Galactic Observer

John J. McCarthy Observatory

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A "Disturbed" Galaxy

For almost two centuries a shining beacon in the southern sky, the galaxy Centaurus A is slowly revealing its dark secrets.. See page 20 for more information.

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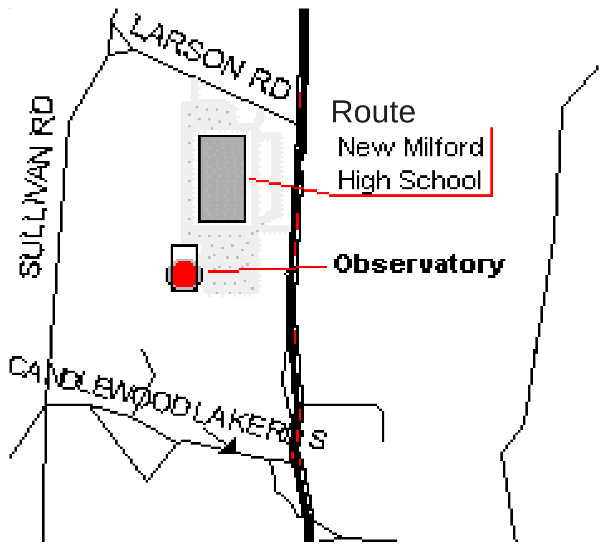
JJMO Staff

It is through their efforts that the McCarthy Observatory has established itself as a significant educational and recreational resource within the western Connecticut community.



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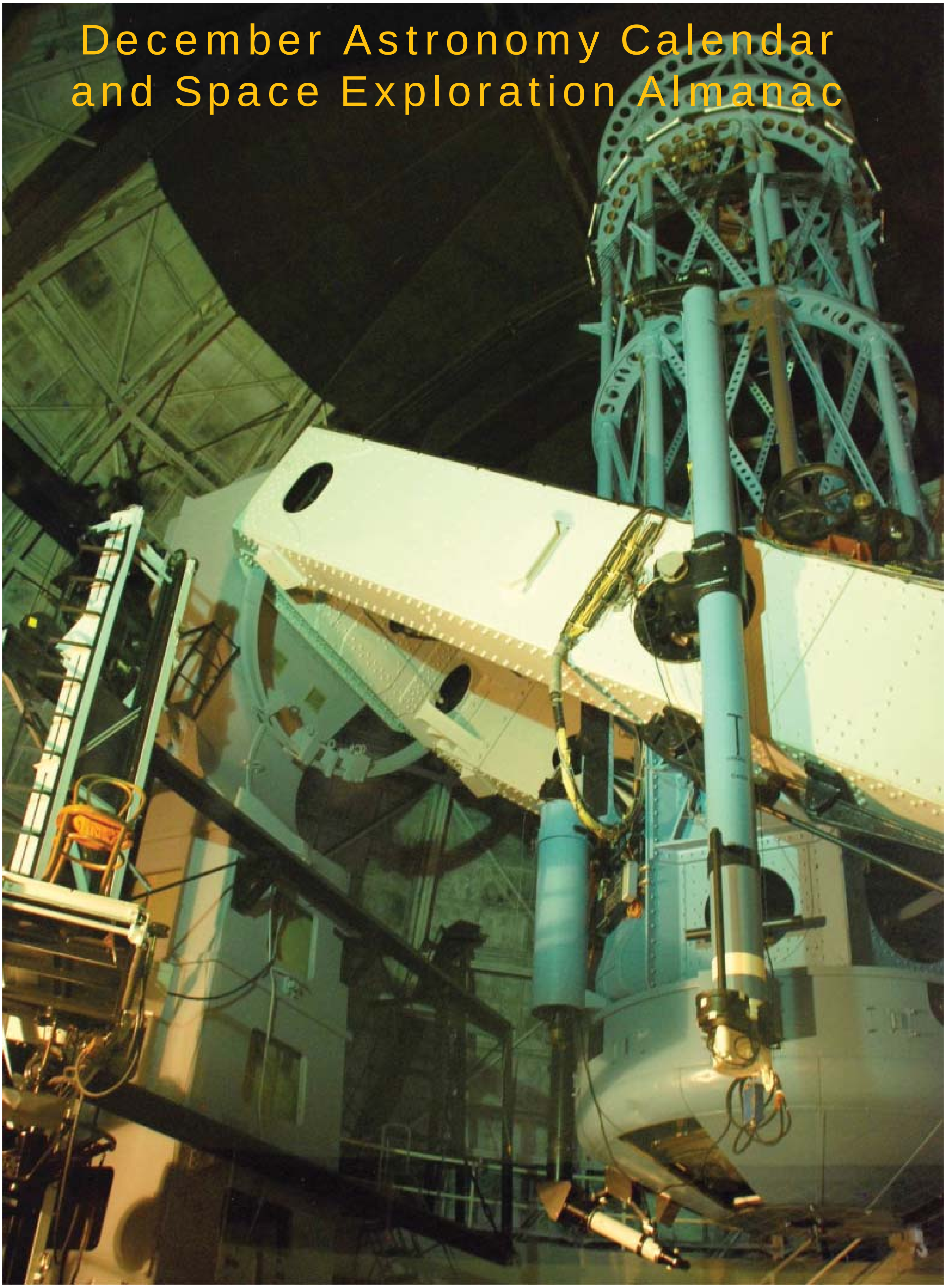
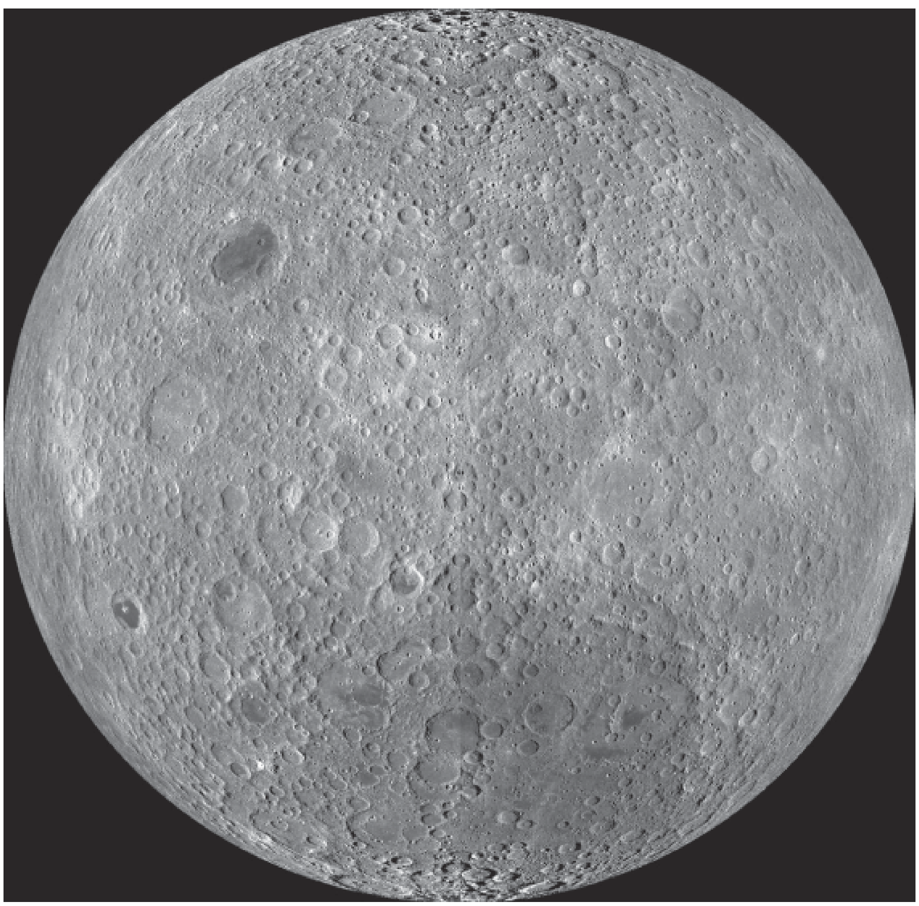


IT’S BEEN MORE than 40 years since we left the last footprint on the dusty lunar surface. Sadly, as a nation founded on exploration and the conquest of new frontiers, we appear to have lost our will to lead as a space-faring nation. But, what if the average citizen had the means to visit our only natural 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).

In the eons since the Moon was formed from an orbiting ring of rocky debris, the gravitational tidal forces of the two bodies have been at work. Over time the Earth’s tidal forces have slowed the Moon’s rotational rate so that its orbital period and rotational period are in sync (approximately 28 days). The Moon has also slowed the rotational rate of Earth but its effects are not as noticeable.

As a result of tidal locking (or synchronous rotation), the Moon only presents one side to Earth. It wasn’t until October 1959 that we were able to view the far side of the Moon for the first time when the Soviet Union’s Luna 3 spacecraft sent back 29 grainy photographs from a distance of approximately 40,000 miles in a lunar flyby.

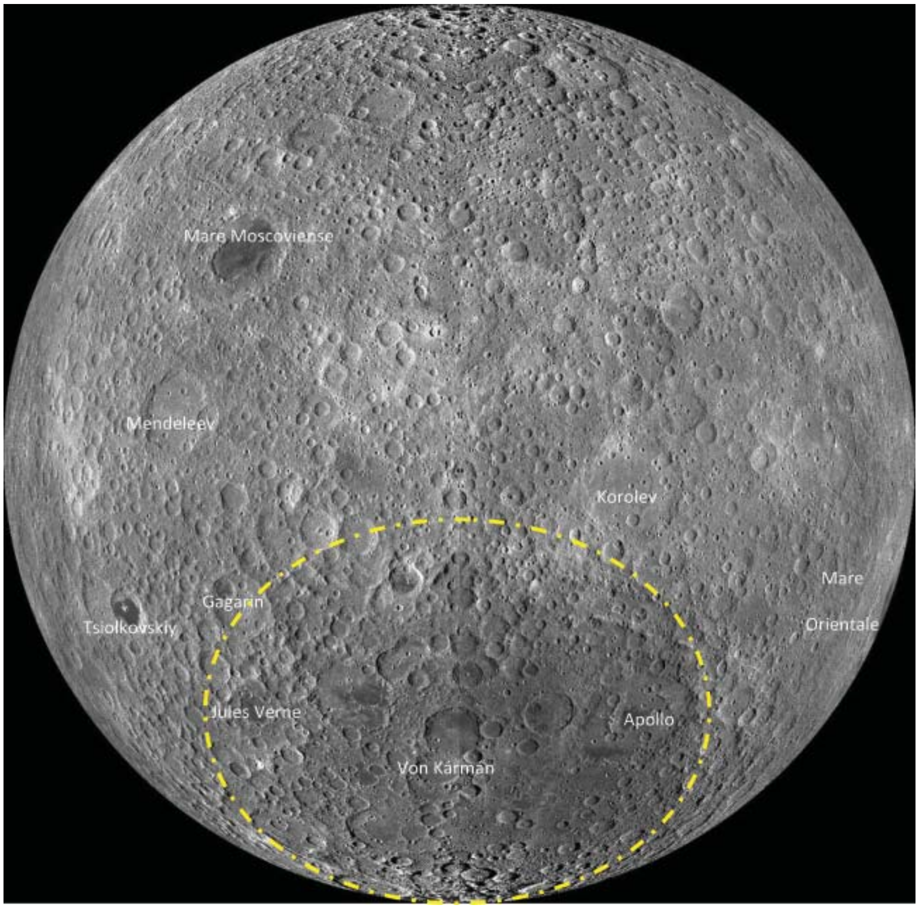
Nine years later, on Christmas Eve, the crew of Apollo 8 became the first humans to look down upon the crater-covered far side. Since then, a fleet of multinational spacecraft have surveyed this yet-unvisited terrain, allowing detailed maps to be produced, including the mosaics in this article from the Lunar Reconnaissance Orbiter (LRO).


Far Side of the Moon LRO Mosaic
Image credit: NASA/GSFC/Arizona State University

The most striking difference in the two sides of the Moon is the absence of large lava flows or maria on the far side. This may be due to the overall higher crustal thickness of the far side (limiting magma intrusion), as measured by the GRAIL gravity-measuring space crafts. The largest mare on the far side is Mare Moscoviense (Sea of Moscow). This relatively young mare lava flow fills the 130 mile (210 km) diameter inner ring of the ancient Moscoviense impact basin and spills into a portion of the outer ring. GRAIL measurements indicate that little or no crust remains at the Moscoviense impact site, in contrast to other regions of the far side where the crust exceeds 35 miles (60 km) in thickness.

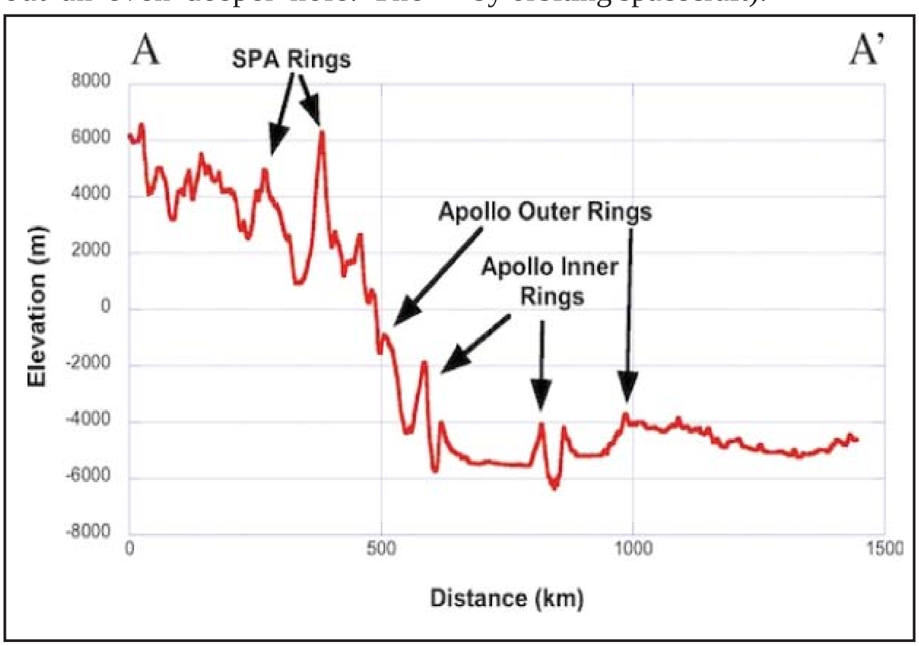
First imaged by the Soviet Union, the features on the far side acknowledge many Russian historical figures including Sergei Korolev, the “Chief Designer” of the Soviet space/Moon program, Konstantin Tsiolkovsky, scientist, inventor and father of Russian rocketry and space travel theory, Dimitri Mendeleev, chemist and creator of the periodic table of elements, and Yuri Gagarin, Soviet pilot, cosmonaut and first human to journey to space when he orbited the Earth on a flight lasting 108 minutes in April 1961.

The largest impact basin (basins are craters larger than 200 to 250 miles, or 300 to 400 km in diameter) on the Moon, and one of the largest in the solar system is the South Pole-Aitken basin. The impact excavated a crater almost 1,500 miles (2,600 km) across and more than 5 miles (8 km) deep. The asteroid penetrated the crust and likely the Moon’s upper mantle. Heat from the impact melted the excavated rock,



creating the floor of the basin. The number of smaller craters present on its floor indicate that the basin is one of the oldest on the Moon.

A subsequent impact within the confines of the basin carved out an even deeper hole. The Apollo crater measures 300 miles (500 km) across. Scientists believe that areas of the excavation may have exposed the Moon's lower mantle (based upon the iron content of the impact melt as measured by orbiting spacecraft).



Elevation Profile of Apollo Crater Japan Aerospace Exploration Agency/NASA

The names adopted by the International Astronomical Union for lunar features in and around the Apollo crater are unique in that they recognize living personalities (the crew of Apollo 8). The region also honors fallen U.S. astronauts (Mare Moscoviense recognize fallen Russian cosmonauts). The names of those individuals recognized for their accomplishment (Apollo 8) and ultimate sacrifice are color coded on the following close-up of the crater.

Crew of Apollo 8 (first to circumnavigate the Moon in December 24, 1968)

- Frank Borman
- William A. Anders
- James A. Lovell

Crew of Apollo 1 (lost in fire on the pad)

- Virgil I. "Gus" Grissom
- Edward H. White II
- Roger B. Chaffee

Crew of the Space Shuttle Challenger (lost shortly after liftoff on January 28, 1986)

- Michael J. Smith
- Dick Scobee
- Ronald McNair
- Ellison Onizuka
- Christa McAuliffe
- Gregory Jarvis
- Judith Resnik

Crew of the Space Shuttle Columbia (lost on reentry February 1, 2003)

- Rick D. Husband
- William C. McCool
- Michael P. Anderson
- Kalpana Chawla
- David M. Brown
- Laurel Clark
- Ilan Ramon

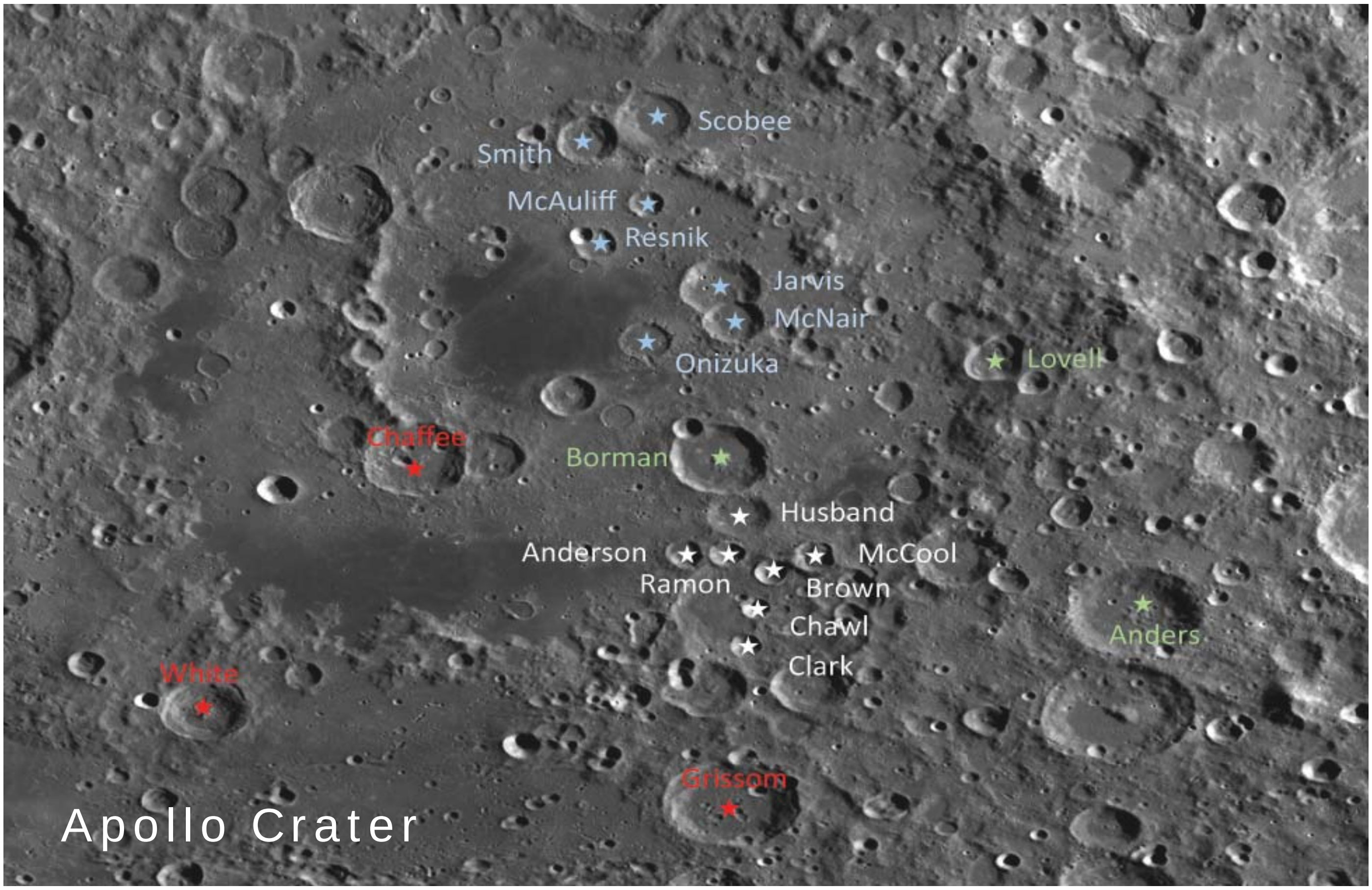
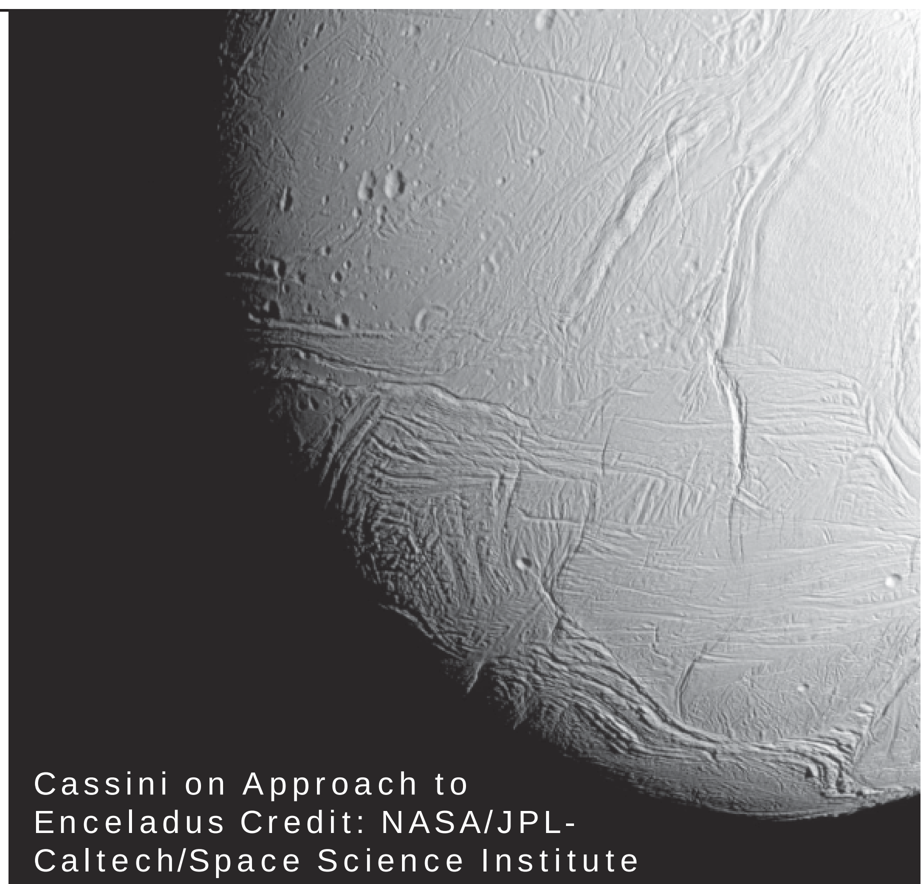


Image credit: NASA/GSFC/Arizona State University

Close Encounters with Enceladus

As the Cassini mission winds down, project scientists have been vying for one last look at several high-value targets within Saturn's mini solar system. On October 14th, Cassini flew within 1,142 miles (1,839 km) of the north pole of the icy moon Enceladus to look for evidence that the northern polar region might have been active in the past. Two weeks later, the spacecraft executed an even closer pass of the moon's south pole. Skimming within 30 miles (49 km) of the surface, Cassini flew through the watery jets erupting from fissures in the ice. This allowed the spacecraft's instruments to analyze the jet's composition (and that of the subsurface ocean). The last targeted encounter of the mission will be on December 19th when Cassini


Cassini on Approach to Enceladus Credit: NASA/JPL-Caltech/Space Science Institute

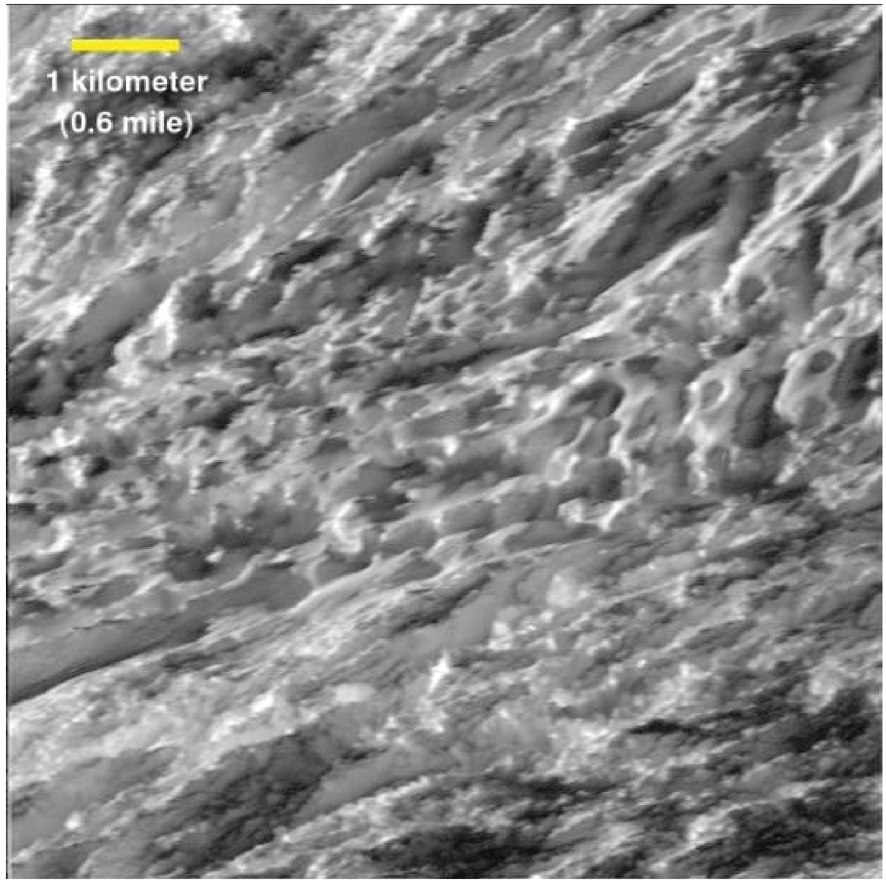
passes within 3,106 miles (4,999 km) of Enceladus, Scientists expect to gather additional information on the heat flow from the moon's interior and its role in powering the watery jets.

Tethys Revisited

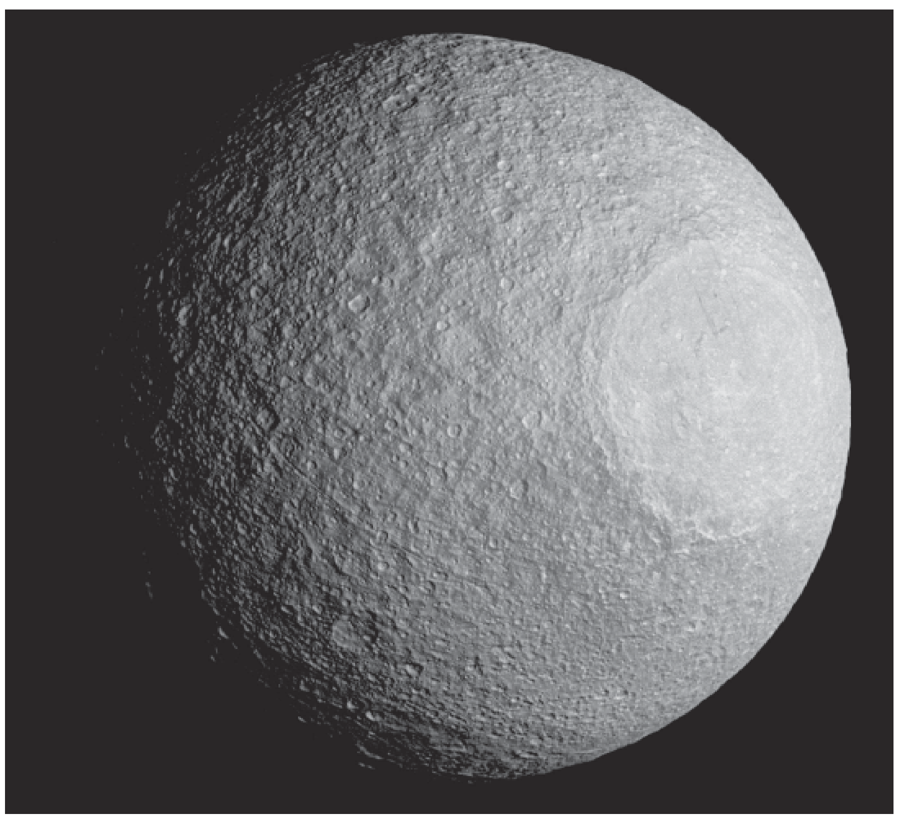
Enceladus isn't the only moon of Saturn that has captured scientists' imagination. Only 662 miles (1,066 km) in diameter, Tethys' landscape is unmatched. A planetary scar, Odysseus Crater is almost 250 miles (400 km) in diameter, nearly two-fifths of Tethys' diameter. That the moon survived such a collision and not shatter suggests that the interior of Tethys was partially molten at the time of the impact. A large valley, Ithaca Chasma, extends 1,200 miles, across the moon's icy surface. Sixty miles (100 km) in width, and two to three miles (3 to 5 km) deep, the graben runs from the moon's north pole to its south pole, dividing the icy world. Theories on its formation include the expansion of liquid water as it froze in the moon's interior and the result of the Odysseus impact. The density of Tethys (0.97 times that of liquid water) suggests that the moon is almost entirely water ice with a smattering of rock.

Deepening the mystery of Tethys are some unusual markings that had been spotted during flybys of the moon earlier this year. Described as reddish streaks or arcs, the markings became the focus of a November 11th flyby.

The reddish steaks are several hundred miles in length but only a few miles across. They appear to be relatively young, as they cut across older features. Theories on their origin include chemical impurities in the ice, but the markings are unique among Saturn's moons.

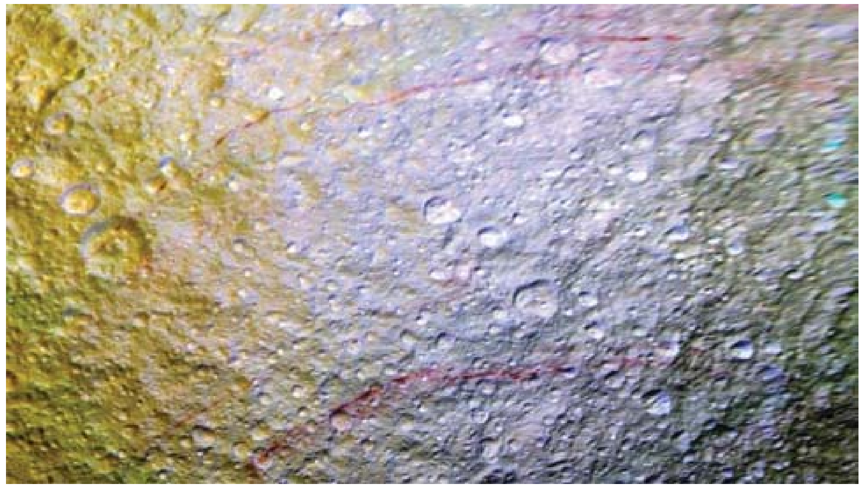


Enceladus Icy Terrain from 77 Miles (124 km)
Credit: NASA/JPL-Caltech/Space Science Institute



Tethys and the Odysseus Impact Basin
Credit: NASA/JPL-Caltech/Space Science Institute

The surface of Jupiter's moon Europa is crisscrossed with reddish streaks that are believed to have been created by salt deposits (from the subsurface ocean), altered by radiation to form sulfurous compounds. Like Europa, Tethys orbits deep within its planet's magnetosphere, exposing the moon to a bombardment of charged particles (electrons and ions). Scientists are hopeful that the November flyby of Tethys will provide clues as to the marking's origin and composition.



Red Arcs on Tethys (enhanced color image)
Credit: NASA/JPL-Caltech/Space Science Institute

SpaceX Returns to Flight

SpaceX has been working to get back to a normal flight schedule since a Falcon 9 rocket broke apart shortly after launch on June 28th. While the company has not released any details, it has tentatively scheduled two launches in December from the Cape Canaveral Air Force Station (an Orbcomm communications satellite and a SES 9 communications satellite).

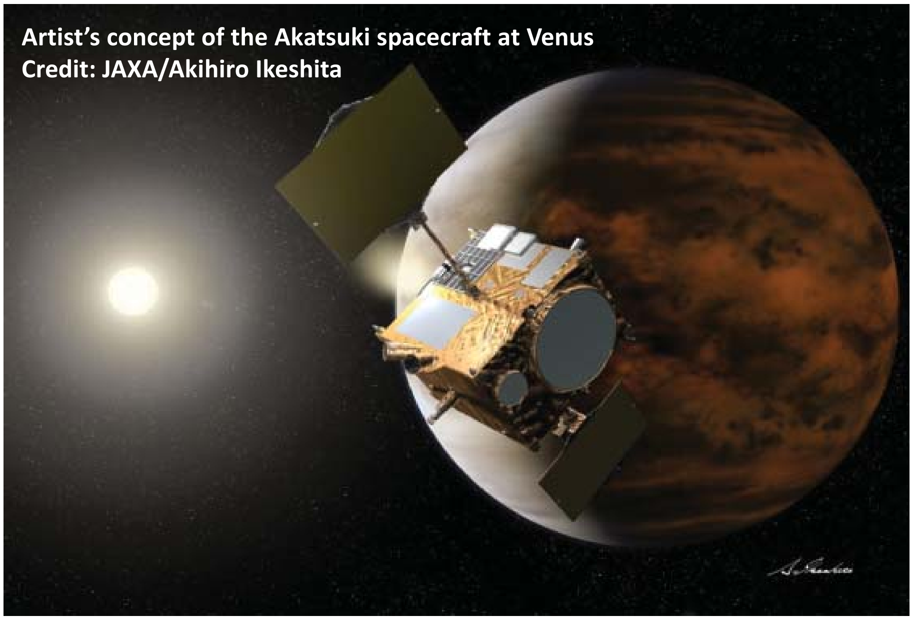
The private rocket company recently received a boost of confidence when NASA awarded SpaceX a "Commercial Crew Transportation Capability" contract (Boeing previously received a similar contract). The contract includes a minimum of two and a maximum of six missions for the transport of up to four NASA or NASA sponsored crew members to the International Space Station (ISS). The spacecraft(s) will remain on station at the ISS for up to 210 days.

The contracts are contingent upon both companies completing the certification process (certifying their vehicles for human transport). The first manned flights to the station are tentatively scheduled for 2017. Currently, NASA astronauts must rely upon the Russian Federal Space Agency for access to the ISS (at approximately $71 million per person per seat).

Taking the Long Way

Five years ago, on approach to Venus, the main engine of the Japanese spacecraft Akatsuki overheated due to a suspected blockage in the propulsion system and had to be shut down. Since then, Akatsuki has been traveling the inner solar system as engineers worked through options to salvage the mission. On December 7th, as the spacecraft nears Venus once again, the Japan Aerospace Exploration Agency plans to use the spacecraft's smaller attitude control thrusters to slow the spacecraft enough to be captured by Venus' gravity.

Despite being exposed to higher than design temperatures in its travels around the Sun, the spacecraft's instruments appear to have survived the long hiatus. If orbit insertion is successful, Akatsuki's will orbit Venus once every eight to ten days (as compared to the original mission's planned for 30-hour orbit). The spacecraft was designed to study the weather on Venus including the cloud structure in the planet's upper atmosphere and the distribution of water vapor and carbon monoxide in the lower atmosphere. Akatsuki will also be looking for signs of lightning on the planet's night side.



Artist's concept of the Akatsuki spacecraft at Venus
Credit: JAXA/Akihiro Ikeshita

Future Mars Missions

The orbits of Mars and the Earth bring the two planets into alignment (opposition) every 26 months or so. With an opposition in May 2016, NASA is targeting the launch of its next Mars mission for March (with landing in September). The InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) lander is a NASA Discovery Program, designed to study the Red Planet's deep interior. The lander is similar in design to the one used on the successful Phoenix polar mission in 2007.

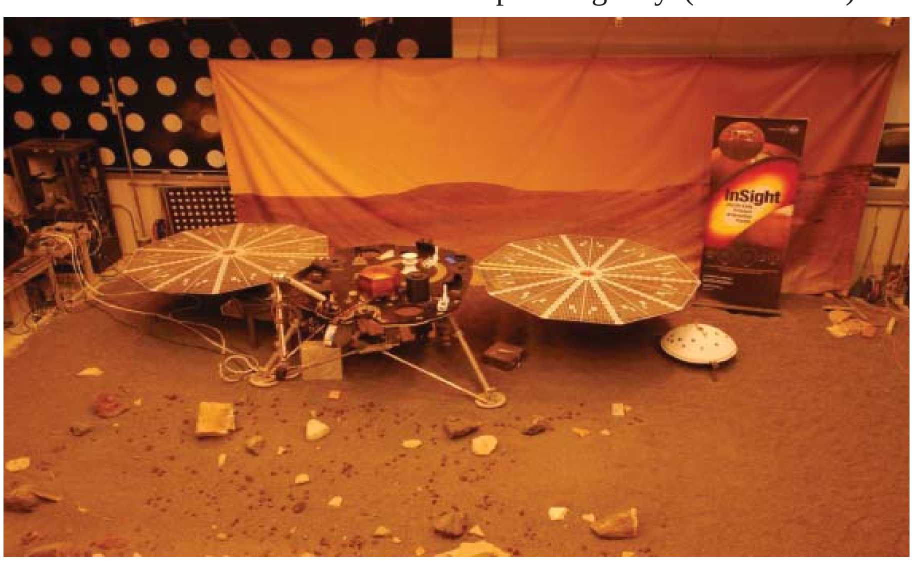
InSight's instruments will study the size, thickness, density and overall structure of the planet's core, mantle and crust. The solar-powered lander is equipped with a heat flow probe that can be hammered up to 16 feet (5 m) into the soil. The probe is designed to measure the heat coming from the planet's interior. InSight is also equipped with a seismometer to take precise measurements of quakes and other internal activity.

The European Space Agency (ESA) and the Russian Federal Space Agency (Roscosmos) are planning a mission that will include launches during the 2016 and 2018 oppositions. ExoMars (Exobiology on Mars) is an ambitious mission to search for biosignatures of Martian life, past or present. The mission will begin with the launch of the ExoMars Trace Gas Orbiter and Schiaparelli demonstration lander in March 2016 to be followed by the launch of a Roscosmos-built lander and ESA-built rover in May of 2018.

The Trace Gas Orbiter will map sources of methane and other gases on Mars. This information will facilitate the selection of the landing site for the ExoMars rover. ESA is currently studying four sites that show evidence of being modified by water in the distant past. The solar powered rover will be capable of taking subsurface soil samples (to a maximum depth of 6 feet or 2 meters) and analyzing their chemistry and spectral composition.

NASA is planning on taking advantage of the 2020 opposition to launch its next mobile science laboratory. Built on the successful Curiosity platform, the yet-unnamed rover will seek biosignatures of microbial life in the Martian rock. Included in the rover's payload is the Mars Oxygen ISRU Experiment (MOXIE). MOXIE is a 1% scale model of an oxygen processing plant that could be used to support a future human expedition (e.g., for propellant, breathing air, water production, etc.).

Mars 2020 will build upon the experience of the Curiosity rover in its exploration of Gale Crater and Mount Sharp. For example, the rover has six, individually powered, aluminum wheels. Several of the wheels have experienced damage and excessive wear from the rugged terrain at the landing site.



InSight Testbed Photo: Bill Cloutier

In addition to a fully equipped Mars Science Laboratory rover available for testing command sequences and troubleshooting operational anomalies in JPL's Mars Yard, there is Scarecrow, a full-sized version of the platform and driving equipment. Scarecrow has been configured to exert the same pressure on the wheels for mobility testing. Damage of the rover's 20 inch (50 cm) aluminum wheels (punctures and tears) has been, to date, confined to the 1/32 inch (0.75 mm) thick aluminum skin between the treads or grousers. Testing results will be used to extend the life of Curiosity's wheels as well as those on future missions.

Conor Cloutier and Scarecrow
Photo: Bill Cloutier

Conor Cloutier and a Damaged Test Wheel
Photo: Bill Cloutier

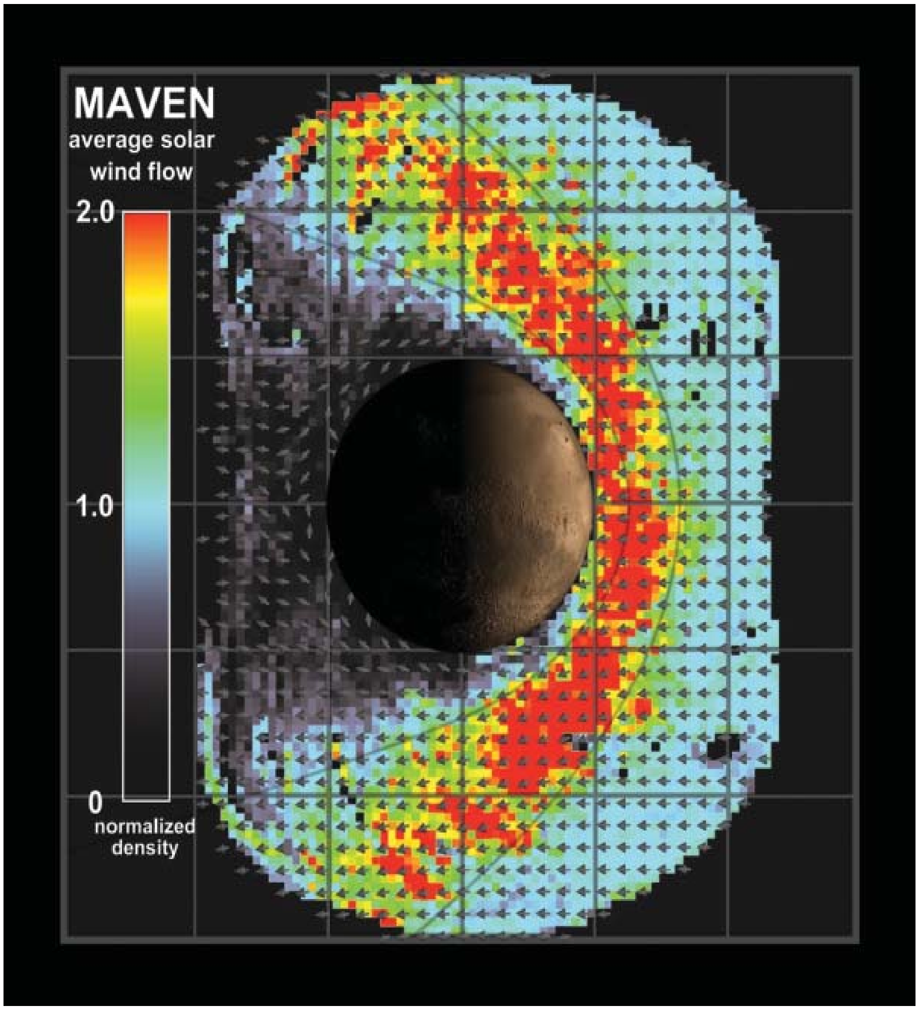
Maven and the Disappearing Martian Atmosphere

The Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft has been studying the space around Mars since arriving on orbit in September 2014. Scientists believe - and the data collected by both orbiters and rovers confirms - that the climate of Mars was much different in the distant past with running rivers and semi-permanent lakes. The planet's current atmosphere is much too thin and cold for water to remain a liquid on the surface. For such a change, Mars would have had to lose much of its atmosphere. MAVEN was designed to quantify the current loss and identify those processes by which the atmosphere has been removed.

The information being collected by the spacecraft points to the Sun's role in the erosion of the Martian atmosphere. The solar wind (a stream of protons and electrons flowing from the Sun's atmosphere at an average speed of 1 million miles an hour) removes approximately 100 grams (¼ pound) of gas every second. The rate of loss is higher (10 to 20 times) during solar storms and was likely even higher billions of years ago when a young Sun was more active.

Earth has a global magnetic field that deflects the solar wind; Mars does not. When the solar wind slams into the Martian atmosphere, a bow shock is created (a stationary shock wave). During solar storms, the inner boundary of the bow shock pushes deeper into the atmosphere, accelerating the erosion process.

Data returned from MAVEN indicates that 75% of the atmosphere escaping to space comes from the tail (where the solar wind flows behind Mars) and 25% from the plume above the planet's polar regions. Projecting the current rate of atmospheric losses back in time supports a much thicker atmosphere on a much younger Mars.



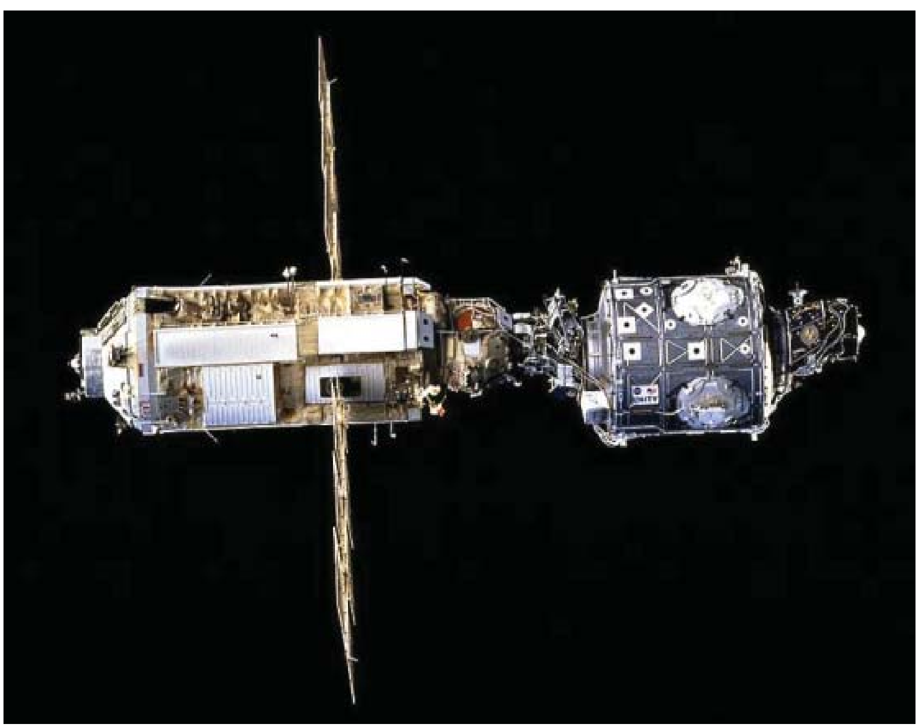
Bow Shock Created by the Solar Wind Around Mars
Credit: NASA's Scientific Visualization Studio and the MAVEN Science Team

First Construction Flight

In December 1998, the space shuttle Endeavour carried the first American component of what would become the International Space Station into orbit. The six crew members mated the Unity module with the Russian Zarya control module already on orbit.

During three spacewalks, Endeavour's astronauts joined cables and other connectors between the two modules. The astronauts were also able to power up the two modules upon entry. This mission represented the first on-orbit construction flight and the first small step in what would become a 450 ton habitat covering the area of a football field. Thirteen years later, Endeavor would return to the station for the final shuttle mission, delivering the Alpha Magnetic Spectrometer physics experiment.

Endeavour was also instrumental in the on-orbit repair of the Hubble Space Telescope. In 1993, the shuttle crew conducted the first and most critical repair mission, correcting the optics, replacing the solar arrays and upgrading the wide field planetary camera.



Zarya Module (left) and Unity Module (right). Credit: NASA

Spaceship Earth and the Blue Marble

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

Purchasing a Telescope

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

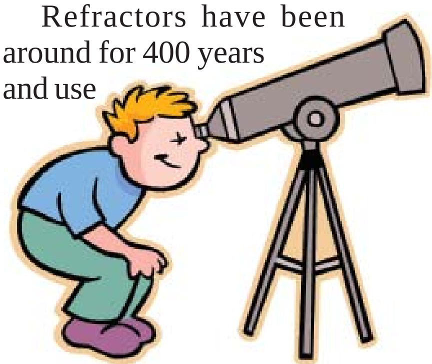
There is no perfect telescope for everyone. An inexpensive, mass-produced telescope that gets carted out of the house and set up every clear night, stimulates the users' imagination and encourages them to push the instrument's capabilities to its limits is far more valuable than the most highly crafted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

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

Types of Telescopes

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

Refractors have been around for 400 years and use



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

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

The most popular compound or catadioptric telescopes combine a large, rear spherical mirror with a front corrector lens to create a very compact optical tube. Companies such as Meade and

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

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

Aperture

Aperture refers to the size of the largest lens or mirror in the telescope, for example, the primary mirror in an 8-inch reflector is 8-inches in diameter. As a general rule, bigger is better, as light gathering and resolution increase with the size of the optics. However, as with everything else, there are other considerations that limit the practical size of a particular instrument. Alvan Clark & Sons figured the 40-inch lens for the Yerkes Observatory's refractor, delivering the lens in 1897. More than 100 years later, it is still the world's largest working refractor. Why? The weight of the glass and the complexities in supporting a large lens by its edge and the absorption of light passing through the glass were factors; however, the refractor was ultimately done in by Sir Isaac Newton when he built the first reflecting telescope in 1668. Mirrors, unlike lenses, can be completely supported from the back. Since light does not pass through the glass, reflected images do not suffer from "chromatic aberration."

Today single mirrors are routinely produced with diameters exceeding 28 feet and telescopes are constructed combining multiple mirrors to achieve even larger light gathering capabilities. So what size is good for you? Before you answer, you may want to consider:

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

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

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

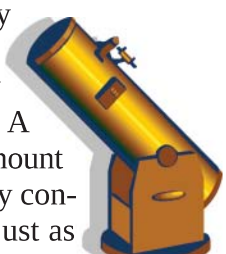
Magnification

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

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

Mounts

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



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).

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

Go-To

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

What to Do

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

December History

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

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

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

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

be washed out in the glare from a higher Sun.

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

The Apollo 8 astronauts were also the first humans to leave Earth orbit and pass through the Van Allen radiation belts that extend up to 15,000 miles from Earth. To accomplish the mission, Apollo 8 had to cross the 240,000 mile void between the Earth and the Moon with sufficient precision so as to intercept the Moon (traveling at 2,300 miles an hour through space) just 69 miles above the lunar surface. By successfully doing so, the astronauts were the first humans to witness the rising of the Earth above the Moon's horizon (Earthrise). They would also be the first to return to Earth and reenter the atmosphere at a speed of 25,000 miles an hour.

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

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

December Nights

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

Sunrise and Sunset (New Milford, CT)

Sun	Sunrise	Sunset
December 1st (EST)	07:01	16:24
December 15th	06:13	16:24
December 31st	07:20	16:33

Astronomical and Historical Events

1st Kuiper Belt Object 2006 QH181 at Opposition (82.373 AU)
1st History: launch of Soviet satellite Sputnik 6 and two dogs: Pchelka and Mushka (1960)
2nd Apollo Asteroid 25143 *Itokawa* closest approach to Earth (0.689 AU); asteroid was target of Japan's spacecraft Hayabusa and sample return mission
2nd Kuiper Belt Object 145451 (2005 RM43) at Opposition (35.301 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: touchdown of Soviet Mars 3 lander: communications were lost with the lander, the first spacecraft to touch down on the Red Planet, after 20 seconds possibly due to raging dust storm (1971)
2nd History: launch of space shuttle Endeavour (STS-61), first servicing of the Hubble Space Telescope, including the installation of corrective optics and new solar panels (1993)
2nd History: Pioneer 11 spacecraft makes its closest approach to Jupiter; encounter redirects the spacecraft to Saturn and an escape trajectory out of the solar system (1974)

Astronomical and Historical Events (continued)

3rd Last Quarter Moon
3rd Scheduled launch of Orbital Sciences' Cygnus cargo freighter to the International Space Station aboard a United Launch Alliance Atlas 5 rocket from the Cape Canaveral Air Force Station, Florida
3rd Centaur Object 8405 *Asbolus* at Opposition (18.632 AU)
3rd History: Pioneer 10 spacecraft makes its closest approach to Jupiter; first space probe to fly through the asteroid belt and to an outer planet (1973)
3rd History: discovery of Jupiter's moon *Himalia* by Charles Perrine (1904)
4th 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 Moon at apogee (furthest distance from Earth)
6th Distant flyby of Saturn's moons *Epimetheus*, *Atlas* and *Prometheus* by the Cassini spacecraft
6th Aten Asteroid 2010 TK7 (Earth Trojan) closest approach to Earth (0.198 AU)
7th Scheduled orbit insertion of the Japanese spacecraft Akatsuki around Venus
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 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 Plutino 84922 (2003 VS2) at Opposition (35.613 AU)
9th Asteroid 951 *Gaspra* closest approach to Earth; visited by the Galileo spacecraft on its way to Jupiter in October 1991 (0.988 AU)
9th Aten Asteroid 2011 YW10 Near-Earth Flyby (0.066 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 Plutino 307463 (2002 VU130) at Opposition (39.595 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 New Moon
11th Kuiper Belt Object 2004 XR190 at Opposition (56.501 AU)
12th Second Saturday Stars - 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 Centaur Object 154783 (2004 PA44) at Opposition (18.186 AU)
13th History: discovery of Saturn's moons *Fenrir* and *Bestla* by Scott Sheppard, et al's (2004)
13th History: Mt. Wilson's 100-inch telescope used to measure the first stellar diameter (Betelgeuse); measured by Francis Pease and Albert Michelson (1920)

Astronomical and Historical Events (continued)

13th History: First light of Mt. Wilson's 60-inch telescope (1908)
14th History: flyby of Venus by Mariner 2; first spacecraft to execute a successful encounter with another planet, finding cool cloud layers and an extremely hot surface (1962)
14th History: flyby of Mars by Japan's Nozomi spacecraft after an attempt to achieve orbit fails (2003)
14th History: creation of the Canadian Space Agency (1990)
14th History: Weston meteorite fall: first documented fall in the United States (1807); best coordinates for the fall are based upon investigative research by Monty Robson, Director of the McCarthy Observatory, published in 2009
14th History: birth of Tycho Brahe, Danish astronomer noted for his observational skills, the precision of his observations, and the instruments he developed; builder of Uraniburg, the finest observatory in Europe (1546)
15th Scheduled launch of the next Expedition crew to the International Space Station aboard a Russian Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan
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 Plutino 55638 (2002 VE95) at Opposition (28.417 AU)
16th History: launch of Pioneer 6, the first of four identical solar orbiting, spin-stabilized spacecraft (1965)
17th Distant flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
17th History: Project Mercury publicly announced (1958)
17th History: Wright Brothers' first airplane flight, Kitty Hawk, North Carolina (1903)
18th First Quarter Moon
19th Flyby of Saturn's moon *Enceladus* by the Cassini spacecraft
19th Distant flyby of Saturn's moons *Aegaeon* and *Calypso* by the Cassini spacecraft
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 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 Moon at perigee (closest distance from Earth)
21st Winter Solstice at 11:49 pm EST (December 22nd at 4:49 UTC)
21st Scheduled launch of a cargo-carrying Progress spacecraft to the International Space Station aboard a Russian Soyuz spacecraft from the Baikonur Cosmodrome, Kazakhstan
20th History: launch of the Active Cavity Radiometer Irradiance Monitor satellite (ACRIMSAT); designed to measure Sun's total solar irradiance (1999)
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 Plutino 2002 XV93 at Opposition (38.043 AU)
22nd Kuiper Belt Object 78799 (2002 XW93) at Opposition (44.392 AU)

Astronomical and Historical Events (continued)

22nd History: discovery of the Mars meteorite LEW 88516 (1988)
23rd Apollo Asteroid 1995 YR1 Near-Earth Flyby (0.043 AU)
23rd History: discovery of Saturn's moon *Rhea* by Giovanni Cassini (1672)
24th Aten Asteroid 2011 YD29 Near-Earth Flyby (0.025 AU)
24th Aten Asteroid 163899 (2003 SD220) Near-Earth Flyby (0.073 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 launcher to serve the commercial market (1979)
25th Full Moon
25th Asteroid 27 *Euterpe* at Opposition (8.3 Magnitude)
25th Apollo Asteroid 2003 YL118 Near-Earth Flyby (0.095 AU)
25th Aten Asteroid 2010 YO Near-Earth Flyby (0.099 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 Aten Asteroid 310442 (2000 CH59) Near-Earth Flyby (0.071 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 History: discovery of the ALH84001 Martian meteorite in the Allan Hills, Far Western Icefield, Antarctica, made famous by the announcement of the discovery of evidence for primitive Martian bacterial life (1984)
27th History: Johannes Kepler born, German mathematician and astronomer who postulated that the Earth and planets travel about the sun in elliptical orbits, developed three fundamental laws of planetary motion (1571)
29th Mercury at its Greatest Eastern Elongation; apparent separation from the Sun in the evening sky (20°)
30th History: Army Air Corp Captain Albert William Stevens takes first photo showing the Earth's curvature (1930)
30th History: flyby of Jupiter by Cassini spacecraft on mission to Saturn (2000)
30th History: discovery of Uranus' moon *Puck* by Stephen Synnott (1985)
31st Distant flyby of Saturn's moon *Rhea* by the Cassini spacecraft
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.
- 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
- 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

International Space Station/Space Shuttle/Iridium Satellites

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

Solar Activity

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

Image Credits

Front page design and graphic calendars: Allan Ostergren

Cover image: First viewed in 1826 by Scottish astronomer James Dunlop in New South Wales, the galaxy Centaurus A is a bright beacon for amateur observers from its parent constellation in the southern sky. But in repeated visits with ever more powerful lenses, the galaxy has revealed more disturbing secrets of its complex evolution.

Born perhaps in a collision between a lenticular (disc shaped) galaxy and a spiral galaxy, the resulting melee has become a proving ground for astronomical forces and theories. A supermassive black hole equivalent to the mass of 55 million of our suns lurks at the center and is emitting X–rays and radio waves at a velocity of half the speed of light across a distance of a million light years.

The relative energy of the X–rays increases from red to green and blue. The bulge in the image consists of "evolved" red stars in their last stage of existence, while the dusty disk in the center is a birthing ground for new star formation. The images, taken by the Chandra Observatory were assembled from data collected over a period of about 230 hours between 1999 and 2012.

Source: NASA/CXC/U.Birmingham/M.Burke et al.

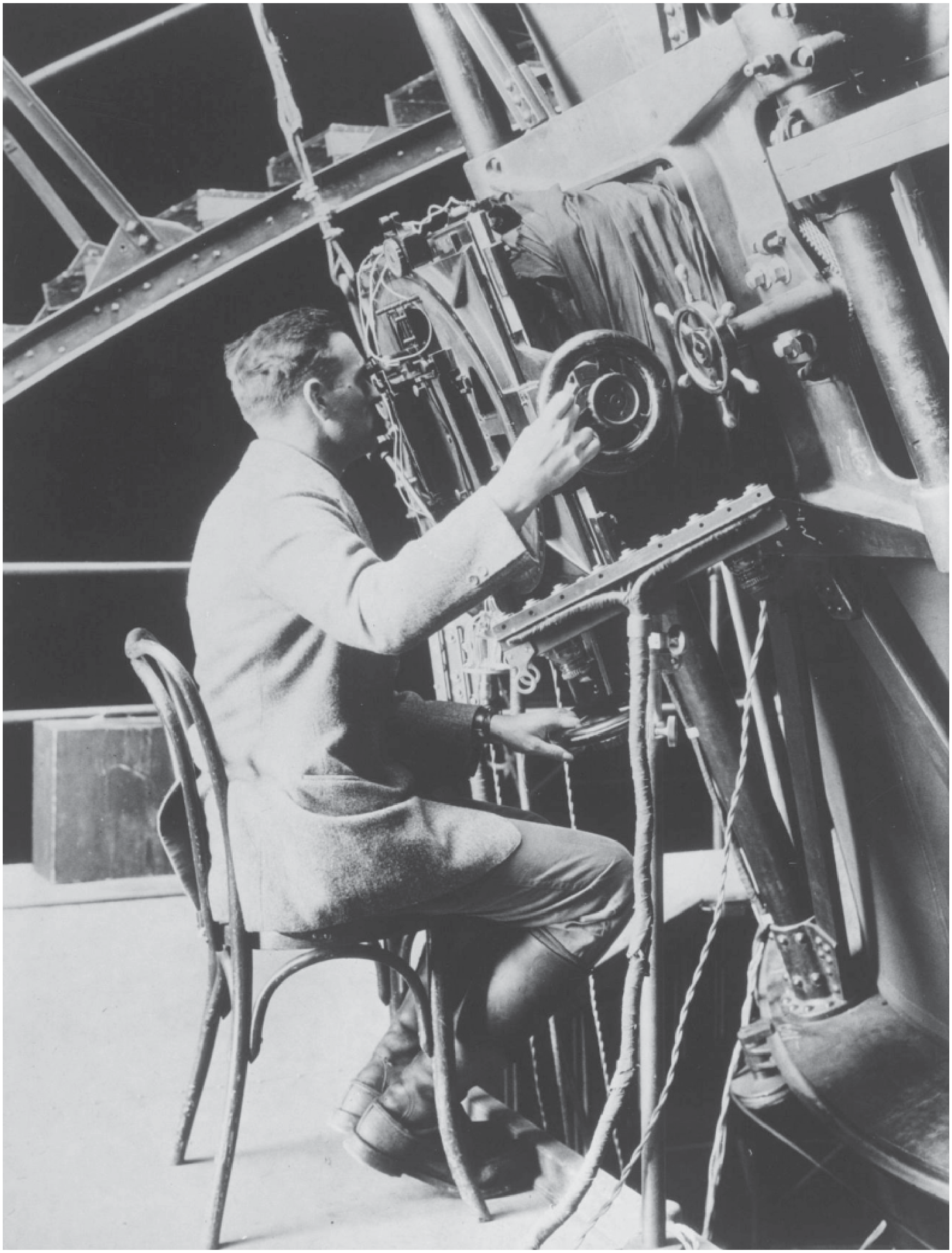
A giant X-Ray image of Centaurus A is displayed at McCarthy Observatory – inside a Chandra X-ray telescope mirror piece on the wall (made especially for JJMO by the Chandra team at the Harvard Smithsonian in Cambridge). That mirror slice is the only one in existence.

Find out more about the Centaurus A imaging project at http://chandra.harvard.edu/photo/2014/cena/.

Page 3 graphic: The Hooker 100-Inch Telescope on Mount Wilson. Note the bentwood chair on the platform in the lower left of the photo. The chair was used by astronomer Edwin Hubble during observing sessions with the 100-Inch telescope (see photo on next page)

Photo: Bill Cloutier

Second Saturday Stars poster: Marc Polansky



Astronomer Edwin Hubble at the telescope circa 1922
Credit: Edwin Hubble Papers/Courtesy of Huntington Library, San Marino, California

Second Saturday Stars

FREE EVENT

Every Month at the

John J. McCarthy Observatory

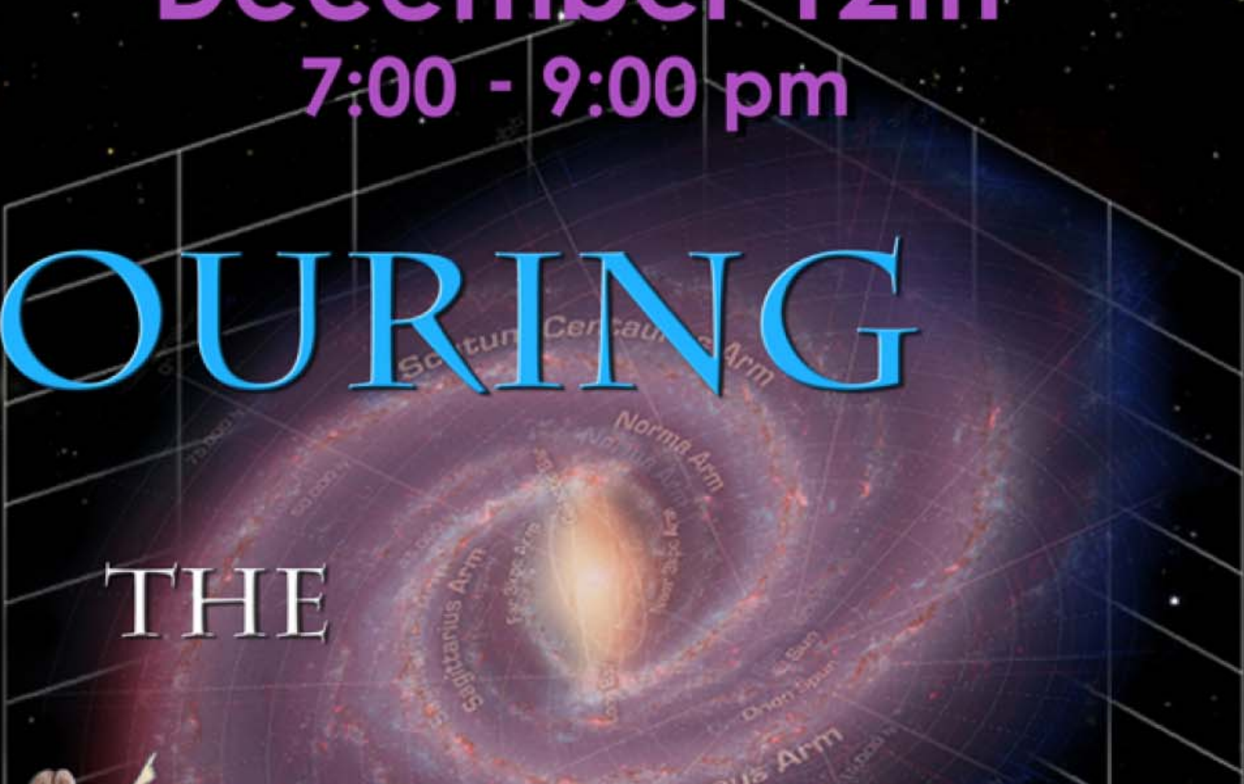
Behind the New Milford High School

860.946.0312

www.mccarthyobservatory.org

December 12th

7:00 - 9:00 pm



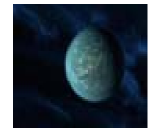
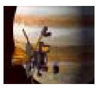
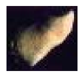
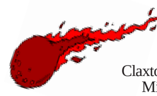
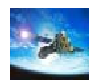
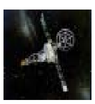
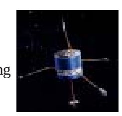
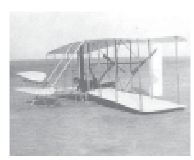
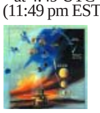
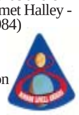
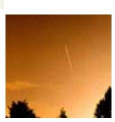
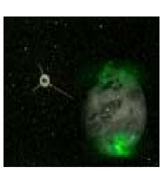
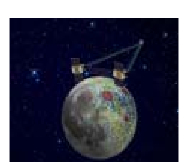
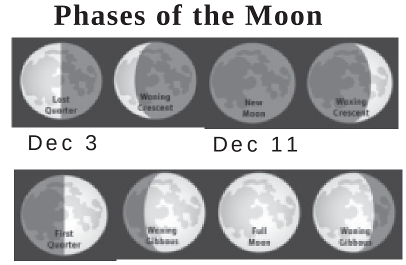
TOURING THE MILKY WAY IN 3D

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

Map

December 2015

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  Gemini 7 launch - Borman/Lovell (1965) Launch of Pathfinder spacecraft to Mars (1996)  Pioneer orbits Venus to study atmosphere (1978) Launch of Little Joe 2 rocket, test flight for the Mercury capsule with Sam, a Rhesus monkey (1959)	5 Moon at apogee (farthest from Earth)  Discovery of Kepler-22b, by NASA's Kepler Space Telescope in the constellation of Cygnus - the first known transiting planet to orbit within the habitable zone of a Sun-like star (2011)
6  America's first attempt at putting a satellite into orbit failed as Vanguard TV3 rose only about four feet off a Cape Canaveral launch pad before crashing back down and exploding (1957)	7 Apollo 17 (Evans, Schmitt, Cernan) 1972 Gerard Kuiper born - proposed belt of minor planetary objects beyond Neptune (1905) Arrival of Galileo space probe at Jupiter (1995)  New Horizons spacecraft wakes up to prepare for its July 2015 encounter with the dwarf planet Pluto	8 Discovery of asteroid 5 Astraea by Karl Hencke (1845)  Galileo spacecraft 1[st] Earth flyby (1990) SpaceX Dragon, launched into low-Earth orbit, is recovered in the Pacific Ocean: first by a commercial company (2010)	9 Pioneer Venus 2 in orbit, 2nd to study planet's atmosphere (1978) Ausson meteorite fall, hits building in France (1858)  Asteroid 2011 WU4 Near-Earth Flyby (0.084 AU)	10 Launch of 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) Launch of XMM-Newton European X- Ray satellite (1999) 	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 Launch of Oscar, first amateur satellite (1961)  2nd Saturday Stars New Milford High School
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 Moon at perigee (closest distance to Earth) Winter Solstice at 4:49 UTC (11:49 pm EST) Launch of Soviet spacecraft Vega 2 to Venus and on to Comet Halley - (1984)  Apollo 8 (Borman, Lovell, Anders), first to circumnavigate the Moon - 1968  Launch of Luna 13, Soviet moon lander (1966)	22 Discovery of LEW 88516 meteorite -Martian origin (1988) Ursids meteor shower peak 	23  Discovery of Saturn's moon Rhea by Giovanni Cassini (1672)	24  inaugural launch of the Ariane rocket (1979) Jean-Louis Pons born - discoverer of comets (1761)  Deep Space Network created (1963)	25 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 3 Dec 11 Dec 18 Dec 25	