Galactic Observer

John J. McCarthy Observatory

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Carina Nebula: Pillars of Creation or Cradle of Doom?

Find out more on page 21.

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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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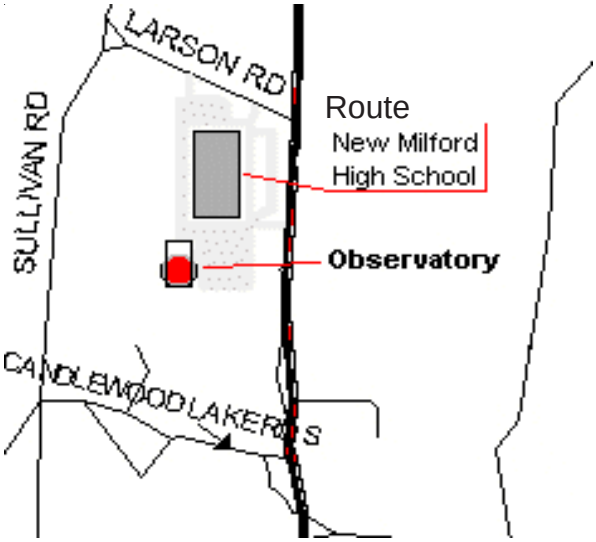

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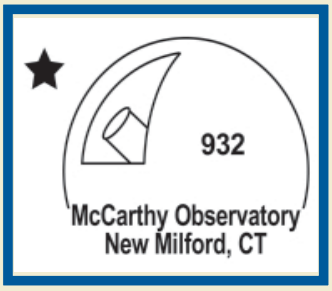
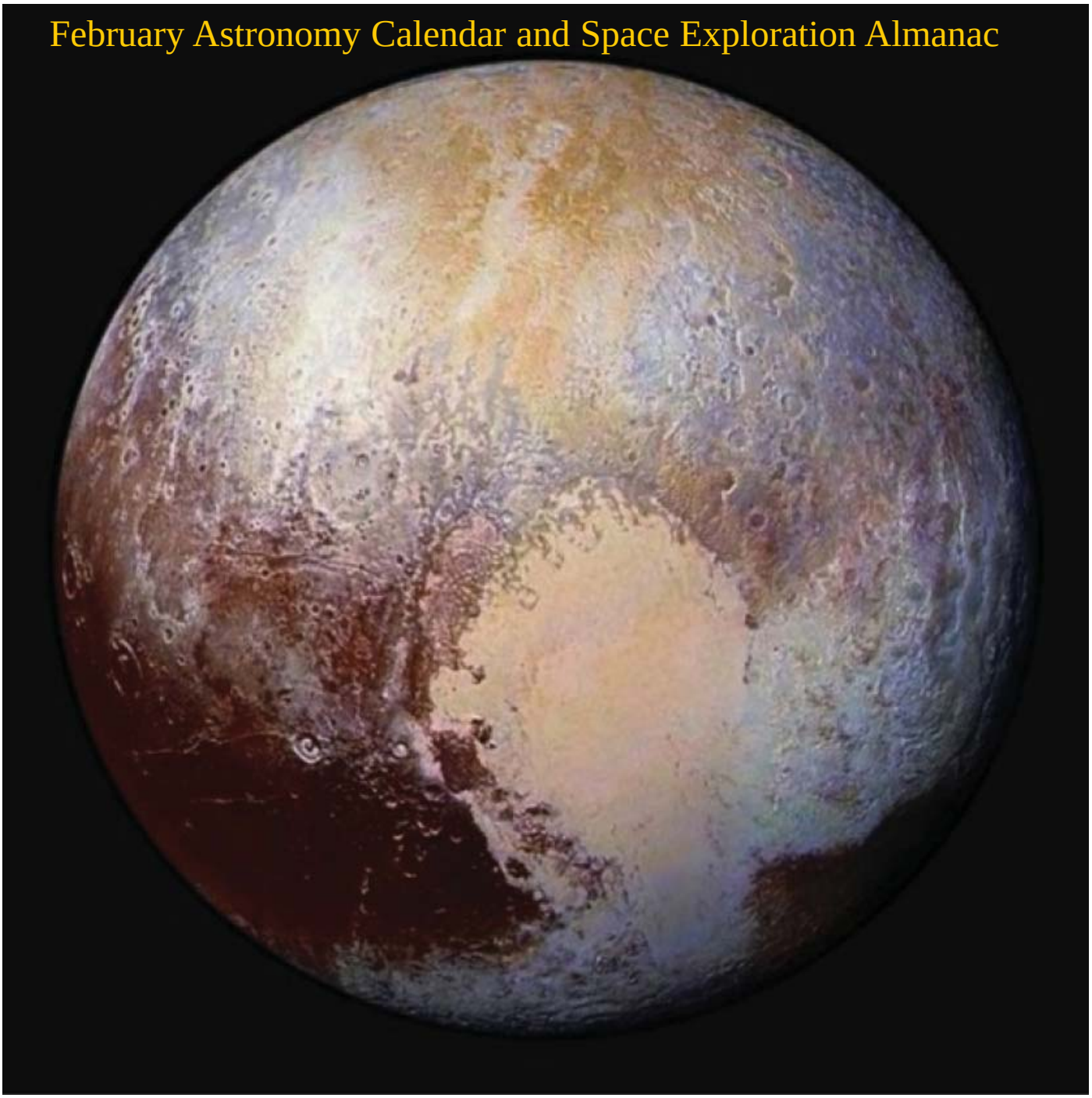


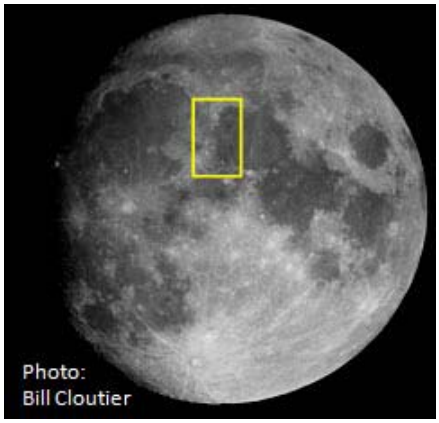


The Heart of Pluto Credits: NASA/JHUAPL/SwRI

The data gathered by New Horizons' instruments in the spacecraft's brief encounter with Pluto took 15 months to transmit across the breadth of the solar system. It was an early Tuesday morning in October when the last bits arrived at the Johns Hopkins Applied Physics Laboratory (APL) in Laurel, Maryland from NASA's Deep Space Network station in Canberra, Australia. With data banks cleared, the spacecraft is racing towards its next target, a small Kuiper Belt object (2014 MU69) which it is expected to reach on January 1, 2019. It has already traveled over 400 million miles (666 million km) since leaving the Pluto system in July 2015.

The western lobe of the heart-shaped feature (shown in the false-color image), informally named Sputnik Planitia, is a relatively deep, ice-filled basin. The ice is rich in frozen nitrogen, methane and carbon monoxide. The icy basin is located directly opposite Pluto's tidally-locked moon Charon.

IT'S BEEN ALMOST 45 years since we left the last footprint on the dusty lunar surface. Sadly, as a nation founded on exploration and the conquest of new frontiers, we appear to have lost our will to lead as a space-faring nation. But, what if the average citizen had the means to visit our only natural satellite; what would

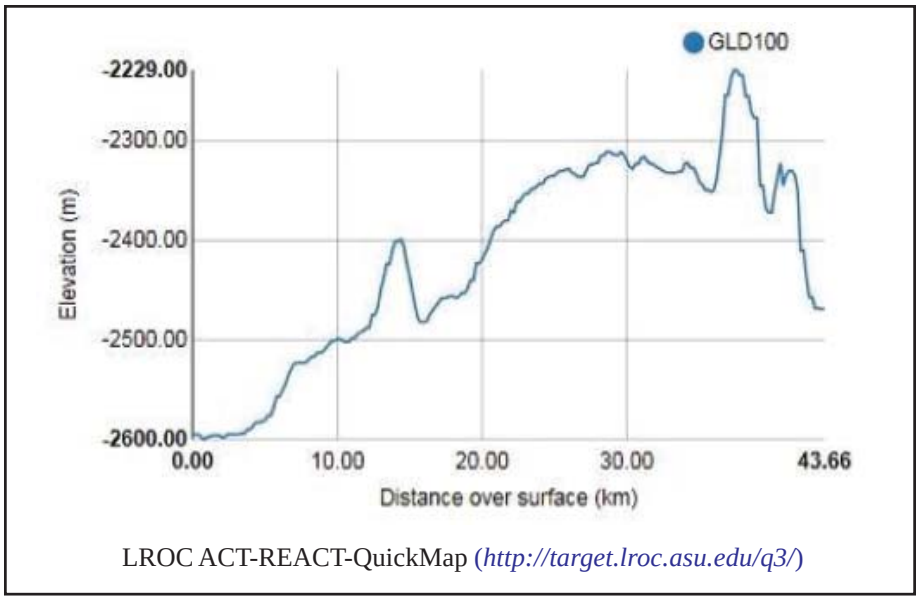


Lunar seas are actually expansive low-lying plains formed by ancient lava flows

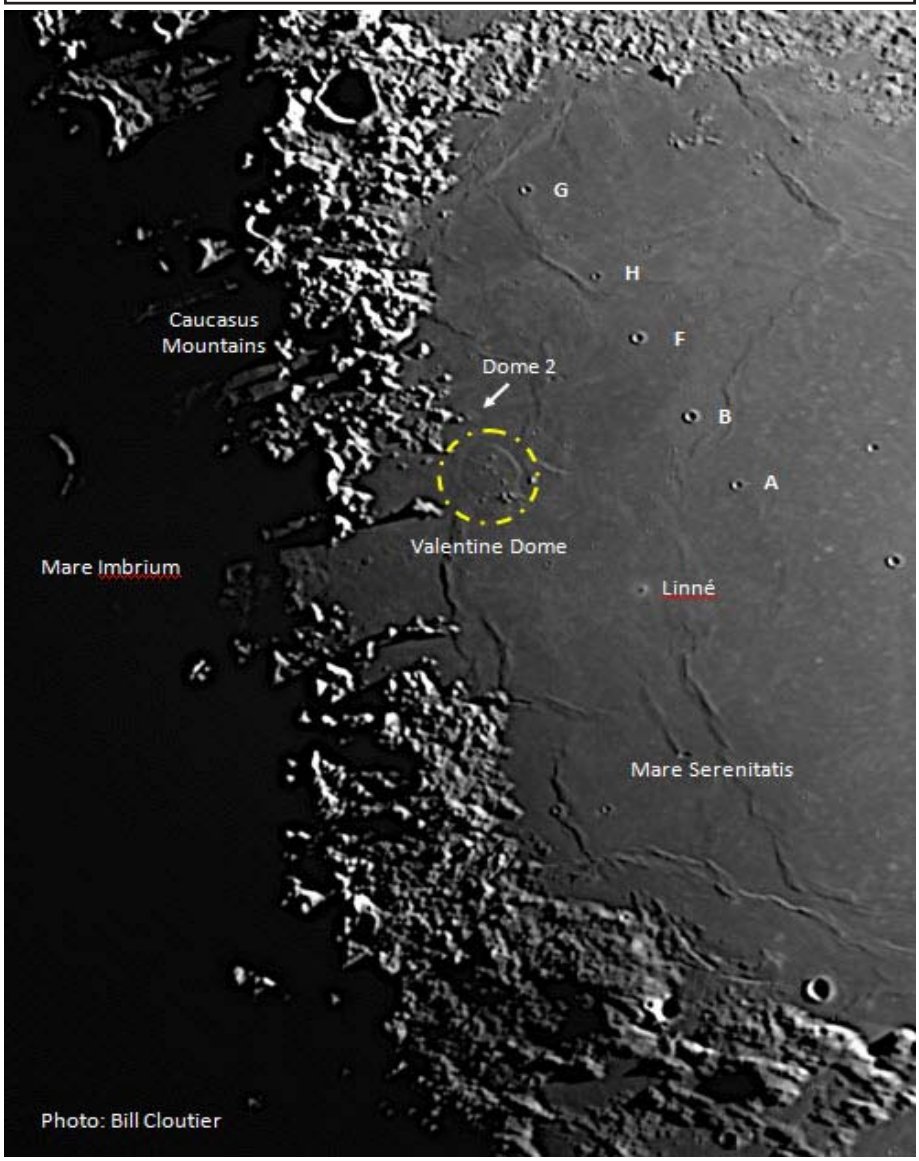
they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

A broad, low-profile lava dome is visible as the waxing Moon achieves first quarter phase on February 3rd and the Sun is low in the lunar sky. Valentine Dome is located along the northwestern shore of Mare Serenitatis (Sea of Serenity), along the Caucasus Mountains and just north of the breech into the Imbrium basin (30.9° latitude, 10.1° longitude). It is one of the largest domes visible on the lunar surface, measuring approximately 18.6 miles (30 km) across its heart-shaped surface.

Lava domes are volcanic protrusions created by an upwelling of magma. On average, the



LROC ACT-REACT-QuickMap (*http://target.lroc.asu.edu/q3/*)



Valentine Dome

top of the Valentine dome rises 400 feet (122 meter) above the adjacent mare. The dome's north-south profile (shown below) was generated from data collected by the Lunar Reconnaissance Orbiter. Older peaks poke through the surface of the dome; several are visible in the photo on the following page, as well as a faint rille (fissure) that traverses the dome in an east-west direction. A second, much smaller dome, lies just to the north of Valentine.

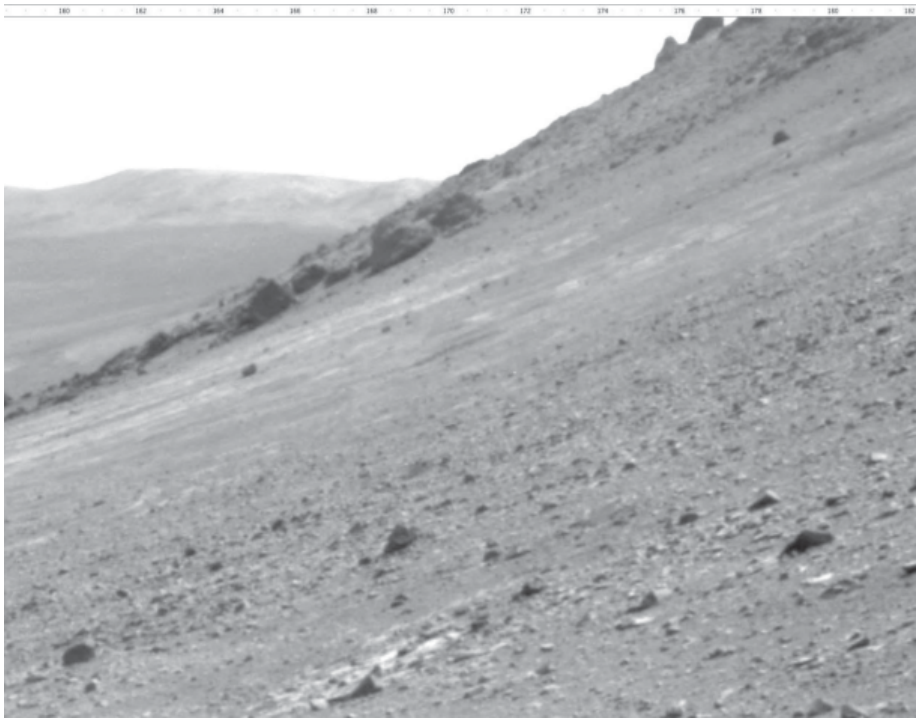
For scale, crater Linné is 1.5 miles (2.4 km) across. Craters F and B are 3 miles (4.8 km) in diameter. Despite its small size, Linné brightens as the Moon waxes, becoming a bright white spot under the sunlight of a Full Moon.

Thirteen Earth-Years on Mars

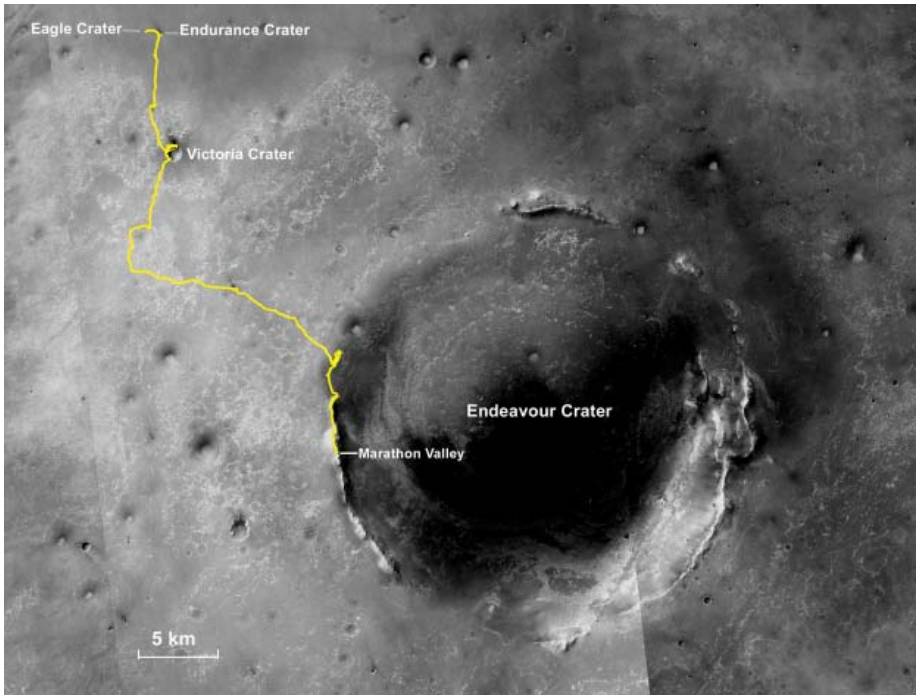
On January 25, 2004, the Mars Exploration Rover Opportunity entered the Martian atmosphere after a six month journey and bounced along the Martian surface in an inflatable cocoon before coming to rest in Eagle crater. While the crater was only 72 feet (22 meters) in diameter, small nodules of hematite (dubbed blueberries) in the rock layers that formed the crater wall provided the first clear evidence that liquid water played a role in geologic processes that transformed the Red Planet over the past 4 billion years. Eagle would be the first of several impact craters that Opportunity would explore as it traveled across the plains of Meridiani Planum.

Opportunity would spend the second half of 2004 traveling to and exploring nearby Endurance crater. In April 2005, the mission would be threatened when the rover became stuck in a sand dune. It would take six weeks of planning and many, centimeter-sized maneuvers to extract the rover. After escaping "Purgatory Dune," Opportunity narrowly avoided another dune when newly installed software stopped the rover before it lost traction. Circumventing the dune, Opportunity continued on its trek to Victoria crater, stopping by the smaller Erebus crater along the way. On its way, it would pass by its own discarded heat shield and the first of several meteorites.

The rover reached Victoria crater in September of 2006, after traveling 4.3 miles (7 km) from its landing site. It would spend the



Climbing the Wall (looking down into Endeavor Crater)
Image Credit: NASA/JPL-Caltech/Cornell Univ./Arizona State Univ.



Route map showing the traverse of Opportunity so far, since landing in Eagle crater in 2004. Image Credit: NASA/JPL-Caltech

first nine months circumnavigating the crater's rim, during which it was photographed by the Mars Reconnaissance Orbiter. In mid-2007, a series of dust storms blotted out the Sun. The loss of power threatened to discharge the rover's battery and permanently disable the rover. By late August, however, the storms began to subside and Opportunity was receiving enough sunlight to recharge its battery and return to normal operation. The rover would spend another year exploring rock outcroppings within the crater.

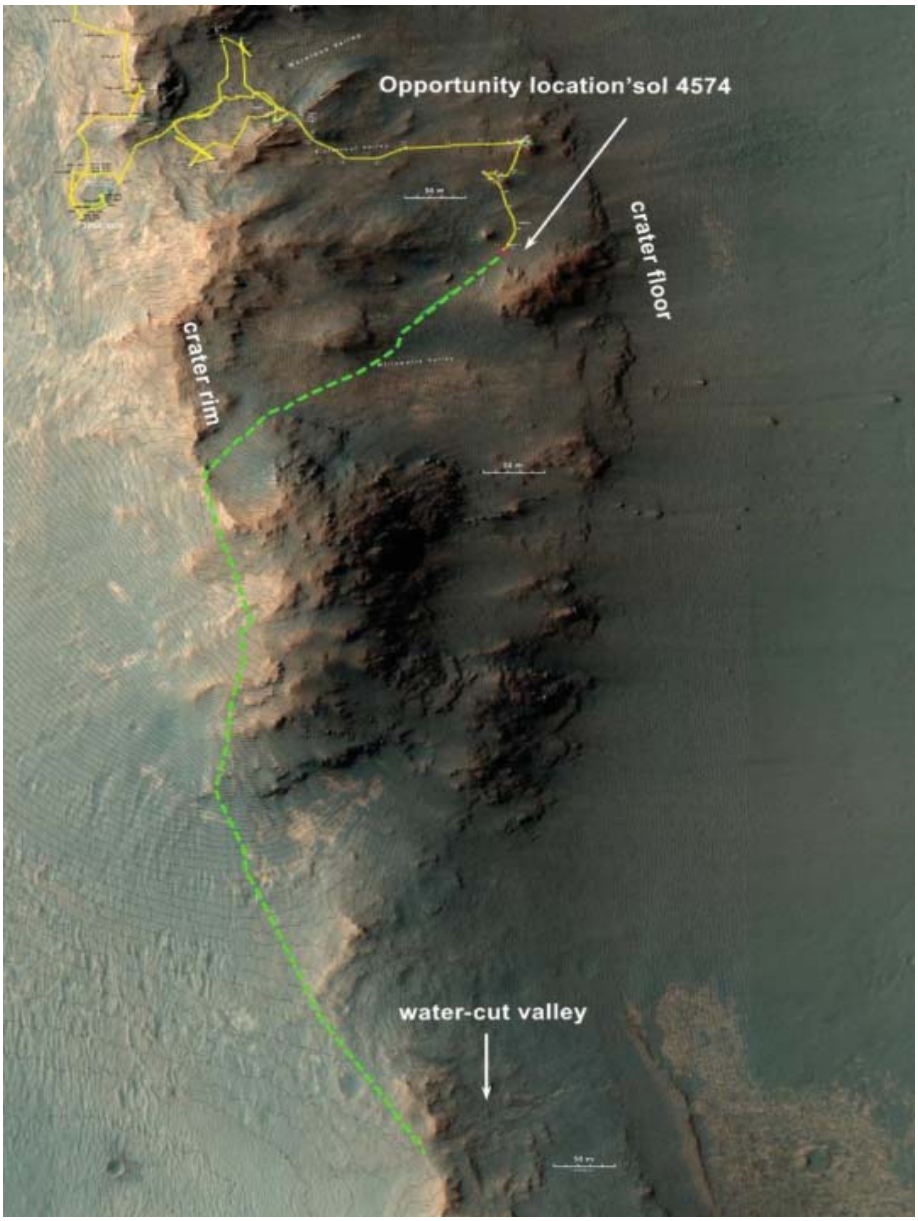
Leaving Victoria, Opportunity would begin a three year journey to Endeavour crater, reaching the rim of the 14 mile (22km) diameter impact crater in August 2011. Shortly after arriving, the rover would discover gypsum deposits on the surface, a clear indication that water once flowed through the surrounding rock. In May 2013, the rover was directed to drive to a high ridge on the rim, designated Solander Point. The sun-facing slope of the ridge allowed Opportunity to continue to work through the Martian winter. On its trek, the rover discovered rocks dating back to the earliest geologic (Noachian) period, approximately 4 billion years ago.

During Opportunity's thirteen Earth-years on Mars, the rover has found water-borne materials and minerals deposited by water (including hematite, clay and gypsum) conclusive signs that liquid water once flowed across or percolated through the Martian surface.

The 4.9 foot (1.5 m) high rover has survived dust storms, sand traps and equipment breakdowns. A malfunctioning heater switch has increased the electrical load. An inoperative shoulder azimuth joint limits the robotic arm movement. Non-functioning science instruments, discontinued use of her flash memory, and other glitches with software have affected Opportunity's operations as well. The rover drives backwards due to an inoperative front wheel. Its ailments include a failed potentiometer in the arm, causing the rover to believe the arm has come unstowed (an event that would preclude driving). Despite the many challenges, however, Opportunity is still capable of executing its mission.

The intrepid rover is currently driving south and climbing the western rim of the 14 mile (22 km) diameter Endeavour crater as it makes its way to a gully believed to have been carved by running water. Slopes encountered by the rover have exceeded 20° and the loose material covering the rock surfaces have made for a treacherous and protracted journey.

The gully is approximately one-half mile south of the rover's current location. Scientists believe that the gully's formation dates back to



Opportunity's Route
Image Credit: NASA/JPL-Caltech/Univ. of Arizona

the Noachian Period on Mars, some 3.7 to 4 billion years ago, when rivers and oceans may have been present on the Red Planet.

The Martian skies are relatively clear with a slightly elevated tau (measure of atmospheric opacity where 0 represents perfectly clear skies) of 0.72 (tau levels reached a high of 5 during a power-crippling dust storm in 2007 when less than 1% of the direct sunlight reached the surface). Power levels are good with 67% of the sunlight hitting the solar arrays penetrating the accumulated dust layer, although the steep terrain and the crater wall are affecting the rover's ability to keep its solar arrays at their optimal configuration with respect to the Sun.

The rover has been operating on Mars for more than 4,600 Martian Sols while driving over 27 miles since its landing thirteen years ago.

Portraits of Jove

The Juno spacecraft completed its third close encounter (of a planned 37) with the planet Jupiter (Perijove 3), on December 11th. The image (below) of a crescent Jupiter was captured by the spacecraft's JunoCam instrument and processed by a citizen scientist (Roman Tkachenko). The spacecraft was about 285,100 miles (458,800 kilometers) from the planet when the image was captured. The camera, which can capture full color views of the planet's atmosphere during close approaches, was designed for public outreach (the public can suggest points of interest for targeting by the camera on each pass) and images from the camera are available to the public for review and processing at *www.missionjuno.swri.edu/junocam*.

Juno was launched in August 2011 and arrived at Jupiter on July 4, 2016. It is the most distant solar-powered spacecraft, operating at approximately 517 million miles (832 million km) from the Sun. To power the spacecraft's instruments at such a great distance, Juno is equipped with three 30-foot long (9 meter) solar panels to capture the Sun's feeble light.

Crescent Jupiter
Credit: NASA/ SwRI / MSSS / Roman Tkachenko

The M in STEM

The movie "Hidden Figures" explores the role and contributions of human mathematicians or "computers," in particular African-American women at NASA's Langley Research Center, in the development of the nation's post-WWII space program. Based on a factual account by Margot Lee Shetterly, the movie joins a number of other stories that are now being told of the contributions by women to astronomy and spaceflight. In 2015, NASA mathematician Katherine Johnson was presented with the Presidential Medal of Freedom for her role in calculating trajectories for the Mercury and Apollo missions.

In 2016, Margaret Hamilton was also presented the Medal for her work on the Apollo flight navigation and guidance software. In the 1960s, she led the Software Engineering Division of the MIT Instrumentation Laboratory (now Draper Labs). The rigor in developing the error-free software used by the Apollo spacecraft(s) was fundamental to mission success and directly contributed to the first manned landing on the Moon and the astronauts' safe return to Earth. The software was subsequently adapted for use on Skylab and for the Space Shuttle.

NASA's Jet Propulsion Laboratory also hired human computers in the 1940s and 1950s, using women to work through equations and perform calculations on missile and rocket design and performance. Nathalia Holt authored a book released in 2016

Katherine Johnson (above) at Langley with a "celestial training device." Credit: NASA

titled the “Rise of the Rocket Girls: The Women Who Propelled Us, from Missiles to the Moon to Mars.”

Dava Sobel, author of several historical narratives including “Longitude” and “Galileo’s Daughter,” continued the trend with the “The Glass Universe: How the Ladies of the Harvard Observatory Took the Measure of the Stars.” The story centers on the women working at the Harvard College Observatory in the late 1800s and early 1900s under the oversight of astronomers Edward Pickering and Harlow Shapley. The women’s contributions underpinned the Observatory’s work on stellar spectra.

Margaret Hamilton and the Apollo Guidance Computer source code. Credits: Courtesy MIT Museum

New Missions Announced

NASA has selected two new Discovery Program class missions targeting Jupiter’s Trojan asteroids and the asteroid Psyche. Discovery missions are relatively low-cost projects as compared to the more complex New Frontiers (New Horizons/Pluto) and multifaceted Flagship missions (Cassini/Saturn). Previous Discovery missions have targeted Mercury (MESSENGER) and the asteroids Vesta and Ceres (Dawn). The InSight Mars lander, originally scheduled to launch in 2016 (now targeting a May 2018 launch), is also a Discovery mission.

Scheduled to launch in 2021, the “Lucy” spacecraft (named for the human fossil that provided insight into the origin of our species) will explore six of Jupiter’s Trojan asteroids from 2027 to 2033 (after a flyby of a main belt asteroid in 2025). The Trojans are trapped by Jupiter’s gravity and share the same orbit as the gas giant. There are two separate swarms, one group leading Jupiter, the other following Jupiter as it travels around the Sun. Trojans are considered remnants or relics of the early solar system and are expected to increase our understanding of the early stages of planetary formation in the solar nebula shortly after the formation of our Sun. Lucy will visit asteroids in both the L_4 (leading) and L_5 (trailing) swarms, mapping the asteroids’ surface composition and geology and determining their mass and densities.

16 Psyche is an atypical asteroid in the main asteroid belt (located between Mars and Jupiter) and the sixteenth minor planet discovered (in 1852 by Italian astronomer Annibale de Gasparis). Psyche is approximately 130 miles (210 kilometers) in diameter with an orbital period of 1,823 days, orbiting the Sun from a distance three times that of Earth. Unlike its other belt companions comprised of ice and rock, Psyche appears to be comprised of mostly metallic nickel-iron, suggesting that it could be a remnant of a core of an ancient protoplanet.

The Psyche mission is scheduled to launch in October 2023. With a gravity assist from Earth in 2024 and a flyby of Mars in 2025, the orbiter is scheduled to arrive at the asteroid in 2030. The spacecraft will use solar electric propulsion (a combination of solar cells and an ion drive) to traverse the void.

Similar to the Ceres mission scenarios, the plan for Psyche includes observations from four different, and progressively closer orbits (characterization, topography, integrated science and elemental mapping orbits). The approach and observational phase of the mission are scheduled to last 12 months.

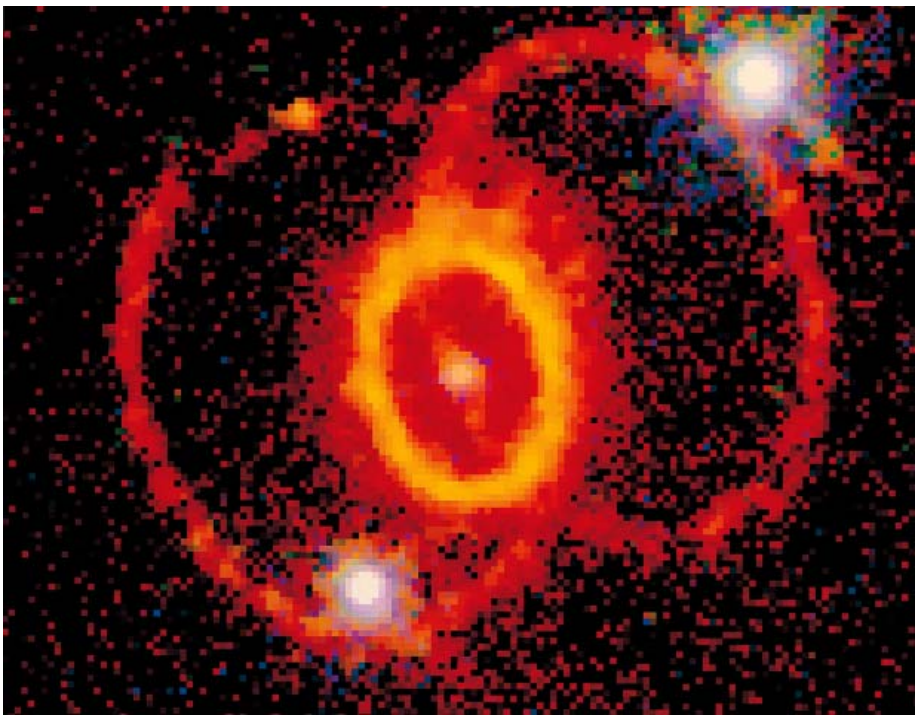
Whether Psyche is a protoplanet remnant or something completely different, the mission will add to our understanding of a time when our solar system was being transformed by collisions, mergers and destruction of newly formed protoplanets.

Supernovas

A supernova is an explosion produced when a massive star exhausts its fuel and collapses. These collapsing stars are typically red supergiants at least 8 times more massive than our Sun. If the original star is less than 20 solar masses, the supernova leaves behind a neutron star, approximately 10 to 17 kilometers (6-10 miles) across, a teaspoon of which weighs 200-400 million tons (more massive stars can collapse into black holes.) One of the more famous remnants of a supernova is the Crab Nebula, visible with a moderately sized telescope in the winter sky in the constellation Taurus.

Many of the supernovas that occur in the Milky Way Galaxy are obscured from our view by gas and dust. On average, one supernova is detected in our galaxy every century (undetected supernovas may occur every 25 to 50 years, based upon our observations of other galaxies). Supernovas can become so bright that they overwhelm their host galaxies for weeks. In the last thousand years, there were four supernovas in the Milky Way that were well documented: a star in the constellation Lupus in the year 1006, one in the constellation Taurus in 1054 (described by Chinese astronomers), one in Cassiopeia in 1572 (observed by Tycho Brahe), and another in Ophiuchus in 1604 (studied by Johannes Kepler).

One of the most scrutinized supernovas occurred within the Large Magellanic Cloud, a satellite galaxy to the Milky Way. In February 1987, a star exploded near the Tarantula nebula some 169,000 light years away. It was the first time that astronomers had detailed observations, not only of the supernova, but of the star before it exploded. The most unusual feature of Supernova 1987A is the circumstellar rings of material seen expanding from the dying star. Since the rings are moving at a speed of 70,000 to 100,000 miles per hour (much slower than the material ejected in the supernova explosion), scientists theorize that the ring material was expelled before the supernova, while the star was still a red giant.



The Mysterious Rings of Supernova 1987A
Credit: (ESA/ STScI), HST, NASA

As Dr. Carl Sagan reminded us: "We are star-stuff." Almost all of the elements in our universe were created inside stellar factories (nucleosynthesis). However, elements heavier than iron are only created in the final moments of the collapse of a massive star and detonation of the core. So the next time that you admire your gold jewelry, remember that although it may have come from your favorite jeweler, those gold atoms were created in the cataclysmic demise of a star many times more massive than our own.

Lunar XPRIZE

By the end of 2017, several private enterprises will be attempting to place a mobile spacecraft on the surface of the Moon in an effort to claim the Google Lunar XPRIZE. The first team to successfully complete the mission (land, travel 500 meters and transmit high-definition video and images back to Earth) will be awarded $20 million.

Thirty-one teams originally announced their intent to compete. The field was reduced to sixteen as teams dropped out of the competition for various reasons or did not formally register to compete for the prize. The remaining participants had until the end of 2016 to secure a launch contract for their spacecraft. The Israeli team (SpaceIL) was the first to do so with an agreement with SpaceX in late 2015. Three other teams followed, Moon Express, Synergy Moon and Team Indus, with verified launch contracts by the required deadline.

Japan's team Hakuto recently arranged to share a ride on Team Indus' Polar Satellite Launch Vehicle (PSLV) after their arrangement with their original launch provider fell through. The Japanese entry is unique in that it includes two rovers linked by a tether. This allows the larger, four-wheeled rover to lower the smaller, two-wheeled rover into areas inaccessible to a single rover, for example, caves or a lava tube skylight.

A German based team, PTScientists, is still awaiting official verification of their launch contract (through a broker). The team is targeting the landing site of Apollo 17 (Taurus-Littrow valley) for exploration with their rover (developed with support from Audi). They are hoping to survey the landing site and assess the condition of the equipment left behind by the astronauts after 45 years.

Two teams (Astrobotichave and PuliSpace) decided to leave the competition, but continue to develop a spacecraft for a future launch. Four other teams (Independence-X, Omega Envoy, Team SpaceMeta and Team Stellar) have tentatively joined forces with Synergy Moon. The remaining teams have yet to announce their intentions.

Remaining Participants in the Google LunarX Challenge

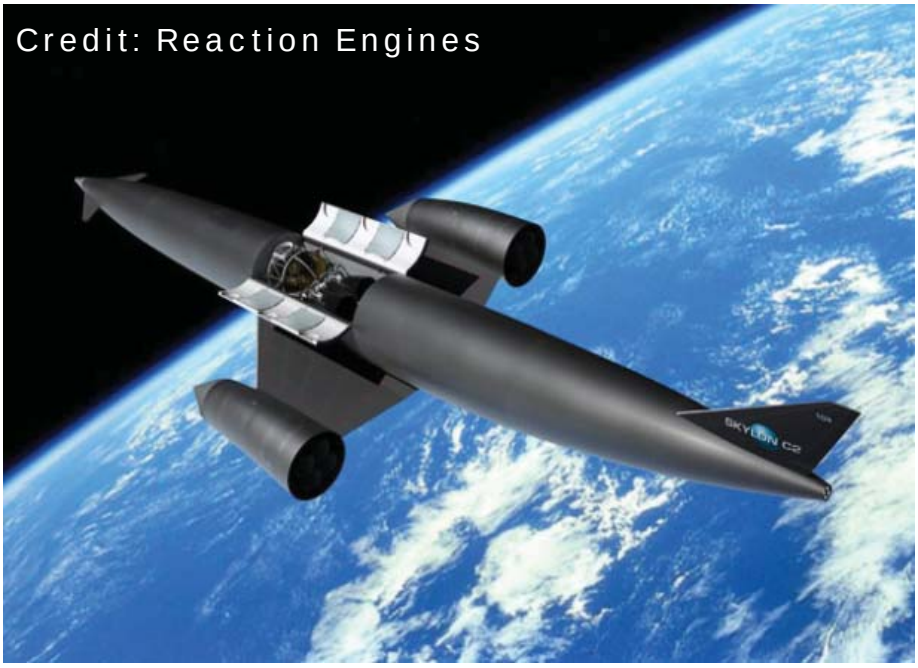
Team	Spacecraft Design	Launch Provider/Booster	Landing Site
SpaceIL	Hopper	SpaceX: Falcon 9	tbd
Moon Express	Mobile/Powered Lander	Rocket Lab: Electron	tbd
Synergy Moon	Lander/Rover	Interorbital Systems: Neptune 8	tbd
Team Indus	Lander/Rover	Indian Space Research Organization: PSLV	Mare Imbrium
Hakuto	Lander/Rover(s)	Indian Space Research Organization: PSLV	tbd
PTScientists	Lander/Rover	Pending	Taurus-Littrow

Spaceplanes and the Los Angeles Traffic Report

Only in Los Angeles would you find a road closed due to a fictional spacecraft, but that's what happened in December when someone parked their Star Wars X-Wing fighter on Hollywood Boulevard for the premier of the latest movie.

While this spacecraft currently only flies on the silver screen, rockets were the stuff of science fiction 100 years ago. In 1920, a New York Times published a scathing editorial on the work of Robert Goddard and his idea that rockets could operate in a vacuum, concluding that Dr. Goddard "seems to lack the knowledge ladled out daily in high schools.'' The Times recognized their error in 1969 as Apollo 11 traveled to the Moon.

The technology available in the next 10 years could enable a spacecraft such as the one in the photo to fly, at least into low-Earth orbit. Reaction Engines Ltd, a UK-based company, has been developing an engine that operates in both an air-breathing and a rocket mode. Its Synergetic Air Breathing Rocket Engine (SABRE) is designed to travel at over five times the speed of sound (Mach 5.4) in the atmosphere and achieve orbital velocity in a rocket mode. The SABRE engine will power the company's futuristic Skylon spaceplane from takeoff on a conventional runway to ascent into orbit.



Artist's illustration of Reaction Engine's Skylon spaceplane

The U.S. Air Force is evaluating innovative spacecraft designs that could be powered using a power plant such as the SABRE engine. China's Aerospace Science and Technology Corporation is also researching single-stage-to-orbit vehicles.

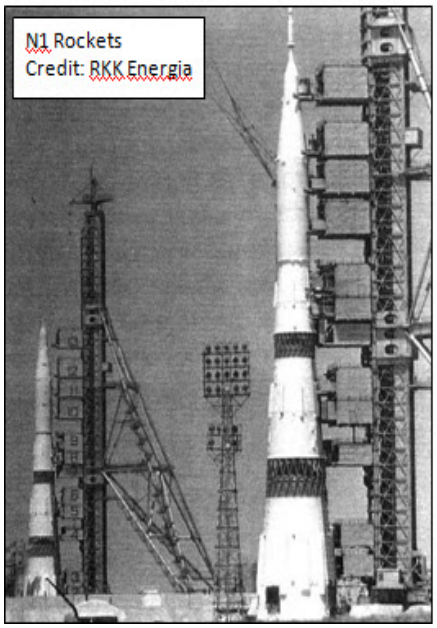
While the SABRE engine will not take you into hyperspace or allow you to travel to the next star system (yet), it's conceivable that the technology could be available in the near future that would transport you from Hollywood Boulevard into orbit and back as routinely as it appears on the silver screen today.

Soviet Moon Program

February marks the beginning of the end of the Soviet Moon program. While publicly denying its intentions to send cosmonauts to the Moon during the 1960s, the Soviets were secretly constructing rockets of mammoth proportions (rivaling the Saturn V). On February 21, 1969, the first N1 Moon rocket exploded during its test flight.

The launch of three more N1 rockets would fail before the Soviet government would abandon their manned-Moon program.

The historic photo on the right shows two N1 rockets on pads at the Soviet Union's launch site at the Baikonur Cosmodrome (also known as Tyuratam) in Kazakhstan. The five stage rockets stood approximately 340 feet high with a first stage powered by 30 individual engines.



Pluto – Yesterday and Today

Pluto was discovered by Clyde Tombaugh, an amateur astronomer hired in 1929 by the Lowell Observatory to systematically image the sky in a search for "Planet X," a hypothetical planet beyond the orbit of Neptune. In the images taken in January of 1930 (on January 23rd and 29th), approximately a year after the

search began, Tombaugh identified an object that was at the predicted distance for the hypothetic planet. The Observatory waited until March 13th to announce the discovery. The date was selected to coincide with Percival Lowell's birthday (the Observatory's founder and advocate for the Planet X search) and the 149th anniversary of William Herschel's discovery of Uranus.

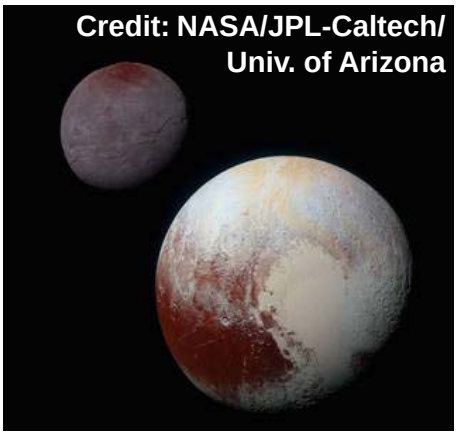
Clyde Tombaugh was born on an Illinois farm in February 1906, the eldest of six children. His family moved to a wheat farm in Kansas in 1922. At age 22, with only a high school diploma, Clyde spent most of his time working the family farm. In his spare time he would grind and test telescope mirrors in the farm's underground cellar. In 1928, Clyde sent several of his drawings of Mars and Jupiter from images seen through his homemade telescope to the Lowell Observatory. By chance, the observatory had just acquired a 13-inch telescope and was looking for a dedicated amateur to conduct photographic surveys of the night sky. With only enough money for a one-way ticket, Clyde left Kansas for Arizona in January of 1929. Thirteen months later, and after photographing millions of stars, he would discover Planet X (its designation before being officially named).

Venetia Phair, an 11 year old girl from England, suggested the name Pluto for the newly discovered planet. Her grandfather, who was the head librarian at Oxford University, passed the suggestion along to the American astronomers. Venetia, a retired school teacher, passed away in 2009 at the age of 90, but remains the only woman in the world to have named a planet (even if it's only a Dwarf Planet today). Venetia wasn't the only family member to have named a celestial object; her great uncle named the moons of Mars (Phobos and Deimos).

Clyde Tombaugh died in 1997. His wife and family attended the launch of New Horizons. The astronomer's ashes were placed on the spacecraft for the journey to Pluto.

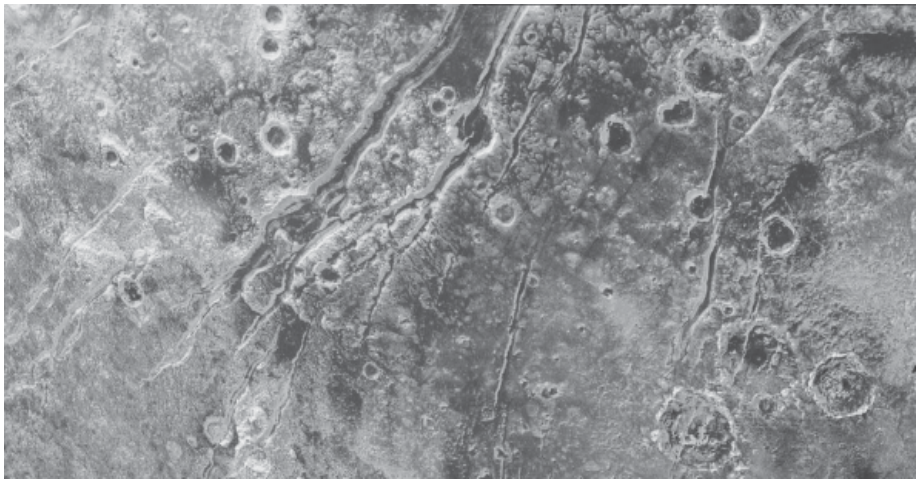
New Horizons passed through the Pluto system in July of 2015. Since then scientists have been studying the data collected during the brief encounter with this surprisingly complex world and companion moons. The data has prompted deliberations on whether liquid water ever existed beneath Pluto's frozen surface and whether it still might exist in some form today.

Surface features such as extensional faults kindled the debate. These faults, some hundreds of miles long, suggest a period of global expansion, consistent with the slow freezing of a subterranean watery ocean. Since many of the surface features on Pluto are relatively young (mountains rising up to 11,000 feet or 3,500 meters and expanses of bright, relatively crater-free ice), the process may not be complete and remnants of a liquid ocean may still exist under an insulating layer of ice and rock.



Composite image of Pluto and Charon taken by New Horizons

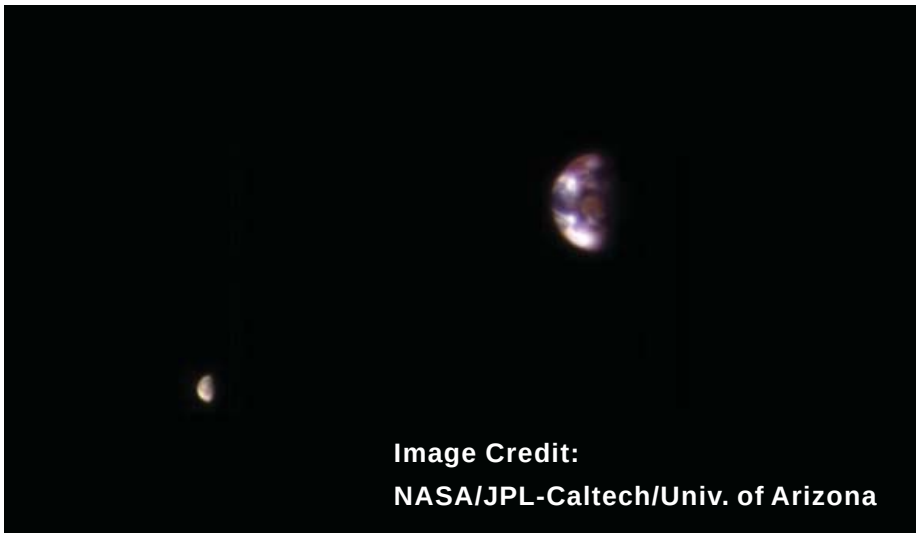
The New Horizons spacecraft is currently heading out into the Kuiper Belt (a disk-shaped region containing relics from the solar system's formation) towards its next target. It will pass by a small Kuiper Belt object (2014 MU69) on January 1, 2019. The object is located almost a billion miles beyond Pluto and estimated to be less than 30 miles (about 45 km) across.



Sinuous or Extensional Faults on Pluto's Surface
New Horizons Image, Credit: NASA/JHUAPL/SwRI

Home Planet

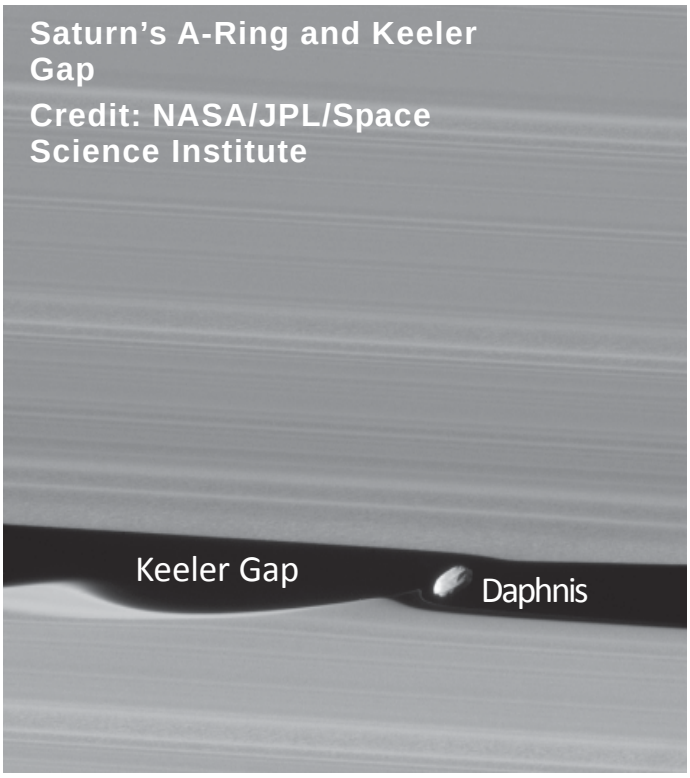
The Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE) camera took time out from surveying the Martian surface to capture a portrait of its home planet (the image was also used to calibrate HiRISE data). The image combines two separate exposures as the Moon would have been barely visible with the much brighter Earth at the same exposure. Due to the angle at which the image was captured, the Moon appears much closer than the 30 Earth diameters that separate the two bodies. The reddish feature near the Earth's terminator is the Australian continent. Mars was approximately 127million miles from the Earth (205 million km) when the image was captured.

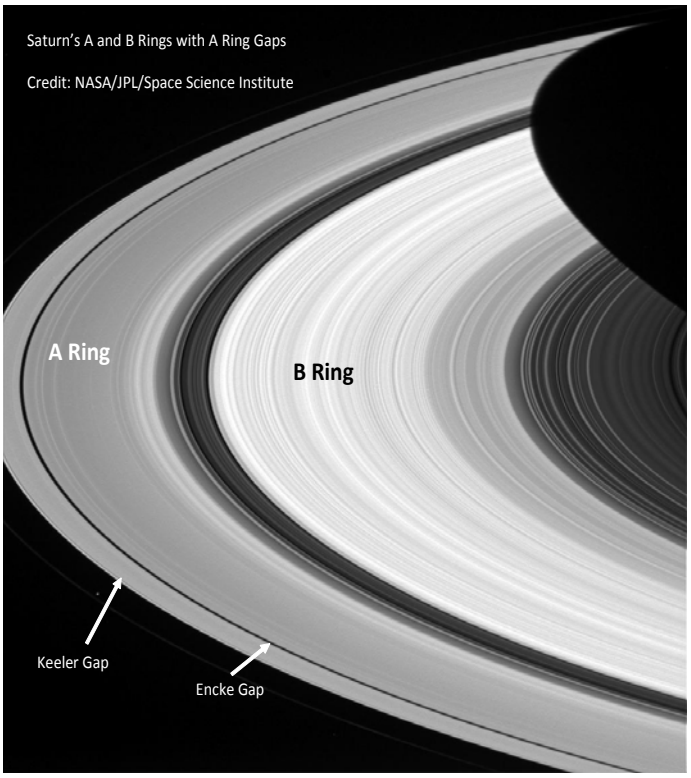


Wave Maker

The Cassini project is heading for a September 15th conclusion and grand finale encounter with Saturn's atmosphere. The spacecraft is currently traveling in a polar, outer ring-grazing orbit. On Monday, January 16th, the orbiter's camera captured the small moon Daphnis traveling within the A-ing's Keeler Gap. Surface detail (craters and possible ridgelines) is visible on the diminutive moon even at a distance of 17,000 miles (28,000 km).

Daphnis is approximately 5 miles (7.5 km) across. Its passage has cleared a path (the Keeler Gap) that is approximately 22 miles wide (35.4 km) within the outer portion of the A-Ring and located approximately 155 miles or 250 km from the ring's bright outer edge. As Daphnis travels around Saturn, its gravity disturbs the fine particles comprising the ring, raising wave-like disturbances in front of and behind the moon that rise almost a mile above the ring plane.





Commercial Crew Progress

Since the retirement of the space shuttle in 2011, the only means for U.S. astronauts to get to and from the International Space Station is for NASA to purchase seats aboard the Russian Soyuz. To address this gap in spacecraft capability, Congress agreed to fund a Commercial Crew Development Program. Administered by NASA, the program is designed to encourage private development of human-rated space transport systems.

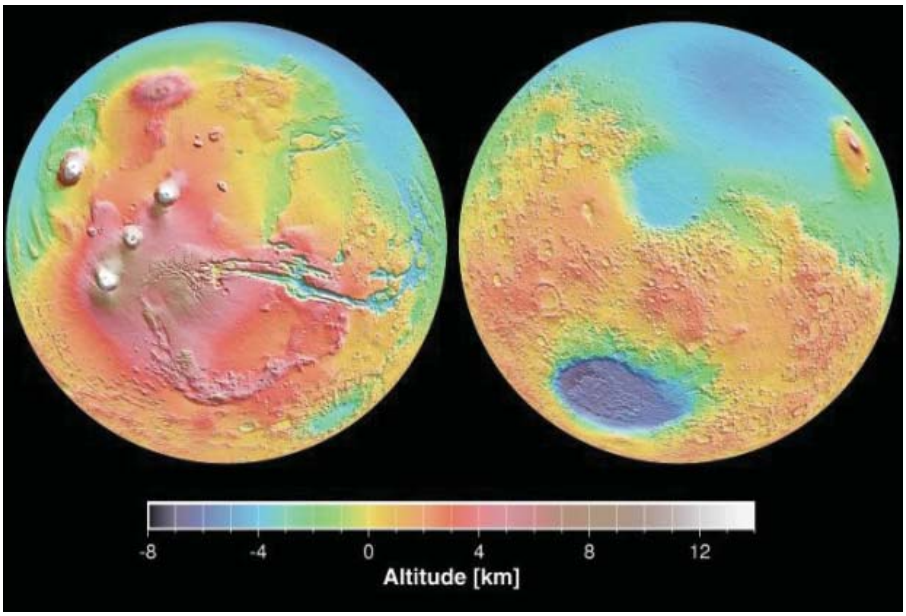
Two of the participants, Boeing and SpaceX, are in the final design stage and constructing spacecraft that can be launched aboard a conventional booster rocket (i.e., United Launch Alliance's Atlas V rocket and SpaceX's Falcon 9 rocket, respectively). During the past year NASA has had astronauts (Bob Behnken, Eric Boe, Doug Hurley and Suni Williams) working with the two companies on human performance testing and spacecraft system's design. NASA has also installed a docking adapter on the International Space Station to receive the two spacecraft.

SpaceX is currently planning an uncrewed test flight of its Crew Dragon capsule in November of this year, followed by a crewed flight in 2018. The maiden flight of Boeing's CST-100 Starliner is scheduled for early next year.

Water in Paradise

Scientists have been using the Mars Reconnaissance Orbiter's ground-penetrating Shallow Radar (SHARAD) instrument to map potential water deposits in the Utopia Planitia region. Data from the surveys indicates that a volume of water (ice) equal to Lake Superior may be buried beneath an insulating layer of soil.

Utopia Planitia is a large impact basin (2,050 miles or 3,300 km across) located in the mid-latitudes of Mars' northern hemisphere. The current tilt of the Red Planet's spin axis (25°) is similar to Earth's. Unlike, Earth,



Topographic Map of Mars Generated by the Mars Global Surveyer's Mars Orbiter Laser Altimeter (MOLA)

which has a large moon to stabilize its spin axis, it is believed that Mars' obliquity (axial tilt) goes through extreme cycles where the tilt angle may be as high as 60° (with the planet almost lying on its side). Under those conditions, ice would accumulate nearer to the equatorial regions. If insulated by blowing dust, a substantial portion of the ice could be preserved as the poles return to a more upright alignment.

The area was originally targeted for survey because of its surface pattern of scalloped depressions (typically about 100 to 200 yards or meters wide), similar to landforms in the Canadian Arctic. The subsurface deposit is believed to be water ice mixed with dust and varies from about 260 feet (80 meters) to about 560 feet (170 meters) in depth. The water ice not only represents a significant resource to future colonists, it may also provide a long-term record of Mar's evolving climate.

John Glenn and the Flight of Freedom 7

On the morning of February 20, 1962, John Glenn became the first American to orbit the Earth aboard a Mercury space capsule that Glenn named Friendship 7. Originally scheduled for the previous December, the launch was delayed by several technical and mechanical issues, including a fuel leak, and by weather.

Glenn's capsule was placed into orbit by an Atlas rocket, a rocket originally developed as an Intercontinental Ballistic Missile. While the advantages of a multi-stage rocket were well known in the 1950s (dropping off spent stages reduces the fuel required to place the payload into orbit),

Astronaut John Glenn entering the Mercury capsule Credit: NASA

starting engines in mid-flight had not been perfected. As such, vehicle weight was reduced during flight of the Atlas by dropping off the two outer engines while its center engine continued to burn until orbit was achieved. The Atlas was also unique in that it relied upon a "balloon" design to minimize its weight. This required pressurization of the fuel tanks so that the booster wouldn't collapse in upon itself.

While no longer a balloon design, the Atlas rocket remains an active expendable launcher today, carrying payloads for NASA, the Air Force and other customers.

Glenn served with the Marine Corps prior to being selected by NASA for its manned spaceflight program. As a fighter pilot, he flew 59 combat missions in the South Pacific during World War II. Following service in the Korean War (baseball Hall of Fame legend Ted Williams was one of his wingmen), he set a speed record for a transcontinental flight on July 16, 1957 when he flew a Vought F8U Crusader from California non-stop to New York in 3 hours 23 minutes in a test of a new Pratt & Whitney engine (it did require 3 mid-air refuelings).

Glenn's trip around the Earth lasted 4 hours and 55 minutes and 23 seconds, completing 3 orbits before splashing down in the Atlantic Ocean southeast of Bermuda. While a public relations success, the flight was not without problems, the most serious of which was an indication that the capsule's heat shield had come loose and its landing bag deployed. Not knowing whether it was a faulty indicator, mission control asked Glenn to leave the retro-pack on during reentry. (The retro-pack consisted of three small rockets that were used to slow the spacecraft down. It was attached to the spacecraft by three straps that extended over the heat shield.) Fortunately, the indicator was faulty and the flaming debris that Glenn saw streaming by his window during reentry was from the retro-pack and not the heat shield.

John Glenn would not return to space for another 36 years. In 1998, at the age of 77, Glenn joined the crew of the space shuttle Discovery for a nine day mission. He was the oldest person to fly in space. John Glenn died Thursday, Dec. 8, 2016 at the age of 95. He was the last of the original Mercury 7 astronauts selected by NASA in 1958 for the agency's fledgling manned spaceflight program.

Planets in 2017

The outer planets are returning to the evening sky. Jupiter is closest to Earth on April 7th when it reaches Opposition (opposite the Sun in the sky, rising with the setting Sun and visible all night). The gas giant can be found in the constellation Virgo. Saturn takes center stage in June, reaching Opposition on June 15th and appearing in the constellation Ophiuchus. The outer ice giants Neptune and Uranus are best observed in September and October, respectively, appearing in the constellations Aquarius and Pisces.

Sunrise and Sunset
(from New Milford, CT)

Sun	Sunrise	Sunset
February 1st (EST)	07:05	17:10
February 15th	06:49	17:27
February 28th	06:29	17:43

Astronomical and Historical Events

1st Aten Asteroid 364136 (2006 CJ) near-Earth flyby (0.080 AU)
1st History: loss of the space shuttle Columbia upon reentry (2003)
1st History: launch of Explorer 1; first artificial satellite by the United States (1958)
2nd Apollo Asteroid 1866 *Sisyphus* closest approach to Earth (1.505 AU)
2nd Amor Asteroid 6456 *Golombek* closest approach to Earth (2.076 AU)
2nd History: Soviet space station Salyut 4 reenters the Earth's atmosphere (1977)
3rd First Quarter Moon
3rd History: Apollo 14, with astronauts Alan Shepard, Stuart Roosa and Edgar Mitchell, lands in the Moon's Fra Mauro region; 3rd manned Moon landing (1971)
3rd History: Soviet spacecraft Luna 9 becomes first spacecraft to soft land on the Moon (1966)
4th Aten Asteroid 2005 VL1 near-Earth flyby (0.023 AU)
4th Apollo Asteroid 2015 CE1 near-Earth flyby (0.061 AU)
4th History: launch of Lunar Orbiter 3; photographed potential Apollo landing sites (1967)
4th History: Clyde Tombaugh born (1906); discovered the dwarf planet Pluto in 1930
5th Apollo Asteroid 2013 FK near-Earth flyby (0.018 AU)
5th Aten Asteroid 2011 EP51 near-Earth flyby (0.090 AU)
5th History: flyby of Venus by the Mariner 10 spacecraft on its way to Mercury; first U.S. spacecraft to photograph Venus, first to use gravity of one planet to propel itself to another, and the first spacecraft to visit Mercury (1974)
6th Moon at perigee (closest distance from Earth)
6th Apollo Asteroid 459872 (2014 EK24) near-Earth flyby (0.060 AU)
6th History: Soviet space station Salyut 7 reenters Earth's atmosphere (1991)
7th Distant Flyby of Saturn's moons *Pan*, *Janus* and *Methone* by the Cassini spacecraft
7th Apollo Asteroid 2015 BN509 near-Earth flyby (0.042 AU)
7th Apollo Asteroid 2016 YN1 near-Earth flyby (0.078 AU)
7th Apollo Asteroid 38086 *Beowolf* closest approach to Earth (1.096 AU)
7th History: launch of the Stardust spacecraft for a rendezvous with Comet Wild 2 (1999)
7th History: Astronomical Society of the Pacific founded (1889)
7th History: William Huggins born, pioneered work in astronomical spectroscopy and first to differentiate nebular and galactic spectra (1824)
8th Apollo Asteroid 2016 YJ4 near-Earth flyby (0.045 AU)
8th Apollo Asteroid 136617 (1994 CC) (2 Moons) closest approach to Earth (1.248 AU)

Astronomical and Historical Events (continued)

- 8th History: discovery of the SAU 094 Mars meteorite in Sayh al Uhaymir, Oman; one of the largest Mars meteorites recovered and the only one with a documented strewn field (2001)
- 8th History: discovery of GRV 99027 Martian Meteorite on the ice sheet near the Grove Mountain region of Antarctica; the 9.97 gram meteorite was later characterized as a shergottite (2000)
- 8th History: flyby of Jupiter by the Ulysses spacecraft on its way to study the polar regions of the Sun (1992)
- 8th History: return of Skylab III crew (astronauts Gerald Carr, William Pogue and Edward Gibson) to Earth after a 3 month stay on the space station (1974)
- 8th History: Jules Verne born, author and futurist (1828)
- 10th Full Moon (Full Snow Moon)
- 10th Aten Asteroid 2014 DV110 near-Earth flyby (0.025 AU)
- 10th History: flyby of Venus by the Galileo spacecraft (for a gravity assist) on its way to Jupiter; the encounter provided the first views of mid-level clouds on Venus and confirmed the presence of lightning (1990)
- 10th History: flyby of Mars by the Soviet Mars 4 spacecraft; failed to enter orbit but did detect night-side ionosphere (1974)
- 10th History: discovery of Asteroid 624 *Hecktor*, largest Jupiter Trojan, by August Kopff (1907)
- 11th Second Saturday Stars – Open House at the McCarthy Observatory
- 11th Atira Asteroid 2007 EB26 closest approach to Earth (0.811 AU)
- 11th History: launch of NASA's Solar Dynamics Observatory from Cape Canaveral, Florida; the first mission in the space agency's "Living with a Star" program; five-year mission to study the Sun's energy and its influence on space weather (2010)
- 11th History: launch of the space shuttle Discovery (STS-82), second Hubble Space Telescope servicing mission; **shuttle tire** on display at the Observatory is from this mission (1997)
- 11th History: launch of first Japanese satellite: Oshumi (1970)
- 12th Apollo Asteroid 2015 QR3 near-Earth flyby (0.034 AU)
- 12th Apollo Asteroid 2014 QC3 near-Earth flyby (0.050 AU)
- 12th History: landing of the Near Earth Asteroid Rendezvous (NEAR) – Shoemaker spacecraft on the asteroid Eros (2001)
- 12th History: Soviet spacecraft Mars 5 enters orbit around Mars, providing information on surface temperatures, CO_2 concentrations, and detecting a thin ozone layer and water vapor concentrations near the Tharsis region (1974)
- 12th History: Sikhote Alin meteorite fall in Russia, one of the largest modern falls at 28 tons (1947)
- 13th Aten Asteroid 99942 *Apophis* closest approach to Earth (1.732 AU)
- 14th Distant flyby of Saturn's moons *Aegaeon* and *Methone* by the Cassini spacecraft
- 14th Atira Asteroid 2006 WE4 closest approach to Earth (1.556 AU)
- 14th Aten Asteroid 341843 (2008 EV5) closest approach to Earth (1.862 AU)
- 14th History: flyby of Comet Tempel 1 by the Stardust spacecraft (2011)
- 14th History: NEAR-Shoemaker enters orbit around Eros, one of the largest of the near-Earth asteroids (2000)
- 14th History: Voyager 1 points its camera back towards the Sun and takes a family portrait, capturing six planets (Venus, Earth, Jupiter, Saturn, Uranus and Neptune) from a distance of approximately 4 billion miles; Mercury was too close to the Sun to be seen and Mars was lost in the scattered sunlight (1990)
- 14th History: launch of the Solar Maximum Mission (1980) to study the Sun during the peak of the solar cycle; a malfunction less than a year later cut the mission short. However, the satellite was recovered and repaired by the Space Shuttle Challenger in April 1984; operated successfully until burning up in the Earth's atmosphere in December 1989
- 14th History: launch of Luna 20, Soviet Moon sample return (1972)

Astronomical and Historical Events (continued)

- 14th History: launch of Syncom 1, the first geosynchronous satellite (1963)
- 15th Scheduled launch of a SpaceX Dragon cargo-carrying spacecraft on a Falcon 9 rocket from the Kennedy Space Center to the International Space Station
- 15th Apollo Asteroid 2016 CN248 near-Earth flyby (0.096 AU)
- 15th History: meteor explodes over the Russian city of Chelybinsk causing hundreds of minor injuries (2013)
- 15th History: discovery of Centaur Object *Chariklo* by Jim Scotti (1997)
- 15th History: flyby of the Moon by the Hiten spacecraft; Earth orbiting satellite designed by the Japanese Space Agency to test technologies for lunar and planetary missions (1992)
- 15th History: Galileo Galilei born (1564)
- 16th History: Gerard Kuiper discovers Uranus' moon Miranda (1948)
- 17th Distant flyby of Saturn's largest moon *Titan* by the Cassini spacecraft
- 17th History: launch of Ranger 8; Moon impact mission (1965)
- 17th History: launch of NEAR spacecraft, asteroid orbiter/lander; first of NASA's Discovery missions and the first mission to go into orbit around an asteroid (1996)
- 17th History: launch of Vanguard 2; designed to measure cloud-cover distribution over Earth (1959)
- 18th Last Quarter Moon
- 18th Moon at apogee (furthest distance from Earth)
- 18th Asteroid 14 *Irene* at Opposition (8.5 Magnitude)
- 18th Apollo Asteroid 2016 CA138 near-Earth flyby (0.059 AU)
- 18th Kuiper Belt Object 55565 (2002 AW197) at Opposition (44.643 AU)
- 18th History: Mike Brown and Jean-Luc Margot's discovery of *Romulus*, the larger of two moon that orbit Asteroid 87 *Sylvia* (2001)
- 18th History: American astronomer Clyde Tombaugh discovers Pluto (1930)
- 19th History: Nicolas Copernicus born (1473)
- 20th Winter Star Party (through the 26th) on Big Pine Key, Florida
- 20th Atira Asteroid 2010 XB11 closest approach to Earth (1.155 AU)
- 20th Kuiper Belt Object 148209 (2000 CR105) at Opposition (60.058 AU)
- 20th History: Clementine spacecraft enters lunar orbit and starts photographic survey; joint project between the Strategic Defense Initiative Organization and NASA, first of a new class of small spacecraft to enable long-duration, deep space missions at low cost using lightweight satellite technology (1994)
- 20th History: launch of the core module of the Soviet space station Mir (1986)
- 20th History: launch of Mercury-Atlas 6 and Friendship 7 with astronaut John Glenn; first American in orbit (1962)
- 21st Scheduled launch of a Russian Progress cargo carrying spacecraft from the Baikonur Cosmodrome in Kazakhstan to the International Space Station
- 21st Distant flyby of Saturn's moons *Pan*, *Prometheus*, *Pallene*, *Ephimetheus* and *Aegaeon* by the Cassini spacecraft
- 21st Asteroid 9 Metis at Opposition (8.7 Magnitude)
- 21st History: Soviet moon rocket (N-1) explodes during first test flight (1969)
- 22nd Apollo Asteroid 2016 CO246 near-Earth flyby (0.039 AU)
- 22nd History: launch of Viking, Sweden's first satellite (1986)
- 22nd History: launch of Soviet spacecraft Kosmos 110, with dogs Veterok and Ugolyok (1966)
- 22nd History: Max Wolf discovers asteroids 587 Hypsipyle and 588 Achilles (1906)
- 23rd History: Supernova 1987A detected in the Large Magellanic Cloud (1987)
- 24th Aten Asteroid 5604 (1992 FE) near-Earth flyby (0.034 AU)
- 24th History: launch of the Space Shuttle Discovery (STS-133) on its final mission. The shuttle delivered space parts and critical components to the ISS (2011)

Astronomical and Historical Events (continued)

24th History: launch of Mariner 6; Mars flyby mission returned images showing the south polar cap as being composed predominantly of carbon dioxide; refined estimates of the mass, radius and shape of Mars (1969)
24th History: Jocelyn Bell announces discovery of rapidly rotating radio sources, later determined to emanate from neutron stars or pulsars (1968)
24th History: launch of Bumper WAC, first two-stage liquid-propellant rocket and the first human-made object to achieve hypersonic speeds (1949)
25th Atira Asteroid 418265 (2008 EA32) closest approach to Earth (1.418 AU)
25th History: flyby of Mars by the Rosetta spacecraft (2007)
25th History: Soviet spacecraft Luna 20 returns lunar soil sample (30 grams) to Earth (1972)
26th New Moon
26th Apollo Asteroid 2016 FU12 near-Earth flyby (0.042 AU)
26th Apollo Asteroid 2014 HP4 near-Earth flyby (0.073 AU)
26th History: launch of the first Saturn 1B rocket booster (1966)
27th Plutino *90482 Orcus* at Opposition; discovered on February 17, 2004; the plutino has one large moon called *Vanth* (47.127 AU)
27th Apollo Asteroid 2005 QB5 near-Earth flyby (0.056 AU)
28th Distant flyby of Saturn's moons *Janus* and *Pandora* by the Cassini spacecraft
28th History: flyby of Jupiter by the New Horizons spacecraft bound for Pluto (2007)
28th History: launch of Discoverer 1; first of a series of satellites which were part of the Corona reconnaissance satellite program and first satellite launched into polar orbit (1959)
29th History: original Gemini 9 crew, command pilot Elliot See and pilot Charles Bassett, killed in a crash while flying a T-38 jet trainer to the McDonnell Aircraft plant in St. Louis, Missouri to inspect their spacecraft (1966)

Commonly Used Terms

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

References on Distances

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

Solar Activity

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

International Space Station and Iridium SatellitesPnce Team

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.

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).

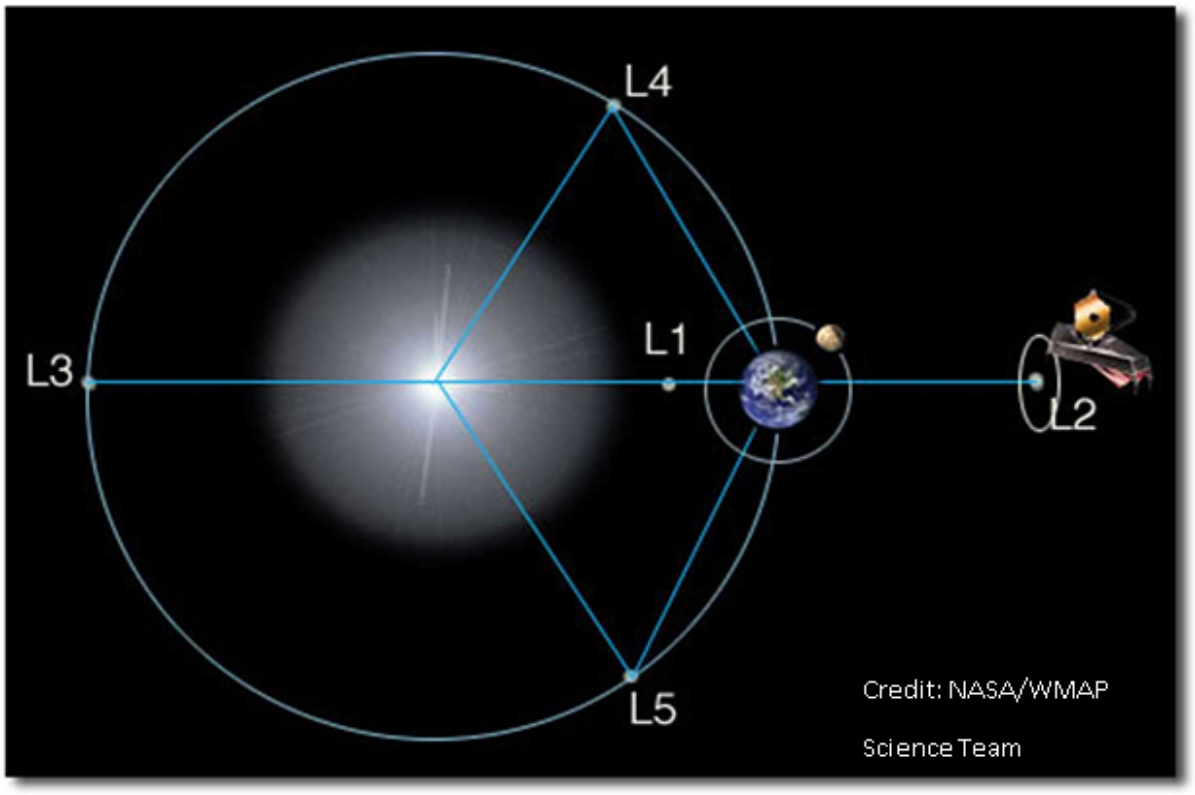


Image Credits

Front page design and graphic calendars: Allan Ostergren.
Second Saturday Stars poster: Marc Polansky.

Cover Images

Carina Nebula: Pillars of Creation or Cradle of Doom?

The answer is yes and yes, with a little of that depends in between.

Carina is a nebula visible in the southern sky about 300 light-years wide and 8,000 light-years from Earth, and is a namesake for its much larger parent constellation. Although a common baby name in the Italian language, its true origin is in Greek mythology, as the keel for the mythical ship used by Jason and the Argonauts in their search for the Golden Fleece. In 1763, the keel was set adrift when the rest of Jason's celestial ship was split off in a reorganization of its parent constellation.

Of course, the tale of Jason and the argonauts is a figment of the ancient Greeks' imagination—but whether cloaked in the myths of Hellenic heroes or in babies' diapers, both concepts are consistant with a view of nebulas as the scattered remains of burned-out suns and the birthing place of new stars in a stellar nursery. This lifecycle analogy becomes a stretch of time and imagination when measured against a process of planetary formation and biological development spanning billions of years. In its curent state, NASA describes it more appropriately as a "giant cauldron of gas and dust."

The main image on page 1 focuses on a cluster of stars (Trumpler 16) within the nebula, and particularly on several of its brightest stars, Keel WR 25 and Tr16-244. [Source: *https://www.spacetelescope.org/images/heic0822a/*]

Credit: NASA, ESA and Jesús Maíz Apellániz (Instituto de Astrofísica de Andalucía, Spain)

The image at the bottom is a montage from four different perspectives taken in April 1999 with Hubble's Wide Field Planetary Camera 3, using six different color filters. Under the title, *Pillars of Creation* to emphasize the upswelling of human society following the birth of Christ, the image has achieved wide acclaim. The use of filters and optical tools, like X-ray and ultraviolet imaging, enables researchers to probe more deeply into the cosmos to unveil its hidden mysteries.

Image Credit: NASA, the Hubble Heritage Team and Nolan R. Walborn (STScI), Rodolfo H. Barba' (La Plata Observatory, Argentina), and Adeline Caulet (France).

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

February 11th
7:00 - 9:00 pm

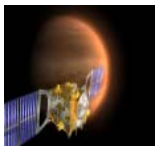
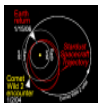
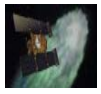
Gravitational WAVES Found!

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

Map

February 2017

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Jan 2017 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 Mar 2017 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31			**1**  Launch of Explorer I (1958) Space Shuttle Columbia breaks up on reentry from orbit (2003) 	**2**  Soviet space station, Salyut 4 reenters Earth's atmosphere (1977)	**3**  Chinese New Year Soviet Luna 9 lands on Moon (1966)   Apollo 14 - 3rd Moon landing-Shepard, Roosa, Mitchell (1971)	**4**  Clyde Tombaugh born (1906)  discoverer of Pluto  Launch of Lunar Orbiter 3, to locate Apollo landing sites (1967)
5  Flyby of Venus by Mariner 10 spacecraft en route to Mercury (1974)	**6**  Moon at perigee (closest distance to Earth)  Soviet space station Salyut 7 reenters Earth's atmosphere (1991)	**7** William Huggins born, pioneer of astronomical spectroscopy (1824)   Astronomical Society of the Pacific founded (1889) Launch of Stardust spacecraft for rendezvous with comet Wild 2 (1999) 	**8**  Jules Verne born (1828) Mars meteorites found - Oman (2001); Antarctica (2000)   Return of Skylab 3 crew after 3 months on space station (1974)	**9**   Astronaut Bernard A. Harris becomes first African-American to perform extra vehicular activity, during shuttle mission STS-63 to Mir spacecraft, flown by first woman shuttle pilot, Eileen Collins (1995)	**10**   Flyby of Venus by Galileo spacecraft on way to Jupiter (1990)  Flyby of Mars by Soviet Mars 4 spacecraft (1974)	**11** Launch of NASA Solar Dynamics Observatory 2010   A solar eclipse inspires Nat Turner to launch slave revolt in Virginia (1831) Launch of Japanese satellite Oshumi (1970)   **2nd Saturday Stars Open House McCarthy Observatory**
12 NEAR spacecraft lands on asteroid Eros (2001)   Sikhote Alin meteorite falls in Russia (1947) Soviet Mars 5 spacecraft in orbit (1974) 	**13**  John Louis Emil Dreyer born, Danish/Irish astronomer and biographer of Tycho Brahe; continued Herschel's work by publishing catalogue of nebulae and clusters (1852)	**14**  Launch of Syncom 1, first geosynchronous satellite (1963) Launch of Solar Maximum Mission to study Sun during peak of cycle (1980)  Flyby of Comet Tempel 1 by the Stardust spacecraft (2011)	**15**  Galileo Galilei born (1564) Flyby of Moon by Japan's Hiten spacecraft (1992) 	**16**   Gerard Kuiper discovers Uranus' moon, Miranda (1948)	**17** Launch of Ranger 8, Moon impact mission (1965)   Launch of Vanguard 2, to measure Earth cloud cover (1959) Plutino 90482 Orcus discovered - has one moon, Vanth (2004) 	**18** Moon at apogee (farthest from Earth) American astronomer Clyde Tombaugh discovers Pluto (1930)
19 Nicholas Copernicus born (1473)	**20** Launch of Mercury Atlas 6 and Friendship 7 with John Glenn, 1st American in orbit (1962) Launch of core module of Soviet Mir space station (1986) Winter Star Party at Big Pine Key, Fl. (thru Sunday the 26th)	**21** Soviet Moon rocket (N-1) explodes (1969) Tom Gehrels born , astronomer and co-discoverer of over 4,000 asteroids (1925)	**22** Launch of Soviet spacecraft Kosmos 110, with dogs Veterok and Ugolyok (1966)	**23** Supernova 1987A detected in Large Magellanic Cloud (1987)	**24** Launch of Bumper WAC, first two-stage liquid ropellant rocket (1949) Launch of Mariner 6, Mars flyby (1969) Jocelyn Bell's discovery of pulsars (1968) Shuttle Discovery final mission (2011)	**25** Flyby of Mars by Rosetta spacecraft (2007) Soviet spacecraft Luna 20 returns 30-gram soil sample to Earth (1972)
26 Launch of first Saturn 1B rocket booster (1966)	**27** Bernard Ferdinand Lyot born, French astronomer and inventor of the coronagraph to observe the sun's corona without waiting for an eclipse, (1897)	**28** Launch of Discoverer 1, first of Corona reconnaissance satellite program (1959) Flyby of Jupiter by New Horizons spacecraft bound for Pluto (2007) 				

Phases of the Moon

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