Galactic Observer

John J. McCarthy Observatory

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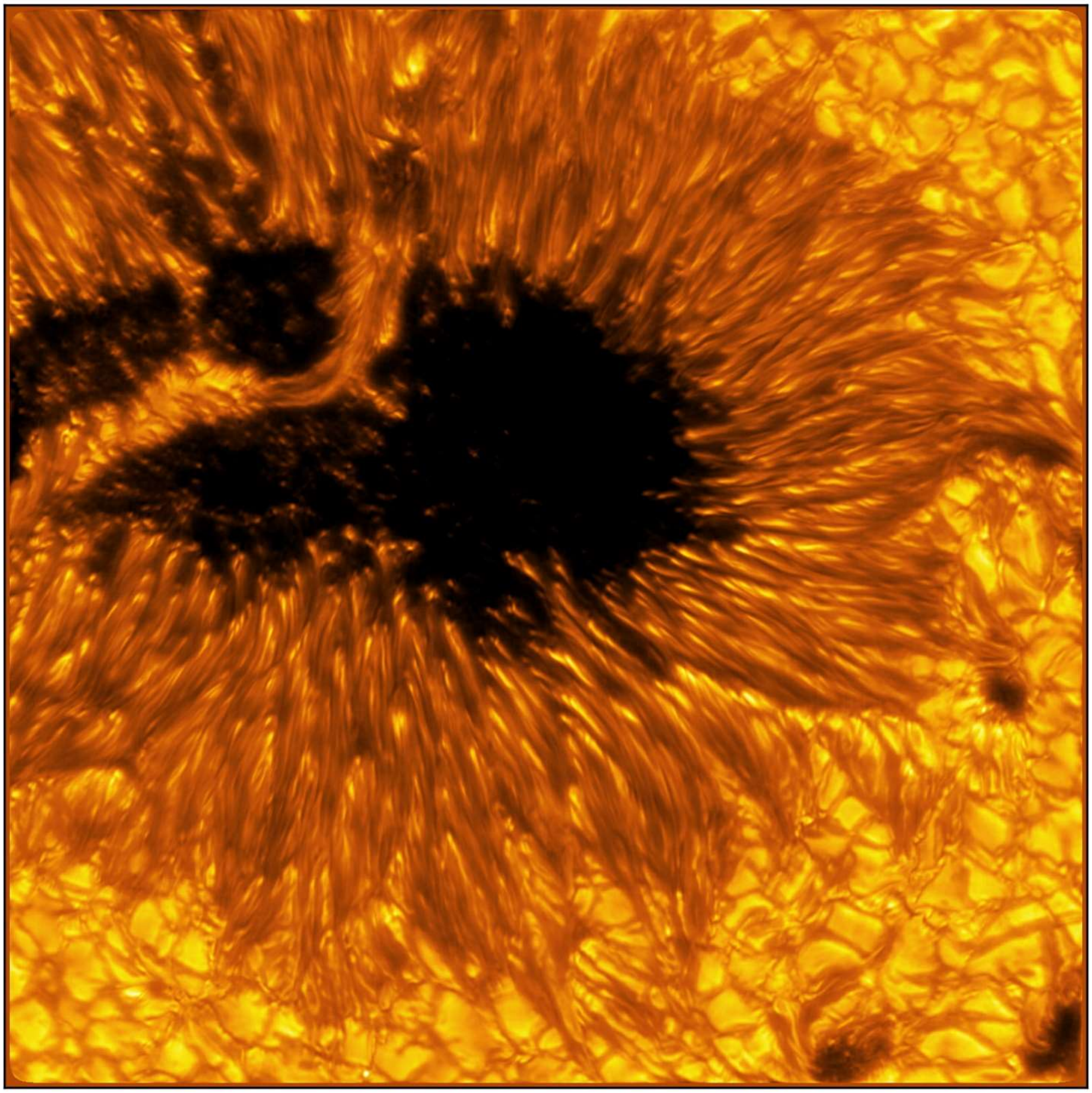
An infrared view of the Crab Nebula from NASA's James Webb Space Telescope reveals new details of the supernova remnant that will aid astronomers in determining the type of explosion witnessed by Earth-bound viewers in the year 1054. The milky-white "smoke" is synchrotron radiation, generated by charged particles such as electrons and accelerated to near-relativistic velocities by the strong magnetic field of the pulsar embedded within the expanding nebula that now spans approximately 11 light years.

Image: NASA, ESA, CSA, STScI, Tea Temim (Princeton University)

December Astronomy Calendar and Space Exploration Almanac



The National Science Foundation's (NSF) Daniel K. Inouye Solar Telescope, currently the world's largest solar telescope, captured the exquisite details of a sunspot. Surrounding the sunspot are convection cells where hot plasma rises in the bright centers, cools off, and then sinks along the dark lanes bounding the cells. The four-meter solar telescope, located on the island of Maui, Hawaii, also captured a "light bridge," a bright lane crossing the darkest part of the sunspot (the "umbra"). Light bridges are commonly found in sunspots undergoing decay or as the sunspot's magnetic flux disappears.

Credit: NSF/AURA/NSO

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"<u>Out the Window on Your Left</u>"

It's been 51 years since Gene Cernan left the last boot print on the Moon's surface. As a nation founded on exploration and the conquest of new frontiers, today's commitment to return to the Moon has been as fleeting as the funding. But what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered orbit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

For Earth-bound lunar observers, the Sun rises on the Taurus-Littrow valley on the evening of December 17th. A narrow breach in the rim of the Serenitatis Basin, the valley is enclosed on three sides by large, blunt peaks - the South, North, and East Massifs. On December 11, 1972, the valley was the destination of Apollo 17, the final lunar mission of the Apollo program.

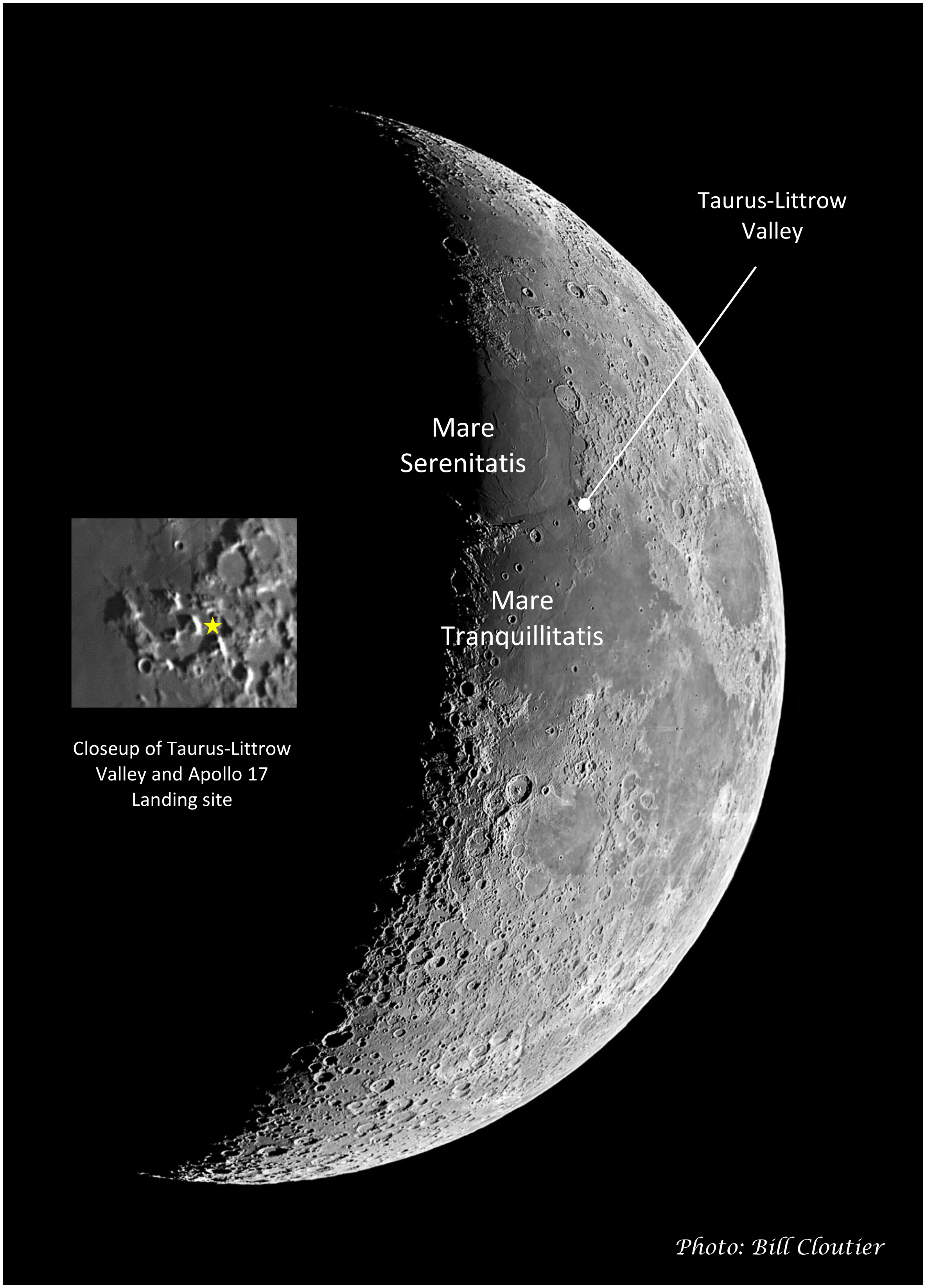
Multiple sites were considered for the last mission, offering diversity of terrains, history and geology. Taurus-Littrow provided the explorers, including astronaut-geologist Harrison Schmitt, an opportunity to visit craters on the valley floor with dark halos. The lunar module set down near one such crater, called "Shorty."

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

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

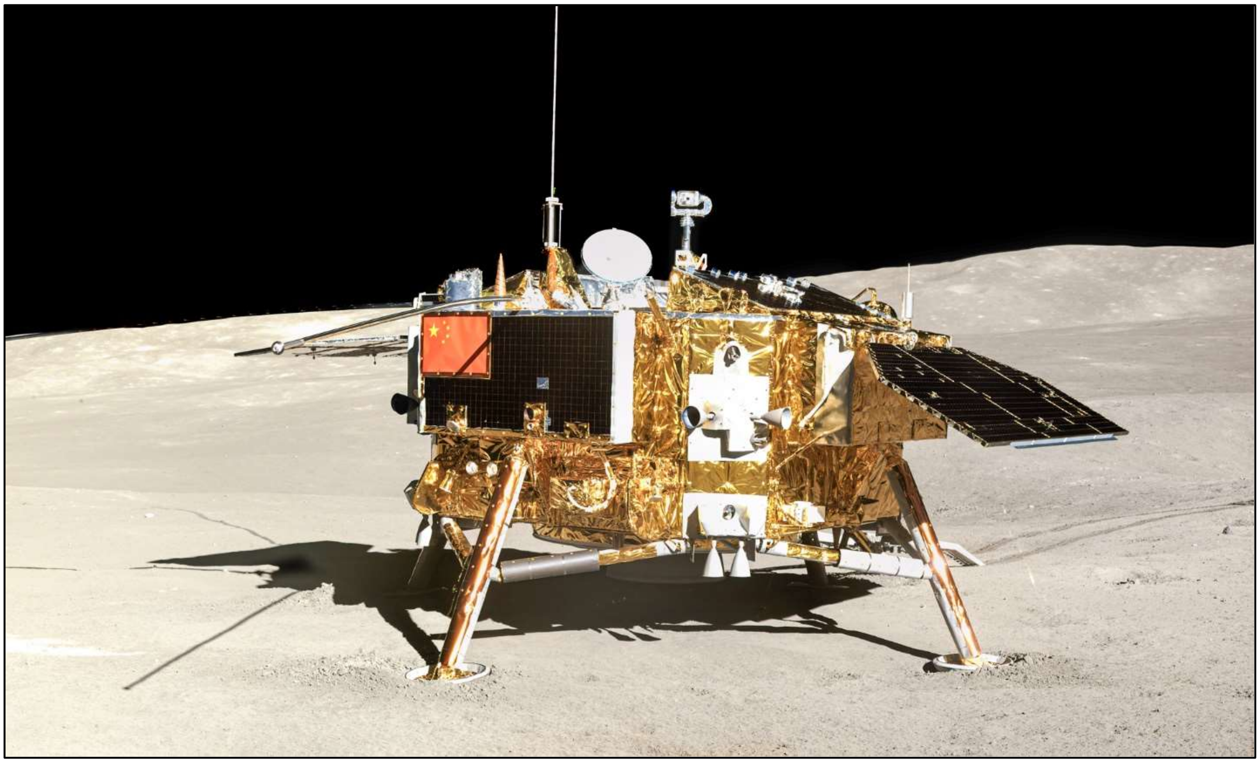
The Apollo 17 mission featured the most extensive lunar exploration of the program with three moonwalks, each lasting more than seven hours. The crew collected the oldest known, unshocked lunar rock (at least 4.2 billion years old) - suggesting that the Moon had, at one time, a magnetic field generated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

<u>Taurus Littrow</u>



China's Space Ambitions

China's long-term space exploration plans were revealed in some detail at the 74th International Astronautical Congress. The plans include more ambitious robotic lunar missions, followed by human exploration, as well as deep space aspirations.



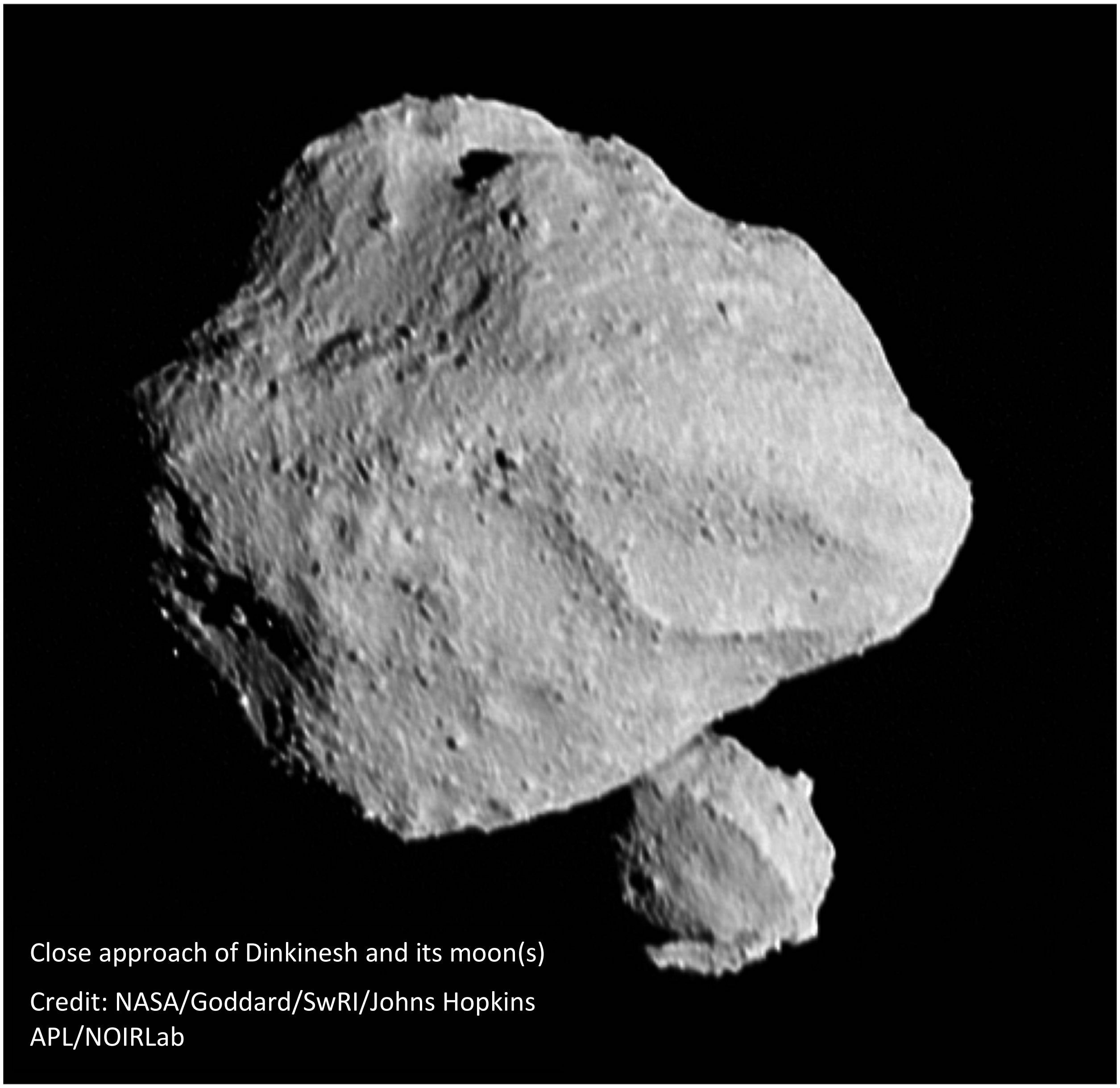
The Chang'e-4 lander imaged by the Yutu-2 rover on the lunar far side. Credit: CLEP/CNSA

The "Chang'e" lunar exploration program, which has already returned samples from the Moon's near side and landed on its far side, will aim to collect and return to Earth core samples from the far side with its Chang'e 6 mission. Chang'e 7 will venture to the Moon's south pole in search of water ice and other resources. The eighth and final Chang'e mission will investigate and evaluate in-situ resources for its future International Lunar Research Station. To support these missions, China will deploy a second relay satellite around the Moon to transmit data back to Earth from these more remote areas (the original satellite was launched in 2018 and is still providing operational support for China's current lunar missions). China intends to land a crewed mission on the Moon by 2030 and establish a permanent research outpost at the lunar south pole by the year 2040.

China's "Tianwen" deep space missions are no less ambitious. Tianwen-2, expected to launch in March 2025, will visit the near-Earth asteroid *469219 Kamo'oalewa*, collect a sample of 100 grams that it will return to Earth, before heading off to explore a comet-like asteroid *311P/PanSTARRS*. Tianwen-3 is designed to return a sample from the surface of Mars and will require the launch of two spacecraft, the first of which is scheduled for a 2028 launch. Sample return is tentatively planned for July 2031. The last mission discussed at the conference, Tianwen-4, will venture out to Jupiter. The launch is currently planned for October 2029, with arrival in the Jovian system in 2035, following gravity-assist flybys of Earth and Venus.

Lucy Discovers First Contact Binary Moon

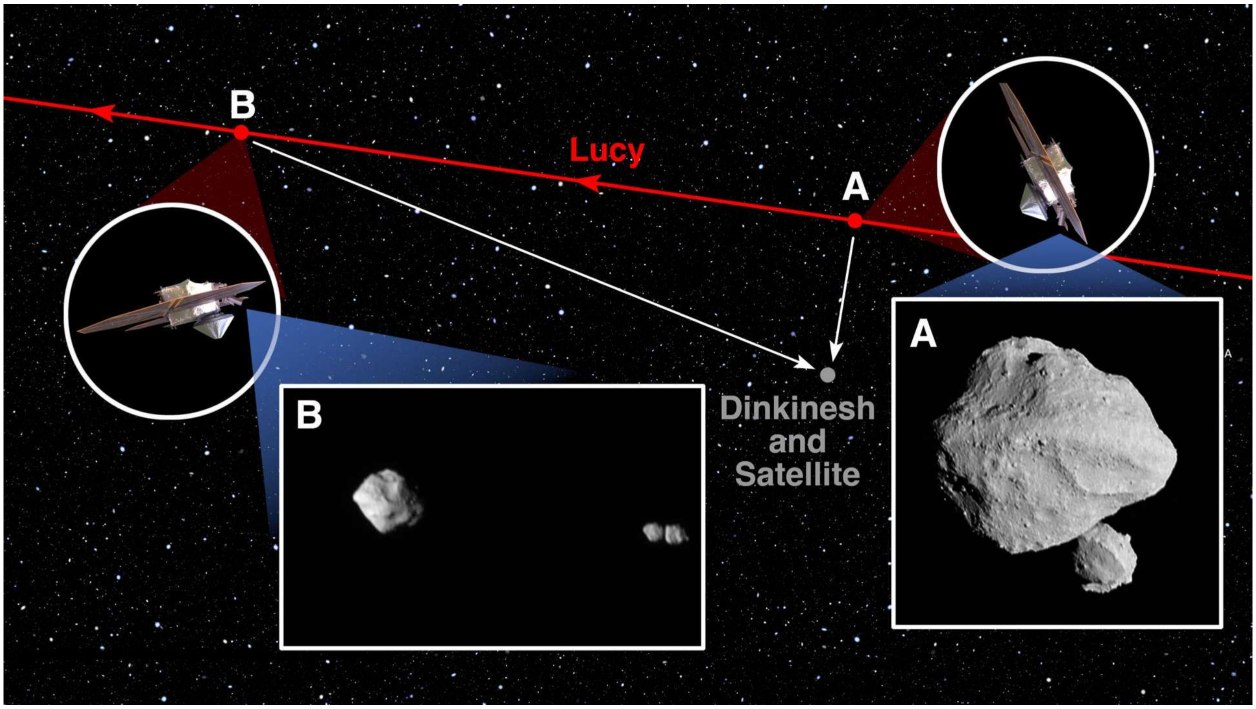
NASA's Lucy mission was launched in 2021 on a 12-year mission to visit five asteroids (and satellites of three of the five) that share Jupiter's orbit (called Trojan asteroids) at two gravitationally stable locations. Along the way, astronomers had identified two main-belt asteroids that the spacecraft would pass close enough for the Lucy team to test and calibrate the spacecraft's instruments in advance of its future scientific targets.



Close approach of Dinkinesh and its moon(s)

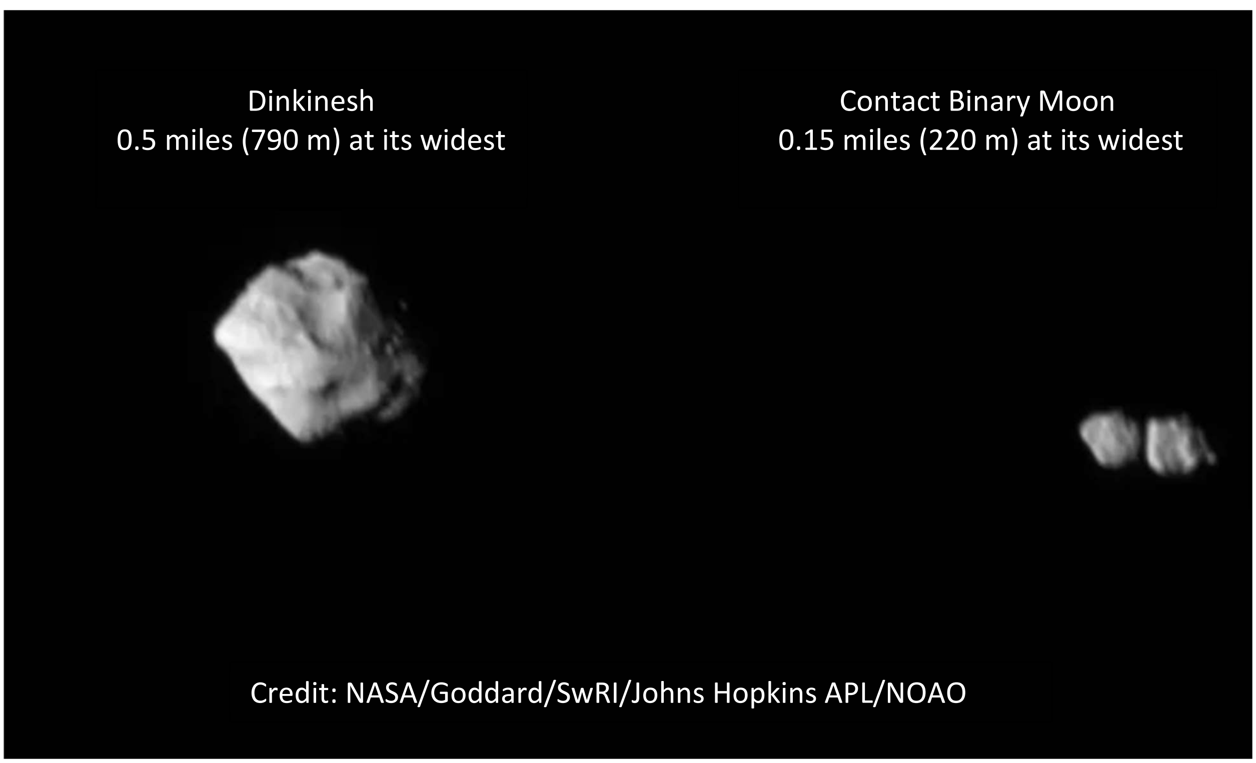
Credit: NASA/Goddard/SwRI/Johns Hopkins APL/NOIRLab

The spacecraft's first encounter with a minor planet occurred on November 1st as Lucy passed by a small rocky body, less than one-half mile across, called Dinkinesh (the Amharic name for the Lucy fossil after which the mission is named). The initial image, taken within a minute of closest approach, and from a range of approximately 270 miles (430 km), revealed a small moon. However, an image taken several minutes later, as the spacecraft was moving away from Dinkinesh (at approximately 10,000 mph or 4.5 km/s), revealed that the small satellite is actually comprised of two bodies - a type of binary system known as a "contact binary."



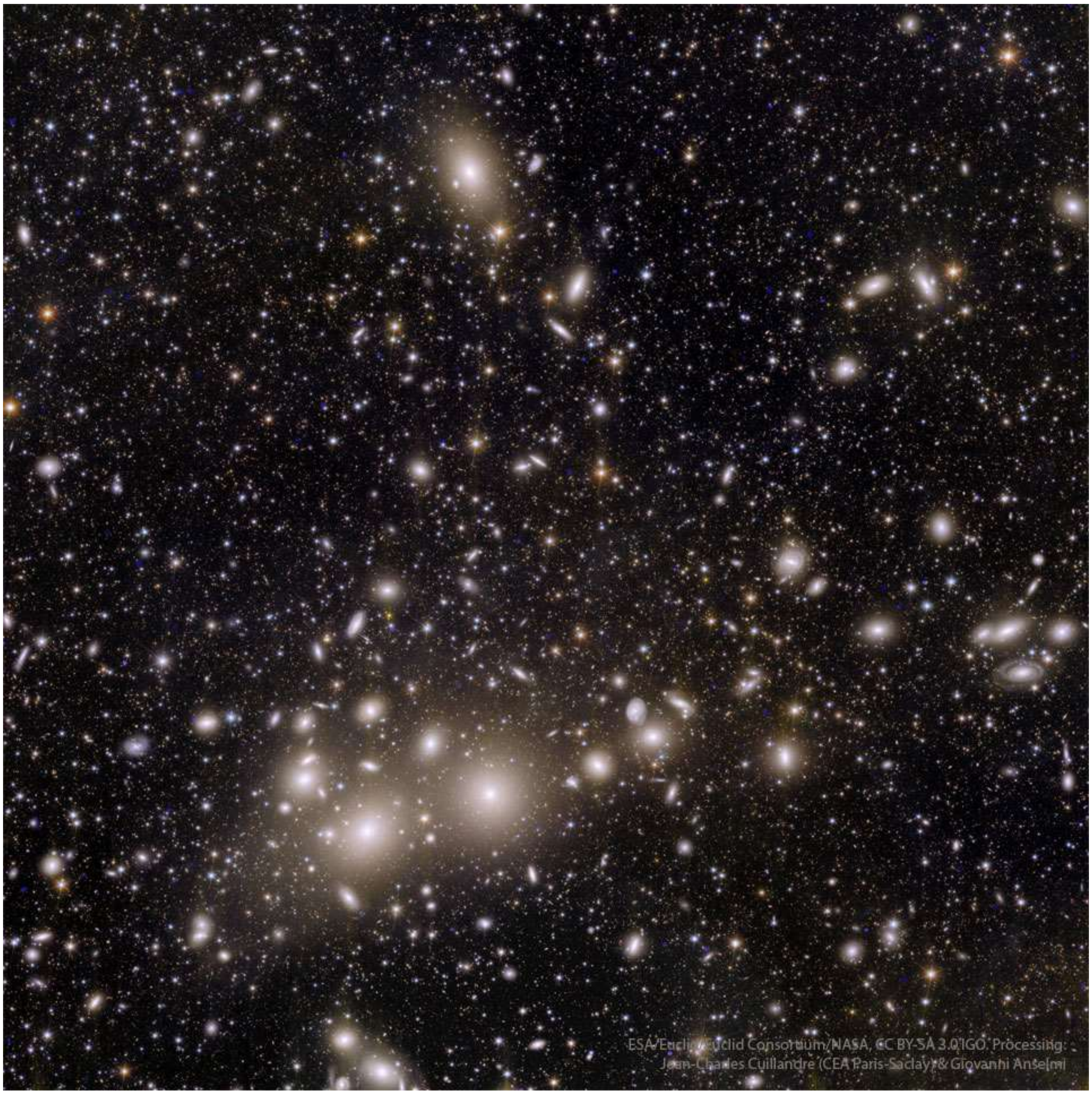
Close approach of Dinkinesh, at point "A", with the moon behind the main body. Images captured from point "B," approximately 960 miles (1,545 km) from the point at which Lucy discovered the moon, revealed its binary nature.

Credit: Overall graphic, NASA/Goddard/SwRI; Inset "A," NASA/Goddard/SwRI/Johns Hopkins APL/NOIRLab; Inset "B," NASA/Goddard/SwRI/Johns Hopkins APL



ESA Releases First Images from Euclid Telescope

Euclid is a European telescope built and operated by the European Space Agency (ESA), with contributions from NASA. It was launched on July 1st from Cape Canaveral, Florida and traveled to, and is operating from, a halo orbit around the Sun-Earth Lagrange point 2 (L2), at an average distance of 1 million miles (1.5 million km) beyond Earth's orbit (a location shared by NASA's James Webb Space Telescope).



The "Perseus cluster," a group of thousands of galaxies located 240 million light-years from Earth. It is one of the most massive objects in the Universe.
Credits: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi; CC BY-SA 3.0 IGO

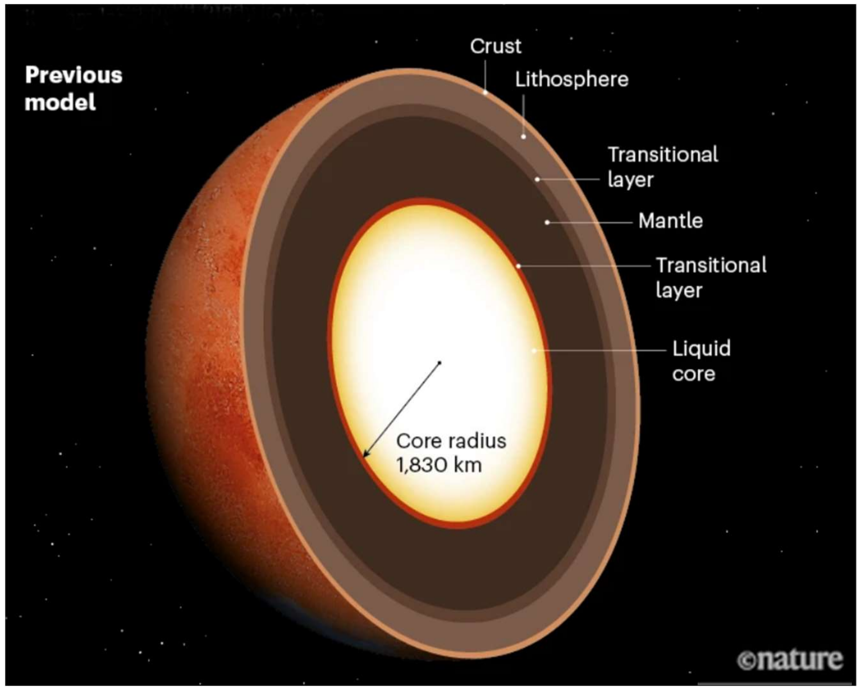
Following a period of commissioning (testing and calibrating), Euclid is scheduled to begin regular science operations in early 2024. During its planned six-year mission, its 600-megapixel camera will be used to produce an extensive 3-D map of billions of galaxies out to 10 billion light-years and across more than a third of the sky. By mapping the structure of the universe over time, astronomers can deduce the properties of dark energy, dark matter and gravity. ESA released its first five science images from the telescope in early November, demonstrating the spacecraft's unique abilities, wide field of view, and high resolution, as compared to previous survey missions.

The Horsehead Nebula, also known as Barnard 33, is located in the Orion constellation at a distance of about 1,375 light-years. It is the closest large star-forming region to Earth.

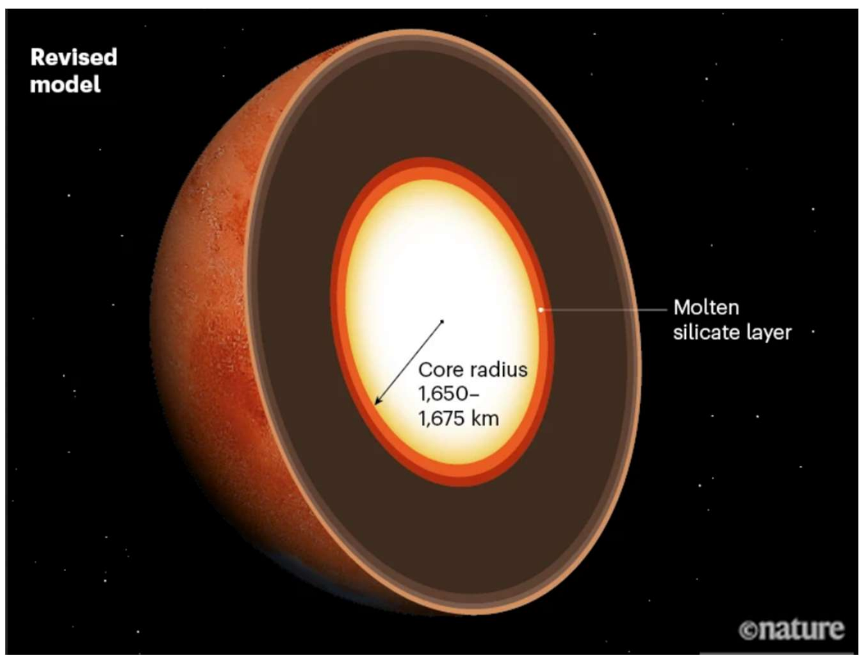
Credit: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi; CC BY-SA 3.0 IGO

Mars' Core Reveal

NASA ended operation of the Mars InSight lander on December 20, 2022 when its solar panels, caked with Martian dust, were unable to produce sufficient power. However, the data collected from over four years of surface operation, and from hundreds of marsquakes, is keeping seismologists busy on Earth as they reconcile different laboratory models and theories pertaining to the interior of the Red Planet.



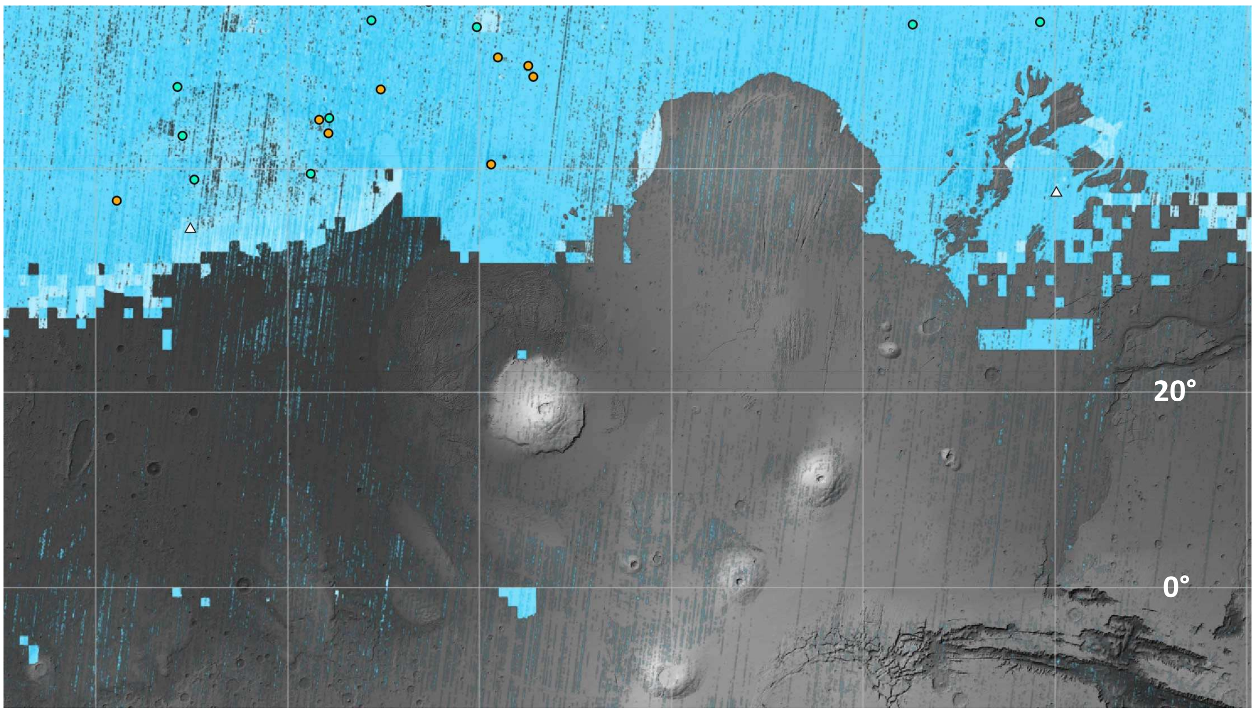
In July 2021, based upon the S-type seismic waves (that only travel through solid media like rock) from eleven different quakes, researchers concluded that Mars had a larger than expected liquid core - one with a radius of approximately 1,137 miles or 1,830 km. A core of this size was puzzling as it suggested a considerable complement of lighter elements, mixed with iron. The determination was upended in September of that year, when a meteoroid slammed into Mars on the opposite side of the planet from the InSight lander. This impact generated stronger P-type seismic waves that can travel through any media.



Analysis of the September event, the subject of two papers recently published in the journal "Nature," conclude that the P-waves traveled through a layer of molten silicates (rock-forming minerals), 93 miles or 150 km thick, that surrounds a smaller liquid metal core (with a radius between 1,025 and 1,040 miles or 1,650 and 1,675 km). The presence of the silicate layer made the core appear larger than it is as the S-waves would not have penetrated the liquid stratum. In the revised model, the smaller Martian core doesn't need to incorporate large amounts of lighter elements and is a better match to theoretical constructs.

Ice Mapping on Mars

NASA has released it most detailed map from the Mars Subsurface Water Ice Mapping (SWIM) initiative since the project began in 2017. While water ice exists at the Martian poles, the regions are too cold for human explorers and too inhospitable for even mechanical emissaries. The objective of the SWIM project is to search for subsurface ice across the more accessible mid-latitudes. Buried ice can be used for drinking water and when the molecules are disassociated into their oxygen and hydrogen components – can be used for rocket fuel and breathing air (oxygen). Ice cores from these deposits could also provide a record of the Red Planet's climate history and provide a potential habitat (past or present) for microbial life.



Global map of Mars showing the likely distribution of water ice buried (in blue) within the upper 3 feet (1 meter) of the planet's surface (from the equator to 60 degrees north latitude). Credit: NASA/JPL-Caltech/ Planetary Science Institute

The project is led by the Planetary Science Institute in Tucson, Arizona, and managed by NASA's Jet Propulsion Laboratory in Southern California. It uses data from several NASA missions, including the Mars Reconnaissance Orbiter, the 2001 Mars Odyssey, and the now-inactive Mars Global Surveyor to identify the likeliest places where ice could be found and accessed by future missions.

Liquid water isn't stable on the surface with the thin Martian atmosphere so NASA is focusing on near-surface deposits which have been exposed as a result of meteorite impacts.

Ice-exposing impact crater at 44°N Lat. Credits: NASA/JPL-Caltech/Univ. of Arizona

A Meteoritic Analog for (16) Psyche?

Estherville Meteorite Slice
McCarthy Observatory Collection

Asteroid (16) Psyche is an enigma. A main-belt asteroid, located three time farther from the Sun than Earth, it is one of the few minor planets that could be a remnant of the core of a protoplanet that was subsequently broken apart in a collision. If so, it should be comprised of mostly metals (e.g., iron and nickel, as well as other heavy elements). While its albedo (reflectivity) and thermal inertia properties suggest a metal-rich content, the estimated bulk density does not. Rather, density estimates appear comparable to a rare class of stony-iron meteorites known as mesosiderites, such as one that fell in Estherville, Iowa in 1879, that are roughly equal parts metal and stone. The density could also be due to high porosity, but scientists may have to wait six years until the Psyche spacecraft arrives at the asteroid in 2029, to fully unravel the evolution of this remote world.

Astrobotic's Peregrine Lander Arrives in Florida

Astrobotic's Peregrine lunar lander has been delivered to Astrotech's facility in Titusville, Florida where it will be the primary payload aboard the first launch of United Launch Alliance's (ULA's) Vulcan rocket.

Peregrine Lunar Lander
Image: ULA

The Peregrine-1 mission will be the first to launch under NASA's Commercial Lunar Payload Services initiative, and is currently scheduled for no earlier than December 24th. Assuming ULA is able to launch in late December, a landing would be expected about a month later in January. The lander is designed to maintain a parking orbit around the Moon until the lighting conditions are optimal for surface operations. In addition to the 21 payloads, including a mix of commercial and government apparatus, the lander will dispense a small rover (named "Iris") built by Carnegie Mellon University.

The mission is targeting Sinus Viscositatis (the "Bay of Stickiness") located on the northwest shore of Mare Imbrium. The Peregrine lunar lander is designed to operate eight to ten Earth-days and not expected to survive a lunar night.

Blue Moon Lander Prototype Unveiled

In 2021, NASA selected SpaceX's reusable Starship design for its Human Landing System, an integral component of the Artemis initiative to return astronauts to the Moon. In May 2023, the agency solicited a second lunar lander, this time from Jeff Bezos' Blue Origin company.

Blue Origin's Jeff Bezos, left, and NASA administrator Bill Nelson, right, stand in front of a Blue Origin Blue Moon Mark 1 moon lander in Huntsville, Alabama. (Image credit: Bill Nelson/NASA via Twitter)

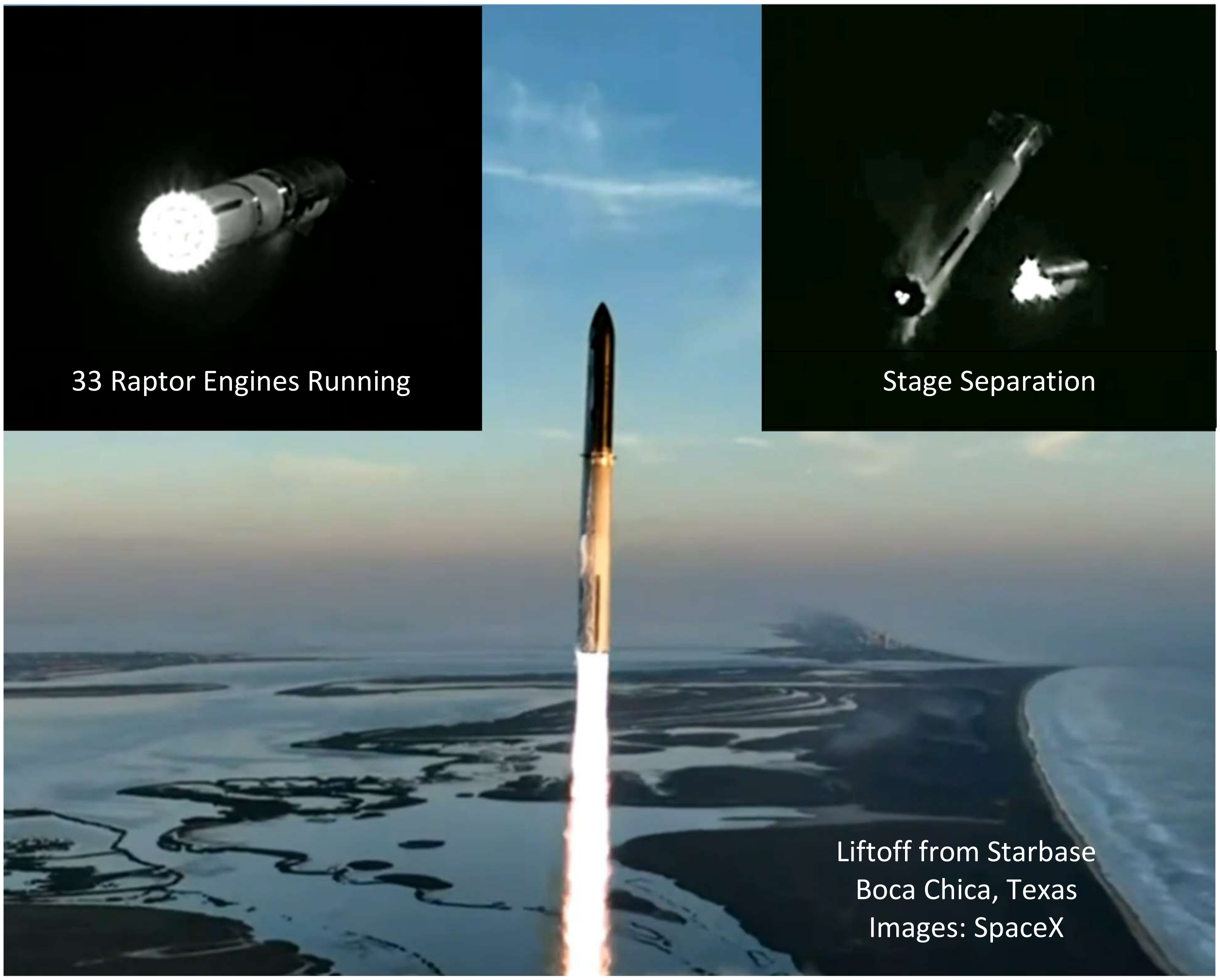
Blue Origin recently showcased one of its prototypes. The "Blue Moon" lunar lander, as currently designed, will be able to deliver up to 3 tons (2.7 metric tons) of cargo to the Moon, as well as ferry astronauts to and from an orbiting space station.

The $3.4 billion award provides for additional research and development, and maturation of the lander's design. With the award, NASA hopes to have two viable alternatives for cis-lunar transportation.

SpaceX's reusable Starship vehicle, if available, will be used to ferry astronauts to and from the lunar surface during the Artemis 3 and 4 missions, currently scheduled for 2025 and 2028, respectively. Blue Origin's lander is currently slated to be used during the Artemis 5 mission which will launch no earlier than 2029.

Blue Origin is also developing its reusable New Glenn rocket to launch its Blue Moon landers. The company is anticipating the launch of its new rocket sometime next year and has already secured a long-term lease for Launch Complex 36 at the Cape Canaveral Space Force Station in Florida.

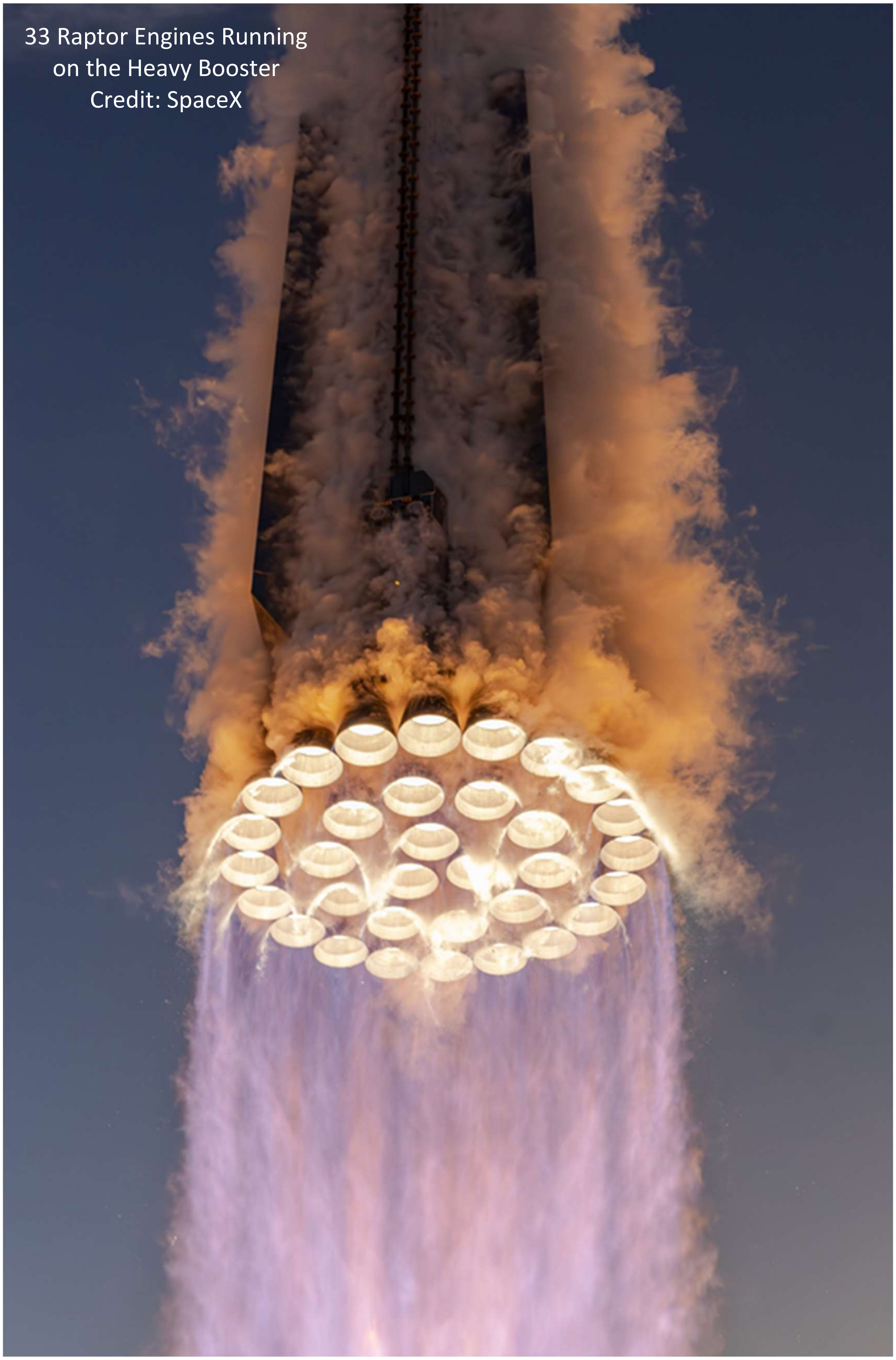
Second Test Flight – Faster, Further



Starship's second test flight, which took place on November 18th, delivered a dazzling spectacle shortly after sunrise along the Texas coast. All thirty-three engines on the heavy booster could be seen burning brightly as the 397 foot-tall rocket sped along its trajectory over the Gulf of Mexico.

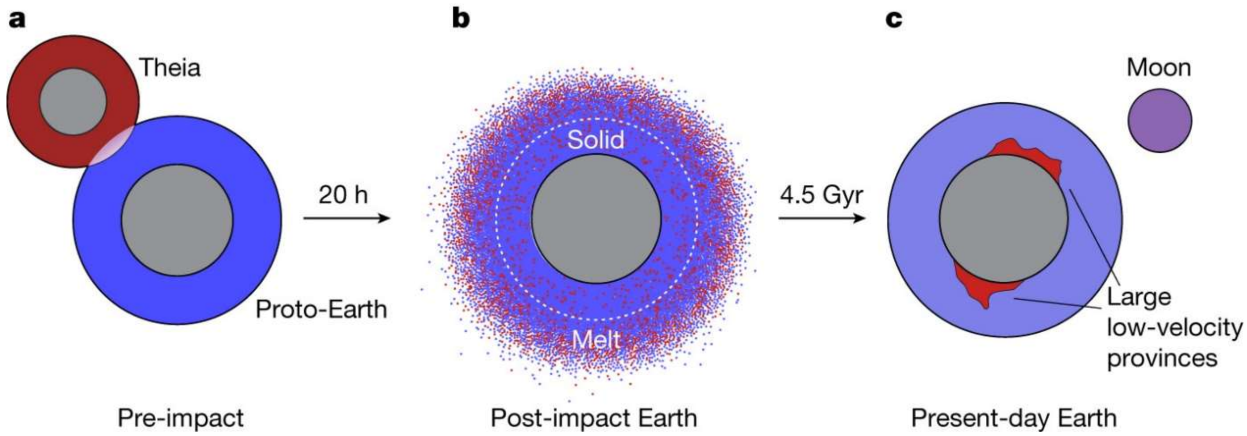
As one of the many modifications and upgrades made to the rocket after Starship's maiden flight in April, this flight used "hot staging," where the ship ignited its engines while several of the engines on the booster were still running. The was done to simplify the separation of the two vehicles (which was not successful on the first flight) and to add additional payload capacity. Stage separation appeared to be nominal on the 18th, however, the booster was lost shortly thereafter (SpaceX had intended to hard land the booster in the Gulf of Mexico). The ship did not appear to be affected and could be seen on the long-range cameras heading to orbit with all six engines running. The mission plan called for the ship to gain sufficient velocity and altitude to test its heat shield during reentry off the coast of Hawaii. Unfortunately, about 8 minutes into the flight, SpaceX lost communications with the vehicle. It was subsequently destroyed by the onboard flight termination system. The November flight successfully addressed several issues experienced during the earlier flight - demonstrating successful staging and greater engine reliability. If SpaceX can secure a launch license from the Federal Aviation Administration it plans to launch again by the end of December, with several completed vehicles waiting in the pipeline.

Ignition: Tower View
Credit: SpaceX


33 Raptor Engines Running
on the Heavy Booster
Credit: SpaceX

Earth's Core May Contain Remnants of Moon Impactor

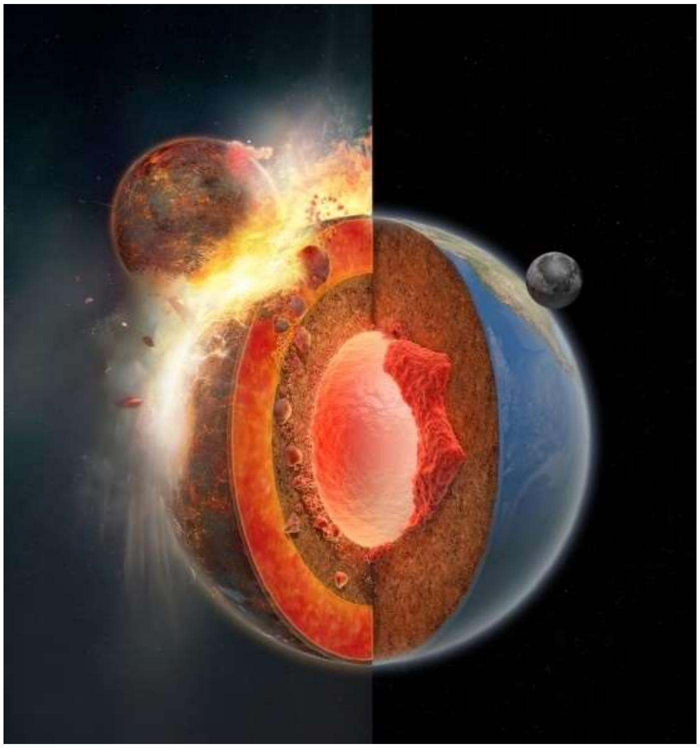
A new theory, published in the journal "Nature," proposes that portions of the protoplanet Theia that collided with the Earth to form the Moon 4.5 billion years ago survived. The researchers believe that remnants are embedded within the Earth's mantle, resting above our planet's core, some 1,800 miles (about 2,900 km) below the surface.



Credit: Nature/ Hernán Cañellas

Seismologist had already identified two massive, distinct structures embedded deep within the Earth. Called large low-velocity provinces, or LLVPs, they were first detected in the 1980s. One lies beneath Africa and another below the Pacific Ocean. The LLVPs are thousands of miles wide, each is roughly twice the mass of the Moon, and denser than the surrounding mantle. Their origin has remained a mystery – if they had been denser, they would have not retained their ragged shape and had they been less dense, they would have been incorporated into the surrounding mantle material.

A new theory suggests that the LLVPs are comprised of material that Theia left behind on Earth. The theory is supported by simulations that show if: Theia were a certain size and consistency and struck the Earth at a specific speed, that the lower half of Earth's mantle would remain mostly solid after the impact. This would allow the remnants of Theia to cool and form solid structures instead of being assimilated into Earth's inner matrix. It would also produce enough debris to create the Moon.



Parts of Theia sink to the bottom of Earth's mantle after the impact, forming the large LLVPs
Credit: Nature/ Hernán Cañellas

Apollo 8 – Lookback

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

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

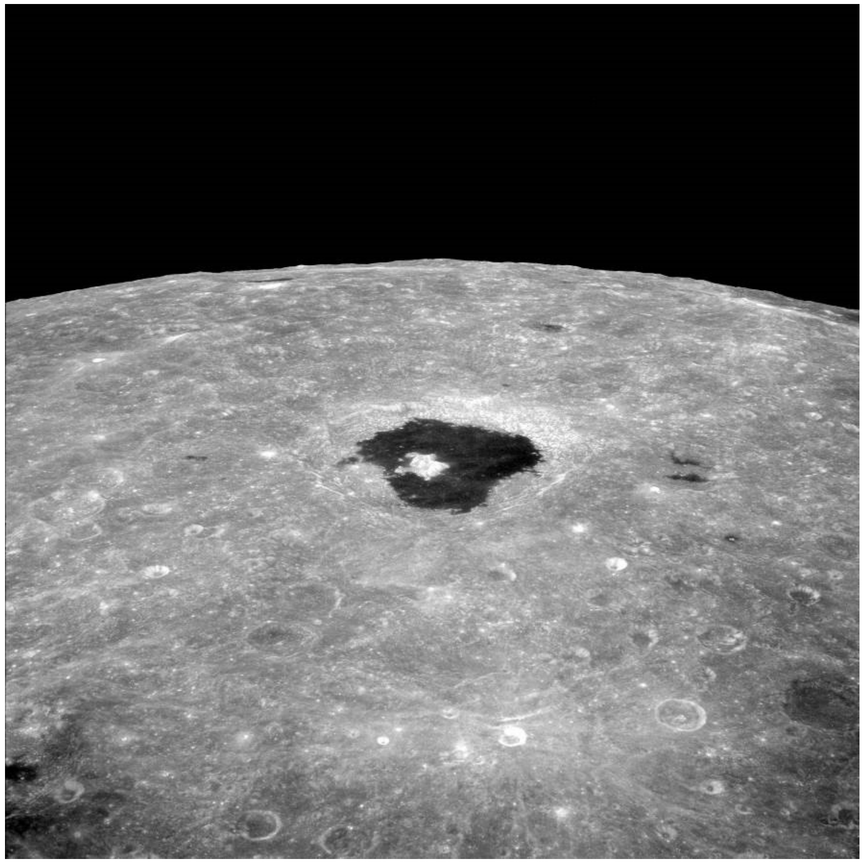
While Apollo 7 had been a successful maiden voyage of the completely redesigned command module (after the Apollo 1 fire), the United States had yet to leave Earth orbit. NASA's original plan was to launch a series of increasingly complex missions to near-Earth orbit before attempting a lunar excursion.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

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

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

The Apollo 8 astronauts were also the first humans to leave Earth orbit and pass through the Van

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



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

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

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

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

Purchasing a Telescope

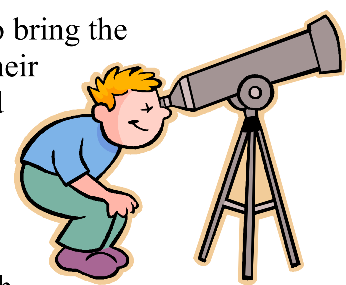
During the holidays it's not uncommon to see parents and grandparents carrying around a telescope that they just picked up at the mall or warehouse store for their budding astronomer. Unfortunately, too many of these thoughtful gifts end up in a basement or attic after one or two uses. All too often,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

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

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

Types of Telescopes

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



Refractors have been around for 400 years and use a series of lenses to bring the light rays from distant objects to focus. They are highly regarded for their unobstructed and high-contrast images. The optical tubes are sealed and generally more rugged than other designs. As such, the optics rarely need to be adjusted (realigned) which makes the refractor a good choice as a travel telescope. Refractors are an excellent choice for planetary and lunar viewing and for double stars, but generally do not have the large light gathering capacity needed for faint objects such as nebula and galaxies. The disadvantages of refractors include: the potential for different wavelengths of light to diverge from a common focus as they pass through the glass (producing color "fringing" around bright objects), the position of the eyepiece at the rear of the optical tube (requiring the telescope to be mounted fairly high off the ground for comfortable viewing), the closed tube that can take some time to cool down, and the price (highest cost per inch of aperture of the basic telescopes designs).

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

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

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

Aperture

Aperture refers to the size of the largest lens or mirror in the telescope, for example, the primary mirror in an 8-inch reflector is 8-inches in diameter. As a general rule, bigger is better, as light gathering and resolution increase with the size of the optics. However, as with everything else, there are other considerations that limit the practical size of a particular instrument. Alvan Clark & Sons figured the 40-inch lens for the Yerkes Observatory's refractor, delivering the lens in 1897. More than 100 years later, it is still the world's largest working refractor. Why? The weight of the glass and the complexities in supporting a large lens by its edge and the absorption of light passing through the glass were factors; however, the refractor was ultimately done in by Sir Isaac Newton when he built the first reflecting telescope in 1668. Mirrors, unlike lenses, can be completely supported from the back. Since light does not pass through the glass, reflected images do not suffer from "chromatic aberration." Today single mirrors are routinely produced with diameters exceeding 28 feet and telescopes are constructed combining multiple mirrors to achieve even larger light gathering capabilities. So what size is good for you? Before you answer, you may want to consider:

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

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

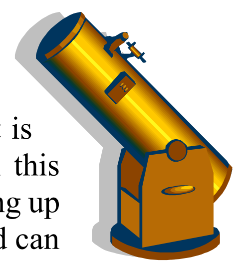
- What are you interested in looking at? Spectacular views of the Sun, Moon and planets can be acquired with a relatively modest instrument. However, if your passion is hunting down the more elusive and distant residents of the Milky Way Galaxy or exploring other galaxies far, far, away, it will require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

Magnification

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

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

Mounts



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

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

Go-To

Essentially a computer controlled pointing system, "go-to" allows the user to select an object from a data base and command the drive motors on the mount to move the telescope to the object's location in the sky. This presupposes that the telescope user has properly set up the telescope and successfully navigated through the alignment process (a process by which the telescope's computer determines where it's pointed, the local time, and its position on the Earth). Most "go-

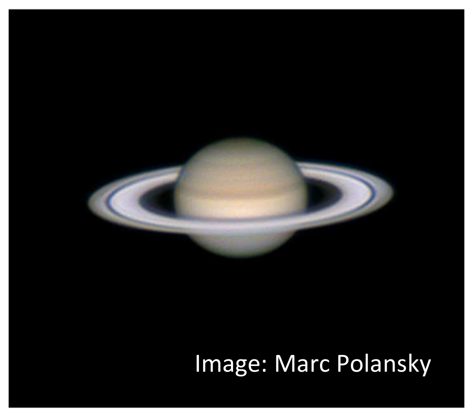
* Dobsonian telescopes are reflectors on a simple, swivel mount. They offer a low-cost solution for those on a limited budget with aperture fever (an insatiable desire for a larger telescope).

to" telescopes come with a large database, some of which can be modified (supplemented) by the user. While "go-to" capability is extremely convenient and can take you to thousands of objects in its database in a blink of an eye, it doesn't necessarily mean that you will be able to see the object. Depending upon the size of your telescope (see Aperture), many objects in these databases are just too dim to see with the equipment provided. CCD cameras are much more sensitive than your eye and can accumulate light for long durations. So, if you are planning on using your telescope primarily as a camera lens, then some of the disadvantage of a small aperture can be overcome. However, if you plan on doing most of your observing at the eyepiece, you may want to consider spending the money on a larger aperture rather than on "go-to" electronics.

What to Do

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

Saturn



Saturn reached Opposition on August 27th when the ringed-world was closest to Earth. Since that time, the distance between the Earth and Saturn has been gradually increasing with Earth's higher orbital velocity. Saturn is still well placed in the early evening sky in the constellation Aquarius. The planet's north pole is currently tilted towards the Earth with its rings inclined at an angle of almost 8° to our line of sight. We see the ring tilt change (from our perspective) over Saturn's 29.5-year orbit. The last ring crossing (when the rings disappeared) was in 2009. Since then, the rings opened to a maximum of 27° before starting to close. The rings will disappear in 2025 before the process begins again, starting to open back up again, this time with the southern hemisphere tilted toward Earth.

Jupiter

Jupiter reached Opposition on November 3rd. At the beginning of the month, the gas giant shines brightly in the eastern sky after sunset almost 30 times brighter than Saturn. The largest planet in the solar system can be found in the constellation Aries and to the east of Saturn.

	Rise and Meridian Transit Times			
	December 1 (EST)		December 31 (EST)	
Planet	Rise	Transit*	Rise	Transit*
Saturn	12:10 pm	5:27 pm	10:17 am	3:36 pm
Jupiter	2:43 pm	9:31 pm	12:41 pm	7:27 pm

* The celestial meridian is an imaginary the line that connects the north and south points of the horizon with the observer's zenith (point directly overhead). A planet is highest in the sky when it crosses or transits the meridian.

Jovian Moon Transits

Jupiter's four Galilean moons are large enough to be seen with a small telescope. The orbits of the inner three moons are synchronized (orbital resonance) with Europa's orbital period twice Io's period, and Ganymede's orbital period twice that of Europa (e.g., in the time it takes Ganymede to go around Jupiter once, Europa makes two orbits and Io makes four orbits). On nights of good visibility, the shadow(s) of Jupiter's moon(s) can also be seen on the cloud tops as they cross (transit) the planet's disk. Due to the current alignment of Jupiter's and Earth's orbits, Callisto won't be transiting across the gas giant's disk until 2025.

Only events that start in the evening are included. A more complete listing can be found in Sky & Telescope's monthly magazine.

Jovian Moon Transits

Date	Moon	Transit Begins	Transit Ends
5th	Europa	7:55 pm	10:14 pm
6th	Io	7:36 pm	9:46 pm
12th	Europa	10:31 pm	12:50 am (13th)
13th	Io	9:32 pm	11:42 pm
20th	Io	11:28 pm	1:37 am (21st)
22nd	Io	5:57 pm	8:06 pm
29th	Io	7:53 pm	10:02 pm
30th	Europa	5:00 pm	7:19 pm
30th	Ganymede	5:17 pm	6:55 pm

Great Red Spot Transits

The Great Red Spot is a large, long-lived cyclone in the upper Jovian atmosphere. The Earth-size storm will cross the center line of the planetary disk on the following evenings during the hours between 7 pm to midnight local time.

Date	Transit Time	Date	Transit Time
1st	10:18 pm	16th	7:42 pm
3rd	11:56 pm	18th	9:20 pm
4th	7:47 pm	20th	10:59 pm

Date	Transit Time	Date	Transit Time
6th	9:26 pm	23rd	8:29 pm
8th	11:04 pm	25th	10:07 pm
11th	8:34 pm	27th	11:46 pm
13th	10:12 pm	28th	7:37 pm
15th	11:50 pm	30th	9:16 pm

December Nights

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

Sunrise and Sunset (New Milford, CT)

Sun	Sunrise	Sunset
December 1st (EST)	07:00	16:24
December 15th	07:13	16:24
December 31st	07:20	16:33

Astronomical and Historical Events

- 1st Closest approach of Near-Earth Object and Apollo class asteroid (2023 VM7)
- 1st History: launch of Soviet satellite Sputnik 6 and two dogs: Pchelka and Mushka (1960)
- 2nd History: Soviet Mars 3 lander became the first spacecraft to attain a soft landing on Mars, only to fail after 110 seconds (1971)
- 2nd History: launch of the Hayabusa 2 spacecraft to the asteroid *162173 Ryugu* from the Tanegashima Space Center, Japan (2014)
- 2nd History: dedication of the John J. McCarthy Observatory in New Milford, CT (2000)
- 2nd History: launch of SOHO solar observatory (1995)
- 2nd History: launch of space shuttle Endeavour (STS-61), first servicing of the Hubble Space Telescope, including the installation of corrective optics and new solar panels (1993)
- 2nd History: Pioneer 11 spacecraft makes its closest approach to Jupiter; encounter redirects the spacecraft to Saturn and an escape trajectory out of the solar system (1974)
- 2nd History: touchdown of Soviet Mars 3 lander: communications were lost with the lander, the first spacecraft to touch down on the Red Planet, after 20 seconds possibly due to raging dust storm (1971)
- 3rd History: NASA spacecraft OSIRIS-REx arrives at asteroid *Bennu* (2018)
- 3rd History: Pioneer 10 spacecraft makes its closest approach to Jupiter; first space probe to fly through the asteroid belt and to an outer planet (1973)
- 3rd Closest approach of Near-Earth Object, Apollo class and Potentially Hazardous Asteroid (1998 WB2)
- 3rd History: discovery of Jupiter's moon *Himalia* by Charles Perrine (1904)
- 4th Moon at apogee (furthest distance from Earth at 251,250 miles or 404,347 km)
- 4th Closest approach of Near-Earth Object and Apollo class asteroid (2013 VX4)

Astronomical and Historical Events (continued)

4th	History: launch of space shuttle Endeavour (STS-88), first International Space Station construction flight, including the mating of the Unity and Zarya modules (1998)
4th	History: launch of the Pathfinder spacecraft to Mars (1996)
4th	History: Pioneer Venus 1 enters orbit, first of two orbiters (and probes) to conduct a comprehensive investigation of the atmosphere of Venus (1978)
4th	History: launch of Gemini 7 with astronauts Frank Borman and Jim Lovell, spending almost 14 days in space (1965)
4th	History: launch of Little Joe 2 rocket, test flight for the Mercury capsule and first U.S. animal flight with Sam, a Rhesus monkey (1959)
5th	Last Quarter Moon
5th	Closest approach of Near-Earth Object, Amor class asteroid (2023 TB27)
6th	Closest approach of Near-Earth Object, Apollo class, Potentially Hazardous Asteroid 139622 (2001 QQ142)
6th	History: recovery of Hayabusa 2's sample return capsule containing material from the asteroid Ryugu (2020)
6th	History: Japanese spacecraft Akatsuki enters around Venus five years after unsuccessful first attempt and main engine failure (2015)
7th	History: launch of the Jason-1 satellite to measure ocean surface topography from the Vandenberg Air Force Base, California (2001)
7th	History: arrival of the Galileo space probe at Jupiter (1995)
7th	History: launch of Apollo 17 with astronauts Ronald Evans, Harrison Schmitt (first scientist – geologist) and Eugene Cernan (last man on the Moon – so far) (1972)
8th	History: launch of the Chinese Chang'e 4 spacecraft to the far side of the Moon from the Xichang, China launch site (2018)
8th	History: Dragon spacecraft, launched by SpaceX into low-Earth orbit, is recovered in the Pacific Ocean: first time a spacecraft recovered by a commercial company (2010)
8th	History: Japanese spacecraft IKAROS becomes the first to successfully demonstrate solar sail technology in interplanetary space during a Venus flyby (2010)
8th	History: discovery of asteroid *5 Astraea* by Karl Hencke (1845)
9th	**Second Saturday Stars – Open House at the McCarthy Observatory (7:00 pm)**
9th	History: Pioneer Venus 2 enters orbit, second of two orbiters (and probes) to conduct a comprehensive investigation of the atmosphere of Venus (1978)
10th	Closest approach of Near-Earth Object, Apollo class asteroid (2020 HX3)
10th	History: launch of the X-ray Multi-Mirror Mission (XMM-Newton), the largest scientific satellite built in Europe and one of the most powerful (1999)
10th	History: launch of Helios 1 (also known as Helios A) into solar orbit; joint venture by Federal Republic of Germany and NASA to study the Sun (1974)
10th	History: launch of the Boeing X-37B Orbital Test Vehicle 1 (unmanned space plane) from the Cape Canaveral Air Force Station (2012)
11th	Closest approach of Near-Earth Object, Aten class asteroid (2010 XF3)
12th	New Moon
12th	History: discovery of Saturn moons *Fornjot*, *Farbauti*, *Aegir*, *Bebhionn*, *Hati* and *Bergeimi*r by Scott Sheppard, et al's (2004)
12th	History: discovery of Saturn moons *Hyrrokkin* by Sheppard/Jewitt/Kleyna (2004)
12th	History: launch of Uhuru, the first satellite designed specifically for X-ray astronomy (1970)

<u>Astronomical and Historical Events</u> (continued)

12th History: launch of Oscar, first amateur satellite (1961)
13th Geminids meteor shower peak
13th History: flyby of Asteroid 4179 *Toutatis* by the Chang'e 2 spacecraft, China's second lunar probe (2012)
13th History: discovery of Saturn's moons *Fenrir* and *Bestla* by Scott Sheppard, et al's (2004)
13th History: launch of Pioneer 8, third of four identical solar orbiting, spin-stabilized spacecraft (1967)
13th History: Mt. Wilson's 100-inch telescope used to measure the first stellar diameter (Betelgeuse); measured by Francis Pease and Albert Michelson (1920)
13th History: first light of Mt. Wilson's 60-inch telescope (1908)
14th History: landing of China's Chang'e 3 Moon lander on Mare Imbrium (2013)
14th History: flyby of Mars by Japan's Nozomi spacecraft after an attempt to achieve orbit fails (2003)
14th History: creation of the Canadian Space Agency (1990)
14th History: flyby of Venus by Mariner 2; first spacecraft to execute a successful encounter with another planet, finding cool cloud layers and an extremely hot surface (1962)
14th History: Weston meteorite fall: first documented fall in the United States (1807); best coordinates for the fall are based upon investigative research conducted by Monty Robson, Director of the McCarthy Observatory, published in 2009
14th History: birth of Tycho Brahe, Danish astronomer noted for his observational skills, the precision of his observations, and the instruments he developed; builder of the Uraniborg and Stjenborg observatories on the Swedish island of Ven (1546)
15th History: launch of Soviet spacecraft, Vega 1 to Venus and then to Comet Halley (1984)
15th History: landing of Soviet spacecraft Venera 7 on the surface of Venus (1970)
15th History: discovery of Saturn's moon *Janus* by Audouin Dollfus (1966)
15th History: launch of Gemini 6 with astronauts Walter Schirra and Thomas Stafford (1965)
15th History: Gemini 6 and 7 execute the first manned spacecraft rendezvous (1965)
15th History: Simon Marius – first observation of the Andromeda Galaxy through a telescope (1612)
16th Moon at perigee (closest distance from Earth at 228,601 miles or 367,899 km)
16th History: launch of the Surface Water and Ocean Topography mission for NASA (SWOT) aboard a SpaceX Falcon 9 from the Vandenberg Space Force Base, California (2022)
16th History: launch of Pioneer 6, the first of four identical solar orbiting, spin-stabilized spacecraft (1965)
16th History: birthday of futurist Arthur C. Clarke (1917)
17th History: GRAIL spacecraft impact Moon (end of mission) (2012)
17th History: Project Mercury publicly announced (1958)
17th History: Wright Brothers' first airplane flight, Kitty Hawk, North Carolina (1903)
18th History: discovery of Saturn's moon *Epimetheus* by Richard Walker (discovery shared with Stephen Larson and John Fountain) (1966)
19th First Quarter Moon
19th Closest approach of Near-Earth Object, Aten class asteroid (2016 XD2)
19th History: launch of the Gaia spacecraft from French Guiana to survey more than one billion stars in an effort to chart the chart the evolution of the Milky Way galaxy (2013)
19th History: launch of space shuttle Discovery (STS-103), third servicing of the Hubble space telescope including the installation of new gyroscopes and computer (1999)

Astronomical and Historical Events (continued)

19th History: launch of Mercury-Redstone 1A; first successful flight and qualification of the spacecraft and booster (1960)
20th Closest approach of Near-Earth Object, Aten class, Potentially Hazardous Asteroid 341843 (2008 EV5)
20th History: launch of the Active Cavity Radiometer Irradiance Monitor satellite (ACRIMSAT); designed to measure Sun's total solar irradiance (1999)
20th History: Ames Research Center founded as the second National Advisory Committee for Aeronautics (NACA) laboratory at Moffett Federal Airfield in California (1939)
20th History: founding of the Mt. Wilson Observatory (1904)
21st Winter Solstice at 10:27 pm EST (03:27 UT on the 22nd)
21st Closest approach of Near-Earth Object, Apollo class, Potentially Hazardous Asteroid (2018 YJ2)
21st Mercury at its Greatest Eastern Elongation (20°) – furthest separation from the Sun in the evening sky
21st History: launch of the Soviet spacecraft Vega 2 to Venus, continued on to Comet Halley (1984)
21st History: landing of Soviet spacecraft Venera 12 on the surface of Venus, found evidence of thunder and lightning in the atmosphere (1978)
21st History: launch of Apollo 8 with astronauts Frank Borman, Jim Lovell and William Anders, first to circumnavigate the Moon (1968)
21st History: launch of Luna 13, Soviet moon lander (1966)
22nd Ursids Meteor Shower peak
22nd Closest approach of Near-Earth Object, Apollo class asteroid (2022 YG)
22nd Closest approach of Near-Earth Object, Apollo class, Potentially Hazardous Asteroid (2023 VD6)
22nd History: first asteroid (323 *Brucia*) discovered using photography (1891)
23rd Closest approach of Near-Earth Object, Apollo class asteroid (2020 YO3)
23rd History: discovery of Saturn's moon *Rhea* by Giovanni Cassini (1672)
24th Closest approach of Near-Earth Object, Apollo class asteroid (2010 UE51)
24th History: inaugural of ESA's Ariane 1 rocket and first artificial satellite carried by an ESA rocket (1979)
24th History: the largest and best recorded meteorite fall in British history over the Leicestershire village of Barwell (1965)
24th History: Deep Space Network created (1963)
24th History: Jean-Louis Pons born into a poor family with only basic education, took post at observatory at Marseilles as concierge, went on to become most successful discover of comets (discovered or co-discovered 37 comets, 26 bear his name) (1761)
24th History: inaugural launch of the Arianne rocket, Europe's attempt to develop a cost-effective launcher to serve the commercial market (1979)
25th Closest approach of Near-Earth Object, Apollo class asteroid (2020 YR2)
25th History: launch of the James Webb Space Telescope (JWST) from Arianespace's ELA-3 launch complex near Kourou, French Guiana (2021)
25th History: European Space Agency's Mars Express spacecraft enters orbit around Mars (2003)
25th History: landing of Soviet spacecraft Venera 11 on Venus, second of two identical spacecraft (1978)

Astronomical and Historical Events (continued)

26th Full Moon (Cold Moon)
26th History: launch of Soviet space station Salyut 4 from Baikonur Cosmodrome; third Soviet space station and second space station devoted primarily to civilian objectives; deorbited in 1977 (1974)
27th History: discovery of the ALH84001 Martian meteorite in the Allan Hills, Far Western Icefield, Antarctica, made famous by the announcement of the discovery of evidence for primitive Martian bacterial life (1984)
27th History: Johannes Kepler born, German mathematician and astronomer who postulated that the Earth and planets travel about the sun in elliptical orbits, developed three fundamental laws of planetary motion (1571)
29th Parker Solar Probe, 18th Perihelion
30th History: flyby of Jupiter by Cassini spacecraft on mission to Saturn (2000)
30th History: discovery of Uranus' moon *Puck* by Stephen Synnott (1985)
30th History: Army Air Corp Captain Albert William Stevens takes first photo showing the Earth's curvature (1930)
31st Closest approach of Near-Earth Object, Aten class asteroid (2021 AM6)
31st History: GRAIL-A, lunar gravity mapping spacecraft enters orbit (2011)

TBD

24th Tentative date for the inaugural flight of United Launch Alliance's Vulcan Centaur rocket, with the Peregrine commercial lunar lander, from the Cape Canaveral Space Force Station, Florida

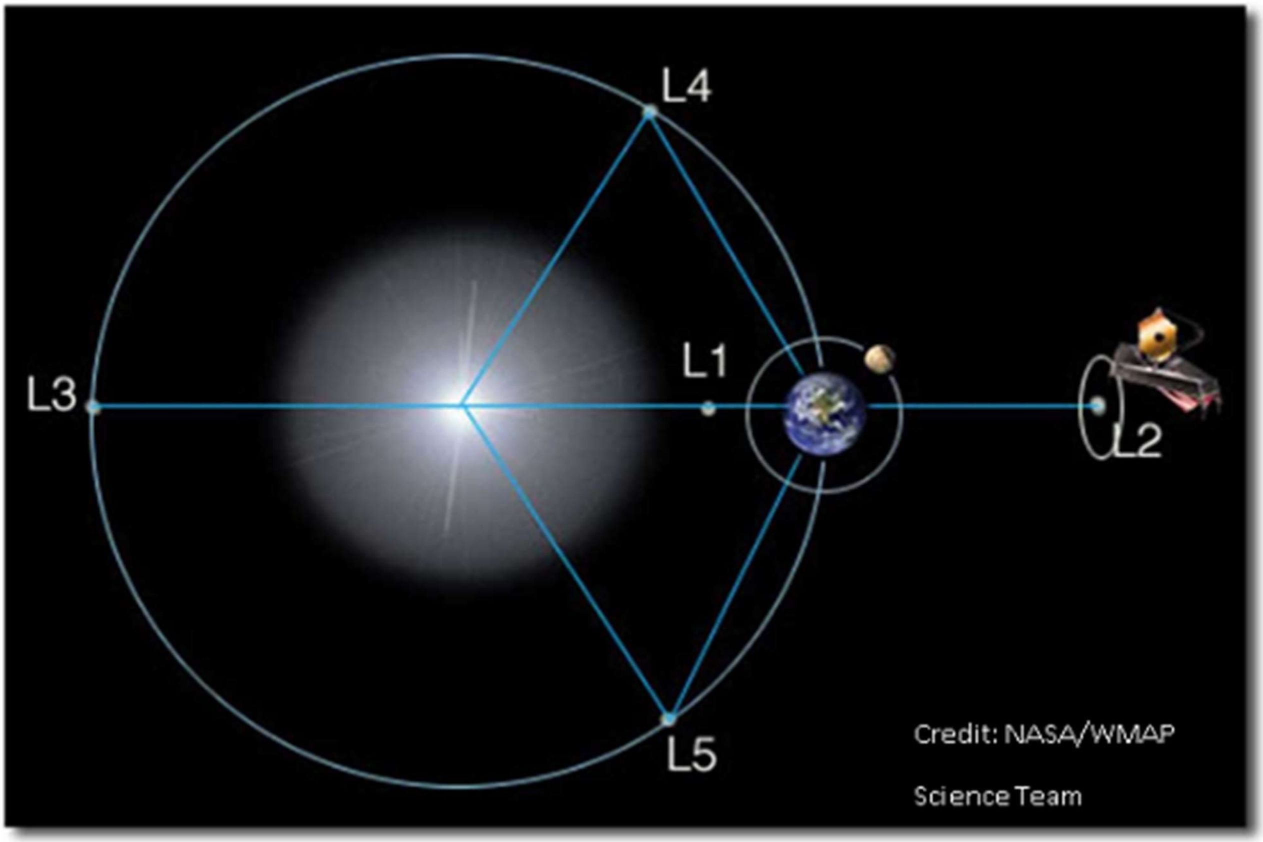
Commonly Used Terms

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

References on Distances

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

Lagrange Points



Five locations discovered by mathematician Joseph Lagrange where the gravitational forces of the Sun and Earth (or other large body) and the orbital motion of the spacecraft are balanced, allowing the spacecraft to hover or orbit around the point with minimal expenditure of energy. The L2 point (location of the Euclide and James Webb telescope) is situated 1.5 million kilometers beyond the Earth (as viewed from the Sun).

James Webb Space Telescope

- https://www.jwst.nasa.gov/

International Space Station and Artificial Satellites

Visit www.heavens-above.com for the times of visibility and detailed star charts for viewing the International Space Station, Hubble Space Telescope, artificial satellites and other spacecraft.

Solar Activity

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

NASA's Global Climate Change Resource

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

Mars – Mission Websites

Mars 2020 (Perseverance rover): https://mars.nasa.gov/mars2020/

Mars Helicopter (Ingenuity): https://mars.nasa.gov/technology/helicopter/

Mars Science Laboratory (Curiosity rover): https://mars.nasa.gov/msl/home/

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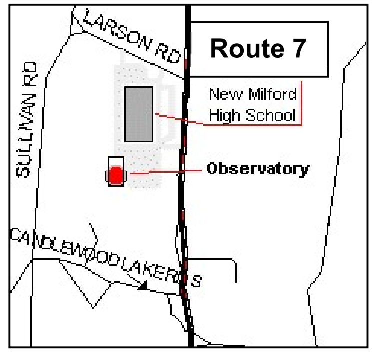

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