SkyWAAtch

Lunar Eclipse

Courtesy of Bob Kelly is this image of the recent lunar eclipse taken between clouds above the hills overlooking Ardsley. Notes Bob: One edge of the Moon is brighter since it's nearer the edge of the Earth's shadow. Visually, it was like a 'diamond ring' effect. Bob used a Canon XS Rebel on a tripod at f/11 (ISO-1600, 2 second exposure at 131 mm focal length).

In This Issue . . .

Events for November 2014

WAA November Lecture

"The Copernicus Complex"
Friday November 7th, 7:30pm
Lienhard Lecture Hall,
Pace University Pleasantville, NY

Our November speaker is Dr. Caleb Scharf. In his lecture Dr. Scharf asks: Are we special or are we unexceptional? For the first time in human history we stand poised to begin to truly answer this question. Extraordinary discoveries in astronomy and biology have revealed a universe filled with dynamic and endlessly diverse planetary systems, and a picture of life as a phenomenon intimately linked with the most fundamental aspects of physics. But where this really leads us is not yet clear. It's possible that we need to find a way to see past the mediocre status that Copernicus assigned to us 500 years ago, and to do that we need to come to grips with the latest scientific research from the microscopic to the cosmic.

Caleb Scharf is Director of Astrobiology at Columbia University in New York, and the author and co-author of more than 100 scientific research articles in astronomy and astrophysics. His textbook, *Extrasolar Planets and Astrobiology*, won the 2011 Chambliss Prize of the American Astronomical Society, and *Gravity's Engines*, his new popular science book was one of New Scientist's "10 books to read in 2012″ and was the basis of the BBC/Science Channel documentary, "Swallowed by a Black Hole". Free and open to the public. Directions and Map.

WAA December Lecture

"Why is Gravity So Weak – What Can the ATLAS at the LHC Tell Us?"
Friday December 5th, 7:30pm
Lienhard Lecture Hall, Pace University Pleasantville, NY

The Standard Particle Model describes the fundamental particles (quarks and leptons) found in nature as well as the fundamental forces (electromagnetic, weak and strong) between those particles. It has worked remarkably well, describing all current experimental evidence. However, there is one remaining force that is not included in that model, gravity--the force of gravity is so weak compared to all the other forces that it typically plays no role in particle physics experiments, although it shapes the large-scale structure of the universe. We do not yet know why the force of gravity is so weak, but some theories, in particular string theories and others based on extra dimensions of space may offer an explanation. Dr. Michael Tuts will describe how these theories could lead to an explanation of why gravity is so weak, and how the ATLAS experiment searches for evidence of the existence of extra dimensions.

Michael Tuts is an experimental particle physicist who has spent his career exploring the sub-atomic world. He has been a member of numerous experiments that have led to the discovery of new fundamental particles such as upsilon mesons, the top quark (the heaviest known fundamental particle) and the long sought after Higgs boson. He received his PhD from the State University of New York at Stony Brook in 1979, and then joined the Columbia Physics Department in 1983. He enjoys talking about the LHC and the ATLAS experiment with general audiences as well as teaching introductory physics courses. He now serves as the chairman of the Columbia Physics Department. Free and open to the public. Directions and Map.

Starway to Heaven

Saturday November 15th, 7:00 pm.
Meadow Picnic Area,
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for November, weather permitting. Free and open to the public. The rain/cloud date is November 22nd. **Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions.

New Members. . .

Thomas Mordasky - Mamaroneck
Emmanouil Makrakis - Scarsdale
Jim Leftwich - White Plains

Renewing Members. . .

Claudia & Kevin Parrington Family - Harrison
Paul Renken - Yorktown
James Frost - Rye Brook
Kristina Newland - White Plains
Greg Williams - New Canaan
John James - Sunnyside
Vince Quartararo - Katonah
Olivier Prache - Pleasantville
Hans Minnich - Bronx

Almanac
For November 2014 by Bob Kelly

Nov 6 Nov 14 Nov 22 Nov 29

Hidden planets, wrong-way meteors, a major time shift

November brings a time shift as humans push time back an hour in much of the United States and many other countries. The dark sky arrives an hour sooner in the evening and ends an hour sooner in the morning, starting Sunday, November 2nd. I know keeping Daylight Time year-round makes sunrise ridiculously late in the far western sections of time zones, but it was nice to see Jupiter every morning on the way to work. We'll have all of November and most of December to get the clock time of sunrise back to where it was in late October since the latest sunrise happens in early January. Sunset will drifts earlier more slowly as we approach the earliest sunset on December 7th.

If you are out in the morning dark skies, Jupiter is highest just before sunrise. Evening viewers have to wait until the end of the month for a Jupiter-rise at 10pm. Jupiter's disc approaches 40 arc seconds wide, wider than any other planet appears, except the occasional crescent Venus. So this is the beginning of a great time to observe the giant planet and its moons. Mercury fades into the morning twilight after its best morning showing of the year at the start of the month. Venus lingers behind the Sun looking about as small as ever it looks from Earth, and Saturn joins Venus in the SOHO C3 camera's field around November 10th. They come closest together on the 12th, hard to see except in SOHO. They both exit before the last week in November.

Mercury joins the SOHO scene, in from the right, after Thanksgiving. But, before then, Mercury completes its good showing in the morning sky, which peaked with a before twilight rising on the 1st, 19 degrees ahead of the Sun.

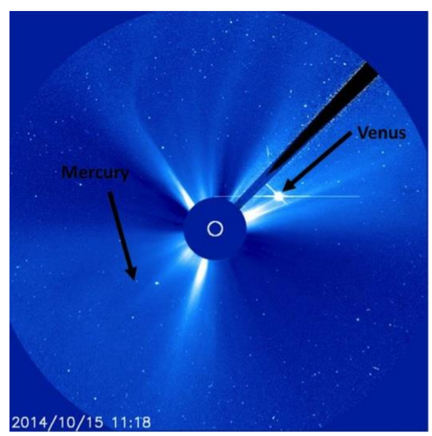
With Saturn, Mercury and Venus spending most of the month on the sidelines, planets that look smaller from Earth have a chance to shine. Uranus and Neptune are well placed in the evening sky, rewarding the telescope user with a good finder chart. They transit highest in the south in the early to mid-evening. Our telescopes will show Uranus and Neptune to be tiny disks instead of star-like points of light.

Mars cruises over the top of Sagittarius, low in the southwest in the evening sky. Pluto is also hiding in Sagittarius, unaware of the upcoming visit next year by the New Horizons spacecraft. The Hubble Space Telescope found three fellow Plutonians. At magnitude +28, we won't be observing them anytime soon ourselves. One of them will be selected for its close-up, to happen around 2018 to 2019.

Another small object, asteroid 3Juno, will make a rarely seen occultation of a relatively bright star - 7th magnitude on the 20th, visible from northern New England, weather permitting. The sixth asteroid to be discovered, Hebe, will brighten to 8th magnitude at opposition this month. Hebe can be found in Eridanus, to the lower right of Orion.

The Leonid meteor shower peaks on the 17th and 18th. Leonids are known for their fast motion through the sky since they come at the Earth almost head-on. Taurid meteors are few and far between, but their orbits follow in the same direction as the Earth, so they appear slower as they enter the atmosphere following the Earth. This 'backdoor' approach to Earth also means they are more commonly seen in the evening sky.

Venus and Mercury in the SOHO C3 solar observatory



Mercury is closer to us than Venus, but is much fainter because it is between us and the Sun, so most of the side of Mercury facing us is not lit by the Sun. In C3 movies, you can tell which 'star' is Mercury because it moves faster across the view than the other stars.

Transits of Objects through the LASCO/C3 field of view
-dates and magnitudes are approximate.

Sep26-Nov23	Venus	mag.-3.9	right to left
Oct13-Oct20	Mercury	mag.+5.2	left to right
Nov10-Nov26	Saturn	mag.+0.5	left to right
Nov26-Dec21	Mercury	mag.-1.1	right to left

Source: Sungrazer Project

Life in the Solar System

Larry Faltz

One of the wonderful things about astronomy is the vast range of scientific questions that it deals with. How did the universe come about? How does it work on the grandest scales? The smallest? What are cosmological objects made of, and what laws do they follow? How did our solar system arise? How did we get here? And, to many the grandest of all questions, is there life elsewhere in the universe?

It's possible that the universe is rife with life. There are many hints that environments conducive to life can be found in our solar system and elsewhere. There are hundreds of millions of galaxies in the observable universe and each contains billions of stars. We know from exoplanet research that planetary systems are fairly common, and recent data suggests that up to one in five stars hosts a planet in the "habitable zone" (or "Goldilocks zone" for those of you who prefer a literary reference) where the star's energy can keep water in a liquid state at the planet's surface.

But, what *is* life? If we find it, will we even recognize it? Do all life forms need to be like what we know on Earth: carbon-based, liquid water-dependent? It turns out that we can't even be sure of what constitutes life on our planet!

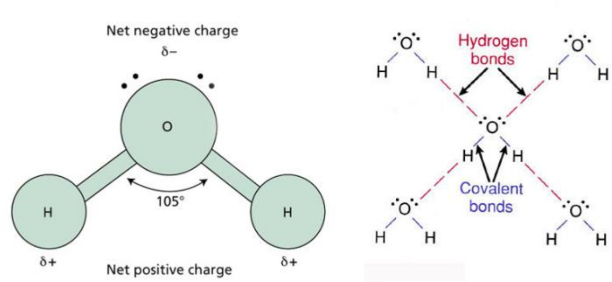
The American Heritage Dictionary defines life as "the property or quality manifested in functions such as metabolism, growth, response to stimulation and reproduction by which living organisms are distinguished from dead organisms of inanimate matter." A bit vague and tautological, I think: "life is what isn't dead" doesn't help a whole lot, nor does "functions *such as*…" Do they all have to be present, or just some, or just one? We would all agree that unicellular or multicellular organisms are alive because they contain a genetic code that directs their own reproduction, powered by energy-transforming chemical processes within the organism (think everything from human beings to bacteria). Are viruses alive? They have genetic material which directs reproduction, but they don't utilize their own energy metabolism, instead commandeering the machinery in a host cell to make copies of themselves. Is that life, or just a form of chemical reaction? And even more problematic are prions, proteins (clearly not genetic material) that induce conformational changes in other proteins, propagating abnormal function in cells, particularly neurons. Diseases such as bovine spongiform encephalopathy (Mad Cow disease), scrapie in sheep and kuru and Creutzfeldt-Jakob disease in humans (and perhaps Alzheimer's as well) are due to these strange organic substances. Their reproduction is more like crystallization than biologic reproduction, but like viruses (they were called "slow viruses" when I was in medical school, only renamed "prions" when they were proven to be proteins in the 1980's) they seem to direct their own multiplication. Are they "alive"?

A definition I find more satisfying comes from physical chemistry, particularly one attributed to John Bernal, Erwin Schrödinger, Eugene Wigner, and John Avery: "Life is a member of the class of phenomena that are open or continuous systems able to decrease their internal entropy at the expense of substances or free energy taken in from the environment and subsequently rejected in a degraded form." A personal reason I like a definition out of physical chemistry is because of something said by Max Gottlieb, the beleaguered scientist who is the protagonist's medical school mentor in in Sinclair Lewis' novel *Arrowsmith*, a work that was an early (age 13) stimulus for my decision to pursue a medical career. "Physical chemistry is power, it is exactness, it is life!" exults Gottlieb. In any case, this definition frees us to think "outside the box" about what constitutes biologic structure or action. Prions would not be alive, because although they use free energy to cause conformational change in other proteins, nothing is degraded. A virus would be considered a life form by virtue of its essentially cellular action (even though it's via hijacking).

The remarkable ability of tetravalent carbon to form a limitless number of complex molecules is also something we feel is necessary for life. Carbon provides the range of molecular architecture necessary to support intricate life functions. The only other tetravalent element that might be invoked as a basis for biologic structure is silicon, one row below carbon in the periodic table. Compared to their carbon equivalents, however, silicon analogues of even simple biomolecules aren't very stable. Also, the simplest silicon oxide, SiO_2 (the major component of sand and glass) is insoluble in water, making it difficult to introduce silicon into a water-based environment. In an aerobic milieu, an organism metabolizing silicon would have exhale SiO_2, which means that the organism's lungs would immediately fill up with sand. The only way to counteract this would be for the organism to exist at enormously high temperatures, where the SiO_2 is at least liquid, if not gaseous. These facts have not stopped science fiction writers from postulating silicon based life forms, most familiarly the acid-secreting, rock-burrowing Horta familiar to aficionados of the original *Star Trek*. The concept that life requires carbon was deemed "carbon chauvinism" by Carl Sagan, but it seems unlikely that another atom can provide the structural complexity that living organisms seem to need.

Captain Kirk and the silicon-based Horta
Star Trek, "Devil in the Dark", Season 1

What about water? Does life require it? The structure of and interaction between organic molecules depends on hydrogen bonds, which are not chemical bonds but electrostatic interactions between positively charged hydrogen and negatively charged oxygen or nitrogen within and between biologic molecules. The 3-dimensional structure of all macromolecules hinges on these bonds. Water is polar. Because the angle between the two hydrogens in H_20 is not 180° but 105°, the oxygen side of the molecule, containing 2 non-binding electron pairs, is slightly negative and the hydrogen side slightly positive. This allows water to be an intermediary in structural arrangements between biologic molecules. Water forms hydrogen bonds with itself, an important property when it comes to its liquid phase. Ammonia, NH_3, is the nitrogen equivalent of water. It's a liquid between -77° and -33° C (at 1 atmosphere). It too is polar, but not as polar as water. Although the possibility of ammonia-based life was suggested by the British geneticist and polymath J.B.S. Haldane in 1954, ammonia's hydrogen bonds are weaker than water's. Another property that probably encouraged the development of life in water is that water ice is less dense that liquid water, meaning that when the air temperature drops below 0° C, water can remain liquid underneath a protective layer of ice, allowing living organisms to continue their biologic activity. Solid ammonia is denser than liquid ammonia, so a layer of protective ammonia ice can't form. But ammonia-based carbonaceous life isn't out of the question somewhere in the universe.



Assuming that living organisms use the same biochemistry as those found on Earth, a few more elements are needed. In addition to hydrogen, carbon, oxygen and nitrogen (to form the basic structures of proteins and metabolic molecules), sulfur is necessary for protein folding and phosphorus is an essential component of energy metabolism, particularly for electron transfer. Since life evolves in an aqueous environment, dissolved salts also play a role, in particular sodium, potassium and chlorine. More complex organisms will utilize iron and a few other metals. These compounds either come from stellar nucleosynthesis or from supernovas. As Carl Sagan famously said, "We are all star-stuff."

There are no other terrestrial environments in our solar system. Earth is unique in possessing large amounts of liquid water and an oxygen rich atmosphere. Its ability to hold on to its atmosphere is a fortuitous result of its magnetic field, in turn the result of a large, molten iron core. As the core spins, it generates magnetic lines which emanate outwards, forming a barrier to charged particles, either cosmic rays or particles emitted by the sun. Mars lacks a large iron core and it's believed that the incessant bombardment of solar and cosmic charged particles caused its early atmosphere, potentially favorable to life, to disperse, taking with it a large amount of water.

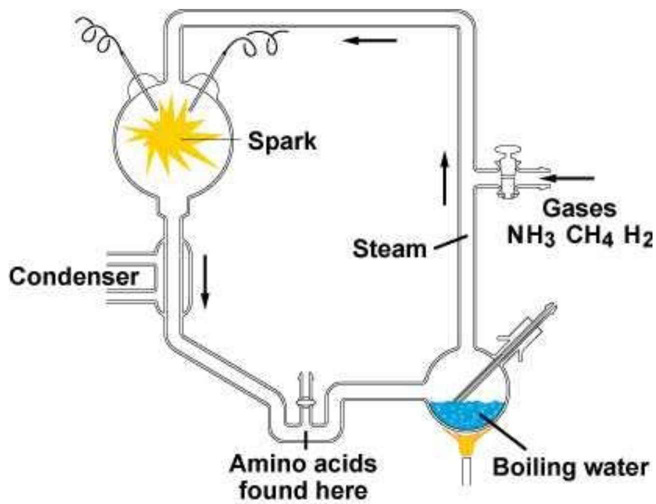
The early history of life on Earth seems to be well established. When the planet condensed from the proto-solar nebula 4.55 billion years ago, its atmosphere contained hydrogen, helium, water vapor, methane and ammonia. As the Earth cooled, the lightest of these gases were driven off by the solar wind. Between 4.1 and 3.8 billion years ago, the inner solar system was invaded by a vast number of asteroids and icy comets during the Late Heavy Bombardment period. The evidence comes from analysis of lunar rocks brought back by Apollo. The Bombardment deposited considerable amounts of water and carbon on the Earth. The first oceans formed under an atmosphere of nitrogen and carbon dioxide. The water dissolved the CO_2 to form carbonate sediments.

3.6 million year old stromatolite from Australia. Note the layers of fossilized organisms.

The first living organisms appeared at the end of the Late Bombardment period. These stromatolites were simple single-celled bacteria that formed organic mats in the oceans, later fossilizing in sediments.

Although we don't know the exact sequence of chemical events that led to living organisms, we do have evidence that complex organic compounds can arise from simple molecules in an environment much like that of the early Earth, a process called "abiogenesis". The critical evidence is the famous Miller-Urey experiment, published in 1953. Stanley Miller and Harold Urey (the discoverer of deuterium) mixed water, methane, ammonia and hydrogen and passed an electric spark through the mixture, alternately heating and cooling it. At the end of two weeks, 15% of the carbon and 18% of the methane was in the form of organic compounds, and 2% was already in simple amino acids, the building blocks of proteins. Sugars were also formed. The original experimental materials have been preserved (the apparatus is at the Denver Science Museum). In 2007, several sealed vials were opened and over 20 different amino acids were found.

The earliest organisms lived in a carbon-rich environment, and some of them evolved the ability to convert carbon dioxide to oxygen and water using sunlight as an energy source, the process familiarly known as photosynthesis. Photosynthetic organisms were probably present as early as 3.5 billion years ago. As the oxygen was liberated into the environment, it combined with free iron, forming iron oxides. All of the natural iron on the surface of today's Earth is in the form of oxides, and if you come upon pure metallic iron it's either man-made or you've found a meteorite. By 2.4 billion years ago, the atmosphere would have been breathable by humans; aerobic life could begin to evolve.



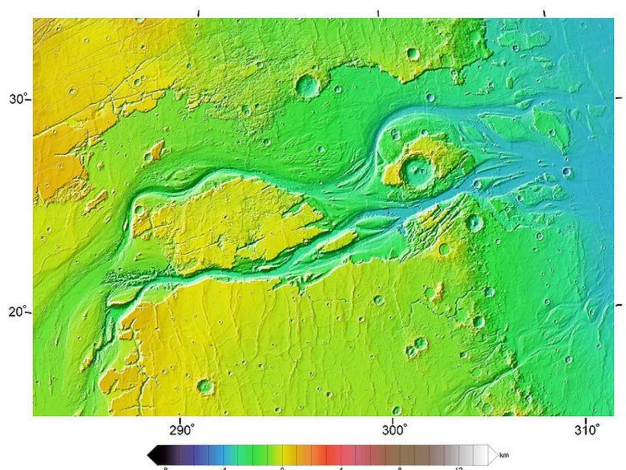
The Miller Urey Experiment (Miller, Stanley L., Urey, Harold C., Organic Compound Synthesis on the Primitive Earth. *Science* 1953; 130: 245–51)

Could this process have originated elsewhere in the early solar system? The prime candidates are Venus and Mars. Venus is just at the inner edge of the habitable zone where water would be a liquid at the planet's surface, although some calculations suggest that for enough of the Cytherean year Venus wanders too close for the sun to boil off all its water. In any case, Venus' meteorologic history certainly precludes the continuous maintenance of life, what with temperatures far beyond the boiling point of water and an atmosphere of carbon dioxide and sulfur dioxide punctuated by rain showers of sulfuric acid.

Mars orbits well within the habitable zone, but its current atmospheric pressure is only six one-thousandths that of Earth and is made up of 95% CO_2. Mars' surface temperature is generally far below zero centigrade although at Martian noon around the equator it can rise to a temperate 20° C. This is only recent (20^{th} century) data. William Herschel noted variations in surface markings on Mars in the 1780's and ascribed them to seasonal changes in vegetation. Observations with better telescopes during close oppositions in the mid and late 19th century brought forth suggestions that the surface markings were engineered structures, an intriguing and dramatic idea eventually debunked in the 20th century through better science and observation. See my article on Mars in the March 2014 newsletter for more about the cartographic history of Mars.

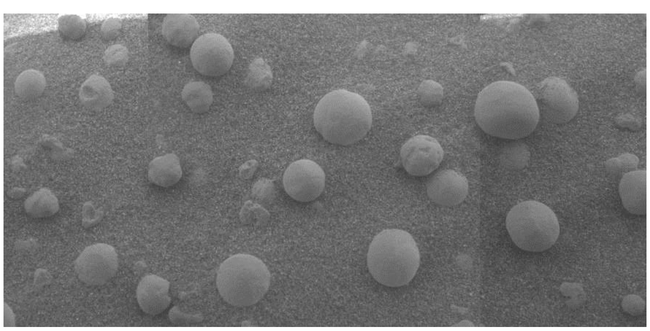
The Viking landers (1976) carried experiments that looked for active biologic metabolism on the surface, particularly the uptake of radioactive carbon-14 CO_2 (supplied by the landers) into organic compounds. The results were negative. The search for life on Mars now is primarily a search for water, current or past.

Martian water does exist, most of it in the polar caps but surface rovers have found both geologic and direct evidence for water elsewhere. Orbiters have photographed surface topography consistent with channels cut by flowing water, such as Karsei Valles.



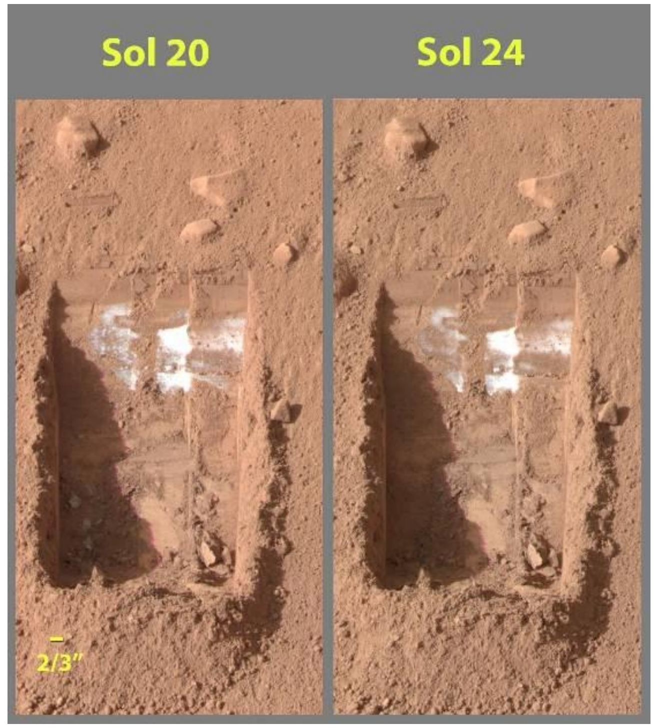
Karsei Valles, Mars Odyssey Laser Altimeter, 2009

Hematite spherules, thought only to form in aqueous environments, were found by the Opportunity rover in 2004.



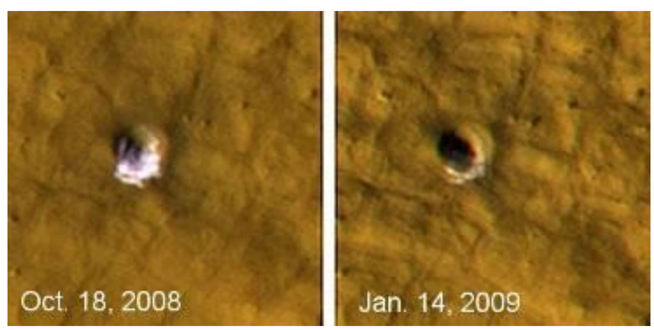
Hematite Spherules, seen close up

The Phoenix lander scraped the surface with its robotic arm, exposing whitish material that seemed to change over time, suggesting it was water ice that evaporated in the sunlight.



Trench dug by Phoenix

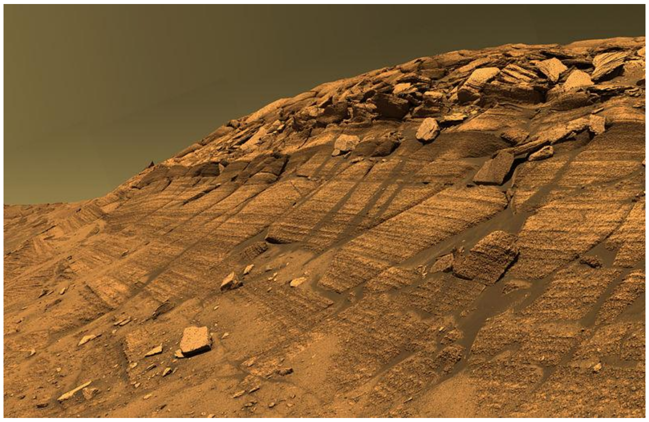
The HiRISE imager, on the Mars Reconnaissance Orbiter, photographed a crater that appeared to be filled with ice that then evaporated.



HiRISE images of a Martian crater

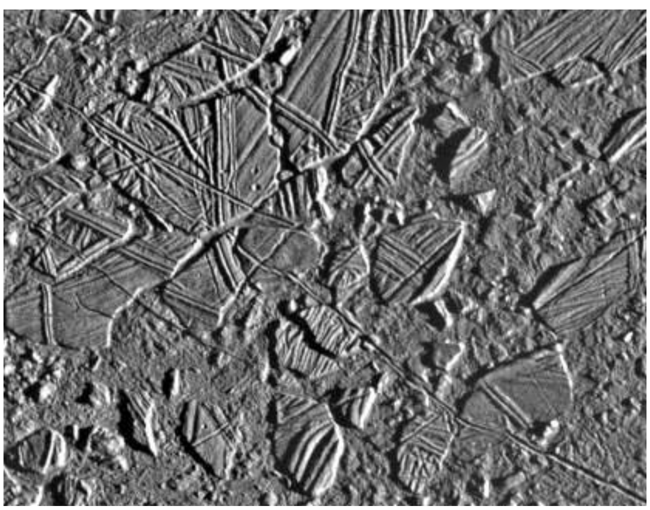
HiRISE also observed surface changes that suggest subsurface water flows resulting from seasonal temperature changes. A time-lapse image makes this conclusion seem irrefutable.

Some geologic and hydrodynamic models suggest that Mars had oceans early in its history in which life may have evolved. Large areas of layered rock similar to the limestone that we see in the American southwest, the edges of ancient seas, are cited as evidence. These features have been observed both from orbit and from the surface.



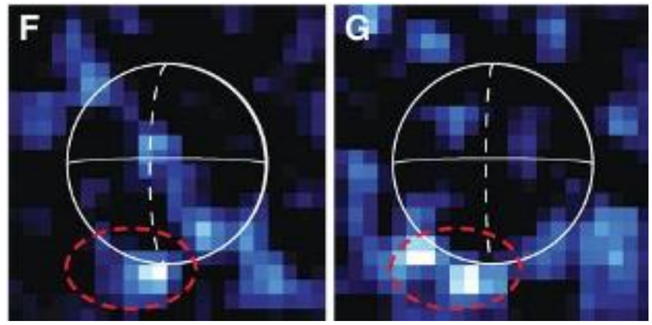
Burns Cliff as seen by Mars Opportunity Rover

Although Mars is the prime candidate, there are three other solar system bodies that might harbor life. When Voyager images of the Jovian moon Europa were first glimpsed in 1979, the unexpected surface was best interpreted as ice riding on a subsurface ocean. Surface patterns mimicked those of Earth's polar ice shelves. Subsequent data and images from the Galileo probe leave only the question of whether the surface is thick (10-30 km) or thin (< 10 km), the latter originally a minority view espoused against the thick surface "party line" by University of Arizona Professor Richard Greenberg, as told in his rather argumentative but interesting 2008 book *Unmasking Europa*.

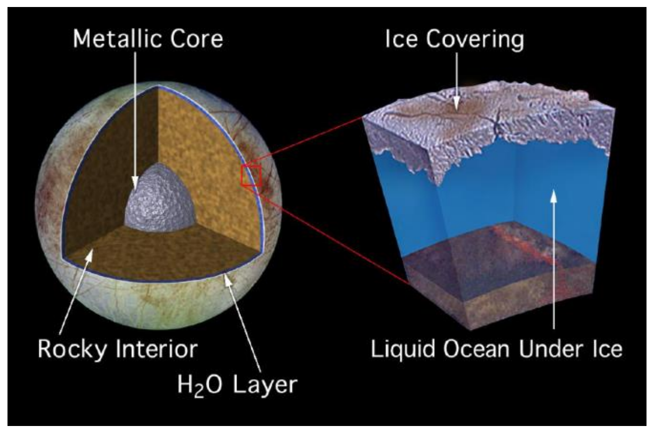


A Galileo image of Europa's surface

Europa's water is kept in a liquid state by tidal heating of its core as it revolves around massive Jupiter. In 2014 UV images from Hubble were published showing evidence of water vapor spewing into space from Europa. The water must be escaping through fissures in the ice. Whether this is evidence in favor of a thin crust isn't clear, since the heat and pressure could force fissures even in thick ice.

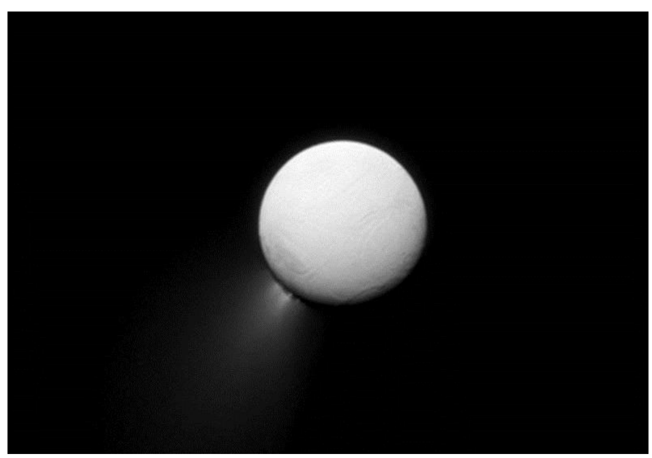


Hubble images of water signal in UV from Europa
Science 2014; 343: 171-4



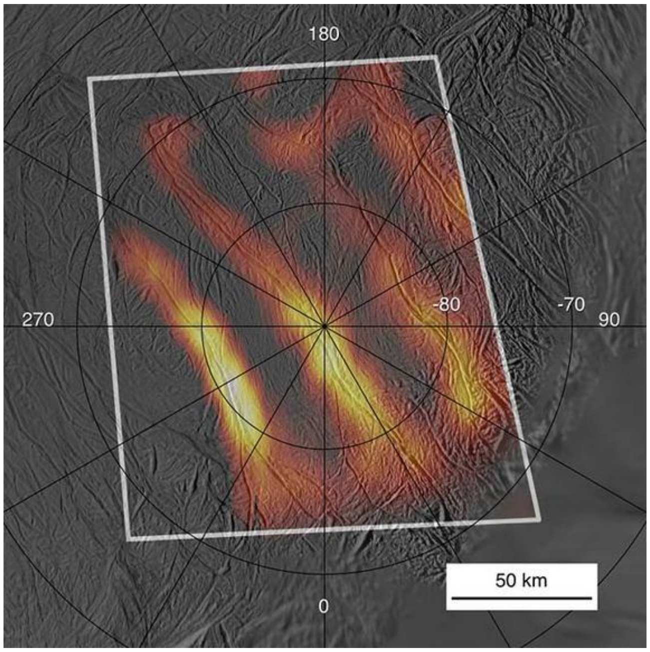
Cartoon of the likely structure of Europa. Only the ice thickness seems still to be debated.

Saturn's moon Enceladus appears to have a subsurface ocean as well, also kept liquid by tidal heating as it circles around the planet. Enceladus' surface has an appearance similar to Europa's, consistent with dynamic ice. Plumes of water vapor and ice particles were photographed by the Cassini spacecraft.



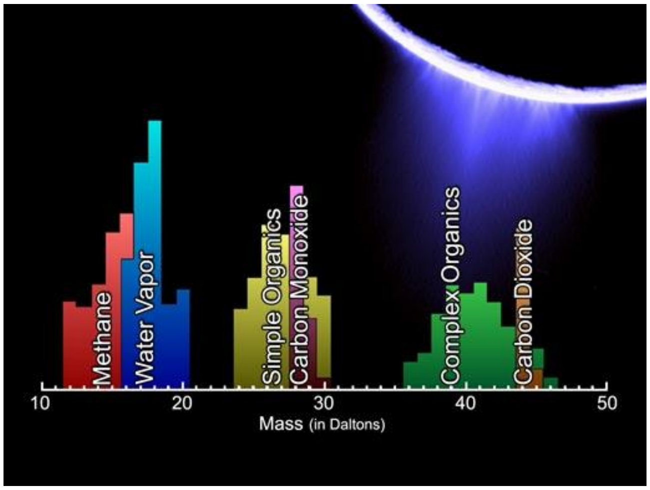
Cassini image of Enceladus

Thermal instruments on Cassini measured the temperature of surface fissures to be -135 degrees Fahrenheit (-93 degrees Celsius), 200 degrees F (111 degrees C) warmer than the rest of the moon's surface. This reflects warmer temperatures below.



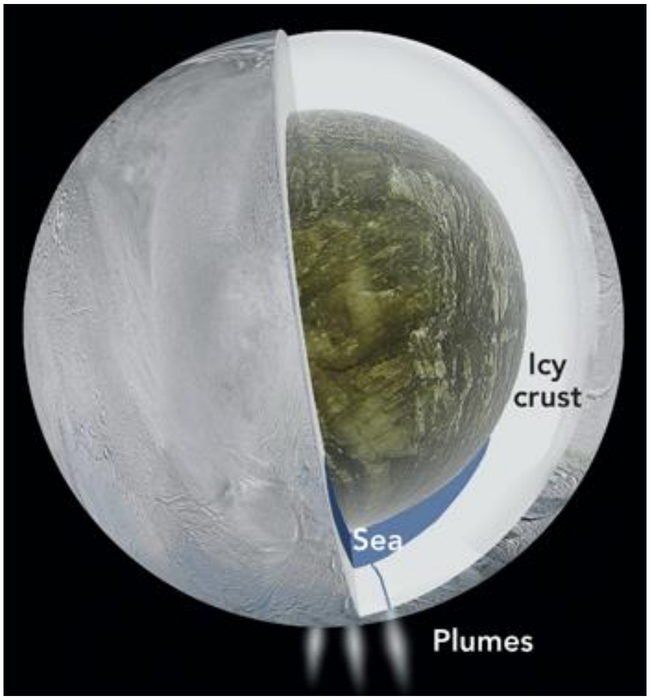
Thermal emission image from Cassini showing warmer temperature along surface fissures

In 2008, carbon-containing molecules were found in the plumes by Cassini's Ion and Neutral Mass Spectrometer. These molecules are not definitive evidence of life, but life can't exist without them.



Data from Cassini's mass spectrometer showing the presence of various compounds in the plumes of Enceladus

A paper in *Science* in April reported that Enceladus has a subsurface ocean in its southern hemisphere, just below the area where the plumes arise. As the Cassini spacecraft passed Enceladus on three of its orbits, changes in its velocity were measured using the Doppler effect. Variations as small as 0.02 millimeters per second could be detected. A map of the gravitational field of Enceladus was constructed, reflecting the moon's internal structure. The map shows a southern ocean under a thick crust with "near certainty".



Iess, L. et. al., The Gravity Field and Interior Structure of Enceladus, *Science* 2014; 344: 78-80

The only other body in the solar system that may harbor an ocean is Titan. Titan's thick nitrogen atmosphere includes a methane cycle similar to Earth's water cycle, with methane vapor condensing into rain, filling rivers, lakes, and gorges on the surface. These features were imaged by the Huygens probe that landed on Titan. Huygens also sent back physical and chemical data for 90 minutes. Using an apparatus similar to that of the Miller-Urey experiment, Sarah Horst of the University of Arizona produced nucleotide bases and amino acids when energy was applied to a combination of gases like those in Titan's atmosphere. Horst also found amino acids. Whether life can evolve in the absence of water is unknown, but some models of Titan suggest a sub-surface ocean of liquid water and ammonia.

Given the spectacular ability of life to arise in all sorts of hostile environments on Earth, it doesn't strain credulity to imagine simple living creatures flitting about on Europa, Enceladus or Titan. "Life will find a way."

September 27th Star Party

A clear, temperate night was our reward for the many canceled or cloudy events this year. A plethora of scopes, at least 20, were brought by old and new members and a couple of non-members who were eager to join the club. There were quite a few guests who had the opportunity to look through telescopes ranging from 3 to 12½ inches, binoculars, a BiPH and a video astronomy setup. The crystal clear sky showed the arc of the Milky Way in its usual faint northern Westchester style, as good as we can see it just 40 miles from Times Square, with the Sky Quality Meter reaching 20.10. Dew arrived later in the evening, as usual for the fall. But the skies were simply glorious.

Here's a gallery of Mallincam single-frame screen captures from the star party. The video signal was wirelessly broadcast from the camera to a laptop using a Terk 2.4 GHz transmitter/receiver combo and a video-USB adaptor on the computer. Captures were 56 seconds (28 for M27 and M57) using a Mallincam Color Hyper Plus video camera on *Locutis*, my Celestron CPC800 f/10 SCT, tracking in alt-az. Focal reducers between the diagonal and the camera dropped the focal ratio to about f/3.6. An IDAS P2 light pollution reduction filter helped reduce skyglow. The fields are all the same size, about 27 arc-minutes (just under ½ degree) across. The greenish glow on the upper left of the images is "amp glow," an inherent imperfection caused by the location of amplifier circuits on the Sony ICX-418AKL color chip inside the camera. Images in the on-scope video screen are even more detailed.

--Larry Faltz

Droughts, Floods and the Earth's Gravity, by the GRACE of NASA

By Dr. Ethan Siegel

When you think about gravitation here on Earth, you very likely think about how constant it is, at 9.8 m/s^2 (32 ft/s^2). Only, that's not quite right. Depending on how thick the Earth's crust is, whether you're slightly closer to or farther from the Earth's center, or what the density of the material beneath you is, you'll experience slight variations in Earth's gravity as large as 0.2%, something you'd need to account for if you were a pendulum-clock-maker.

But surprisingly, the amount of *water content* stored on land in the Earth actually changes the gravity field of where you are by a significant, measurable amount. Over land, water is stored in lakes, rivers, aquifers, soil moisture, snow and glaciers. Even a change of just a few centimeters in the water table of an area can be clearly discerned by our best space-borne mission: NASA's twin Gravity Recovery and Climate Experiment (GRACE) satellites.

Since its 2002 launch, GRACE has seen the water-table-equivalent of the United States (and the rest of the world) change significantly over that time. Groundwater supplies are vital for agriculture and provide half of the world's drinking water. Yet GRACE has seen California's central valley and the southern high plains rapidly deplete their groundwater reserves, endangering a significant portion of the nation's food supply. Meanwhile, the upper Missouri River Basin—recently home to severe flooding—continues to see its water table rise.

NASA's GRACE satellites are the only pieces of equipment currently capable of making these global, precision measurements, providing our best knowledge for mitigating these terrestrial changes. Thanks to GRACE, we've been able to quantify the water loss of the Colorado River Basin (65 cubic kilometers), add months to the lead-time water managers have for flood prediction, and better predict the impacts of droughts worldwide. As NASA scientist Matthew Rodell says, "[W]ithout GRACE we would have no routine, global measurements of changes in groundwater availability. Other satellites can't do it, and ground-based monitoring is inadequate." Even though the GRACE satellites are nearing the end of their lives, the GRACE Follow-On satellites will be launched in 2017, providing us with this valuable data far into the future. Although the climate is surely changing, it's water availability, *not* sea level rise, that's the largest near-term danger, and the most important aspect we can work to understand!

Learn more about NASA's GRACE mission here: http://www.nasa.gov/mission_pages/Grace/

Kids can learn all about launching objects into Earth's orbit by shooting a (digital) cannonball on NASA's Space Place website. Check it out at: http://spaceplace.nasa.gov/how-orbits-work/

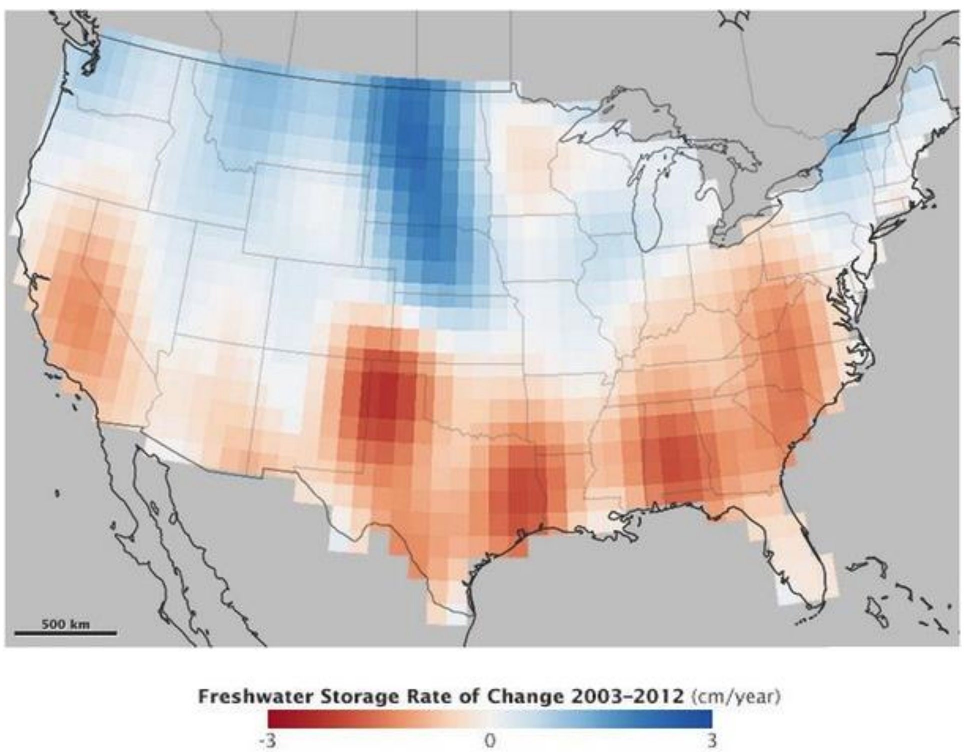
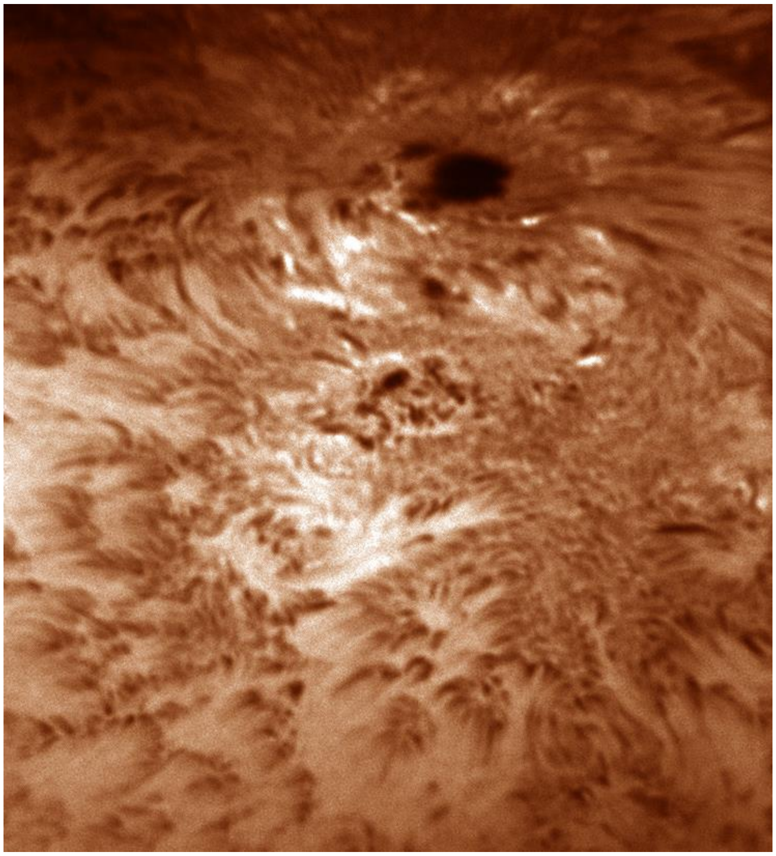


Image credit: NASA Earth Observatory image by Jesse Allen, using GRACE data provide courtesy of Jay Famigleitti, University of California Irvine and Matthew Rodell, NASA Goddard Space Flight Center. Caption by Holli Riebeek.

Astrophotos



Solar Close Up

John Paladini took this photo of the Sun, featuring a prominent sunspot, through his homemade 90mm solar scope. The details of John's scope are described in his article, "A Homemade 90 mm Hydrogen Alpha Telescope" on page 6 of the [September WAA newsletter.]

Centered on M31

Courtesy of Olivier Prache is this 3-hour color image of the core of the great galaxy in the Andromeda. Olivier used a Hyperion 12.5-inch astrograph and an ML16803 CCD camera.