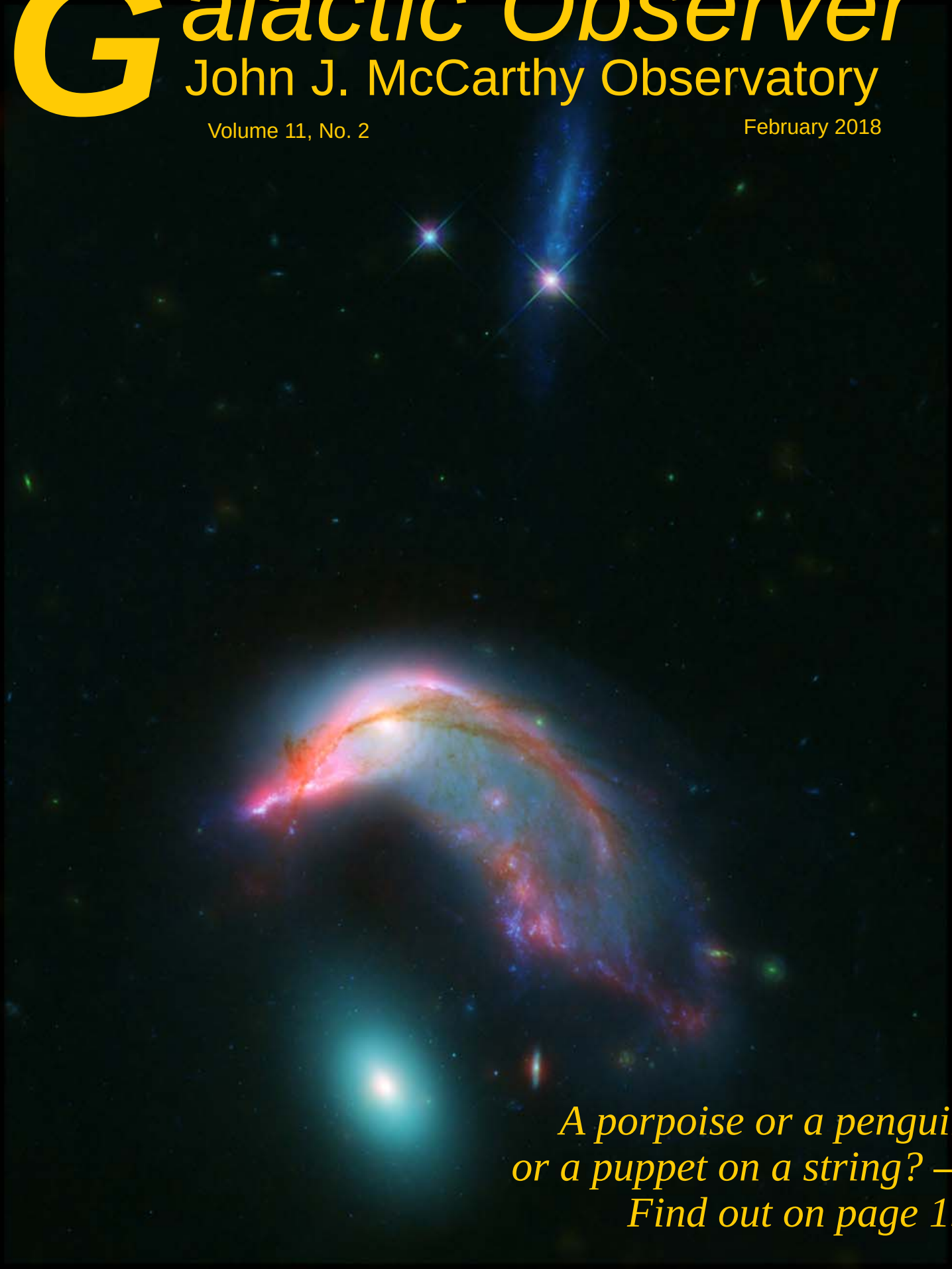
Galactic Observer

John J. McCarthy Observatory

Volume 11, No. 2

February 2018



A porpoise or a penguin or a puppet on a string? — Find out on page 19

The John J. McCarthy Observatory

New Milford High School
388 Danbury Road
New Milford, CT 06776

Phone/Voice: (860) 210-4117
Phone/Fax: (860) 354-1595
www.mccarthyobservatory.org

JJMO Staff

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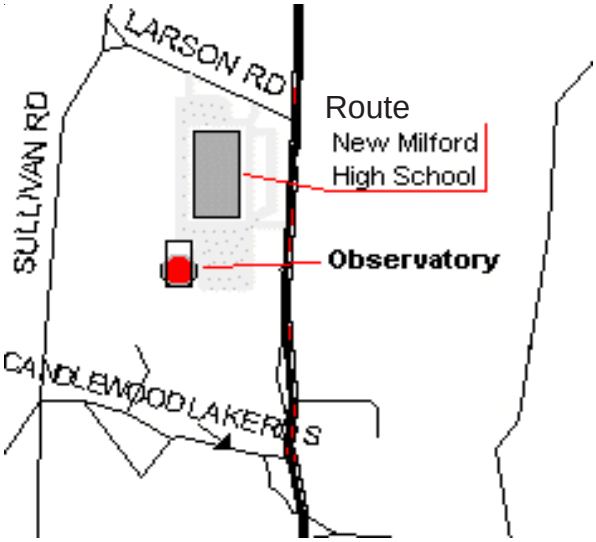


In This Issue

February Astronomy Calendar and Space Exploration Almanac

Perihelion and Aphelion

The Earth's orbit, like all planets that are bound to the Sun, is elliptical although its eccentricity (amount by which the orbit deviates from a perfect circle) is small. At its closest point to the Sun (perihelion), around January 3rd, the Earth is approximately 91.7 million miles (147 km) from the Sun while at the furthest, around July 4th, the Earth is approximately 94.8 million miles (152 km) from the Sun (a 3.1 million mile difference).

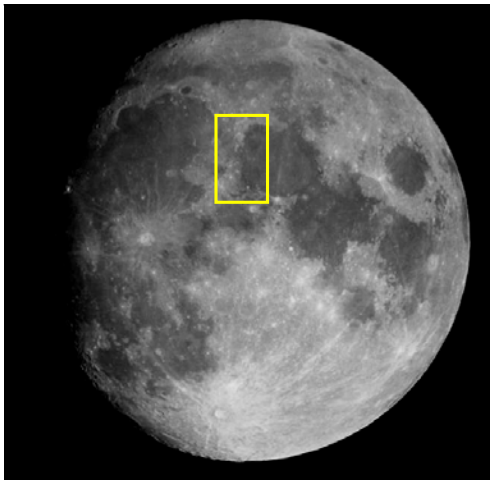
The images (above) were taken in early July 2017 and January 2018 with the same camera and identical settings. While the difference in the diameter of the Sun is small (with the 3.5% difference in the max/min distance), it is still noticeable.

The sunlight falling on the Earth is slightly more intense in January but with the northern hemisphere tilted away from the Sun and the Sun lower in the sky, the days are shorter and colder.

Photos: Bill Cloutier

Out the Window on Your Left"

It's been more than 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;

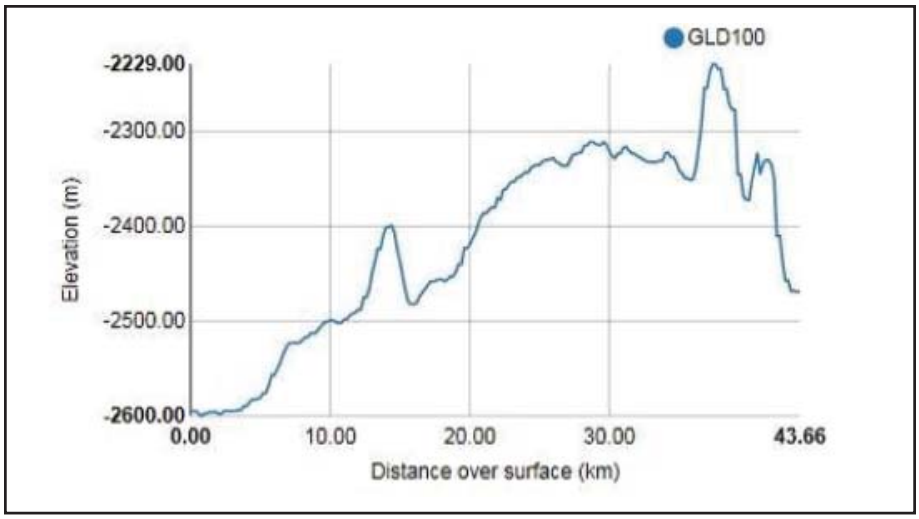


Lunar seas are actually expansive low-lying plains formed by ancient lava flows

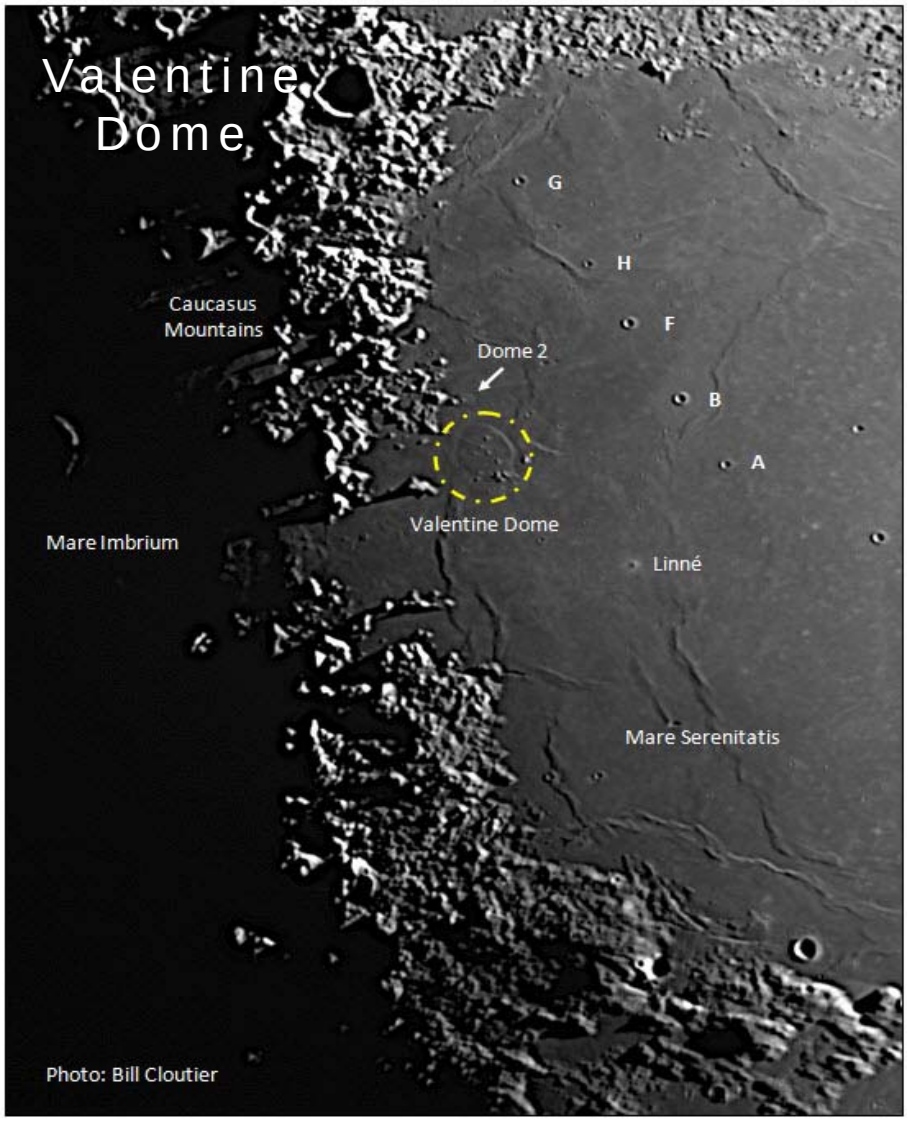
what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

A broad, low-profile lava dome is visible as the waxing Moon achieves first quarter phase on February 23rd 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 top of the Valentine dome rises 400 feet (122 meters) 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



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



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.

Passing of Astronaut John Young

NASA astronaut John Young passed away on January 5th at the age of 87. He was one of NASA's most experienced astronauts and the first to fly in space six times, with two Gemini missions (3 and 10), as command module pilot on Apollo 10, commander and moonwalker on Apollo 16, commander of Columbia on the space shuttle's maiden flight (STS-1), and as commander of STS-9, the first space shuttle Spacelab mission.

John Young joined NASA in 1962 after serving in the Navy and Fighter Squadron 103, and a 3 year assignment at the Naval Air Test Center where he set world time-to-climb records in the F-4 Phantom supersonic jet. He served in several capacities at NASA, including Chief of the Astronaut Office for 13 years. He retired from NASA in 2004 but remained a strong and vocal advocate of human space exploration.

Falcon Heavy Debut

SpaceX's new heavy-lift Falcon Heavy rocket made its launch pad debut on December 28, 2017. Its appearance on Pad 39A at the Kennedy Space Center for a "fit test" was short with the rocket lowered to a horizontal position and returned to its hanger on the following day.

Its maiden flight, scheduled for early February, was conditional on the test firing of the rocket's 27 first stage engines which produce more than 5 million pounds of thrust at lift off, second only to the Saturn V in raw power. The static firing took place just after noon on the 24th. According to Elon Musk, the "hold-down firing … was good…Launching in a week or so."

If the launch is successful, SpaceX will attempt to recover the first stage, returning the two side boosters to landing pads at the Kennedy Space Center and the core booster to its automated ocean barge. Always the showman, Musk decided to forego a traditional payload ballast. Instead, the rocket will attempt to place Musk's

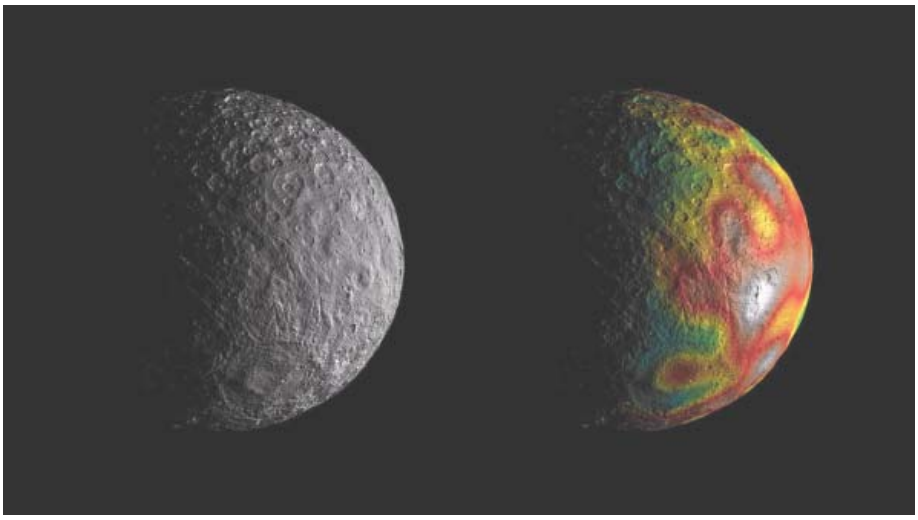
cherry red roadster into heliocentric orbit while David Bowie's "Space Oddity" plays on the car's radio.

Ceres Update

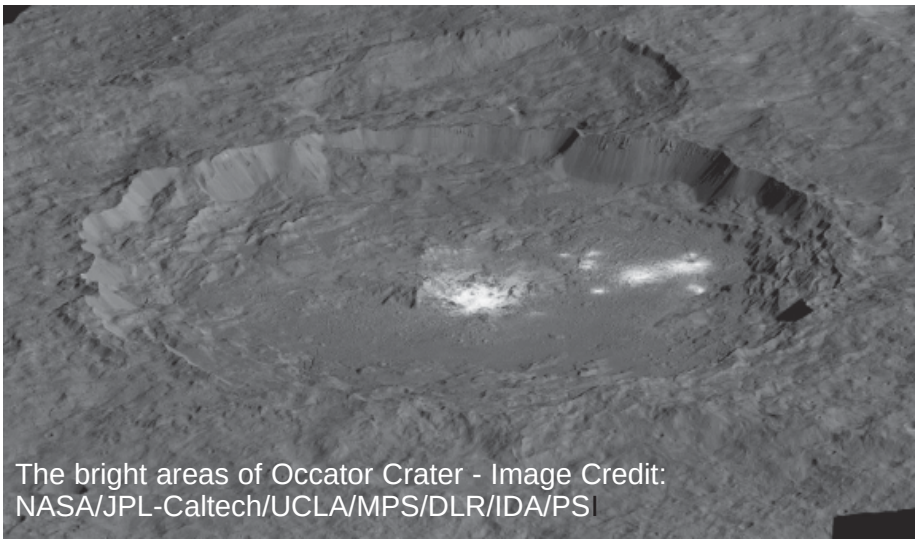
The complexity of the dwarf planet Ceres continues to surprise more than three years after the Dawn spacecraft entered orbit around the diminutive world in January 2015. New studies, published in Earth and Planetary Science Letters, the Journal of Geophysical Research: Planets and the journal Icarus, describe a geologically active world and one that may have had a global ocean.

In the first study, tiny changes in the spacecraft's orbit as it flew over the frozen landscape - as measured by NASA's Deep Space Network radio antennas, were used to create a gravity map of Ceres. From the gravity map, the composition and interior structure of the planet, as well as the density of its crust, can be deduced. For example, large craters such as Occator, Kerwan and Yalode, and Ceres' solitary 2.8 mile (4.5 km) high mountain Ahuna Mons appear as mass anomalies (either a negative free-air gravity anomaly for craters or a positive free-air gravity anomaly for mountains). The discrepancies between what is observed by Dawn visually and inferred from the gravity data supports the presence of subsurface structures and possible past cryovolcanism (icy volcanoes), as well as a crust that is a mixture of rock and ice (possibly 60 percent rock and 40 percent ice) as a crust which is predominately ice would be softer and would relax over millions of years and flatten. The presence of salts and hydrated materials on the surface is also suggestive of an ancient global ocean.

The mountain Ahuna Mons appears to be a volcanic dome composed primarily of water ice. The number of craters in the surrounding area suggests that the mountain is relatively young, possibly less than 200 million years old. It is believed that the density of the mountain is less than the crust through which it erupted.



Gravity measurements overlaid on Dawn's mapping of the dwarf plant (right). Red colors indicate a stronger gravity fields, while blue colors show weaker fields. Credits: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA



The bright areas of Occator Crater - Image Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA/PSI

The authors of the second study make the case for a softer, deformable layer beneath Cere's hard surface. This layer is surmised to contain some liquid, a residue of the global ocean, which has allowed the surface features to soften over time.

The more than 300 hundred bright areas on the planet's surface imaged by Dawn suggest, to the researchers, that the planet was recently geologically active and may still be evolving. The 57-mile-wide (92-km) crater Occator contains several bright areas on its floor that are salt-rich. The deposit may have come from a subsurface briny reservoir which was exposed to the surface by faults created by the impact that formed the crater.

The bright streaks on the walls of other craters are believed to be subsurface deposits excavated in the initial impact or impact ejecta, while the bright material on Ahuna Mons is thought to be from cryovolcanism (salts and other reflective material brought to the surface in the eruptions).

New Frontiers Mission - Finalists

NASA conducts three basic types of planetary missions: the high-end and most capable Flagship missions (e.g., Cassini or the Mars Science Laboratory), the cost of which can exceed $2 billion, the mid-range New Frontiers missions (e.g., New Horizons, Dawn, Juno and OSIRIS-REx) the cost of which can range from $600 to $700 million and low-cost Discovery missions (e.g., Lucy and Psyche) that can range between $450 and $600 million. In December 2016, NASA's Mission Directorate released an Announcement of Opportunity for future New Frontiers missions. Proposals were limited to the following six mission themes:

- Comet Surface Sample Return,
- Lunar South Pole-Aitken Basin Sample Return,
- Ocean Worlds (Titan and/or Enceladus),
- Saturn Probe,
- Trojan Tour and Rendezvous, and
- Venus In Situ Explorer

Twelve proposals were received. In December 2017, NASA announced two finalists: CAESAR (Comet Astrobiology Exploration SAmple Return) mission and Dragonfly (a dual-quadcopter lander destined to operate on Saturn's largest moon Titan). Two other missions were selected for additional development: Enceladus Life Signatures and Habitability (ELSAH) and Venus In situ Composition Investigations (VICI).

The CAESAR mission would take NASA back to the nucleus of comet Churyumov-Gerasimenko where the European Space Agency's Rosetta spacecraft spent more than two years investigating the primordial world and traveling with it though perihelion. The NASA spacecraft would collect a cometary sample and return that sample back to Earth (circa 2038).

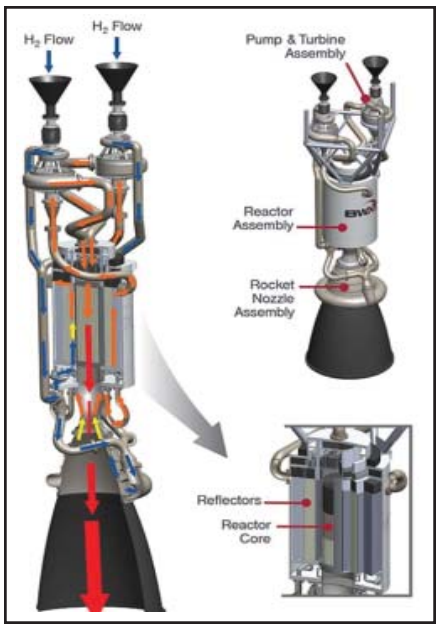
The Dragonfly mission would land a rotorcraft on Titan in 2034. The rotorcraft would be able to investigate several locations on the moon over its multi-year mission life, analyzing Titan's chemistry and potential habitability. It would also report back on the moon's dynamic atmospheric and seasonal climate.

Artist's concept of Dragonfly mission on Titan. Credits: NASA

NASA will fund the maturation of the two finalists through the end of the year. It is expected that the missions will then be reevaluated, with one of the two selected in early 2019.

Harnessing the Atom for Space Exploration

The adverse effects of microgravity and dangers of deep space (e.g., solar and galactic radiation) on the human body can be mitigated by keeping travel times (and exposure to the hazards) as short as reasonably possible. With chemical rockets, a mission to Mars can require 6 to 9 months or more, depending upon the alignment of the two planets (distance) and the amount of energy that you are willing to invest. In an effort to reduce travel time (as much as 50% or more), the United States and Russia have been working on new propulsion technologies and revisiting older ones.



In 2017, NASA awarded BWXT Nuclear Energy a contract worth $18.8 million to design a nuclear thermal propulsion reactor. Over the three-year contract, the company also expects to refine the design of the engine, manufacture and test prototype fuel elements, as well as support NASA in negotiating regulatory hurdles. The BWXT reactor would use low-enriched uranium (19.75%) in a ceramic metallic matrix to heat a fuel, e.g., hydrogen, to a high temperature. The plasma would then be discharged through the rocket nozzle to generate vehicle thrust. The nuclear rocket engine is more efficient than its chemical counterpart (with efficiencies up to twice that of the Space Shuttle main engines), reducing the amount of

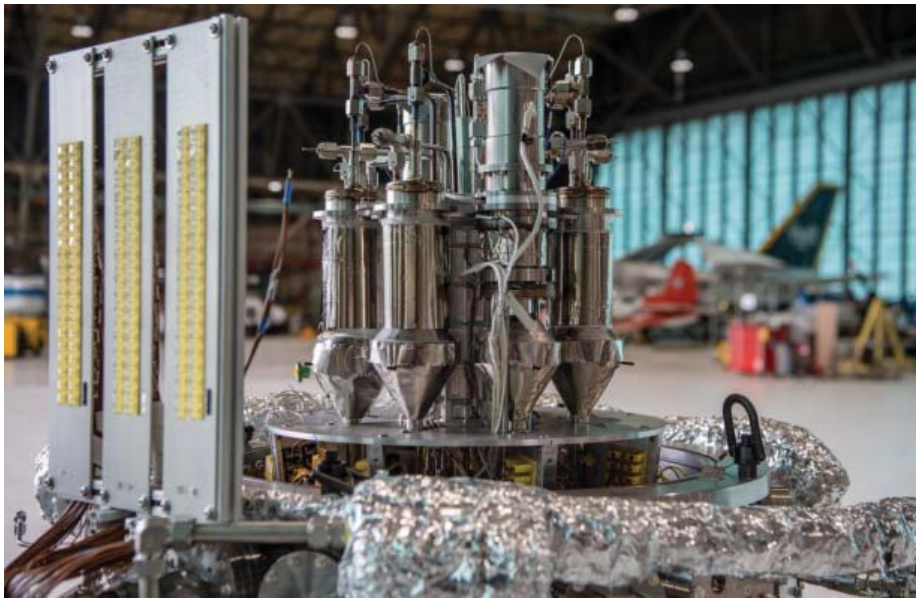
propellant allowing for larger payloads, while reducing travel time to approximately 4 months.

On December 11, 2017, the president signed Space Policy Directive 1, intended to reinvigorate America's Human Space Exploration Program. The policy directs that "Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations..."

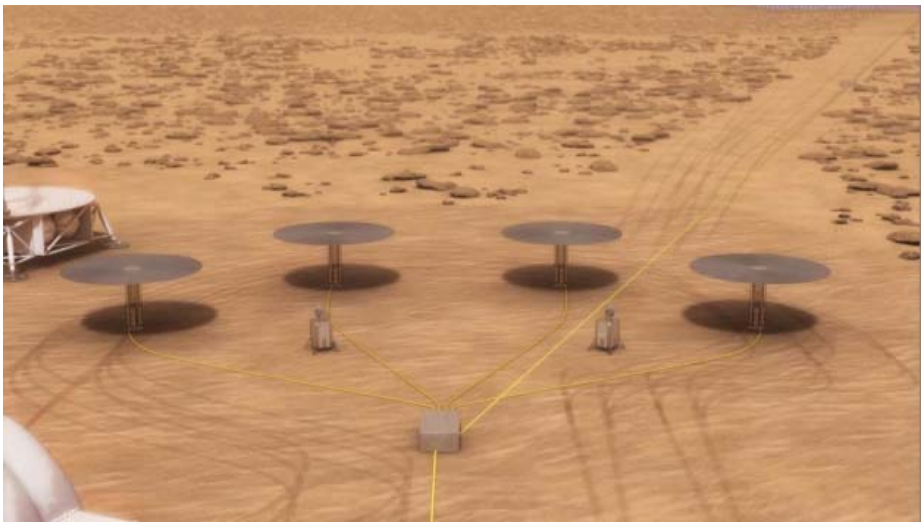
Nuclear thermal propulsion is the technology of choice for deep space travel. Dr. Stanley Borowski, an engineer at NASA's John Glenn Research Centre, presented a concept vehicle at the 2012 IEEE Aerospace Conference. Modular, the vehicle can be reconfigured depending upon the mission and cargo.

The propulsion drives for Borowski's interplanetary transfer vehicle (named Copernicus), uses liquid hydrogen as a both a fuel and coolant. As the hydrogen passes through the reactor core's fuel elements, the hydrogen is superheated to a plasma before being expelled through a supersonic nozzle to produce the high thrust. The compact fission core would use 93% enriched Uranium-235 to generate several hundred megawatts of power.

Developing more efficient means of traveling through space is only one challenge in establishing off-world outposts. Astronauts and future colonists will also need to be self-sufficient and human habitats can be power intensive. To meet that demand, NASA is developing a new generation of modular and scalable reactors with the Kilopower project. The compact reactor can operate in extreme environments and provide significantly more power than a conventional radioisotope thermoelectric generator (that relies upon the decay of radioisotopes to generate heat).



Prototype Kilopower system - Credit: NASA



Artist's concept of four Kilopower reactors at a Mars base
Credit: NASA Glenn Research Center

The Kilopower reactor is rated at 10 kilowatts and can run continuously for ten years without refueling. The reactor is powered by a solid, cast Uranium-235 reactor core, 6 inches (15 cm) in diameter. Heat is transferred by a sodium coolant to a set of high-efficiency Stirling engines. Excess heat is rejected by an umbrella-shaped radiator. The reactor has successfully completed an initial test run at the Department of Energy's Nevada National Security Site in Nevada in 2017. Full power testing is expected to begin in March 2018.

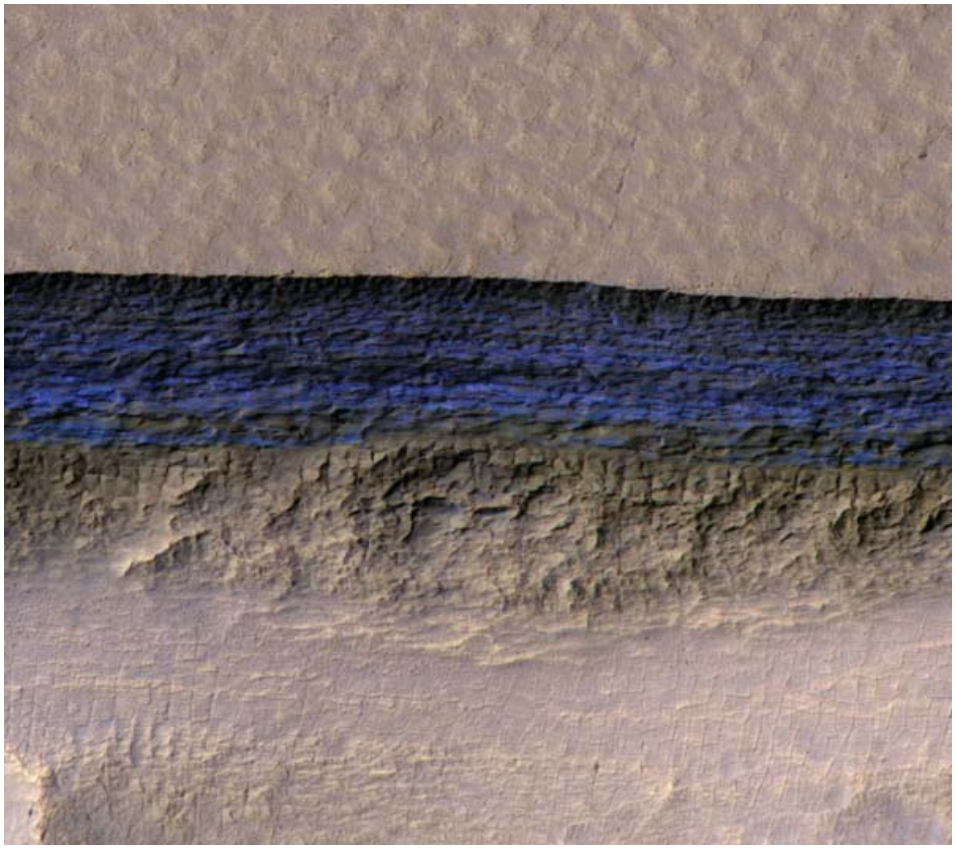
Internationally, Russia's Rosatom is reported to be working on a nuclear electric rocket that they claim will enable cosmonauts to reach Mars in just 6 weeks. Russia's national nuclear corporation has acquired its first batch of fuel and is planning on testing an experimental prototype sometime in 2018.

Martian Water Ice

With the exception of the polar caps, where water ice is abundant and within plain sight, researchers have had to rely upon indirect methods of ferreting out subsurface ice on Mars at its lower latitudes (for example, using ground-penetrating radar, neutron spectrometers and analyzing ejecta from recent impact craters). The evidence collected by the fleet of orbiting spacecraft is compelling, that large ice deposits existed below the Martian sands, even at equatorial regions - but until recently, confirmation was elusive.

Researchers have now found eight locations at latitudes ranging from about 55 to 58 degrees, in both the northern and southern hemispheres, where subsurface ice is visible on the face of steep, eroded scarps or slopes. The sites were found in images captured by NASA's Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) camera. The ice, possibly deposited as snow when the planet's axial tilt was greater, is covered by several yards (meters) of rock and dust.

The water ice, confirmed by MRO's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), is more than 100 yards (meters) thick. For future astronauts and colonists, these scarps provide an accessible source of water.

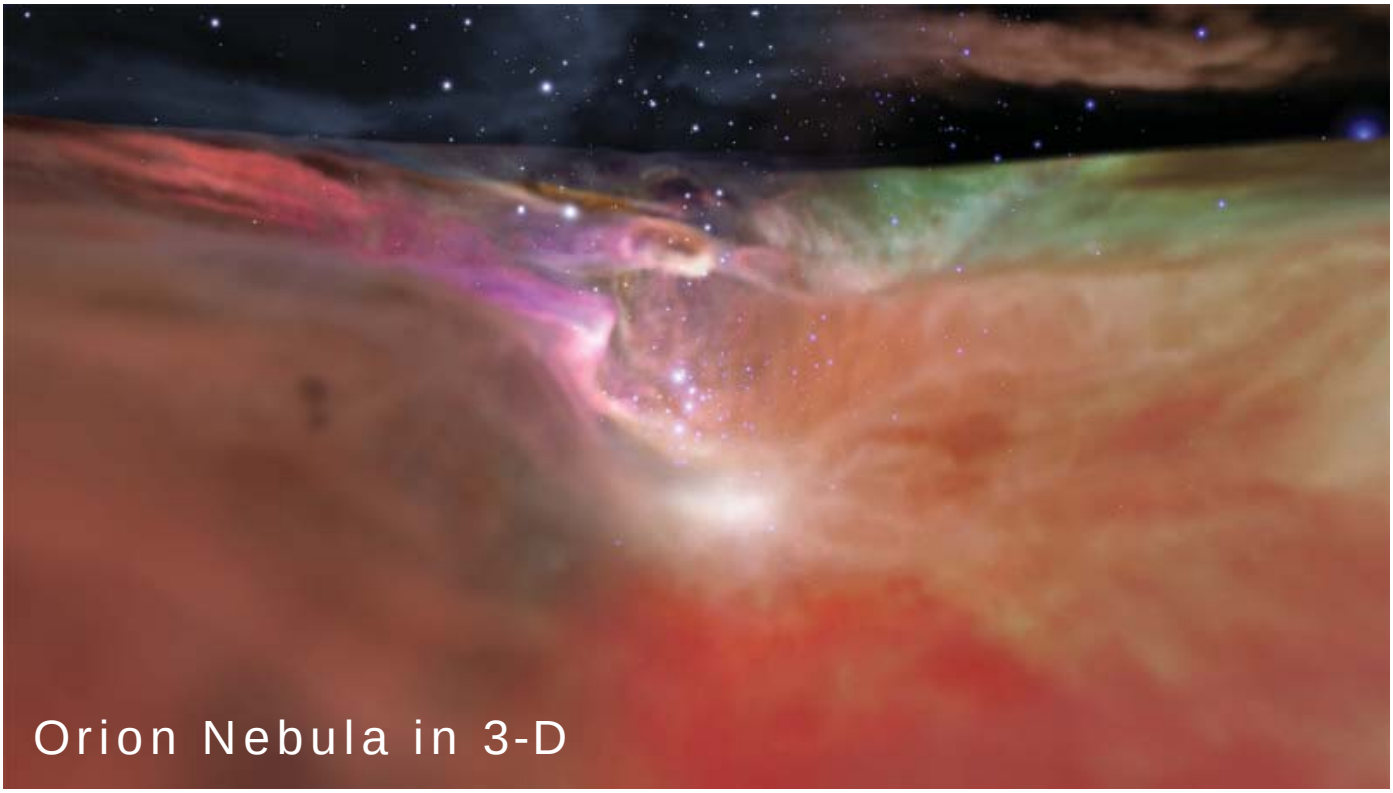


Enhanced color image of the subsurface ice (bright blue) as exposed in a Martian scarp and imaged by the MRO's HiRISE camera. The area above the ice is level ground while the ground at the bottom is about 140 yards (130 meters) lower. The ice layer is approximately 260 vertical feet (80 vertical meters) thick. Image credit: NASA/JPL-Caltech/UA/USGS

Orion Nebula in 3D

A favorite deep sky target in the winter sky is the Great Orion Nebula, a stellar nursery a mere 1,350 light years away in the constellation Orion the Hunter. For Earth-bound observers, the vast energized cloud of molecular hydrogen gas and dust appears two dimensional upon a star-filled backdrop, its true nature hidden.

Using observational data from the Hubble Space Telescope (near-ultraviolet, visible and near-infrared) and the Spitzer Space Telescope (infrared), astronomers and visualization specialists have created a multi-wavelength, three dimensional fly-through of the nebula. The three minute movie created from data collected by the two telescopes reveals the core of the nebula and the cavernous star forming regions within, eroded by the radiation streaming from the young stars (see image below:).



Credits: NASA, ESA, F. Summers, G. Bacon, Z. Levay, J. DePasquale, L. Frattare, M. Robberto and M. Gennaro (STScI), and R. Hurt (Caltech/IPAC)

The Spitzer telescope is able to detect infrared radiation, heat radiated by newborn stars embedded within the nebula and obscured from our view by dust. The infrared observations combined with the wavelengths discernable to the Hubble telescope create a detailed simulation complete with stars, protoplanetary disks, bow shocks and other topographic features of the nebula in the fly-through.

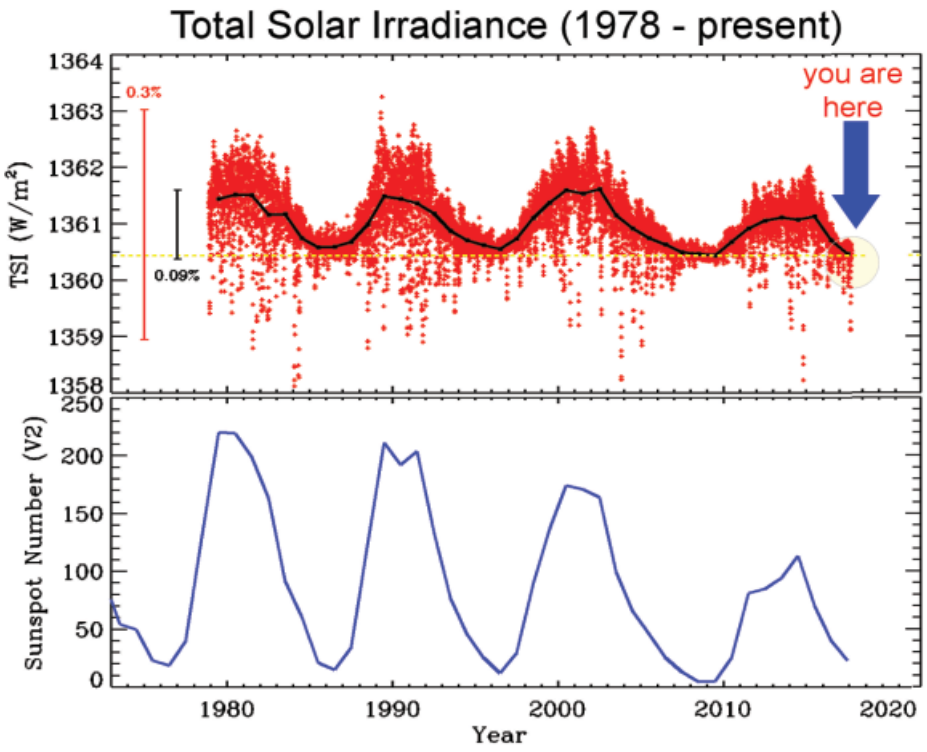
The fly-through can be accessed at *https://www.jpl.nasa.gov/news/news.php?feature=7035*.

Solar Power

A cargo-carrying SpaceX Dragon docked with the International Space Station on December 17th.

Tucked inside its unpressurized trunk was an instrument developed by the Laboratory for Atmospheric Physics at the University of Colorado, Boulder. The NASA-funded Total and Spectral Solar Irradiance Sensor, or TSIS-1, will monitor the Sun's energy output after a 3 month calibration period.

The data collected by TSIS-1 will contribute to our understanding of the Earth's climate and its response to the Sun's cyclical levels of light energy or irradiance (the Sun's energy output waxes and wanes with the 11-year sunspot cycle). The instrument will mea-



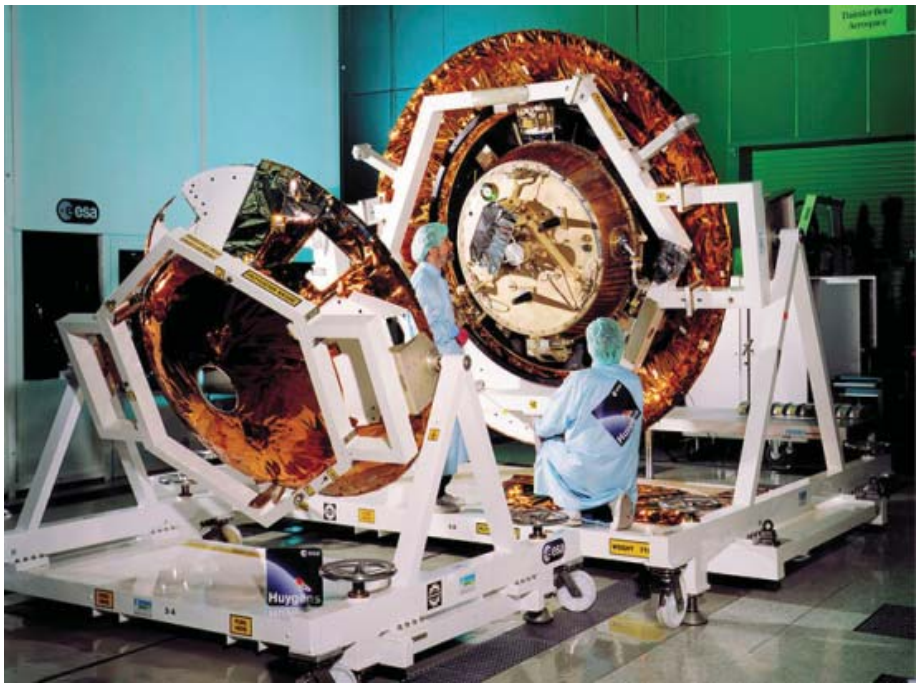
sure the amount of the Sun's energy reaching Earth as well as how the Earth's atmosphere responds to the energy.

NASA satellites have been tracking a decline in total solar irradiance with a progressively lower peak output during the last several solar cycles. TSIS-1 will continue the work currently performed by NASA's Solar Radiation and Climate Experiment (SORCE) satellite and, with a five-year mission life, should be able to record the Sun's rebound from its latest solar minimum, expected to occur in 2019-2020. Solar output is a critical factor in determining the Earth's overall energy balance and assessing impacts, both manmade and natural on the climate.

Titan, Past and Future

Thirteen years ago on January 14, 2005, the European Space Agency's Huygens probe completed its two hour and 27 minute descent through the atmosphere of Titan, Saturn's largest moon, landing on a frozen floodplain. The probe had hitched a ride aboard the Cassini spacecraft before being released on Christmas Day 2004 for its 21-day cruise to Titan.

The probe was protected during its seven year journey to Saturn and in the initial stages of decelerating through Titan's atmosphere by a 9 foot diameter (2.7 meters) shell and heat shield. After the initial aerobraking, parachutes were deployed to slow the probe and allow its instruments to record the descent, before landing among a field of icy pebbles - the first successful landing in the outer solar system. The probe is believed to have created a hole about 5 inches (12 cm) deep in the frozen crust before bouncing and sliding across the flat surface.



ESA's Huygens probe resting inside the descent module's heat shield
Image Credit and Copyright: European Space Agency

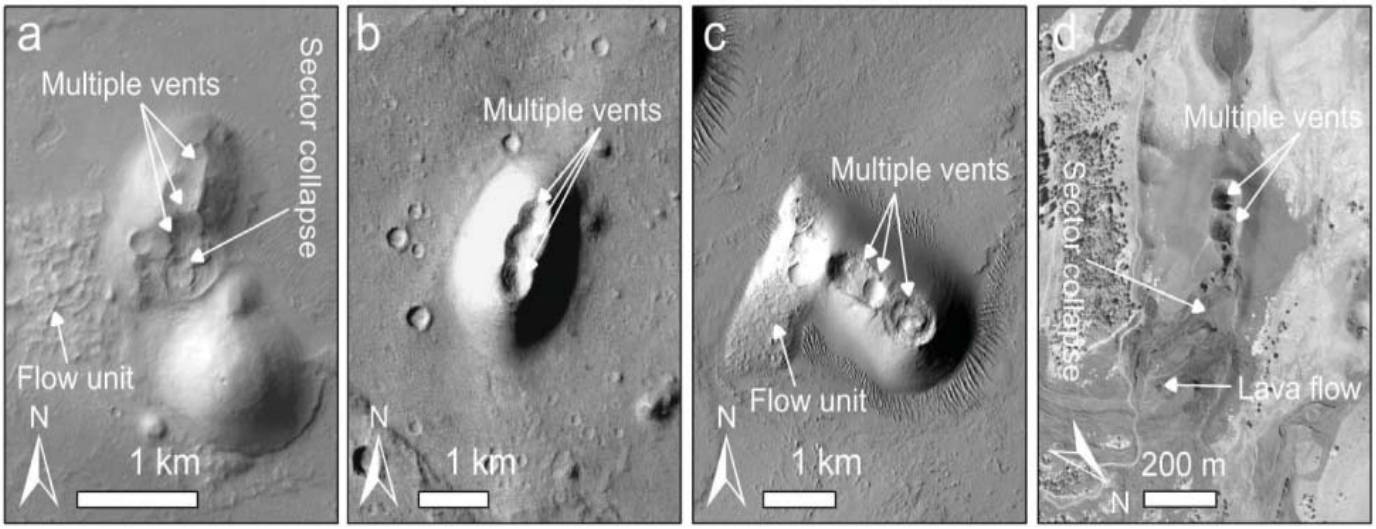
The icy pebble field at Huygens landing site. The large flat pebble below the middle of the image and on the left is approximately 6 inches (15 cm) across.
Image Credit: NASA/JPL/ESA/ University of Arizona

Once on the surface, the Huygens probe transmitted data to the Cassini spacecraft for approximately 72 minutes until the spacecraft was below Titan's horizon - although some additional data was still received by the radio telescopes on Earth for a short time thereafter. In its short operating life, the Huygens probe provided critical data on the smoggy atmosphere and winds of Titan, and the moon's topography, including mountains, lake beds and features resembling dry river channels. Subsequent imaging by Cassini's radar would confirm the existence of large methane lakes, a methane cycle (evaporation and rain) and evidence of a subsurface ocean.

If the proposed New Frontiers mission Dragonfly is ultimately selected, we could be back exploring Titan (with a rotorcraft) by 2034.

Amazonian Volcanism

Valles Marineris is one of the most striking landforms in the solar system, a grand canyon that if placed on Earth would traverse the continental United States. The network of canyons runs along the Martian equator just east of the Tharsis region with its gargantuan shield volcanoes. One of the lowest points in the valley is Coprates Chasma. More than a hundred outcropping on the floor of Coperates Chasma have been identified and interpreted as volcanic in origin as described in Volume 473 of Earth and Planetary Science Letters (September 2017). The authors present a case for volcanism within the valley as recently as 400 to 200 million years ago. They include spectral data that suggests possible magma-water interaction (for example, at a hydrothermal vent) which would create an environment conductive to biological activity.



Several volcanic features (cones and vents) on Mars (a, b and c) and on Mt. Etna, Sicily (d) on Earth for comparison, as imaged by the Mars Reconnaissance Orbiter's Context Camera (CTX). Credit: NASA/ JPL-Caltech/Malin Space Science Systems

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).

Hubble Heritage Team
(NASA/ScI/AURA

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.

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.

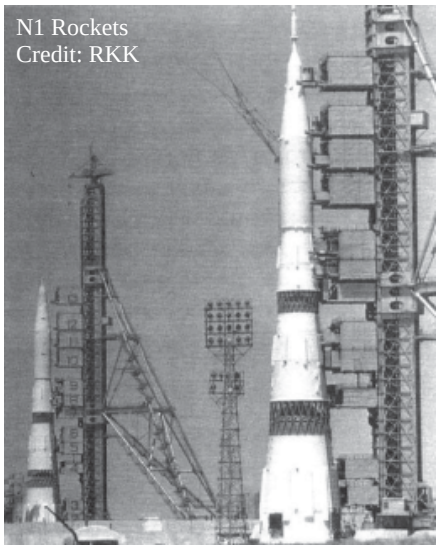
This Hubble Space Telescope image shows Supernova 1987A within the Large Magellanic Cloud, a neighboring galaxy to our Milky Way.

Credits: NASA, ESA, R. Kirshner (Harvard-Smithsonian Center for Astrophysics and Gordon and Betty Moore Foundation), and M. Mutchler and R. Avila (STScI)

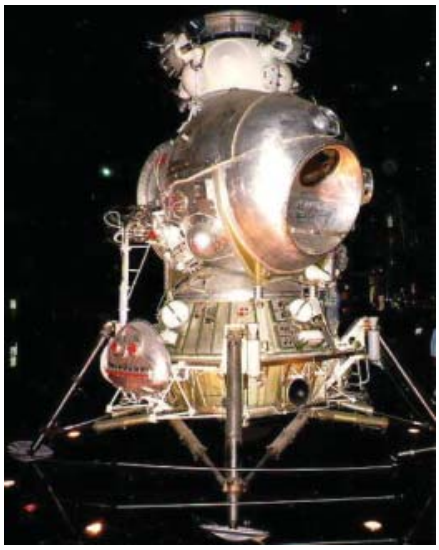
Soviet Moon Program

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 N1 moon rocket exploded during its first test flight. The rocket fell back to Earth after a safety system mistakenly shut down all 30 engines when a fire was detected in the first stage less than 70 seconds after liftoff. Three more failures would follow before the Soviet government would abandon their manned-Moon program.

The historic photos on the right and on the following page show 1) the N1 under construction with the 30-engine first stage, 2) the Soviet lunar lander and 3) two N1 rockets on pads at the Baikonur Cosmodrome (also known as Tyuratam) in Kazakhstan. The five stage rockets stood approximately 340 feet high.



N1 Rockets
Credit: RKK



John Glenn and the Flight of Freedom 7

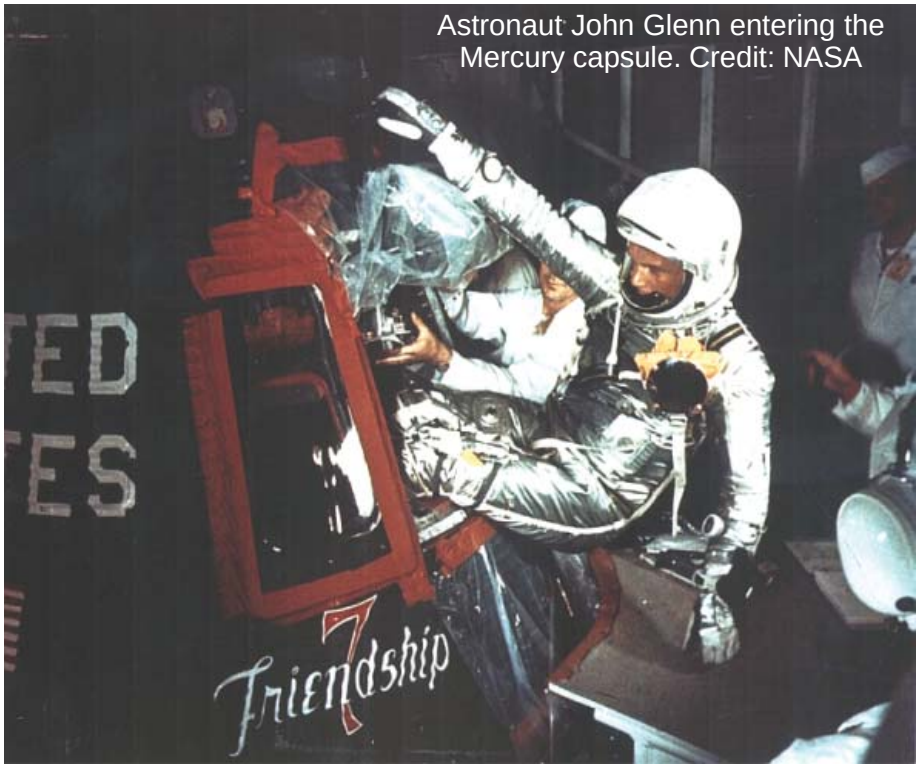
On the morning of February 20, 1962, John Glenn became the first American to orbit the Earth aboard a Mercury space capsule that Glenn named Friendship 7. Originally scheduled for the previous December, the launch was delayed by several technical and mechanical issues, including a fuel leak, and by weather.

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), 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.

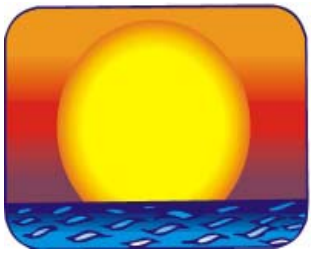
Glenn served with the Marine Corps prior to being selected by NASA for its manned spaceflight program. As a fighter pilot, he flew 59 combat missions in the South Pacific during World War II. Following service in the Korean War (baseball Hall of Fame legend Ted Williams was one of his wingmen), he set 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.



Astronaut John Glenn entering the Mercury capsule. Credit: NASA

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.



Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
February 1st (EDT)	07:05	17:09
February 15th	06:49	17:27
February 28th	06:29	17:43

Astronomical and Historical Events

1st Apollo Asteroid 2018 AG12 near-Earth flyby (0.075 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 2002 CB19 near-Earth flyby (0.027 AU)
2nd Dwarf Planet Ceres closest approach to Earth (1.602 AU)
2nd History: Soviet space station Salyut 4 reenters the Earth's atmosphere (1977)
3rd Apollo Asteroid 6489 Golevka closest approach to Earth (2.510 AU)
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 Apollo Asteroid 276033 (2002 AJ129) near-Earth flyby (0.028 AU)
4th Apollo Asteroid 2018 AH12 near-Earth flyby (0.014 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 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 History: Soviet space station Salyut 7 reenters Earth's atmosphere (1991)
7th Last Quarter Moon
7th Apollo Asteroid 505657 (2014 SR339) near-Earth flyby (0.054 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 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)
9th Apollo Asteroid 2015 BN509 near-Earth flyby (0.033 AU)
9th Apollo Asteroid 2018 BL1 near-Earth flyby (0.043 AU)
10th Second Saturday Stars - Open House at the McCarthy Observatory
10th Aten Asteroid 2015 FV118 near-Earth flyby (0.093 AU)

Astronomical and Historical Events (continued)

10th Apollo Asteroid 1865 Cerberus closest approach to Earth (0.425 AU)
10th Apollo Asteroid 14827 Hypnos closest approach to Earth (3.383 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: MIT, using Millstone Hill radar in Westford, MA, bounces radar off Venus (1958)
10th History: discovery of Asteroid 624 Hecktor, largest Jupiter Trojan, by August Kopff (1907)
11th Moon at apogee (furthest distance from Earth)
11th Scheduled launch of a Russian Progress cargo carrying spacecraft from the Baikonur Cosmodrome in Kazakhstan to the International Space Station
11th Aten Asteroid 2014 WQ202 near-Earth flyby (0.039 AU)
11th Apollo Asteroid 1991 VG near-Earth flyby (0.047 AU)
11th Apollo Asteroid 2016 WQ3 near-Earth flyby (0.095 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 Winter Star Party (through the 18th) on the Florida Keys, Florida
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, CO2 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 Apollo Asteroid 2015 SY16 near-Earth flyby (0.053 AU)
13th Apollo Asteroid 137052 Tjelvar closest approach to Earth (0.260 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)
14th History: launch of Syncom 1, the first geosynchronous satellite (1963)
15th New Moon
15th Atira Asteroid 2010 XB11 closest approach to Earth (1.056 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)

Astronomical and Historical Events (continued)

15th History: Pioneer 10 becomes the first spacecraft to traverse the Main Asteroid Belt (1973)
15th History: Galileo Galilei born (1564)
16th Apollo Asteroid 162882 (2001 FD58) near-Earth flyby (0.088 AU)
16th History: Gerard Kuiper discovers Uranus' moon Miranda (1948)
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 Apollo Asteroid 2016 CA138 near-Earth flyby (0.056 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 Apollo Asteroid 2101 Adonis closest approach to Earth (0.219 AU)
19th Aten Asteroid 341843 (2008 EV5) closest approach to Earth (1.797 AU)
19th Kuiper Belt Object 55565 (2002 AW197) At Opposition (44.522 AU)
19th History: Nicolas Copernicus born (1473)
20th Apollo Asteroid 3752 Camillo closest approach to Earth (0.138 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 Apollo Asteroid 2017 VX1 near-Earth flyby (0.099 AU)
21st Kuiper Belt Object 148209 (2000 CR105) At Opposition (60.582 AU)
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 First Quarter Moon
23rd Atira Asteroid 2013 TQ5 closest approach to Earth (0.374 AU)
23rd History: Supernova 1987A detected in the Large Magellanic Cloud (1987)
24th Aten Asteroid 2017 DR109 near-Earth flyby (0.009 AU)
24th Aten Asteroid 99942 Apophis closest approach to Earth (1.552 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)
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 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 Apollo Asteroid 2016 FU12 near-Earth flyby (0.034 AU)
26th Apollo Asteroid 2004 CK39 near-Earth flyby (0.086 AU)

Astronomical and Historical Events (continued)

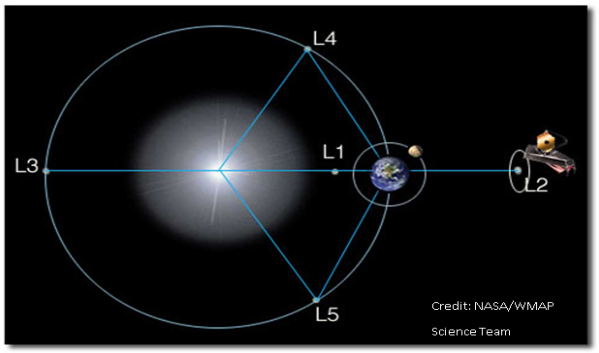
26th Apollo Asteroid 2017 DF38 near-Earth flyby (0.098 AU)
26th Amor Asteroid 4487 Pocahontas closest approach to Earth (1.151 AU)
26th History: launch of the first Saturn 1B rocket booster (1966)
27th Moon at perigee (closest distance from Earth)
27th Apollo Asteroid 2014 EY24 near-Earth flyby (0.038 AU)
27th History: discovery of Jupiter's moon Herse was by Brett J. Gladman, John J. Kavelaars, Jean-Marc Petit, and Lynne Allen (2003)
28th Apollo Asteroid 2015 BF511 near-Earth flyby (0.030 AU)
28th Atira Asteroid 1998 DK36 closest approach to Earth (0.824 AU)
28th Plutino 90482 Orcus at Opposition; discovered on February 17, 2004 by American astronomers Michael Brown of Caltech, Chad Trujillo of the Gemini Observatory, and David Rabinowitz of Yale University; the plutino has one large moon called Vanth (47.134 AU)
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)

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

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).



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 Satellites

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

Image Credits

Front page design and graphic calendar: Allan Ostergren

Second Saturday Stars poster: Marc Polansky

All other non-credited photos were taken by the author: Bill Cloutier

Front Page Graphics

About 300 million light years out in the constellation Hydra (*Water Snake*), a massive elliptical galaxy NGC 2937) and a younger, more dynamic, spiral galaxy (NGC 2936), are locked on a path toward a fateful liaison. The pair are jointly designated as Arp 142. To astronomers and illustraters, the celestial odd couple have been variously depicted as a porpoise or as a penguin and its egg.

The egg would seem to have the upper hand (perhaps from an active black hole at its center) as its mating partner is stretched and squeezed and its tendrilled arms left dangling and trailing away. Both galaxies are being slowly merged by the gravitational forces powering their embrace, and in another billion years their elements will combine to spawn a new galactic entity.

(Image Credit NASA, ESA, & Hubble Heritage Team (STScI/AURA)).

For more information, go to *https://apod.nasa.gov/apod/ap130624.html* or *https://www.nasa.gov/image-feature/jpl/pia22092/the-penguin-and-the-egg*.

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

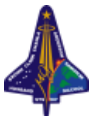
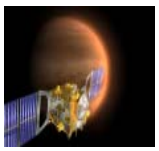
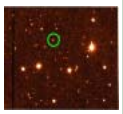
February 10th
7:00 - 9:00 pm

Exploration of Jupiter by Robotic Spacecraft

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

February 2018

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Jan 2018 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 2018 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**  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)  **2nd Saturday Stars Open House McCarthy Observatory**
11  Moon at apogee (farthest from Earth) 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) 	**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) 
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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** Moon at perigee (closest distance to Earth) 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** Feb 7 Feb 15 Feb 23	