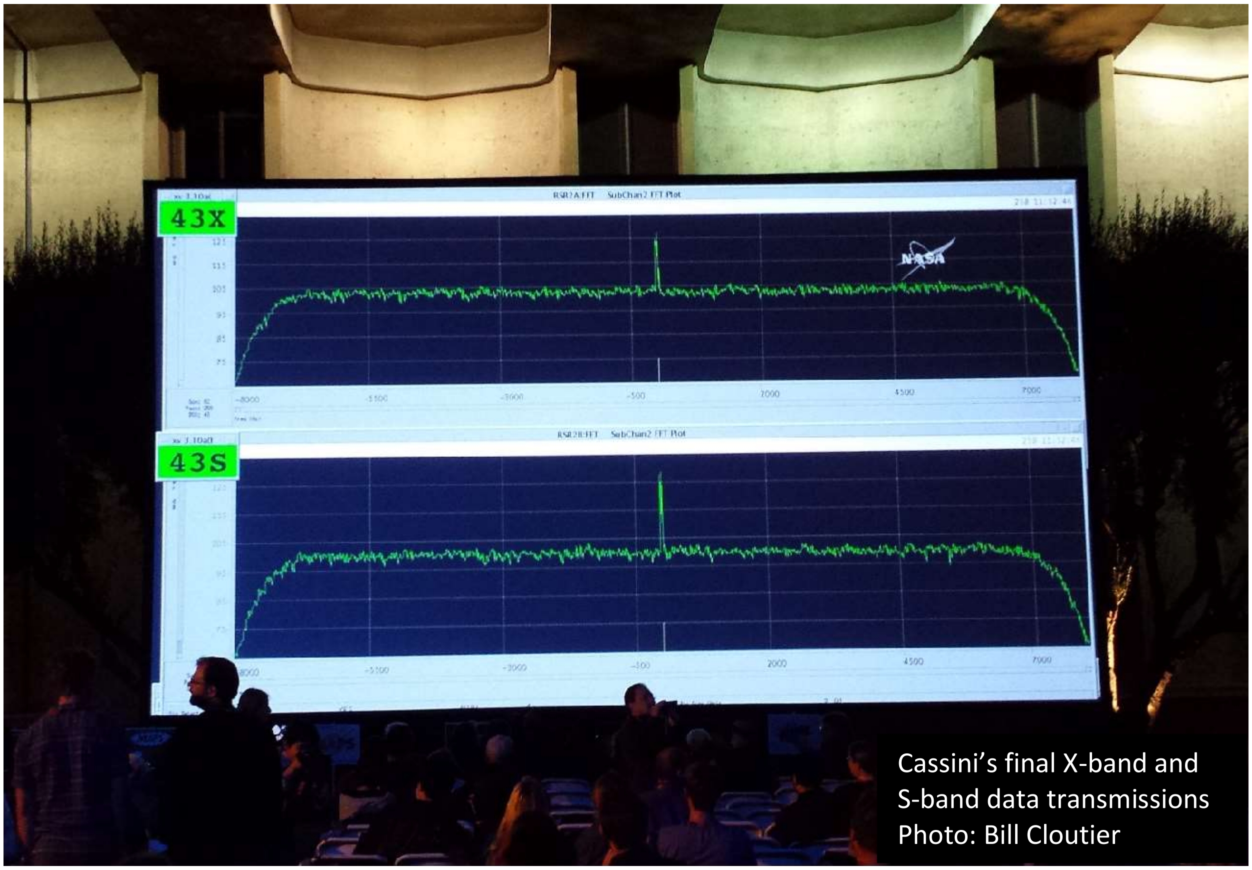
The twin Mars' orbiters in Rocket Lab's clean room prior to shipment to Blue Origin's launch facility at Cape Canaveral Space Force Station
Image: Rocket Lab

Blue Origin's first flight of its New Glenn heavy-lift rocket is tentatively scheduled for late September. The company's first orbital rocket will carry a pair of Mars-bound satellites: NASA's Escape and Plasma Acceleration and Dynamics Explorers (EscaPADE) mission. The two satellites, called Blue and Gold, had originally been manifested on NASA's Psyche mission until the agency changed launch vehicles (which altered the mission trajectory). EscaPADE is designed to study the interaction between the solar wind, the planet's magnetic environment, and the loss of the Martian atmosphere through a process called "sputtering."

The New Glenn rocket
Image: Blue Origin

The journey to Mars will take approximately 11 months. Both spacecraft will share a common orbit for the first half of the year-long science campaign, which is expected to start in April 2026, for simultaneous observations. After six months, the orbit of one spacecraft will be modified so that it crosses the orbit of the other. The apoapse (furthest point in the orbit) will then be raised for both satellites.

Cassini's Blaze of Glory



Cassini's final X-band and S-band data transmissions
Photo: Bill Cloutier

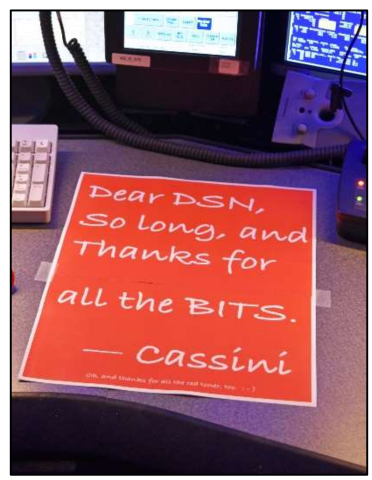
Seven years ago, in the early morning hours of September 15th, the streets of Pasadena, California were quiet. It wasn't until you pulled into the parking garage on the campus of the California Institute of Technology that you saw shadowy figures moving from streetlight to streetlight, all walking towards a common destination. Hundreds of people gathered that morning, scientists and engineers from the Cassini mission team, past and present, along with family and friends, to witness the conclusion of the flagship mission that had been launched 20 years earlier. Three large movie screens were set up at the center of campus, displaying scenes from the Jet Propulsion Laboratory's control room seven miles away, as well as transmissions from the spacecraft received by the Deep Space Network's Space Station 43 (DSS-43) in Canberra, Australia.

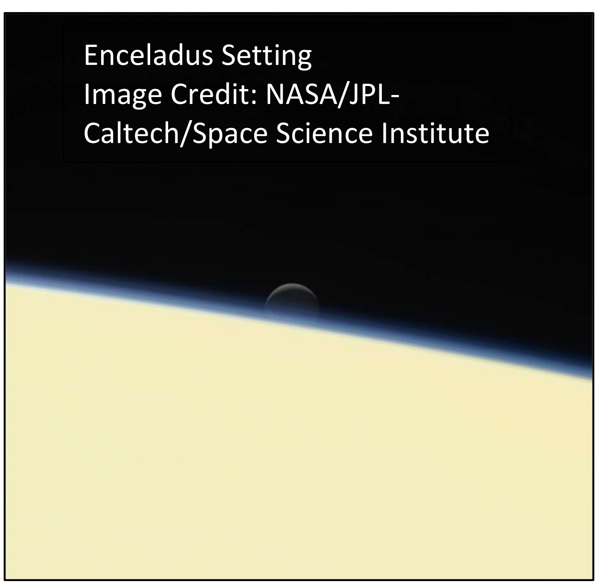
Low on fuel, and to preclude any possibility of contaminating the ocean moons of Saturn, NASA set a final course for the spacecraft that would plunge it into the planet's atmosphere. Diving for a final time between the rings and the planet, streaking across the cloud tops at over 75,000 miles per hour (120,000 km/hr), Cassini's thrusters struggled to keep its main antenna locked on Earth and deliver science right to the very end as atmospheric resistance began to build.

After traveling more than 4.9 billion miles since launch (7.9 billion km), NASA received its last data transmission from the spacecraft at 4:55:46 a.m. (PDT). Due to the vast distance between the Earth and Saturn, 83 minutes had already elapsed between the time Cassini broke up in the atmosphere and when its last signal was received. If there was anything alive in the clouds of Saturn, they would have been witness to a dazzling shooting star that morning.

The Ace is the engineer who monitors and communicates with a spacecraft during mission events. Only an empty chair could be found at the Cassini station in the JPL control room later in the morning of the 15th. Photos: Bill Cloutier

Cassini spent 13 years in the Saturnian system, collecting 635 GB of science data and 453,048 images. Six new named-moons, two oceans (on Titan and Enceladus), and three seas and hundreds of small lakes on Titan were discovered over 294 orbits and the deployment of the Huygens probe. The spacecraft's suite of science instrument provided an in-depth look at the gas giant's interior and planetary magnetic field, as well as collected data that may help explain the source and age of its ring system.





Enceladus Setting
Image Credit: NASA/JPL-Caltech/Space Science Institute

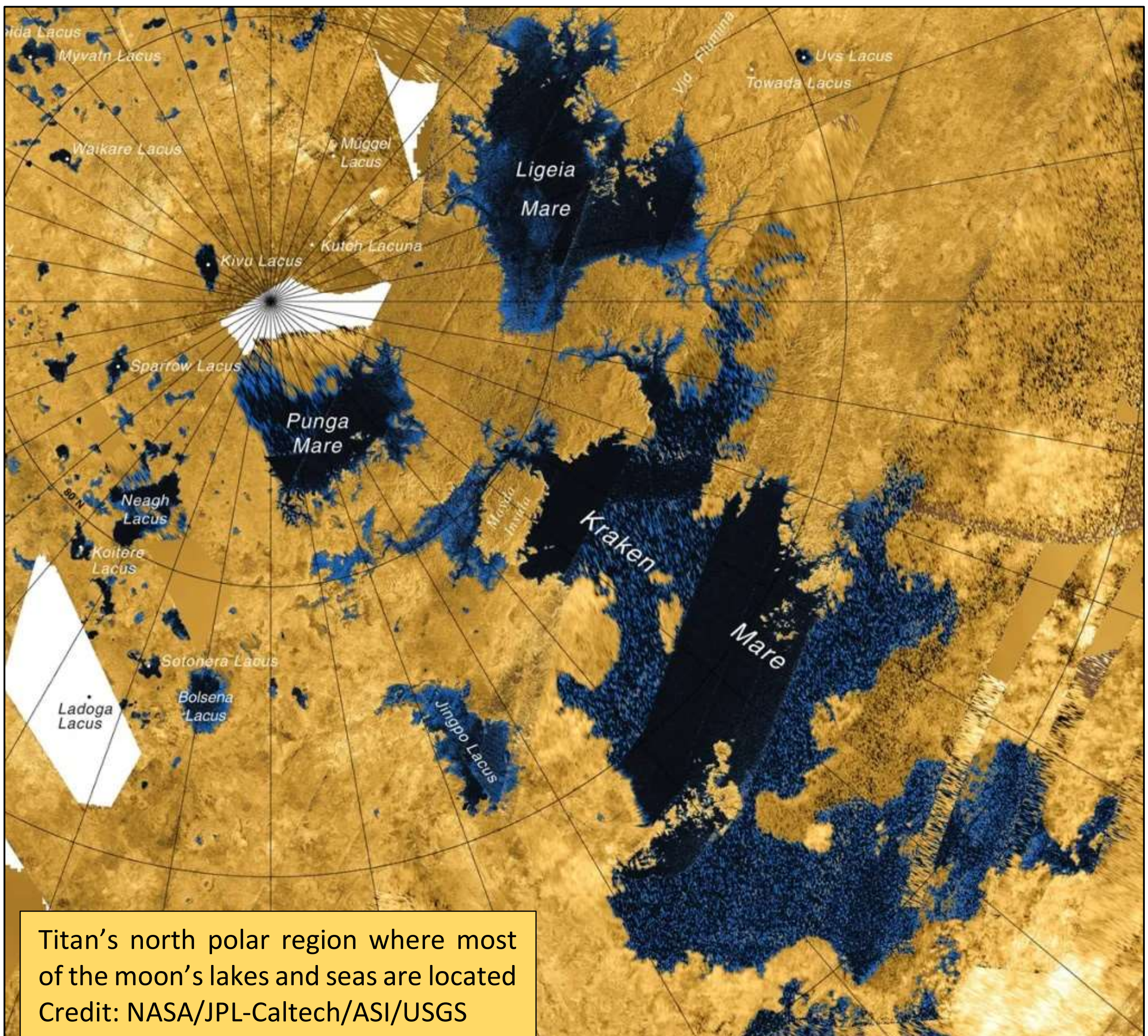
One of the final images captured by the orbiter was the setting of the moon Enceladus behind the planet's limb. The diminutive moon is a prime candidate in the search for extraterrestrial life.

Ice crystals from the active geysers located near the moon's south pole are believed to have created, and sustain, Saturn's very faint and tenuous E-ring. Enceladus was also found to be a major source of the ionized material in Saturn's magnetosphere, ejecting about 200 pounds (100 kg) of water into space every second.

Cassini Science and Titan’s Polar Seas

NASA Cassini’s mission continues to deliver science seven years after is conclusion. Researchers have been using ballistic radar data collected during four flybys of Titan to analyze the composition and roughness of the moon’s seas. The technique (ballistic radar) bounced a radio beam off Titan as Cassini approached the moon and again as it moved away. The beam is orientated such that it is reflected back towards Earth.

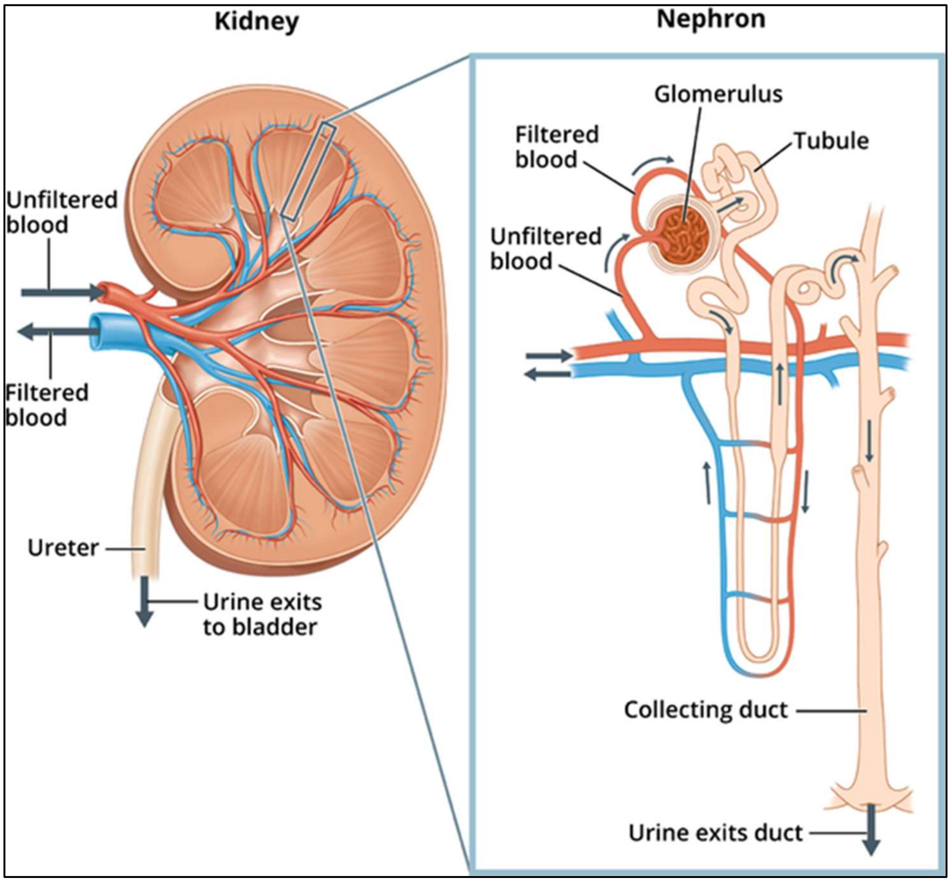
The polar seas on Titan, Kraken Mare, Ligeia Mare, and Punga Mare, unlike on Earth, are comprised of hydrocarbons, a class of organic chemicals that include methane and ethane. At Titan’s surface temperature, -290º F (-180º C), these hydrocarbons are in a liquid state. The largest sea, Kraken Mare, covers 154,000 square miles (400,000 square km), and is estimated to be more than 1,000 feet deep (300 meters) and contain about 80% of the moon’s surface liquids. The radar data showed calm seas during Cassini’s flybys with waves around 3.3 millimeters (1/8 of an inch). The waves were slightly higher (5.2 mm) along the coast indicating the presence of a weak tidal current. Researchers also found that the rivers that feed the seas were more ethane-rich than the predominately methane seas.



Titan’s north polar region where most of the moon’s lakes and seas are located
Credit: NASA/JPL-Caltech/ASI/USGS

Hidden Danger for Spacefarers

A new study, published in *Nature Communications*, on the effects of spaceflight on the human body focused on a somewhat marginalized organ – the kidneys. Researchers have known that astronauts traveling beyond the Earth's protective magnetic field would be exposed to radiation from both the Sun and galactic sources and at risk for loss of bone mass, weakening of the heart and circulatory system, changes in eyesight, and development of kidney stones. This study, the most comprehensive to date, analyzed samples from over 40 missions involving humans and mice, most of which traveled to the International Space Station, as well as 11 space simulations involving mice and rats. In seven of the simulations, mice were exposed to simulated Galactic Cosmic Radiation (GCR) doses equivalent to 1.5-year and 2.5-year Mars Missions.



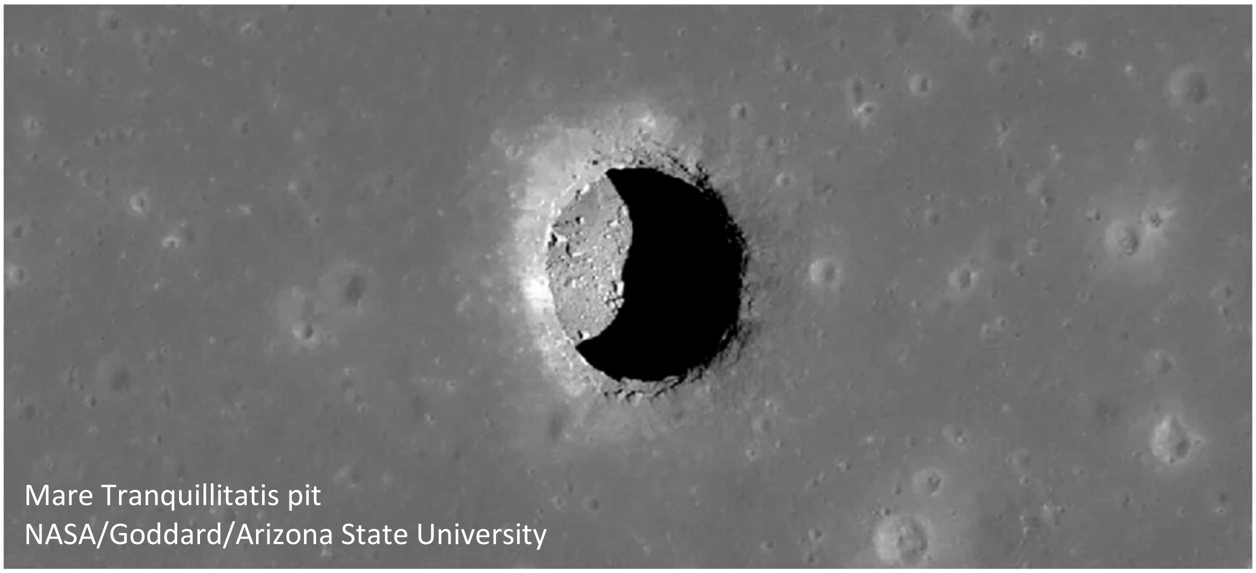
Our kidneys each contain about a million blood filtering units called nephrons. The nephron is comprised of a filter, called the glomerulus, which removes excess fluid and waste, and the tubule which returns minerals and fluid that the body needs back into the bloodstream.

Excess water and waste flows to the bladder and is removed from the body as urine.

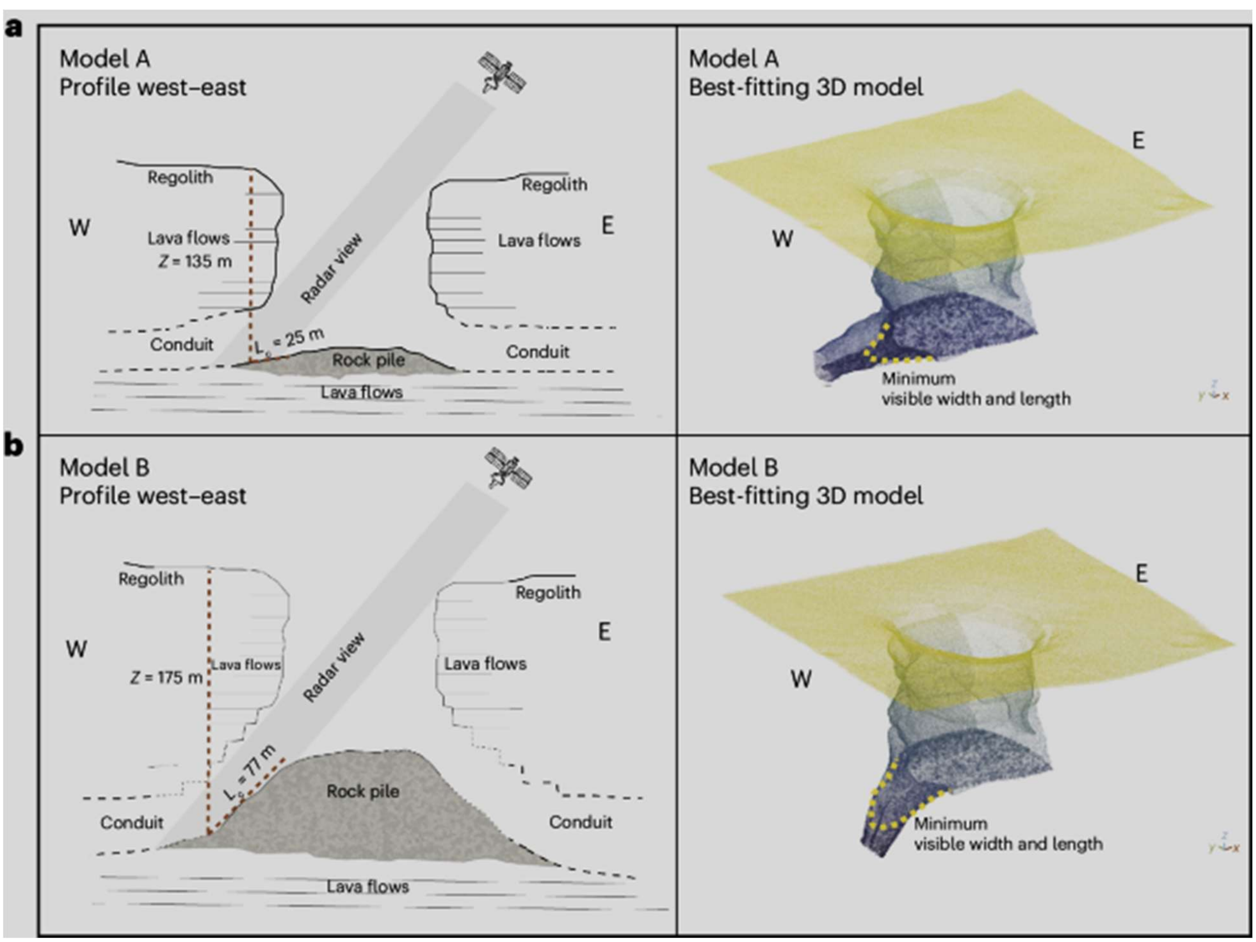
Microgravity is known to disrupt the function and shrink the kidney tubules responsible for calcium and salt balance, leading to the formation of kidney stones over a relatively short time in space (less than a month). This study found that GCR exposure can accelerate function loss and affect structural changes in the organ, to the point of failure, during prolonged spaceflight (e.g., required for a Mars mission).

Researchers caution that kidney failure could be catastrophic for mission success, since, by the time there are indications of radiation damage (and the kidney are slow to show signs), the damage may be permanent and astronauts could require dialysis to complete the journey. As we plan to travel beyond the moon, protecting radiation-sensitive organs may be what ultimately drives spacecraft design, personal shielding and pharmaceutical countermeasures.

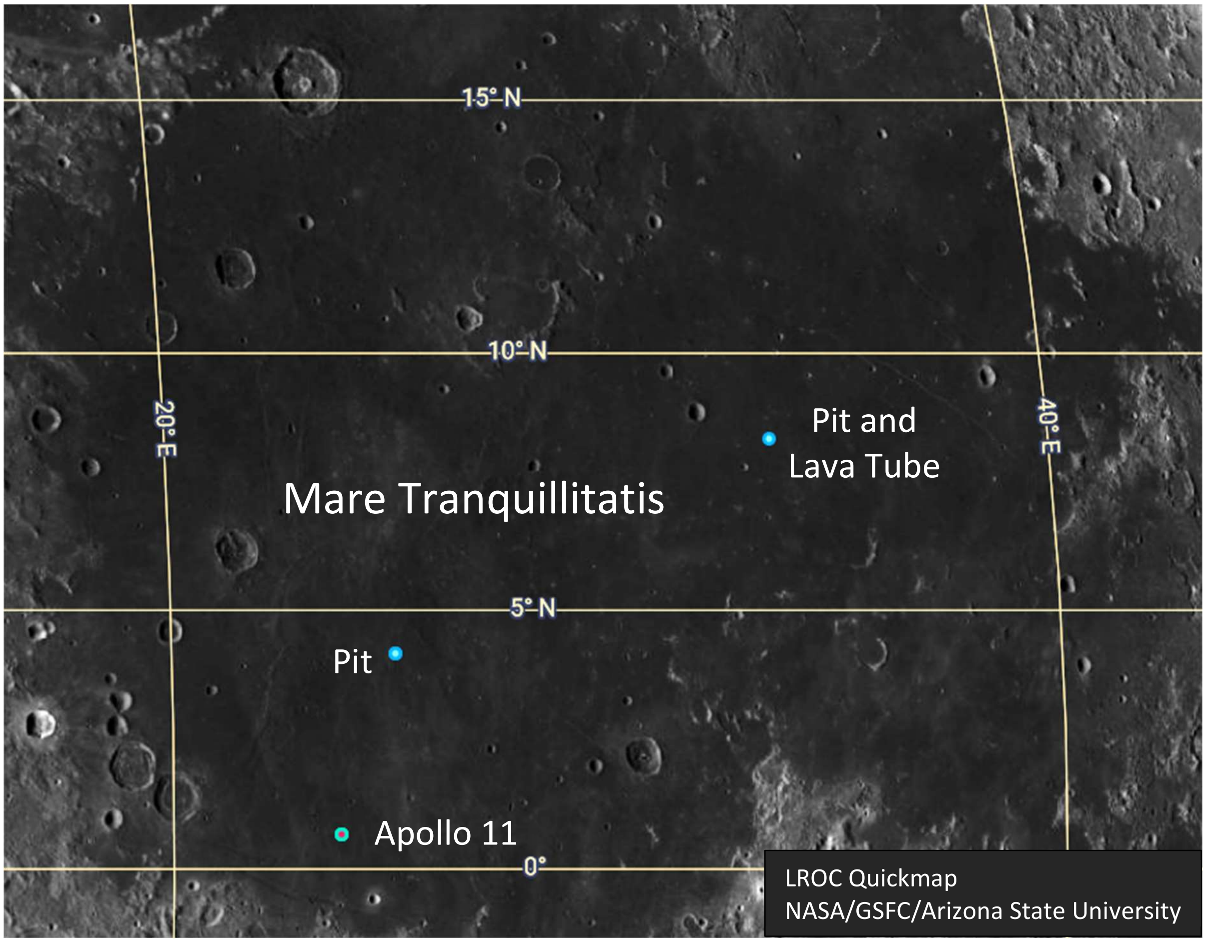
Lunar Refuge



An international research team has discovered a lava tube connected to an open pit on the Moon's Mare Tranquillitatis. The pit is located at latitude 8.3°N and longitude 33.2° E, about 230 miles (375 km) northeast of the Apollo 11 landing site. The underground structure could be a potential refuge for astronauts or the site of a permanent base of operations.



Previous page citation: Carrer, L., Pozzobon, R., Sauro, F. et al. Radar evidence of an accessible cave conduit on the Moon below the Mare Tranquillitatis pit. Nat Astron (2024). https://doi.org/10.1038/s41550-024-02302-y



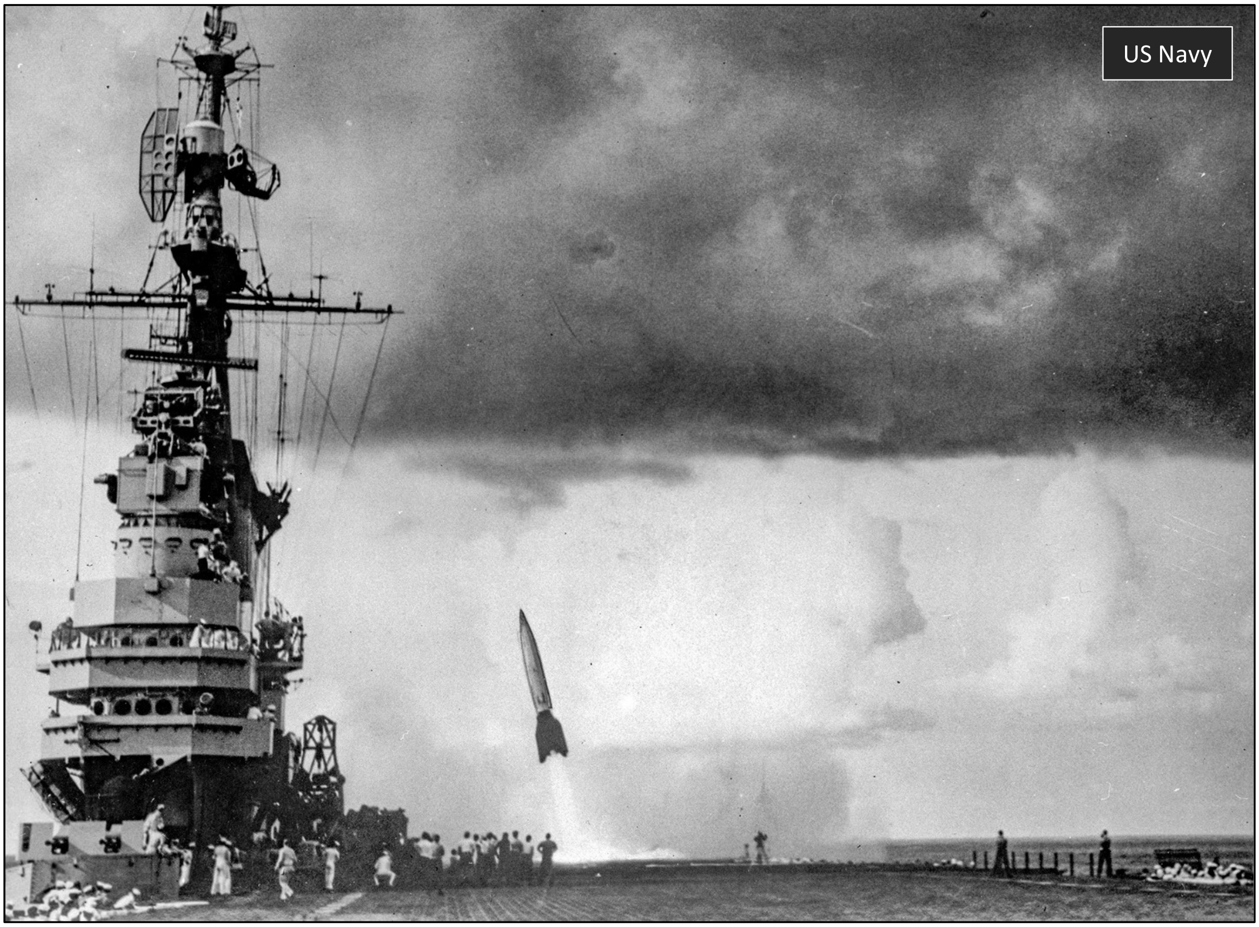
The cave was discovered when the team revisited radar scans collected by NASA's Lunar Reconnaissance Orbiter. In the data, researchers found a cavity at a depth of 426 to 558 feet (130 to 170 meters) at the base of a nearly circular sinkhole about 330 feet (100 meters) across.

The newly revealed cave measures at least 148 feet (45 meters) wide and between 98 and 262 feet (30 and 80 meters) long. It could be just a portion of a longer tube-like cavity. Lava tubes form when the outer surfaces of a lava stream cools and forms a hardened exterior shell. In time, once the lava drains, it leaves a hollow duct behind. The Mare Tranquillitatis pit is likely the result of the ceiling of the tube collapsing.

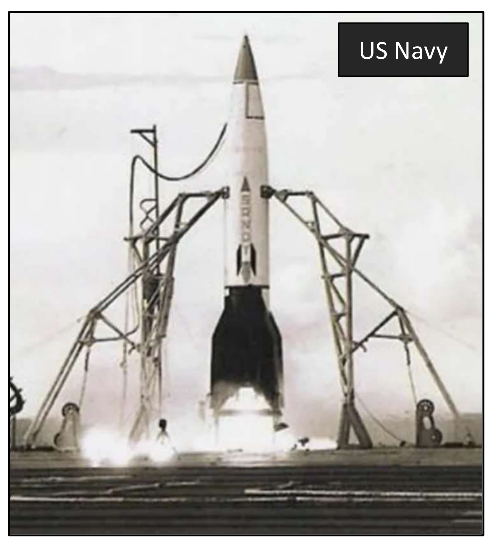
The Moon has more than 200 known pits, but the one on the eastern side of Mare Tranquillitatis is the first found to connect to a hollow or network of hollows. Near the Moon's equator the day/night temperature can vary by more than 450° F (or 250°C). A 2022 study found that the shaded areas of several pits examined were thermally stable and remained at around 63°F (17°C). While it sounds like science fiction today, in the future, lava tubes could offer ready-made sites for lunar colonization, providing protection from radiation and micrometeorites, as well as a relatively benign environment from which to conduct surface operations. While access to a deep pit may pose an initial challenge, the Moon's lower gravity field (16%) should be an advantage.

Operation Sandy

On September 6, 1947, the United States launched a captured Nazi V-2 rocket (designed by Wernher von Braun and his team) from the deck of an aircraft carrier. Codename "Operation Sandy," the USS Midway was chosen to conduct the V-2 test launch. It was the first time such a large rocket was launched at sea and the first and only time for a V-2.

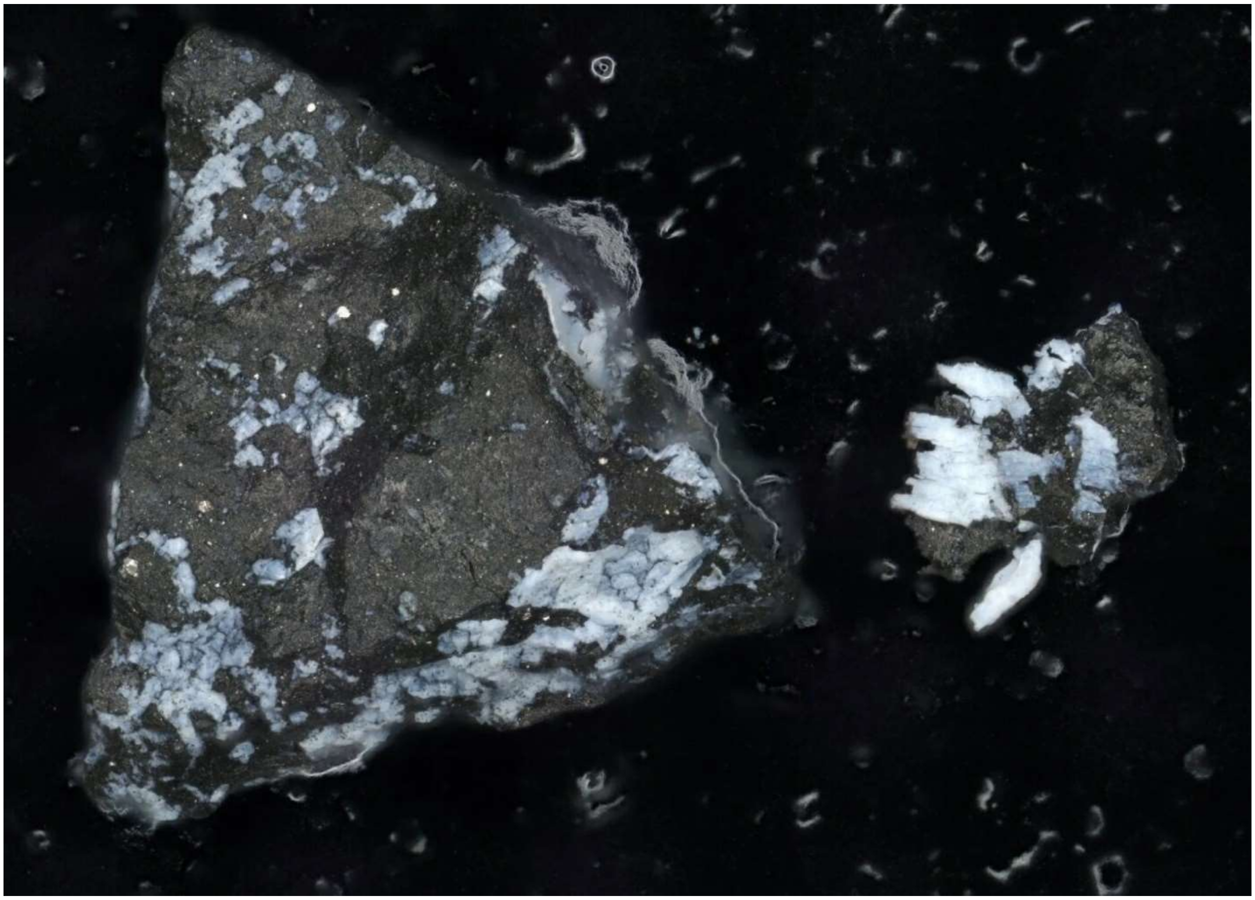

US Navy

Following Germany's surrender in May 1945, hundreds of rocket components were shipped from Germany to the White Sands Proving Grounds in New Mexico. Along with the German rocket scientists who had defected to the U.S., the V-2 would accelerate the country's fledgling ballistic missile program.


US Navy

While the Midway launch was officially deemed a success, the flag officers on the carrier may have had a different opinion as the rocket headed right for the flight-deck island before righting itself. Shortly thereafter, the rocket's trajectory became erratic and the V-2 broke up at an altitude of approximately 12,000 feet before falling into the sea three miles from the ship. However, lessons learned from the launch would be incorporated into the design of future guided missiles for naval use.

OSIRIS-REx Mission – Bennu Surprises



A microscope image of a dark Bennu particle with a crust of bright phosphate
Credits: From Lauretta & Connolly et al. (2024) Meteoritics & Planetary Science, doi:10.1111/maps.14227

One year ago, on September 24th, NASA's Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx) spacecraft dropped off a sample collected from the asteroid Bennu as it flew by Earth. The sample of dust and rock had been collected in October 2020 from the "Nightingale" site during six seconds of contact with the asteroid's surface.

Early analysis of the 4.3-ounce (121.6-gram) sample presented some surprises, including the presence of magnesium-sodium phosphate in the stony matrix, a water-soluble mineral. While phosphate had been detected in the sample of the asteroid Ryugu collected by JAXA's (Japan Aerospace Exploration Agency) Hayabusa2 mission in 2020, Bennu's phosphate is unprecedented in grain size and purity, and is similar to that found on Saturn's ocean moon Enceladus.

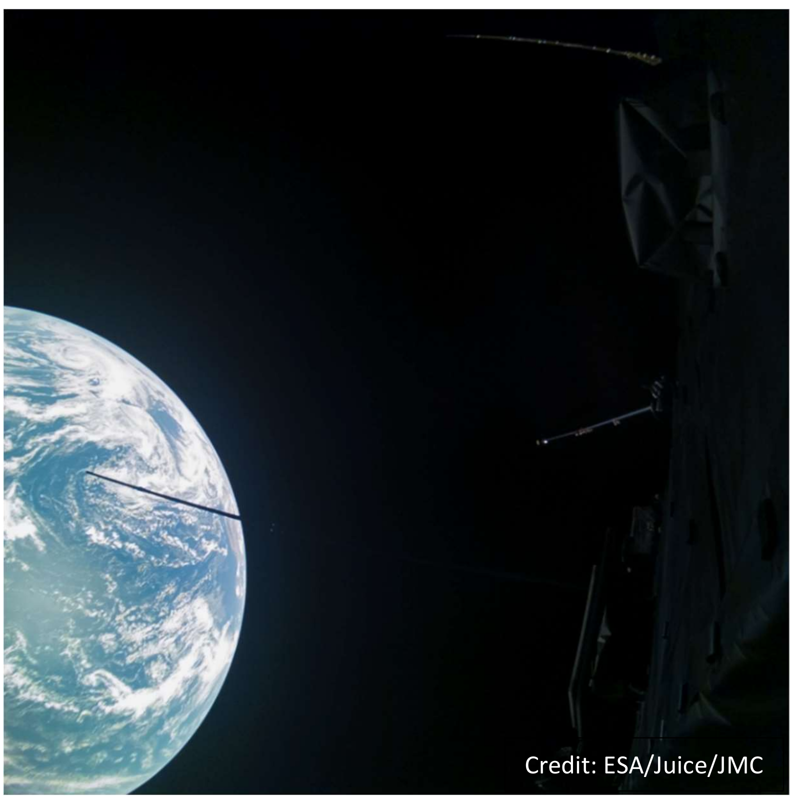
The Bennu sample is rich in carbon, nitrogen, and organic compounds, essential components in the biochemistry for life on Earth. The analysis also suggests that the asteroid came from a larger body, one with an active hydrothermal system and even subsurface lakes or oceans. While there's evidence of a watery past, the asteroid is chemically primitive with its elemental proportions closely resembling those of the Sun – offering a glimpse of the state of the early solar system over 4.5 billion years ago.

Webb Anniversary Image

To celebrate the second anniversary of the James Webb Space Telescope's science operations, NASA released an image of two interacting galaxies, known as Arp 142. On the right is a spiral galaxy, also call the Penguin because of its resemblance to the flightless bird or NGC 2936. On the left is a small elliptical galaxy, known as the Egg or NGC 2937. The two galaxies are in the process of merging, linked by a blue haze comprised of gas, dust and stars. The merger has been underway for tens of millions of years and, at some point in the future, the two will become one.

The Penguin and the Egg
Credit: NASA, ESA, CSA, STScI

First Earth-Moon Flyby



The European Space Agency (ESA) successfully executed the first ever lunar-Earth flyby which set their Jupiter Icy Moons Explorer (JUICE) spacecraft on course for a gravity assist from Venus in August 2025.

JUICE is an ESA mission to Jupiter's moon and scheduled to arrive in the Jupiter system in 2031. It's fuel-efficient trajectory uses gravity assists to save tons of propellent that would otherwise be needed for a straight shot to the gas giant.

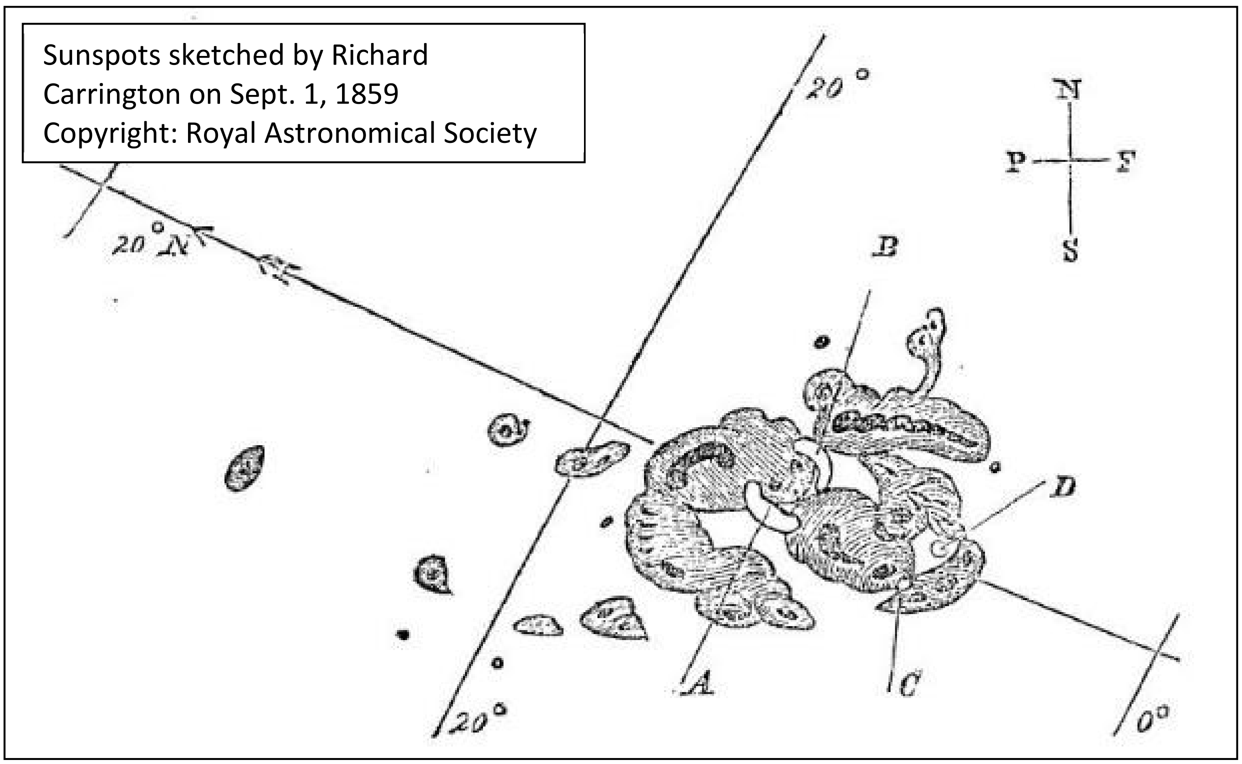
On August 19th, JUICE flew by the Moon, passing within 435 miles (700 km) of its desolate surface. The encounter redirected the spacecraft towards Earth. A day later, a flyby over eastern Asia and the Pacific, at a distance of 4,250 miles (6,840 km), slowed the spacecraft and sent it towards the inner solar system where it will begin a series of acceleration boosts, starting with Venus in 2025. JUICE will return to flyby Earth in September 2026 and again in January 2029 before arriving at Jupiter. The spacecraft will conduct 35 flybys of the potential ocean-bearing moons Europa, Ganymede and Callisto before settling into a final orbit around Ganymede.

The precision of the lunar-Earth flyby was accomplished with less fuel than expected – increasing the spacecraft's fuel reserves that could be used to extend the science mission upon arrival at Jupiter.

The Carrington Event

One hundred and sixty-five years ago, on the morning of September 1st, Richard Carrington was at his observatory in Surrey, England, sketching sunspots from an image projected by his telescope. At 11:18 am, two bright flares emerged from a group of sunspots. After realizing that the blinding points of light were coming from the Sun and not stray light or reflections entering the observatory, he hastened to find another witness to what he had observed. Unfortunately, the flares faded quickly and all but disappeared within five minutes. While he remained at his telescope for several hours, the sunspots did not display any additional activity.

The following morning, the sky as far south as Hawaii and the Caribbean erupted in filaments of color as aurora bright enough to easily read a newspaper were visible. Sailors reported compass needles swinging wildly, making it impossible to navigate, and power surges in telegraph wires damaged equipment, sending sparks that set nearby paper on fire.



Sunspots sketched by Richard Carrington on Sept. 1, 1859
Copyright: Royal Astronomical Society

Carrington subsequently traveled to the observatory at Kew Gardens in London, looking for confirmation of what he had witnessed. While the observatory didn't have any images of the Sun on September 1st, it did have records from its magnetometer (an instrument measuring changes in the Earth's magnetic field).

The Kew Gardens magnetometer showed a significant magnetic disturbance approximately 17 hours after Carrington had seen the flares. Today, we know that Carrington had seen a white-light (visible in only the most intense solar eruptions) and that the magnetic disturbance was the result of a Coronal Mass Ejection (cloud of solar plasma) that had traveled the distance between the Earth and Sun (approximately 93 million miles or 150 million km) in less than 24 hours. In the 1800's, when sunspots were thought by some to be localized phenomena in the Sun's atmosphere, the concept that activity on the Sun could affect the Earth was ground-breaking.

In November of 2003, the most powerful flare in the "space age" was recorded (twice as powerful, by some measurements, as the most powerful, previously recorded flares), saturating the detector of the satellite monitoring the Sun. Eruptions on the Sun have been linked to communication disruptions on Earth, widespread damage to the electrical grid and transmission equipment, and power blackouts. Flares have also been responsible for damaging the sensitive electronics in orbiting satellites and sending astronauts scampering into shelters on the International Space Station.

It is believed that the Carrington event was even more powerful than what has been observed to date. Instead of a sparse network of land lines and telegraphs of the 1800's, today's global economy is satellite-based, with fleets of spacecraft providing instantaneous communications, global positioning (in air, on sea and land), with national security applications, weather forecasting, as well as supporting multi-national transactions and business operations. The Federal Emergency Management Agency has identified extreme space weather as one of its greatest challenges, as severe damage to the U.S. electrical grid could take years to fully recover and leave a large portion of the population without life-saving power and essential services.

Autumnal Equinox

The Sun crosses the celestial equator at 8:44 am (EDT) on the morning of September 22nd, heading south, marking the beginning of the fall season in the northern hemisphere.

Aurora and the Equinoxes:

Geomagnetic storms that are responsible for auroras happen more often during the months around the equinox (March and September). Check your evening sky or log onto www.spaceweather.com for the latest on solar activity.

Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
September 1st (EDT)	06:20	19:25
September 15th	06:34	19:01
September 30th	06:49	18:36

September Nights

Enjoy the jewels of the summer Milky Way while the nights are still warm and the skies are clear. From Cygnus to Sagittarius, follow the star clouds and dust lanes that comprise the inner arms of our spiral galaxy. In the south after sunset, the stars in the constellation Sagittarius form an asterism, or pattern, of a teapot. The spout of the teapot points the way to the center of the Milky Way galaxy with its resident black hole. Check out the July/August calendar for more details.

Present and Future Pole Stars

Vega, the fifth brightest star and located in the constellation Lyra, is placed high in the evening sky during September. Vega is also destined to become the Pole Star in 12,000 years. Precession, or the change in the direction of the rotational axis of the Earth over time, is best exemplified in a comparison of the position of Vega to that of Polaris (the current Pole Star).

Astronomical and Historical Events

1st Closest approach of Apollo class asteroid and Near-Earth Object (NEO) 2021 JT
1st Closest approach of Apollo class asteroid and NEO 2021 RB16
1st History: astronomer Richard Carrington observes solar flares which created the "Solar Storm of 1859" (1859)
1st History: flyby of Saturn by the Pioneer 11 spacecraft (1979)
2nd New Moon
2nd Closest approach of Apollo class asteroid and NEO 2007 RX8
2nd History: discovery of asteroid *3 Juno* by Karl Harding (1804)
3rd History: controlled impact of the SMART-1 spacecraft on the lunar surface at the conclusion of a successful mission; precursor of NASA's LCROSS mission (2006)
3rd History: Apollo 12 third stage rediscovered (J002E3), by amateur astronomer Bill Yeung, after temporarily transferring from a heliocentric orbit to an Earth orbit (2002)
3rd History: Viking 2 spacecraft lands on the Martian surface (1976)
4th History: Dawn spacecraft leaves *Vesta* orbit, bound for the dwarf planet *Ceres* (2012)
5th Moon at apogee (furthest distance from the Earth)
5th History: flyby of Asteroid 2867 *Steins* from a distance of 500 miles (800 km) by the Rosetta spacecraft (2008)
5th History: launch of Voyager 1 to the planets Jupiter and Saturn (1977); at 13.6 billion miles (21.9 billion km) from Earth, Voyager 1 has entered the interstellar space
7th Closest approach of Apollo class asteroid and NEO 2022 SR
8th Saturn at Opposition
8th History: launch of OSIRIS-REx (asteroid sample return mission) to the near-Earth asteroid *Bennu* for arrival in 2018 (2016)
8th History: sample return canister from the Genesis spacecraft crashes back to Earth when drogue parachute fails to deploy. Spacecraft was returning to Earth from Lagrange Point 1 with its collection of solar wind particles (2004)
8th History: launch of the Surveyor 5 spacecraft (lunar science mission); landed on Mare Tranquillitatis three days later (1967)
8th History: first Star Trek episode airs on television (1966)
8th History: Marshall Space Flight Center's dedication by President Eisenhower (1960)
9th Closest approach of Aten class asteroid and NEO 2023 SP2
9th Closest approach of Apollo class asteroid and NEO 2024 PM6
9th History: launch of Conestoga I, first private rocket (1982)
9th History: launch of Soviet spacecraft Venera 11 (Venus lander) to the planet Venus (1978)
9th History: launch of the Viking 2 spacecraft (Mars Orbiter/Lander) (1975)
9th History: discovery of Jupiter's moon *Amalthea* by Edward Barnard (1892)
10th History: launch of the GRAIL spacecraft aboard a Delta 2 rocket from the Canaveral Air Force Station; lunar gravity mapping mission (2011)
10th History: debut flight of the Japanese H-2 Transfer Vehicle (or HTV) to the International Space Station (2009)
10th History: discovery of Dwarf Planet Eris' moon *Dysnomia* by Mike Brown, et al's (2005)
11th First Quarter Moon

Astronomical and Historical Events (continued)

11th Scheduled launch of a Russian Soyuz spacecraft with cosmonauts Alexey Ovchinin and Ivan Vagner, along with NASA astronaut Don Pettit, from the Baikonur Cosmodrome, Kazakhstan to the International Space Station
11th Closest approach of Aten class asteroid and NEO 2016 TU19
11th History: discovery of Jupiter's moon Leda by Charles Kowal (1974)
11th History: Mars Global Surveyor enters orbit around Mars (1997)
11th History: flyby of Comet *Giacobini-Zinner* by the International Cometary Explorer (ICE), first spacecraft to visit a comet (1985)
12th McCarthy Observatory's Second Saturday Stars (open house)
12th History: President John F. Kennedy's Moon Speech at Rice University (1962)
12th History: Japanese sample return spacecraft Hayabusa arrives at Asteroid *25143 Itokawa* (2005)
12th History: astronaut Mae Jemison becomes the first African American woman in space as a member of the space shuttle Endeavour crew (STS-47) (1992)
12th History: launch of Soviet Luna 16; first robotic probe to land on the Moon and return a coring sample (101 grams) of lunar regolith to Earth (1970)
12th History: launch of Gemini XI with astronauts Charles Conrad and Richard Gordon (1966)
12th History: launch of the Soviet spacecraft Luna 2, first to impact the Moon's surface (1959)
13th History: launch of the Japanese Moon orbiter "Kaguya" (Selene 1) (2007)
14th History: launch of Soviet spacecraft Venera 12 (Venus lander) to the planet Venus (1978)
14th History: discovery of Jupiter's moon *Leda* by Charles Kowal (1974)
14th History: launch of the Zond 5 spacecraft from the Baikonur Cosmodrome - first successful Soviet circumlunar Earth-return mission (1968)
14th History: John Dobson born, architect of the Dobsonian alt-azimuth mounted Newtonian telescope (1915)
15th Closest approach of Apollo class asteroid and NEO 2019 DJ1
15th History: launch of NASA's ICESat 2 from the Vandenberg Air Force Base in California to observe ice-sheet elevation change and sea-ice (2018)
15th History: End of the Cassini mission with plunge into Saturn's atmosphere (2017)
15th History: launch of China's second space station (Tiangong 2) (2016)
16th History: discovery of Saturn's moon *Hyperion* by William and George Bond and William Lassell (1848)170th Anniversary (1848)
17th Full Moon (Full Harvest Moon)
17th Closest approach of Apollo class asteroid, Potentially Hazardous Asteroid (PHA) and NEO 2024 ON
17th History: Konstantin Tsiolkovsky born in Izhevskoye, Russia; one of the fathers of rocketry and cosmonautics, along with Goddard and Oberth (1857)
17th History: discovery of Saturn's moon *Mimas* by William Herschel (1789)
18th Moon at perigee (closest distance to Earth)
18th Closest approach of Apollo class asteroid, PHA and NEO (2013 FW13)
18th Closest approach of Aten class asteroid and NEO 2022 SW3
18th History: discovery of Comet *Ikeya-Seki* by Kaoru Ikeya and Tsutomu Seki (1965)
18th History: discovery of Neptune moons *Thalassa* and *Naiad* by Rich Terrile (1989)
18th History: launch of Vanguard 3, designed to measure solar X-rays, the Earth's magnetic field, and micrometeoroids (1959)
19th Closest approach of Apollo class asteroid and NEO 2015 SH

Astronomical and Historical Events (continued)

19th History: NASA unveiled plans to return humans to the moon (2005)
19th History: first launch of the Wernher von Braun-designed Jupiter C rocket from Cape Canaveral (1956)
20th Closest approach of Aten class asteroid and NEO 2023 RX1
20th Closest approach of Aten class asteroid and NEO 2018 VG
21st Neptune at Opposition
21st History: MAVEN (Mars Atmosphere and Volatile Evolution) spacecraft enters orbit around Mars (2014)
21st History: second flyby of Mercury by the Mariner 10 spacecraft (1974)
21st History: Gustav Holst born, composer of the symphony "The Planets" (1874)
21st History: Soviet spacecraft Zond 5 returns after circumnavigating the Moon (1968)
21st History: Galileo spacecraft impacts Jupiter after completing its mission (2003)
22nd Autumnal Equinox: 8:44 am EDT (12:44 UT)
22nd History: Deep Space 1 spacecraft passes within 1,400 miles (2,200 km) of the 5-mile-long potato-shaped nucleus of Comet *Borrelly* (2001)
23rd History: discovery of Saturn's moons *Siarnaq*, *Tarvos*, *Ijiraq*, *Thrymr*, *Skathi*, *Mundilfari*, *Erriapus* and *Suttungr* by Brett Gladman & John Kavelaars (2000)
23rd History: Johann Galle discovers the planet Neptune (1846)
24th Last Quarter Moon
24th Closest approach of Aten class asteroid and NEO 2020 GE
24th Tentative launch of a SpaceX Crew Dragon from the Cape Canaveral Space Force Station, Florida, carrying NASA astronaut Zena Cardman and Roscosmos cosmonaut Aleksandr Gorbunov to the ISS (Nick Hague and Stephanie Wilson were bumped to accommodate the return of Butch Wilmore and Suni Williams)
24th History: India's MOM (Mars Orbiter Mission) spacecraft enters orbit around Mars (2014)
24th History: John Young born (1930), first person to fly in space six times, including Gemini 3 (1965), Gemini 10 (1966), Apollo 10 (1969), Apollo 16 (1972), STS-1, the first flight of the Space Shuttle (1981), and STS-9 (1983)
25th History: launch of the Mar Observer (also known as the Mars Geoscience/Climatology Orbiter) - communications were lost shortly before spacecraft was scheduled to enter orbit, likely due to a catastrophic failure of the propulsion system (1992)
26th History: Cosmonauts V. Titov and Strekalov escape moments before Soyuz T-10-1 explodes on the pad (1983)
27th Closest approach of Apollo class asteroid and NEO 2011 ST12
27th History: Zhai Zhigang becomes first Chinese taikonaut to spacewalk during Shenzhou 7 mission (2008)
27th History: launch (2007) of the Dawn spacecraft to *Vesta* (2011) and *Ceres* (2015)
27th History: launch of SMART-1, the first European lunar probe (2003)
28th History: launch of Soviet lunar orbiter Luna 19; studied lunar gravitational fields and mascons (mass concentrations), radiation environment, and the solar wind (1971)
28th History: launch of Alouette, Canada's first satellite (1962)
28th History: discovery of Jupiter's moon *Ananke* by Seth Nicholson (1951)
29th History: 3rd Mercury flyby by the MESSENGER spacecraft (2009)
29th History: discovery of asteroid 243 *Ida* by Johann Palisa (1884)
29th History: launch of Salyut 6, first of a second generation of Soviet orbital space station designs (1977)

Astronomical and Historical Events (continued)

30th History: controlled descent of the Rosetta spacecraft to the surface of Comet 67P/*Churyumov-Gerasimenko* (mission complete) (2016)
30th History: all instruments deployed on the Moon by the Apollo missions are shut off (1977)
30th History: discovery of Jupiter's moon *Themisto* by Charles Kowal (1975)
30th History: Henry Draper takes first photo taken of the Orion (1880)

Commonly Used Terms

- Apollo: a group of near-Earth asteroids whose orbits also cross Earth's orbit; Apollo asteroids spend most of their time outside Earth orbit.
- Aten: a group of near-Earth asteroids whose orbits also cross Earth's orbit, but unlike Apollos, Atens spend most of their time inside Earth orbit.
- Atira: a group of near-Earth asteroids whose orbits are entirely within Earth's orbit
- Centaur: icy planetesimals with characteristics of both asteroids and comets
- Kuiper Belt: region of the solar system beyond the orbit of Neptune (30 AUs to 50 AUs) with a vast population of small bodies orbiting the Sun
- Opposition: celestial bodies on opposite sides of the sky, typically as viewed from Earth
- Plutino: an asteroid-sized body that orbits the Sun in a 2:3 resonance with Neptune
- Trojan: asteroids orbiting in the 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

References on Distances

- the apparent width of the Moon (and Sun) is approximately one-half a degree (½°), less than the width of your little finger at arm's length which covers approximately one degree (1°); three fingers span approximately five degrees (5°)
- 1 astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

International Space Station and Artificial Satellites

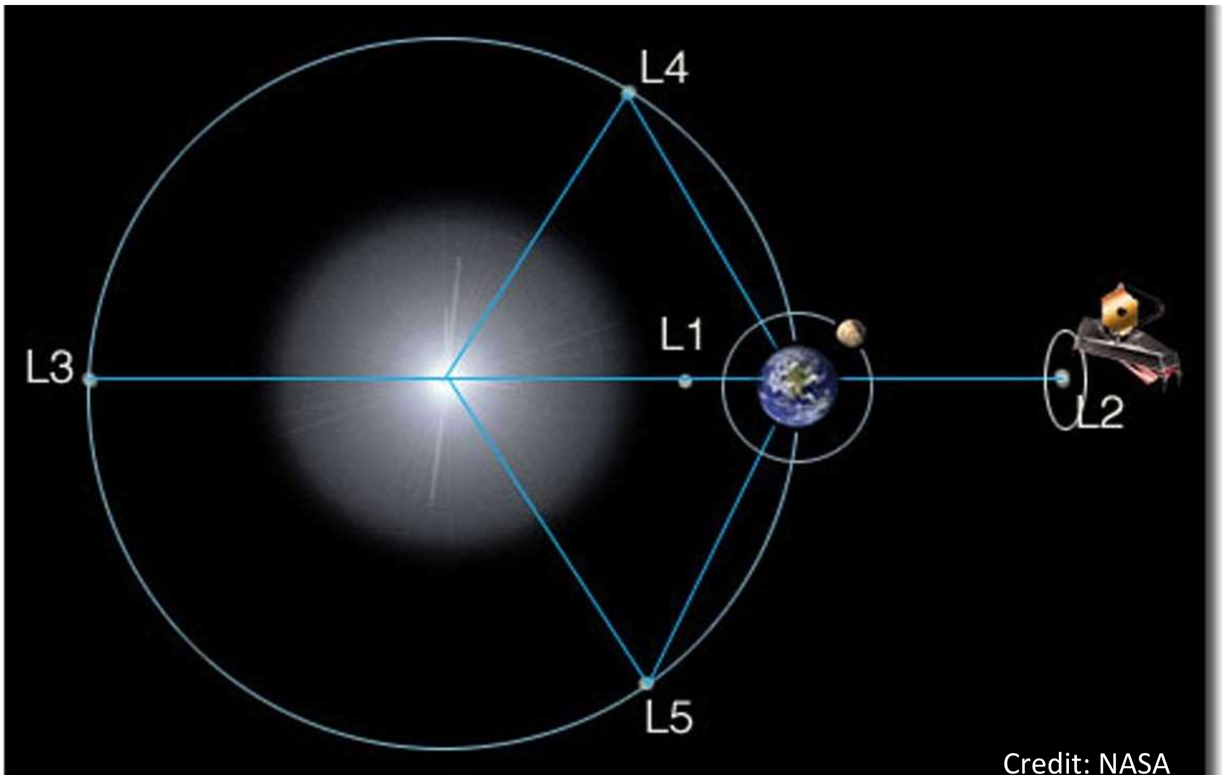
Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and other man-made objects in low-Earth orbit.

Solar Activity

For the latest on what's happening on the Sun and the current forecast for flares and aurora, check out www.spaceweather.com.

Lagrange Points

Five locations discovered by mathematician Joseph Lagrange where the gravitational forces of the Sun and Earth (or other large body) and the orbital motion of the spacecraft are balanced, allowing the spacecraft to hover or orbit around the point with minimal expenditure of energy. The L2 point (and future location of the James Webb telescope) is located 1.5 million kilometers beyond the Earth (as viewed from the Sun).



Credit: NASA

James Webb Space Telescope

https://webb.nasa.gov/index.html

Euclid Space Telescope

https://www.esa.int/Science_Exploration/Space_Science/Euclid

NASA's Global Climate Change Resource

Vital Signs of the Planet: https://climate.nasa.gov/

Mars – Mission Websites

- Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/
- Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/
- Mars Atmosphere and Volatile EvolutioN (MAVEN): https://science.nasa.gov/mission/maven/

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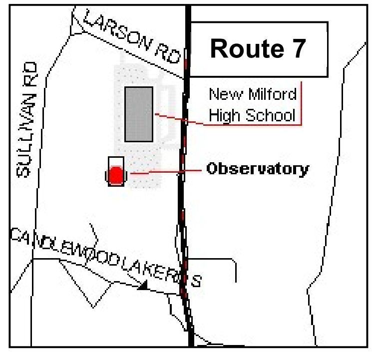

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