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John J. McCarthy Observatory

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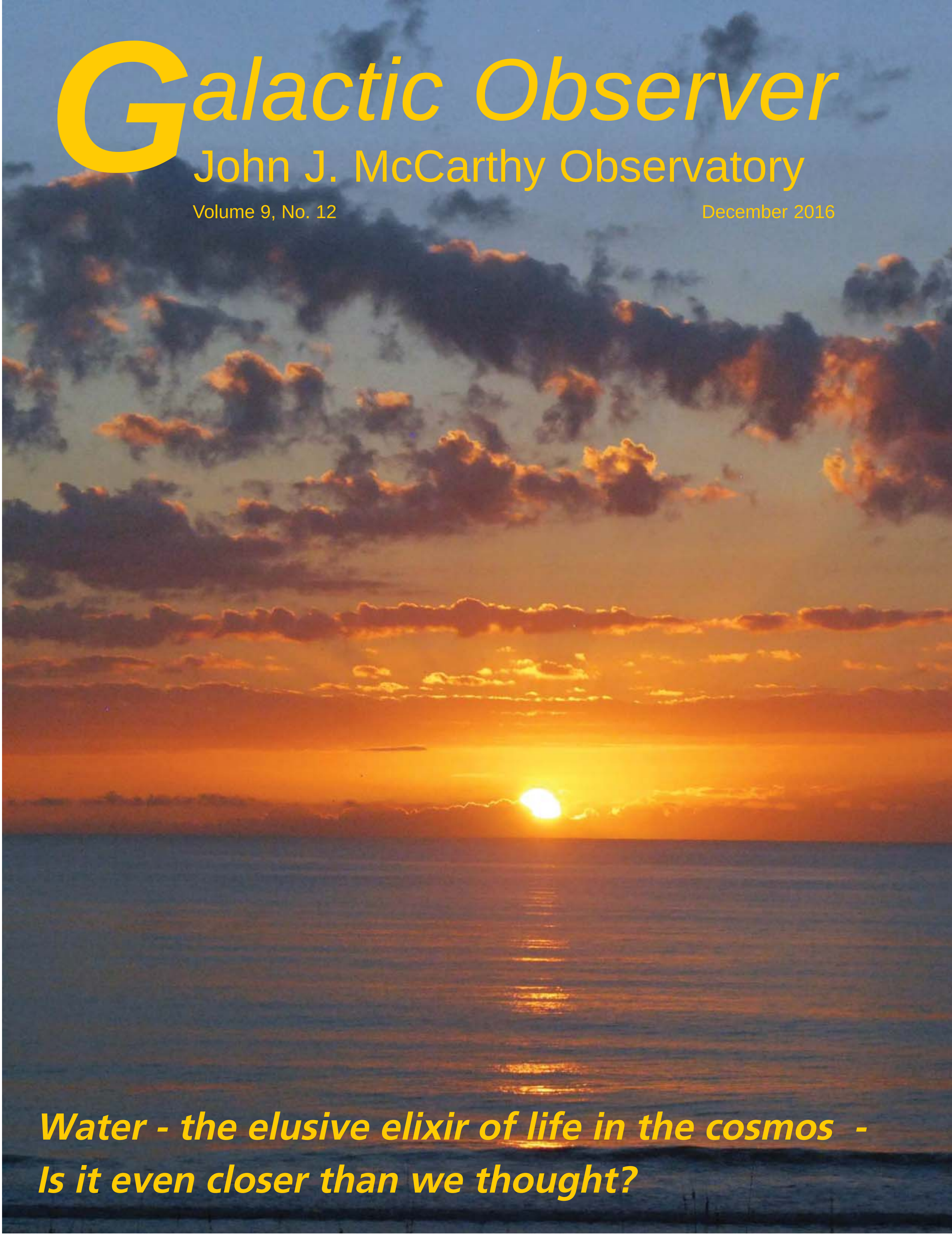

Water - the elusive elixir of life in the cosmos - Is it even closer than we thought?

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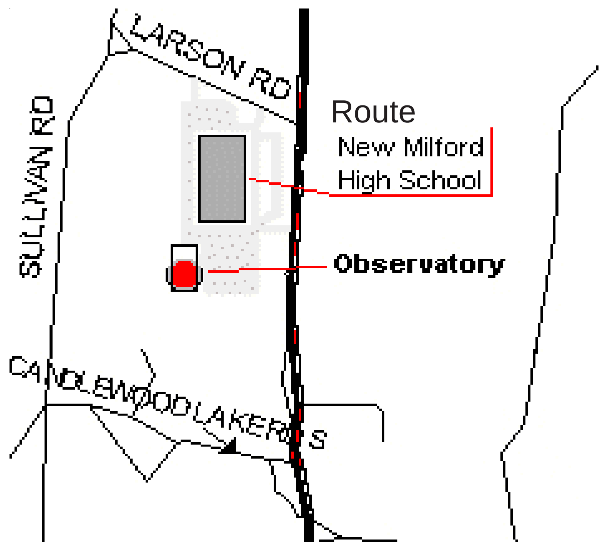

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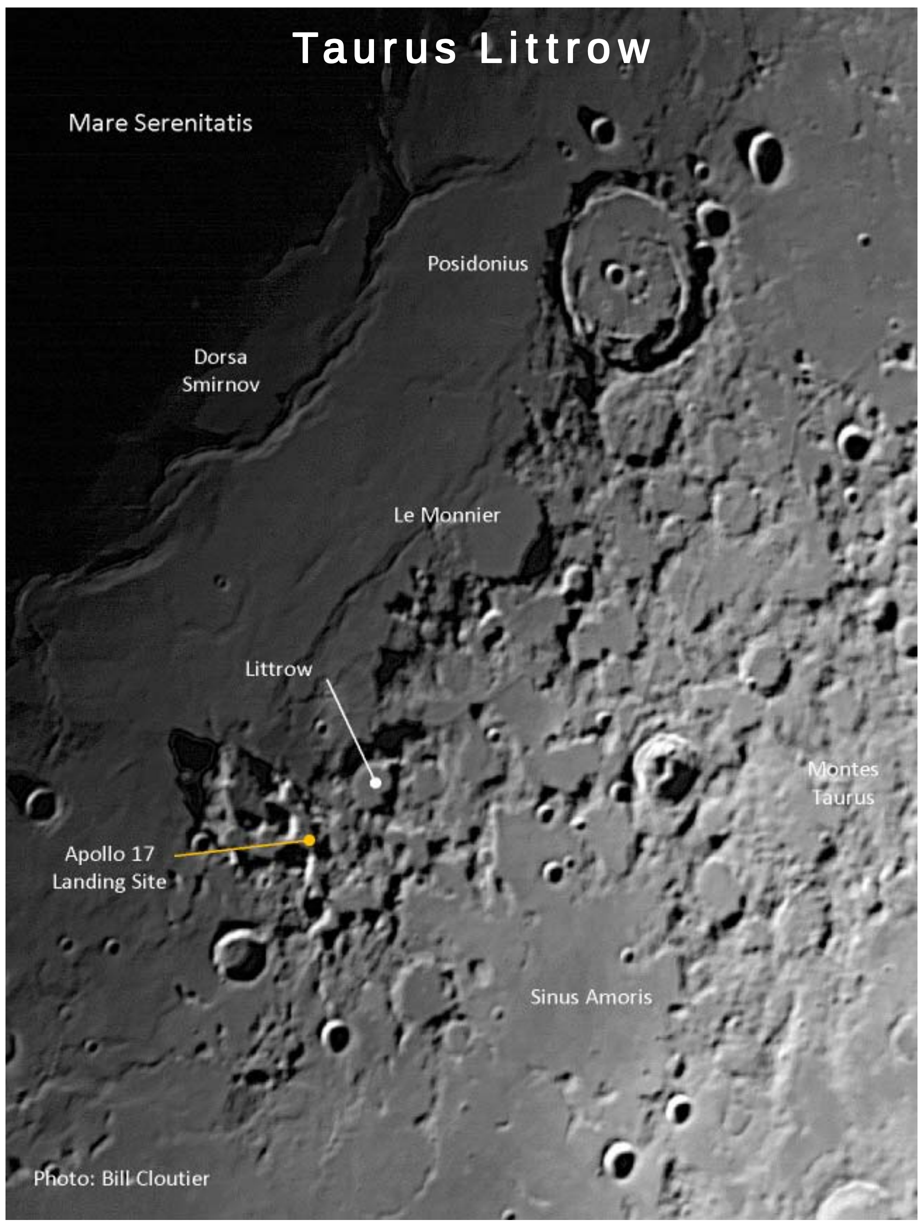
“Out the Window on Your Left”

IT’S BEEN 44 YEARS since we left the last footprint on the dusty lunar surface. Sadly, as a nation founded on exploration and the conquest of new frontiers, we appear to have lost our will to lead as a space-faring nation. But, what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

Shortly after midnight (EST) on December 14, 1972, Apollo 17 astronaut Gene Cernan drove the Lunar Rover Vehicle to its final parking spot so that its camera could record the Lunar Module’s upper stage ascent to orbit and rendezvous with the Command Module. He then knelt down and traced his nine year old daughter’s initials “TDC” in the lunar dust, knowing that, in the absence of weather, Tracy’s initials could remain undisturbed for eons. With Cernan climbing back aboard the Lunar Module, manned exploration of the Moon came to an abrupt end.

The Apollo 17 landing site is along the southeastern rim of the Serenitatis impact basin, created 3.8 to 3.9 billion years ago. Astronauts Cernan and Harrison Schmitt (geologists by training) set their lander down in a valley amid several large, rounded mountains (massifs) that were actually blocks of the lunar crust thrust upward by the initial basin-creating impact. Several hundred million years later, magma from deep within the Moon erupted, flooding the basin through fractures in the underlying rock. Multiple eruptions darkened the surface while with each torrent of lava the basin slowly filled, creating the relatively smooth surface seen today.

The Taurus-Littrow valley was selected for the last Apollo mission due to its varied geology. From flyovers of the valley from orbit and the darkened halos observed around valley craters, scientists were hopeful that site might contain a relatively young volcanic vent. While no vent was found, Harrison Schmitt did find “orange soil” on the rim of a 46 foot deep (14 meter) impact crater named Shorty. The orange in the soil was found to be titanium-rich volcanic glass from an ancient fire fountain. The glass had been buried beneath



lava flows for billions of years until excavated by the Shorty-forming impact.

The low Sun angle in the Taurus-Littrow photo accentuates low profile features. Contraction of the basaltic lava layers as they cooled formed ridges in the lunar mare. Dorsa Smirnov is a segment of a 300 mile (500 km) long serpentine ridge along the shore of Mare Serenitatis.

Over the Top

NASA's Cassini spacecraft is now in a polar trajectory as it prepares for its final series of orbits dubbed the "Grand Finale." The polar orientation provides a unique perspective of the gas giant, its poles and ring system. In this view, Saturn's six-sided polar jet stream, known as "the hexagon," is fully illuminated. The hexagon is an immense hurricane rotating around the planet's north pole with an eye 50 times larger than a comparable terrestrial hurricanes. The clouds near the center are spinning counterclockwise (from this vantage point) at speeds in excess of 340 mph (547 kph), almost twice as fast as the planet. A similar storm encircles Saturn's south pole.

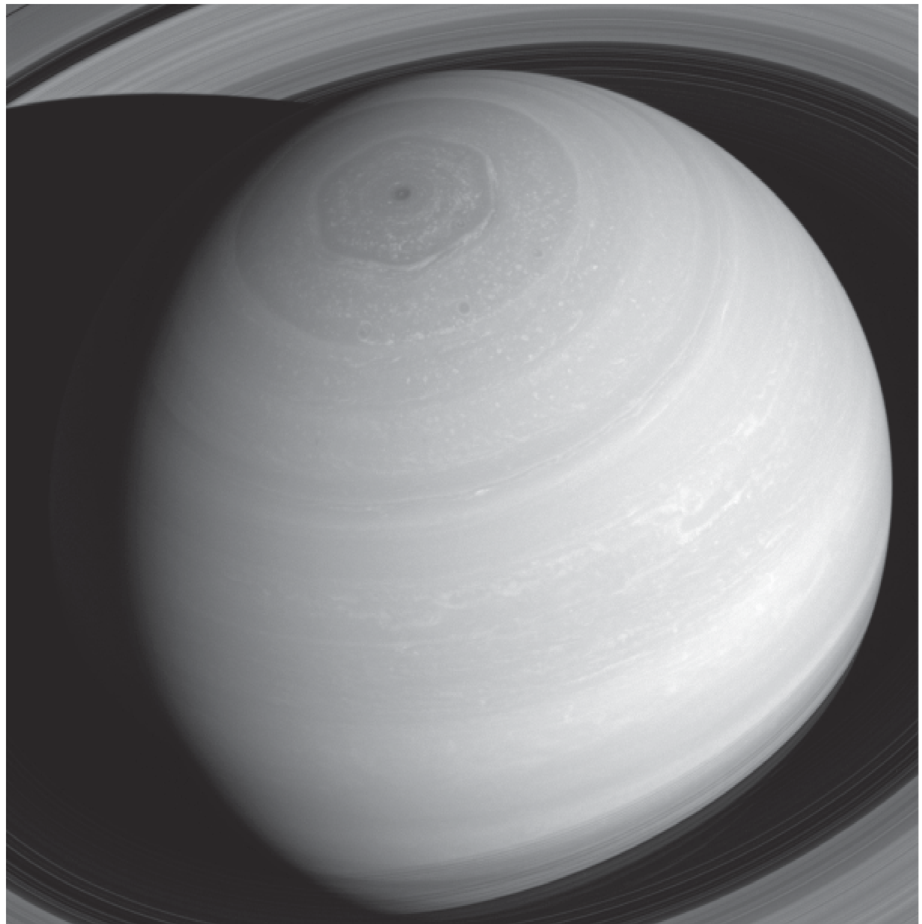


Image Credit: NASA/JPL-Caltech/Space Science Institute

The image (above) was taken looking down on the gas giant and the planet's north pole. The spacecraft was approximately 1 million miles (2 million km) from Saturn when the image was acquired.

Insight into Cataclysmic Planetary Impacts

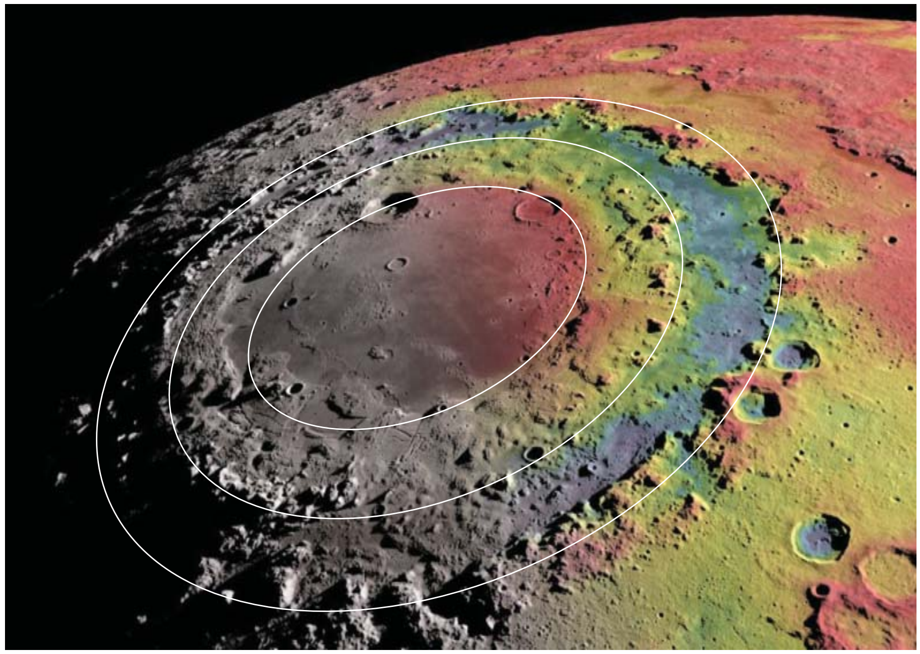
NASA launched twin spacecraft into lunar polar orbit in September 2011. For almost a year, the GRAIL spacecraft (named Ebb and Flow) flew in formation on an identical track over the lunar landscape. Minute change in the distance between the two spacecraft (either moving slightly closer or further away from one another) as they passed over areas of different density (caused by mountains, craters or subsurface formations) enabled scientists to create an accurate map of the Moon's gravitational field. While the mission ended in 2012, the data collected by the spacecraft is still being mined for insight into the Moon's formation and its history of massive impacts by asteroids, comets and other proto-planet debris.

Two new papers have been published on the formation of the Orientale impact basin, located on the Moon's southwestern limb (as viewed from Earth), using GRAIL data. The basin, 580 miles (930 km) across, was created approximately 3.8 billion years ago. Unlike other basins on the Moon that have been concealed by lava flows or degraded by subsequent impacts, there has been little change to Orientale's original basin's structure (exemplified by the characteristic multi-ring, bullseye pattern). At mission's end, the orbit of the GRAIL spacecrafts was lowered from a nominal altitude of 30 miles (50 km) to less than 1.2 miles (2 km), for a closer look at Orientale, since it exemplified large impact basins throughout the solar system.

The first paper examined the relationship of the impact rings with the size of the initial impact crater. The GRAIL gravity field data indicated that the impactor that created the Orientale basin excavated at least

816,000 cubic miles (3.4 million cubic km) of rock, producing a crater with a diameter somewhere in size between the two inner impact rings. The crater quickly collapsed as the Moon's surface rebounded from the impact.

The second paper addressed the formation process for the impact rings. Simulations correlated with the GRAIL data suggest that the rings (at least the outer rings) were produced by the collapse of s ub-surface structures due to the energy imparted by the impactor (the impactor, was estimated at 40 miles (64 km) across and was likely traveling at 9 miles a second (14 km/s) when it collided with the Moon). The ring-shaped faults and scarps that define the outer rings are theorized to have been formed by the subsidence of the mantle, heated by the impact, which fractured the overlying crust, thrusting up blocks of rock. The inner ring is theorized to have been formed from the remnants of the "central peak" after its collapse.



Mare Orientale (circles defining impact rings added). The colors represent the strength of the moon's gravity field with red indicating areas of higher gravity, or excess mass, and blue indicating lower gravity or areas of mass deficits. Image credit: Ernest Wright,

Fully Assembled Sunshield
Credit: Northrop Grumman

Shady Side of Space

Construction of the James Webb Space Telescope reached another milestone towards its 2018 launch with the assembly of the telescope's sunshield. The sunshield, assembled at Northrop Grumman's Space Park facility in Redondo Beach, California, is the size of a tennis court and designed to keep the telescope and its instruments at the optimal operating temperature (colder than -370° F or -223° C).

The sunshield (and telescope) will be stowed inside a 16.4 foot (5 meter) diameter fairing of an Ariane rocket. It will be unfurled during the first week after launch as the telescope travels to its observing position around the second Lagrange (L2) point, approximately 1 million miles (1.5 million km) from Earth and opposite the Sun (see page 24). It will take a month for the telescope to reach L2.

Comprised of five separate Kapton membranes, each the thickness of a human hair, the sunshield is supported by a deployable boom structure. The support structure contains over 7,000 parts, including springs, bearings, pulleys, actuators, cables, motors and magnets, and 150 mechanism assemblies that will have to work in a choreographed sequence for a successful deployment.

The European Space Agency is providing the launch vehicle as their contribution to the mission. Currently scheduled for October 2018, the Ariane 5 rocket will carry the elescope into orbit from Arianespace's launch complex near Kourou, French Guiana.

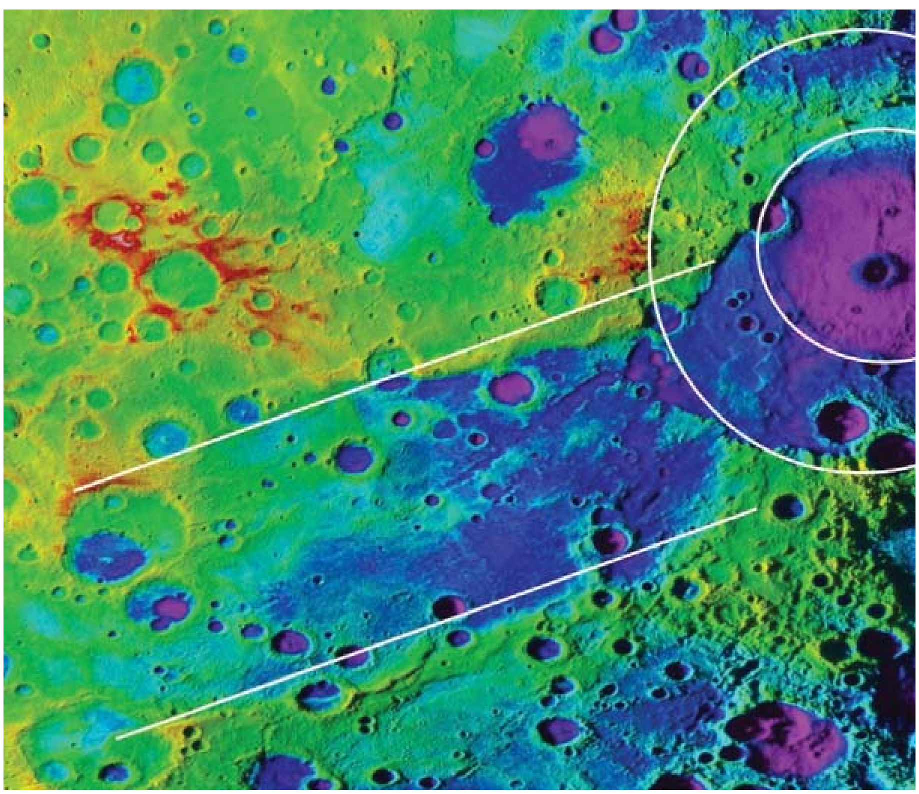
Still Active After All These Years

DATA COLLECTED by NASA's MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft has revealed a world that is still evolving. Mercury, the Sun's closest companion, is tectonically active based upon research supported by MESSENGER's surveys.

NASA's Mariner 10 was the first spacecraft to visit Mercury with three flybys during 1974 and 1975. The spacecraft returned images of a planet that resembled the Earth's moon with a heavily cratered surface and large fault lines or scarps. Scientists would have to wait more than 30 years to get a closer look at the diminutive world.

MESSENGER executed the first of three flybys of Mercury in January 2008 before settling into orbit in March 2011. The spacecraft spent four years orbiting the planet before running out of fuel and crashing into the surface in April 2015. In the final eighteen months, the spacecraft was moved into a lower orbit for high resolution imaging. The images revealed small scale scarps (faults and cliffs), an indication that the planet's crust may still be shrinking. Scarps form as the interior of a planet cools and the outer layers of the planet contract. The contraction or shrinking causes the crust to fracture, creating long fault lines and precipices hundreds of miles long and more than a mile high. Newly formed scarps suggest relatively recent tectonic activity since older features would have been eroded by the constant bombardment of micrometeoroids.

The false color image (lower elevations shown in increasingly darker colors) below displays the topography adjacent to the Rembrandt impact basin (upper right of the image with bullseye pattern added). The ringed structure is one of the youngest and better preserved basins, as well as one of the largest in the solar system at approximately 444 miles or 715 km in diameter. A large valley southwest of the basin (that extends into the basin), is bounded by two fault scarps (Enterprise Rupes to the north of the valley and Belgica Rupes to the south). The valley is more than 600 miles (1,000 km) in length and 250 miles (400 km) in width. The valley floor is as much as 2 miles (3 km) lower than the surrounding surface. The scarps likely formed as Mercury cooled, the crust contracted with rock layers thrust upward. Likewise, the valley was formed with the slumping of crust as it was deformed and buckled.



Credit: NASA/JHUAPL/Carnegie Institution of Washington/DLR/Smithsonian Institution

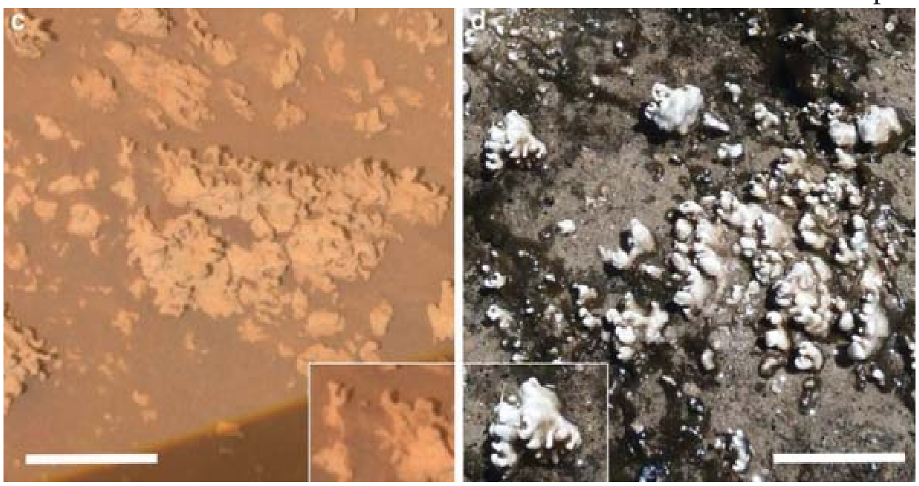
Return to the Columbia Hills?

In 2010, at a place called "Troy," NASA's Mars Exploration Rover Spirit fought her final battle against the harsh Martian environment after having become embedded in soft sand, possibly hung up on a rock, with energy levels falling as dust storms coated her solar panels, two inoperable wheels and winter coming. Sometime between March 22-30, Spirit entered a deep, power-starved hibernation, never to be heard from again.

Spirit's final resting place was on the west side of the low plateau called Home Plate, a feature linked to possible geothermal activity. While still mobile and operational, the rover had uncovered a rich deposit of silica (from dragging her inoperative front wheel) in 2007. The Martian silica included nodules with fingerlike protuberances.

Fast forwarding several years, scientists identified nodules near the hot springs in El Tatio, Chile, at the edge of the Atacama Desert, similar in size and appearance to their Martian counterparts. The cold, arid and high altitude Chilean desert offers an environment analogous to Mars. More importantly, microscopic organisms are associated with the formation of the Chilean nodules.

The Mars Exploration Rovers Spirit and Opportunity were designed as field geologists and furnished with a miniature spectrometer to assist scientists in the determination of mineral composition and a microscopic imager for discerning surface characteristics. Rovers were not equipped to detect biosignatures of organisms past or present. While the Home Plate nodules compare favorably with the nodules collected at El Tatio on many levels, there is no way to ascertain whether microbial activity was involved in their formation without a more detailed microscopic analysis of the Martian nodules and their interior features, and the capability to detect organic matter. It may be that the work by ASU astrobiologist Jack Farmer and ASU planetary scientist Steve Ruff will prompt NASA to send a next generation rover back to the Columbia Hills (Home Plate is currently one of eight potential sites for the Mars 2020 rover).

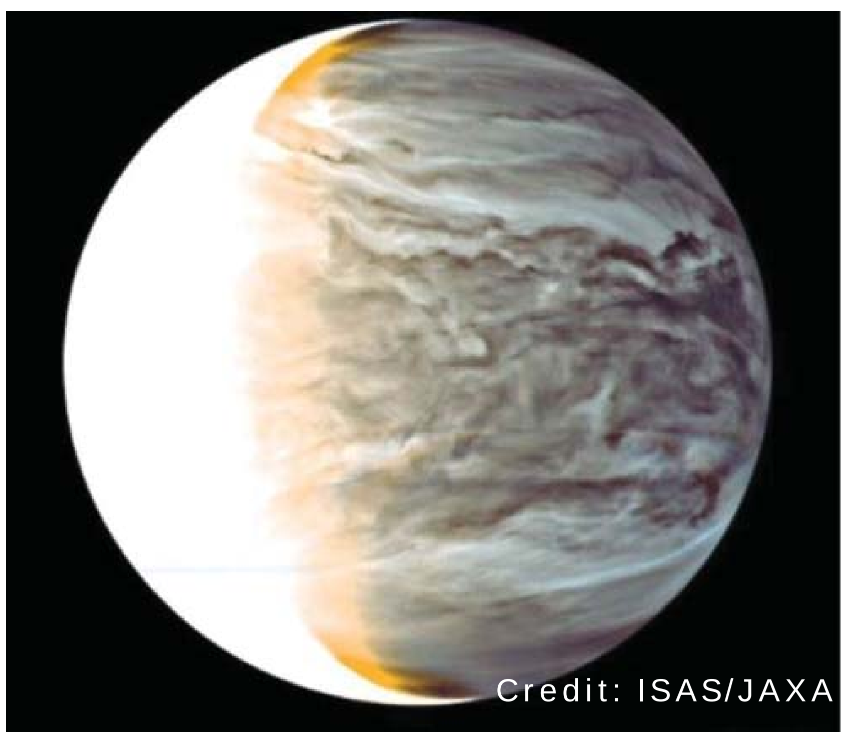

Credits: Silica nodules on Mars by NASA/JPL-Caltech, similar nodules at El Tatio by Steve Ruff, Arizona State University

Update on Schiaparelli

Exploring Mars presents many challenges and, historically, almost half of all missions to the Red Planet have failed. On October 19th, the Schiaparelli lander that had been carried to Mars with the ExoMars Trace Gas Orbiter entered the Martian atmosphere. Entry and descent appeared nominal until telemetry was lost less than a minute before landing. The European Space Agency now believes that a data error in the lander's navigation system caused the guidance system to believe that the lander was already on the ground and resulted in the premature release of the supersonic parachute. The lander subsequently went into a free fall for 12,000 feet (3,700 meters) when it likely exploded on impact with its fuel tanks still full. NASA's Mars Reconnaissance Orbiter confirmed the landers demise with images of a newly formed, debris-strewn crater near the intended landing site.

Beneath the Cloud Deck

Japan's Venus Climate Orbiter (Akatsuki) has been scanning the cloud-shrouded planet since entering orbit in December 2015 (5 years late due to the failure of the main engine on the original attempt) with full scale science operations ongoing since April. The image (below) captures the night side of Venus in the infrared and the clouds in the lower atmosphere.


Credit: ISAS/JAXA

Winds on Venus vary with altitude, much like on the Earth, but to a greater extent. In the upper cloud levels of an atmosphere that reaches 155 miles (250 km) in altitude, winds reach speeds of 220 miles per hour (355 km/hr). Winds in the middle cloud layers reach even higher speeds, more than 435 mph (700 km/hr). At the surface, however, the thick atmosphere is almost stagnant, moving at only a few miles an hour.

Orbiting spacecraft have provided credible evidence that Venus is an active world with signs of recent volcanism, fresh channels carved by lava, atmospheric lightning, and intermittent bursts of sulfur dioxide (associated with volcanic eruptions on Earth).

A Perigee Moon

Publicized by the media as a "Super Moon," the November 14th Full Moon was the largest and brightest in almost 70 years. The Moon's elliptical orbit varies by 30,000 miles (50,000 km) from its closest point to Earth (perigee) to the furthest (apogee). The celestial beacon was the result of the Moon being at perigee within 2½ hours of the near side being 100% illuminated by the Sun (the "full" phase). As a result, the Moon appeared 14% larger and 30% brighter than a typical full Moon. A similar arrangement won't happen again for another 18 years (November 2034).

This spectacular composite image of the supermoon (below) was created by astrophotographer Marc Polansky. The color saturation in the original image was adjusted to emphasize the mineral difference between the various regions of the Moon, in particular the lunar mare. The mare's blue hue in Mare Tranquillitatis (Sea of Tranquility), along the eastern shore of Mare Serenitatis (Sea of Serenity) and in the western reaches of Oceanus Procellarum (Ocean of Storms) is associated with iron and a relatively high concentration of titanium (in the form of the titanium-iron

Image: Marc Polansky

oxide mineral ilmenite) in the basaltic lava. The lighter orange tint in Serenity, Mare Frigoris (Sea of Cold) in the far north and in the other impact basins correlates with lower concentrations. The bright highlands are devoid of any iron or titanium signature, consistent with the great abundance of less dense rock forming minerals such as plagioclase feldspar.

Spaceship Earth and the Blue Marble

On December 7, 1972, the crew of Apollo captured this iconic image of the receding Earth. Christened the "Blue Marble," the image underscored the fragility of humanity's only sanctuary. The photo, taken at a distance of 28,000 miles (45,000 km), provides a view extending from the Mediterranean Sea, across the African continent, to the south polar ice cap.


Credit: NASA

Purchasing a Telescope

During the holidays it's not uncommon to see parents and grandparents carrying around a telescope that they just picked up at the mall or warehouse store for their budding astronomer. Unfortunately, too many of these thoughtful gifts end up in a basement or attic after one or two uses. All too often, telescope manufacturers prey on consumer's expectations, which are often out of line with the capabilities of the product, resulting in frustration and disillusionment. However, even a crudely constructed telescope can be coaxed to produce acceptable images, if the observer understands the limitations of his or her instrument.

There is no perfect telescope for everyone. An inexpensive, mass-produced telescope that gets carted out of the house and set up every clear night, stimulates the users' imagination and encourages them to push the instrument's capabilities to its limits is far more valuable than the most highly crafted optical masterpiece that spends its nights in a closet.

There are several types of telescopes available to the general consumer. Each has advantages and disadvantages, and with a little education, a consumer can find a telescope that fits his or her needs and lifestyle. Again, if you don't use it, a telescope is about as useful as a garden gnome and not as cute.

Types of Telescopes

There are three basic types of telescopes: refractors, reflectors and compound or catadioptric telescopes.

Refractors have been around for 400 years and use a series of lenses to bring the light rays from distant objects to focus. They are highly regarded for their unobstructed and high-contrast images. The optical tubes are sealed and generally more rugged that other designs. As such, the optics rarely need to be adjusted (realigned) which makes the refractor a good choice as a travel telescope. Refractors are an excellent choice for planetary and lunar viewing and for double stars, but generally do not have the large light gathering capacity needed for faint objects such as nebula and galaxies. The disadvantages of refractors include: the potential for different wavelengths of light to diverge from a common focus as they pass through the glass (producing color “fringing” around bright objects), the position of the eyepiece at the rear of the optical tube (requiring the telescope to be mounted fairly high off the ground for comfortable viewing), the closed tube that can take some time to cool down, and the price (highest cost per inch of aperture of the basic telescopes designs).

Reflectors have been around for almost as long as refractors, but use mirrors instead of lenses to bring light to the observer’s eye. A large mirror located at the closed end of the optical tube reflects light back up the tube to a smaller mirror mounted near the open end and out to an eyepiece. Mirrors are much easier and less expensive to manufacture than lenses with only an optical curve required on the front of the mirror. With mirrors, the light never passes through the glass, so there is no divergence of the light rays. However, since the optical tube is open to the atmosphere, mirrors will require periodic cleaning, adjustment and, eventually, recoating. Reflectors offer the best value, particularly for larger apertures.

The most popular compound or catadioptric telescopes combine a large, rear spherical mirror with a front corrector lens to create a very compact optical tube. Companies such as Meade and Celestron built their businesses on the Schmidt-Cassegrain design. While generally more expensive than reflectors, the compound telescope offers a very portable alterative for large aperture telescopes. Disadvantages include cool down time (since the optical tubes are sealed), and a relatively large secondary mirror that degrades the image of high contrast objects (planets or the Moon). The front corrector plate is also susceptible to dew formation although this can be managed with a dew shield or corrector plate heater.

There are several terms that are used in the sales promotion of telescopes. Some of the common ones are discussed below:

Aperture

Aperture refers to the size of the largest lens or mirror in the telescope, for example, the primary mirror in an 8-inch reflector is 8-inches in diameter. As a general rule, bigger is better, as light gathering and resolution increase with the size of the optics. However, as with everything else, there are other considerations that limit the practical size of a particular instrument. Alvan Clark & Sons figured the 40-inch lens for the Yerkes Observatory’s refractor, delivering the lens in 1897. More than 100 years later, it is still the world’s largest working refractor. Why? The weight of the glass and the complexities in supporting a large lens by its edge and the absorption of light passing through the glass were factors; however, the refractor was ultimately done in by Sir Isaac Newton when he built the first reflecting telescope in 1668. Mirrors, unlike lenses, can be completely supported from the back. Since light does not pass through the glass, reflected images do not suffer from “chromatic aberration.” Today single mirrors are routinely produced with diameters exceeding 28 feet and telescopes are constructed combining multiple mirrors to achieve even larger light gathering capabilities. So what size is good for you? Before you answer, you may want to consider:

◦ Are you planning on setting up your telescope in a permanent installation, e.g., backyard observatory, or will you be moving it in and out of your home every time you plan on observing. If the latter, then weight, portability and ease of set up are important considerations. Due to its size and weight, my telescope saw very little use until I invested in a wheeled platform that allows me to easily roll the fully assembled telescope in and out of my garage in minutes.

◦ Are you planning on taking your telescope on the road, with you on vacation or planning to travel some distance to find truly dark skies or observe a “once in a lifetime event?” Whether by train, plane or automobile, care must be taken to protect your telescope and ensure that it arrives at its destination in working order (mechanically and optically). If this is important to you, a smaller and simpler design such as a refractor may be a good choice.

◦ What are you interested in looking at? Spectacular views of the Sun, Moon and planets can be acquired with a relatively modest instrument. However, if your passion is hunting down the more elusive and distant residents our the Milky Way Galaxy or exploring other galaxies far, far, away, it will require a much larger aperture to capture those meager photons.

Magnification

Magnification is likely the most overrated measure of a telescope’s capabilities. Magnification is a function of the eyepiece placed in the path of the incoming light and in front of the observer’s eye; the observer can change the magnification by simply selecting a different eyepiece. As such, it shouldn't be a criterion in selecting a telescope.

The limiting useful magnification is approximately 50 times the diameter of the objective lens or primary mirror. For example, a small refracting telescope with a 4-inch objective lens can be pushed to a magnification of 200 times; however, only under the best observing conditions and, in general, only on bright objects such as the Moon and planets. Most astronomers prefer the views that lower magnification provides with a wider field and brighter image. So, the next time you are captured by the stunning views of the universe on the packaging of a modest instrument, remember that the potential of most telescopes is rarely realized, particularly if you reside in the light polluted skies of the northeast. A higher power eyepiece magnifies not only the telescope's intended target but also the side-effects of living under 20 miles of Earth's atmosphere.

Mounts

While generally not at the top of the list as far as features, the telescope's mounting system and construction is key to its ease of use and the stability of the image. A poorly designed mount or one with flimsy construction can be just as frustrating to deal with as poor optics. An altitude-azimuth or alt-az mount is the simplest type of telescope mount and generally the easiest to set up. In this arrangement, the mount allows the telescope to move left and right while pivoting up and down. It is commonly found on Dobsonian* telescopes, is user friendly and can be mechanized to track celestial objects across the sky.

Another common mount design is the equatorial mount. In this design, one axis is aligned with the celestial pole, requiring only the movement around this axis to follow objects across the sky. It is the easiest configuration for tracking and is generally preferred for astrophotography. Some alt-az mounts can be converted to an equatorial configuration with the addition of an "equatorial wedge." Equatorial mounts, however, can be heavier than their alt-az counterparts.

Go-To

Essentially a computer controlled pointing system, "go-to" allows the user to select an object from a data base and command the drive motors on the mount to move the telescope to the object's location in the sky. This presupposes that the telescope user has properly set up the telescope and successfully navigated through the alignment process (a process by which the telescope's computer determines where it's pointed, the local time, and its position on the Earth). Most "go-to" telescopes come with a large database, some of which can be modified (supplemented) by the user. While "go-to" capability is extremely convenient and can take you to thousands of objects in its database in a blink of an eye, it doesn't necessarily mean that you will be able to see the object. Depending upon the size of your telescope (see Aperture), many objects in these databases are just too dim to see with the equipment provided. CCD cameras are much more sensitive than your eye and can accumulate light for long durations. So, if you are planning on using your telescope primarily as a camera lens, then some of the disadvantage of a small aperture can be overcome. However, if you plan on doing most of your observing at the eyepiece, you may want to consider spending the money on a larger aperture rather than on "go-to" electronics.

Dobsonian-type telescopes are reflectors on a simple, swivel mount. They offer a low-cost solution for those on a limited budget with aperture fever (an insatiable desire for a larger telescope).

What to Do

If you are seriously considering acquiring a telescope, a little bit of research can go a long way in enjoying your final purchase. If possible, try to observe through the telescope(s) that you are considering. The McCarthy Observatory has a monthly open house. When the skies are clear, up to a dozen telescopes can be found on the premises (including refractors, reflectors, a Dobsonian, and several Schmidt-Cassegrains). Compare the same celestial objects through different scopes, talk to the owners about portability, ease of setup and operation. Check out product reviews in trade magazines such as Sky and Telescope and Astronomy and on their websites. Contact reputable dealers and visit trade shows such as the Northeast Astronomical Forum where you can pick the brains of industry experts.

December History

1968 was a year of turmoil. The United States was entangled in a war that even the Secretary of Defense concluded could not be won and he resigned from office. The My Lai massacre was one of many atrocities of the Vietnam War perpetrated by both sides during this year. Major U.S. cities were the target of race riots and anti-war protests. Chicago police violently clashed with protesters at the Democratic National Convention and civil rights leader Martin Luther King and presidential candidate Robert Kennedy were assassinated in 1968. To many Americans, the only heartening event in this otherwise horrific year was the reading from the Book of Genesis by the crew of Apollo 8 as they orbited the Moon on Christmas Eve.

The race to beat the Soviets to the Moon took a dramatic turn in 1968 and saw the United States take its first lead by year's end. Apollo 7 was launched in October 1968 into Earth orbit. A week or so later, the Soviets launched two Soyuz space craft into Earth orbit (one manned and one unmanned for a planned rendezvous). In November, another unmanned Zond flew around the Moon and photographed the unseen far side. The United States expected that the Soviets would attempt another moon shot in early December when the launch window for the Baikonur space center in Kazakhstan reopened (a Zond stood poised on the launching pad). Curiously, the opportunity passed without any activity. Cosmonaut Alexei Leonov would later attribute the Soviet's loss of initiative and resolve to the premature death of Sergei Korolev, the "Chief Designer" of the Soviet space program as well as the design complexities of their Moon rocket (the N1).

While Apollo 7 had been a successful maiden voyage of the completely redesigned command module (after the Apollo 1 fire), the United States had yet to leave Earth orbit. NASA's original plan was to launch a series of increasingly complex missions to near-Earth orbit before attempting a lunar excursion. Development of the lunar lander was behind schedule and violent vibrations in the Saturn rocket's main stage needed to be corrected before NASA felt confident of sending men to the Moon. However, the apparent progress by the Soviets threatened to upstage the United States once again. It was a proposal by a quiet engineering genius, George Low, (Manager of the Apollo Spacecraft Program Office) to send the Apollo 8 command module alone into lunar orbit that would ultimately place the United States in a position to achieve President Kennedy's goal to land a man on the Moon and safely return him to Earth by the end of the decade.

Apollo 8 was launched on December 21st under the command of Frank Borman with astronauts William Anders and Jim Lovell (Lovell replaced Michael Collins on the original team; Collins, who required back surgery, would go on to be the Command Module Pilot for Apollo 11). The launch was scheduled so that the crew would arrive at the Moon as the Sun was rising on the Sea of Tranquility. With the Sun low in the sky, the astronauts could photograph potential landing sites and resolve surface detail that would otherwise be washed out in the glare from a higher Sun.

The crew of Apollo 8 was the first to ride the three stage Saturn V rocket, with the explosive energy of an atomic bomb (the Saturn V had only been launched twice before – both unmanned). The night before the launch, the astronauts were visited by Charles Lindbergh. During the visit, it was discussed that the engines on the Saturn V would burn 10 times the amount of fuel every second that Lindbergh had used to fly nonstop from New York to Paris.

The Apollo 8 astronauts were also the first humans to leave Earth orbit and pass through the Van Allen radiation belts that extend up to 15,000 miles from Earth. To accomplish the mission, Apollo 8 had to cross the 240,000 mile void between the Earth and the Moon with sufficient precision so as to intercept the Moon (traveling at 2,300 miles an hour through space) just

69 miles above the lunar surface. By successfully doing so, the astronauts were the first humans to witness the rising of the Earth above the Moon's horizon (Earthrise). They would also be the first to return to Earth and reenter the atmosphere at a speed of 25,000 miles an hour.

The highlight of the mission, to many, was the broadcast from the Apollo 8 command module during the ninth orbit of the Moon. After a brief introduction of the crew and their general impressions of the lunar landscape, William Anders said that the crew had a message for all those on Earth. The astronauts took turns reading from the book of Genesis, the story of creation. Frank Borman closed the broadcast with: "And from the crew of Apollo 8, we close with: Good night, Good luck, a Merry Christmas, and God bless all of you, all you on the good Earth." It is estimated that a quarter of

Earth's population saw the Christmas Eve transmission.

In order to safely return to Earth, the main engine had to be restarted on the far side of the Moon (out of contact with the Earth). If successful, Apollo 8 would reappear from behind the Moon at a predetermined time. As predicted, the spacecraft reemerged on time, and when voice contact was regained, astronaut Jim Lovell would announce: "Please be informed, there is a Santa Claus." It was Christmas Day. Apollo 8 would return safely to the Earth two days later, splashing down in the Pacific Ocean shortly before sunrise. The astronauts and the capsule were recovered by the aircraft carrier USS Yorktown.

December Nights

Nights in December are not to be missed. While the often frigid and turbulent atmosphere can be frustrating for astronomers, the reflection of shimmering starlight (or moonlight) off a snow covered landscape can be truly magical. The bright stars of the winter sky glow with color from orange to yellow to brilliant blue-white. A star-filled sky in December is unsurpassed in grandeur.

Sunrise and Sunset

Sun	Sunrise	Sunset
December 1st (EST)	07:01	16:24
December 15th	07:14	16:24
December 30th	07:20	16:34

Astronomical and Historical Events

1st Scheduled launch of a cargo-carrying Progress spacecraft to the International Space Station aboard a Russian Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan
1st Aten asteroid 2016 LO1 near-Earth flyby (0.063 AU)
1st Kuiper Belt Object 229762 (2007 UK126) at Opposition (41.879 AU)
1st Kuiper Belt Object 2006 QH181 at Opposition (82.599 AU)
1st History: launch of Soviet satellite Sputnik 6 and two dogs: Pchelka and Mushka (1960)
2nd History: dedication of the John J. McCarthy Observatory in New Milford, CT (2000)
2nd History: launch of SOHO solar observatory (1995)
2nd History: touchdown of Soviet Mars 3 lander: communications were lost with the lander, the first spacecraft to touch down on the Red Planet, after 20 seconds possibly due to raging dust storm (1971)
2nd History: launch of space shuttle Endeavour (STS-61), first servicing of the Hubble Space Telescope, including the installation of corrective optics and new solar panels (1993)
2nd History: Pioneer 11 spacecraft makes its closest approach to Jupiter; encounter redirects the spacecraft to Saturn and an escape trajectory out of the solar system (1974)
3rd Apollo asteroid 2007 VM184 near-Earth flyby (0.057 AU)
3rd Kuiper Belt Object 145451 (2005 RM43) at Opposition (35.513 AU)
3rd History: Pioneer 10 spacecraft makes its closest approach to Jupiter; first space probe to fly through the asteroid belt and to an outer planet (1973)
3rd History: discovery of Jupiter's moon *Himalia* by Charles Perrine (1904)
4th Distant flyby of Saturn's' moons *Methone* and *Pan* by the Cassini spacecraft
4th Comet 10P/Tempel closest approach to Earth (2.441 AU)
4th Aten asteroid 2005 WS3 near-Earth flyby (0.065 AU)
4th History: launch of space shuttle Endeavour (STS-88), first International Space Station construction flight, including the mating of the Unity and Zarya modules (1998)
4th History: launch of the Pathfinder spacecraft to Mars (1996)
4th History: Pioneer Venus 1 enters orbit, first of two orbiters (and probes) to conduct a comprehensive investigation of the atmosphere of Venus (1978)
4th History: launch of Gemini 7 with astronauts Frank Borman and Jim Lovell, spending almost 14 days in space (1965)
4th History: launch of Gemini Joe 2 rocket, test flight for the Mercury capsule and first U.S. animal flight with Sam, a Rhesus monkey (1959)

Astronomical and Historical Events (continued)

5th Aten asteroid 2010 TK7 (Earth Trojan) closest approach to Earth (0.200 AU)
5th Apollo asteroid 137052 *Tjelvar* closest approach to Earth (0.548 AU)
5th Centaur object 8405 *Asbolus* at Opposition (19.452 AU)
6th Moon occults the planet Neptune
6th History: Japanese spacecraft Akatsuki enters around Venus five years after unsuccessful first attempt and main engine failure (2015)
6th Apollo asteroid 2016 TD18 near-Earth flyby (0.045 AU)
6th Amor asteroid 2016 UN36 near-Earth flyby (0.054 AU)
7th First Quarter Moon
7th History: arrival of the Galileo space probe at Jupiter (1995)
7th History: launch of Apollo 17 with astronauts Ronald Evans, Harrison Schmitt (first scientist – geologist) and Eugene Cernan (last man on the Moon – so far) (1972)
8th Atira asteroid 164294 (2004 XZ130) closest approach to Earth (1.263 AU)
8th History: a Dragon spacecraft, launched by SpaceX into low-Earth orbit, is recovered in the Pacific Ocean: first time a spacecraft recovered by a commercial company (2010)
8th History: discovery of asteroid *5 Astraea* by Karl Hencke (1845)
9th Scheduled launch of a Japanese H-2 Transfer Vehicle (unmanned cargo vehicle) to the International Space Station from the Tanegashima Space Center, Japan
9th Aten asteroid 1994 XL1 near-Earth flyby (0.092 AU)
9th History: Pioneer Venus 2 enters orbit, second of two orbiters (and probes) to conduct a comprehensive investigation of the atmosphere of Venus (1978)
10th Second Saturday Stars - Open House at the McCarthy Observatory (7:00 pm)
10th Apollo asteroid 2014 HM4 near-Earth flyby (0.060 AU)
10th Plutino 84922 (2003 VS2) at Opposition (35.638 AU)
10th Plutino 307463 (2002 VU130) at Opposition (39.392 AU)
10th Kuiper Belt Object 2004 XR190 at Opposition (56.401 AU)
10th History: launch of the X-ray Multi-Mirror Mission (XMM-Newton), the largest scientific satellite built in Europe and one of the most powerful (1999)
10th History: launch of Helios 1 (also known as Helios A) into solar orbit; joint venture by Federal Republic of Germany and NASA to study the Sun (1974)
11th Mercury at its Greatest Eastern Elongation; apparent separation from the Sun in the evening sky (21°)
11th Distant flyby of Saturn's moons *Prometheus* and *Pallene* by the Cassini spacecraft
12th Moon at perigee (closest distance from Earth)
12th Atira asteroid 2008 UL90 near-Earth Flyby (0.039 AU)
12th History: discovery of Saturn moons *Fornjot*, *Farbauti*, *Aegir*, *Bebhionn*, *Hati* and *Bergeimi*r by Scott Sheppard, et al's (2004)
12th History: discovery of Saturn moons *Hyrrokkin* by Sheppard/Jewitt/Kleyna (2004)
12th History: launch of Uhuru, the first satellite designed specifically for X-ray astronomy (1970)
12th History: launch of Oscar, first amateur satellite (1961)
13th Full Moon
13th Geminids meteor shower peak
13th Moon occults the star Aldebaran
13th Aten asteroid 2015 XX169 near-Earth flyby (0.019 AU)
13th Apollo asteroid 2015 YA near-Earth flyby (0.025 AU)
13th Aten asteroid 2014 XU6 near-Earth flyby (0.095 AU)
13th Apollo asteroid 6489 *Golevka* closest approach to Earth (2.921 AU)
13th Kuiper Belt Object 19521 *Chaos* at Opposition (40.401 AU)
13th History: discovery of Saturn's moons *Fenrir* and *Bestla* by Scott Sheppard, et al's (2004)

Astronomical and Historical Events (continued)

- 13th History: Mt. Wilson's 100-inch telescope used to measure the first stellar diameter (Betelgeuse); measured by Francis Pease and Albert Michelson (1920)
- 13th History: first light of Mt. Wilson's 60-inch telescope (1908)
- 14th Apollo asteroid 3838 *Epona* closest approach to Earth (1.565 AU)
- 14th Centaur object 154783 (2004 PA44) at Opposition (18.986 AU)
- 14th History: flyby of Venus by Mariner 2; first spacecraft to execute a successful encounter with another planet, finding cool cloud layers and an extremely hot surface (1962)
- 14th History: flyby of Mars by Japan's Nozomi spacecraft after an attempt to achieve orbit fails (2003)
- 14th History: creation of the Canadian Space Agency (1990)
- 14th History: Weston meteorite fall: first documented fall in the United States (1807); best coordinates for the fall are based upon investigative research by Monty Robson, Director of the McCarthy Observatory, published in 2009
- 14th History: birth of Tycho Brahe, Danish astronomer noted for his observational skills, the precision of his observations, and the instruments he developed; builder of Uraniburg, the finest observatory in Europe (1546)
- 15th Distant flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
- 15th Apollo asteroid 2011 MD closest approach to Earth (1.981 AU)
- 15th History: launch of Soviet spacecraft, Vega 1 to Venus and then to Comet Halley (1984)
- 15th History: landing of Soviet spacecraft Venera 7 on the surface of Venus (1970)
- 15th History: discovery of Saturn's moon *Janus* by Audouin Dollfus (1966)
- 15th History: launch of Gemini 6 with astronauts Walter Schirra and Thomas Stafford (1965)
- 15th History: Gemini 6 and 7 execute the first manned spacecraft rendezvous (1965)
- 16th Aten asteroid 2001 YE4 near-Earth flyby (0.081 AU)
- 16th History: launch of Pioneer 6, the first of four identical solar orbiting, spin-stabilized spacecraft (1965)
- 17th Apollo asteroid 2016 NL15 near-Earth flyby (0.077 AU)
- 17th Apollo asteroid 4581 *Asciepius* closest approach to Earth (0.331 AU)
- 17th Atira asteroid 2010 XB11 closest approach to Earth (1.077 AU)
- 17th History: Project Mercury publicly announced (1958)
- 17th History: Wright Brothers' first airplane flight, Kitty Hawk, North Carolina (1903)
- 18th Distant flyby of Saturn's moons *Aegaeon*, *Pandora*, *Janus* and *Pan* by the Cassini spacecraft
- 18th Plutino 55638 (2002 VE95) at Opposition (28.609 AU)
- 18th History: discovery of Saturn's moon *Epimetheus* by Richard Walker (discovery shared with Stephen Larson and John Fountain) (1966)
- 19th History: launch of the Gaia spacecraft from French Guiana to survey more than one billion stars in an effort to chart the chart the evolution of the Milky Way galaxy (2013)
- 19th History: launch of space shuttle Discovery (STS-103), third servicing of the Hubble space telescope including the installation of new gyroscopes and computer (1999)
- 19th History: launch of Mercury-Redstone 1A; first successful flight and qualification of the spacecraft and booster (1960)
- 20th Last Quarter Moon
- 20th Aten asteroid 2016 GK135 near-Earth flyby (0.093 AU)
- 20th History: Ames Research Center founded as the second National Advisory Committee for Aeronautics (NACA) laboratory at Moffett Federal Airfield in California (1939)
- 20th History: founding of the Mt. Wilson Observatory (1904)
- 20th History: launch of the Active Cavity Radiometer Irradiance Monitor satellite (ACRIMSAT); designed to measure Sun's total solar irradiance (1999)
- 21st Winter Solstice at 5:44 am EST (10:44 UT)
- 21st Aten asteroid 2015 YQ1 near-Earth flyby (0.016 AU)

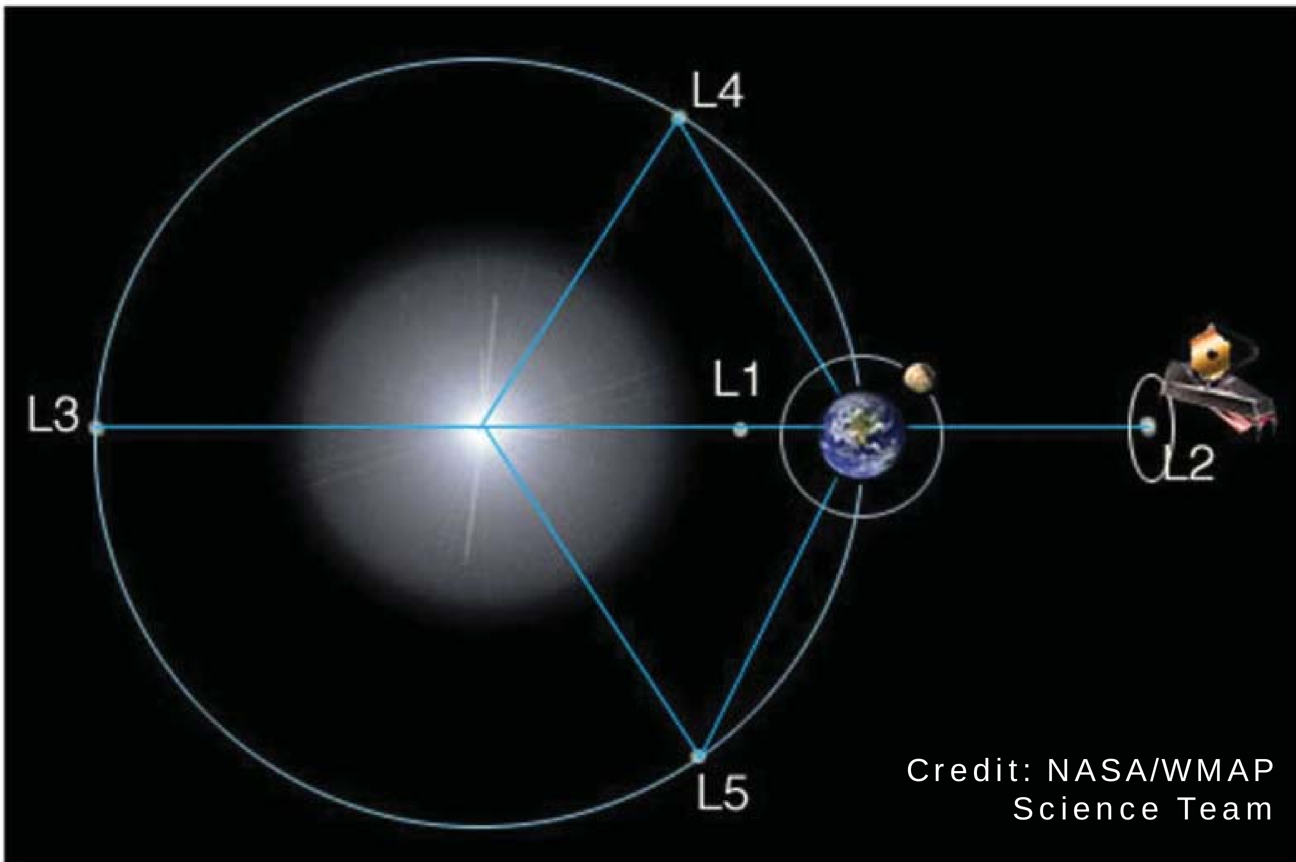
Astronomical and Historical Events (continued)

21st Apollo asteroid 2006 XD2 near-Earth flyby (0.048 AU)
21st Apollo asteroid 418849 (2008 WM64) near-Earth flyby (0.072 AU)
21st Kuiper Belt Object 78799 (2002 XW93) at Opposition (44.501 AU)
21st History: launch of the Soviet spacecraft Vega 2 to Venus, continued on to Comet Halley (1984)
21st History: landing of Soviet spacecraft Venera 12 on the surface of Venus, found evidence of thunder and lightning in the atmosphere (1978)
21st History: launch of Apollo 8 with astronauts Frank Borman, Jim Lovell and William Anders, first to circumnavigate the Moon (1968)
21st History: launch of Luna 13, Soviet moon lander (1966)
22nd Ursids Meteor Shower peak
22nd Aten Asteroid 2340 *Hathor* closest approach to Earth (1.437 AU)
22nd History: first asteroid (323 Brucia) discovered using photography (1891)
23rd Aten asteroid 2014 BA3 closest approach to Earth (1.461 AU)
23rd Plutino 2002 XV93 at Opposition (37.915 AU)
23rd History: discovery of Saturn's moon *Rhea* by Giovanni Cassini (1672)
24th History: inaugural of ESA's Ariane 1 rocket and first artificial satellite carried by an ESA rocket (1979)
24th History: Deep Space Network created (1963)
24th History: Jean-Louis Pons born into a poor family with only basic education, took post at observatory at Marseilles as concierge, went on to become most successful discover of comets (discovered or co-discovered 37 comets, 26 bear his name) (1761)
24th History: inaugural launch of the Arianne rocket, Europe's attempt to develop a cost-effective launcher to serve the commercial market (1979)
25th Moon at apogee (furthest distance from Earth)
25th History: European Space Agency's Mars Express spacecraft enters orbit around Mars (2003)
25th History: landing of Soviet spacecraft Venera 11 on Venus, second of two identical spacecraft (1978)
26th Distant flyby of Saturn's moons *Enceladus*, *Mimas* and *Aegaeon* by the Cassini spacecraft
26th History: launch of Soviet space station Salyut 4 from Baikonur Cosmodrome; third Soviet space station and second space station devoted primarily to civilian objectives; deorbited in 1977 (1974)
27th Atira asteroid 2007 EB26 closest approach to Earth (0.823 AU)
27th History: discovery of the ALH84001 Martian meteorite in the Allan Hills, Far Western Icefield, Antarctica, made famous by the announcement of the discovery of evidence for primitive Martian bacterial life (1984)
27th History: Johannes Kepler born, German mathematician and astronomer who postulated that the Earth and planets travel about the sun in elliptical orbits, developed three fundamental laws of planetary motion (1571)
28th Apollo asteroid 12923 Zephyr closest approach to Earth (1.634 AU)
29th New Moon
29th Apollo asteroid 4179 *Toutatis* closest approach to Earth (0.251 AU)
30th Aten asteroid 2012 YK near-Earth flyby (0.043)
30th Apollo asteroid 2102 *Tantalus* closest approach to Earth (0.138 AU)
30th History: Army Air Corp Captain Albert William Stevens takes first photo showing the Earth's curvature (1930)
30th History: flyby of Jupiter by Cassini spacecraft on mission to Saturn (2000)
30th History: discovery of Uranus' moon *Puck* by Stephen Synnott (1985)
31st Distant flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
31st Apollo asteroid 4341 *Poseidon* closest approach to Earth (0.374 AU)
31st Kuiper Belt Object 2014 WP509 at Opposition (41.501 AU)
31st History: GRAIL-A, lunar gravity mapping spacecraft enters orbit (2011)

Commonly Used Terms

- 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

Earth-Sun Lagrange Points and the James Webb Telescope



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°)
- One astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

International Space Station/Space Shuttle/Iridium Satellites

Visit *www.heavens-above.com* for the times of visibility and detailed star charts for viewing the International Space Station, the Space Shuttle (when in orbit) and the bright flares from Iridium satellites.

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.*

Cover Photo

Planets within the habitable zones around stars (where liquid water can exist on the surface) are typically targeted in exoplanet searches. However, the search within our own solar system has found that, with tidal heating, oceans can exist under the frozen surfaces of distant moons. ***Ocean Sunrise*** photo: Bill Cloutier.

For more information on the search for water, go to *https://www.nasa.gov/jpl/the-solar-system-and-beyond-is-awash-in-water.*

Image Credits

Front page design and graphic calendars: Allan Ostergren.

Second Saturday Stars poster: Marc Polansky.

Second Saturday Stars

FREE EVENT

Every Month at the

John J. McCarthy Observatory

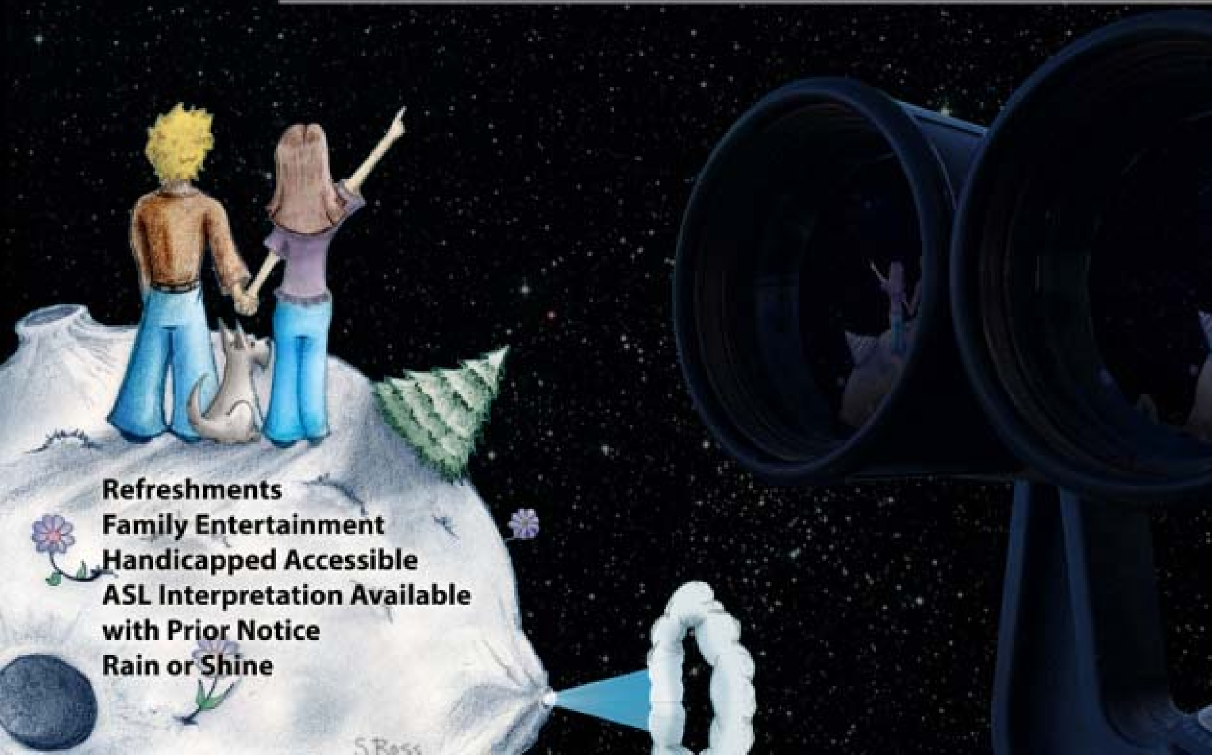
Behind the New Milford High School

860.946.0312

www.mccarthyobservatory.org

December 10th

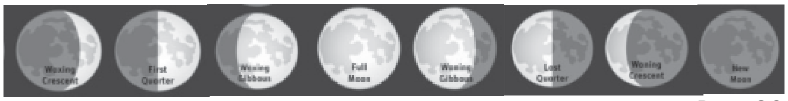
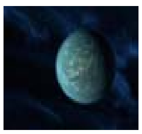
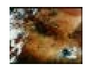
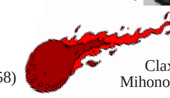
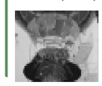
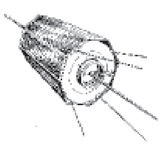
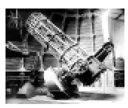
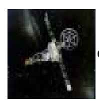
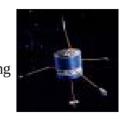
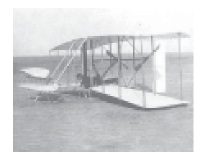
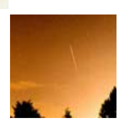
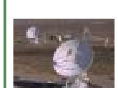
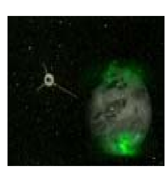
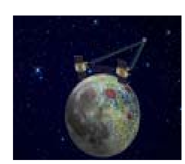
7:00 - 9:00 pm



Refreshments
Family Entertainment
Handicapped Accessible
ASL Interpretation Available with Prior Notice
Rain or Shine

December 2016

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Phases of the Moon  Dec 7 Waxing Crescent, First Quarter; Dec 13 Waxing Gibbous, Full Moon; Dec 20 Waning Gibbous, Last Quarter; Dec 29 Waning Crescent, New Moon				**1**  Launch of Soviet satellite Sputnik 6 with two dogs, Pchelak and Mushka (1960)	**2** Flyby of Jupiter by Pioneer 11 spaccraft (1974)  Launch of SOHO solar observatory (1995) Space Shuttle Endeavour first Hubble servicing mission (1993) Dedication of John J. McCarthy Observatory in New Milford, CT (2000)	**3**  Pioneer 10 closest approach to Jupiter (1973)  Discovery of Jupiter moon Himalia by Charles Perrine (1904)
4 Orion test flight launch, Cape Canaveral Gemini 7 launch - Borman/Lovell (1965) Launch of Pathfinder spacecraft to Mars (1996)  Pioneer orbits Venus to study atmosphere (1978) Launch of Little Joe 2 rocket, test flight for the Mercury capsule with Sam, a Rhesus monkey (1959)	**5**  Discovery of Kepler-22b, by NASA's Kepler Space Telescope in the constellation of Cygnus - the first known transiting planet to orbit within the habitable zone of a Sun-like star (2011)	**6**  America's first attempt at putting a satellite into orbit failed as Vanguard TV3 rose only about four feet off a Cape Canaveral launch pad before crashing back down and exploding (1957)	**7** Apollo 17 (Evans, Schmitt, Cernan) 1972  Gerard Kuiper born - proposed belt of minor planetary objects beyond Neptune (1905) Arrival of Galileo space probe at Jupiter (1995) New Horizons spacecraft wakes up to prepare for its July 2015 encounter with the dwarf planet Pluto	**8** Discovery of asteroid 5 Astraea by Karl Hencke (1845)  Galileo spacecraft 1st Earth flyby (1990) SpaceX Dragon, launched into low-Earth orbit, is recovered in the Pacific Ocean: first by a commercial company (2010)	**9** Pioneer Venus 2 in orbit, 2nd to study planet's atmosphere (1978) Ausson meteorite fall, hits building in France (1858)  Asteroid 2011 WU4 Near-Earth Flyby (0.084 AU)	**10** Launch of XMM-Newton European X-Ray satellite (1999)  Launch of Helios 1 into solar orbit - joint project of NASA and Federal Republic of Germany (1974) St Louis meteorite, hits automobile (1950) Claxton, GA, hits mailbox (1984) Mihonoseki, Japan, hits house (1992) 2nd Saturday Stars New Milford High School
11  Challenger, the Lunar Lander for Apollo 17, touched down on the Moon's surface with astronauts Harrison Schmitt and Eugene Cernan - last two men to walk on moon (1972)	**12** Moon at Perigee (closest to Earth)  Launch of Oscar, first amateur satellite (1961)	**13**  First light of Mt. Wilson's 60-inch telescope (1908) Geminids meteor shower peak	**14**  Flyby of Venus by Mariner 2; first spacecraft to execute a successful encounter with another planet (1962) Weston, CT Meteorite, first documented U.S. strike (1807) Tycho Brahe born, 1546 - Danish astronomer	**15**  Discovery of Saturn moon Janus by Audouin Dollfus (1966) Soviet Venus missions: landing of Venera 7 on the surface of Venus (1970); Vega 1 to Venus and Comet Halley (1984); Gemini 6 launch (Schirra, Stafford) 1965	**16** Launch of Pioneer 6, first of four solar orbiting spacecraft (1965)  Mars origin meteorite QUE 94201 discovered in Queen Alexandra range, Antarctica (1994)	**17**  Wright Brothers first flight, Kitty Hawk, NC (1903)
18  NASA showed the first images from the $670 million Spitzer Space Telescope, launched 4 months earlier (2003)	**19** Mercury 1, unmanned spacecraft (1960) Launch of Discovery STS-103, 3rd Hubble servicing mission (1999)  Benares meteorite, hits house in India (1798)	**20** Founding of the Mt. Wilson Observatory (1904) Soviet cosmonaut Georgy Grechko makes the first spacewalk during the Salyut 6 EO-1 mission (1977)  Comet 21P Giacobini–Zinner discovered in the constellation Cygnus by Michel Giacobini from (Nice, France) (1900)	**21** Winter Solstice at 21:23:03 UT (4:23 pm EST)  Launch of Soviet spacecraft Vega 2 to Venus and on to Comet Halley - (1984) Apollo 8 (Borman, Lovell, Anders), first to circumnavigate the Moon - 1968 Launch of Luna 13, Soviet moon lander (1966)	**22** Discovery of LEW 88516 meteorite -Martian origin (1988) Ursids meteor shower peak 	**23**  Discovery of Saturn's moon Rhea by Giovanni Cassini (1672)	**24** inaugural launch of the Ariane rocket (1979) Jean-Louis Pons born - discoverer of comets (1761)  Deep Space Network created (1963)
25 Moon at apogee (farthest from Earth) Mars Express spacecraft orbits Red planet (2003)  Launch of Soviet Salyut 4 space station (1974) Venera 11 on Venus, 4 days after sister lander Venera 12 (1978)	**26**  Charles Babbage born - British mathematician, co-founder of Royal Astronomical Society and inventor of first mechanical computer (1791)	**27**  Johannes Kepler born 1571 - established laws of planetary motion ALH 84001 meteorite in Antarctica - cross section shows signs of possible Martian bacterial life (1984)	**28**  Galileo spacecraft explores auroras during eclipse of Jovian moon Ganymede (2000)	**29**  Nancy Jane Sherlock Currie born - an engineer, US Army officer and a NASA astronaut, designed hardware for space station and served on four shuttle missions (1956)	**30** John Michel born, gravity scientist and first to predict existence of "dark stars", later called black holes (1724) Discovery of Uranus' moon Puck by Stephen Synnott (1985) Cassini meets Galileo at Jupiter and gets Jovian gravity boost, while en route to Saturn (2000) 	**31**  GRAIL-A spacecraft (Gravity Recovery And Interior Laboratory) enters lunar orbit, to be followed by GRAIL-B the following day. Duo will map the moon's gravity field (2011)