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John J. McCarthy Observatory

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First Image of the surface of Mars as transmitted by the InSight spacecraft moments after landing on November 26th . The image was transmitted via the MarCO cubesats. The dust cover (covered with black specks) will be ejected once the dust settles (approximately two days after landing)

Image Credit: NASA/JPL-Caltech

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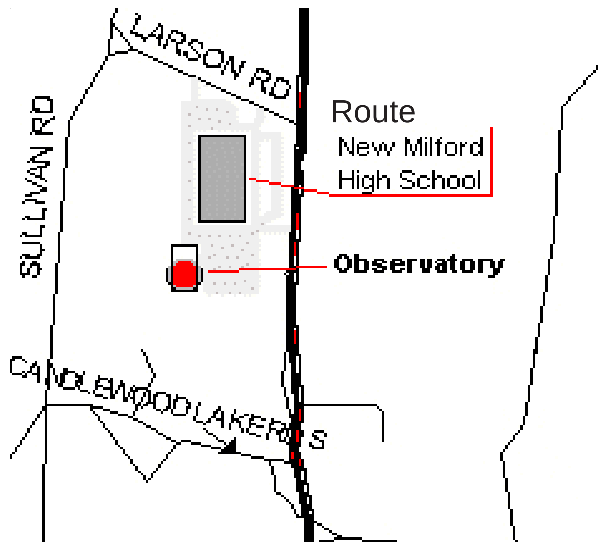

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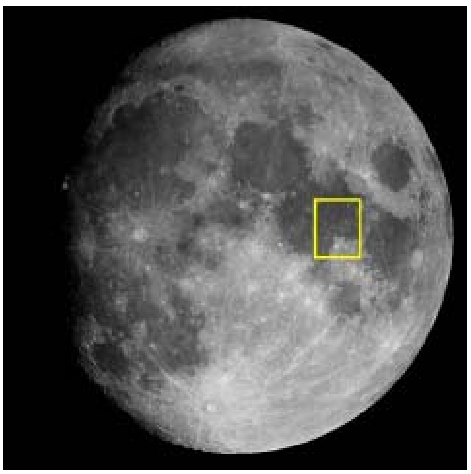
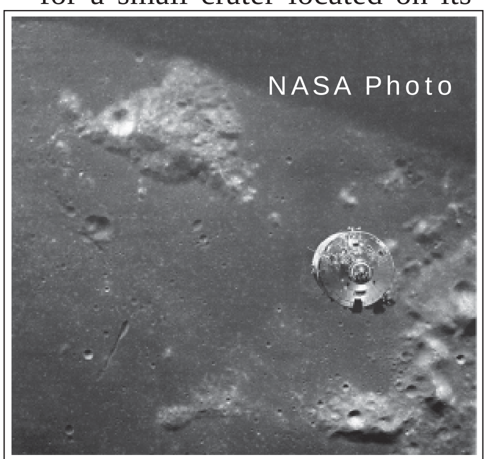
"Out the Window on Your Left"

IT'S BEEN 45 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



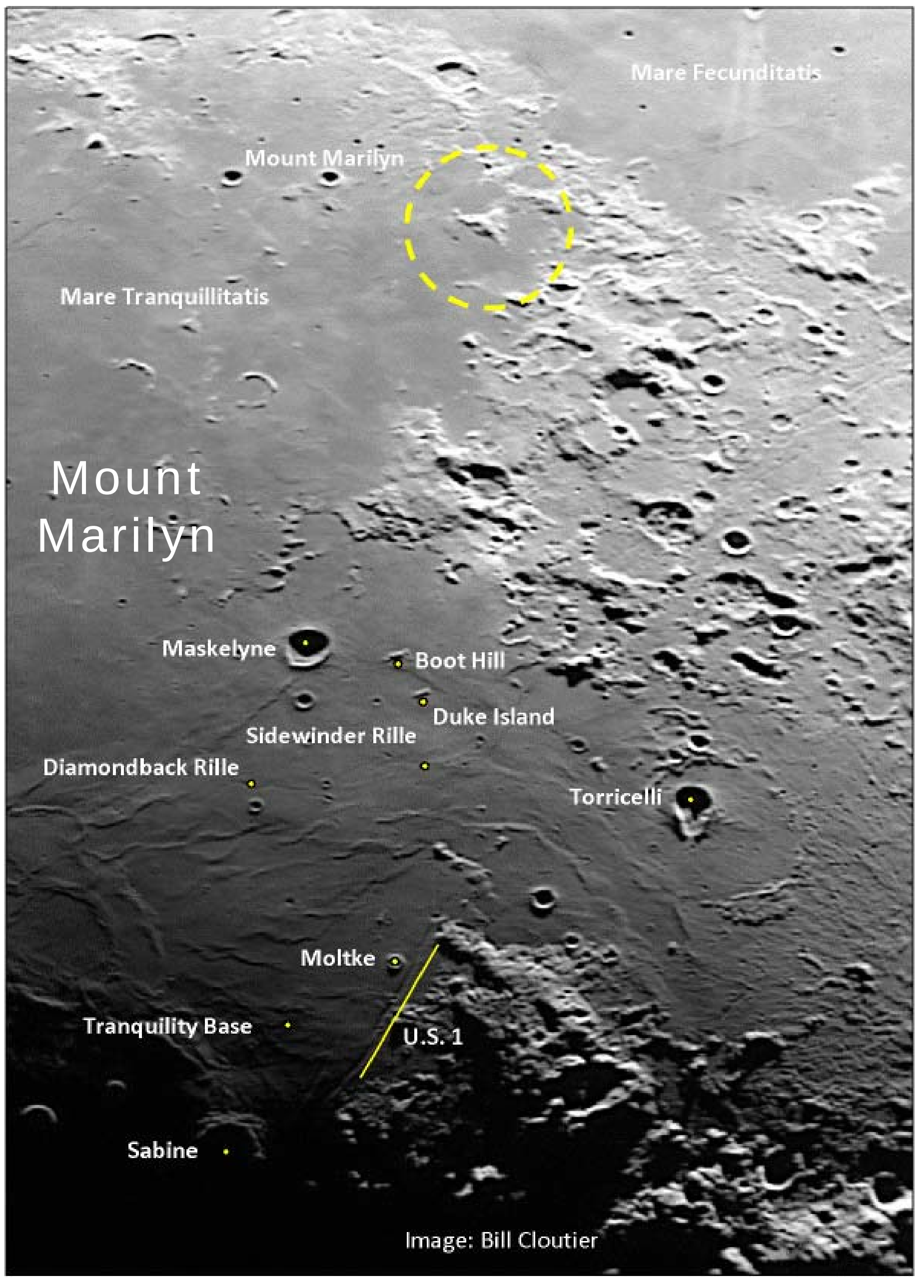
to ponder when planning your visit (if only in your imagination).

Prior to 1968, a triangular-shaped outcrop of rock located between two dark patches of lava (Mare Tranquillitatis and Mare Fecunditatis) was noteworthy only for a small crater located on its flank. Jim Lovell, the Command Module Pilot on the crew of Apollo 8, was one of the first people to circumnavigate the Moon. He named that ancient rock outcrop "Mount Marilyn" as a tribute to his wife. Forty-nine years later (in 2017), the International Astronomical Union (IAU) formally adopted the name for the lunar feature, based upon its significance as a navigation landmark for the Apollo 11 landing (along with Little West and Double craters).



The Apollo 10 Command Module as seen from the Lunar Module with Mt. Marilyn visible in the background

Apollo 10 was a dress rehearsal for Apollo 11, with astronauts Thomas Stafford and Eugene Cernan taking the Lunar Module down to within 9 miles (14 km) of the lunar surface. Along the way, the Apollo 10 crew created dozens of informal landmarks (like Boot Hill and Sidewinder Rille) that could be used by Armstrong and Aldrin, and mission control, as waypoints to check their progress against the nominal descent timeline. The names appear on the charts used by the astronauts, in



technical reports, and in transcripts of communications between the astronauts and the ground.

The 4,593 foot (1,400 meters) high Mt. Marilyn is just one of the landmarks identified on the following page. It was likely created over 4 billion years ago in the aftermath of the impact that formed the nearby basins.

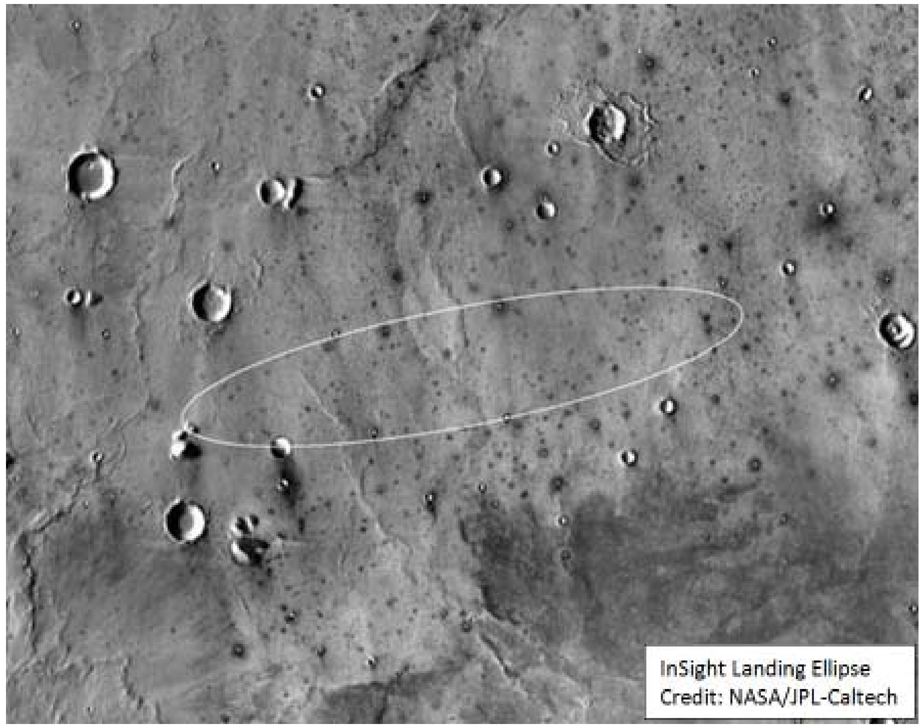
Entry, Descent and Landing

The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) spacecraft separated from its cruise stage on November 26th and entered the Martian atmosphere approximately 80 miles (128 km) above the planet's surface at 12,300 miles per hour (5.5 km/sec). It was protected from the heat of reentry by an aeroshell (which experienced a peak temperature of approximately 2,700°F or 1,500°C). The aeroshell's heatshield, a large parachute and twelve retrorockets (braking rockets) slowed down the spacecraft for a gentle landing on its three shock-absorbing legs.

Just before 3 pm EST, on a winter's day in the northern hemisphere of Mars, the InSight spacecraft set down on an expansive lava plain, Elysium Planitia, 373 miles (600 km) from Gale Crater, currently being explored by the Mars Science Laboratory (Curiosity) rover. The high temperature on landing day was a chilly -4ºF (-20ºC).

The landing ellipse (area in which the spacecraft had a 99 percent chance of landing when targeting the center of the ellipse) was 81 miles (130 km) long and 17 miles (27 km) wide. Unlike other Martian landing sites, with compelling geologic features, ancient water-carved channels or river delta deposits, Elysium Planitia was selected for its lack of diversity. The lander's science team is interested in probing below the surface and that requires a smooth, level area upon which to set down its experiments. InSight will spend the first two to three months on the surface surveying its landing area, before using its robotic arm to place its two instruments on the surface.

The first instrument, a six-sensor seismometer called the Seismic Experiment for Interior Structure (SEIS), will record seismic waves (from impacts or marsquakes) as they travel through the planet. Scientist use the waves' characteristics and speed of travel, to build a model of the planet's interior. InSight's seismometer will be the



InSight Landing Ellipse
Credit: NASA/JPL-Caltech

Mission Planning and Sequencing Engineers post-landing celebration (Kyle Cloutier center)   Image Credit: NASA/JPL-Caltech first to be placed on the surface and is thousands of times more sensitive than the ones permanently mounted on the Viking landers. Because of the instrument's extreme sensitivity (SEIS is sensitive enough to detect vibrations smaller than the width of a hydrogen atom), a wind and thermal shield will be placed over the seismometer to eliminate vibrations from the wind and temperature fluctuations.

InSight will also measure the heat flowing out of the planet's core with a self-burrowing, mechanical mole. The Heat Flow and Physical Properties Package (HP3), the second instrument, will burrow into the soil to a maximum depth of 16 feet (5 meters). At that depth, the instrument will be able to detect heat trapped below the surface.

InSight's lander's two X-band antennas will also be used to measure the wobble in Mars' rotation over time. The "wobble" about the rotational axis provides scientists information about the makeup of the planet's interior, and whether the core is still liquid.

Apollo 8 - 50 Year Lookback

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.

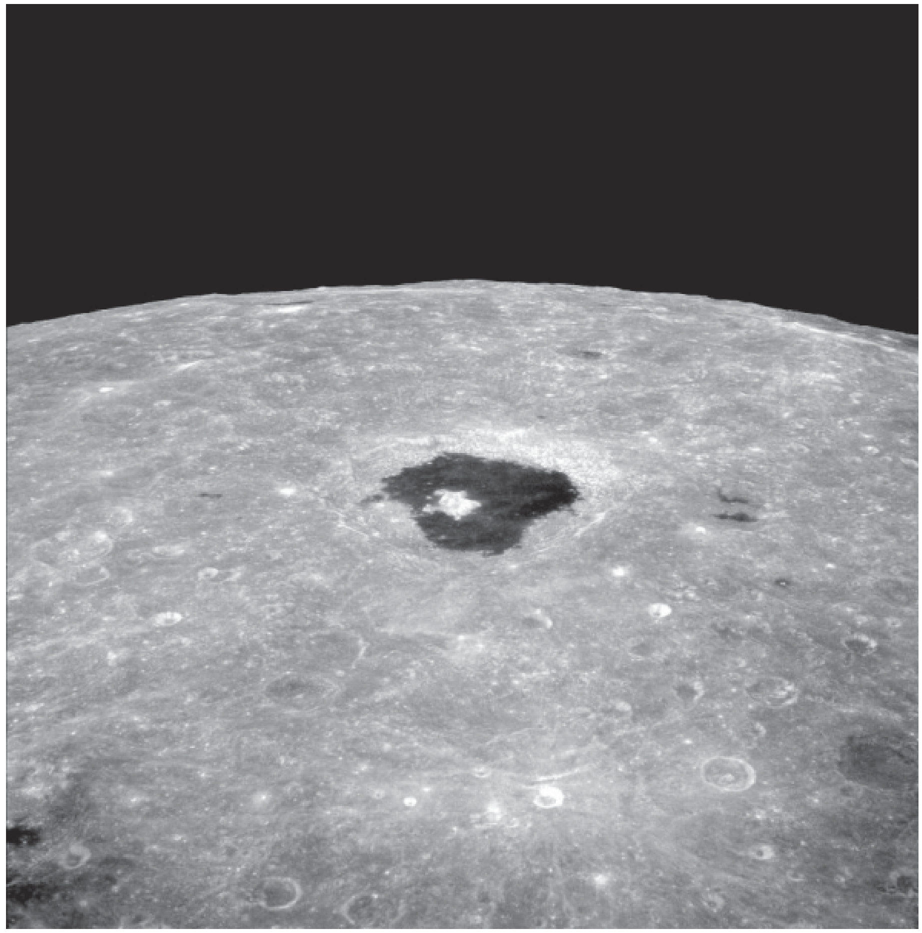
Apollo 8 was launched on December 21st under the command of Frank Borman with astronauts William Anders and Jim Lovell (Lovell replaced Michael Collins on the original team; Collins, who required back surgery, would go on to be the Command Module Pilot for Apollo 11). The launch was scheduled so that 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 Earth). If successful, Apollo 8 would reappear from behind the Moon at a predetermined time. As predicted, the spacecraft re-emerged 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.



Apollo 8's view of Tsiolkovsky crater with its lava covered floor on the Moon's far side Credit: NASA

Following the success of Apollo 8, the Soviet Moon program fell further behind with catastrophically unsuccessful launches of their N1 booster in February and again in July of 1969. An unmanned, sample return mission attempted to upstage the Apollo 11 landing, but Luna 15 crashed into Mare Crisium shortly before Armstrong and Aldrin were scheduled to lift off from the Moon. The Soviets officially cancelled their Moon program in the early 1970s.

OSIRIS-REx

NASA's OSIRIS-REx spacecraft is closing in on its target, the asteroid Bennu, with arrival targeted for December 3rd. The spacecraft successfully executed a series of maneuvers over the past two months to slow the spacecraft and match its relative velocity with that of the asteroid.

Bennu is a carbonaceous asteroid, 1,614 feet (492 meters) across. With an average orbital distance of 105 million miles (168 million km) from the Sun, it has an orbital period of 438 days. The asteroid makes a close approach to Earth every six years, although the distance varies due to its 5 degree orbital inclination relative to Earth. It is considered a potentially hazardous asteroid with a non-zero probably of impacting the Earth in the distant future.

Discovered in 1999, scientists believe that Bennu is a fragment of a much larger asteroid that was broken off in a cataclysmic collision between 1 to 2 billion years ago. Bennu is likely to contain material from the formation of the early solar system which could include organics, water and precious metals.

OSIRIS-REx will survey the asteroid for almost two years before attempting to collect a sample from its surface. If successful, the sample will be returned to Earth in 2023. Bennu was selected as a sampling target for its proximity to Earth, but also for its size. It is large enough that its rotation rate (once every 4.3 hours) is slow enough for a spacecraft to match velocities when attempting a landing.

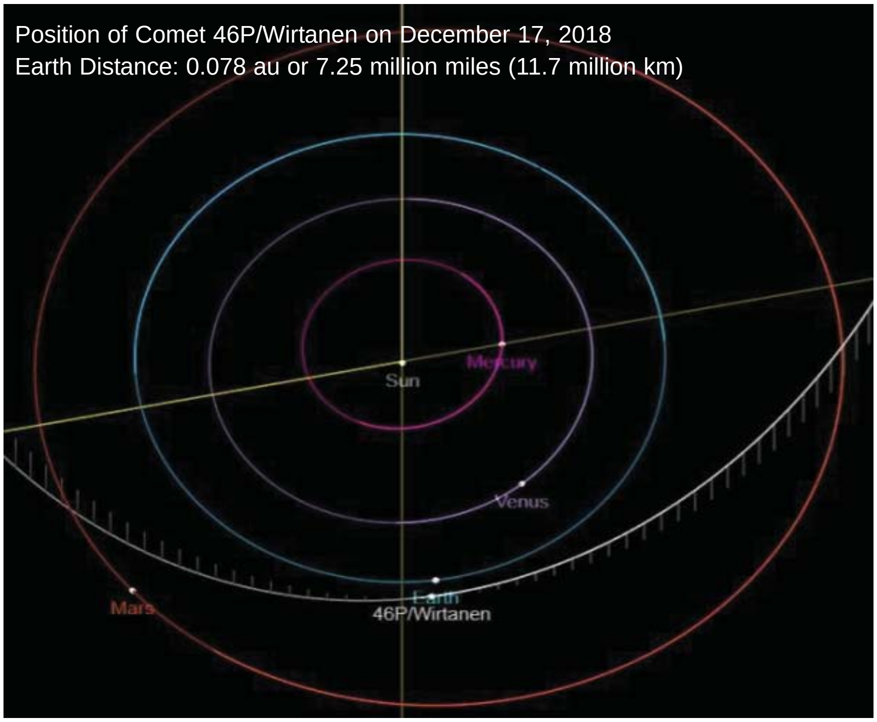
While Bennu's current orbit has been determined with great precision, it has also slowly drifted towards the Sun (0.18 miles or 280 meters per year) since it was discovered. This, comparatively inconsequential change in position, becomes important when calculating future encounters with the Earth. The asteroid is predicted to pass closer to the Earth than the Moon in 2135, and possibly even closer in the distant future. The small changes in the asteroid's orbit are believed to be related to a phenomenon called the Yarkovsky effect, first described by Ivan Yarkovsky, a Russian civil engineer, around the year 1900. Yarkovsky described a process where sunlight warms one side of a small, dark asteroid. As the asteroid rotates, the heat energy is radiated into space, providing a small thrust. OSIRIS-REx should be able to measure the Yarkovsky effect during its stay, which will enable scientists to refine their predictions as they relate to the opportunities for close encounters of near-Earth asteroids. It is believed the Yarkovsky effect, over eons, has nudged Bennu from the main asteroid belt to an orbit that intersects Earth's. Understanding the effect could help in formulating our planetary defense plans.

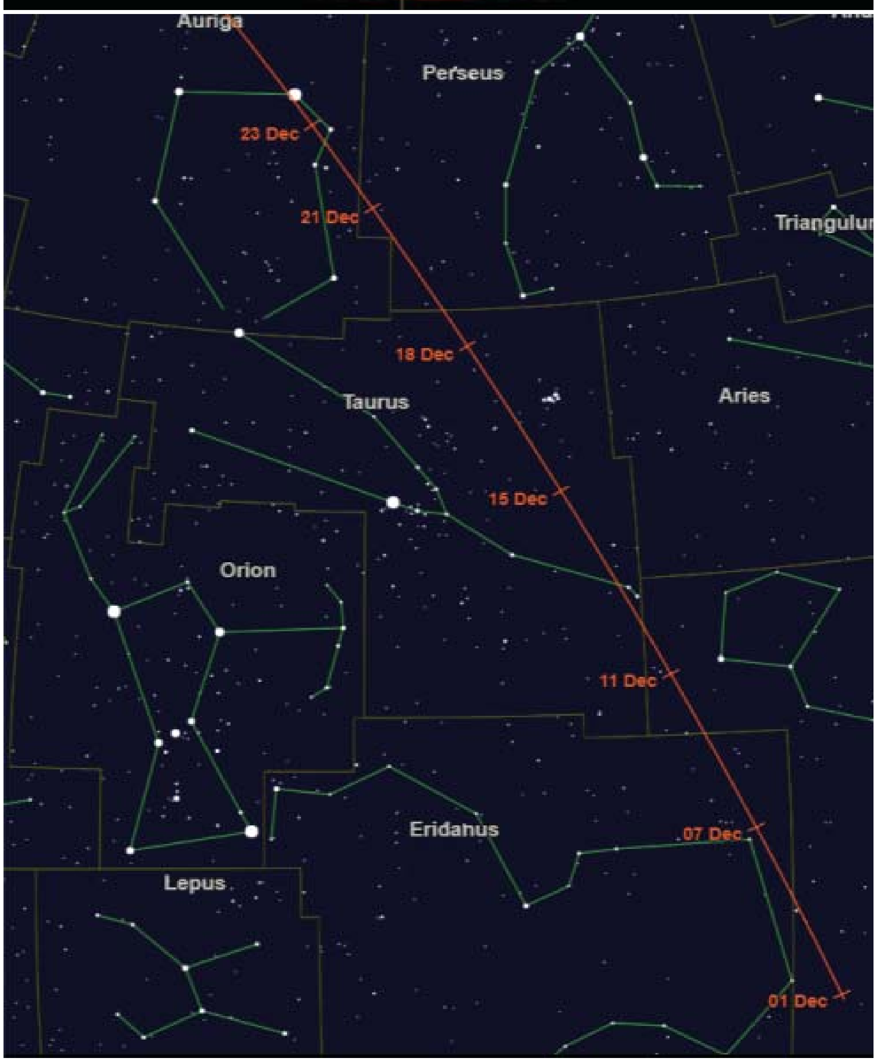
This mosaic image of asteroid Bennu is composed of 12 PolyCam images collected on Dec. 2 by the OSIRIS-REx spacecraft from a range of 15 miles (24 km). Credit: NASA/Goddard/University of Arizona

December Comet

46P/Wirtanen is a short period comet (comets with orbital periods less than 200 years). Its 5.4 year orbit carries the dirty snowball almost out to the orbit of Jupiter at its furthest (5.1 Astronomical Units or AUs) and just beyond the orbit of Earth when closest to the Sun (1.05 AU). In mid-December, the comet will pass by Earth. Originally, the comet was predicted to be as bright as magnitude 6.1 (just beyond visual range), based upon previous apparitions. However, observers in early November reported that the comet is already as bright as a magnitude 6 object, suggesting that it will reach magnitude 3 at its peak. Since comets are not points of light like stars - and relatively diffuse - binoculars or a small telescope may still be required to observe Wirtanen.

As shown on the finder chart (next page), comet 46P Wirtanen starts off the month of December in the constellation Eridanus, racing through the sky at 4 degrees per day (eight times the diameter of the Full Moon). The comet will be well placed in the southern sky before midnight as it passes through the constellations Taurus and Auriga. On or around December 16th, the comet will be near the Pleiades open cluster (M45), providing a celestial signpost and a nice photo opportunity.





Comet Finder Chaart

Comet 46P/Wirtanen in the December night sky

Copyright: Dominic Ford and In-The-Sky.org

ExoMars Updat

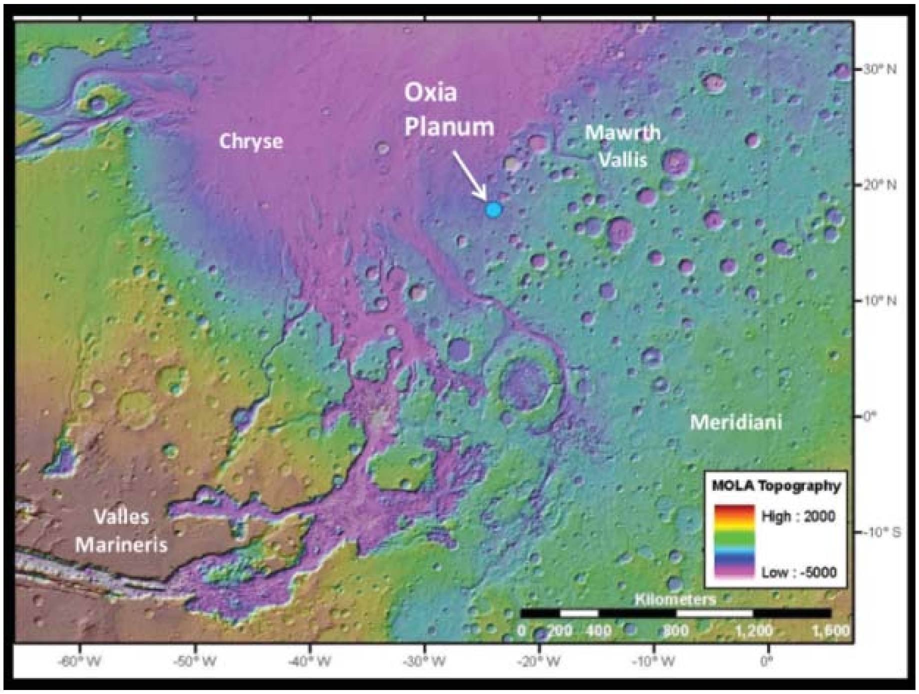
The ExoMars Landing Site Selection Working Group has recommended Oxia Planum as the future landing site for the European Space Agency (ESA)-Roscosmos Mars lander and rover. The spacecraft is scheduled to launch in 2020 (a July-August launch window) with arrival at Mars in March of 2021. The planned surface operation is the continuation of a mission that began with the launch of the ExoMars Trace Gas Orbiter in 2016 (the orbiter is searching for trace amounts of gases such as methane that could be linked to biological or geological activity on the surface).

Oxia Planum was one of two sites under consideration (Mawrth Vallis being the second). Both sites are located in regions characterized by features associated with a wetter and warmer Mars some four billion year ago (with discernable channels appearing to have been carved by water, delta-like structures and paleolakes).

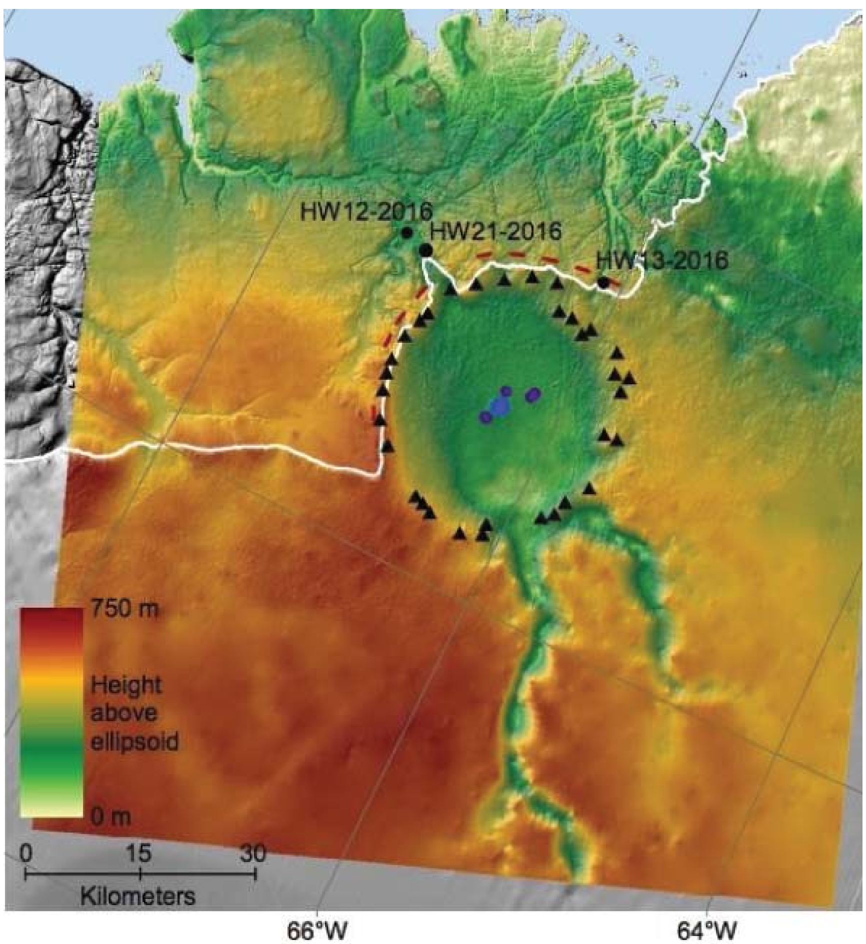
The ExoMars surface mission is engineered to look for biosignatures, indicators of past or present life on Mars. The rover will be able to drill to a depth of six feet (two meters) to extract unspoiled samples that are sheltered beneath the radiation-sterilized surface (see next page)

Orbital surveys have identified the presence of clay-rich minerals in the Oxia Planum region, indicative of a long-lasting body of standing water in the distant past. The landing area is located at the terminus of several channels and where the layers of clay-rich material have been exposed by erosion.

While Mawrth Vallis was considered a scientifically unique site, its higher elevation put it at a disadvantage in the selection process (the lower altitude of Oxia Planum provides an additional margin of safety for entry, descent and landing by parachute in the thin Martian atmosphere). The recommendation is expected to be confirmed in mid-2019, after an internal review by ESA and Roscosmos officials.



Candidate Landing Areas Topography
Mars Global Surveyor, Mars Orbiter Laser Altimeter (MOLA)
Copyright NASA



Topography under Hiawatha glacier in Greenland. Black triangles and purple circles are elevated peaks around the rim and in the center of the depression. Credit: Kjær et al./Science Advances

Newly Discovered Impact Crater

NASA's Operation IceBridge conducts aerial surveys of the Earth's polar regions, assessing the extent and measuring the depth of sea and land ice.

Scientists flying out of the Thule Air Base in northern Greenland use radar to map the thickness of glacial ice. On their way to and from their targets, they would fly over Hiawatha glacier, located about 150 miles to the north of the base. Surveys are generally performed at low altitudes, but, by happenstance, a high altitude test while flying over Hiawatha glacier showed evidence of a bowl-shaped depression under the ice.

The finding triggered a more detailed examination of the area from both the air and on the ground. The structure of the depression is consistent with an impact crater, with a raised rim and central peak(s). It is 19 miles across and covered by approximately 3,000 feet of ice. Scientists have preliminarily dated the age of the crater between 3 million and 12,000 years old. The 12,000 age is particularly intriguing since it coincides with the Younger Dryas event, a 1,000 year long cold snap that occurred 12,800 years ago. It temporarily reversed a warming trend that had started after the end of last ice age. A meteoritic impact had been suspected, but, up to now, no crater had been found from that time period. Determining a more precise age may provide the answer.

Mission to the Far Side

China is preparing to send a spacecraft to the far side of the Moon in early December.

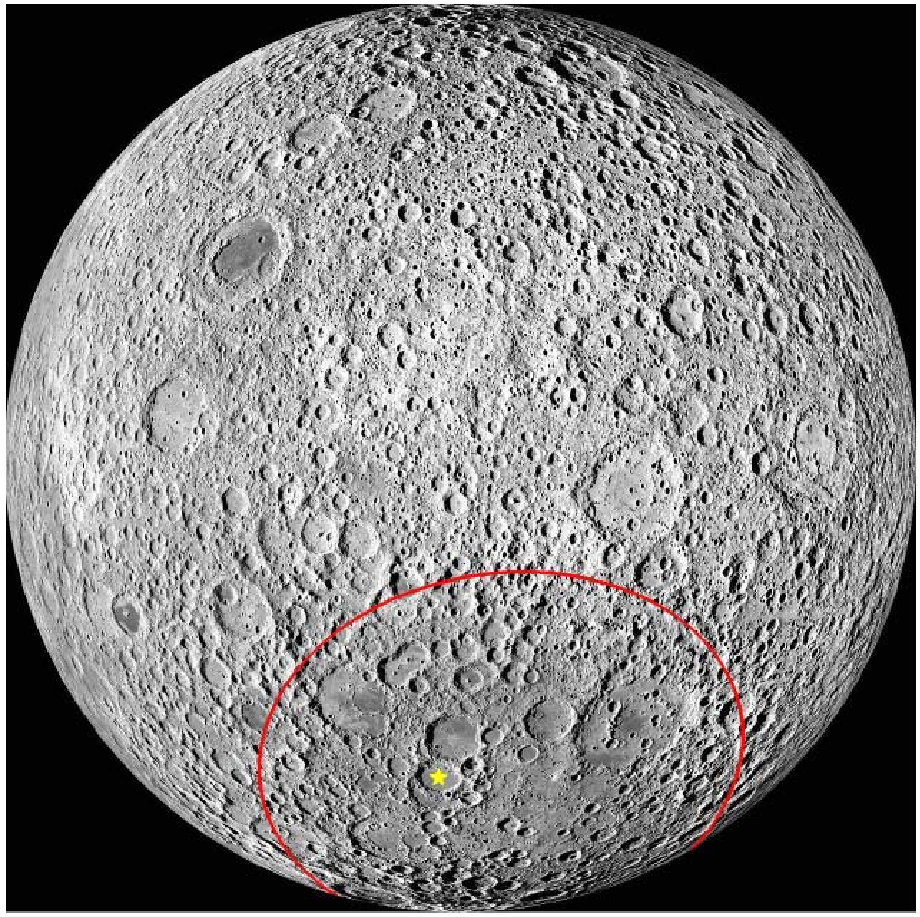
Launched from the Xichang Satellite Launch Centre in southwestern China, the Chang'e-4 lander and rover are expected to soft-land in the Moon's South Pole-Aitken Basin, one of the largest impact features in the solar system.

The South Pole-Aitken Basin is the most expansive and oldest impact basin on the Moon (pre-Nectarian period) with a diameter of approximately 1,550 miles (2,500 km). The basin is more than 5 miles (8 km) deep and some of the deeper areas likely penetrate the Moon's crustal layer, exposing upper mantle material. While the exact landing site hasn't been officially announced, the Von Kármán crater has been identified as the likely target in several Chinese scientific publications on the exploration of the South Pole-Aitken Basin.

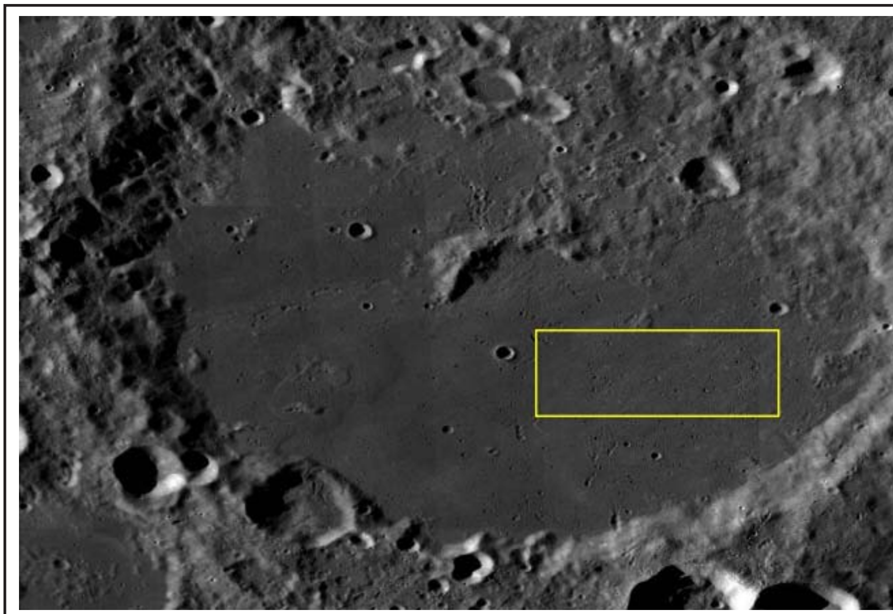
Chang'e-4 was a backup to China's Chang'e-3 spacecraft that soft-landed on the Moon's Mare Imbrium and deployed the Yutu (Jade Rabbit) rover in 2013. Since a lander on the far side won't be able to communicate directly with the Earth, China launched a relay satellite (called Queqiao) into a halo orbit around the Earth-Moon L2 (Lagrande 2) point. The satellite will allow simultaneous communications with the lander and Earth stations.

The Chang'e-4 lander will be equipped with a number of science instruments including a Low Frequency Spectrometer, a Landing Camera, Terrain Camera, and the Lunar Lander Neutrons and Dosimetry Experiment. The rover will carry a Panoramic Camera, Lunar Penetrating Radar, Visible and Near-Infrared Imaging Spectrometer and the Advanced Small Analyzer for Neutrals.

Chang'e-4 is a precursor to a sample return mission (Chang'e-5). The Chang'e-5 lander will target another unexplored area of the Moon, the Rümker region in northern Oceanus Procellarum. The region includes what is believed to be the youngest mare lavas on the Moon (less than three billion years old). The high-



South Pole-Aitken Basin (red circle) and Von Kármán crater (yellow star). Credit: Lunar Reconnaissance Orbiter/NASA/GSFC/ Arizona State University



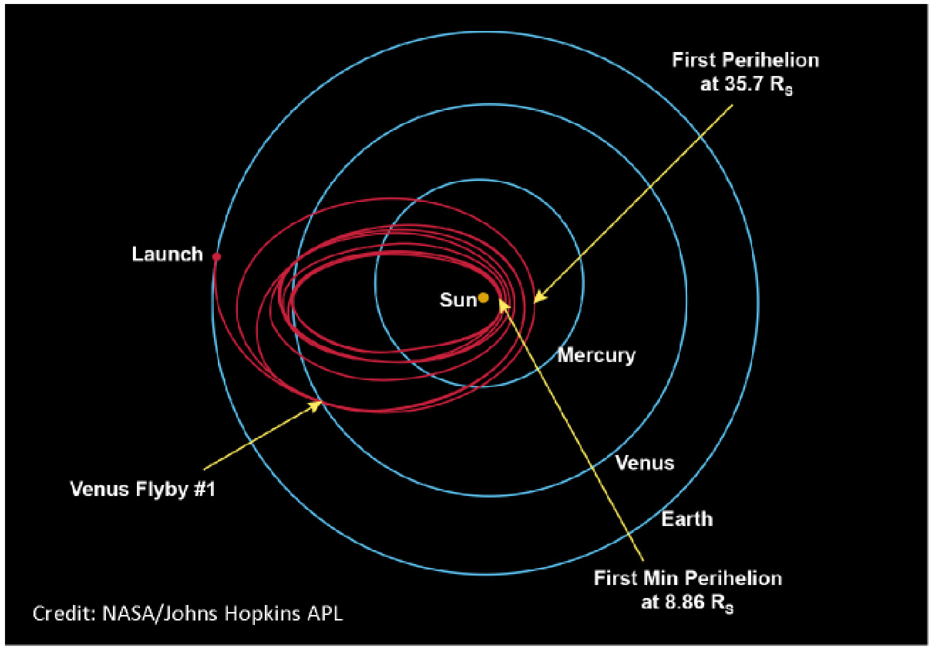
Likely landing area of Chang'e-4 inside the Von Kármán crater Credit: Lunar Reconnaissance Orbiter/NASA/GSFC/Arizona State University titanium basalts also contain high levels of thorium, uranium, and potassium (heat producing elements through decay) and KREEP (an acronym for potassium, rare earth elements and phosphorus). Samples returned by Chang'e'5 may provide some insight into why KREEP is found almost exclusively in the Oceanus Procellarum region.

First Encounter

The Parker Solar Probe successfully executed its first perihelion (close pass of the Sun) on the evening of November 5th. On this first pass, the spacecraft was moving at a top speed of 213,200 miles per hour (343,112 km/hr), relative to the Sun, and came within 15 million miles (24 million km) of the Sun's surface.

Solar radiation increased the temperature of the spacecraft's carbon-composite thermal shield to approximately 820°F (438°C) during the pass. The shield kept the spacecraft's systems and instruments in the shield's shadow in the mid-80s °F (20s °C). Since the Sun is such an intense radio source, communications are limited during close encounters. The spacecraft did transmit a status beacon two days later on November 7th, indicating that all systems are nominal (the best of all four possible signals). Science transmissions are expected to begin in early December.

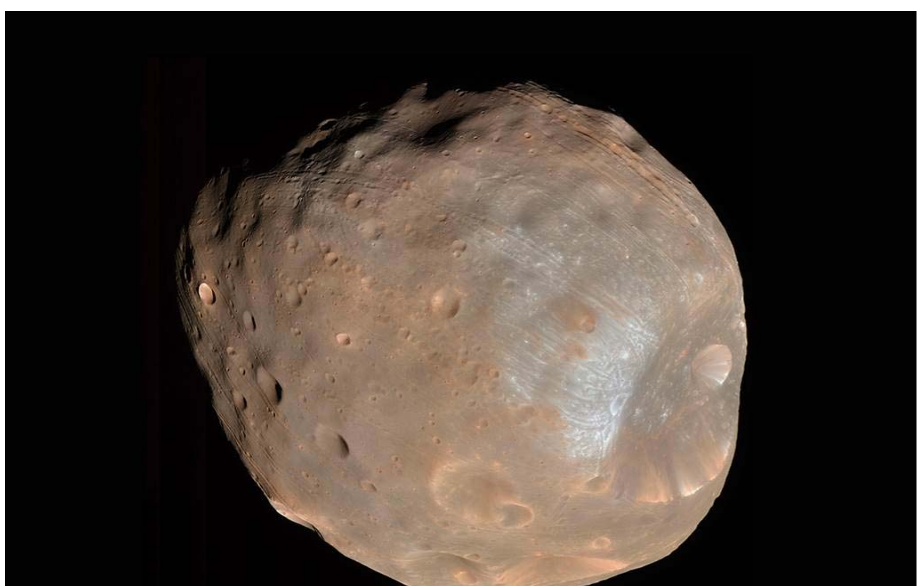
Over its seven year mission, the Parker Solar Probe wll complete 24 orbits around the Sun. It will use Venus' gravity (on seven separate encounters) to modify the spacecraft's orbit, for increasingly closer passes through the Sun's outer atmosphere. At its closest, the spacecraft will come within 3.8 million miles (6.1 million km) of the Sun at a speed approaching 430,000 miles per hour (692,000 km per hour).The temperature of the spacecraft's thermal shield is expected to reach 2,500°F (1,370°C) during the closest encounter.



The Parker Solar Probe's transits of the Sun's outer atmosphere (the corona) will help scientists better understand the inner workings of our closest star and its connection with the space weather experienced by life on Earth.

Impact Relics?

The planet Mars has two small and irregular lumps of rocks for moons. Phobos, the larger of the two moons, is 17 x 14 x 11 miles (27 x 22 x 18 km) in size. Deimos, by comparison, is only 9 x 7 x 6.8 miles in size (15 x 12 x 11 km). Phobos orbits the planet three times a day, while Deimos completes one orbit every 30 hours.



Phobos, from a distance of about 4,200 miles (6,800 km)
Credit: NASA/JPL/University of Arizona

The spectra best matched finely particulate basalt, a material abundant on the surface of Mars. The authors suggest that the basaltic component may be from the planet's crust, with the moons (including Deimos), relics of an ancient impact.

The moons are thought to be captured asteroids, based upon their similarity to carbonaceous chondrite asteroids, but that thinking has been recently challenged by the authors of an article published in the September issue of the Journal of Geophysical Research.The authors revisited the mid-infrared spectra acquired by the Mar Global Surveyor's Thermal Emission Spectrometer, or TES, from Phobos, collected during almost ten years on orbit around Mars.

Phobos' days are numbered, its orbit decaying at a rate of six feet (1.8 meters) every hundred years. At that rate, the moon will either break up or crash into the surface in approximately 50 million years.

Spaceship Earth and the Blue Marble

On December 7, 1972, the crew of Apollo 17 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 ute

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.

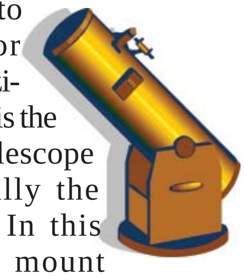
Magnification

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

* Dobsonian 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).

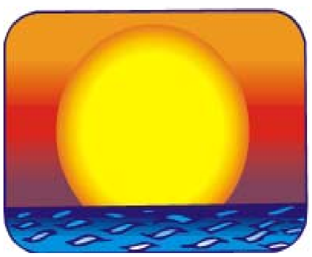
process (a process by which the telescope's computer determines where it's pointed, the local time, and its position on the Earth). Most "go-to" telescopes come with a large database, some of which can be modified (supplemented) by the user. While "go-to" capability is extremely convenient and can take 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.

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 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 (from New Milford, CT)

Sun	Sunrise	Sunset
December 1st (EDT)	07:01	16:24
December 15th (EST)	07:13	16:24
December 30th	07:20	16:33

Astronomical and Historical Events

1st Apollo Asteroid 2012 MM11 near-Earth flyby (0.086 AU)
1st Apollo Asteroid 10563 Izhdubar closest approach to Earth (1.131 AU)
1st Apollo Asteroid 314082 Dryope closest approach to Earth (1.923 AU)
1st Kuiper Belt Object 145453 (2005 RR43) at Opposition (38.694 AU)
1st History: launch of Soviet satellite Sputnik 6 and two dogs: Pchelka and Mushka (1960)
2nd Apollo Asteroid 2018 TG6 near-Earth flyby (0.010 AU)
2nd Kuiper Belt Object 2006 QH181 at Opposition (83.021 AU)
2nd History: dedication of the John J. McCarthy Observatory in New Milford, CT (2000)
2nd History: launch of SOHO solar observatory (1995)
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)
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)
3rd NASA spacecraft OSIRIS-REx arrives at asteroid Bennu
3rd Kuiper Belt Object 229762 (2007 UK126) at Opposition (41.244 AU)

Astronomical and Historical Events (continued)

3rd Scheduled launch of a Russian Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan to the International Space Station with the next Expedition crew
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 Scheduled launch of a SpaceX Falcon 9 rocket and carrying-cargo Dragon spacecraft to the International Space Station from the Cape Canaveral Air Force Station, Florida
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)
5th Aten Asteroid 2017 RH16 near-Earth flyby (0.081 AU)
5th Aten Asteroid 2010 TK7 (Earth Trojan) closest approach to Earth (0.208 AU)
6th Apollo Asteroid 161989 Cacus closest approach to Earth (1.803 AU)
6th Kuiper Belt Object 145451 (2005 RM43) at Opposition (35.987 AU)
6th History: Japanese spacecraft Akatsuki enters around Venus five years after unsuccessful first attempt and main engine failure (2015)
7th New Moon
7th Apollo Asteroid 2212 Hephaistos closest approach to Earth (2.697 AU)
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 Second Saturday Stars - Open House at the McCarthy Observatory (7:00 pm)
8th Apollo Asteroid 9162 Kwiila closest approach to Earth (0.385 AU)
8th Tentative launch date for the Chinese Chang'e 4 spacecraft to the far side of the Moon from the Xichang, China launch site
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 Apollo Asteroid 2013 VX4 near-Earth flyby (0.011 AU)
9th Apollo Asteroid 29075 (1950 DA) closest approach to Earth (1.556 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 Apollo Asteroid 2015 XV129 near-Earth flyby (0.060 AU)
10th Apollo Asteroid 2003 NW1 near-Earth flyby (0.069 AU)
10th Aten Asteroid 2017 NK near-Earth flyby (0.090 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 Apollo Asteroid 12923 Zephyr closest approach to Earth (1.590 AU)
11th Centaur Object 8405 Asbolus at Opposition (20.963 AU)
11th History: launch of the Boeing X-37B Orbital Test Vehicle 1 (unmanned space plane) from the Cape Canaveral Air Force Station (2012)
12th Moon at apogee (furthest distance from Earth)

Astronomical and Historical Events (continued)

12th Comet 46P/Wirtanen Perihelion - closest to the Sun (1.055 AU)
12th Kuiper Belt Object 2004 XR190 at Opposition (56.215 AU)
12th History: discovery of Saturn moons Fornjot, Farbauti, Aegir, Bebhionn, Hati and Bergeimir 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 Geminids meteor shower peak
13th Apollo Asteroid 2015 XX169 near-Earth flyby (0.043 AU)
13th History: flyby of Asteroid 4179 Toutatis by the Chang'e 2 spacecraft, China's second lunar probe (2012)
13th History: discovery of Saturn's moons Fenrir and Bestla by Scott Sheppard, et al's (2004)
13th History: launch of Pioneer 8, third of four identical solar orbiting, spin-stabilized spacecraft (1967)
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 Plutino 84922 (2003 VS2) at Opposition (35.694 AU)
14th Plutino 307463 (2002 VU130) at Opposition (38.981 AU)
14th History: landing of China's Chang'e 3 Moon lander on Mare Imbrium (2013)
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: 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: 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 the Uraniborg and Stjenborg observatories on the Swedish island of Ven (1546)
15th First Quarter Moon
15th Mercury at its Greatest Western Elongation (21°) in the morning sky
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 History: launch of Pioneer 6, the first of four identical solar orbiting, spin-stabilized spacecraft (1965)
17th Comet 46P/Wirtanen near-Earth flyby (0.077 AU)
17th Apollo Asteroid 6239 Minos closest approach to Earth (0.956 AU)
17th Kuiper Belt Object 19521 Chaos at Opposition (40.318 AU)
17th History: Project Mercury publicly announced (1958)
17th History: Wright Brothers' first airplane flight, Kitty Hawk, North Carolina (1903)
18th History: discovery of Saturn's moon Epimetheus by Richard Walker (discovery shared with Stephen Larson and John Fountain) (1966)
19th Amor Asteroid 2014 JU54 near-Earth flyby (0.086 AU)
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)

Astronomical and Historical Events (continued)

19th History: launch of Mercury-Redstone 1A; first successful flight and qualification of the spacecraft and booster (1960)
20th Apollo Asteroid 2012 MS4 near-Earth flyby (0.082 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 5:23 pm EST (22:23 UT)
21ST Asteroid 6 Hebe closest approach to Earth (1.257 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 Full Moon (Long Night or Cold Moon)
22nd Ursids Meteor Shower peak
22nd Aten Asteroid 163899 (2003 SD220) near-Earth flyby (0.019 AU)
22nd Apollo Asteroid 2016 AO131 near-Earth flyby (0.052 AU)
22nd History: first asteroid (323 Brucia) discovered using photography (1891)
23rd Apollo Asteroid 418849 (2008 WM64) near-Earth flyby (0.043 AU)
23rd Apollo Asteroid 2010 GT7 near-Earth flyby (0.057 AU)
23rd Apollo Asteroid 2015 YQ1 near-Earth flyby (0.077 AU)
23rd History: discovery of Saturn's moon Rhea by Giovanni Cassini (1672)
24th Moon at perigee (closest distance from Earth)
24th Asteroid 2062 Aten closest approach to Earth (1.218 AU)
24th Centaur Object 154783 (2004 PA44) at Opposition (20.397 AU)
24th Plutino 55638 (2002 VE95) at Opposition (29.023 AU)
24th Kuiper Belt Object 78799 (2002 XW93) at Opposition (44.715 AU)
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 thST
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 Amor Asteroid 1943 Anteros closest approach to Earth (0.670 AU)
26th Aten Asteroid 2014 BA3 closest approach to Earth (1.853 AU)
26th Apollo Asteroid 4486 Mithra closest approach to Earth (2.426 AU)
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 Apollo Asteroid 488789 (2004 XK50) near-Earth flyby (0.089 AU)
27th Plutino 2002 XV93 at Opposition (37.658 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)

Astronomical and Historical Events (continued)

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)
29th Last Quarter Moon
30th Apollo Asteroid 137052 Tjelvar closest approach to Earth (1.281 AU)
30th Apollo Asteroid 3838 Epona closest approach to Earth (1.685 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 History: GRAIL-A, lunar gravity mapping spacecraft enters orbit (2011)

Commonly Used Terms

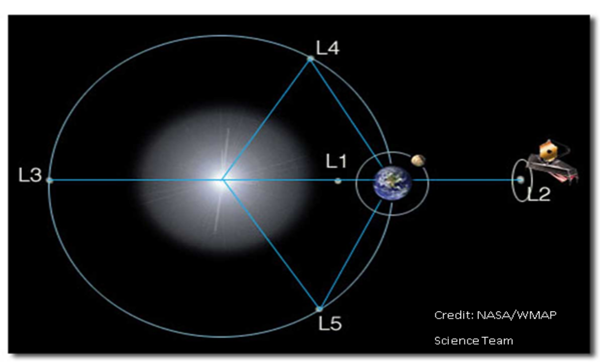
- **Apollo**: A group of near-Earth asteroids whose orbits also cross Earth's orbit; Apollo asteroids spend most of their time outside Earth orbit.
- **Aten**: A group of near-Earth asteroids whose orbits also cross Earth's orbit, but un like Apollos, Atens spend most of their time inside Earth orbit.
- **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°)
- One astronomical unit (AU) is the distance from the Sun to the Earth or approximately 93 million miles

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).



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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.*

International Space Station and Iridium Satellites

Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station and the bright flares from Iridium satellites.

NASA's Global Climate Change

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

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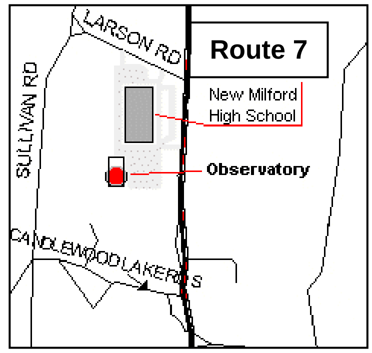

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December 2018

Celestial Calendar

Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday

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
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
Gemini 7 launch - Borman/Lovell (1965)
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)
2nd Saturday Stars
New Milford High School

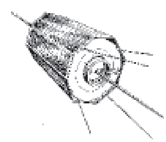
9

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)

11

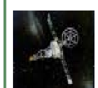
Challenger, the Lunar Lander for Apollo 17, touched down on the Moon's surface with astronauts Harrison Schmitt and Eugene Cernan - last two men to walk on moon (1972)

12
Moon at apogee (farthest from Earth)

Launch of Oscar, first amateur satellite (1961)

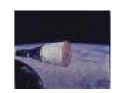
13

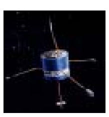
First light of Mt. Wilson's 60-inch telescope (1908)

Geminids meteor shower peak

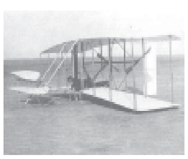
14

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)

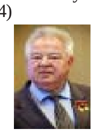
17

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)

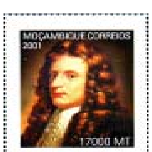
21
Winter Solstice

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

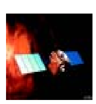
Discovery of LEW 88516 meteorite -Martian origin (1988)
Ursids meteor shower peak


23


Discovery of Saturn's moon Rhea by Giovanni Cassini (1672)

24
inaugural launch of the Ariane rocket (1979)
Jean-Louis Pons born - discoveror of comets (1761)

Deep Space Network created (1963)

25
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)

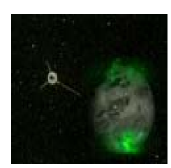
26

Charles Babbage born - British mathematician, co-founder of Royal Astronomical Society and inventor of first mechanical computer (1791)

27

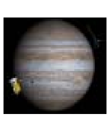
Johannes Kepler born 1571 - established laws of planetary motion

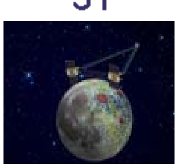
ALH 84001 meteorite in Antarctica - cross section shows signs of possible Martian bacterial life (1984)

28

Galileo spacecraft explores auroras during eclipse of Jovian moon Ganymede (2000)

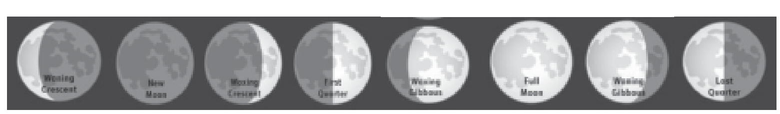
29

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)

Phases of the Moon



Dec 7 | Dec 15 | Dec 22 | Dec 26