Galactic Observer

John J. McCarthy Observatory

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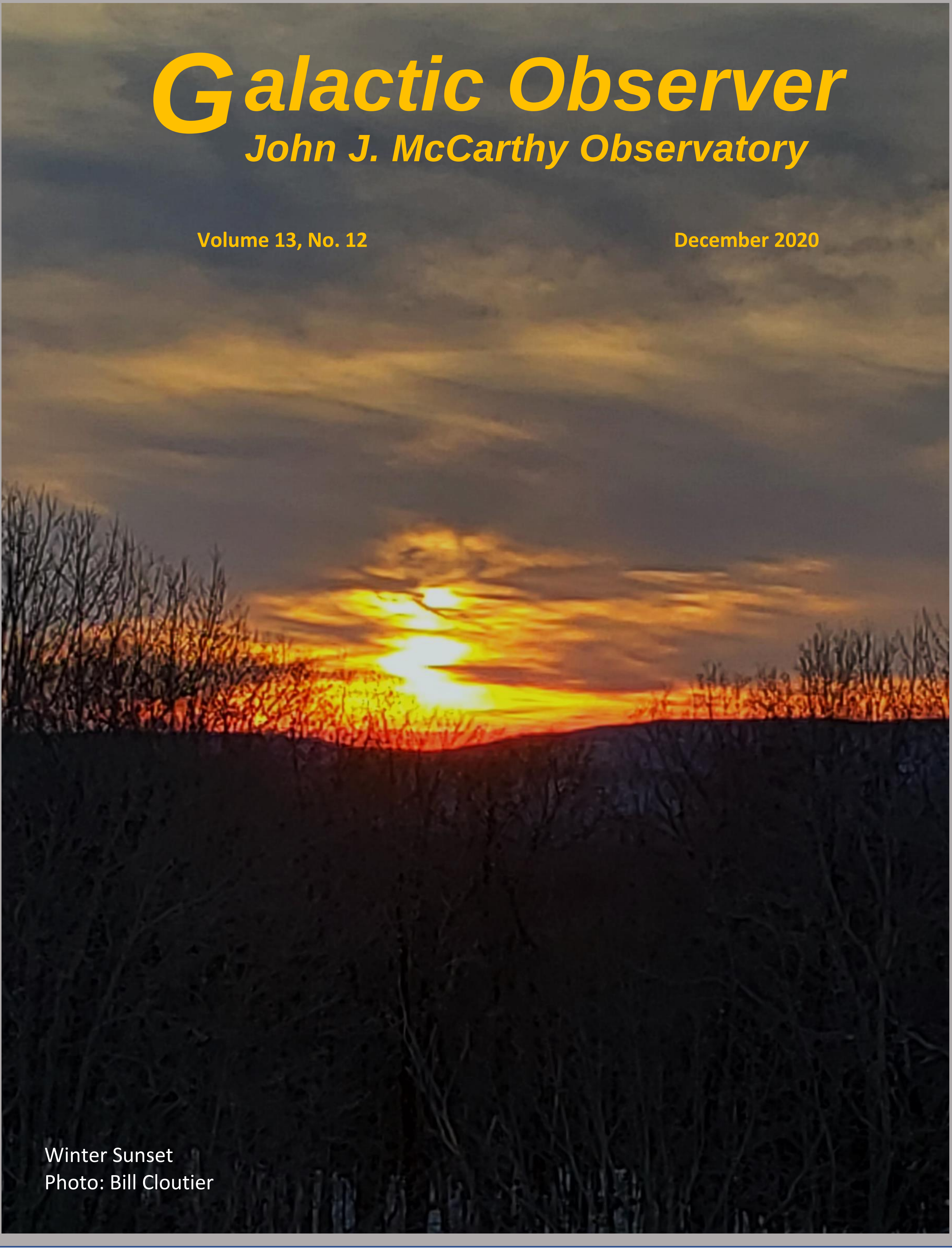


Winter Sunset
Photo: Bill Cloutier

December Astronomy Calendar and Space Exploration Almanac

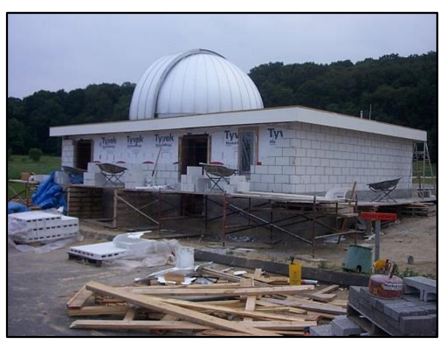
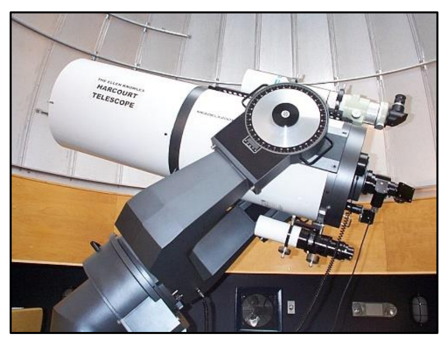










John J. McCarthy Observatory
2000

John J. McCarthy Observatory

In This Issue

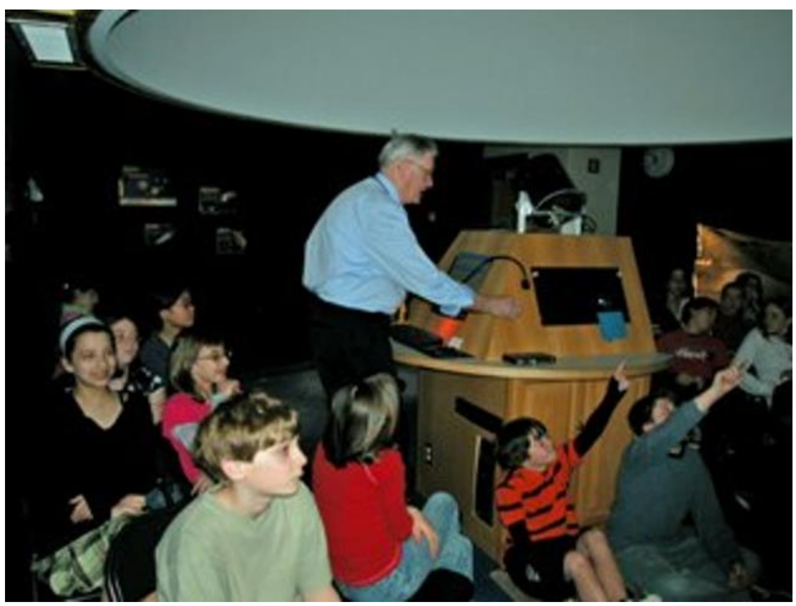
932
McCarthy Observatory
New Milford, CT

The John J. McCarthy Observatory (2000-2020)

Seven months after the shovels hit the dirt in May 2000, the community gathered together for the dedication of a world-class observatory on the campus of the newly constructed high school in New Milford, Connecticut. The inspiration of local resident and senior airline pilot Monty Robson, and his response to a decline in science literacy among the public, the opening of this multi-purpose science facility was the result of over two years of planning and fundraising.

Robson and his telescope could be found on the New Milford green on Fair days, encouraging passersbys to take in a filtered-view of the Sun - using astronomy to encourage curiosity and an interest in science. A cosmic pied piper, he drew together like-minded folks and benefactors from across the region. Appeals for donations, whether for money or building supplies, were met with enthusiasm from the public, individuals and local businesses. Organized as a chapter of the Society for Amateur Scientists, a diverse group of knowledgeable and accomplished individuals from towns around western Connecticut (that would also provide the bulk of the labor during construction) would meet at the homes of Robson and Brookfield resident Bob Lambert on a regular basis to deliberate on the key requirements and capabilities of a state-of-the-art observatory. The design process was methodical, evolving over the two years prior to groundbreaking, as the best qualities garnered from visits to regional public and private observatories were incorporated. Accessibility was paramount in the design and in setting expectations for the observatory's future operation, from its convenient location, to the incorporation of an elevator to the observing deck where the telescope would reside, a ramp to the outside sky-deck, to accommodations for visitors with a range of disabilities.

The dedication of the John J. McCarthy Observatory (the "Observatory") on December 2, 2000, was only the beginning. Over the past twenty years, thousands of visitors have had the opportunity to look through a telescope, experience the wonders of the night (and day) sky, and learn about our place in the universe. Students have had the ability to volunteer in public outreach activities, contribute to various scientific endeavors and create award-winning science fair entries. Throughout, the Observatory's volunteers have encouraged critical thinking in a welcoming environment.



Dr. Parker Moreland teaches an Astronomy-to-Go lesson in the Sarah Noble planetarium.

Not to rest on their laurels, the next twelve months kept the volunteers very busy. In March 2001, the Minor Planet Center issued an observatory code (932) to the facility after Robson and Jeff Miskie (principal observatory architect) submitted sufficiently accurate observations of the near-Earth and potentially hazardous asteroid Geographos. Over the next 19 years, the observatory staff would submit over 2,000 highly-accurate observations that have contributed to the refinement of near-Earth object orbits and the likelihood of future encounters.

Mrs. Shemeley's third grade Northville class gathered together to watch the launch of the New Horizons spacecraft to Pluto on January 19, 2006 before visiting the McCarthy Observatory in April on a school field trip.

The Observatory's volunteers were then commissioned to construct a planetarium in the Sarah Noble Intermediate School – finishing up only hours before the school was rededicated. The year ended with thousands of visitors gathering at and around the Observatory - spending the night watching a once-in-a-lifetime Leonid meteor storm, as shooting stars filled the sky until dawn encroached.

In October 2003, the Observatory became a public sensation when Robson discovered three main-belt asteroids while making observations of a newly-reported, near-Earth asteroid. It didn't take long for the Observatory's outreach activities to ramp up with student projects and public programs. A monthly newsletter was first published in early 2004, followed by live television coverage of the 2004 transit of the Sun by the planet Venus in June (the first in almost 122 years). The Observatory also hosted its first semiannual Adult Ed class at the facility – an informal night sky appreciation class that would be offered each year in the fall and spring.

Elaine Green organized the first "Second Saturday Stars" event in early 2005, a tradition that continues today, with subject matter experts sharing their passions on topics of astronomy and space exploration with the public, as well as showcasing the night sky on clear nights. Later that year, Dr. Parker Moreland took charge of an "Astronomy-to-Go" initiative, bringing timely talks and science-based demonstrations into the classrooms of area schools.

To ease congestion under the dome and allow more visitors to view the night sky, construction of an outside observing space began in 2006. The "Sky Deck" has multiple, powered piers and room for large crowds to congregate during public events. For nights of inclement weather, Midwest-benefactor Larry Pavell provided the public the opportunity to hold and examine relics of the early solar system with his generous donation of a stony and iron meteorite collection.

The Observatory's collection of scientific and historic artifacts grew in 2008 when NASA awarded the facility a main landing gear tire that flew on space shuttle Discovery to the Hubble Space Telescope. The tire, one of two that the Observatory would acquire, is displayed on the front of the building (the second is located inside the observing dome in the southeast corner of the room). This was followed by the donation of a ring-segment from one of the Chandra X-ray space telescope's barrel-shaped mirrors by Goodrich Optical Space Systems in Danbury, likely the only piece remaining on Earth.

The year 2008 ended with a bang when Robson successfully imaged an asteroid called 2008 TC_3 less than 24 hours after it was discovered and just seventy-five minutes before it exploded over the desert of the northern Sudan. The following year, Robson would have his ground-breaking work on the historic Weston meteorite fall published in *Meteoritics & Planetary Science*. Robson's revised coordinates for the fall that occurred in December 1807 are now referenced by the international Meteoritical Society.

Moon rocks on loan from NASA arrived in January 2009 (the first of several loans from the Goddard Space Flight Center). The samples acquired by several Apollo missions were shared with students at local schools and with the public at the New Milford Library. Members of the Observatory's staff went on the road in May, with Robson in Prague presenting his findings on the Weston meteorite fall while Bill Cloutier flew to Florida for the launch of the space shuttle Atlantis to the Hubble Space Telescope, courtesy of NASA's Museum Alliance. The year wrapped up with the dedication of a scale model solar system that stretched across town, from the high school campus to Canterbury School. The larger planets were cast in bronze and all of the solar system icons were mounted upon stainless-steel pyramids for uniformity and ease of locating. Thousands of "passports" were made available at the Observatory and the town library for visitors to record their tour of the solar system which became a destination for many (distant) travelers.

Throughout the Observatory's first decade, thousands of visitors (from all over the United States and from several countries) visited the multi-purpose science facility and benefited from the tireless efforts of its staff to educate, inform and engage. The second decade would be no different.

A second space shuttle tire would be acquired by the Observatory in 2011, thanks to then Hill and Plain teacher Cecilia Page, along with several heat-insulating silica tiles from the space shuttle program. This second tire would include a wheel rim and brake drum. In late 2011, the Observatory received a very special donation – an antique refractor. Crafted by skilled optician, inventor and amateur astronomer John Benjamin Dancer circa 1850, the telescope has a four-inch objective lens, which is the same size as the one Dancer used to take the first photograph of the Moon from England in February 1852. Thanks to the generosity of several talented folks who donated their time and skills, in particular Dick Parker, the telescope has been restored to

Observatory volunteer and NASA engineer Ms. Kyle Cloutier visits Ms. Allison's science class at Sarah Noble to discuss her Mars exploration mission.

working condition – allowing the public a connection to the past and view of the night sky as Dancer would have had 160 to 170 years ago.

Apollo moon rock samples visit Ms. Page's (Detrich) classes at Hill and Plain Elementary School

Just days after another transit of Venus in June 2012 (they occur in pairs eight years apart, separated by over a century), the public gathered for the dedication of Galileo's Garden and its centerpiece, the Kathleen Fisher Sundial, located just to the south of the observatory and Sky Deck.

Dedicated to the memory of an inspirational sixth-grade science teacher, the 9-foot stainless steel sundial is an open armillary, with an adjustable hour band for standard and daylight time. The upper part of the gnomon (the part of a sundial that casts a shadow) is a bronze and brass, true-size portrayal of Galileo's first telescope. The sundial is mounted on a one-ton granite disk, one of many pieces donated by Goodrich Optical Space System that, in their former life, were used in the tooling process for making telescope mirrors. The 2012 iteration of Galileo's Garden would be the first of many habitats created under the watchful eye of Lambert and his team of volunteers and master gardeners as a place of reflection and environmental awareness.

Building on its observations of near-Earth asteroids, the first-generation All-Sky camera was installed on the Observatory's roof. The camera (and its successors) detects and records transits of bright meteors that are visible on clear nights. The camera was made possible by a 2013 grant from United Technologies Corporation and Tom Heydenburg. (In 2018, Peter Gagne would custom design and build the first prototype of the latest generation of cameras operating as the Observatory's night sky sentry).

The support of local teachers has been critical to the Observatory's mission, inviting the Observatory's volunteers into their classrooms for special presentations and/or lessons on various astronomy-themed subjects and bringing students down to the Observatory on field trips during the school day and at night with friends and family. In recent years, teachers at the high school have taken advantage of the facility for multi-discipline applications (including English and Choral).

Special events hosted by the Observatory typically drew large crowds, both during the day or at night. The Observatory has seen several of its student volunteers go on to vocations in science and technology – returning to the Observatory to give back to the community. For example, Ms. Louise Gagnon, in break from her studies, has offered a well-attended summer course at the Observatory, free to local students, on diverse astronomical topics.

Star parties haven't been confined to the Observatory. The volunteers have packed up their telescopes and traveled to venues near and far to engage the public, from solar observing in downtown New Milford, planetary watching behind Northville school, to parks and open meadows for evenings under the stars with the scouts or other organizations. For the past three years, the Observatory staff has helped celebrate the International Observe the Moon Night with the students at Thurgood Marshall Intermediate School in Lynn, Massachusetts.

In 2018, the Observatory acquired an extensive meteorite collection from a local collector. With over 200 specimens from historical finds and witnessed falls, the collection is an ideal complement to the larger and more rugged Pavell samples. The acquisition was augmented with the donation of a teaching microscope - made possible by a doctor at the Danbury Hospital, so that the public can explore the micro-features of these ancient relics that date back over 4 billion years to the formation of our solar system.

In recent years, Galileo's Garden has undergone a major change in an effort to attract pollinators. Plants native to New England are replacing "standard" nursery stock. In addition, a small meadow was created on the north side of the observatory, complete with a water feature. The Garden is now a Registered Pollinator Pathway Site by the National Wildlife Foundation and Pollinator Pathways and a Certified Wildlife Habitat.

In its twenty years of operation, the McCarthy Observatory has developed professional associations with educational organizations such as Telescopes-In-Education, JPL's Night Sky Network, NASA's Museum Alliance, and NASA's Solar System Ambassadors. The resources and opportunities provided by these organizations have greatly benefited the Observatory's outreach efforts.

Despite being closed during the recent pandemic, Observatory volunteers have not been inactive - developing virtual programs and offering timely talks at several locales. They are also engaged in establishing a regional meteor watch, working with Westport Astronomical Society on a second camera node. Entering its third decade, the Observatory's mission is as relevant as it was the day it opened – if history is any indication, the volunteers and supporters of this unique facility are up to the challenge.

John J. McCarthy Observatory
Twenty Years of Excellence

"Out the Window on Your Left"

It's been more than 51 years since Neil Armstrong first stepped onto the moon's surface and 48 years since Gene Cernan left the last footprint. As a nation founded on exploration and the conquest of new frontiers, today's commitment to return to the moon has been as fleeting as the funding. 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).

For lunar observers, the sun rises on the Taurus-Littrow valley around midnight on the 19th in December. A narrow opening in the rim of the Serenitatis Basin, the valley is enclosed on three sides by large, rounded mountains - the South, North, and East Massifs. It is also the landing site of Apollo 17 on December 11, 1972, the final lunar mission of the Apollo program.

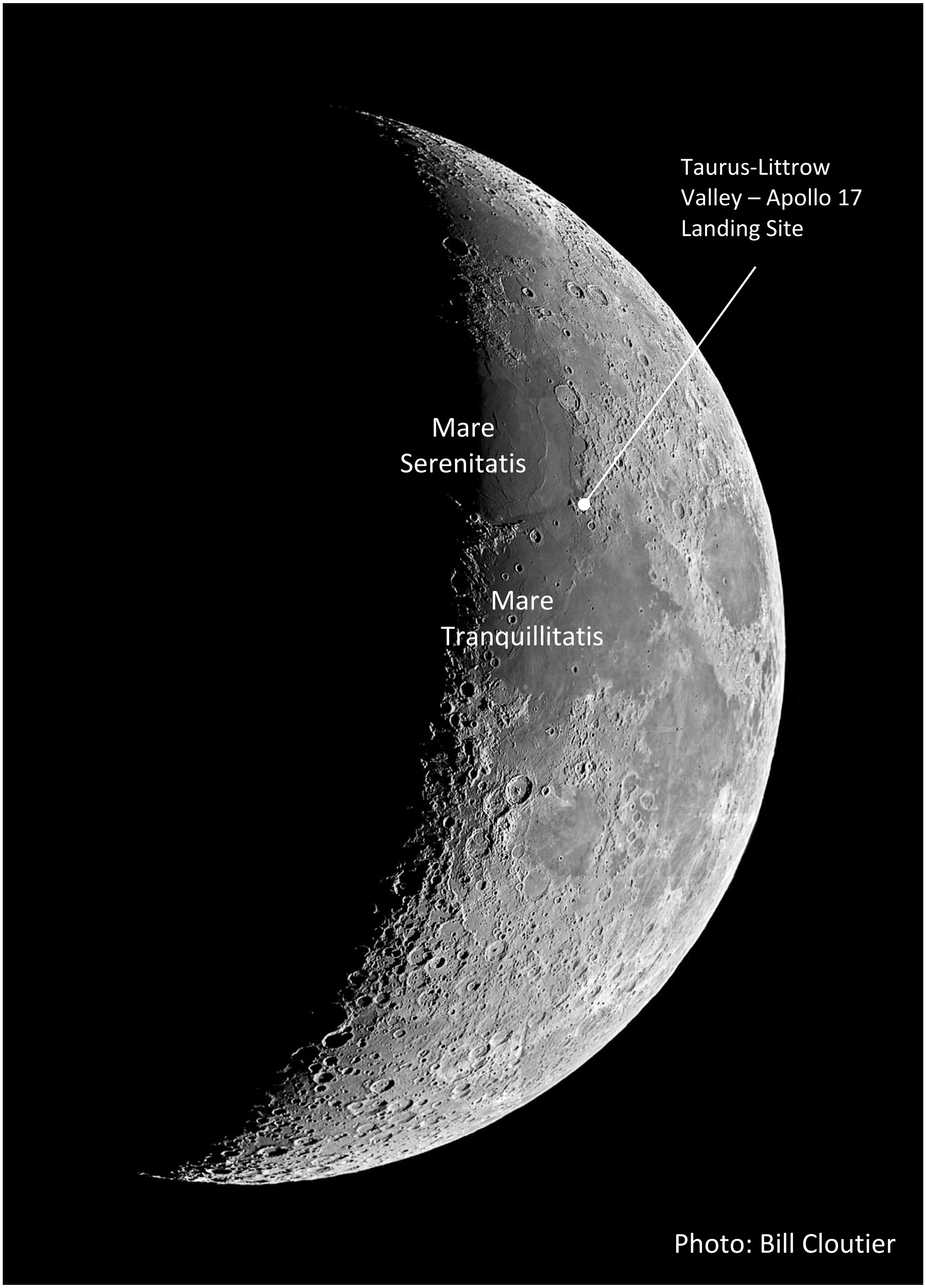
Multiple sites competed for the last mission, offering a variety of terrains, history and geology. Taurus-Littrow provided astronauts, including astronaut-geologist Harrison Schmitt, the opportunity to explore craters on the valley floor with dark halos that had been identified from orbit by earlier missions. The lunar module set down near one of these craters, designated Shorty.

It was on the rim of Shorty that Schmitt discovered a deposit of "orange soil." The orange particles were later determined to be volcanic glass, likely produced by a volcanic vent or fire fountain. The glass formed 3.64 billion years ago from material that melted several hundred miles below the surface. The glass was then buried and later excavated by impacts.

Scientist-astronaut Harrison Schmitt stands next to a huge, split lunar boulder during the third Apollo 17 extravehicular activity at the Taurus-Littrow landing site. The Lunar Roving Vehicle can be seen in the background.
Image Credit: NASA/Eugene Cernan

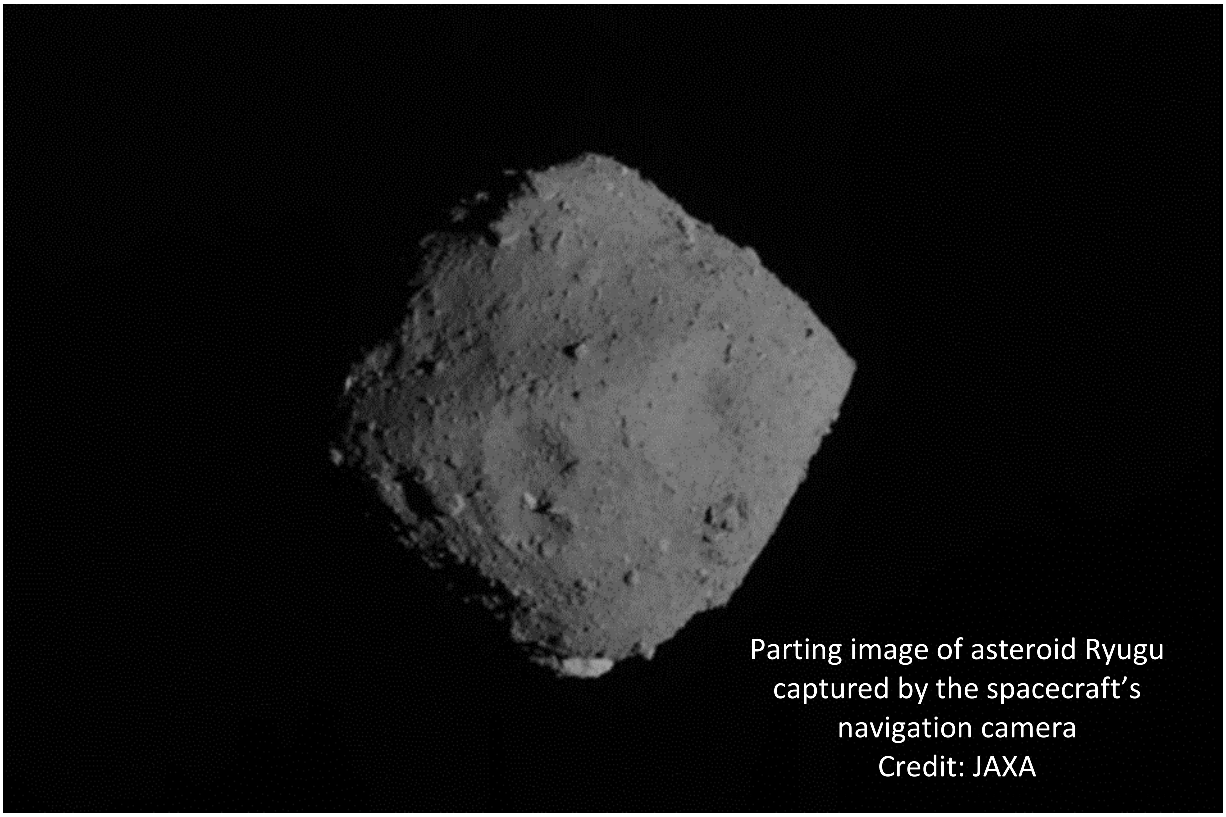
Apollo 17 featured the most extensive lunar exploration of the program, with three moonwalks that each lasted more than seven hours. The crew collected the oldest known unshocked lunar rock (at least 4.2 billion years old) - suggesting that the Moon had, at one time, a magnetic field generated by a dynamo at its core. The astronauts took more than 2,000 photographs and collected about 243 pounds (110 kg) of soil and rock samples at 22 different sites.

Taurus Littrow



Sample Return

Hayabusa 2's primary mission is coming to an end. Six years after its launch from the Tanegashima Space Center, the Japanese spacecraft is scheduled to return. On December 6, Hayabusa 2 will fly by the Earth, dropping off a sample-return capsule containing material collected from the surface of the Ryugu carbonaceous asteroid.



Parting image of asteroid Ryugu captured by the spacecraft's navigation camera
Credit: JAXA

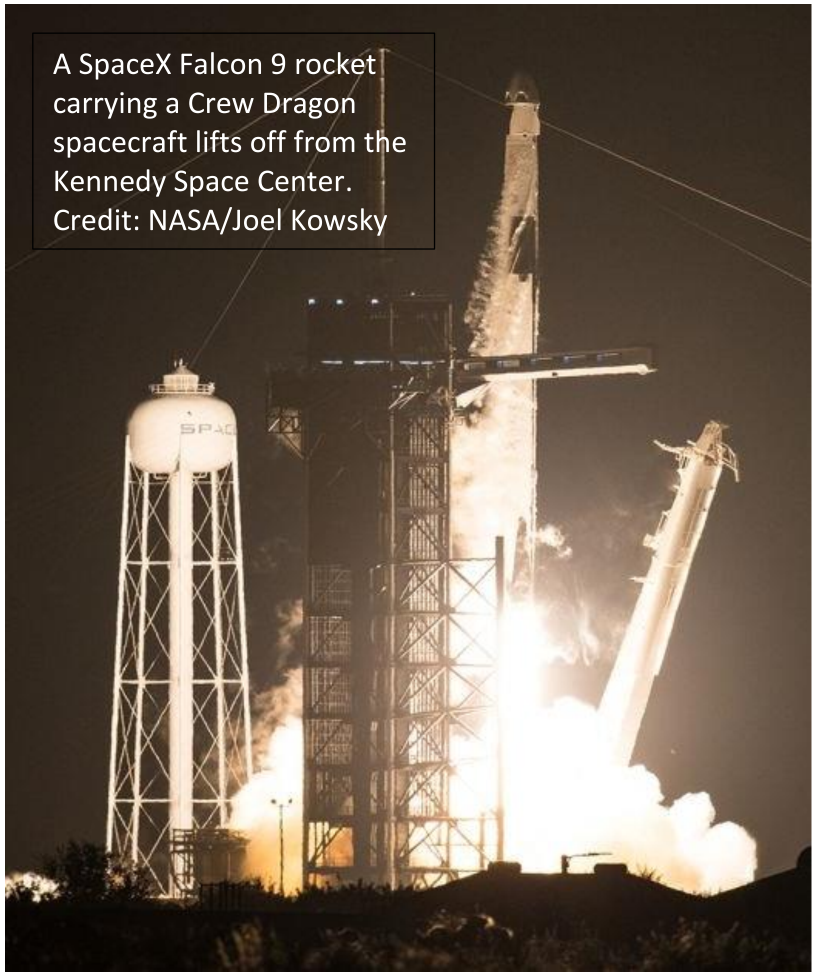
The insulated capsule will enter the Earth's atmosphere, traveling at almost 27,000 mph (12 km/sec). Shedding velocity with its heat shield, which is expected to reach a peak temperature of 5,400°F (3,000°C), a parachute will deploy at an altitude of about 6 miles (10 km). The capsule will descend the final distance under parachute, landing in the Woomera Prohibited Area in Australia.

Targeted landing area in the Woomera desert
Credit: JAXA

Once its primary mission is complete, Japan's Aerospace Exploration Agency (JAXA) is considering options for sending the spacecraft to another asteroid.

Launch America

Nearly thirty hours after an early evening liftoff on Sunday, November 15 from Pad 39A, the hatches on the Crew Dragon spacecraft and the International Space Station (ISS) were opened around 1:10 am Tuesday morning, allowing the four new crew members to join the three already onboard.



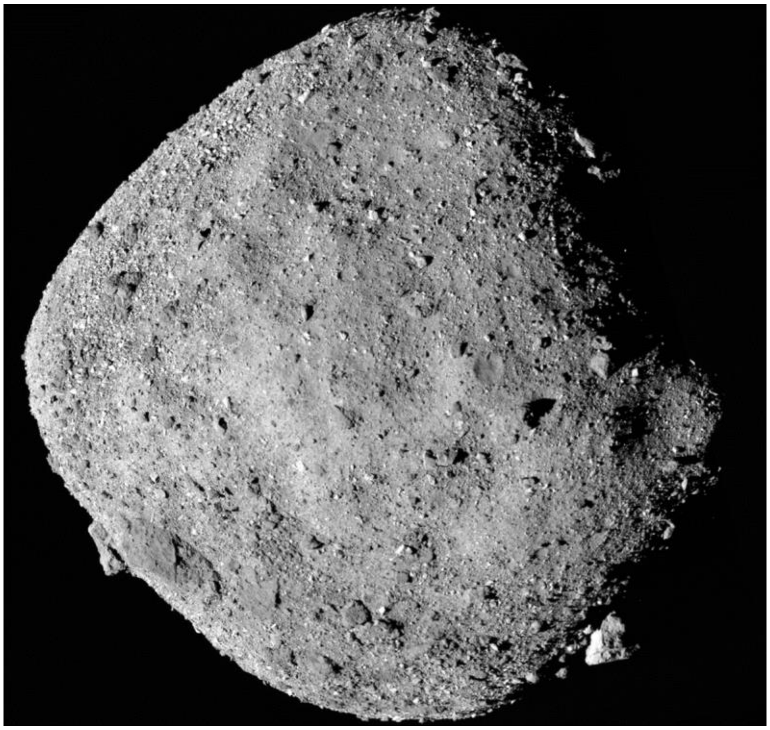
A SpaceX Falcon 9 rocket carrying a Crew Dragon spacecraft lifts off from the Kennedy Space Center. Credit: NASA/Joel Kowsky

The spacecraft, which is named "Resilience," docked with the station's Harmony module. The crew included NASA astronauts Michael Hopkins, spacecraft commander, Victor Glover, pilot, Shannon Walker, mission specialist, and JAXA astronaut Soichi Noguchi, mission specialist.

Crew Dragon, the first commercial spacecraft to be certified by NASA for transporting humans to and from low-Earth orbit, is the culmination of the agency's Commercial Crew Program which began in 2011 with the retirement of the space shuttle (the Russian Soyuz spacecraft has been the sole means of human transportation to the ISS since 2011). Certification followed a thorough Flight Readiness Review by NASA, a successful demonstration flight that concluded in August, as well as years of design, development, and rigorous testing.

Crew Dragon docked Credit: NASA TV

A Hollow Asteroid?



Mosaic image of asteroid Bennu from a range of 15 miles (24 km)
Credits: NASA/Goddard/University of Arizona

NASA's OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer) spacecraft has been orbiting the asteroid (101955) Bennu for the past two years – recently touching down on its surface to gather a sample of soil and rock for return to Earth. Based upon the data collected by the spacecraft, investigators have concluded that this relatively unstable world may have an interior void and be in the process of spinning itself apart (as described in a research article published in Science Advances in October).

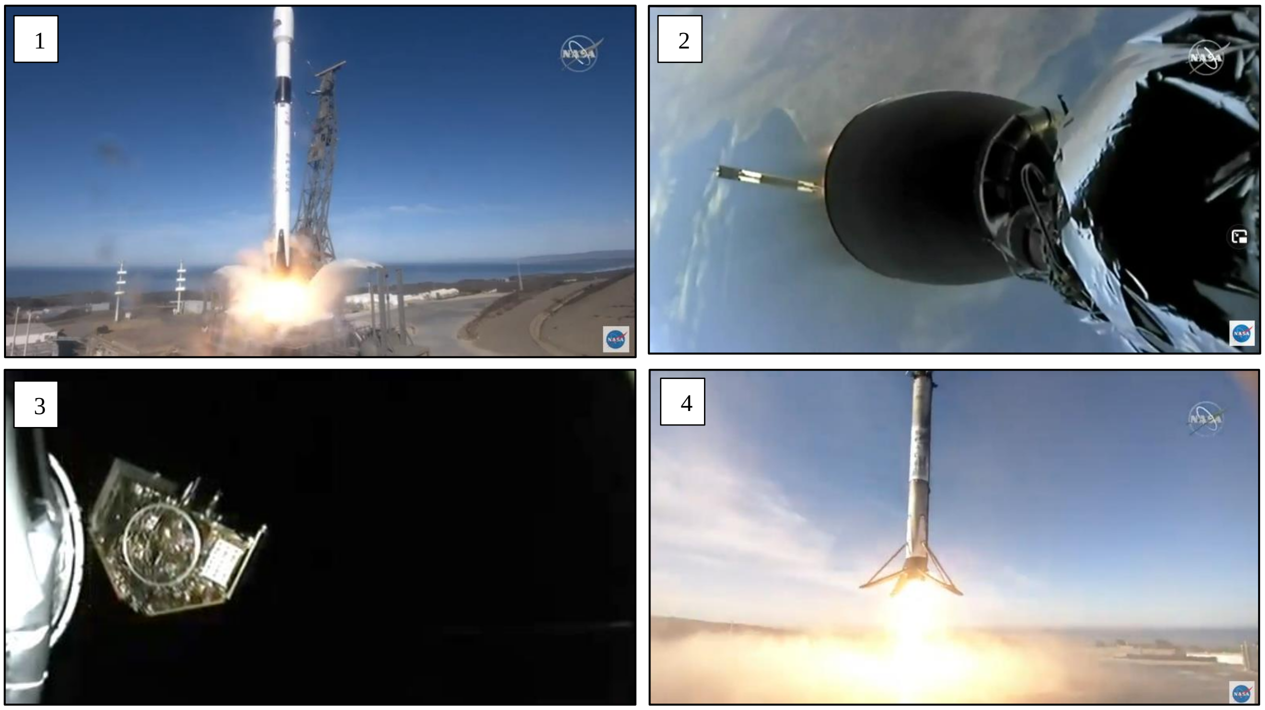
The interior of this rubble pile has been deduced by modeling the spacecraft's orbit, and the asteroid's influence on that orbit, and the behavior of particles ejected from the asteroid's surface. Shortly after OSIRIS-Rex's arrival in 2018, its instruments detected sporadic bursts of particles, from smaller than an inch up to 4 inches (10 cm) in size. The particles either briefly orbited Bennu and fell back to its surface or escaped (three possible mechanisms have been identified as the source of the events - meteoroid impacts, thermal stress fracturing, and releases of water vapor). The motion of the particles, like that of the spacecraft, provided a second and independent measurement of the strength of Bennu's gravity. Together, they allowed researcher to calculate how the asteroid's mass is distributed.

Bennu completes one rotation every 4.3 hours, and it's slowly accelerating as a result of the uneven heating and cooling of its surface as it rotates (the Yarkovsky-O'Keefe-Radzievskii-Paddack or YORP effect). Surface temperatures range from a toasty 170°F to a frigid -100°F (77°C to -73°C) over the day/night cycle due to the absence of an atmosphere. The rotation appears to be pushing its heterogeneous interior outward, toward the surface, creating an interior void or cavity and a top-like shape (existing measurements suggest that Bennu is about 20 to 40 percent empty space inside). The thinnest parts of the asteroid are likely at the equator which exhibits a well-defined ridge. Based upon the data returned by the Canadian Space Agency's laser altimeter on the spacecraft, the equator's radius is approximately 90 feet (27 meters) larger than the asteroid's mean radius.

Researchers will have the opportunity to take a closer look at the composition of Bennu when OSIRIS-ReX drops off the sample return capsule in 2023 during a flyby of Earth. The capsule is expected to land in the Utah desert.

Ocean Watch

The Sentinel-6 Michael Freilich spacecraft (named after Dr. Michael Freilich, the former director of NASA's Earth Science Division) was successfully launched at 12:17 pm (EST) on November 21 from the Vandenberg Air Force Base, in California. The spacecraft, which is part of a joint mission between the European Space Agency, NASA, NOAA, CNES and Eumetsat, will continue the work of the Jason series of ocean-monitoring satellites over the past 30 years. Sentinel-6(A) is the first of two identical spacecraft that comprise the Sentinel-6/Jason-CS (Continuity of Service) mission - its twin, Sentinel-6B, will launch in 2025.



Views from NASA television: 1. launch, 2. stage separation with the second stage's Merlin Vacuum engine in the foreground and the expended first stage dropping back to Earth in the background, 3. separation of the Sentinel-6 spacecraft from the second stage, and 4. landing of the Falcon 9's first stage back at Vandenberg

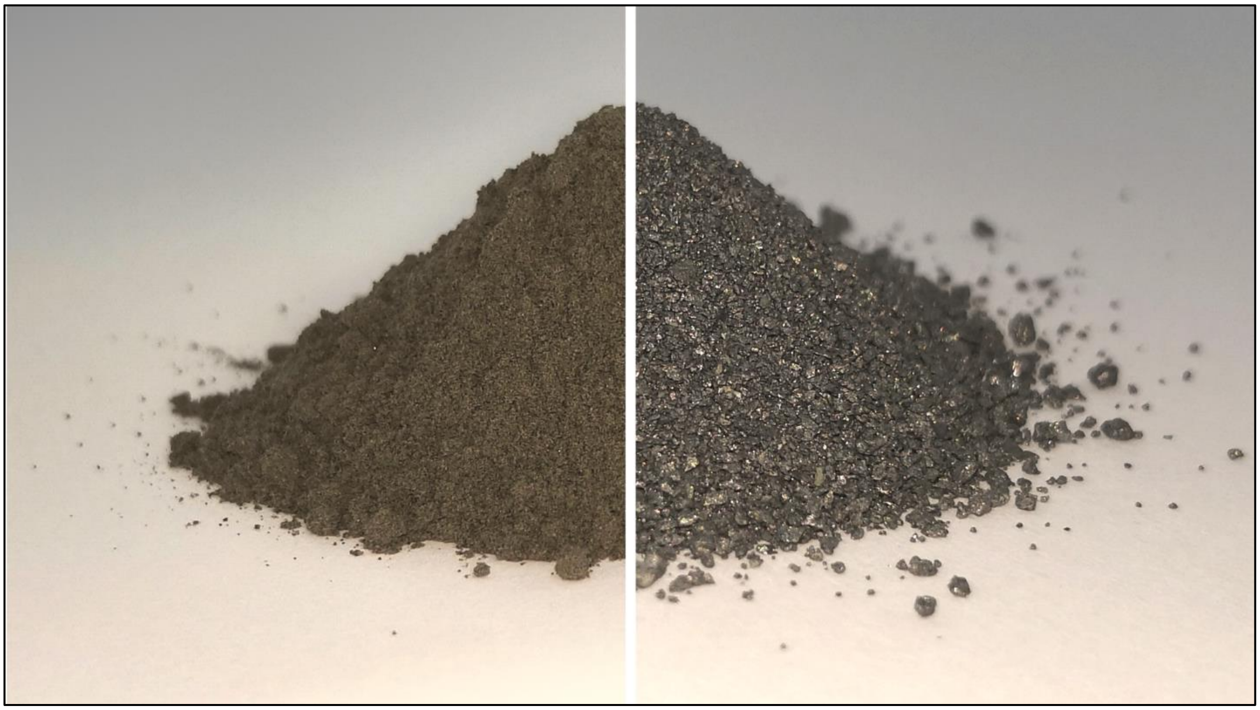
The spacecraft was placed into a polar orbit, approximately 830 miles (1,336 kilometers) above the Earth. From there, its radar altimeter will be able to accurately determine sea surface conditions, including wave height to an accuracy of a few centimeters, for more than 90 percent of the world's oceans.

The information gathered by the spacecraft will aid .in our understanding of how climate change is reshaping Earth's coastlines, how quickly the change is occurring, and in much greater detail than previous spacecraft. Data will also be collected on the temperature of the upper layer of the ocean, and on atmospheric temperature and humidity – information that can be used to improve hurricane and storm forecasts. Almost 40 percent of the population in the United States lives in relatively high population-density coastal areas – areas subject to flooding, shoreline erosion, and hazards from storms. Since 1880, the global mean sea level has risen about 8–9 inches (21–24 centimeters) and that rate of change is accelerating, with 30 percent of the sea level increase occurring in the last twenty-five years.

Mining Lunar Oxygen

The British company Metalysis has been awarded a contract from the European Space Agency (ESA) to further develop a method for extracting oxygen from the lunar regolith. The process, developed at the University of Cambridge, has been demonstrated to work on Earth - ESA funding is to validate the process in an extra-terrestrial environment.

Scientists affiliated with Metalysis believe that they can extract up to 96% of the oxygen from the regolith. The byproduct, a mixed metal alloy, could be used as a raw material for lunar construction projects. The oxygen would be available for life support and as an oxidizer for rocket fuel.

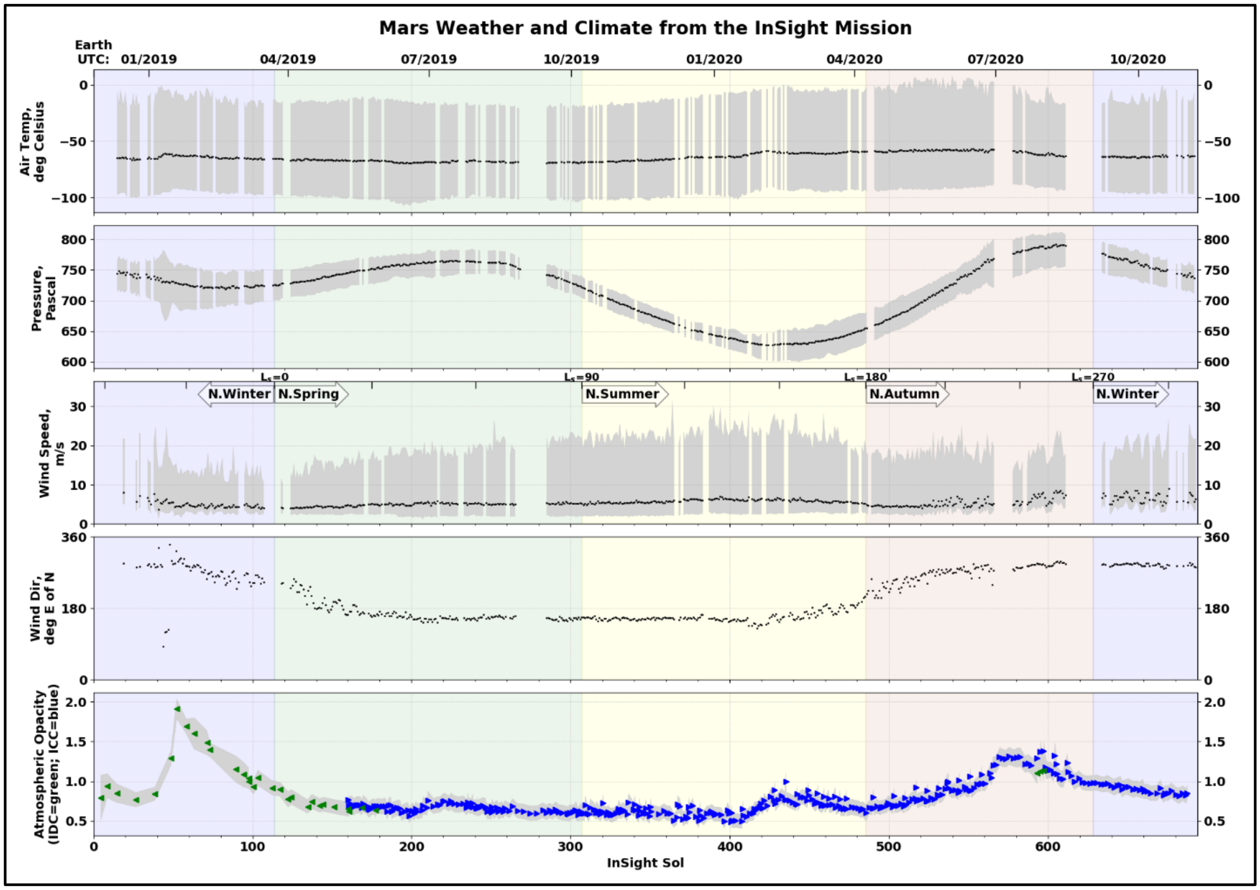


Before and after images of a sample of simulated lunar soil regolith in which essentially all the oxygen has been removed. The end product (right) is a mixture of metallic compounds. Credit: Beth Lomax, University of Glasgow

Analysis of the samples returned from the lunar surface indicate that oxygen is the most abundant element (40% to 45% percent oxygen by weight, depending upon sample location). However, since oxygen is chemically bound as an oxide in the minerals or amorphous glass, it is not readily available for use. Freeing up the oxygen is done using a method called molten salt electrolysis.

In the proposed process, the regolith is placed in a mesh-lined basket with molten calcium chloride salt. The salt serves as an electrolyte. The mixture is heated to temperature of more than 1700°F (950°C). An electrical current was then applied to release the oxygen, which migrated across the salt to an anode. It took 50 hours in all to extract 96% of the total oxygen from JSC-2A lunar regolith simulant, although only 15 hours to reach 75%. In the laboratory, approximately one third of the total oxygen was released in the form of CO2 and CO using graphite anode – the remainder was likely lost to corrosion of the reactor vessel. Researchers believe that they will be able to generate oxygen directly with an oxygen-evolving anode.

Martian Weather Report



Weather readings since landing in November 2018
Image credit: NASA/JPL-Caltech/Cornell/CAB

Weather data from instruments on the InSight lander have provided scientists a complete profile of seasonal changes over a Martian year (687 Earth-days) – at least near the equator.

InSight landed on Elysium Planitia, just 4.5° north of the Martian equator. Daily temperatures are recorded by InSight's Temperature and Wind for InSight (TWINS) instrument mounted on the lander's deck. The two identical TWIN booms are located on opposite sides of the lander, approximately 55

Time		Air Temperature (°F | °C)		
Date	Sol	Max.	Avg.	Min.
Nov. 8, 2020	694	14.9° F	-64.6° F	-156.5° F
Nov. 7, 2020	693	9.7° F	-88.6° F	-142° F
Nov. 6, 2020	692	13.1° F	-86.7° F	-142.2° F
Nov. 5, 2020	691	3.1° F	-78.4° F	-142.6° F
Nov. 4, 2020	690	5.3° F	-88° F	-142.2° F
Nov. 3, 2020	689	-1° F	-69.1° F	-142.2° F
Nov. 2, 2020	688	9° F	-89.2° F	-140.2° F

Extreme variability in daily highs and lows due to Mars' very thin atmosphere
Image credit: NASA/JPL-Caltech/Cornell/CAB

inches (1.4 meters) above the ground and 8 inches (200 mm) above the lander's top deck.

The atmosphere of Mars is so thin, less than one percent of the sea level pressure on Earth, that the temperature at the surface can be more than 70°F (20°C) warmer than it is only six feet above the surface (for example, the height of an astronaut).

On the larger graph, Earth months run along the top with the number of days (or Sols on Mars) along the bottom. The vertical columns of color delineate the Martian seasons (winter in the northern hemisphere started on September 2). The black lines (for air temperature, pressure and wind speed) indicate the daily average while each Sol's maximum and minimum are shown at the top and bottom of the vertical grey bars.

Wind Direction is shown in degrees east of north (East is at 90°, South at 180°, West at 270° and North at 360°). Atmospheric Opacity (or tau) is a measurement of how much sunlight is blocked by dust in the atmosphere before it reaches the ground.

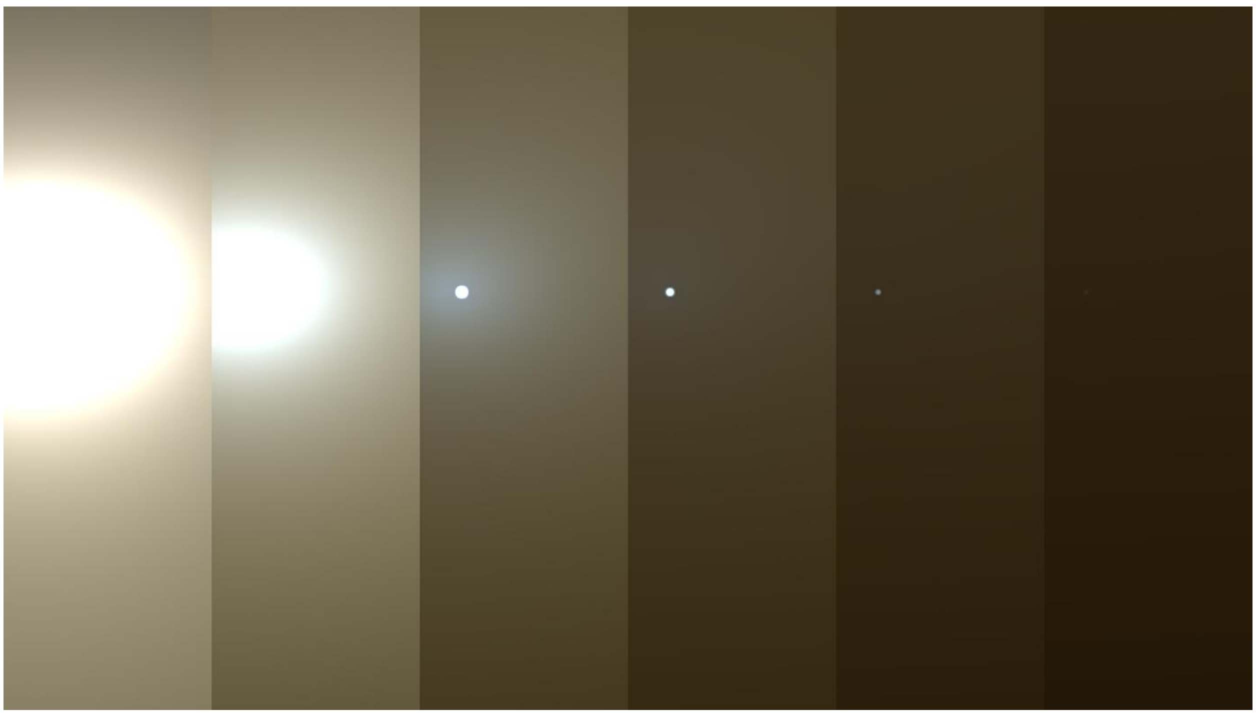


Image credit: NASA/JPL-Caltech/TAMU

The clarity of the Martian atmosphere is critical to solar-powered landers and rovers (as well as dust accumulation). In the summer of 2018, NASA's Opportunity rover became the victim of a global dust storm which prevented sunlight from reaching the rover's solar panels and creating the energy necessary to keep its vital instruments warm.

This simulated image (above) shows the progression of dust-darkening skies from Opportunity's point of view, starting with a mid-afternoon sky. The corresponding tau values (from left to right) are 1, 3, 5, 7, 9 and 11. A tau of five means that less than one percent of direct sunlight is reaching the Mars surface. A tau value of 10.5 was recorded on June 10, 2018, the highest on record, in Opportunity's final communication with its mission team on Earth. InSight recorded a peak tau of around 2 in early 2019 - the skies have been relatively clear since then.

Meteorite Spotlight - Barwell

In the summer of 2018, the Observatory greatly expanded its meteorite teaching collection with the addition of a diverse and comprehensive set of meteoritic specimens from a reputable collector looking to convey his collection to someone who would maintain its integrity and capitalize on its intrinsic educational value. The collection includes whole stones, slices and fragments, numbering more than 200, from historic and scientifically-significant falls and meteorite finds dating back to 1492. From time to time, we will highlight one or more of the specimens from the collection in this newsletter.

McCarthy Observatory's sample of the Barwell meteorite Image: Gerard Bianchi

A flash of light followed by a loud bang lit up the sky over the small Leicestershire village of Barwell. The year was 1965 - it was Christmas Eve - and carol singers were making their rounds.

The breakup of the meteor occurred around 4:20 pm, with the bright terminal flash witnessed by several residents in the village, as well as in Coventry, twelve miles away. Fragments could also be heard hitting the frozen ground.

Being quite unexpected, only two pieces of the visitor from outer space were recovered that evening. The first piece shattered upon impact with a local road – a fragment of which went through the front window of the home of Mr. and Mrs. Grewcock, landing in a vase of imitation flowers where it remained undiscovered for 19 days. A second piece landed on the hood of a Vauxhall Viva, a small family car. The owner, Percy England, who had just purchased the car, tossed the piece aside believing it was the work of vandals. When his insurance claim was denied as being "an act of God," he approached the local church for compensation – to no avail.


The Grewcocks inspect their broken window from a Barwell fragment
Credit: The Hinckley Times

Following a public appeal, an offer to purchase any fragments, and the publicity generated by a visit by public astronomer and "Sky at Night" presenter Patrick Moore, the largest piece, weighing 17 pounds (7.7 kg) was found in a hole about 2½ feet (75 cm) deep in a nearby field. In total, 97 pounds (44 kg) of the stony meteorite were recovered – the largest fall in the UK (second only in mass to the largest find – the Wiltshire meteorite).

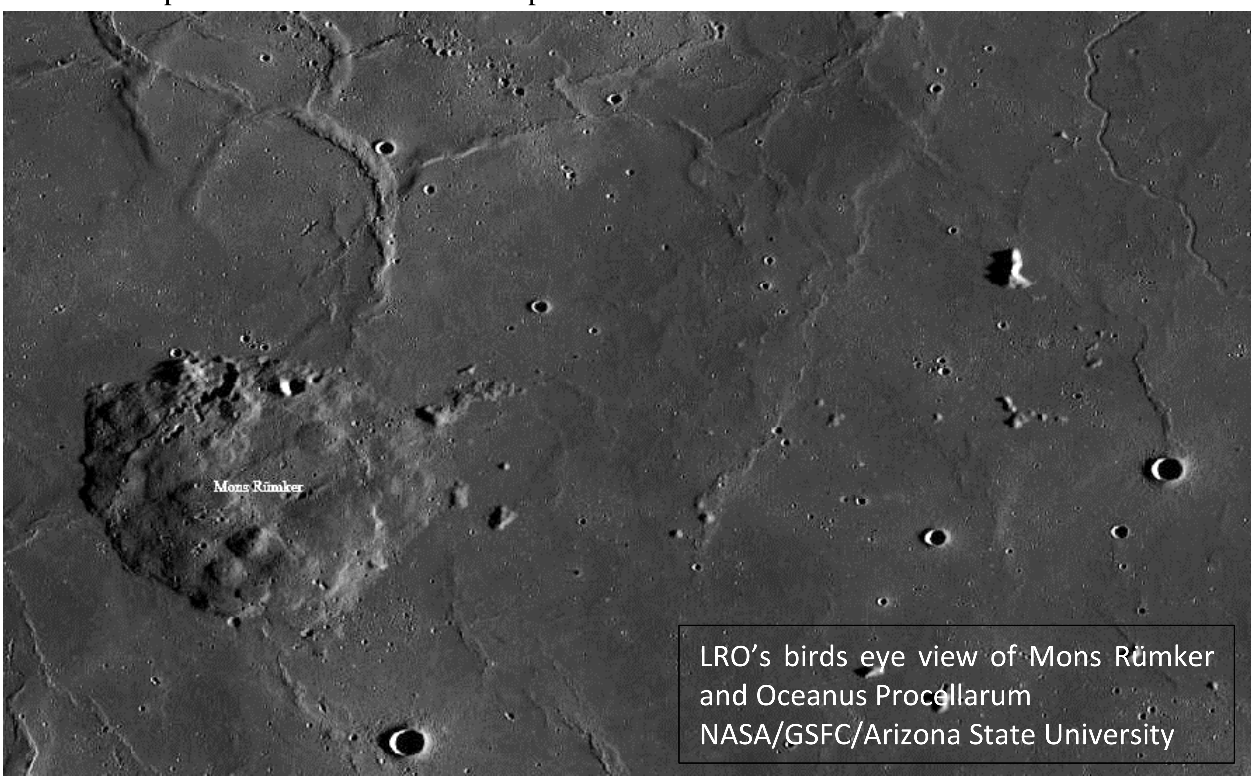
The sample of Barwell (an ordinary chondrite from the low-iron chemical group) in the Observatory's collection is a fragment weighing 2.6 grams.

Red Moon Rising

It has been forty-four years since the last bit of rock and soil were returned from the Moon. Luna 24, the Soviet Union's final lunar mission, collect about six ounces (more than 170 grams) of regolith down to a depth of about 6½ feet (2 meters) from the Mare Crisium (Sea of Crises) region. A small portion of the sample was shared with NASA in December 1976.

On November 23 (EST), China launched its Chang'e-5 mission to the northern Oceanus Procellarum (Ocean of Storms) region with the objective of bringing back up to 4½ pounds (2 kg) of lunar material. Timed to land near the Mons Rümker edifice around sunrise (on November 27), the lander will spend up to 14 days (one lunar daytime), using its robotic arm and drill to explore this relatively young lunar feature and load its ascent vehicle.

Mons Rümker is a large volcanic structure - rising 650 to almost 4,300 feet (200 to 1300 meters) above the surrounding mare surface with more than 20 distinct domes that may have been active as recently as 1.3 billion years ago (much younger than the areas sampled by the Apollo astronauts which were between 3.1 and 4.4 billion years old). With a diameter of 40 miles (about 65 km), the volcanic complex is surrounded by multiple geologic units, with distinctly different elemental and mineral compositions – a rich area for exploration.



LRO's birds eye view of Mons Rümker and Oceanus Procellarum NASA/GSFC/Arizona State University

Chang'e-5 is not equipped to survive a lunar night, so the entire mission is expected to last around three weeks (from launch until the sample container returns - landing in the grasslands of Inner Mongolia - the same area where the Shenzhou astronaut crews have landed). Scientists are hopeful that the samples from Mons Rümker can provide a greater understanding of the changes in lunar volcanism over time and insight into how the interior of the Moon remained so hot, so long after formation. Magma production and surface eruptions are thought to have occurred on the Moon between 4.3 and about 1 billion years ago, with the peak between 3.8 and 3.0 billion years, although NASA's Lunar Reconnaissance Orbiter (LRO) has found deposits less than one million years old.

Apollo 8 – 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).

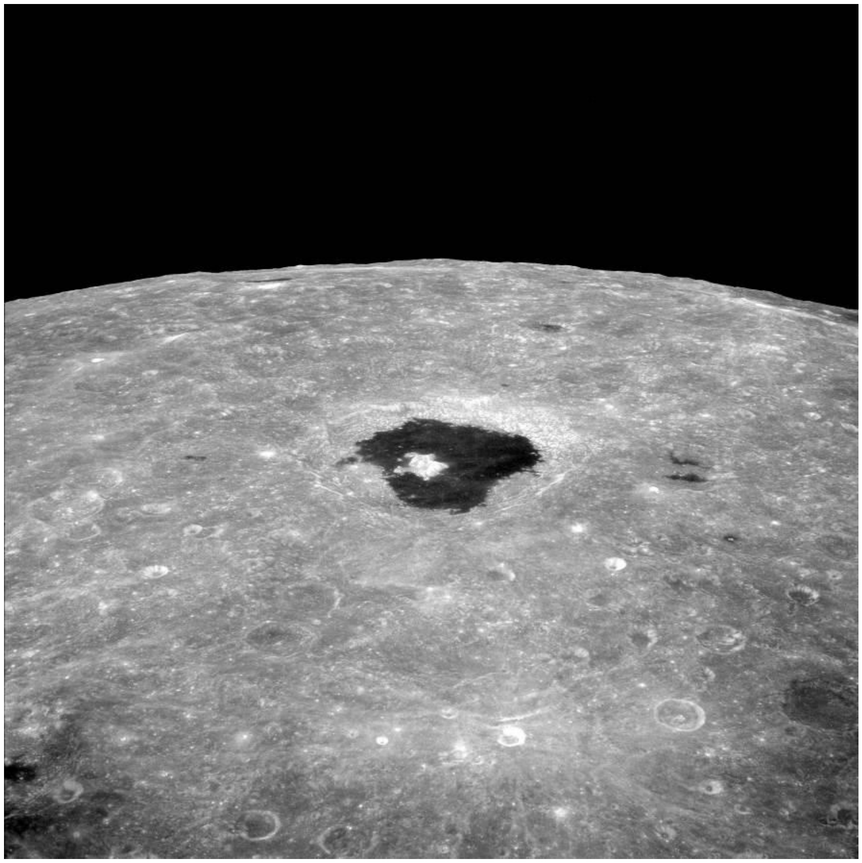
While Apollo 7 had been a successful maiden voyage of the completely redesigned command module (after the Apollo 1 fire), the United States had yet to leave Earth orbit. NASA's original plan was to launch a series of increasingly complex missions to near-Earth orbit before attempting a lunar excursion. 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.



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

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 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.

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.

Purchasing a Telescope

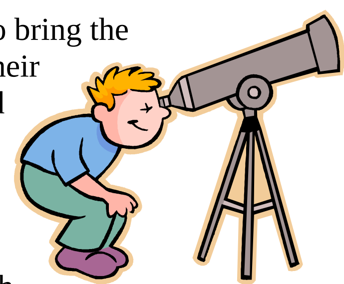
During the holidays it's not uncommon to see parents and grandparents carrying around a telescope that they just picked up at the mall or warehouse store for their budding astronomer. Unfortunately, too many of these thoughtful gifts end up in a basement or attic after one or two uses. All too often, 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.

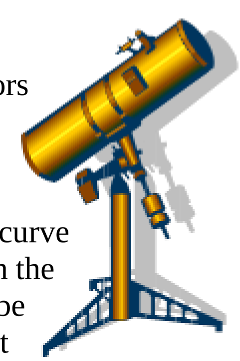
There are several types of telescopes available to the general consumer. Each has advantages and disadvantages, and with a little education, a consumer can find a telescope that fits his or her needs and lifestyle. Again, if you don't use it, a telescope is about as useful as a garden gnome and not as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

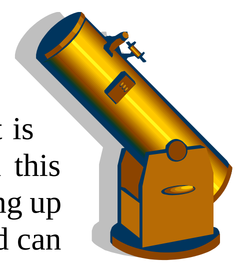
- What are you interested in looking at? Spectacular views of the Sun, Moon and planets can be acquired with a relatively modest instrument. However, if your passion is hunting down the more elusive and distant residents of the Milky Way Galaxy or exploring other galaxies far, far, away, it will require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

* 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).

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. Check out product reviews in trade magazines such as Sky & 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. When the McCarthy Observatory reopens - attend an 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.

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 (New Milford, CT)

Sun	Sunrise	Sunset
December 1st (EST)	07:01	16:22
December 15th	07:13	16:22
December 31st	07:20	16:32

Astronomical and Historical Events

1st Apollo Asteroid 2020 SO near-Earth flyby (0.0003 AU)
1st Apollo Asteroid *10563 Izhdubar* closest approach to Earth (1.199 AU)
1st History: launch of Soviet satellite Sputnik 6 and two dogs: Pchelka and Mushka (1960)
2nd Apollo Asteroid 2019 XH2 near-Earth flyby (0.041 AU)
2nd Binary Apollo Asteroid *69230 Hermes* closest approach to Earth (0.262 AU)
2nd Apollo Asteroid *1566 Icarus* closest approach to Earth (0.748 AU)
2nd Aten Asteroid *2340 Hathor* closest approach to Earth (1.044 AU)
2nd Atira Asteroid 2006 WE4 closest approach to Earth (1.182 AU)
2nd Apollo Asteroid 1620 *Geographos* closest approach to Earth (1.787 AU)

Astronomical and Historical Events (continued)

2nd Kuiper Belt Object 2006 QH181 at Opposition (83.460 AU)
2nd History: launch of the Hayabusa 2 spacecraft to the asteroid *162173 Ryugu* from the Tanegashima Space Center, Japan (2014)
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 Aten Asteroid 2010 TK7 (Earth Trojan) closest approach to Earth (0.217 AU)
3rd Asteroid 16 *Psyche* closest approach to Earth (1.689 AU)
3rd Kuiper Belt Object 145453 (2005 RR43) at Opposition (38.930 AU)
3rd History: NASA spacecraft OSIRIS-REx arrives at asteroid *Bennu* (2018)
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 Amor Asteroid *452307 Manawydan* closest approach to Earth (0.654 AU)
4th Centaur Object 2015 KJ153 at Opposition (8.221 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 Little Joe 2 rocket, test flight for the Mercury capsule and first U.S. animal flight with Sam, a Rhesus monkey (1959)
5th Scheduled launch of a SpaceX Dragon 2 spacecraft on its first cargo resupply mission to the International Space Station from the Kennedy Space Center, Florida
6th Scheduled recovery of Hayabusa 2's sample return capsule containing material from the asteroid Ryugu
6th Kuiper Belt Object 2018 VG18 at Opposition (123.168 AU)
6th History: Japanese spacecraft Akatsuki enters around Venus five years after unsuccessful first attempt and main engine failure (2015)
7th Last Quarter Moon
7th Amor Asteroid *1036 Ganymed* closest approach to Earth (1.607 AU)
7th Kuiper Belt Object *229762 G!kun||'homdima* at Opposition (40.641 AU)
7th Kuiper Belt Object *148780 Altjira* at Opposition (45.058 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 Aten Asteroid *2018 PK21* near-Earth flyby (0.031 AU)
8th Amor Asteroid *1580 Betulia* closest approach to Earth (1.912 AU)

Astronomical and Historical Events (continued)

8th Centaur Object *54598 Bienor* at Opposition (13.297 AU)
8th History: launch of the Chinese Chang'e 4 spacecraft to the far side of the Moon from the Xichang, China launch site (2018)
8th History: 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: Japanese spacecraft IKAROS becomes the first to successfully demonstrate solar sail technology in interplanetary space during a Venus flyby (2010)
8th History: discovery of asteroid *5 Astraea* by Karl Hencke (1845)
9th Amor Asteroid *3908 Nyx* closest approach to Earth (0.496 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 Amor Asteroid *4487 Pocahontas* closest approach to Earth (0.679 AU)
10th Apollo Asteroid *14827 Hypnos* closest approach to Earth (2.942 AU)
10th Kuiper Belt Object 145451 (2005 RM43) at Opposition (36.530 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)
10th Kuiper Belt Object 470443 (2007 XV50) at Opposition (45.997 AU)
10th History: launch of the Boeing X-37B Orbital Test Vehicle 1 (unmanned space plane) from the Cape Canaveral Air Force Station (2012)
11th Scheduled launch of a Russian Progress cargo-carrying spacecraft to the International Space Station from the Baikonur Cosmodrome, Kazakhstan
12th Second Saturday Stars – Virtual Open House at the McCarthy Observatory (7:00 pm)
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 Geminids meteor shower peak
13th Atira Asteroid 481817 (2008 UL90) closest approach to Earth (0.325 AU)
13th Kuiper Belt Object 2004 XR190 at Opposition (56.041 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 New Moon
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)

Astronomical and Historical Events (continued)

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 Centaur Object 8405 *Asbolus* at Opposition (22.311 AU)
15th Comet 9P/*Tempel* at Opposition (3.621 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 Amor Asteroid 2608 *Seneca* closest approach to Earth (1.939 AU)
16th Plutino 84922 (2003 VS2) at Opposition (35.762 AU)
16th Plutino 307463 (2002 VU130) at Opposition (38.568 AU)
16th History: launch of Pioneer 6, the first of four identical solar orbiting, spin-stabilized spacecraft (1965)
17th History: Project Mercury publicly announced (1958)
17th History: Wright Brothers' first airplane flight, Kitty Hawk, North Carolina (1903)
12th Moon at perigee (closest distance from Earth at 224,797 miles or 361,776 km)
18th History: discovery of Saturn's moon *Epimetheus* by Richard Walker (discovery shared with Stephen Larson and John Fountain) (1966)
19th Apollo Asteroid *428694 Saule* closest approach to Earth (0.438 AU)
19th Apollo Asteroid *137052 Tjelvar* closest approach to Earth (1.024 AU)
19th Kuiper Belt Object *19521 Chaos* at Opposition (40.250 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)
19th History: launch of Mercury-Redstone 1A; first successful flight and qualification of the spacecraft and booster (1960)
20th Centaur Object *60558 Echeclus* at Opposition (9.233 AU)
20th History: launch of the Active Cavity Radiometer Irradiance Monitor satellite (ACRIMSAT); designed to measure Sun's total solar irradiance (1999)
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)
21st Winter Solstice at 05:02 am EST (10:02 UT)
21st First Quarter Moon
21st Jupiter Passes 0.1° from Saturn shortly after sunset in the western sky
21st Apollo Asteroid 2017 XQ60 near-Earth flyby (0.032 AU)

Astronomical and Historical Events (continued)

- 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 Apollo Asteroid *6489 Golevka* closest approach to Earth (2.995 AU)
- 22nd Centaur Object 154783 (2004 PA44) at Opposition (21.523 AU)
- 22nd Plutino 15875 (1996 TP66) at Opposition (28.873 AU)
- 22nd History: first asteroid (323 *Brucia*) discovered using photography (1891)
- 23rd History: discovery of Saturn's moon *Rhea* by Giovanni Cassini (1672)
- 24th Moon at apogee (furthest distance from Earth at 251,661 miles or 405,009 km)
- 24th Aten Asteroid 2011 CL50 near-Earth flyby (0.003 AU)
- 24th History: inaugural of ESA's Ariane 1 rocket and first artificial satellite carried by an ESA rocket (1979)
- 24th History: the largest and best recorded meteorite fall in British history over the Leicestershire village of Barwell (1965)
- 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 Aten Asteroid 501647 (2014 SD224) near-Earth flyby (0.020 AU)
- 25th Kuiper Belt Object 78799 (2002 XW93) at Opposition (44.911 AU)
- 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 Solar Orbiter, Venus flyby, first of eight encounters with Venus which will bring it closer to the Sun and also out of the plane of the Solar System so as to observe the Sun from progressively higher inclinations
- 26th Asteroid 3530 Hammel closest approach to Earth (1.607 AU) – named for astronomer and planetary scientist Dr. Heidi Hammel
- 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 Aten Asteroid 2016 AF2 near-Earth flyby (0.019 AU)
- 27th Aten Asteroid 2012 XE133 near-Earth flyby (0.030 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)
28th Atira Asteroid 2018 JB3 closest approach to Earth (0.505 AU)
28th Amor Asteroid 164215 *Doloreshill* closest approach to Earth (1.755 AU)
28th Plutino 55638 (2002 VE95) at Opposition (29.475 AU)
28th Plutino 2005 TV189 at Opposition (31.722 AU)
29th Full Moon (Cold Moon)
29th Apollo Asteroid 162173 *Ryugu* near-Earth flyby (0.061 AU)
29th Aten Asteroid 2014 BA3 closest approach to Earth (1.479 AU)
29th Apollo Asteroid 314082 *Dryope* closest approach to Earth (2.407 AU)
29th Plutino 2002 XV93 at Opposition (37.404 AU)
30th Aten Asteroid 2012 UK171 near-Earth flyby (0.040 AU)
30th History: flyby of Jupiter by Cassini spacecraft on mission to Saturn (2000)
30th History: discovery of Uranus' moon *Puck* by Stephen Synnott (1985)
30th History: Army Air Corp Captain Albert William Stevens takes first photo showing the Earth's curvature (1930)
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 unlike Apollos, Atens spend most of their time inside Earth orbit.
- Atira: a group of near-Earth asteroids whose orbits are entirely within Earth's orbit
- Centaur: icy planetesimals with characteristics of both asteroids and comets
- Kuiper Belt: region of the solar system beyond the orbit of Neptune (30 AUs to 50 AUs) with a vast population of small bodies orbiting the Sun
- Opposition: celestial bodies on opposite sides of the sky, typically as viewed from Earth
- Plutino: an asteroid-sized body that orbits the Sun in a 2:3 resonance with Neptune
- Trojan: asteroids orbiting in the 4th and 5th Lagrange points (leading and trailing) of major planets in the Solar System

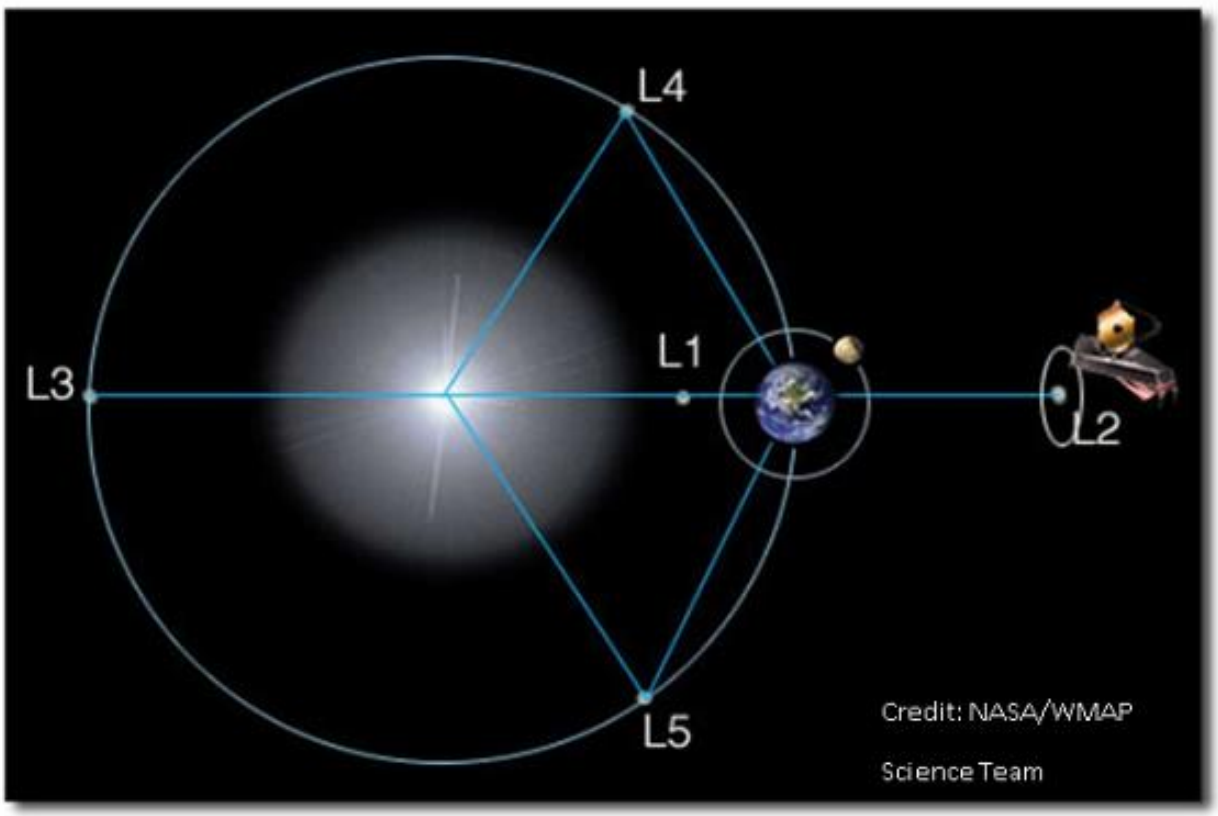
References on Distances

- the apparent width of the Moon (and Sun) is approximately one-half a degree (½°), less than the width of your little finger at arm's length which covers approximately one degree (1°); three fingers span approximately five degrees (5°)

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

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).



International Space Station and Starlink 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.

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

NASA's Global Climate Change Resource

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

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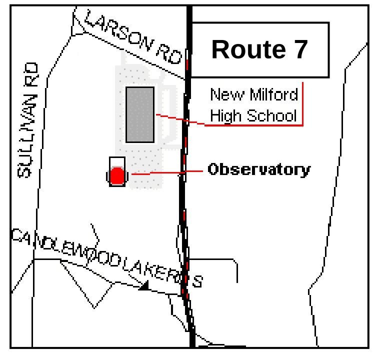

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