Galactic Observer

John J. McCarthy Observatory

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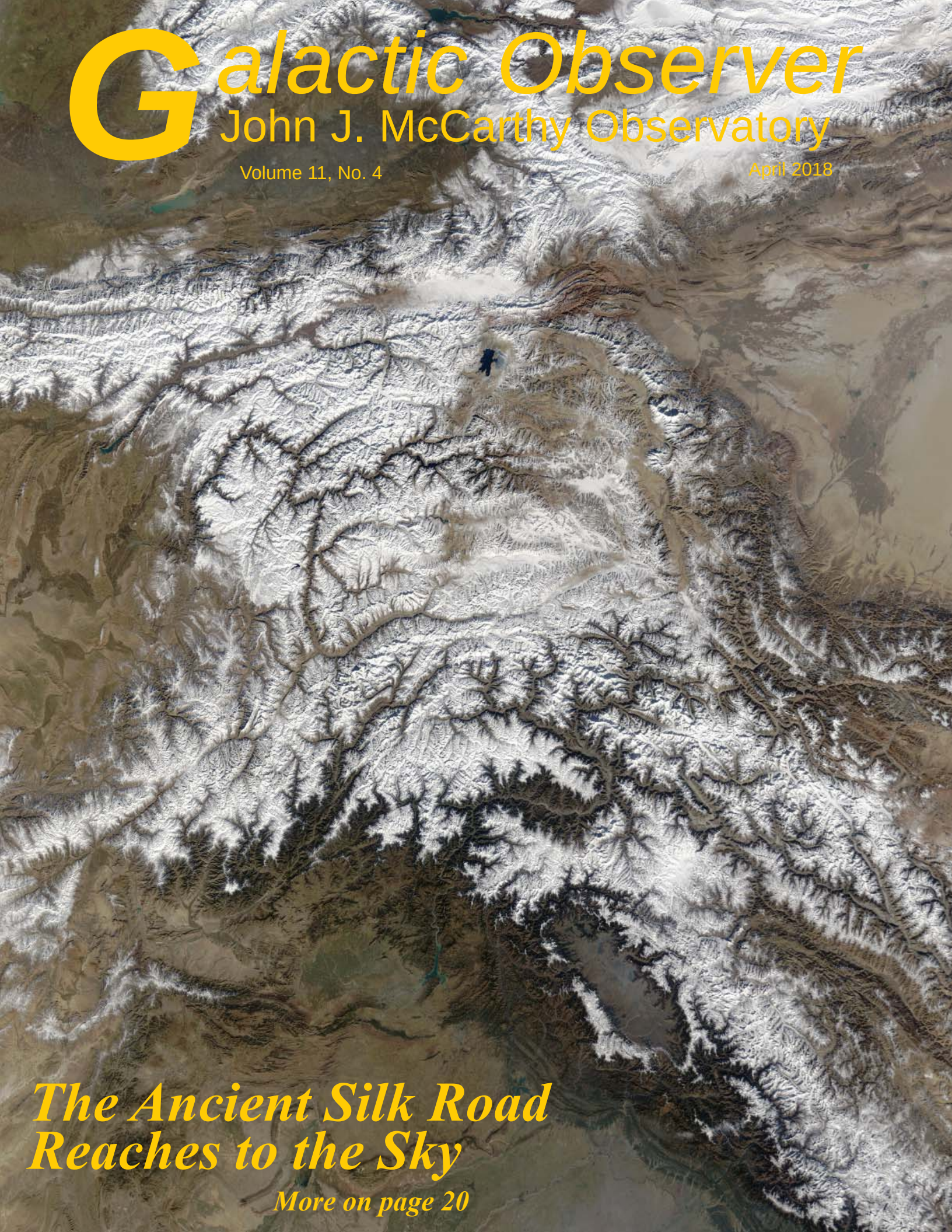
April 2018



The Ancient Silk Road Reaches to the Sky

More on page 20

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

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

Steve Barone
Colin Campbell
Dennis Cartolano
Mike Chiarella
Jeff Chodak
Bill Cloutier
Doug Delisle
Cecilia Detrich
Dirk Feather
Randy Fender
Louise Gagnon
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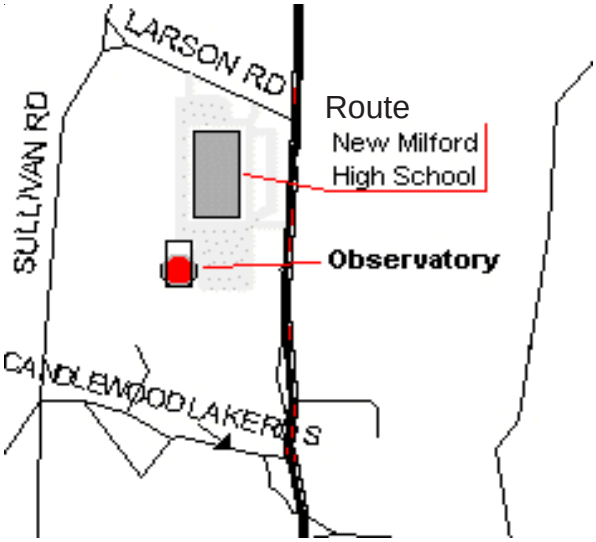
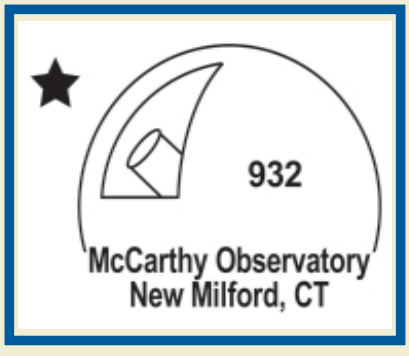


In This Issue



April Astronomy Calendar and Space Exploration Almanac

An early evening gathering of the two inner planets and a waxing crescent Moon, as viewed from New Milford, Connecticut. At the time the photo was taken, Mercury was approximately 73.9 million miles (118.9 million km) from Earth and Venus was a distant 150.2 million miles (241.7 million km). The Moon at the time was a mere 235.2 thousand miles or 378.5 thousand km from the Earth.

Mercury, on its inside orbit, is quickly closing the distance. Mercury reaches Inferior Solar Conjunction on April 1, 2018 when Mercury is directly between the Earth and Sun and closest to Earth. Venus, which has just emerged from behind the Sun, doesn't reach Inferior Solar Conjunction until October 26, 2018.

Photo: 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 lea"d as a space-faring nation. But, what if the average citizen had the means to visit our only natural satellite; what would they see out the window of their spacecraft as they entered or bit around the Moon? This column may provide some thoughts to ponder when planning your visit (if only in your imagination).

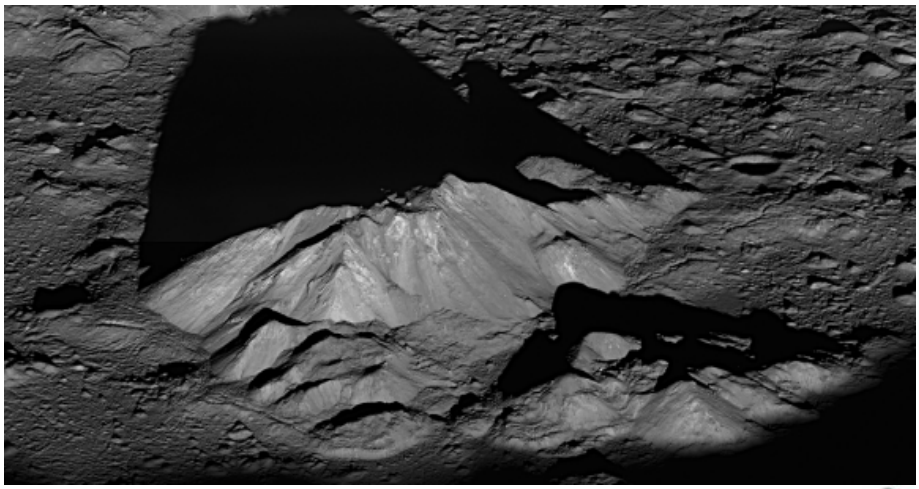
On April 2, 1968, Metro-Goldwyn-Mayer (MGM) released the now classic science fiction film "2001: A Space Odyssey." The film, premiering shortly before the first manned missions to the Moon, was based on a screenplay co-developed by producer S tanley Kubrick and author Arthur C. Clarke. It was inspired by a short story that Clarke had written in 1948 called "The Sentinel." The storyboard assumed that mankind would establish a permanent colony and research base on the Moon by the year 2001. In reality , since 1972, U.S. astronauts have not left low-Earth orbit (venturing only as far as 350 miles in altitude to service the Hubble Space Telescope), and since 2011 have relied upon Russian rockets to go to and from the International Space Station.

There is renewed interest in returning to our celestial neighbor . In December, President Trump signed the Space Policy Directive 1, an unfunded mandate that directs NASA to refocus their efforts on establishing a more permanent presence on our Moon. Unfortunately, as with past presidential directives, rockets don't get off the pad without funding.

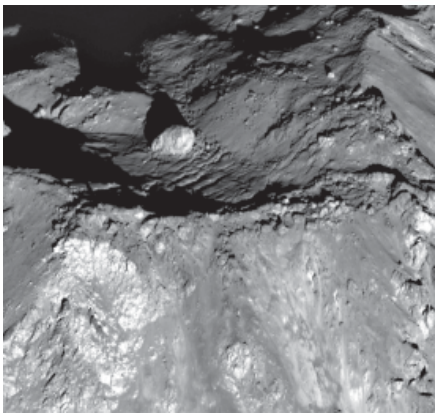
This month's lunar photo (page 5) shows the location of two of the more prominent craters in the southern hemisphere and the fictional movie locations; Tycho and Clavius craters. Tycho at 52.8 miles (85 km) in diameter is much smaller than Clavius at 142 miles (228.5 km) in diameter. However, when the Moon is full, Tycho is much more conspicuous with its gray halo and bright system of rays (comprised of impact ejecta) that extend for hundreds of miles across the face of the Moon. Rays darken and fade with time, so Tycho's bright rays suggest that the impact was relatively recent. One of the crater's rays traversed theApollo 17 landing site and samples returned from there have been used to date the formative event to 109 million years ago (compared to billions of years for most craters including Clavius).

Tycho is a classic, lar ge complex impact crater with a terraced inner wall, relatively flat floor with deposits of impact melt, and a central peak (comprised of material brought to the surface by the rebound of rock initially compressed by the impact). Its rays are not symmetrical, indicating that the crater was formed by an oblique impact (with the incoming projectile impacting the surface at an angle less than 45°).

Tycho's diverse topographies, including ponds and frozen rivers of impact melt, have been extensively mapped by the Lunar Reconnaissance Orbiter's (LRO) cameras. In these images, details as small as boulders can be seen rest-



Credit: NASA/GSFC/ Arizona State University



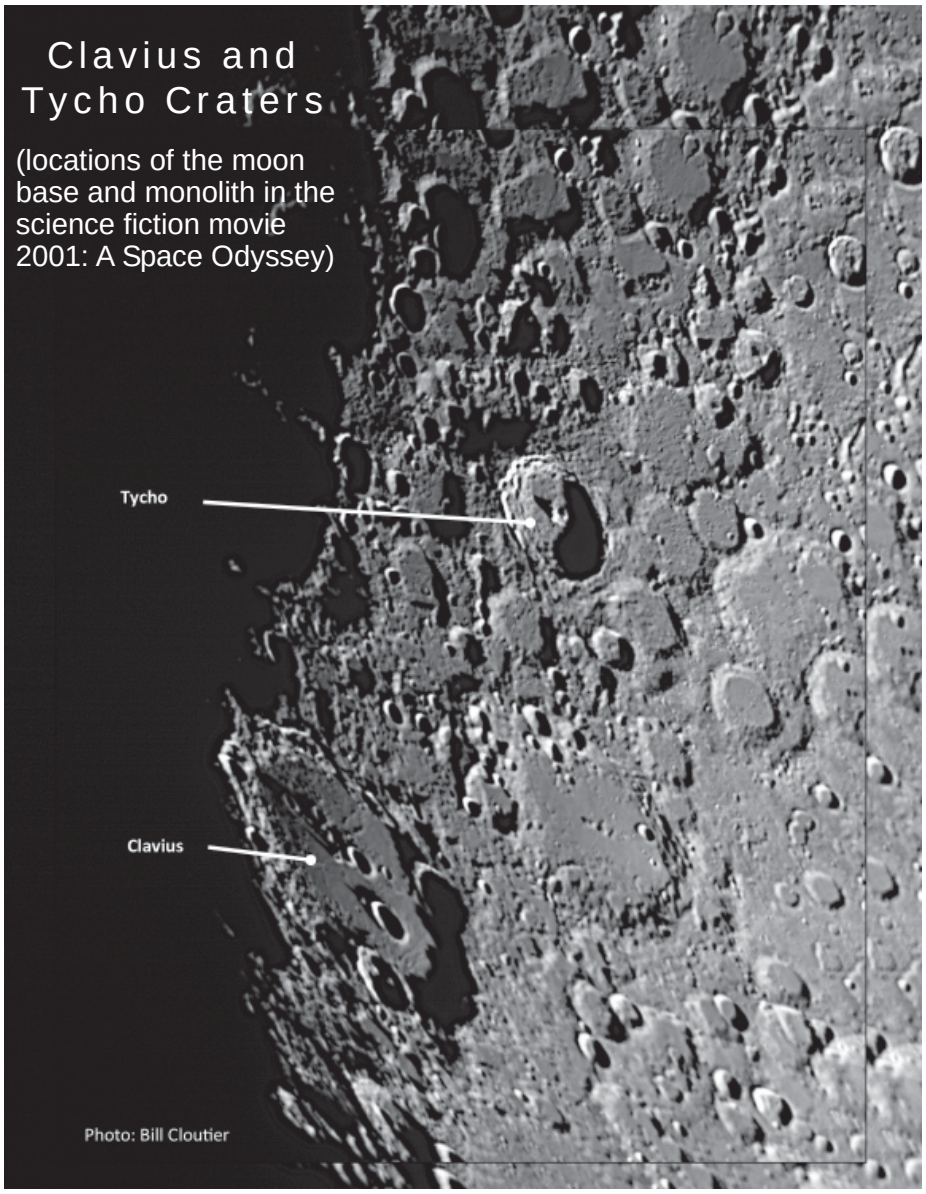
ing on the crater's 1.4 mile (2.25 km) high central peak.

The view of the crater's interior was captured from an altitude of 36.7 miles (59 km), with the spacecraft rolled over for an oblique perspective.

LRO was launched on June 18, 2009 and, despite what appeared to be an impact by a micrometeoroid in 2014, its wide and narrow angle cameras have returned more than 2.2 billion images (in the form of engineering data records), totaling more than 929.6 TBytes of accumulated data. Much of this information can be accessed through the ACT-REACT-QuickMap interface at *http://quickmap.lroc.asu.edu.*

Clavius and Tycho Craters

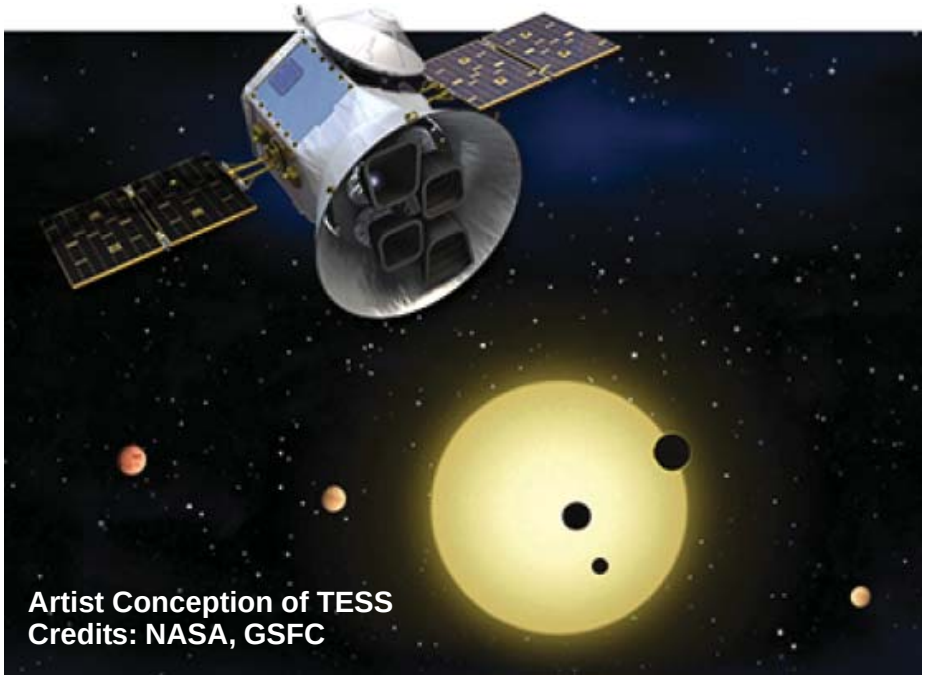
(locations of the moon base and monolith in the science fiction movie 2001: A Space Odyssey)



TESS

As of March 2018, more than 3,700 exoplanets have been found orbiting distant stars by various techniques. The vast majority (approximately 79%) were detected by measuring small, temporary variations (dips) in the light as a planet crosses or transits across the stellar disk. Approximately 71% of the confirmed planets were discovered by the Kepler spacecraft. (Kepler has identified an additional 2,700 candidates that have yet to be confirmed as exoplanets).

Tentatively scheduled for April 16th, NASA will launch its next generation planet finder, the Transiting Exoplanet Survey Satellite (TESS). The spacecraft's four wide field CCD cameras will monitor more than 200,000 stars over an area 400 times lar ger than surveyed by Kepler. While not as sensitive as Kepler (Kepler's search area was a relatively small field of view in the constellations Cygnus



and Lyra, 3,000 light years distant), TESS is designed to monitor brighter, nearby stars in an all-sky search for planets, in particular planets less than two Earth radii in size (Super Earths or smaller). In a mission designed to last two years, astronomers expect to find more than 1,500 candidates based upon Kepler's census (for example, the number of stars discovered to date with Earth-size planets and the percentage of those planets located in the habitable zone around their stars).

In searching the local neighborhood (bright, close stars) for planets, ground-based telescopes (as well as the Hubble Space Telescope and the future James Webb Space Telescope) can be used for follow-up observations. Astronomers expect that by observing candidate exoplanets with several different instruments, they can tease out the size, mass, density and composition of the planets, and possibly atmospheric constituents. The Massachusetts Institute of Technology (MIT) is the lead institution for TESS.

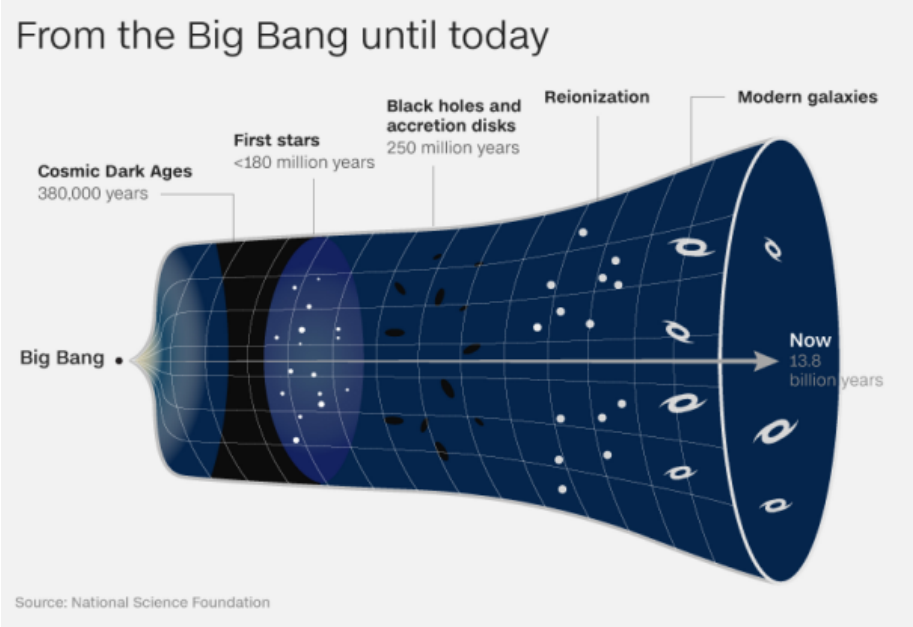
First Light

The timeline for the birth of the universe is believed to begin approximately 13.8 billion years ago with the "Big Bang," a primal event where the universe underwent a rapid expansion and cooling. Approximately 380,000 years later the temperature cooled sufficiently to permit the free electrons to combine with the nuclei (protons and neutrons) that had formed shortly after the start, creating the elements that would coalesce to form the first stars. The first generation stars would illuminate the darkness 180 million years later.

Astronomers now believe that they have detected (indirect) evidence of the first light from these early stars using a radio telescope in western Australia. In an article published in Nature in February, the authors describe the discovery of the signal from the early light (actually the subtle impact of the light on interstellar hydrogen) and the surprising strength of the signal (twice the magnitude predicted). The magnitude was so unexpected that the research team spent two years eliminating other possibilities and went so far as to build a second antenna.

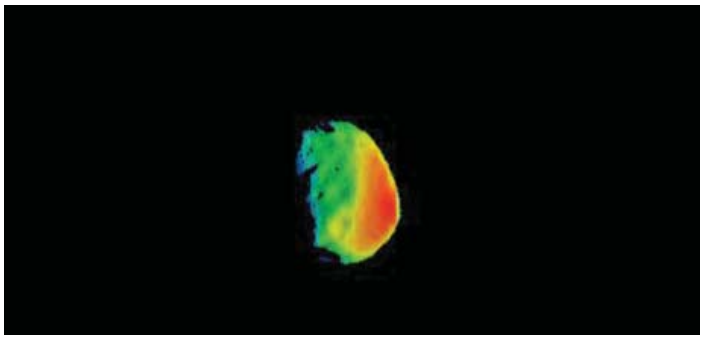
The strength of the signal suggests either a stronger source (more radiation) or that the interstellar hydrogen gas was cooler than predicted. One possibility that has been offered is that dark matter (matter that has not been directly observed but believed to be the source of 85% of the gravity that we measure) had a cooling effect on the gas.

If the signal strength of the radiation from that first light can be attributed to the influence or effects of dark matter, it would confirm what has only be inferred to date by its gravitation effects on ordinary matter.



Martian Workhorse

NASA's 2001 Mars Odyssey spacecraft (a tribute to Arthur C. Clarke's science fiction novel) was launched on April 7, 2001. After a seven month long cruise and several months of aerobraking (controlled skimming the Martian atmosphere to shape and refine its orbit), Odyssey commenced a global mapping campaign. The spacecraft's Thermal Emission Imaging System (THEMIS) camera has since fully mapped the Red Planet in both visible light (during the day) and the infrared (at night). The data returned by spacecraft's instruments has been used to identify surface mineral deposits, their abundance and distribution. The spacecraft currently orbits the Red Planet every 2 hours. With no major operational issues, Odyssey has a sufficient fuel reserve to operate for several more years.



Above left: Phobos was approximately 3,489 miles (5,615 km) from Odyssey and Deimos about 12,222 miles (19,670 kilometers) when the image was taken . Phobos, is 14 miles across (22 km) and Deimos is only 8 miles (13 km). Phobos orbits the Red Planet three times a day while Deimos takes just over a day to complete an orbit. ***Above right:*** Phobos captured by Mars Odyssey's THEMIS camera Credit: NASA/JPL-Caltech/Arizona State University.

During Odyssey's seventeen years in orbit, the spacecraft has served as a data relay for the Spirit and Opportunity rovers and, more recently, for the Mars Science Laboratory Curiosity rover (in tandem with the Mars Reconnaissance Orbiter). To support the upcoming InSight mission, Odyssey has surveyed potential landing sites (for rocks, sand and dust), as well as the selected site in Elysium Planitia. Dust is a poor insulator and rocks retain heat, so scientists can determine the abundance of each by measuring the change in how the surface (and features on the surface) warms and cools over the Martian day and night, as they evaluate the ideal spot upon which to set the lander down. The lander carries two main instruments, a heat probe and a seismometer, which will need to be deployed by the lander's robotic arm. Since the arm has a limited reach, the terrain around the lander needs to be relatively level and penetrable.

In September of 2017, after sixteen years of studying the surface of Mars, NASA rotated the spacecraft so that it could observe the Martian moons, Phobos and Deimos. Scientists plan to use the visible-light and infrared images of moons to learn more about the surface texture and mineral composition of these asteroid-like bodies.

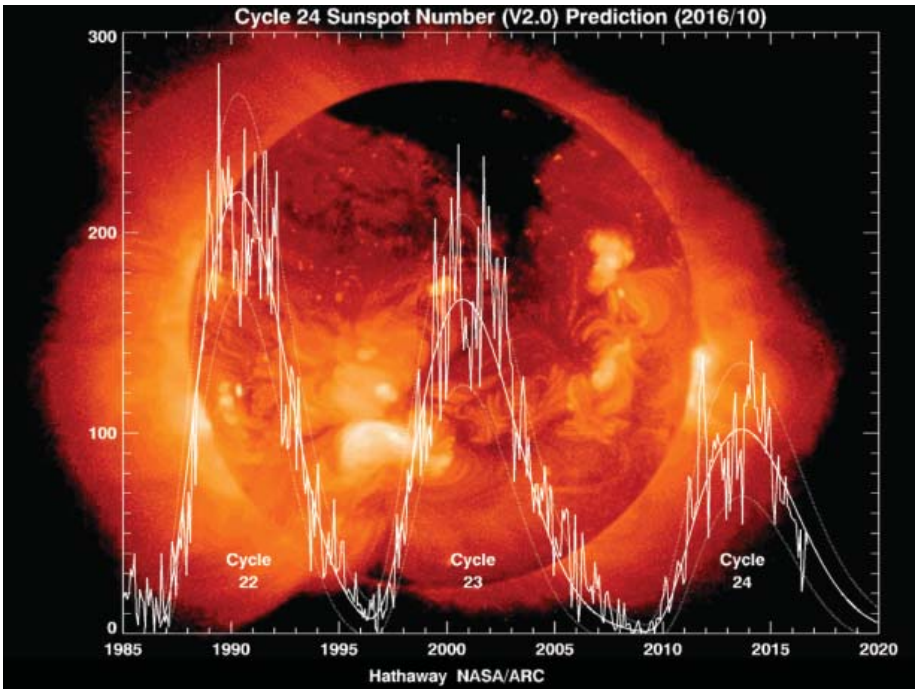
Day (top) and night infrared (bottom) views of selected landing site in Elysium Planitia are shown above. The landing ellipse measures 81 miles (130 km) in length by 17 miles (27 km) in width. The white spots and rings (along the rims of craters) in the nighttime image are rocks radiating heat collected over the daytime. Darker areas are believed to be dust-covered regions that cool more quickly once the Sun has set. Credit: NASA/JPL-Caltech/Arizona State University

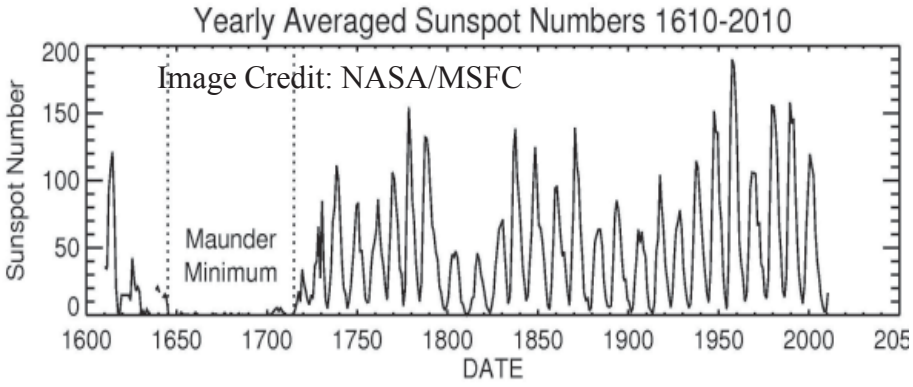
Increasing Radiation Levels

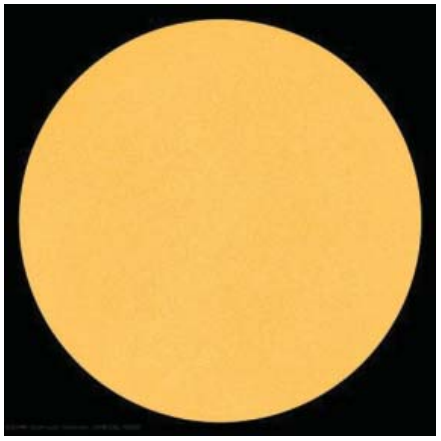
One of the greatest challenges in keeping astronauts safe during a long-duration mission is minimizing their exposure to radiation. Astronauts are exposed to radiation from our Sun (char ged particles from the solar wind, x-ray flares and corona mass ejections), as well as from sources outside our solar system (high-ener gy heavy ions in the form of galactic cosmic rays). The exposure to cosmic rays is mitigated by the Sun's magnetic field and solar wind that deflect, to some degree, the heavy nuclei born in cataclysmic events and accelerated to near-light speed. The effectiveness of the Sun to shield the Earth waxes and wanes with the 11-year solar cycle. In a study published in the research journal Space Weather, the authors identify a disconcerting trend as radiation from cosmic sources appears to be steadily increasing. The increase in cosmic radiation appears to correlate with an overall decrease in solar activity and weakening of the Sun's magnetic field.

NASA's Lunar Reconnaissance Orbiter's Cosmic RayTelescope for the Effects of Radiation (CRaTER) instrument has recorded radiation levels that would significantly restrict the time astronauts would be able to spend outside Earth's protective magnetic field (and remain within NASA's radiation exposure limits). The authors calculate that the radiation dose received by astronauts in 1,000 days in the 1990s would be surpassed in only 700 days in 2014. If the trend continues, and Sun's activity continues to decline, space travel will become more dangerous.

Space travelers are not the only ones to be affected by an increase in cosmic radiation. The interaction of cosmic rays with the Earth's upper atmosphere produces a shower of secondary radiation including x-rays and gamma rays. Airline passengers are exposed to low levels of radiation from cosmic sources, as well as from our Sun. Total exposure can vary, but factors include the length of the flight (exposure time), the altitude (amount of shielding available from atmosphere) and the latitude (Earth's magnetic field provides the greatest protection at the equator and the least at the poles).







The Sun on March 28, 2018 as recorded by the Solar Dynamics Observatory (in geosynchronous Earth orbit). March 28th was the ninth consecutive day without sunspots. In 2018, the Sun has been without sunspots 57% of the time, as compared to 28% in 2017, 9% in 2016 and 0% in 2015. Solar minimum expected in 2019-2020.

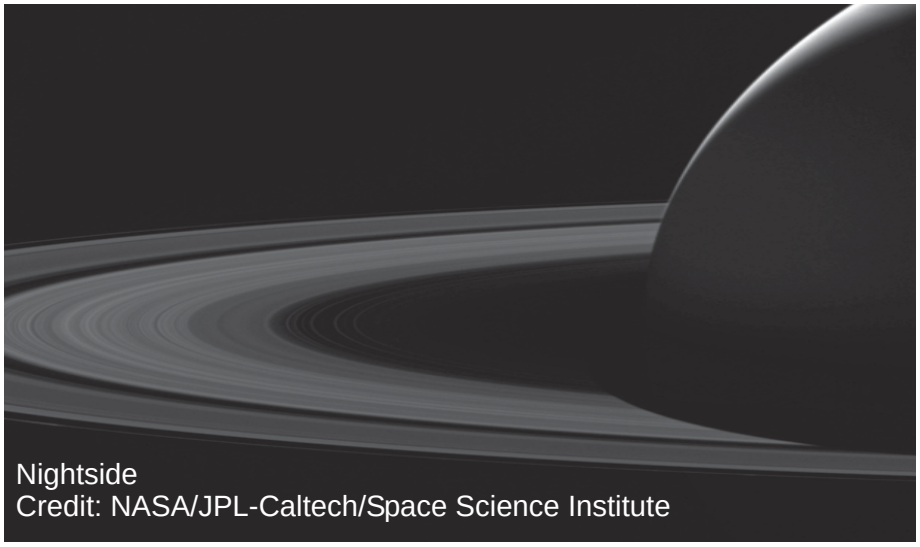
Credit: SDO/HMI

Cassini Retrospective

In April 2017, engineers transmitted a set of commands to the Cassini spacecraft that would initiate the concluding phase of the "Grand Finale" sequence, starting with a close flyby of Titan on April 22nd. The Titan encounter (flying within 608 miles or 979 km of the moon) was used to adjust the orbit of the spacecraft from one that skimmed the outer edge of the ring plane (and Saturn's F ring) to one that would take Cassini between the inner edge of the rings and Saturn's cloud tops. Four days later, Cassini completed its first of 22 passages through the gap between the rings and the planet. The final orbit, on September 15th, would take the spacecraft into the gas giant's atmosphere and end the mission.

Without the Cassini spacecraft, which operated in the Saturian system for more than 13 years, we have lost a local emissary. While Earth-bound and LEO telescopes can observe Saturn and its moons from, at best, one billion miles, in-depth exploration of these worlds will have to wait until we return.

This view of the night side of Saturn, captured by Cassini in 2017, is not possible from Earth where we can only observe the sunlit side. The image was recorded by Cassini's wide-angle camera as the spacecraft was traveling just above the ring plane, at a distance of approximately 751,000 miles (1.21 million km) from Saturn.



Nightside
Credit: NASA/JPL-Caltech/Space Science Institute

This view of the night side of Saturn, captured by Cassini in 2017, is not possible from Earth where we can only observe the sunlit side. The image was recorded by Cassini's wide-angle camera as the spacecraft was traveling just above the ring plane, at a distance of approximately 751,000 miles (1.21 million km) from Saturn.

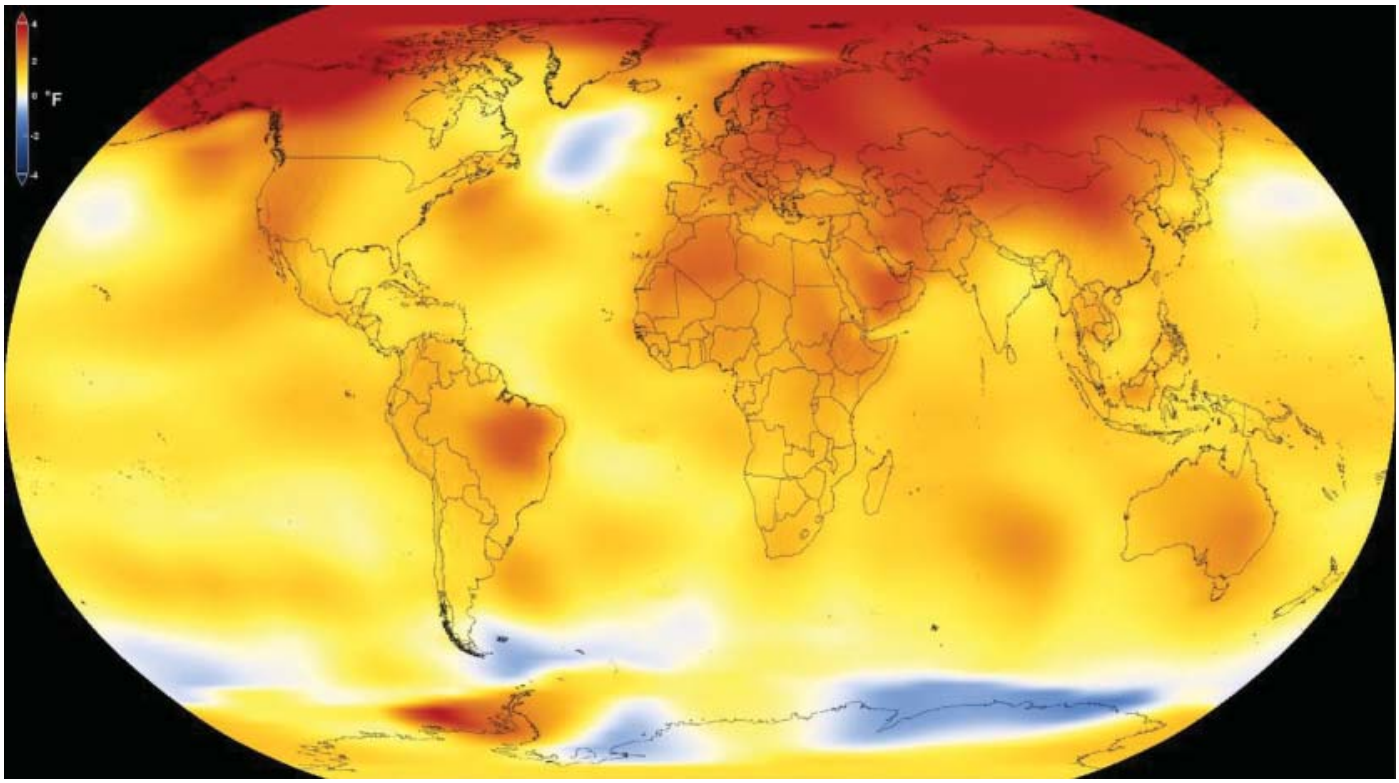
ISS Photo of Earth's Limb
Credit: NASA

Sunset image of the Earth's limb taken from the International Space Station showing several layers of the Earth's atmosphere (the Earth's atmosphere has several distinct layers). The majority (75% by mass and 99% of the water vapor) of the atmosphere (troposphere), highlighted in yellows and oranges, extends 5 to 10 miles above the surface (wider at the equator). Above the troposphere (pink and white region) is the stratosphere which extends to an altitude of 31 miles. Overlying layers - the mesosphere, thermosphere and exosphere become progressively thinner as the Earth's atmosphere transitions to the vacuum of space.

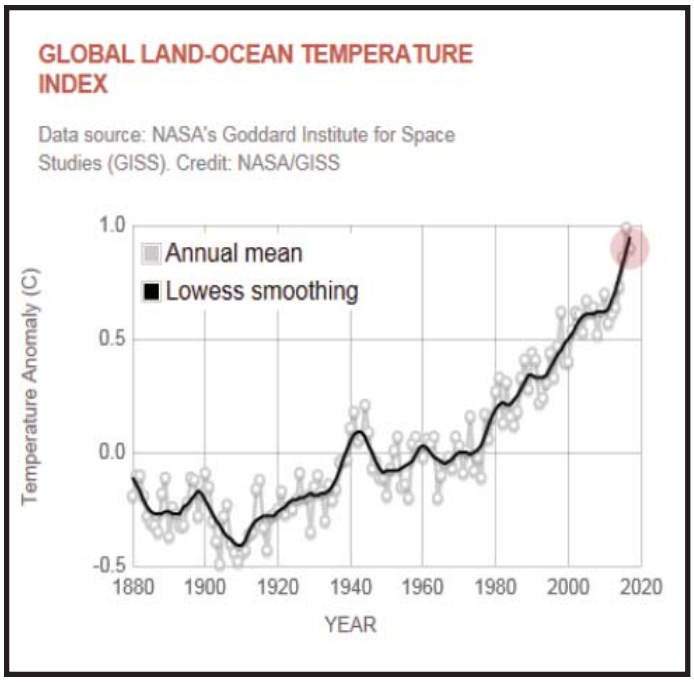
Earth Day 2018

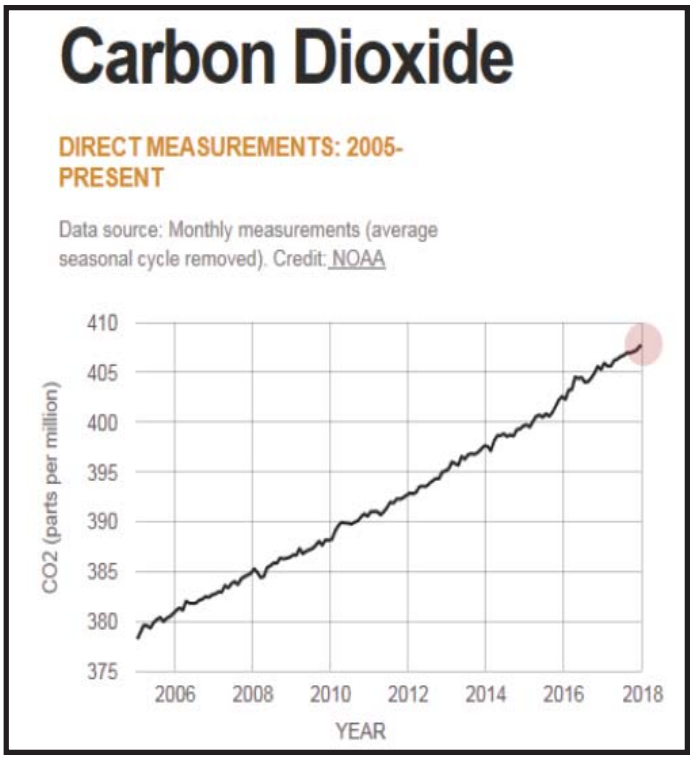
Setting aside a day to focus on spaceship Earth, its natural environment and the impact that humans have had on its fragile biosphere, was the idea of U.S. Senator Gaylord Nelson after witnessing the aftermath of the 1969 Santa Barbara oil spill (a well blowout in an off-shore drilling platform that spilled an estimated 80,000 to 100,000 barrels along the southern California coastline). In the first Earth Day, on April 22, 1970, 20 million Americans participated in country-wide events. The public awakening was credited for the establishment of the Environmental Protection Agency and the passage of important clean air and water legislation.

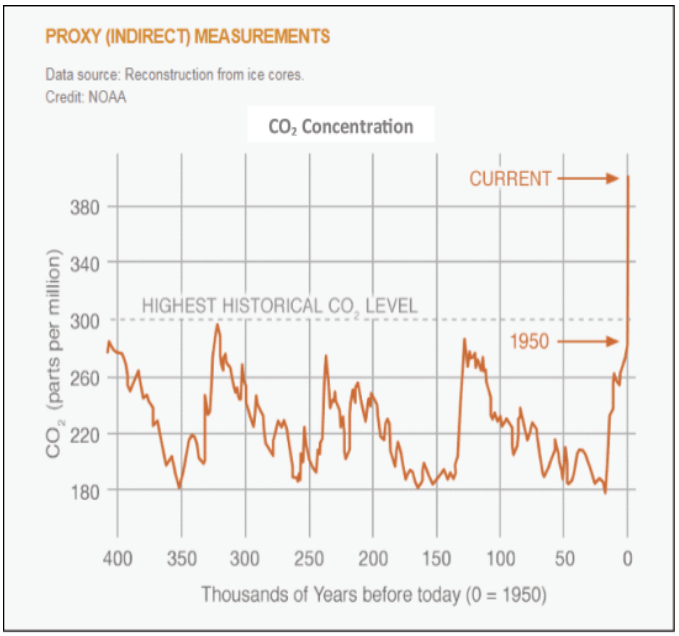
Earth Day 2018 finds the threats to the environment infinitely more challenging than an oil spill and their consequences potentially irreversible. Unlike a breached oil well, there are no quick fixes or easy answers if we do decide to address the source(s) of Earth's rapidly changing climate. Earth's health report is presented in the following graphs. It's not that the climate is changing -- change is inevitable in such a complex, dynamic system over eons - it's the rate of change over such a short period of time that should be reawakening public consciousness.

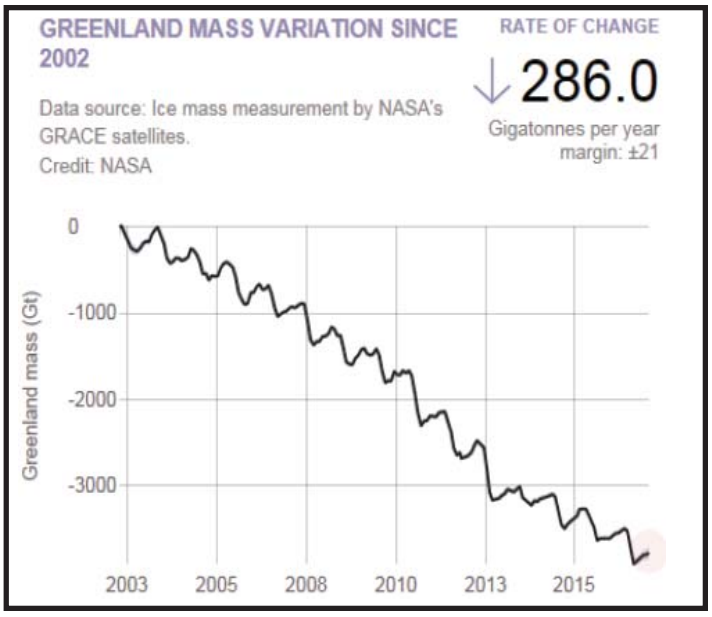


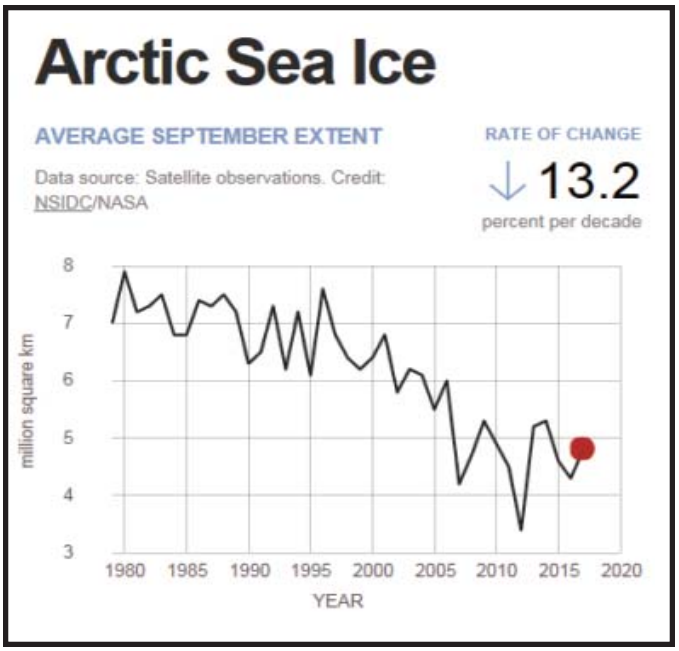
Orange colors represent temperatures that are warmer than the 1951-1980 baseline average, and blues represent temperatures cooler than the baseline. .Credits: NASA/Scientific Visualization Studio

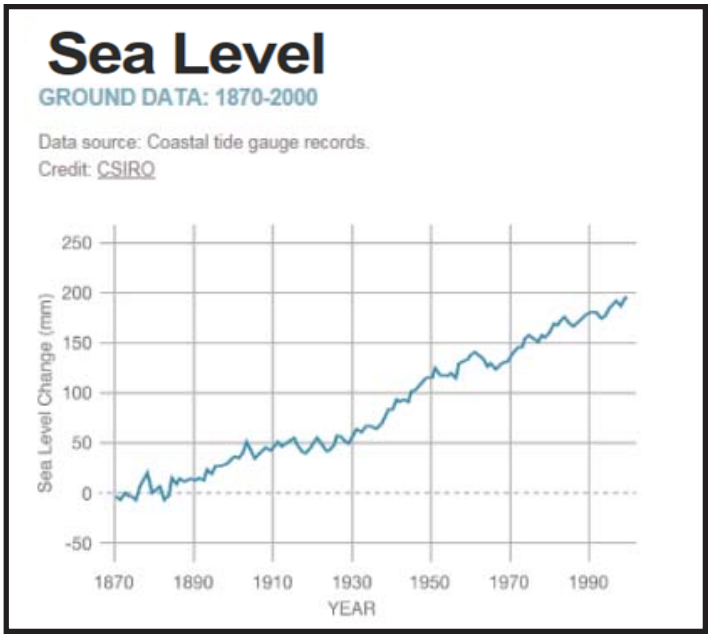


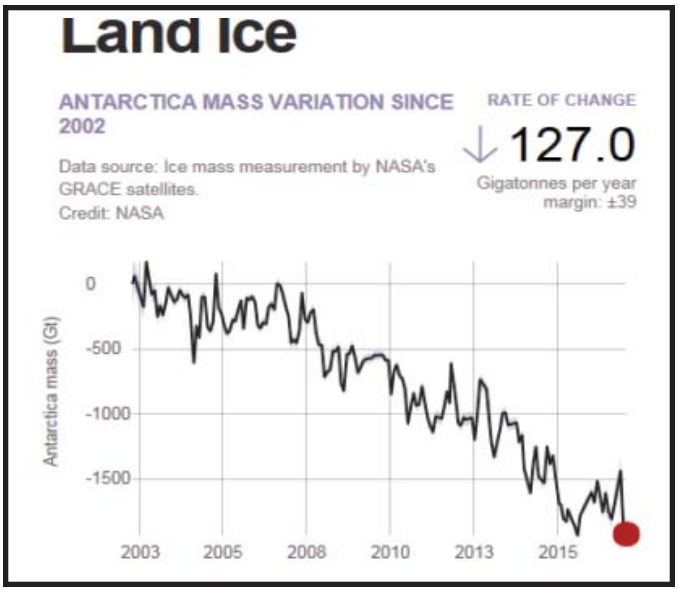


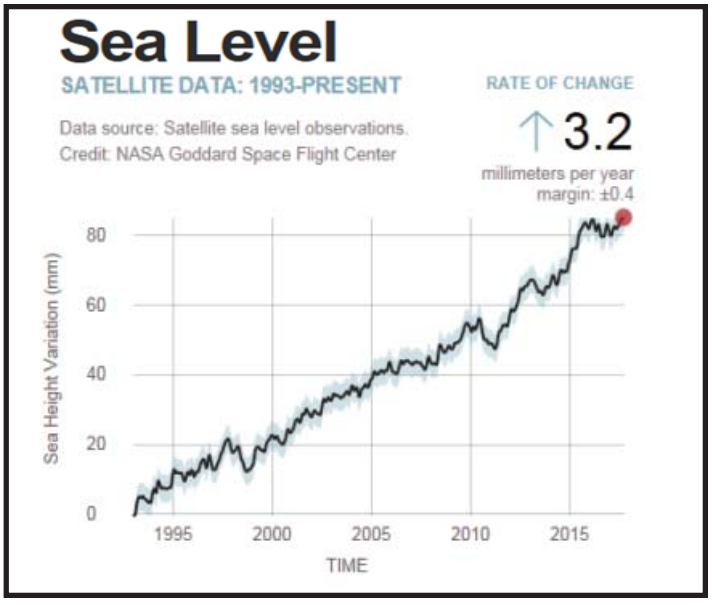

PROXY (INDIRECT) MEASUREMENTS
Data source: Reconstruction from ice cores.
Credit: NOAA
CO_2 Concentration
CURRENT
HIGHEST HISTORICAL CO_2 LEVEL
1950
CO_2 (parts per million)
380
340
300
260
220
180
400 350 300 250 200 150 100 50 0
Thousands of Years before today (0 = 1950)


GREENLAND MASS VARIATION SINCE 2002
RATE OF CHANGE
286.0
Gigatonnes per year
margin: ±21
Data source: Ice mass measurement by NASA's GRACE satellites.
Credit: NASA
Greenland mass (Gt)
0
-1000
-2000
-3000
2003 2005 2008 2010 2013 2015


Arctic Sea Ice
AVERAGE SEPTEMBER EXTENT
RATE OF CHANGE
13.2
percent per decade
Data source: Satellite observations. Credit: NSIDC/NASA
million square km
8
7
6
5
4
3
1980 1985 1990 1995 2000 2005 2010 2015 2020
YEAR


Sea Level
GROUND DATA: 1870-2000
Data source: Coastal tide gauge records.
Credit: CSIRO
Sea Level Change (mm)
250
200
150
100
50
0
-50
1870 1890 1910 1930 1950 1970 1990
YEAR


Land Ice
ANTARCTICA MASS VARIATION SINCE 2002
RATE OF CHANGE
127.0
Gigatonnes per year
margin: ±39
Data source: Ice mass measurement by NASA's GRACE satellites.
Credit: NASA
Antarctica mass (Gt)
0
-500
-1000
-1500
2003 2005 2008 2010 2013 2015


Sea Level
SATELLITE DATA: 1993-PRESENT
RATE OF CHANGE
3.2
millimeters per year
margin: ±0.4
Data source: Satellite sea level observations.
Credit: NASA Goddard Space Flight Center
Sea Height Variation (mm)
80
60
40
20
0
1995 2000 2005 2010 2015
TIME

Based upon independent analyses by NASA and NOAA, 2017 was the second warmest year on record (since record keeping began in 1880). Only 2016 was warmer.

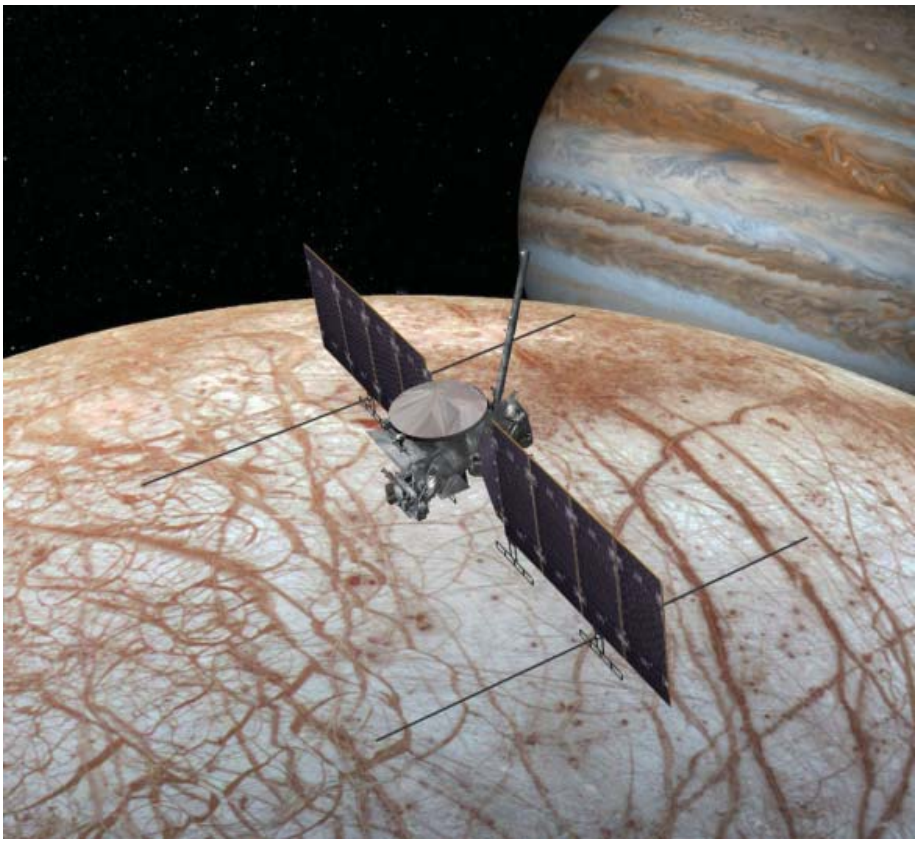
The global sea level is not only rising, but the increase has been accelerating. The increase is being driven by melt waters from the Greenland and Antarctica ice sheets and warmer water temperatures (warmer water expands). The increase (since 1992) and rate of increase (from 0.1 inch (2.5 mm) per year in the 1990s to about 0.13 inches (3.4 mm) per year today) has been recorded by a succession of Topex/ Poseidon, Jason-1, Jason-2 and Jason-3 satellite missions.

Two new missions will be launched in 2018 that will improve our monitoring abilities; the Gravity Recovery and Climate Experiment Follow-On spacecrafts and the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2). These missions will record changes in the mass of ice sheets and their elevation.

Satellite data is supplemented by a network of tidal gauges that record changes in the local water levels, airborne campaigns such as NASA's Operation IceBridge and JPL's campaign, Oceans Melting Greenland, to observe changes in the glaciers as they react to the warmer ocean water temperatures.

Extremophiles

The Mponeng gold mine in South Africa is the world's deepest mine (from the ground level), extending 2½ miles (4 km) below the surface. At this depth, the conditions are intolerable for humans (the rock face can reach 140°) without intervention (thousands of tons of an ice slurry are pumped into the mine tunnels where it is used to cool the air). However, even under these most inhospitable conditions, life has found a way to adapt.



Artist's rendering of a flyby of Europa by NASA's Europa Clipper spacecraft. Image credit: NASA/JPL-Caltech

In the dark, hot waters of Mponeng, scientists have found a single-species ecosystem. The bacterium, Desulforudis audaxviator, is believed to be self-suf ficient, despite the temperature, intense pressure, high pH and lack of nutrients. In complete darkness, it is believed that the bacterium relies on water radiolysis as a source of energy (the decay of radioactive elements from naturally occurring radioactive minerals in the rock breaks down the water molecules, forming reactive, free radicals that interact with the rock to produce sulfates and other compounds that can be used by the bacterium).

In a study published in Scientific Reports, the authors suggest that conditions in the Mponeng gold mine may be comparable to those on the icy moons of Jupiter and Saturn. On these ocean worlds, where a thick icy crust blocks all sunlight and external ener gy sources, and gravitational heating warms the rocky core, radioactive minerals in the mantle may provide a source of energy for production of the chemical compounds available to emergent microscopic organisms.

NASA's Europa Clipper spacecraft is scheduled for launch in the mid-2020s, arriving in the Jovian system several years later. Early mission planning includes 40 to 45 flybys of Europa (to minimize the time spent in Jupiter's radiation belts) at altitudes ranging from 1,675 miles to as low as 16 miles (2,700 to 25 km). The spacecraft's ten instruments will image the surface and probe the icy shell and subsurface ocean in an assessment of conditions suitable for life.

Is Life Waiting to be Discovered?

One of the last images transmitted by the Cassini spacecraft before entering Saturn's cloud deck was that of Enceladus, setting behind the limb of gas giant. From a distance of 810,000 million miles (1.3 million km), Enceladus looks much like Saturn's other major moons (Saturn has 62 or more moons, eight of which are lar ge enough to be considered major moons). However, in 2005, during a flyby of the moon, Enceladus became a prime candidate for astrobiology when Cassini's instruments detected a cloud of water vapor over the moon's south pole and an active system of icy geysers. Subsequent flybys confirmed a watery reservoir beneath the moon's icy crust and the possibility of a global ocean.

Enceladus Setting
Credit: NASA/JPL-Caltech/
Space Science Institute

Enceladus is believed to have a rocky core, approximately 235 to 250 miles (380 to 400 km) in diameter, surrounded by an ocean 6 to 38 miles (10 to 60 km) in depth, and topped by an icy crust that could be as thin as 1.3 miles (2.1 km) or as thick as 32 miles (52.1 km). Silica rich dust particles found in the moon's icy plumes suggest hydrothermal activity on the seabed. Cassini's instruments also detected methane, carbon dioxide, ammonia, molecular nitrogen and hydrogen in the plumes.

In a recent study, published in Nature Communications, researchers evaluated the viability of several methanogenic archaea (microorganisms on Earth capable of producing methane in the absence of oxygen) under conditions that might exists in Enceladus' ocean and/or near thermal vents on the sea floor. One methanogen in particular, Methanothermococcus okinawensis, found in the deep ocean at a depth of 3,200 feet (972 meters) near Okinawa, Japan, was not only tolerant, but thrived under the Enceladus-like conditions, including a wide range of temperatures, high pH, salinity and extreme pressure.

life on Enceladus may be very dissimilar to what is found on Earth, the research on highly tolerate organisms, and their biomarkers, may contribute to the design of "life detection" instrumentation that can be carried on future missions to these "ocean" worlds.

April History

Apollo 16 wasn't the only lunar mission launched in the month of April. Two years earlier, on April 11, 1970, Apollo 13 lifted off from Cape Canaveral in what was intended to be the third manned mission to the Moon. The crew of James Lovell, Fred Haise and Jack Swigert never got their chance.

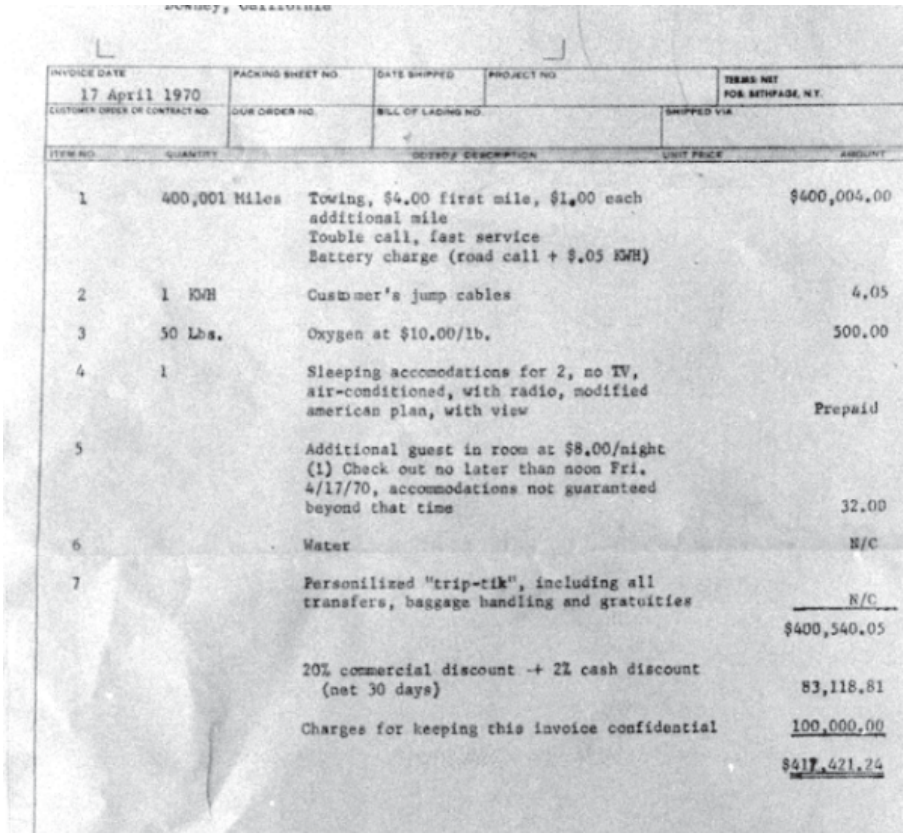
Two days later and almost 200,000 miles from Earth, the No. 2 oxygen tank exploded, cracking the feed pipe to the No. 1 oxygen tank and crippling the fuel cells providing the electrical power to the Command Module. The next four days would become the greatest human drama in space history.

With failing power and a cloud of debris surrounding the space craft, the three astronauts shut down the Command Module and moved into the Lunar Module (LM). The LM was designed to support two astronauts for a maximum of 45 hours. The LM needed to support the three astronauts for 75 to 100 hours for a safe return to Earth. To conserve supplies, almost all the spacecraft's systems were turned off. The temperature dropped to just above freezing, water condensed on all the internal surfaces and instruments and the level of carbon monoxide increased to life-threatening levels. Fluids and gases being expelled from the crippled Command Module acted like small rockets, continually pushing the spacecraft of f course.

The debris cloud prevented anything more than rudimentary navigation. The astronauts became dehydrated (fuel cells also provide water) and the conditions inside the spacecraft became increasingly unsanitary when the crew, through a misunderstanding, began to accumulate human waste inside the spacecraft (instead of discharging it).

Only through the ingenuity of the engineers back in mission control, the backup crew and hundreds of contractors involved in the assembly and operation of the spacecraft was the crew returned safely to Earth. The crew and the spacecraft reentered the Earth's atmosphere not knowing whether the heat shield had been damaged in the explosion or whether the parachutes would still deploy after four days of extreme cold. While Houston lost contact with the spacecraft for a minute longer than expected, Apollo 13 splashed down right on target.

The cause of the accident was eventually traced to damage the oxygen tank had sustained dur - ing its removal from Apollo 10. Due to a defective drain, internal heaters were used to empty the tank. Unfortunately, the pad power supply was not compatible with the spacecraft's power systems. The higher voltage melted the insulation leaving bare metal exposed to the pure oxygen environment. When Jack Swigert turned on the tank fan, the contents exploded. The story of Apollo 13 is detailed in astronaut Jim Lovell's book "Lost Moon," former Flight Director Gene Kranz's book "Failure is Not an Option," and recreated in the Ron Howard/Tom Hanks film "Apollo 13."



INVOICE DATE	PACKING SHEET NO.	DATE SHIPPED	PROJECT NO.	TERMS: NET FOB: BETHPAGE, N.Y.
17 April 1970				
CUSTOMER ORDER OR CONTRACT NO.	OUR ORDER NO.	BILL OF LADING NO.	SHIPPED VIA	

ITEM NO.	QUANTITY	DESCRIPTION	UNIT PRICE	AMOUNT
1	400,001 Miles	Towing, $4.00 first mile, $1.00 each additional mile Touble call, fast service Battery charge (road call + $.05 KWH)		$400,004.00
2	1 KWH	Customer's jump cables		4.05
3	50 Lbs.	Oxygen at $10.00/lb.		500.00
4	1	Sleeping accomodations for 2, no TV, air-conditioned, with radio, modified american plan, with view		Prepaid
5		Additional guest in room at $8.00/night (1) Check out no later than noon Fri. 4/17/70, accommodations not guaranteed beyond that time		32.00
6		Water		N/C
7		Personilized "trip-tik", including all transfers, baggage handling and gratuities		N/C
				$400,540.05
		20% commercial discount -+ 2% cash discount (net 30 days)		83,118.81
		Charges for keeping this invoice confidential		100,000.00
				$417,421.74

Post flight levity: an image of invoice sent to North American Rockwell (command and service module manufacturer) by Grumman Aerospace (lunar lander manufacturer) for services rendered in providing roadside assistance following the Apollo 13 accident and the use of the LM as a lifeboat.

Comet History

In the photo (right) Comet Hale-Bopp graced the evening sky on April 2, 1997, one day after perihelion (closest approach to the Sun). The comet was brighter than the brightest stars in the sky, with a dust tail that stretched almost 45 degrees across the sky. The photo shows the brighter, yellow dust tail and the dimmer, blue ion (gas) tail.

The orbital period of Hale-Bopp as it entered the inner solar system was 4,206 years. A close encounter with Jupiter in April of 1996

Jupiter and its Moons

Jupiter reaches Opposition on May 9th, with the gas giant opposite the Sun in the Earth's sky. By the beginning of April, Jupiter will be rise around 10:30 pm, but almost 2 hours earlier by month's end as the distance closes between the Earth and Jupiter. As one of the brightest star-like objects in the night sky, Jupiter can be found in the constellation Libra.

One of the more interesting and easier events to observe through a telescope is the projection of a shadow from one or more of Jupiter's moons on the Jovian disk as the moon(s) passes in front of (or transits) the planet. The photo (below) shows the moons Ganymede and Io completing a transit of Jupiter while their shadows lag behind on the cloud deck. On nights of good visibility the following events should be visible through a moderately-sized telescope, starting before midnight.

Transit of Jupiter's Red Spot

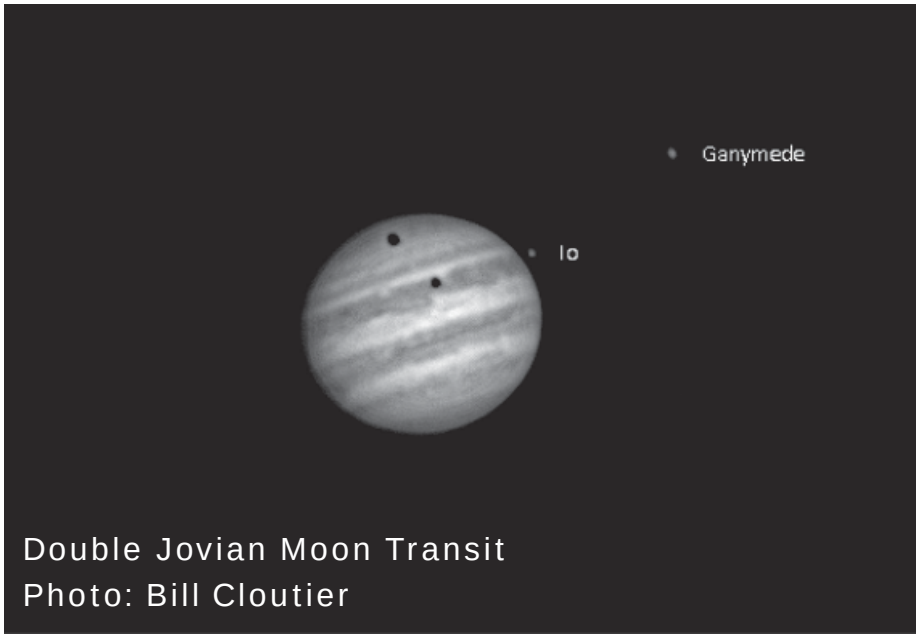
The Red Spot is a large cyclone in the upper Jovian atmosphere.The rapid rotation of this gas giant (10 hours) may be responsible for the longevity of this storm, which has been observed for over 300 years. The Red Spot will cross the center line of the planetary disk on the following evenings during the hours between 8 pm to midnight local time:

April Showers

The Lyrid meteor shower is expected to peak just before dawn on April 22nd. The dust producing the shooting stars is from Comet Thatcher. Expect to see 10 to 20 meteors per hour if light from an early morning moon doesn't interfere. As with all meteor showers, the Lyrids are named for the constellation (Lyra) from which they appear to radiate.

Jovian Moon Transits

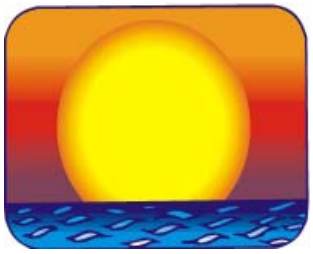
Date	Moon	Transit Begins	Transit Ends
Mar. 31st	Ganymede	9:19 pm	11:04 pm
7th	Io	8:53 pm	11:03 pm
10th	Europa	9:01 pm	11:17 pm
14th	Io	9:46 pm	11:56 pm
17th	Europa	10:36 pm	12:51 am (18th)
21st	Io	11:40 pm	1:50 am (22nd)
22nd	Io	7:08 pm	9:18 pm



Double Jovian Moon Transit
Photo: Bill Cloutier

Transit of Jupiter's Red Spot

Date	Transit Time	Date	Transit Time
4th	11:27 pm	19th	8:48 pm
9th	10:34 pm	21st	10:26 pm
12th	12:12 am	24th	12:04 am
14th	9:41 pm	26th	9:33 pm
16th	11:19 pm	28th	11:11 pm



Sunrise and Sunset (from New Milford, CT)

Sun	Sunrise	Sunset
April 1st (EDT)	06:37	7:19
April 15th	06:14	7:34
April 30th	05:52	7:51

Astronomical and Historical Events

1st Easter Sunday
1st Apollo Asteroid 2007 RX8 near-Earth flyby (0.085 AU)
1st Asteroid 100000 Astronautica closest approach to Earth (1.067 AU)
1st Apollo Asteroid 12923 Zephyr closest approach to Earth (1.365 AU)
1st History: Comet Hale-Bopp reaches perihelion - closest approach to Sun (0.914 AU) (1997)
1st History: launch of the first weather satellite, Tiros 1 (1960)
2nd Scheduled launch of a SpaceX cargo-carrying Dragon spacecraft to the International Space Station from the Cape Canaveral Air Force Station, Florida
2nd Aten Asteroid 2004 FG29 near-Earth flyby (0.010 AU)
2nd Aten Asteroid 3554 Amun closest approach to Earth (1.116 AU)
2nd History: U.S. release of the movie "2001 A Space Odyssey" (1968)
2nd History: launch of Zond 1, Soviet Venus flyby mission (1964)
2nd History: selection of the Mercury 7 astronauts (1959)
2nd History: French physicists Louis Fizeau and Leon Foucault take first photo of the Sun (1845)
3rd History: Soviet spacecraft Luna 10 becomes the first artificial satellite to orbit the Moon (1966)
4th History: launch of Apollo 6, last test flight of the Saturn V rocket (1968)
5th Asteroid 5261 Eureka (Mars Trojan) closest approach to Earth (0.722 AU)
5th Atira Asteroid 2015 DR215 closest approach to Earth (0.970 AU)
5th History: launch of the Compton Gamma Ray Observatory (1991)
5th History: launch of the first Pegasus rocket (1990)
5th History: launch of Pioneer 11, Jupiter and Saturn flyby mission (1973)
6th History: launch of Intelsat 1, first commercial communications satellite (1965)
7th Last Quarter Moon
7th History: first spacewalk from the space shuttle (Story Musgrave, Don Peterson, STS-6) (1983)
7th History: launch of Luna 14, Soviet Moon orbiter mission designed to test radio transmission stability, measure the lunar gravity field, solar wind and cosmic rays (1968)
8th Moon at apogee (furthest distance from Earth)
8th Amor Asteroid 2018 CZ13 near-Earth flyby (0.072 AU)
8th Kuiper Belt Object 2014 FT71 at Opposition (46.680 AU)
8th History: launch of the Bigelow Expandable Activity Module (2016) aboard a SpaceX Dragon cargo vehicle - module was installed on the International Space Station for a two year long demonstration of the expandable habitat
8th History: discovery of Saturn moon's Telesto by the Voyager 1 spacecraft (1980)
8th History: meteorite hits house in Wethersfield, Connecticut (1971)
8th History: launch of the unmanned Gemini 1 (1964)
8th History: Project Ozma, the search for extraterrestrial intelligence, begins as Frank D. Drake, an astronomer at the National Radio Astronomy Observatory in Green Bank, West Virginia, turns the 85-foot Howard Tate telescope toward the star Tau Ceti (1960)
9th Apollo Asteroid 4179 Toutatis closest approach to Earth (2.818 AU)

Astronomical and Historical Events (continued)

9th Kuiper Belt Object 2013 FS28 at Opposition (83.812 AU)
10th Amor Asteroid 3757 Anagolay closest approach to Earth (0.950 AU)
10th History: Japanese lunar probe Hiten impacts Moon; first non-U.S./Soviet lunar probe, also first to visit the Lagrangian Points L4 and L5 during its three year mission (1993)
11th Apollo Asteroid 2008 GY21 near-Earth flyby (0.026 AU)
11th Apollo Asteroid 2018 BY2 near-Earth flyby (0.061 AU)
11th History: ESA spacecraft Venus Express enters orbit around the planet Venus (2006)
11th History: launch of Apollo 13 with astronauts James Lovell, Fred Haise and Jack Swigert; mission aborted when oxygen tank explodes and cripples the Command Module (1970)
12th Apollo Asteroid 363599 (2004 FG11) near-Earth flyby (0.049 AU)
12th History: launch of the first space shuttle (Columbia) with astronauts John Young and Robert Crippen (1981)
12th History: launch of Vostok 1 with cosmonaut Yuri Gagarin, first person to orbit the Earth (1961)
12th History: Edward Maunder born; studied solar cycle and sunspots Analyzed period between 1645 and 1715 when almost no sunspots where recorded - known as the "Maunder minimum" or "Little Ice Age" because of the severe winters (1851)
12th History: discovery of Asteroid 10 Hygiea by Annibale de Gasparis (1849)
13th Aten Asteroid 2005 GZ128 near-Earth flyby (0.074 AU)
13th Apollo Asteroid 2013 GF84 near-Earth flyby (0.077 AU)
13th History: launch of Transit 1B, first experimental navigation satellite (1960)
14th Second Saturday Stars - Open House at McCarthy Observatory
14th Aten Asteroid 2014 UR near-Earth flyby (0.024 AU)
14th History: Christiaan Huygens born, Dutch scientist and discoverer of Saturn's rings and lar gest moon Titan (1629)
15th New Moon
15th Apollo Asteroid 2016 GB222 near-Earth flyby (0.074 AU)
15th Dwarf Planet 136108 Haumea at Opposition (49.617 AU)
16th Scheduled launch of the Transiting Expoplanet Survey Satellite (TESS) by a SpaceX Falcon 9 rocket from the Cape Canaveral Air Force Station, Florida
16th History: launch of Apollo 16 with astronauts John Young, Ken Mattingly and Charles Duke, the only mission to the lunar highlands (1972)
16th History: Leonardo Da Vinci born, first to correctly explain Earthshine (1452)
17th Asteroid 21 Lutetia closest approach to Earth (1.644 AU)
17th History: closest flyby of the Sun by a spacecraft, Helios 2 (1976)
17th History: launch of Surveyor 3, Moon lander, first to experience a lunar eclipse from the Moon's surface during which the temperature fell 250° F; Apollo 12 would later land near Surveyor 3 in 1969, retrieving pieces of the lander for return to Earth and analysis of the ef fects of the harsh lunar environment (1967)
19th Apollo Asteroid 2014 JG15 near-Earth flyby (0.050 AU)
19th Apollo Asteroid 2015 HD10 near-Earth flyby (0.098 AU)
19th History: launch of the last Soviet Salyut space station, Salyut 7 (1982)
19th History: launch of the first space station, Soviet Salyut space station, Salyut 1 (1971)
20th Moon at perigee (closest distance from Earth)
20th Aten Asteroid 2016 JP near-Earth flyby (0.031 AU)
20th Apollo Asteroid 2010 JO33 near-Earth flyby (0.060 AU)
20th Atira Asteroid 164294 (2004 XZ130) closest approach to Earth (0.667 AU)

Astronomical and Historical Events (continued)

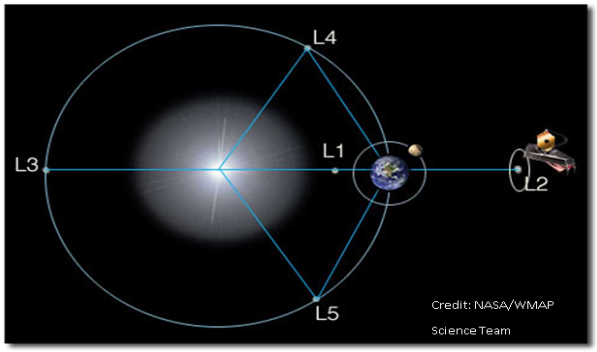
21st Northeast Astronomy Forum and Telescope Show (NEAF), Rockland Community College, Sufern, NY (21st and 22nd)
21st Apollo Asteroid 2018 CY near-Earth flyby (0.098 AU)
22nd First Quarter Moon
22nd Lyrids Meteor Shower peak
22nd Earth Day
22nd History: Cassini's final close flyby of Saturn's moon Titan, initiating the 22 Grand Finale orbits between the planet and its rings and the end of mission in September (2017)
22nd History: launch of the Air Force's X-37B prototype space plane from Cape Canaveral, Florida; first orbital mission (2010)
23rd Aten Asteroid 2012 XL16 near-Earth flyby (0.041 AU)
23rd Aten Asteroid 2017 HF1 near-Earth flyby (0.061 AU)
23rd Apollo Asteroid 2015 XF352 near-Earth flyby (0.090 AU)
24th Apollo Asteroid 469219 (2016 HO3) closest approach to Earth (0.145 AU)
24th Kuiper Belt Object 42355 Typhon at Opposition (20.615 AU)
24th History: launch of space shuttle Discovery (STS-31) and deployment of the Hubble Space Telescope (1990)
24th History: launch of Mao 1, first Chinese satellite (1970)
24th History: cosmonaut Vladimir Komarov dies during re-entry of a prototype Soviet lunar spacecraft (Soyuz 1) when parachute lines become entangled (1967)
25th Apollo Asteroid 4581 Asciepius closest approach to Earth (0.293 AU)
25th Scheduled launch of Sentinel 3B, a European SpaceAgency Earth observation satellite designed to measure sea surface topography, sea and land surface temperature, and ocean and land color. Launch will be from the Plesetsk Cosmodrome, Russia.
26th Amor Asteroid 450648 (2006 UC63) near-Earth flyby (0.082 AU)
26th History: Venus flyby (gravitation assist) by the Cassini spacecraft (1998)
26th History: Ranger 4 impacts Moon (1962) - while the mission didn't return any scientific data due to an onboard computer failure, Ranger 4 become the first U.S. spacecraft to reach another celestial body when it crashed on the far side of the Moon
26th History: launch of Sputnik 14 (Cosmos 4), first successful Soviet reconnaissance satellite - designed to study upper layers of atmosphere and monitor U.S. nuclear tests (1962)
26th History: discovery of Asteroid 9 Metis by Andrew Graham (1848)
27th Apollo Asteroid 444193 (2005 SE71) near-Earth flyby (0.062 AU)
27th Amor Asteroid 194126 (2001 SG276) near-Earth flyby (0.084 AU)
27th Apollo Asteroid 5786 Talos closest approach to Earth (0.792 AU)
28th History: launch of the Cloudsat/Calipso cloud imaging and profiling satellites (2006)
29th Full Moon (Full Pink Moon)
29th Mercury at its Greatest Western Elongation (27°) - apparent separation from the Sun in the morning sky
28th Tentative schedule for launch of two Gravity Recovery and Climate Experiment Follow-On (GRACE Follow-On) satellites for NASA and the German Research Centre for Geosciences (GFZ) on a SpaceX Falcon 9 from Vandenberg Air Force Base, California
29th Apollo Asteroid 2013 US3 near-Earth flyby (0.026 AU)
29th Aten Asteroid 2002 JR100 near-Earth flyby (0.028 AU)
30th Kuiper Belt Object 2014 FC69 at Opposition (83.812 AU)
30th History: the Surveyor 3 lander takes the first picture of Earth from the Moon's surface (1967)

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 lar ge 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

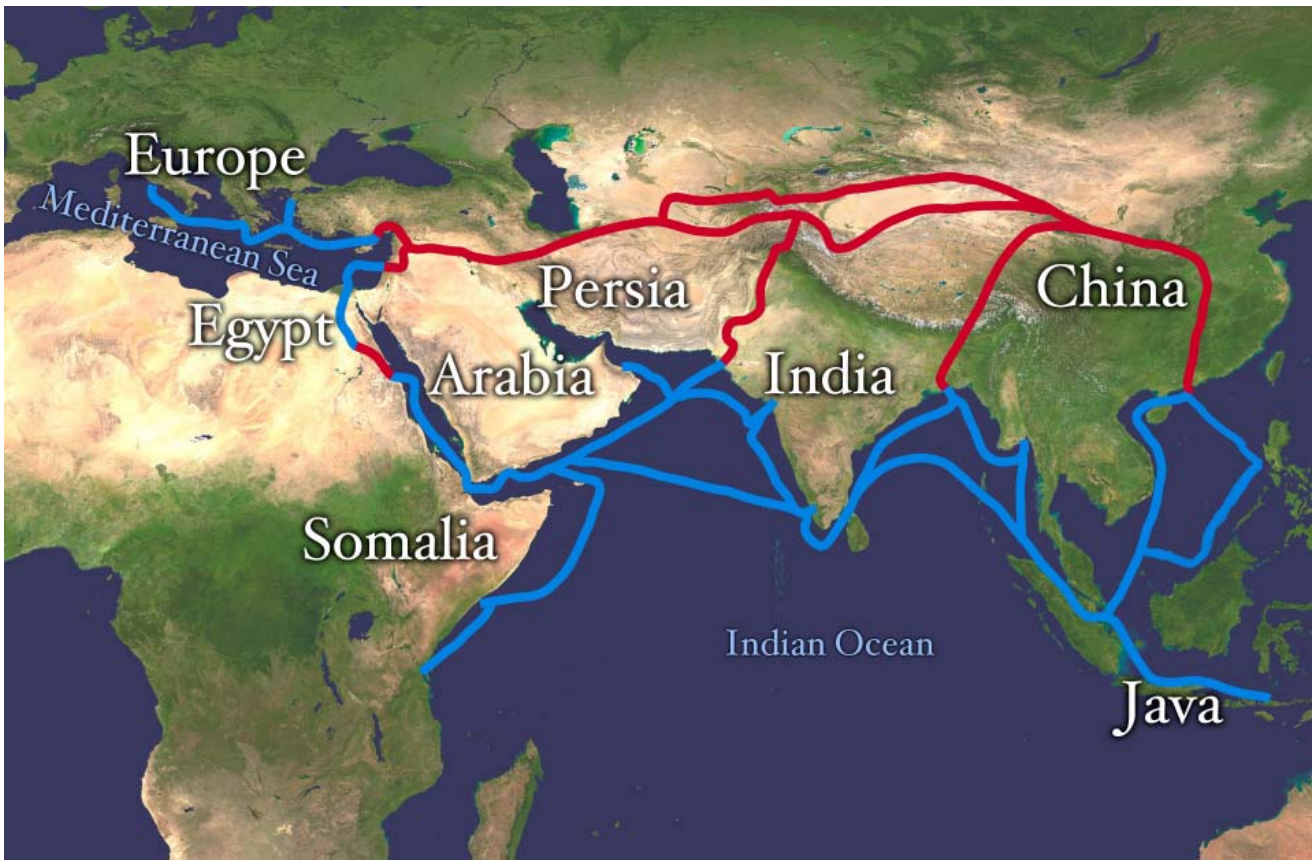
An image from orbit of the Hindu Kush of Central Asia, spanning the knurled borders and geological barriers shared by Pakistan, Afghanistan and India in the south and the plains of Kazakhstan Uzbekistan and Turkmenistan above.

Alhough appearances would suggest a desolate, barren wasteland, the region is widely inhabited and has been a historical venue for trade and commerce from Roman times - the Silk Road. Based in the silk trade, this network quickly grew to became a cultural link to civilizations across the Eurasian ecumene, spreading religions, philosophies, culture and conquest throughout the known world.

The Silk Road was a product of a stable and thriving economyand in bad times fell into disuse and decline, its trails blurred and overgrown. But today a new trading system is being etched not in the mountains, steppes and deserts of central Asia, but in the skies above.

China's BeiDou (*Big Dipper*) navigation system is a home-grown satellite program developed as an alternative to GPS. Designated "belt and road technology" to emphasize its breadth over land and sea, the trillion-dollar network of 35 satellites is planned to cover more than 68 countries, encompassing 65% of the world's population and 40% of global GDPas of 2017. An arctic BeiDu link with Russia is also being considered.As a home-grown initiative, BeiDou will enable China to end its dependence on GPS and project its economic and military power directly into space.

Source*:https://en.wikipedia.org/wiki/One_Belt_One_Road_Initiative; https://earthobservatory.nasa.gov/IOTD/view.php?id=4103; http://www.chinadaily.com.cn/china/2017-11/07/content_34212037.htm.*



The red lines indicate the Silk Road land route; blue lines are sea connections.
Source: NASA/Goddard Space Flight Center - Visible Earth -*https://visibleearth.nasa.gov/*

Contact Information

The John J. McCarthy Observatory

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

Phone/Message: (860) 946-0312
Phone/Voice: (860) 210-4117u7
Phone/Fax: (860) 354-1595
www.mccarthyobservatory.org

www.mccarthyobservatory.org

@McCarthy Observatory

@McCarthy Observatory

mccarthy.observatory@gmail.com

@JJMObservatory

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

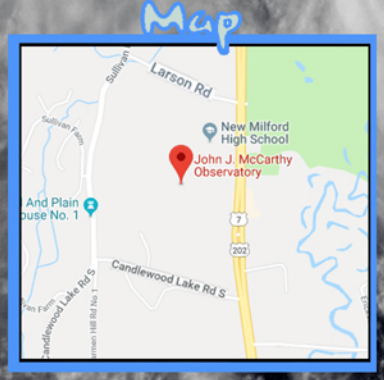
April 14th
8:00 - 10:00 pm

State

of

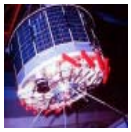
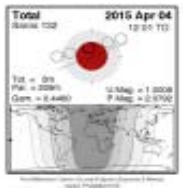
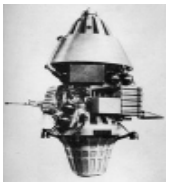
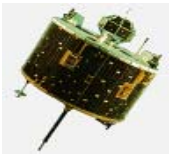
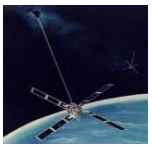
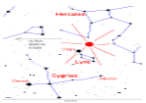
The Earth

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



April 2018

Celestial Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1  1960: First successful weather observation satellite, TIROS I (Television Infra-Red Observation Satellite), launched by NASA; operated for 78 days. (1960)	**2**   Launch of Zond 1, Soviet Venus flyby mission (1964) Selection of the Mercury 7 astronauts (1959)  French physicists Louis Fizeau and Leon Foucault take first photo of the Sun (1845)	**3**  Soviet spacecraft Luna 10 first artificial satellite to orbit moon (1966)	**4** Launch of Apollo 6, last test flight of the Saturn V rocket (1968)   Total Lunar Eclipse, seen in U.S. West, before sunrise - less than 5 minutes	**5**  Launch of Pioneer 11, Jupiter and Saturn flyby mission (1973) Launch of Compton Gamma Ray Observatory (1991)   launch of the first Pegasus rocket (1990)	**6**  Launch of Intelsat 1, first commercial communica-tions satellite (1965)	**7**  Launch of Luna 14, Soviet Moon orbiter mission (1968)
8  Moon at apogee (furthest from the Earth) Launch of unmanned Gemini I (1964)   Project OZMA, search for extraterrestrial life (1960) Discovery of Saturn's moon Telesto by Voyager 1 (1980) 	**9**  Charles-Eugène Delaunay born - a French astronomer and mathematicianwho advancing advanced both the theory of planetary motion and mathematics (1816)	**10**  Japanese lunar probe Hiten impacts Moon's surface (1993)	**11** ESA spacecraft Venus Express enters orbit around Venus (2006)   Apollo 13 launch on ill-fated moon mission (1970)	**12**  Edward Maunder born. studied solar cycle and sunspots. (1851) Shuttle, Columbia, with John Young and Robert Crippen (1981)   Yuri Gagarin first man in space on Vostok I (1961)	**13**  Launch of Transit 1B, first experimental navigation satellite (1960)	**14**  Christiaan Huygens, discoverer of Saturn's rings and moon Titan born (1629) 2nd Saturday Stars Open House McCarthy Observatory 
15  Leonhardt Euler, Swiss mathematician, precisely calculated the orbits of comets and other celestial bodies and contributed to the wave theory of light (1707)	**16**  Apollo 16 launch to lunar highlands (1972) Leonardo da Vinci born (1452) 	**17**  Closest flyby of the Sun by a spacecraft, Helios 2 (1976) Launch of Surveyor 3 Moon lander (1967) 	**18**  Albert Einstein dies in Princeton, NJ (1955)	**19**  Launch of Salyut 1 (1971) and Salyut 7 (1982), first and last Soviet space stations	**20** Moon at perigee (closest distance to Earth)   Harold Graham performs 1.2-meter, 13- second free flight of a rocket pack, designed at Bell Aerosystems. (1961)	**21**  Apollo 16 on the Moon (Young, Mattingly and Duke) - fifth manned mission and first to land in the lunar highlands (1972)
22  Lyrids meteor shower peak launch of the Air Force's X-37B prototype space plane from Cape Canaveral, Florida; first orbital mission (2010) 	**23**  Ranger 4 Lunar probe launched - failed its mission, but became first U.S. craft to impact the Moon (1962)	**24** Launch of shuttle Discovery with Hubble space telescope (1990)  Cosmonaut Valery Komarov dies on re-entry on lunar spacecraft Soyuz 1 (1967) Launch of 1st Chinese Mao 1 (*aka "the East is Red"*) satellite, (1970)	**25** The 20th Annual Great Moonbuggy Race, Huntsville, AL, at the U.S. Space & Rocket Center (April 25-27) Nikolai Semenovich Kardashev born, astrophysicist and deputy director of the Russian Space Research Institute, pioneered search for extraterrestrials (1932) 	**26** Cassini spacecraft gets gravitational assist from Venus on way to Saturn 1998	**27** Karl Jansky, a Bell Labs physicist and radio engineer, announces discovery of radio transmissions from Milky Way (1932)	**28** Launch of the Air Force's X-37B prototype space plane from Cape Canaveral, first orbital mission (2010) Isaac Newton publishes *Principia*, describing gravitation and 3 laws of motion (1686)
29 Cornelis de Jager, Dutch astronomer born; worked on predicting solar variation, to assess the Sun's impact on future climate (1921)	**30** Plinius' Eclipse, described by Pliny the Elder, Roman naturalist in Campagnia, Italy : "Then the sun was suddenly darkened and the fourteen districts of the city were struck by lightning" (59 AD)					

Phases of the Moon

April 7 — April 15 — April 22 — April 29