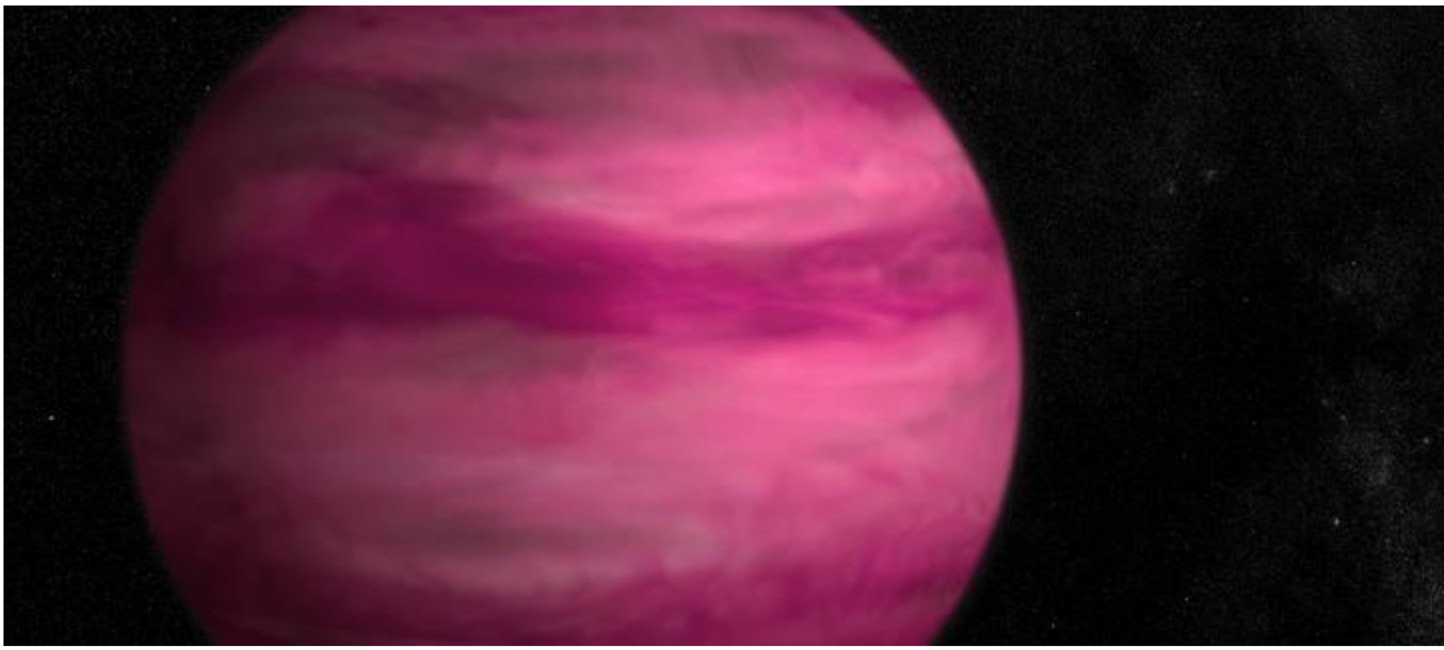
NASA is looking for life in the sky

At first, NASA thinks that life on the earth only, next that it was seeking hard in the universe and understood the horizontal universes and existent many, many lives in universal existence, this organization who can see the unseen unlimited universe, NASA said: there are life in the sky (see many papers from NASA are attached), further it isn't need to building navigational - roads in spaces of EarthSky around the earth, the riches of people can go to somewhere else those NASA has prepared for living them so full rest as paradises so much beautiful and the best , therefore , well-done to NASA , WELL-DONE.

BY: Mahmoud saneipour

Astrobiology



July 1, 2003

The Search for Life in the Universe

Reflections on the Scientific and Cultural Implications of Finding Life in the Cosmos

By Neil deGrasse Tyson

Editor's note: This essay first appeared in 2003 in NASA's Astrobiology magazine.

If the person on next to me on a long airplane flight ever finds out that I am an astrophysicist, nine times out of ten they ask, with wide eyes, about life in the universe. And only later do they ask me about the big bang and black holes. I know of no other discipline that triggers such a consistent and reliable reaction in public sentiment. This phenomenon is not limited to Americans. The time-honored question: "What is our place in the universe" might just be genetically encoded in our species. All known cultures across all of time have attempted to answer that question. Today we ask the same question, but with fewer words: "Are we alone?"

Ordinarily, there is no riskier step that a scientist (or anyone) can take than to make sweeping generalizations from just one example. At the moment, life on Earth is the only known life in the universe, but there are compelling arguments to suggest we are not alone. Indeed, most astrophysicists accept a high probability of there being life elsewhere in the universe, if not on other planets or on moons within our own solar system. The numbers are, well, astronomical: If the count of planets in our solar system is not unusual, then there are more planets in the universe than the sum of all sounds and words ever uttered by every human who has ever lived. To declare that Earth must be the only planet in the cosmos with life would be inexcusably egocentric of us.

Many generations of thinkers, both religious and scientific, have been led astray by anthropic assumptions, while others were simply led astray by ignorance. In the absence of dogma and data, history tells us that it's prudent to be guided by the notion that we are not special, which is generally known as the Copernican principle, named for the Polish astronomer Nicholas Copernicus who, in the mid 1500s, put the Sun back in the middle of our solar system where it belongs. In spite of a third century B.C. account of a sun-centered universe proposed by the Greek philosopher Aristarchus, the Earth-centered universe was by far the most popular view for most of the last 2000 years. Codified by the teachings of Aristotle and Ptolemy, and by the preachings of the Roman Catholic Church, people generally accepted Earth as the center of all motion. It was self-evident: the universe not only looked that way, but God surely made it so. The sixteenth century Italian monk Giordano Bruno suggested publicly that an infinite universe was filled with planets that harbor life. For these thoughts he was burned upside down and naked at the stake. Fortunately, today we live in somewhat more tolerant times.

While there is no guarantee that the Copernican principle will guide us correctly for all scientific discoveries to come, it has humbled our egos with the realization that not only is Earth not in the center of the solar system, but the solar system is not in the center of the Milky Way galaxy, and the Milky Way galaxy is not in the center of the universe. And in case you are one of those people who thinks that the edge may be a special place, then we are not at the edge of anything either.

A wise contemporary posture would be to assume that life on Earth is not immune to the Copernican principle. If so, then how can the appearance or the chemistry of life on Earth provide clues to what life might be like elsewhere in the universe?

I do not know whether biologists walk around every day awestruck by the diversity of life. I certainly do. On this single planet called Earth, there co-exist (among countless other life forms), algae, beetles, sponges, jellyfish, snakes, condors, and giant sequoias. Imagine these seven living organisms lined up next to each other in size-place. If you didn't know better, you would be hard-pressed to believe that they all came from the same universe, much less the same planet. Try describing a snake to somebody who has never seen one: "You gotta believe me. There is this animal on Earth that 1) can stalk its prey with infrared detectors, 2) swallows whole live animals up to five times bigger than its head, 3) has no arms or legs or any other appendage, yet 4) can slide along level ground at a speed of two feet per second!"

Given the diversity of life on Earth, one might expect a diversity of life exhibited among Hollywood aliens. But I am consistently amazed by the film industry's lack of creativity. With a few notable exceptions such as life forms in *The Blob* (1958) and in *2001: A Space Odyssey* (1968), Hollywood aliens look remarkably humanoid. No matter how ugly (or cute) they are, nearly all of them have two eyes, a nose, a mouth, two ears, a head, a neck, shoulders, arms, hands, fingers, a torso, two legs, two feet - and they can walk. From an anatomical view, these creatures are practically indistinguishable from humans, yet they are supposed to have come from another planet. If anything is certain, it is that life elsewhere in the universe, intelligent or otherwise, will look at least as exotic as some of Earth's own life forms.

The chemical composition of Earth-based life is primarily derived from a select few ingredients. The elements hydrogen, oxygen, and carbon account for over 95% of the atoms in the human body and in all known life. Of the three, the chemical structure of the carbon atom allows it to bond readily and strongly with itself and with many other elements in many different ways, which is how we came to be carbon-based life, and which is why the study of molecules that contain carbon is generally known as "organic" chemistry. The study of life elsewhere in the universe is known as exobiology, which is one of the few disciplines that, at the moment, attempts to function in the complete absence of first-hand data.

Is life chemically special? The Copernican principle suggests that it probably isn't. Aliens need not look like us to resemble us in more fundamental ways. Consider that the four most common elements in the universe are hydrogen, helium, carbon, and oxygen. Helium is inert. So the three most abundant, chemically active ingredients in the cosmos are also the top three ingredients in life on Earth. For this reason, you can bet that if life is found on another planet, it will be made of a similar mix of elements. Conversely, if life on Earth were composed primarily of, for example, molybdenum, bismuth, and plutonium, then we would have excellent reason to suspect that we were something special in the universe.

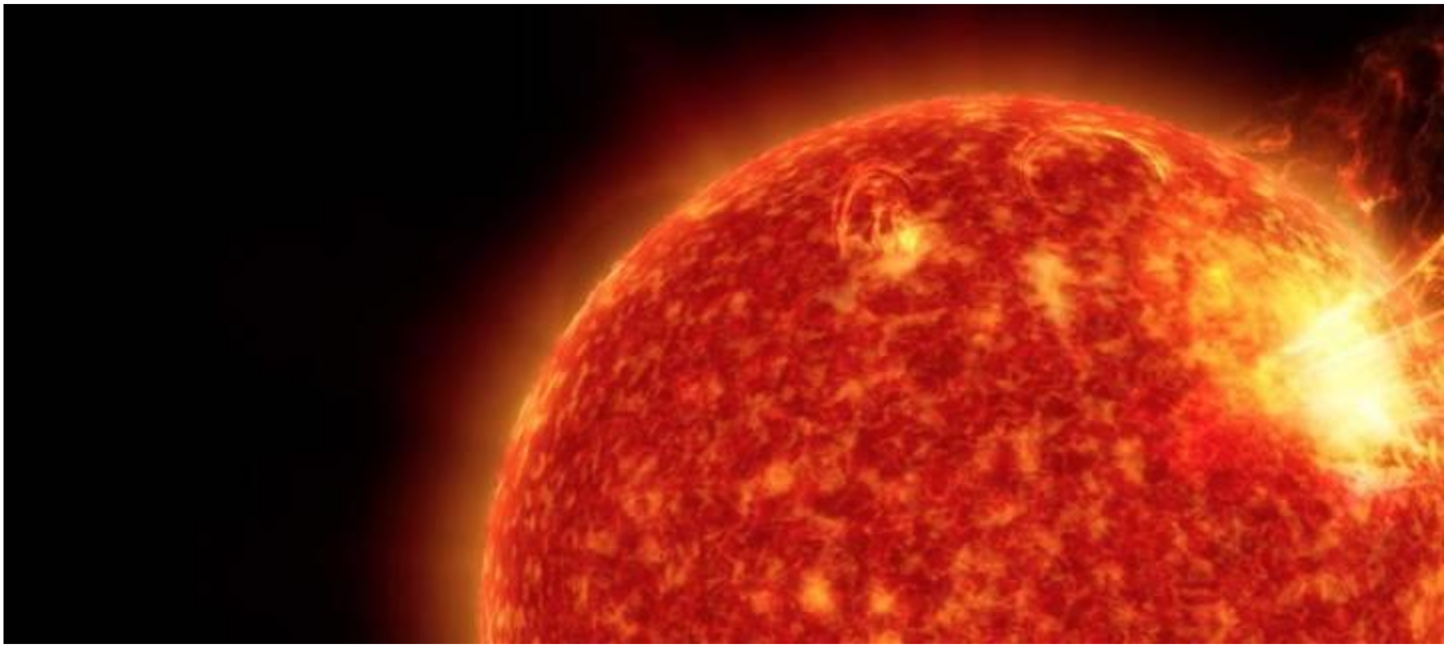
Appealing once again to the Copernican principle, we can assume that the size of an alien organism is not likely to be ridiculously large compared with life as we know it. There are cogent structural reasons why you would not expect to find a life the size of the Empire State Building strutting around a planet. But if we ignore these engineering limitations of biological matter we approach another, more fundamental limit. If we assume that an alien has control of its own appendages, or more generally, if we assume the organism functions coherently as a system, then its size would ultimately be constrained by its ability to send signals within itself at the speed of light - the fastest allowable speed in the universe. For an admittedly extreme example, if an organism were as big as the entire solar system (about 10 light-hours across), and if it wanted to scratch its head, then this simple act would take no less than 10 hours to accomplish. Subslothlike behavior such as this would be evolutionarily self-limiting because the time since the beginning of the universe may be insufficient for the creature to have evolved from smaller forms of life over many generations.

Last Updated: July 31, 2015

Editor: NASA Administrator

Tags: **Astrobiology**

Sun



May 24, 2016

NASA: Solar Storms May Have Been Key to Life on Earth

Our sun's adolescence was stormy—and new evidence shows that these tempests may have been just the key to seeding life as we know it.

Some 4 billion years ago, the sun shone with only about three-quarters the brightness we see today, but its surface roiled with giant eruptions spewing enormous amounts of solar material and radiation out into space. These powerful solar explosions may have provided the crucial energy needed to warm Earth, despite the sun's faintness. The eruptions also may have furnished the energy needed to turn simple molecules into the complex molecules such as RNA and

DNA that were necessary for life. The research was published in Nature Geoscience on May 23, 2016, by a team of scientists from NASA.

Watch this movie to see how energy from our young sun – 4 billion years ago -- aided in creating molecules in Earth's atmosphere that allowed it to warm up enough to incubate life.

Credits: NASA's Goddard Space Flight Center/Genna Duberstein

Download this video in HD formats from NASA Goddard's Scientific Visualization Studio

Understanding what conditions were necessary for life on our planet helps us both trace the origins of life on Earth and guide the search for life on other planets. Until now, however, fully mapping Earth's evolution has been hindered by the simple fact that the young sun wasn't luminous enough to warm Earth.

"Back then, Earth received only about 70 percent of the energy from the sun than it does today," said Vladimir Airapetian, lead author of the paper and a solar scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "That means Earth should have been an icy ball. Instead, geological evidence says it was a warm globe with liquid water. We call this the Faint Young Sun Paradox. Our new research shows that solar storms could have been central to warming Earth."

Scientists are able to piece together the history of the sun by searching for similar stars in our galaxy. By placing these sun-like stars in order according to their age, the stars appear as a functional timeline of how our own sun evolved. It is from this kind of data that scientists know the sun was fainter 4 billion years ago. Such studies also show that young stars frequently produce powerful flares – giant bursts of light and radiation -- similar to the flares we see on our own sun today. Such flares are often accompanied by huge clouds of solar material, called coronal mass ejections, or CMEs, which erupt out into space.

NASA's Kepler mission found stars that resemble our sun about a few million years after its birth. The Kepler data showed many examples of what are called "superflares" – enormous explosions so rare today that we only experience them once every 100 years or so. Yet the Kepler data also show these youngsters producing as many as ten superflares a day.

While our sun still produces flares and CMEs, they are not so frequent or intense. What's more, Earth today has a strong magnetic field that helps keep the bulk of the energy from such space weather from reaching Earth. Space weather can, however, significantly disturb a magnetic bubble around our planet, the magnetosphere, a phenomenon referred to as geomagnetic storms that can affect radio communications and our satellites in space. It also creates auroras – most often in a narrow region near the poles where Earth's magnetic fields bow down to touch the planet.

Our young Earth, however, had a weaker magnetic field, with a much wider footprint near the poles.

"Our calculations show that you would have regularly seen auroras all the way down in South Carolina," says Airapetian. "And as the particles from the space weather traveled down the magnetic field lines, they would have slammed into abundant nitrogen molecules in the atmosphere. Changing the atmosphere's chemistry turns out to have made all the difference for life on Earth."

The atmosphere of early Earth was also different than it is now: Molecular nitrogen – that is, two nitrogen atoms bound together into a molecule – made up 90 percent of the atmosphere, compared to only 78 percent today. As energetic particles slammed into these nitrogen molecules, the impact broke them up into individual nitrogen atoms. They, in turn, collided with carbon dioxide, separating those molecules into carbon monoxide and oxygen.

The free-floating nitrogen and oxygen combined into nitrous oxide, which is a powerful greenhouse gas. When it comes to warming the atmosphere, nitrous oxide is some 300 times more powerful than carbon dioxide. The teams' calculations show that if the early atmosphere housed less than one percent as much nitrous oxide as it did carbon dioxide, it would warm the planet enough for liquid water to exist.

This newly discovered constant influx of solar particles to early Earth may have done more than just warm the atmosphere, it may also have provided the energy needed to make complex chemicals. In a planet scattered evenly with simple molecules, it takes a huge amount of incoming energy to create the complex molecules such as RNA and DNA that eventually seeded life.

While enough energy appears to be hugely important for a growing planet, too much would also be an issue -- a constant chain of solar eruptions producing showers of particle radiation can be quite detrimental. Such an onslaught of magnetic clouds can rip off a planet's atmosphere if the magnetosphere is too weak. Understanding these kinds of balances help scientists determine what kinds of stars and what kinds of planets could be hospitable for life.

"We want to gather all this information together, how close a planet is to the star, how energetic the star is, how strong the planet's magnetosphere is in order to help search for habitable planets around stars near our own and throughout the galaxy," said William Danchi, principal investigator of the project at Goddard and a co-author on the paper. "This work includes scientists from many fields -- those who study the sun, the stars, the planets, chemistry and biology. Working together we can create a robust description of what the early days of our home planet looked like – and where life might exist elsewhere."

For more information about the Kepler mission, visit:

http://www.nasa.gov/kepler

By Karen C. Fox
NASA's Goddard Space Flight Center, Greenbelt, Md.

Last Updated: May 24, 2016

Editor: Rob Garner

Tags: Astrobiology, Earth, Goddard Space Flight Center, Kepler and K2, Solar System, Space Weather, Stars, Sun

Astrobiology

Feb. 27, 2016

NASA Tests Life-Detection Drill in Earth's Driest Place

Mary Beth Wilhelm (in white cleanroom suit) carefully samples ground-truth material obtained from the 2.2 meter depth science excavation pit, assisted by Jonathan Araya (Univ. de Antofagasta) and watched by ARADS co-investigators Miriam Villadangos, and the SOLID instrument lead, Victor Parro, both of Centro de Astrobiologia (CAB), Spain.

Credits: NASA

In a harsh environment with very little water and intense ultraviolet radiation, most life in the extreme Atacama Desert in Chile exists as microbial colonies underground or inside rocks.

Researchers at NASA hypothesize that the same may be true if life exists on Mars.

The cold and dry conditions on Mars open the possibility that evidence for life may be found below the surface where negative effects of radiation are mitigated, in the form of organic molecules known as biomarkers. But until humans set foot on the Red Planet, obtaining samples from below the surface of Mars will require the ability to identify a location of high probability for current or ancient life, place a drill, and control the operation robotically.

ARADS test on dry salt lake (halite flats), feeding sample from the drill to the Signs of Life Detector (SOLID) instrument (box on right) and the Wet Chemistry Laboratory (WCL) prototype (box on left). WCL is a version of the 2007 Phoenix Mars instrument.

Credits: NASA

The Atacama Rover Astrobiology Drilling Studies (ARADS) project has just completed its first deployment after one month of fieldwork in the hyperarid core of the Atacama Desert, the "driest place on Earth." Despite being considerably warmer than Mars, the extreme dryness the soil chemistry in this region are remarkably similar to that of the Red Planet. This provides scientists with a Mars-like laboratory where they can study the limits of life and test drilling and life-detection technologies that might be sent to Mars in the future.

"Putting life-detection instruments in a difficult, Mars-analog environment will help us figure out the best ways of looking for past or current life on Mars, if it existed," said Dr. Brian Glass, a NASA Ames space scientist and the principal investigator of the ARADS project. "Having both subsurface reach and surface mobility should greatly increase the number of biomarker and life-target sites we can sample in the Atacama," Glass added.

More than 20 scientists from the United States, Chile, Spain, and France camped together miles from civilization and worked in extremely dry, 100+ degree heat with high winds during the first ARADS field deployment. Their work was primarily at Yungay Station, a mining ghost town at one of the driest places in the Atacama, owned by the University of Antofagasta in Chile. Yungay has been a focal point for astrobiology studies in the last two decades. ARADS field scientists also evaluated two other Atacama sites – Salar Grande, an ancient dried-up lake composed of thick beds of salt, and Maria Elena, a similarly extremely dry region – to be considered along with Yungay as the host location for the future ARADS tests in 2017-19.

During this initial deployment, scientists put several technologies through the paces under harsh and unpredictable field conditions: a Mars-prototype drill; a sample transfer arm; the Signs of Life Detector (SOLID) created by Spain's Centro de Astrobiologia (CAB); and a prototype version of the Wet Chemistry Laboratory (WCL), which flew on the Phoenix Mars mission in 2007.

Engineers and scientists were successful in accomplishing their primary technology goal of this season—to use the ARADS drill and sample transfer robot arm at Yungay to acquire and feed sample material to the SOLID and WCL instruments under challenging environmental conditions. The in situ analyses of the drilled samples help set a yardstick for interpreting future results from these two instruments, and will be compared to results obtained from the same samples in some of the best laboratories.

Additionally, researchers from Johns Hopkins University and NASA Ames collected samples for laboratory investigations of the extreme microorganisms living inside salt habitats in the Atacama. These salt habitats could be the last refuge for life in this extremely dry region that is otherwise devoid of plants, animals, and most types of microorganisms. “We are excited to learn as much as we can about these distinctive, resilient microorganisms, and hope that our studies will improve life-detection technology and strategies for Mars,” said Mary Beth Wilhelm, a NASA Ames researcher and member of the ARADS science team.

Over the next four years, the ARADS project will return to the Atacama to demonstrate the feasibility of integrated roving, drilling and life-detection, with the goal of demonstrating the technical feasibility and scientific value of a mission that searches for evidence of life on Mars.

ARADS team members will be sending photos and captions from their fieldwork. Updates will be posted on www.nasa.gov and www.nasa.gov/ames.

Last Updated: March 1, 2016

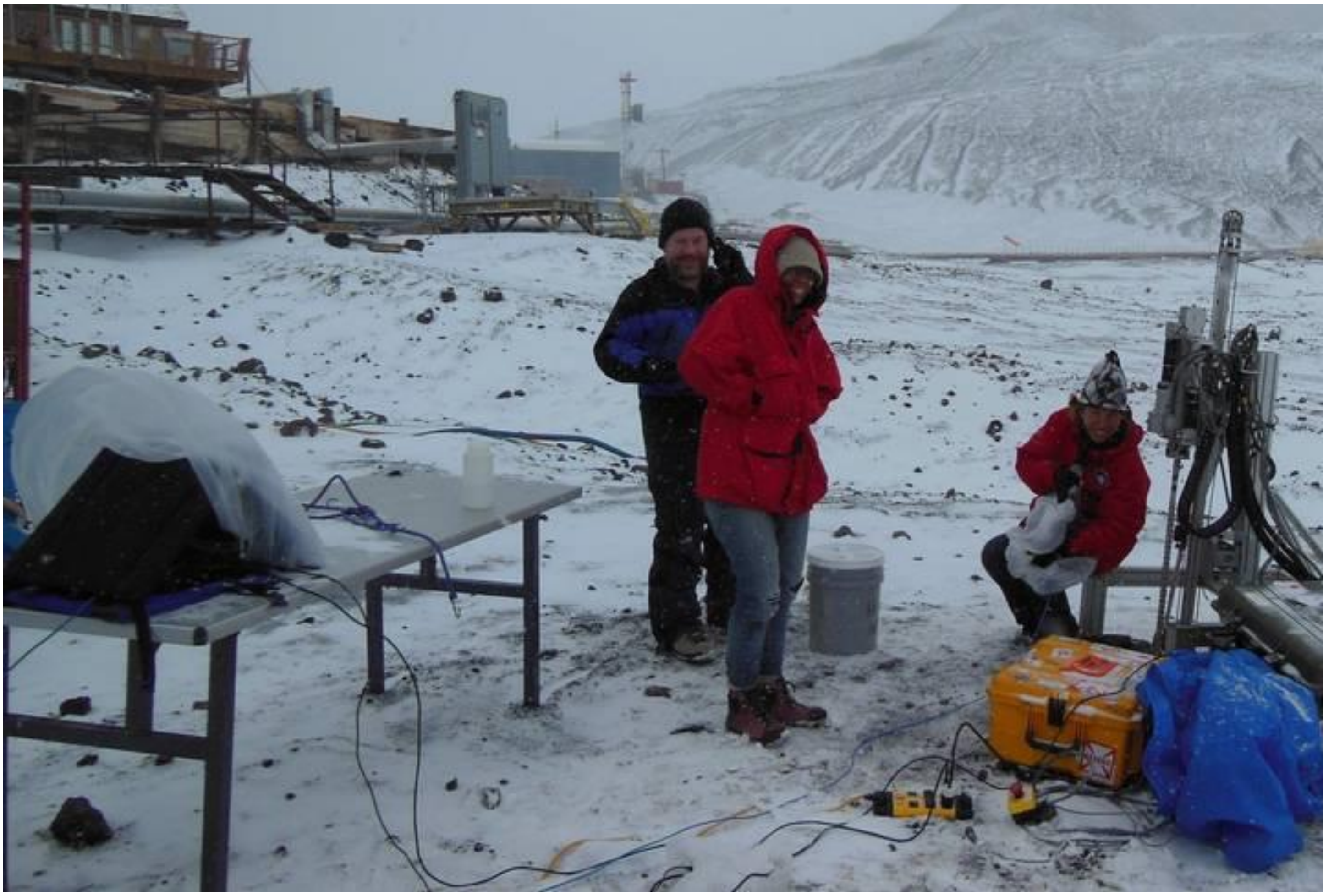
Editor: Darryl Waller

Tags: Ames Research Center, Astrobiology, Journey to Mars, Science Instruments, Technology

NASA Ames

Feb. 3, 2016

NASA's Ames Research Center Leads the Search for Microbial Life in Antarctica's Permafrost



In the image above, students operate the Icebreaker drill in a remote classroom at the McMurdo Dry Valley site in Antarctica (left to right: Brian J. Glass, Jackie Goordial, and Margarita Marinova)

The mission was conducted by a team from NASA's Ames Research Center, led by Chris McKay, and included scientists from McGill University, Montreal, Quebec. The effort was part of an NASA ASTEP (Astrobiology Science and Technology for Exploring Planets) project to test the IceBite auger, a permafrost drill designed to drill into Martian permafrost.

The projects two primary goals were to investigate the microbiology of the driest coldest soils on Earth, and to field test the "Icebreaker" drill. This equipment is designed to drill into Mars' permafrost and determine if life on Earth can live in Mars-like permafrost.

The University Valley site, located in the high elevation McMurdo Dry Valleys of Antarctica, is home to extremely cold and dry conditions that have existed for over 150,000 years. This location is believed to be the place on Earth that most closely resembles the permafrost found in the northern polar region of Mars at the Phoenix landing site. The results were published Jan. 19 in the International Society for Microbial Ecology (ISME) journal.

Media contact: Darryl E. Waller, Ames Research Center

Last Updated: Feb. 4, 2016

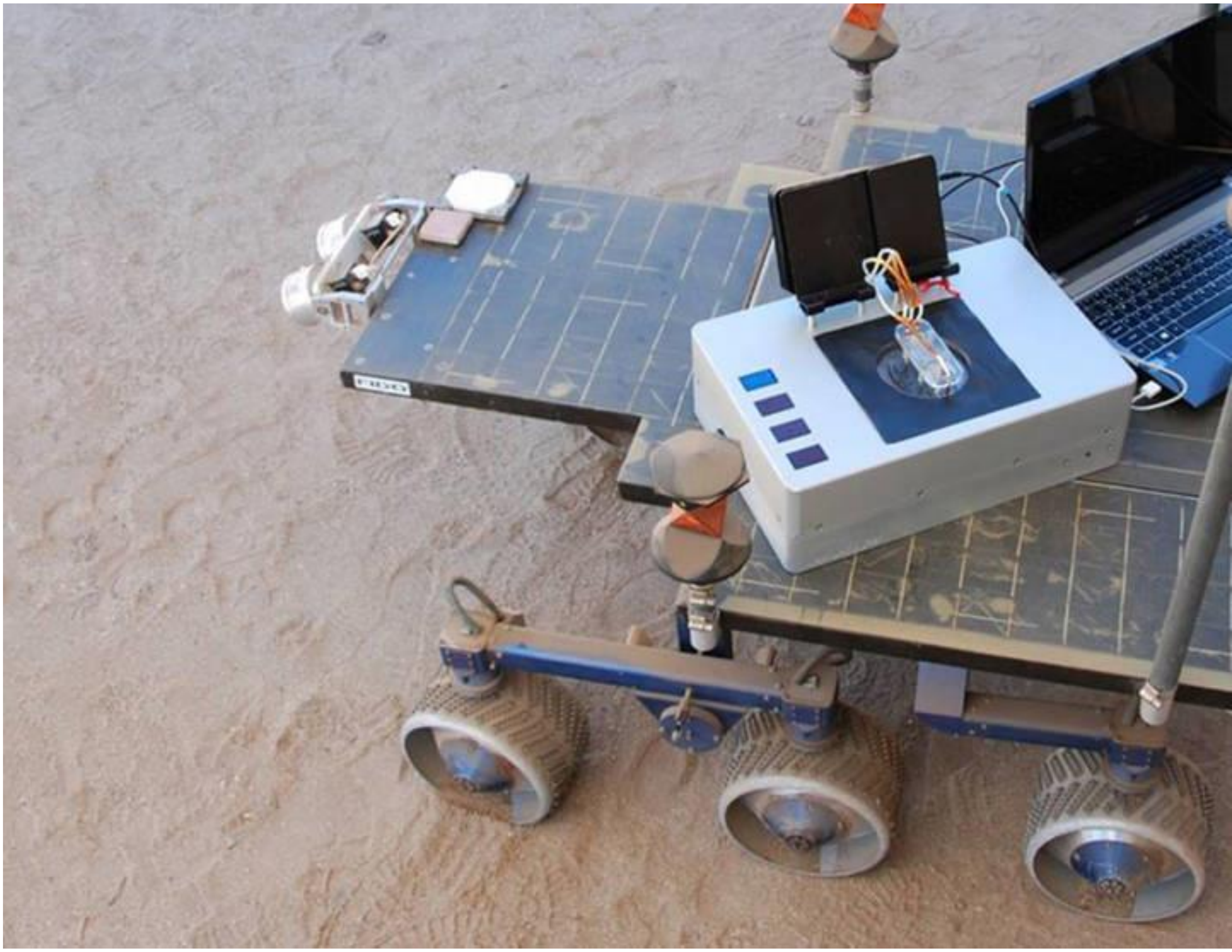
Editor: Darryl Waller

Tags: Ames Research Center, Astrobiology

High-Tech Computing

Nov. 17, 2015

'Chemical Laptop' Could Search for Signs of Life Outside Earth



Researchers took the Chemical Laptop to JPL's Mars Yard, where they placed the device on a test rover. This image shows the size comparison between the Chemical Laptop and a regular laptop.

Credits: NASA/JPL-Caltech

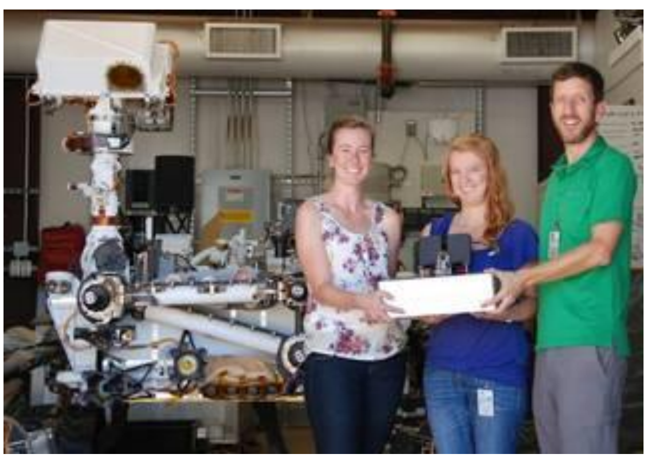
If you were looking for the signatures of life on another world, you would want to take something small and portable with you. That's the philosophy behind the "Chemical Laptop" being developed at NASA's Jet Propulsion Laboratory in Pasadena, California: a miniaturized laboratory that analyzes samples for materials associated with life.

"If this instrument were to be sent to space, it would be the most sensitive device of its kind to leave Earth, and the first to be able to look for both amino acids and fatty acids," said Jessica Creamer, a NASA postdoctoral fellow based at JPL.

Like a tricorder from "Star Trek," the Chemical Laptop is a miniaturized on-the-go laboratory, which researchers hope to send one day to another planetary body such as Mars or Europa. It is roughly the size of a regular computing laptop, but much thicker to make room for chemical analysis components inside. But unlike a tricorder, it has to ingest a sample to analyze it.

"Our device is a chemical analyzer that can be reprogrammed like a laptop to perform different functions," said Fernanda Mora, a JPL technologist who is developing the instrument with JPL's Peter Willis, the project's principal investigator. "As on a regular laptop, we have different apps for different analyses like amino acids and fatty acids."

Amino acids are building blocks of proteins, while fatty acids are key components of cell membranes. Both are essential to life, but can also be found in non-life sources. The Chemical Laptop may be able to tell the difference.



JPL researchers Jessica Creamer, Fernanda Mora and Peter Willis (left to right) pose with the Chemical Laptop, a device designed to detect amino acids and fatty acids. At left is a near-identical copy of the Curiosity rover, which has been on Mars since 2012.

Credits: NASA/JPL-Caltech

What it's looking for

Amino acids come in two types: Left-handed and right-handed. Like the left and right hands of a person, these amino acids are mirror images of each other but contain the same components. Some scientists hypothesize that life on Earth evolved to use just left-handed amino acids because that standard was adopted early in life's history, sort of like the way VHS became the standard for video instead of Betamax in the 1980s. It's possible that life on other worlds might use the right-handed kind.

"If a test found a 50-50 mixture of left-handed and right-handed amino acids, we could conclude that the sample was probably not of biological origin," Creamer said. "But if we were to find an excess of either left or right, that would be the golden ticket. That would be the best evidence so far that life exists on other planets."

The analysis of amino acids is particularly challenging because the left- and right-handed versions are equal in size and electric charge. Even more challenging is developing a method that can look for all the amino acids in a single analysis.

When the laptop is set to look for fatty acids, scientists are most interested in the length of the acids' carbon chain. This is an indication of what organisms are or were present.

How it works

The battery-powered Chemical Laptop needs a liquid sample to analyze, which is more difficult to obtain on a planetary body such as Mars. The group collaborated with JPL's Luther Beegle to incorporate an "espresso machine" technology, in which the sample is put into a tube with liquid water and heated to above 212 degrees Fahrenheit (100 degrees Celsius). The water then comes out carrying the organic molecules with it. The Sample Analysis at Mars (SAM) instrument suite on NASA's Mars Curiosity rover utilizes a similar principle, but it uses heat without water.

Once the water sample is fed into the Chemical Laptop, the device prepares the sample by mixing it with a fluorescent dye, which attaches the dye to the amino acids or fatty acids. The sample then flows into a microchip inside the device, where the amino acids or fatty acids can be separated from one another. At the end of the separation channel is a detection laser. The dye allows researchers see a signal corresponding to the amino acids or fatty acids when they pass the laser.

Inside a "separation channel" of the microchip, there are already chemical additives that mix with the sample. Some of these species will only interact with right-handed amino acids, and some will only interact with the left-handed variety. These additives will change the relative amount of time the left and right-handed amino acids are in the separation channel, allowing scientists to determine the "handedness" of amino acids in the sample.

The Chemical Laptop, developed at JPL, analyzes liquid samples and detects amino acids and fatty acids. These are both chemicals that are essential to life.

Credits: NASA/JPL-Caltech

Testing for future uses

Last year the researchers did a field test at JPL's Mars Yard, where they placed the Chemical Laptop on a test rover.

"This was the first time we showed the instrument works outside of the laboratory setting. This is the first step toward demonstrating a totally portable and automated instrument that can operate in the field," said Mora.

For this test, the laptop analyzed a sample of "green rust," a mineral that absorbs organic molecules in its layers and may be significant in the origin of life, said JPL's Michael Russell, who helped provide the sample.

"One ultimate goal is to put a detector like this on a spacecraft such as a Mars rover, so for our first test outside the lab we literally did that," said Willis.

Since then, Mora has been working to improve the sensitivity of the Chemical Laptop so it can detect even smaller amounts of amino acids or fatty acids. Currently, the instrument can detect concentrations as low as parts per trillion. Mora is currently testing a new laser and detector technology.

Coming up is a test in the Atacama Desert in Chile, with collaboration from NASA's Ames Research Center, Moffett Field, California, through a grant from NASA's Planetary Science & Technology Through Analog Research (PSTAR) program.

"This could also be an especially useful tool for icy-worlds targets such as Enceladus and Europa. All you would need to do is melt a little bit of the ice, and you could sample it and analyze it directly," Creamer said.

The Chemical Laptop technology has applications for Earth, too. It could be used for environmental monitoring -- analyzing samples directly in the field, rather than taking them back to a laboratory. Uses for medicine could include testing whether the contents of drugs are legitimate or counterfeit.

Creamer recently won an award for her work in this area at JPL's Postdoc Research Day Poster Session.

NASA's PICASSO program, part of the agency's Science Mission Directorate in Washington, supported this research. The California Institute of Technology in Pasadena manages JPL for NASA.

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2015-350

Last Updated: Dec. 4, 2015

Editor: Martin Perez

Tags: Ames Research Center, Astrobiology, High-Tech Computing, Journey to Mars, Mars, Science Instruments, Solar System

NASA Goddard

Sept. 15, 2015

Danny Glavin - Searching For Life in Antarctica

Danny Glavin

Credits: NASA/C. Gunn

Name: Danny Glavin
Title: Associate Director for Strategic Science
Formal Job Classification: Research scientist
Organization: Code 690, Solar System Exploration, Sciences

Danny Glavin – Looks for the building blocks of life in Antarctica's meteorites.

What do you do and what is most interesting about your role here at Goddard? How do you help support Goddard's mission?

My job has two components. I'm the associate director for strategic science in the Solar System Exploration Division. I serve as a voice for our division's scientists, including their research interests and visions for future activities, making sure we are well represented within Goddard, NASA Headquarters and the science community at large.

Strategic science means looking at all the different research activities in our division and matching people with similar goals to form strong collaborations. It also means looking ahead five to 10 years to try to predict what NASA will be doing at a high level. We want to make sure that our research is supporting the key NASA science goals and objectives so we maximize our resources and people by putting them into the most promising areas.

The second part of my job is astrobiology research. I study the organic composition of extraterrestrial materials, such as meteorites and interplanetary dust particles, which are pieces of asteroids and comets. I examine their organic chemicals, the building blocks of life, including amino acids and the components of DNA.

Why and how did you become an astrobiologist?

After I got a physics degree from the University of California at San Diego (UCSD), I thought that I wanted to study astrophysics, in particular black holes. I graduated the summer of 1996 and got a NASA summer internship in exobiology, the study of the origin and evolution of life on Earth and the search for life elsewhere, at the Scripps Institution of Oceanography (SIO), part of UCSD. This was the only summer internship I was offered at the time, so I took it.

What happened during the internship was pretty exciting. NASA announced that they had found signs of life in a Martian meteorite discovered in Antarctica called Allan Hills 84001, a conclusion that is still debated to this day. Nevertheless, the Allan Hills meteorite completely reenergized the astrobiology community. Soon after, NASA formed the Astrobiology Institute to help develop the field of astrobiology and future missions. Everyone wanted to learn more about the origin of life and we had a renewed hope about the possibility of life on Mars.

As a young researcher, I quickly realized that I needed to learn organic chemistry if I wanted to get involved in searching for evidence of life on Mars, which was primarily about chemistry. If you're looking for ancient signs of life, you look for the chemical fingerprints; so you have to understand organic chemistry.

Glavin lies next to a meteorite found in Antarctica.

Credits: Courtesy of D. Glavin

I took some organic and biochemistry courses at UCSD and then got into the Ph.D. program in earth sciences at SIO. My supervisor during the summer internship became my Ph.D. adviser, who helped me get a NASA fellowship for graduate school.

Where do you find Martian meteorites?

Meteorites fall everywhere on the Earth but it's much easier to find them on land. The Antarctic ice sheet is one of the best places in the world to recover meteorites. The black meteorites, burned from entering our atmosphere, show up well on the blue ice. Also, it is very dry and cold in Antarctica, and there are very few people and animals there to contaminate the samples. It’s a very pristine environment. When looking for chemical evidence of extraterrestrial life, we don’t want to be fooled by contamination from the Earth.

Please tell us about your field work in Antarctica.

In 2002, I spent nearly six weeks in Antarctica at a remote field camp in the MacAlpine Hills region of the Transantarctic Mountains. The mountains provide areas that can accumulate meteorites on the ice over time which are called blue ice fields. The Antarctic Search for Meteorites, a partnership between NASA, the National Science Foundation and Case Western Reserve University, sends a team of scientists, engineers, astronauts, writers, teachers and many other professionals to search for and collect meteorites from the ice using snowmobiles and by foot.

We go for the Antarctic summer, which is winter here. We leave around mid-November and return mid-January. During the Antarctic summer, there are 24 hours of daylight. The sun just circles above the horizon, which can make sleeping a challenge.

Every meteorite hunter has to pass a physical and dental exam. They also take a week-long safety and survival training course at McMurdo Station, a U.S. research station on the southern tip of Ross Island off the coast of Antarctica.

That summer, our team of 12 recovered more than 900 meteorites and a few “meteo-wrongs,” terrestrial rocks that we picked up by mistake. We bagged the rocks, labeled them and put them into ice coolers to keep them organized and to prevent contamination. We sent the rocks to NASA’s Johnson Space Center in Houston and the Smithsonian’s Natural History Museum in Washington where they are classified to determine their origin.

What was the most exciting about doing fieldwork in Antarctica?

The biggest thrill for me was finding a football-size rock from space on top of the ice. Nobody else had likely ever seen this meteorite before. This rock turned out to be a piece of an asteroid, but not from Mars. It was still an exciting find. We love to find large meteorites because they provide more samples for scientists to study.

Are you planning to do more field work in Antarctica?

There is a saying: “Every day you’re in Antarctica, you think about the day when you’re going to leave. And when you get back home, you spend every day thinking about how you’re going to get back.”

I often think about going back and I’d love to return. It was one of the highlights of my career. But I don’t want to miss spending Thanksgiving, Christmas and New Year’s with my wife and two young boys.

Who is the most interesting, inspiring or amazing person you have met or worked with at Goddard?

My former supervisor, Paul Mahaffy, showed me what it means to be a true leader. He encourages the scientists in his group to work independently and gives them opportunities to take on new challenges. He provides them with an environment in which they can grow and become leaders themselves. He is not the type of person who needs to receive all the credit.

He is also one of the hardest-working people I know. He is extremely dedicated to his job, building mass spectrometer instruments for spaceflight.

What was one of the most surprising moments of your career?

I was very pleased and surprised when the International Astronomical Union named main belt asteroid 2000 WA_{191} the 24480 Glavin.

Is there something surprising about you, your hobbies, interests or activities outside of work that people do not generally know?

I grew up in San Luis Obispo, California, where I learned to surf when I was 10. I even surfed in a couple of long boarding competitions in San Diego.

What was your favorite comfort food in Antarctica?

I love Mexican food, especially shrimp soft tacos.

OF NOTE:

- Antarctica Service Medal of the United States (2003)
- The Meteoritical Society Nier Prize (2010)
- NASA Goddard Internal Research and Development (IRAD) Innovator of the Year Award (2007)
- NASA Robert H. Goddard Exceptional Achievement Award-Science (2009)
- NASA Robert H. Goddard Exceptional Achievement Award-Science (2014)

Elizabeth M. Jarrell
NASA's Goddard Space Flight Center

Last Updated: Sept. 15, 2015

Editor: Lynn Jenner

Tags: Goddard Space Flight Center

Journey to Mars

Aug. 20, 2015

Drilling for Data: Simulating the Search for Life on Mars

The Life-detection Mars Analog Project (LMAP) rotary-percussive drill, in action during testing.

Credits: NASA photo by Brian J. Glass and Carol Stoker

Toiling in barren rock fields in southern Spain under temperatures as high as 108 degrees Fahrenheit, a team from NASA's Ames Research Center, Honeybee

Robotics, and Spain’s Centro de Astrobiologia (CAB, INTA-CSIC) is changing dirt into data in a way that could one day be replicated on Mars.

Working in early July at a site at Rio Tinto, Spain -- identified as a good analog to certain conditions on Mars -- the team used a computerized 35-inch drill to successfully obtain samples from the region’s barren acidic hardened soil. A robotic arm, developed and built at Ames, then transferred the drilled samples to CAB’s Signs of Life Detector (SOLID) instrument, mounted on a full-scale mock-up of a Mars lander’s deck platform.

“We chose Rio Tinto for our tests because of its extreme, organic-depleted subsurface conditions,” said Ames scientist Brian Glass, principal investigator of the Life-detection Mars Analog Project (LMAP) team. “Any present life there would be subsisting primarily on stored energy in the rocks themselves. It’s a bio-analog site rather than a mechanical or textural one.”

Once the samples were in place, the SOLID instrument examined them for specific organic compounds that could be present. The LMAP team chose the drill site for its soil characteristics, a soil that is processed by an acid stream in which microbes grow in extreme acidic environments.

“These are the kinds of microbes most likely of known Earth types to survive and grow in similar environments on Mars,” said Victor Parro, a co-investigator and lead for the SOLID instrument.

Chris McKay, LMAP co-investigator noted, “It’s critical for us to demonstrate and test the acquisition of subsurface material into instruments on a lander deck, so-called ‘dirt-to-data’, under both laboratory and field conditions.”

NASA’s Science Mission Directorate is funding the LMAP field study through its Planetary Science and Technology through Analog Research (PSTAR) program. The field study includes testing of the many prototype components required for future missions: its drill, a full-scale mockup lander platform, a robot arm for transferring samples, cameras on the deck and arm, and the primary Signs of Life Detector from the CAB in Spain. NASA and the CAB have an agreement for shared astrobiology research through 2019, kicking off with the LMAP teams’ first joint field test.

“We want to know if there is Mars life and if we have the appropriate instrumentation,” said Parro. “This collaboration with NASA Ames to participate in development of these technologies drives our possibilities of detecting life outside the Earth.”

“The search for evidence of ancient climates, extinct life and potential habitats for existing life on Mars, given the desiccated and irradiated conditions near the surface, will require drilling or some other form of subsurface access,” said Glass. “The LMAP tests in Rio Tinto are an important first step, by testing robotic drill and sampling systems along with prototype life-detection instruments to assess the ‘ground truth’ of organics and biomarkers found underground at an easily-accessible Mars analog site.”

The methods utilized by the LMAP team in Spain may become standard operating procedure for future NASA space exploration.

“This month’s LMAP tests demonstrated the utilization of realistic field simulation and biomarker detection technologies that will be a candidate method for deployment in flight on future Mars missions,” said McKay.

Last Updated: Aug. 21, 2015

Editor: Jerry Colen

Tags: Ames Research Center, Journey to Mars

Astrobiology

Aug. 6, 2015

Researchers Use 'Seafloor Gardens' to Switch on Light Bulb

This photo simulation shows a laboratory-created "chemical garden," which is a chimney-like structure found at bubbling vents on the seafloor.

Credits: NASA/JPL-Caltech

Full image and caption

A laboratory-created "chemical garden" made of a combination of black iron sulfide and orange iron hydroxide/oxide is shown in this photo.

Credits: NASA/JPL-Caltech

[Full image and caption]

This image from the floor of the Atlantic Ocean shows a collection of limestone towers known as the "Lost City." Alkaline hydrothermal vents of this type are suggested to be the birthplace of the first living organisms on the ancient Earth.

Credits: D. Kelley and M. Elend/University of Washington

One of the key necessities for life on our planet is electricity. That's not to say that life requires a plug and socket, but everything from shrubs to ants to people harnesses energy via the transfer of electrons -- the basis of electricity. Some experts think that the very first cell-like organisms on Earth channeled electricity from the seafloor using bubbling, chimney-shaped structures, also known as chemical gardens.

In a new study, researchers report growing their own tiny chimneys in a laboratory and using them to power a light bulb. The findings demonstrate that the underwater structures may have indeed given an electrical boost to Earth's very first life forms.

"These chimneys can act like electrical wires on the seafloor," said Laurie Barge of NASA's Jet Propulsion Laboratory, Pasadena, California, lead author of a new paper on the findings in the journal Angewandte Chemie International Edition. "We're harnessing energy as the first life on Earth might have."

The findings are helping researchers put together the story of life on Earth, starting with the first chapter of its origins. How life first took root on our nascent planet is a topic riddled with many unanswered chemistry questions. One leading theory for the origins of life, called the alkaline vent hypothesis, is based on the idea that life sprang up underwater with the help of warm, alkaline (as opposed to acidic) chimneys.

Chimneys naturally form on the seafloor at hydrothermal vents. They range in size from inches to tens of feet (centimeters to tens of meters), and they are made of different types of minerals with, typically, a porous structure. On early Earth, these chimneys could have established electrical and proton gradients across the thin mineral membranes that separate their compartments. Such gradients emulate critical life processes that generate energy and organic compounds.

"Life doesn't want to get electrocuted, but needs just the right amount of electricity," said Michael Russell of JPL, a co-author of the study. "This new experiment confirms what that amount of electricity is -- just under a volt." Russell first proposed the alkaline vent hypothesis in 1989, and even predicted the existence of alkaline vent chimneys more than a decade before they were actually discovered in the Atlantic Ocean and dubbed "The Lost City."

Previously, researchers at the University of Tokyo and the Japan Agency for Marine-Earth Science and Technology recorded electricity in "black smoker" vent chimneys in the Okinawa Trough in Japan. Black smokers are acidic -- and hotter and harsher -- than alkaline vents.

The new study demonstrates that laboratory chimneys similar to alkaline vents on early Earth had enough electricity to do something useful -- in this case power an LED (light-emitting diode) light bulb. The researchers connected four of the chemical gardens, submerged in iron-containing fluids, to turn on one light bulb.

The process took months of patient laboratory work by Barge and Russell's team, with the help of an undergraduate student intern at JPL, Yeghegis "Lily" Abedian.

"I remember when Lily told me the light bulb had turned on. It was shocking," said Barge (while admitting she likes a good pun).

The scientists hope to do the experiment again using different materials for their laboratory chimneys. In the current study, they made chimneys of iron sulfide and iron hydroxide, geological materials that can conduct electrons. Future experiments can assess the electrical potential of additional materials thought to have been present in Earth's early oceans and hydrothermal vents, such as molybdenum, nickel, hydrogen and carbon dioxide.

"With the right recipe, maybe one chimney alone will be able to light the LED – or instead, we could use that electrochemical energy to power other reactions," said Barge. "We can also start simulating higher temperature and pressures that occur at hydrothermal vents."

Materials or other energy sources thought to have been involved in the possible development of life on other planets and moons can be tested too, such as those on early Mars, or icy worlds like Jupiter's moon Europa.

The electrical needs of life's first organisms are only one of many puzzles. Other researchers are trying to figure out how organic materials, such as DNA, might have assembled from scratch. The ultimate goal is to fit all the pieces together into one amazing story of life's origins.

The JPL research team is part of the Icy Worlds team of the NASA Astrobiology Institute, based at NASA's Ames Research Center in Moffett Field, California. The Icy Worlds team is led by Isik Kanik of JPL.

JPL is managed by the California Institute of Technology in Pasadena for NASA.

For more information about the NASA Astrobiology Institute, visit:

http://astrobiology.nasa.gov/nai

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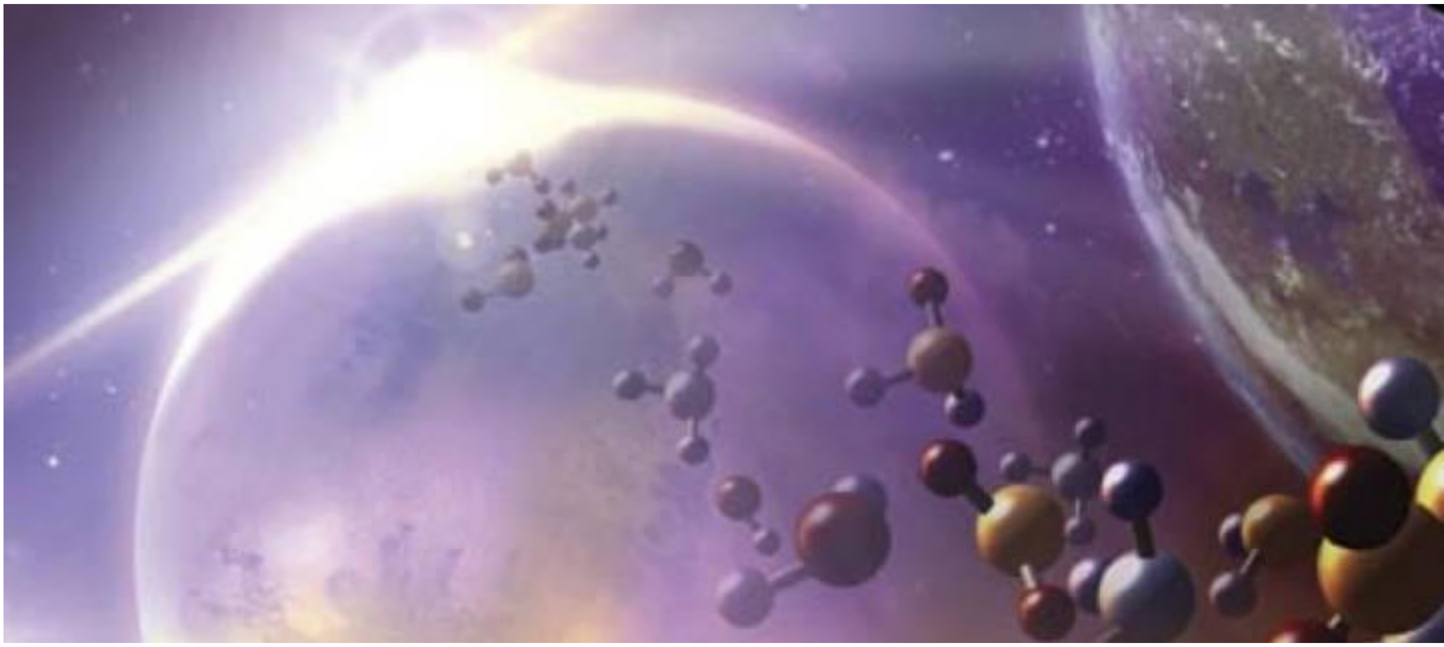
2015-257

Last Updated: Aug. 7, 2015

Editor: Tony Greicius

Tags: **Ames Research Center**, **Astrobiology**, **Earth**, **Jet Propulsion Laboratory**, **Universe**

Astrobiology



June 13, 2015

MEDIA ADVISORY M15-092

NASA, University Researchers Discuss Search for Life in Solar System, Beyond

NASA and university scientists will discuss at 2 p.m. EDT, Tuesday June 16, astrobiology research activities and technology that are advancing the search for evidence of habitability in our solar system and beyond. The briefing will air live on NASA Television and the agency's website.

Briefing topics will include the quest for evidence of habitability and life on Mars, plans for exploring the habitability of Europa and Enceladus, and progress in identifying signs of habitability on exoplanets.

The briefing will be held during the 2015 Astrobiology Science Conference in Chicago June 15-19 in Salon A5 of the Hilton Downtown Chicago, located at 720 South Michigan Avenue.

Briefing participants are:

- John Grunsfeld, associate administrator for Science at NASA Headquarters in Washington
- Vikki Meadows, professor of astronomy and principal investigator at the University of Washington's Virtual Planetary Laboratory in Seattle
- Britney Schmidt, assistant professor in the Department of Earth and Atmospheric Sciences at the Georgia Institute of Technology, and principal investigator for the NASA-funded project Sub-Ice Marine and Planetary Analog Ecosystems
- Alexis Templeton, associate professor in the Department of Geological Sciences at the University of Colorado-Boulder, and principal investigator for the NASA Astrobiology Institute Rock-Powered Life team

Media representatives not in attendance may submit questions to dwayne.c.brown@nasa.gov.

Watch the briefing and conference sessions online at:

http://ac.arc.nasa.gov/abscicon

For more information about NASA's astrobiology activities, visit:

http://astrobiology.nasa.gov

For NASA's activities in the solar system and beyond, visit:

http://www.nasa.gov/topics/solarsystem

-end-

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Last Updated: July 31, 2015

Editor: Karen Northon

Tags: Astrobiology, Solar System

Distant Planets

April 22, 2015

NASA's NExSS Coalition to Lead Search for Life on Distant Worlds

The search for life beyond our solar system requires unprecedented cooperation across scientific disciplines. NASA's NExSS collaboration includes those who study Earth as a life-bearing planet (lower right), those researching the diversity of solar system planets (left), and those on the new frontier, discovering worlds orbiting other stars in the galaxy (upper right).

Credits: NASA

NASA is bringing together experts spanning a variety of scientific fields for an unprecedented initiative dedicated to the search for life on planets outside our solar system.

The Nexus for Exoplanet System Science, or “NExSS”, hopes to better understand the various components of an exoplanet, as well as how the planet stars and neighbor planets interact to support life.

“This interdisciplinary endeavor connects top research teams and provides a synthesized approach in the search for planets with the greatest potential for signs of life,” says Jim Green, NASA’s Director of Planetary Science. “The hunt for exoplanets is not only a priority for astronomers, it’s of keen interest to planetary and climate scientists as well.”

The study of exoplanets – planets around other stars – is a relatively new field. The discovery of the first exoplanet around a star like our sun was made in 1995. Since the launch of NASA’s Kepler space telescope six years ago, more than 1,000 exoplanets have been found, with thousands of additional candidates waiting to be confirmed. Scientists are developing ways to confirm the habitability of these worlds and search for biosignatures, or signs of life.

The key to this effort is understanding how biology interacts with the atmosphere, geology, oceans, and interior of a planet, and how these interactions are affected by the host star. This “system science” approach will help scientists better understand how to look for life on exoplanets.

NExSS will tap into the collective expertise from each of the science communities supported by NASA’s Science Mission Directorate:

- **Earth scientists** develop a systems science approach by studying our home planet.
- **Planetary scientists** apply systems science to a wide variety of worlds within our solar system.
- **Heliophysicists** add another layer to this systems science approach, looking in detail at how the Sun interacts with orbiting planets.
- **Astrophysicists** provide data on the exoplanets and host stars for the application of this systems science framework.

NExSS will bring together these prominent research communities in an unprecedented collaboration, to share their perspectives, research results, and approaches in the pursuit of one of humanity’s deepest questions: Are we alone?

The team will help classify the diversity of worlds being discovered, understand the potential habitability of these worlds, and develop tools and technologies needed in the search for life beyond Earth.

Dr. Paul Hertz, Director of the Astrophysics Division at NASA notes, “NExSS scientists will not only apply a systems science approach to existing exoplanet data, their work will provide a foundation for interpreting observations of exoplanets from future exoplanet missions such as TESS, JWST, and WFIRST.” The Transiting Exoplanet Survey Satellite (TESS) is working toward a 2017 launch, with the James Webb Space Telescope (JWST) scheduled for launch in 2018. The Wide-field Infrared Survey Telescope is currently being studied by NASA for a launch in the 2020’s.

NExSS will be led by Natalie Batalha of NASA’s Ames Research Center, Dawn Gelino with NExScI, the NASA Exoplanet Science Institute, and Anthony del Genio of NASA’s Goddard Institute for Space Studies. The NExSS project will also include team members from 10 different universities and two research institutes. These teams were selected from proposals submitted across NASA’s Science Mission Directorate.

The Berkeley/Stanford University team is led by James Graham. This "Exoplanets Unveiled" group will focus on this question: “What are the properties of exoplanetary systems, particularly as they relate to their formation, evolution, and potential to harbor life?”

http://astro.berkeley.edu/p/Berkeley-NExSS

Daniel Apai leads the “Earths in Other Solar Systems” team from the University of Arizona. The EOS team will combine astronomical observations of exoplanets and forming planetary systems with powerful computer simulations and cutting-edge microscopic studies of meteorites from the early solar system to understand how Earth-like planets form and how biocritical ingredients — C, H, N, O-containing molecules — are delivered to these worlds.

http://otherearths.org

The Arizona State University team will take a similar approach. Led by Steven Desch, this research group will place planetary habitability in a chemical context, with the goal of producing a “periodic table of planets”. Additionally, the outputs from this team will be critical inputs to other teams modeling the atmospheres of other worlds.

Researchers from Hampton University will be exploring the sources and sinks for volatiles on habitable worlds. The “Living, Breathing Planet Team," led by William B. Moore, will study how the loss of hydrogen and other atmospheric compounds to space has profoundly changed the chemistry and surface conditions of planets in the solar system and beyond. This research will help determine the past and present habitability of Mars and even Venus, and will form the basis for identifying habitable and eventually living planets around other stars.

http://sol.hamptonu.edu/project/the-living-breathing-planet/

The team centered at NASA’s Goddard Institute for Space Studies will investigate habitability on a more local scale. Led by Tony Del Genio, it will examine the habitability of solar system rocky planets through time, and will use that foundation to inform the detection and characterization of habitable exoplanets in the future.

http://www.giss.nasa.gov/projects/astrobio/

The NASA Astrobiology Institute's Virtual Planetary Laboratory, based at the University of Washington, was founded in 2001 and is a heritage team of the NExSS network. This research group, led by Dr. Victoria Meadows, will combine expertise from Earth observations, Earth system science, planetary science, and astronomy to explore factors likely to affect the habitability of exoplanets, as well as the remote detectability of global signs of habitability and life.

Five additional teams were chosen from the Planetary Science Division portion of the Exoplanets Research Program (ExRP). Each brings a unique combination of expertise to understand the fundamental origins of exoplanetary systems, through laboratory, observational, and modeling studies.

A group led by Neal Turner at NASA’s Jet Propulsion Laboratory, California Institute of Technology, will work to understand why so many exoplanets orbit close to their stars. Were they born where we find them, or did they form farther out and spiral inward? The team will investigate how the gas and dust close to young stars interact with planets, using computer modeling to go beyond what can be imaged with today's telescopes on the ground and in space.

A team at the University of Wyoming, headed by Hannah Jang-Condell, will explore the evolution of planet formation, modeling disks around young stars that are in the process of forming their planets. Of particular interest are "transitional" disks, which are protostellar disks that appear to have inner holes or regions partially cleared of gas and dust. These inner holes may be caused in part by planets inside or near the holes.

A Penn State University team, led by Eric Ford, will strive to further understand planetary formation by investigating the bulk properties of small transiting planets and implications for their formation.

A second Penn State group, with Jason Wright as principal investigator, will study the atmospheres of giant planets that are transiting hot Jupiters with a novel, high-precision technique called diffuser-assisted photometry. This research aims to enable more detailed characterization of the temperatures, pressures, composition, and variability of exoplanet atmospheres.

http://science.psu.edu/news-and-events/2015-news/FordWright4-2015

The University of Maryland and NASA's Goddard Space Flight Center team, with Wade Henning at the helm, will study tidal dynamics and orbital evolution of terrestrial class exoplanets. This effort will explore how intense tidal heating, such as the temporary creation of magma oceans, can actually save Earth-sized planets from being ejected during the orbital chaos of early solar systems.

Another University of Maryland project, led by Drake Deming, will leverage a statistical analysis of Kepler data to extract the maximum amount of information concerning the atmospheres of Kepler's planets.

The group led by Hiroshi Imanaka from the SETI Institute will be conducting laboratory investigation of plausible photochemical haze particles in hot, exoplanetary atmospheres.

The Yale University team, headed by Debra Fischer, will design new spectrometers with the stability to reach Earth-detecting precision for nearby stars. The team will also make improvements to Planet Hunters, www.planethunters.org, a web interface that allows citizen scientists to search for transiting planets in the NASA Kepler public archive data. Citizen scientists have found more than 100 planets not previously detected; many of these planets are in the habitable zones of host stars.

A group led by Adam Jensen at the University of Nebraska-Kearney will explore the existence and evolution of exospheres around exoplanets, the outer, ‘unbound’ portion of a planet's atmosphere. This team previously made the first visible light detection of hydrogen absorption from an exoplanet's exosphere, indicating a source of hot, excited hydrogen around the planet. The existence of such hydrogen can potentially tell us about the long-term evolution of a planet's atmosphere, including the effects and interactions of stellar winds and planetary magnetic fields.

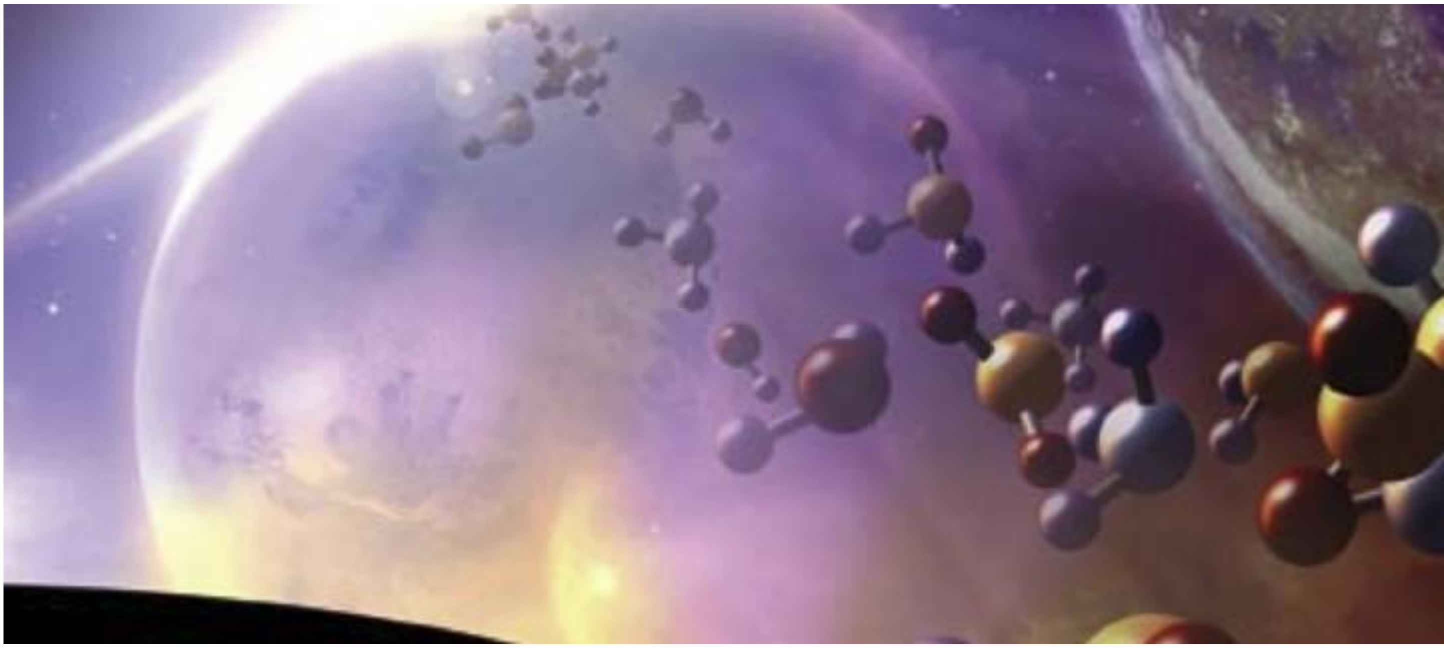
From the University of California, Santa Cruz, Jonathan Fortney’s team will investigate how novel statistical methods can be used to extract information from light which is emitted and reflected by planetary atmospheres, in order to understand their atmospheric temperatures and the abundance of molecules.

Last Updated: July 31, 2015

Editor: Sarah Loff

Tags: **Astrobiology**, **Distant Planets**, **Kepler and K2**, **Universe**

NASA Ames



Dec. 16, 2014

NASA Ames Celebrates Its History: Establishing Astrobiology Science

After the National Advisory Committee for Aeronautics' Ames Research Laboratory was transferred to the National Aeronautics and Space Administration in 1958, new areas of space-related research started to appear at NASA's Ames Research Center. One of the most important organizational changes at Ames was starting a life sciences activity in 1961.

NASA had begun to fund this new space science research with the establishment of the Office of Life Sciences Programs at Headquarters in 1960. A year later, it became the Exobiology Division, led by Harold P. Klein, the former chair of the Biology Department at Brandeis University in Waltham, Massachusetts. NASA knew that to perform biological experiments in space, a laboratory was needed to conduct ground experimentation prior to flight. To support the necessary research, a new laboratory was built at Ames. By 1963, the agency had expanded the program and established the Life Sciences Directorate at Ames. Klein was selected to lead this extraordinary challenge.

Richard S. Young replaced Klein as the chief of the Exobiology Division. By then, the division consisted of the Chemical Evolution Branch, the Life-Detection Systems Branch, and the Biological Adaptation Branch. The work of the division was of a very basic nature; research was conducted in-house, none with human subjects, and little with animal subjects other than micro-organisms, eggs and frogs.

The possibility that life may exist somewhere other than on Earth is an exciting prospect of space research. Scientists hypothesized that a possible discovery could be of some basic life form in an phase through which life on Earth passed several billions of years ago, or somewhere in the transition from inanimate to animate chemistry.

During the early years of the division, NASA scientists faced a number of problems. In their search for extraterrestrial life, they had to know what kind of evidence to look for, how to detect it in a foreign environment, how to recover it by means of a remote-controlled vehicle, how to nurture any life forms discovered to facilitate later studies and, if such discoveries are returned to Earth, how to protect the foreign and the domestic life forms from each other.

If extraterrestrial life does exist, many scientists assumed that it would have developed through a general evolutionary process which began with a primordial, hydrogen-rich environment and proceeded first through numerous organic chemical phases, then through biological stages of increasing sophistication The crux of the process is the step, or steps, from the chemical to the biological stage, and it is assumed that this step would not take place unless the chemical environment was favorable. The nominal purpose of the Chemical Evolution Branch was to investigate some of the chemical steps in the evolutionary process.

Much work has been done in this field by scientists at Ames. In 2009, when studying the origin of life, researchers reproduced uracil, a key component of our hereditary material, in the laboratory. They discovered that an ice sample containing pyrimidine exposed to ultraviolet radiation under space-like conditions produces this essential ingredient of life.

Pyrimidine is a ring-shaped molecule made up of carbon and nitrogen and is the basic structure for uracil, part of a genetic code found in ribonucleic acid (RNA). RNA is central to protein synthesis, but has many other roles.

These scientists demonstrated for the first time that they could make uracil non-biologically in a laboratory under conditions found in space. They showed that these laboratory processes, which simulate occurrences in outer space, can make a fundamental building block used by living organisms on Earth.

Understanding the chemical evolution of life is an important step toward understanding the origin of life. But how would the existence of life, extraterrestrial or otherwise, be judged? To determine the existence of life, scientists in the Life Detection Systems Branch decided it was first necessary to establish the criteria to evaluate such an existence. Although the boundary between the animate and inanimate is uncertain, scientists generally agree that living matter is of organic composition, metabolizes (uses up energy and rejects a byproduct substance), grows and reproduces. The first criterion is not conclusive in itself and, while the addition of the second is very encouraging, the matter is more confidently approached when the third one is also present.

In view of the uncertainties of extraterrestrial life forms, Ames scientists started to investigate the tolerance of Earth life forms to extreme conditions of temperature, pressure, atmosphere, moisture, radiation, salts and gravity.

Credits: U.S. Geological Service

In view of the uncertainties of extraterrestrial life forms, the Exobiology Division assumed that useful related knowledge might be obtained from an investigation of the tolerance of Earth life forms to extreme conditions of temperature, pressure, atmosphere, moisture, radiation, salts and gravity such as may be found naturally, or produced artificially, on Earth. This work, which came under the surveillance of the Biological Adaptation Branch, was still, in 1964, in early development.

The division started developing life-detection procedures for such extreme environments in Death Valley in 1964. This effort later was led by Chris McKay, a planetary scientist at Ames, who continues to study life in extreme environments to better understand how to search for life on other planets, such as Mars. McKay's scientific contributions in planning for future Mars missions includes research in Mars-like environments on Earth, traveling to the Antarctic dry valleys, the Canadian Arctic, Siberia and the Atacama Desert in Chile. These investigations to advance our understanding of the evolution of the solar system and the origin of life on Earth have given rise to a new interdisciplinary science called astrobiology.

Many feel Klein was the primary force that established Ames' reputation as the key NASA institution for the study of astrobiology in all its various facets, including exobiology, gravitational biology and biomedicine, and recruited a brilliant staff of scientists for the Life Sciences Directorate. More than any other individual, Harold Klein is the man who built the foundation upon which rests Ames' current leadership in astrobiology.

Today, Ames is home to the NASA Astrobiology Institute (NAI), a virtual institute designed to catalyze interdisciplinary research among competitively selected teams. Research encompasses the search for habitable environments in our solar system, as well as habitable planets outside our solar system, the search for evidence of prebiotic chemistry and life on Mars and other bodies in our solar system, laboratory and field research into the origins and early evolution of life on Earth, and studies of the potential for life to adapt to challenges on Earth and in space. Ames continues to play a leading NASA role in research expeditions to "Mars analog" sites on Earth, where microbial life is found in very inhospitable environments, ranging from Antarctica to the heights of the Atacama Desert and to deep-sea geothermal events.

Source: Hartman, Edwin. "Adventures in Research: A History of Ames Research Center, 1940-1965," (NASA SP-4302) 1970.

Ruth Marlaire
NASA's Ames Research Center

Last Updated: July 31, 2015

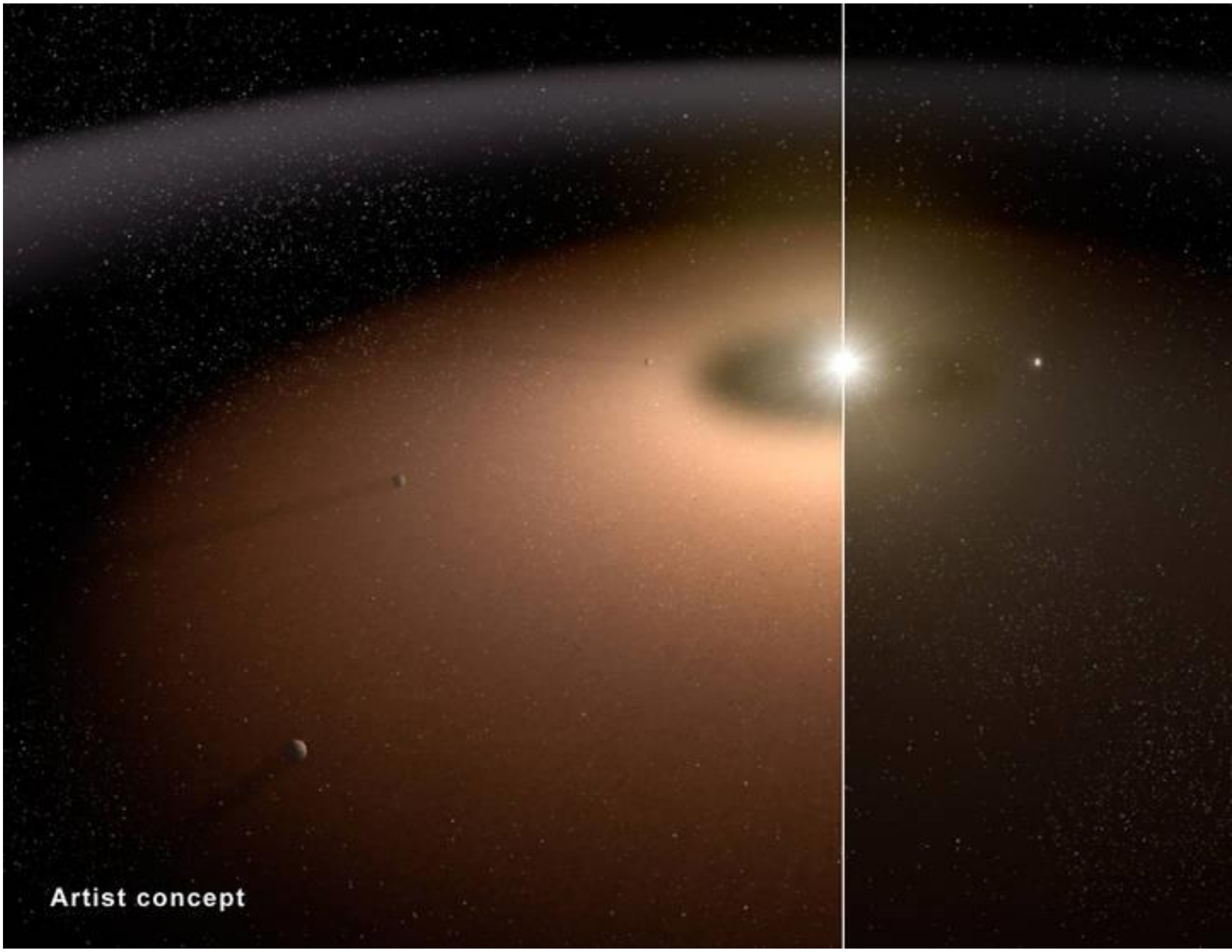
Editor: Ruth Marlaire

Tags: Ames Research Center, Astrobiology

Distant Planets

Dec. 3, 2014

Stardust Not Likely to Block Planet Portraits



A dusty planetary system (left) is compared to another system with little dust in this artist's conception.

Credits: NASA/JPL-CalTech

Planet hunters received some good news recently. A new study concluded that, on average, sun-like stars aren't all that dusty. Less dust means better odds of snapping clear pictures of the stars' planets in the future.

These results come from surveying nearly 50 stars from 2008 to 2011 using the Keck Interferometer, a former NASA key science project that combined the power of the twin W. M. Keck Observatory telescopes atop Mauna Kea, Hawaii.

"Dust is a double-edged sword when it comes to imaging distant planets," explained Bertrand Mennesson of NASA's Jet Propulsion Laboratory, Pasadena, California, lead author of an Astrophysical Journal report to be published online Dec. 8. "The presence of dust is a signpost for planets, but too much dust can block our view." Mennesson has been involved in the Keck Interferometer project since its inception more than 10 years ago, both as a scientist and as the optics lead for one of its instruments.

Ground- and space-based telescopes have already captured images of exoplanets -- planets orbiting stars beyond our sun. These early images, which show giant planets in cool orbits far from the glow of their stars, represent a huge technological leap. The glare from stars can overwhelm the light of planets, like a firefly buzzing across the sun. So, researchers have developed complex instruments to block the starlight, allowing information about the planet to shine through.

The next challenge is to image smaller planets in the "habitable" zone around stars where possible life-bearing "exo-Earths" -- Earth-like planets outside the solar system -- could reside. Such a lofty goal may take decades, but researchers are already on the path to getting there, developing new instrument designs and analyzing the dust kicked up around stars to better understand how to snap crisp planetary portraits. Scientists want to find out which stars have the most dust, and how dusty the habitable zones of sun-like stars are.

The Keck Interferometer was built to seek out this dust, and to ultimately help in the design and target selection of future NASA exo-Earth missions. Like planets around other stars, dust near a star is also hard to detect. Interferometry is a high-resolution imaging technique that can be used to block out a star's light, making the region nearby easier to observe. Light waves from the precise location of a star, collected separately by the twin 10-meter Keck Observatory telescopes, are combined and canceled out in a process called nulling.

"If you don't turn off the star, you are blinded and can't see dust or planets," said co-author Rafael Millan-Gabet of NASA's Exoplanet Science Institute at the California Institute of Technology in Pasadena, who led the Keck Interferometer's science operations system.

In the latest study, mature, sun-like stars were analyzed with high precision to search for warm, room-temperature dust in their habitable zones. Roughly half of the stars selected for the study had previously shown no signs of cool dust circling in their outer reaches. This outer dust is easier to see than the inner, warm dust due to its greater distance from the star. Of this first group of stars, none were found to host the warm dust, making them good targets for planet imaging, and a good indication that other, relatively dust-free stars are out there.

The other stars in the study were already known to have significant amounts of distant, cold dust orbiting them. In this group, many of the stars were found to also have the room-temperature dust. This is the first time a direct link between the cold and warm dust has been established. In other words, if a star is observed to have a cold belt of dust, astronomers now can make an educated guess that its warm habitable zone is also riddled with dust, making it a poor target for imaging exo-Earths.

"We want to avoid planets that are buried in dust," said Mennesson. "The dust glows in the infrared and reflects starlight in the visible, both of which can outshine the planet's light."

Like a busy construction site, the process of building planets is messy. It is common for young, developing star systems to be covered in dust. Proto-planets collide, scattering dust. But eventually, the chaos settles and the dust clears -- except around some older stars. Why are these mature stars still laden with warm dust in their habitable zones?

The newfound link between cold and warm dust belts helps answer this question.

"The outer belt is somehow feeding material into the inner, warm belt," said Geoff Bryden of JPL, a co-author of the study. "This transport of material could be accomplished as dust smoothly flows inward, or there could be larger comets thrown directly into the inner system."

Upcoming, more-sensitive measurements by NASA's Large Binocular Telescope Interferometer on Mount Graham in Arizona will further improve these measurements of dust in star systems, narrowing in on its quantity, origin and whereabouts. With these early efforts to sift through the murk around stars, astronomers are making their way down the path to one day finding planets similar to our own.

The Keck Interferometer completed its NASA prime mission in 2012. It was funded by NASA and managed by JPL. JPL is managed by Caltech for NASA.

The W. M. Keck Observatory operates the largest, most scientifically productive telescopes on Earth. The two, 10-meter optical/infrared telescopes near the summit of Mauna Kea on the Island of Hawaii feature a suite of advanced instruments including imagers, multi-object spectrographs, high-resolution spectrographs, integral-field spectrographs and world-leading laser guide star adaptive optics systems.

Keck Observatory is a private 501(c) 3 non-profit organization and a scientific partnership of Caltech, the University of California System and NASA.

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2014-413

Last Updated: July 31, 2015

Editor: Tony Greicius

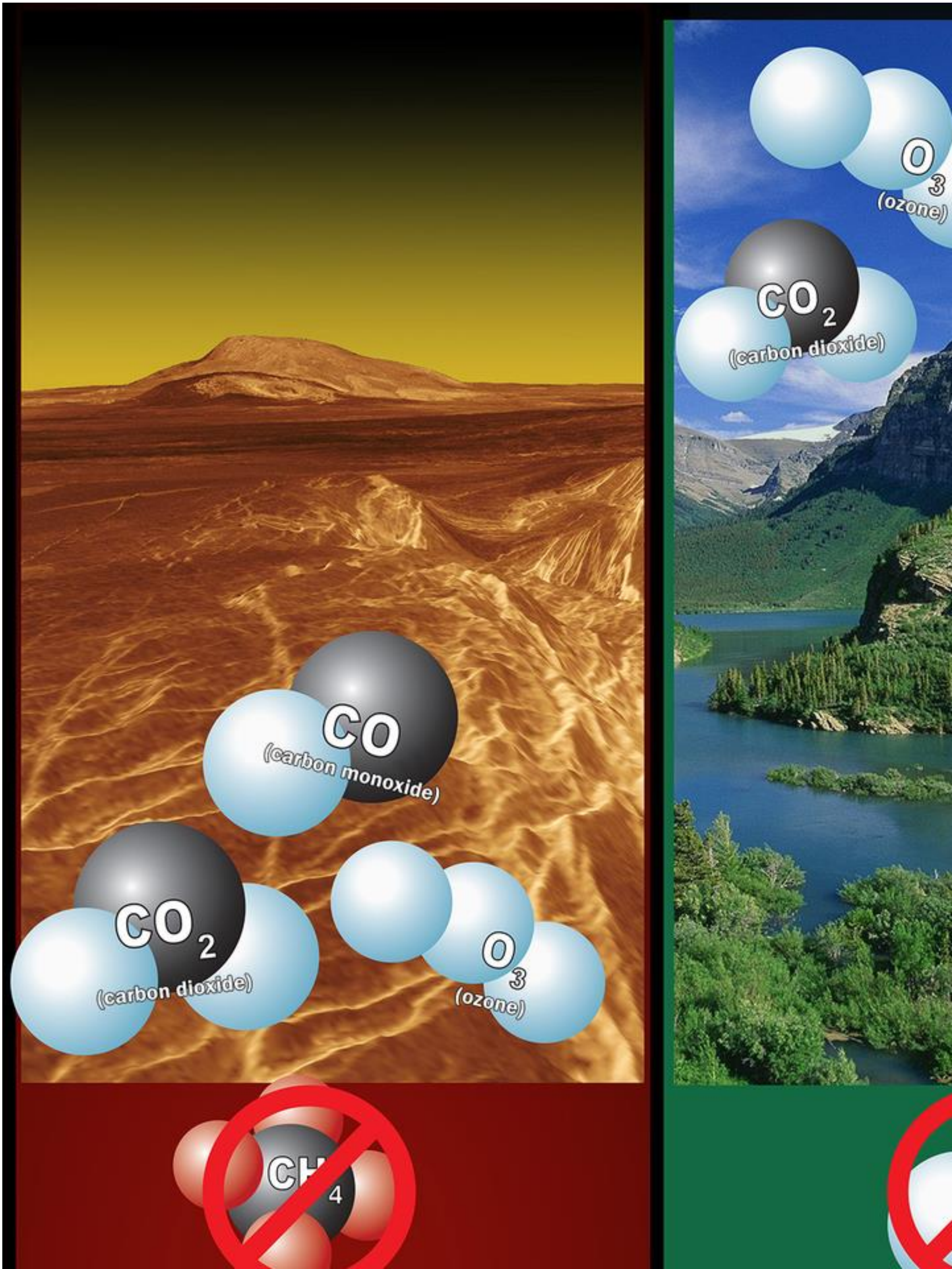
Tags: Astrobiology, Distant Planets, Universe

Astrobiology

Sept. 12, 2014

NASA Research Gives Guideline for Future Alien Life Search

Astronomers searching the atmospheres of alien worlds for gases that might be produced by life can't rely on the detection of just one type, such as oxygen, ozone, or methane, because in some cases these gases can be produced non-biologically, according to extensive simulations by researchers in the NASA Astrobiology Institute’s Virtual Planetary Laboratory.


CO
(carbon monoxide)
CO2
(carbon dioxide)
O3
(ozone)
CH4
O3
(ozone)
CO2
(carbon dioxide)

Left: Ozone molecules in a planet's atmosphere could indicate biological activity, but ozone, carbon dioxide and carbon monoxide -- without methane, is likely a false positive. Right: Ozone, oxygen, carbon dioxide and methane -- without carbon monoxide, indicate a possible true positive.

Credits: NASA

The researchers carefully simulated the atmospheric chemistry of alien worlds devoid of life thousands of times over a period of more than four years, varying the atmospheric compositions and star types. "When we ran these calculations, we found that in some cases, there was a significant amount of ozone that built up in the atmosphere, despite there not being any oxygen flowing into the atmosphere," said Shawn Domagal-Goldman of NASA's Goddard Space Flight Center in Greenbelt, Maryland. "This has important implications for our future plans to look for life beyond Earth."

Methane is a carbon atom bound to four hydrogen atoms. On Earth, much of it is produced biologically (flatulent cows are a classic example), but it can also be made inorganically; for example, volcanoes at the bottom of the ocean can release the gas after it is produced by reactions of rocks with seawater.

Ozone and oxygen were previously thought to be stronger biosignatures on their own. Ozone is three atoms of oxygen bound together. On Earth, it is produced when molecular oxygen (two oxygen atoms) and atomic oxygen (a single oxygen atom) combine, after the atomic oxygen is created by other reactions powered by sunlight or lightning. Life is the dominant source of the molecular oxygen on our planet, as the gas is produced by photosynthesis in plants and microscopic, single-cell organisms. Because life dominates the production of oxygen, and oxygen is needed for ozone, both gases were thought to be relatively strong biosignatures. But this study demonstrated that both molecular oxygen and ozone can be made without life when ultraviolet light breaks apart carbon dioxide (a carbon atom bound to two oxygen atoms). Their research suggests this non-biological process could create enough ozone for it to be detectable across space, so the detection of ozone by itself would not be a definitive sign of life.

"However, our research strengthens the argument that methane and oxygen together, or methane and ozone together, are still strong signatures of life," said Domagal-Goldman. "We tried really, really hard to make false-positive signals for life, and we did find some, but only for oxygen, ozone, or methane by themselves." Domagal-Goldman and Antígona Segura from the Universidad Nacional Autónoma de México in Mexico City are lead authors of a paper about this research, along with astronomer Victoria Meadows, geologist Mark Claire, and Tyler Robison, an expert on what Earth would look like as an extrasolar planet. The paper appeared in the Astrophysical Journal Sept. 10, and is available online.

Methane and oxygen molecules together are a reliable sign of biological activity because methane doesn't last long in an atmosphere containing oxygen-bearing molecules. "It's like college students and pizza," says Domagal-Goldman. "If you see pizza in a room, and there are also college students in that room, chances are the pizza was freshly delivered, because the students will quickly eat the pizza. The same goes for methane and oxygen. If both are seen together in an atmosphere, the methane was freshly delivered because the oxygen will be part of a network of reactions that will consume the methane. You know the methane is being replenished. The best way to replenish methane in the presence of oxygen is with life. The opposite is true, as well. In order to keep the oxygen around in an atmosphere that has a lot of methane, you have to replenish the oxygen, and the best way to do that is with life."

Scientists have used computer models to simulate the atmospheric chemistry on planets beyond our solar system (exoplanets) before, and the team used a similar model in its research. However, the researchers also developed a program to automatically compute the calculations thousands of times, so they could see the results with a wider range of atmospheric compositions and star types.

In doing these simulations, the team made sure they balanced the reactions that could put oxygen molecules in the atmosphere with the reactions that might remove them from the atmosphere. For example, oxygen can react with iron on the surface of a planet to make iron oxides; this is what gives most red rocks their color. A similar process has colored the dust on Mars, giving the Red Planet its distinctive hue. Calculating the appearance of a balanced atmosphere is important because this balance would allow the atmosphere to persist for geological time scales. Given that planetary lifetimes are measured in billions of years, it's unlikely astronomers will happen by chance to be observing a planet during a temporary surge of oxygen or methane lasting just thousands or even millions of years.

It was important to make the calculations for a wide variety of cases, because the non-biological production of oxygen is subject to both the atmospheric and stellar environment of the planet. If there are a lot of gases that consume oxygen, such as methane or hydrogen, then any oxygen or ozone produced will be destroyed in the atmosphere. However, if the amount of oxygen-consuming gases is vanishingly small, the oxygen and the ozone might stick around for a while. Likewise, the production and destruction of oxygen, ozone, and methane is driven by chemical reactions powered by light, making the type of star important to consider as well. Different types of stars produce the majority of their light at specific colors. For example, massive, hot stars or stars with frequent explosive activity produce more ultraviolet light. "If there is more ultraviolet light hitting the atmosphere, it will drive these photochemical reactions more efficiently," said Domagal-Goldman. "More specifically, different colors (or wavelengths) of ultraviolet light can affect oxygen and ozone production and destruction in different ways."

Astronomers detect molecules in exoplanet atmospheres by measuring the colors of light from the star the exoplanet is orbiting. As this light passes through the exoplanet's atmosphere, some of it is absorbed by atmospheric molecules. Different molecules absorb different colors of light, so astronomers use these absorption features as unique "signatures" of the type and quantity of molecules present.

“One of the main challenges in identifying life signatures is to distinguish between the products of life and those compounds generated by geological processes or chemical reactions in the atmosphere. For that we need to understand not only how life may change a planet but how planets work and the characteristics of the stars that host such worlds”, said Segura.

The team plans to use this research to make recommendations about the requirements for future space telescopes designed to search exoplanet atmospheres for signs of alien life. "Context is key – we can't just look for oxygen, ozone, or methane alone," says Domagal-Goldman. "To confirm life is making oxygen or ozone, you need to expand your wavelength range to include methane absorption features. Ideally, you'd also measure other gases like carbon dioxide and carbon monoxide [a molecule with one carbon atom and one oxygen atom]. So we're thinking very carefully about the issues that could trip us up and give a false-positive signal, and the good news is by identifying them, we can create a good path to avoid the issues false positives could cause. We now know which measurements we need to make. The next step is figuring out what we need to build and how to build it."

The research was funded in part by the NASA Astrobiology Institute's (NAI) Virtual Planetary Laboratory (VPL). The NAI is administered by NASA's Ames Research Center in Mountain View, California, and funded as part of the NASA Astrobiology Program at NASA Headquarters, Washington. The VPL is based at the University of Washington, and comprises researchers at 20 institutions working to understand how telescopic observations and modeling studies can determine if exoplanets are able to support life, or had life in the past. Additional support for the research was provided by the NASA Postdoctoral Program, managed by Oak Ridge Associated Universities.

The team represented an international collaboration that included researchers from NASA Goddard, NASA Ames, the NAI/VPL, the Instituto de Ciencias Nucleares, Universidad Nacional Autónoma de México, Mexico; the University of St. Andrews, St. Andrews, Scotland; and the University of Washington, Seattle.

For more information about the NASA Astrobiology Institute, visit:

http://astrobiology.nasa.gov/

The research paper is available online at:

http://stacks.iop.org/0004-637X/792/90

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Last Updated: July 31, 2015

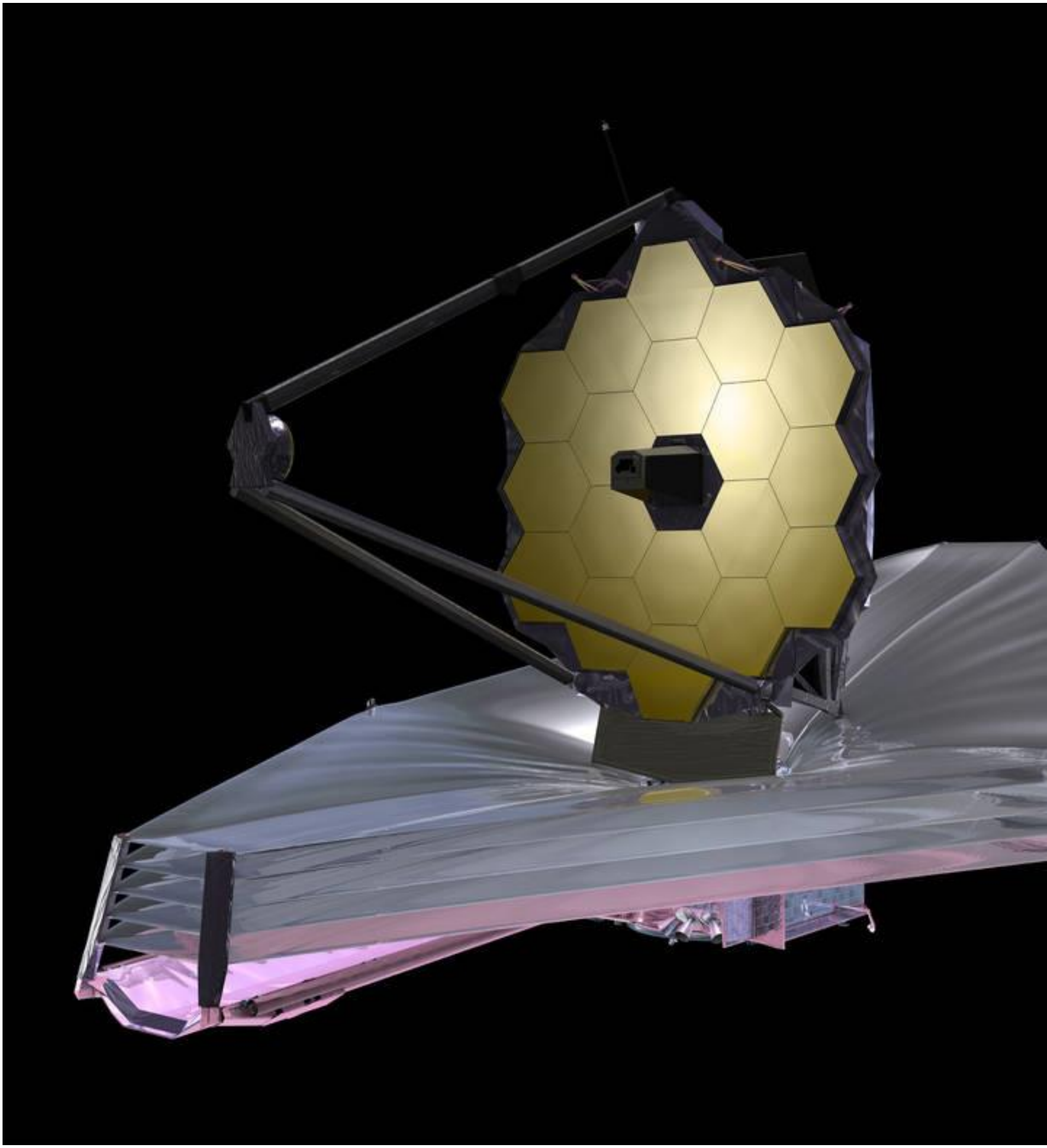
Editor: Rob Garner

Tags: Astrobiology, Distant Planets, Goddard Space Flight Center, Universe

Astrobiology

July 15, 2014

Finding Life Beyond Earth is Within Reach



The James Webb Space Telescope (artist's concept above) will be one of the primary instruments scientists use to continue the search for planets outside our solar system.

Credits: NASA

Many scientists believe we are not alone in the universe. It's probable, they say, that life could have arisen on at least some of the billions of planets thought to exist in our galaxy alone -- just as it did here on planet Earth. This basic question about our place in the Universe is one that may be answered by scientific investigations. What are the next steps to finding life elsewhere?

Experts from NASA and its partner institutions addressed this question on July 14, at a public talk held at NASA Headquarters in Washington. They outlined NASA's roadmap to the search for life in the universe, an ongoing journey that involves a number of current and future telescopes. Watch the video of the event:

Leading science and engineering experts discuss a scientific and technological roadmap to lead to the discovery of potentially habitable worlds among the stars.

Credits: NASA TV

"Sometime in the near future, people will be able to point to a star and say, 'that star has a planet like Earth'," says Sara Seager, professor of planetary science and physics at the Massachusetts Institute of Technology in Cambridge, Massachusetts. "Astronomers think it is very likely that every single star in our Milky Way galaxy has at least one planet."

NASA's quest to study planetary systems around other stars started with ground-based observatories, then moved to space-based assets like the Hubble Space Telescope, the Spitzer Space Telescope, and the Kepler Space Telescope. Today's telescopes can look at many stars and tell if they have one or more orbiting planets. Even more, they can determine if the planets are the right distance away from the star to have liquid water, the key ingredient to life as we know it.

The NASA roadmap will continue with the launch of the Transiting Exoplanet Surveying Satellite (TESS) in 2017, the James Webb Space Telescope (Webb Telescope) in 2018, and perhaps the proposed Wide Field Infrared Survey Telescope - Astrophysics Focused Telescope Assets (WFIRST-AFTA) early in the next decade. These upcoming telescopes will find and characterize a host of new exoplanets -- those planets that orbit other stars -- expanding our knowledge of their atmospheres and diversity. The Webb telescope and WFIRST-AFTA will lay the groundwork, and future missions will extend the search for oceans in the form of atmospheric water vapor and for life as in carbon dioxide and other atmospheric chemicals, on nearby planets that are similar to Earth in size and mass, a key step in the search for life.

"This technology we are using to explore exoplanets is real," said John Grunsfeld, astronaut and associate administrator for NASA's Science Mission Directorate in Washington. "The James Webb Space Telescope and the next advances are happening now. These are not dreams -- this is what we do at NASA."

Since its launch in 2009, Kepler has dramatically changed what we know about exoplanets, finding most of the more than 5,000 potential exoplanets, of which more than 1700 have been confirmed. The Kepler observations have led to estimates of billions of planets in our galaxy, and shown that most planets within one astronomical unit are less than three times the diameter of Earth. Kepler also found the first Earth-size planet to orbit in the "habitable zone" of a star, the region where liquid water can pool on the surface.

"What we didn't know five years ago is that perhaps 10 to 20 percent of stars around us have Earth-size planets in the habitable zone," says Matt Mountain, director and Webb telescope scientist at the Space Telescope Science Institute in Baltimore. "It's within our grasp to pull off a discovery that will change the world forever. It is going to take a continuing partnership between NASA, science, technology, the U.S. and international space endeavors, as exemplified by the James Webb Space Telescope, to build the next bridge to humanity's future."

This decade has seen the discovery of more and more super Earths, which are rocky planets that are larger and heftier than Earth. Finding smaller planets, the Earth twins, is a tougher challenge because they produce fainter signals. Technology to detect and image these Earth-like planets is being developed now for use with the future space telescopes. The ability to detect alien life may still be years or more away, but the quest is underway.

Said Mountain, "Just imagine the moment, when we find potential signatures of life. Imagine the moment when the world wakes up and the human race realizes that its long loneliness in time and space may be over -- the possibility we're no longer alone in the universe."

Last Updated: July 31, 2015

Editor: Brian Dunbar

Tags: Astrobiology, James Webb Space Telescope, Universe

Astrobiology

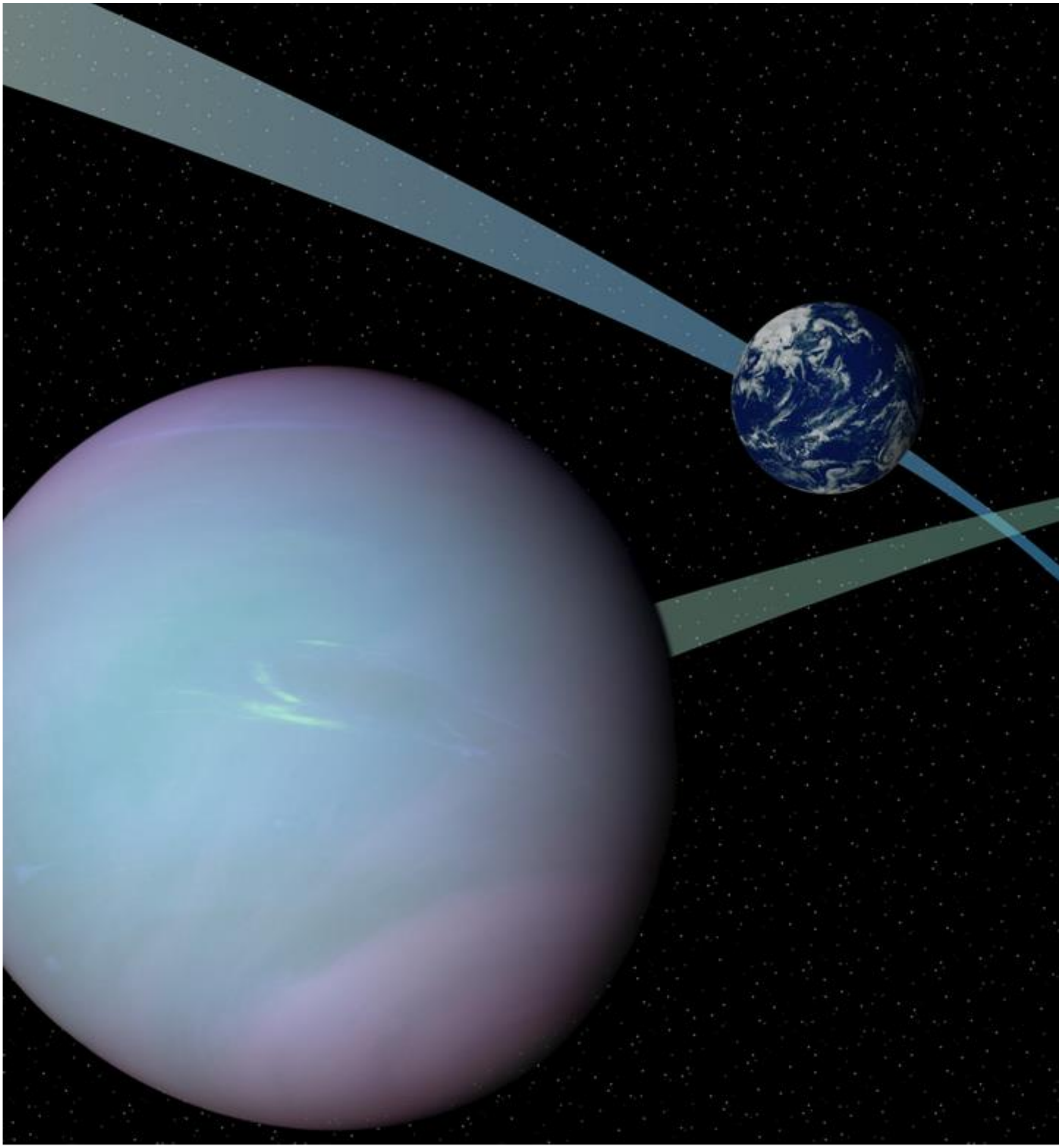
April 16, 2014

Odd Tilts Could Make More Worlds Habitable

Pivoting planets that lean one way and then change orientation within a short geological time period might be surprisingly habitable, according to new modeling by NASA and university scientists affiliated with the NASA Astrobiology Institute.

The climate effects generated on these wobbling worlds could prevent them from turning into glacier-covered ice lockers, even if those planets are somewhat far from their stars. And with some water remaining liquid on the surface long-term, such planets could maintain favorable conditions for life.

"Planets like these are far enough from their stars that it would be easy to write them off as frozen, and poor targets for exploration, but in fact, they might be well-suited to supporting life," said Shawn Domagal-Goldman, an astrobiologist at NASA's Goddard Space Flight Center in Greenbelt, Md. "This could expand our idea of what a habitable planet looks like and where habitable planets might be found."



Tilted orbits might make some planets wobble like a top that's almost done spinning, an effect that could maintain liquid water on the surface.

Credits: NASA's Goddard Space Flight Center

The new modeling considers planets that have the same mass as Earth, orbit a sun-like star and have one or two gas giants orbiting nearby. In some cases, gravitational pulls from those massive planets could change the orientation of the terrestrial world's axis of rotation within tens to hundreds of thousands of years – a blink of an eye in geologic terms.

Though it might seem far-fetched for a world to experience such see-sawing action, scientists have already spotted an arrangement of planets where this could happen, in orbit around the star Upsilon Andromedae. There, the orbits of two enormous planets were found to be inclined at an angle of 30 degrees relative to each other. (One planet was, as usual, farther from the star than the other planet.)

Compared to our solar system, that arrangement looks extreme. The orbits of Earth and its seven neighboring planets differ by 7 degrees at most. Even the tilted orbit of the dwarf planet Pluto, which really stands out, is offset by a relatively modest 17 degrees.

"Knowing that this kind of planetary system existed raised the question of whether a world could be habitable under such conditions," said Rory Barnes, a scientist at the University of Washington in Seattle who was part of the team that studied the orbits of the two Andromedae planets.

The habitability concept is explored in a paper published in the April 2014 issue of *Astrobiology* and available online now. John Armstrong of Weber State University in Ogden, Utah, led the team, which includes Barnes, Domagal-Goldman, and other colleagues.

The team ran thousands of simulations for planets in 17 varieties of simplified planetary systems. The models the researchers built allowed them to adjust the tilt of the planetary orbits, the lean in the axes of rotation, and the ability of the terrestrial planet's atmosphere to let in light.

In some cases, tilted orbits can cause a planet to wobble like a top that's almost done spinning – and that wobbling should have a big impact on the planet's glaciers and climate. Earth's history indicates that the amount of sunlight glaciers receive strongly affects how much they grow and melt. Extreme wobbling, like that seen in some models in this study, would cause the poles to point directly at the sun from time to time, melting the glaciers. As a result, some planets would be able to maintain liquid water on the surface despite being located nearly twice as far from their stars as Earth is from the sun.

"In those cases, the habitable zone could be extended much farther from the star than we normally expect," said Armstrong, the lead author of the paper. "Rather than working against habitability, the rapid changes in the orientation of the planet could turn out be a real boon sometimes."

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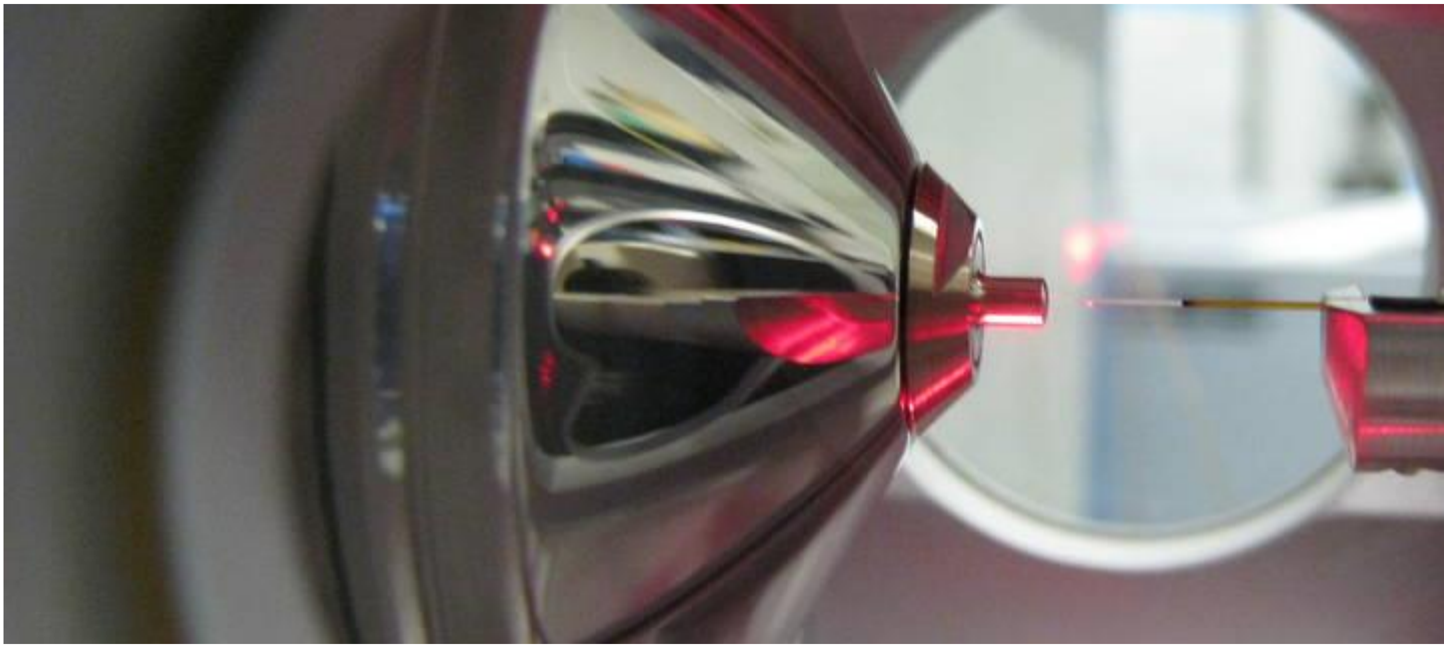
Last Updated: July 31, 2015

Editor: Rob Garner

Tags: Astrobiology, Distant Planets, Goddard Space Flight Center, Universe

Astrobiology



Feb. 4, 2014

New Technique Could Be Used to Search Space Dust for Life's Ingredients

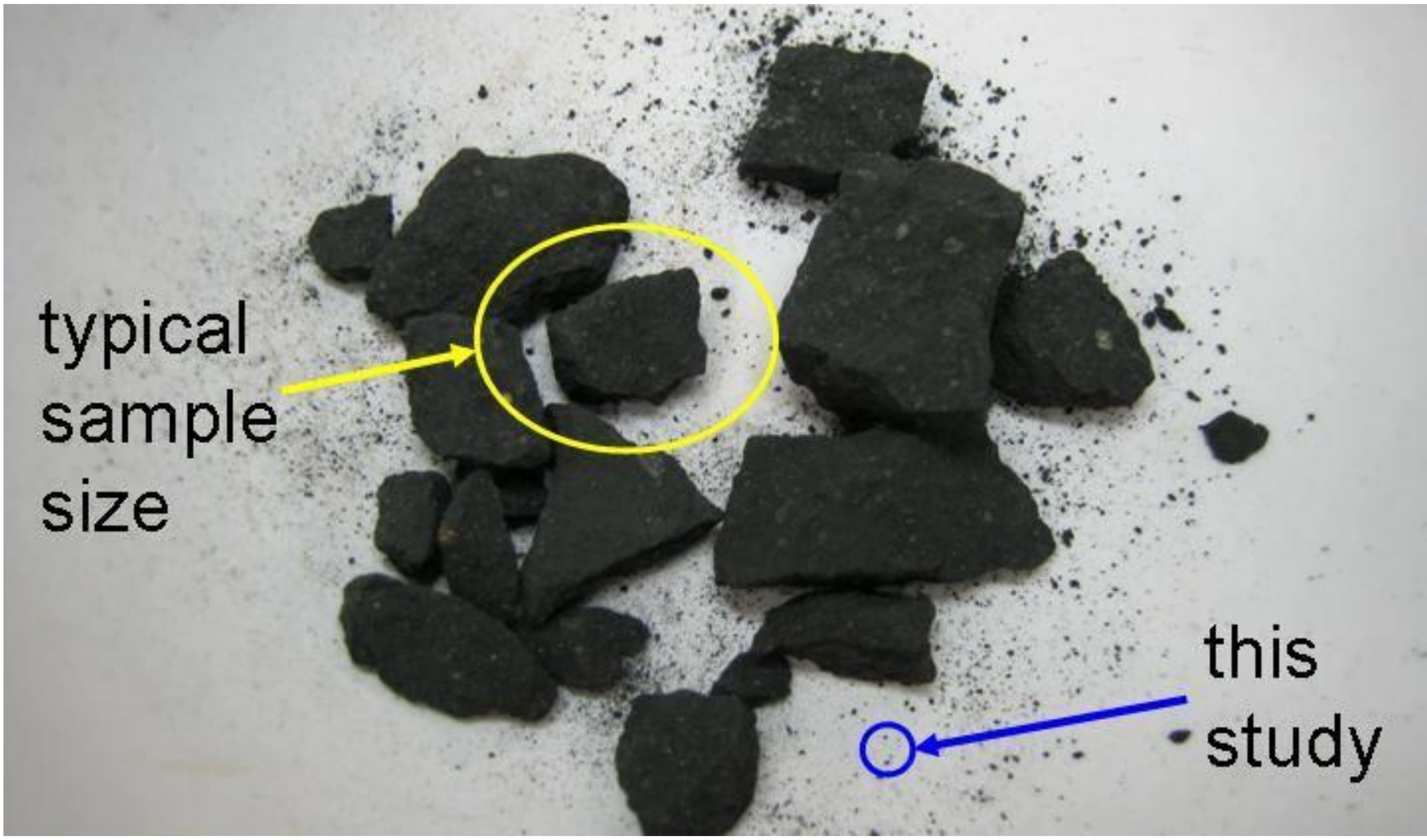
While the origin of life remains mysterious, scientists are finding more and more evidence that material created in space and delivered to Earth by comet and meteor impacts could have given a boost to the start of life. Some meteorites supply molecules that can be used as building blocks to make certain kinds of larger molecules that are critical for life.

Researchers have analyzed carbon-rich meteorites (carbonaceous chondrites) and found amino acids, which are used to make proteins. Proteins are among the most important molecules in life, used to make structures like hair and skin, and to speed up or regulate chemical reactions. They have also found components used to make DNA, the molecule that carries the instructions for how to build and regulate a living organism, as well as other biologically important molecules like nitrogen heterocycles, sugar-related organic compounds, and compounds found in modern metabolism.

However, these carbon-rich meteorites are relatively rare, comprising less than five percent of recovered meteorites, and meteorites make up just a portion of the extraterrestrial material that comes to Earth. Also, the building-block molecules found in them usually have been at low concentrations, typically parts-per-million or parts-per-billion. This raises the question of how significant their supply of raw material was. However, Earth constantly receives other extraterrestrial material – mostly in the form of dust from comets and asteroids.

"Despite their small size, these interplanetary dust particles may have provided higher quantities and a steadier supply of extraterrestrial organic material to early Earth," said Michael Callahan of NASA's Goddard Space Flight Center in Greenbelt, Md. "Unfortunately, there have been limited studies examining their organic composition, especially with regards to biologically relevant molecules that may have been important for the origin of life, due to the miniscule size of these samples."

Callahan and his team at Goddard's Astrobiology Analytical Laboratory have recently applied advanced technology to inspect extremely small meteorite samples for the components of life. "We found amino acids in a 360 microgram sample of the Murchison meteorite," said Callahan. "This sample size is 1,000 times smaller than the typical sample size used." A microgram is one-millionth of a gram; 360 micrograms is about the weight of a few eyebrow hairs**.** 28.35 grams equal an ounce.



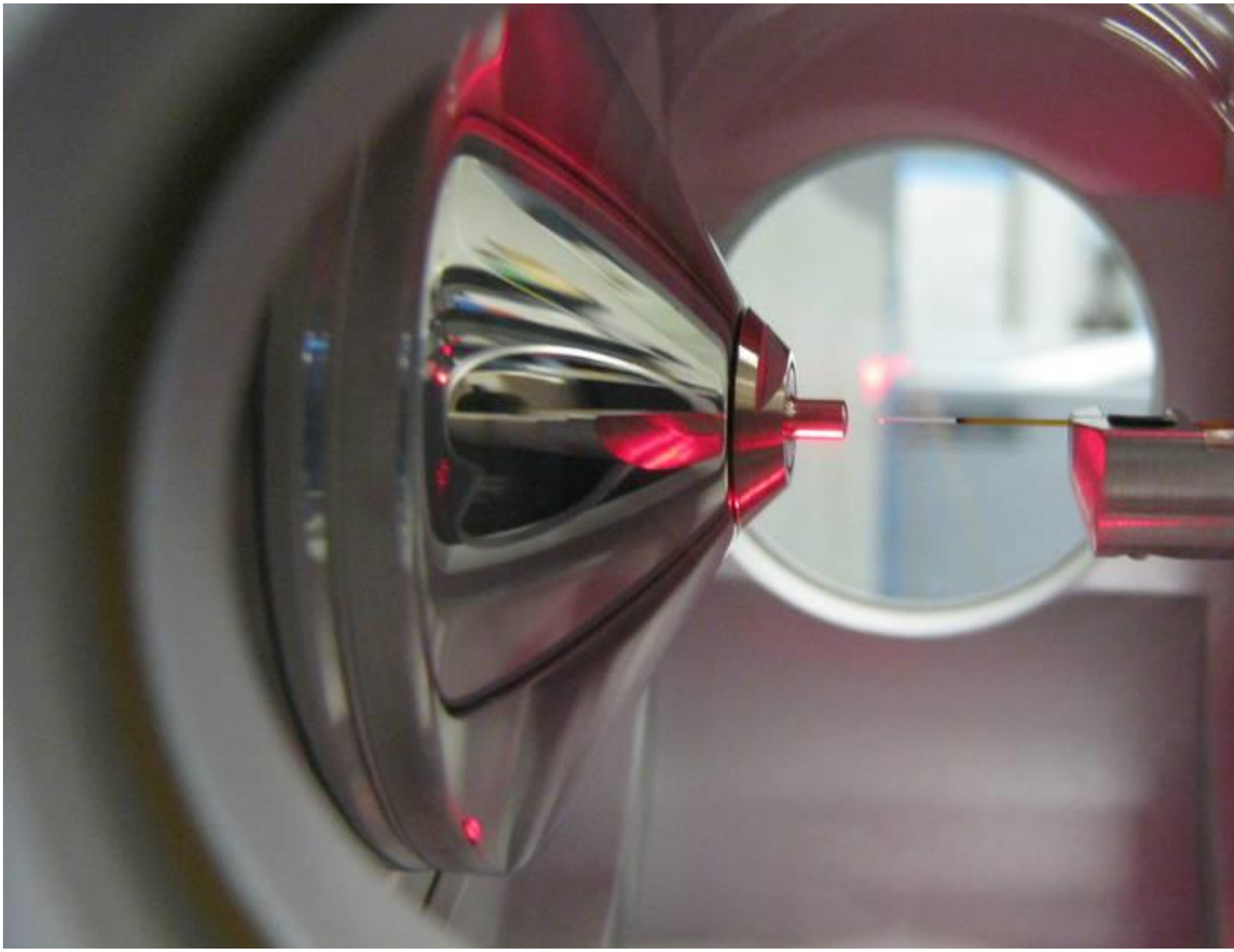
This photo compares the sample size typically used in meteorite studies (yellow oval) to the sample size used with the new equipment (blue circle) in Goddard's Astrobiology Analytical Laboratory.

Credits: Michael Callahan

"Our study was for proof-of-concept," adds Callahan. "Murchison is a well-studied meteorite. We got the same results looking at a very small fragment as we did a much larger fragment from the same meteorite. These techniques will allow us to investigate other small-scale extraterrestrial materials such as micrometeorites, interplanetary dust particles, and cometary particles in future studies." Callahan is lead author of a paper on this research available online in the Journal of Chromatography A.

Analyzing such tiny samples is extremely challenging. "Extracting much less meteorite powder translates into having much lower amino acid concentration for analyses," said Callahan. "Therefore we need the most sensitive techniques available. Also, since meteorite samples can be highly complex, techniques that are highly specific for these compounds are necessary too."

The team used a nanoflow liquid chromatography instrument to sort the molecules in the meteorite sample, then applied nanoelectrospray ionization to give the molecules an electric charge and deliver them to a high-resolution mass spectrometer instrument, which identified the molecules based on their mass. "We are pioneering the application of these techniques for the study of meteoritic organics," said Callahan. "These techniques can be highly finicky, so just getting results was the first challenge."



This equipment is used by Goddard's Astrobiology Analytical Lab to analyze very small samples. On the right is the nanoelectrospray emitter, which gives sample molecules an electric charge and transfers them to the inlet of the mass spectrometer (left), which identifies the molecules by their mass.

Credits: Michael Callahan

"I'm particularly interested in analyzing cometary particles from the Stardust mission," adds Callahan. "It's one of the reasons why I came to NASA. When I first saw a photo of the aerogel used to capture particles for the Stardust mission, I was hooked."

"This technology will also be extremely useful to search for amino acids and other potential chemical biosignatures in samples returned from Mars and eventually plume materials from the outer planet icy moons Enceladus and Europa," said Daniel Glavin of the Astrobiology lab at Goddard, a co-author on the paper.

This technology and the laboratory techniques that the Goddard lab develops to apply it to analyze meteorites will be valuable for future sample-return missions since the amount of sample likely will be limited. "Missions involving the collection of extraterrestrial material for sample return to Earth usually collect only a very small amount and the samples themselves can be extremely small as well," said Callahan. "The traditional techniques used to study these materials usually involve inorganic or elemental composition. Targeting biologically relevant molecules in these samples is not routine yet. We are not there either, but we are getting there."

The research was funded by the NASA Astrobiology Institute, the Goddard Center for Astrobiology and the NASA Cosmochemistry Program.

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Last Updated: July 31, 2015

Editor: Bill Steigerwald

Tags: Astrobiology, Goddard Space Flight Center, Science Instruments, Technology, Universe

MAVEN

Nov. 14, 2013

NASA Video Illustrates MAVEN Mission's Investigation of a Lost Mars

NASA has prepared a new video to illustrate its Mars Atmosphere and Volatile Evolution (MAVEN) mission's investigation of dramatic climate change on Mars. Today, Mars is a cold and barren desert world, with no sign of life, at least on the surface. However, billions of years ago when the Red Planet was young, it appears to have had a thick atmosphere that was warm enough to support oceans of liquid water – a critical ingredient for life.

This video is an artist's concept showing the transition from an ancient, habitable Mars capable of supporting liquid water on its surface to the cold desert world of today.

Credits: Michael Lentz/NASA Goddard Conceptual Image Lab

Download this video in HD formats from NASA Goddard's Scientific Visualization Studio

Liquid water cannot exist pervasively on the Martian surface today due to the low atmospheric pressure and surface temperature, although there is evidence for spurts of liquid flow that perhaps consist of a briny solution with reduced freezing temperature, according to Joseph Grebowsky of NASA's Goddard Space Flight

Center in Greenbelt, Md. Water under current Martian atmospheric conditions can be ice or sublimate directly into vapor without staying in a liquid phase. Grebowsky is the project scientist for the mission.

The video shows how the surface of Mars might have appeared during this ancient clement period, beginning with a flyover of a Martian lake. The artist's concept is based on evidence that Mars was once very different.

Surface features and mineral compositions suggest ancient Mars had a denser atmosphere and liquid water on its surface, according to Grebowsky. "There are characteristic dendritic structured channels that, like on Earth, are consistent with surface erosion by water flows. The interiors of some impact craters have basins suggesting crater lakes, with many showing connecting channels consistent with water flows into and out of the crater. Small impact craters have been removed with time and larger craters show signs of erosion by water before 3.7 billion years ago. And sedimentary layering is seen on valley walls. Minerals are present on the surface that can only be produced in the presence of liquid water, e.g., hematite and clays," said Grebowsky.

Estimates of the amount of water needed to explain these features have been made that equated to possibly as much as a planet-wide layer one-half a kilometer (1,640 feet) deep or more, according to Grebowsky. If liquid surface water existed in the past, then Mars' atmosphere had to have had a different climate that was warmer and a pressure near or greater than the current terrestrial atmospheric pressure at the surface.

This is an artist's concept of an ancient, habitable Mars capable of supporting liquid water on its surface.

Credits: Michael Lentz/NASA Goddard Conceptual Image Lab

In the video, rapidly moving clouds are employed to suggest the passage of time, and the shift from a warm and wet to a cold and dry climate is shown as the video progresses. The lakes dry up and freeze over, while the atmosphere gradually transitions from Earthlike blue skies to the dusty pink and tan hues seen on Mars today.

This is an artist's concept of present-day Mars -- a barren, cold, desert world.

Credits: Michael Lentz/NASA Goddard Conceptual Image Lab

It's unknown if the habitable climate lasted long enough for life to emerge on Mars. "The only direct evidence for life early in the history of a planet's evolution is that on Earth," said Grebowsky. "The earliest evidence for terrestrial life is the organic chemical structure of a rock found on the surface in Greenland. The surface was thought to be from an ancient sea floor sediment. The age of the rock was estimated to be 3.8 billion years, 700 million years from the Earth's creation. No fossil evidence of life has yet been found from this period. The oldest claimed micro-fossils (found in Western Australia) date to 3.5 billion years ago. The existence of a potential life-nurturing climate on Mars ended near these times. A comparison between the two planet's life histories must be done with caution, due to the different chemical compositions of the surfaces (e.g., Mars' chemistry may have been more suitable early on than Earth's) and different volcanic and meteoroid impact histories. Also, the histories of life on either planet may not have been continuous. Catastrophic events could have killed off all life at one time only to have it start anew."

The video ends with an illustration of NASA's MAVEN mission in orbit around present-day Mars. MAVEN will investigate how Mars lost its atmosphere. Scheduled to be launched in November, it will arrive at Mars in September 2014.

There are several theories of how Mars was stripped of its thick atmosphere. "Hydrodynamic outflow and ejection from massive asteroid impacts during the later heavy bombardment period (ending 4.1 billion to 3.8 billion years ago) were early processes removing part of the atmosphere, but these were not prominent loss processes afterwards," said Grebowsky. "The leading theory is that Mars lost its intrinsic magnetic field that was protecting the atmosphere from direct erosion by the impact of the solar wind."

The solar wind is a thin stream of electrically charged particles (plasma) blowing continuously from the sun into space at about a million miles per hour. "The interaction of the atmosphere with the solar wind leads to escape by sputtering of atoms and molecules out of the atmosphere, electromagnetic loss process of the planet's ionospheric particles, direct escape of hot plasma particles or by chemical processes that produce atoms with escape speeds," said Grebowsky.

"Studies of the remnant magnetic field distributions measured by NASA's Mars Global Surveyor mission set the disappearance of the planet's convection-produced global magnetic field at about 3.7 billion years ago, leaving the Red Planet vulnerable to the solar wind," said Grebowsky.

"MAVEN has been designed to measure the escape rates for all the applicable processes and will be able to single out the most prominent," said Grebowsky. It will also work with other missions to examine the past habitability of Mars. "Previous remote Mars observations from orbiting spacecraft have observed the geological features that have been used to estimate the amount of water that did exist and have analyzed the global distribution of water ice and surface chemistry to infer that water was lost through time. Mars Curiosity rover has the ability to analyze the chemical composition of the solid surface, which contains information of the atmospheric composition during the formation of the planet, in particular the isotope ratios, the lower atmosphere composition, and the current gas exchange with surface reservoirs. MAVEN is going to measure the current rates of loss to space and the controlling processes. Given the lower-atmosphere information and the nature of the escaping processes, one can extrapolate from current conditions into the climate of the past," said Grebowsky.

The video is one of the most complex animations ever produced by NASA's Conceptual Image Lab, located at Goddard. "We have a lot going on in this," said Michael Lentz of Universities Space Research Association, lead animator on the project. "We have time-lapse clouds happening, the atmosphere and terrain are changing, the water is evaporating away."

Adding to the complexity is the incredibly detailed terrain. Close to three billion polygons – the basic building blocks of computer-generated scenery -- were used, compared to hundreds of thousands for a typical animation, according to Lentz. "We also used a wide Cinemascope aspect ratio to better showcase the landscape. All this stuff wreaks havoc on the computer system in terms of trying to figure out how to render it."

"Rendering is the process by which a computer calculates how to paint a scene, and things like the presence of water increase the complexity of the computations tremendously. The computer has to calculate how the light is hitting the water, how it reflects off the water, how it distorts what's under the water and is refracted by the water. We also used global illumination, a technique to give really realistic outdoor lighting so you don't have intense, sharp black shadows. You have a lot of bounce coming off, so if you have sunlight hitting one side of a canyon, that light then is reflected to the other side, so you're not going to get a black shadow there, you will instead get some of the color off the wall from where the sunlight is reflecting," said Lentz.

This is an artist's concept of water flowing through a canyon on ancient Mars.

Credits: Michael Lentz/NASA Goddard Conceptual Image Lab

To complete the animation, the team augmented their existing "render farm" – a computer network -- with retired supercomputers. "The NASA Center for Climate Simulation is upstairs from our lab, and they routinely upgrade their supercomputers. We got their old machines and now have this new capability to create ultra-high resolution (4K) animations for a fraction of the cost of new machines, all thanks to this complex MAVEN video project," said Lentz.

"It's been a fun process despite all the hard work with it," said Lentz. "It was really cool working with MAVEN Principal Investigator Bruce Jakosky, talking to him about what MAVEN is going to do and envisioning what Mars may have looked like with flowing water on the surface and things like that. To hear him talk about that and see how excited he is to get MAVEN off the ground got me really excited to be working on the piece for him. Now after working on it for so long, I'm excited to get the video out there and have more people see it. So far, it's just been shown to a handful of people on the project."

MAVEN's principal investigator is based at the University of Colorado Laboratory for Atmospheric and Space Physics in Boulder. The university provides science instruments and leads science operations, education and public outreach. Goddard manages the project and provides two of the science instruments for the mission. Lockheed Martin built the spacecraft and is responsible for mission operations. The University of California at Berkeley's Space Sciences Laboratory provides science instruments for the mission. NASA's Jet Propulsion Laboratory in Pasadena, Calif., provides navigation support, Deep Space Network support, and Electra telecommunications relay hardware and operations.

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Last Updated: July 31, 2015

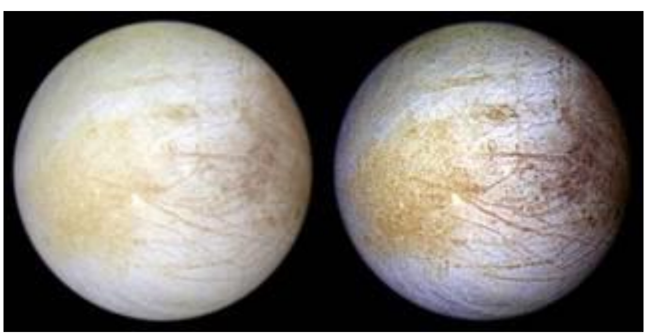
Editor: Bill Steigerwald

Tags: Astrobiology, Goddard Space Flight Center, Mars, MAVEN (Mars Atmosphere and Volatile Evolution), Solar System

Astrobiology

April 5, 2013

Mapping the Chemistry Needed for Life at Europa



This color composite view combines violet, green, and infrared images of Jupiter's intriguing moon, Europa, for a view of the moon in natural color (left) and in enhanced color designed to bring out subtle color differences in the surface (right).

Credits: NASA/JPL-Caltech/University of Arizona

Full image and caption

A new paper led by a NASA researcher shows that hydrogen peroxide is abundant across much of the surface of Jupiter's moon Europa. The authors argue that if the peroxide on the surface of Europa mixes into the ocean below, it could be an important energy supply for simple forms of life, if life were to exist there. The paper was published online recently in the Astrophysical Journal Letters.

"Life as we know it needs liquid water, elements like carbon, nitrogen, phosphorus and sulfur, and it needs some form of chemical or light energy to get the business of life done," said Kevin Hand, the paper's lead author, based at NASA's Jet Propulsion Laboratory, Pasadena, Calif. "Europa has the liquid water and elements, and we think that compounds like peroxide might be an important part of the energy requirement. The availability of oxidants like peroxide on Earth was a critical part of the rise of complex, multicellular life."

The paper, co-authored by Mike Brown of the California Institute of Technology in Pasadena, analyzed data in the near-infrared range of light from Europa, using the Keck II Telescope on Mauna Kea, Hawaii, over four nights in September 2011. The highest concentration of peroxide found was on the side of Europa that always leads in its orbit around Jupiter, with a peroxide abundance of 0.12 percent relative to water. (For perspective, this is roughly 20 times more diluted than the hydrogen peroxide mixture available at drug stores.) The concentration of peroxide in Europa's ice then drops off to nearly zero on the hemisphere of Europa that faces backward in its orbit.

Hydrogen peroxide was first detected on Europa by NASA's Galileo mission, which explored the Jupiter system from 1995 to 2003, but Galileo observations were of a limited region. The new results show that peroxide is widespread across much of the surface of Europa, and the highest concentrations are reached in regions where Europa's ice is nearly pure water with very little sulfur contamination. The peroxide is created by the intense radiation processing of Europa's surface ice that comes from the moon's location within Jupiter's strong magnetic field.

"The Galileo measurements gave us tantalizing hints of what might be happening all over the surface of Europa, and we've now been able to quantify that with our Keck telescope observations," Brown said. "What we still don't know is how the surface and the ocean mix, which would provide a mechanism for any life to use the peroxide."

The scientists think hydrogen peroxide is an important factor for the habitability of the global liquid water ocean under Europa's icy crust because hydrogen peroxide decays to oxygen when mixed into liquid water. "At Europa, abundant compounds like peroxide could help to satisfy the chemical energy requirement needed for life within the ocean, if the peroxide is mixed into the ocean," said Hand.

The study was funded in part by the NASA Astrobiology Institute through the Icy Worlds team based at JPL, a division of Caltech. The NASA Astrobiology Institute, based at NASA's Ames Research Center, Moffett Field, Calif., is a partnership among NASA, 15 U.S. teams and 13 international consortia. The Institute is part of NASA's astrobiology program, which supports research into the origin, evolution, distribution and future of life on Earth and the potential for life elsewhere.

Last Updated: July 31, 2015

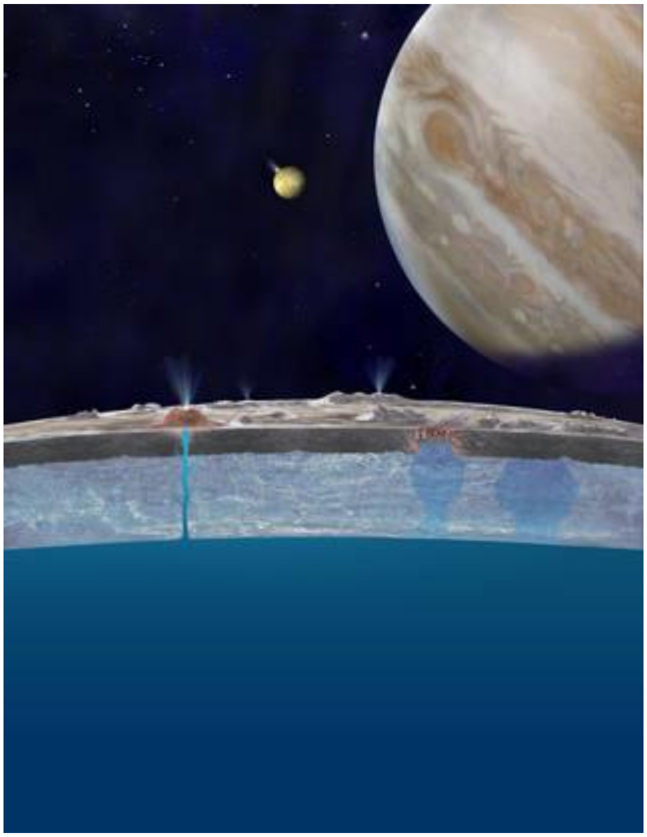
Editor: NASA Administrator

Tags: **Astrobiology**, **Europa (Moon)**, **Moons**, **Solar System**

Solar System and Beyond

March 6, 2013

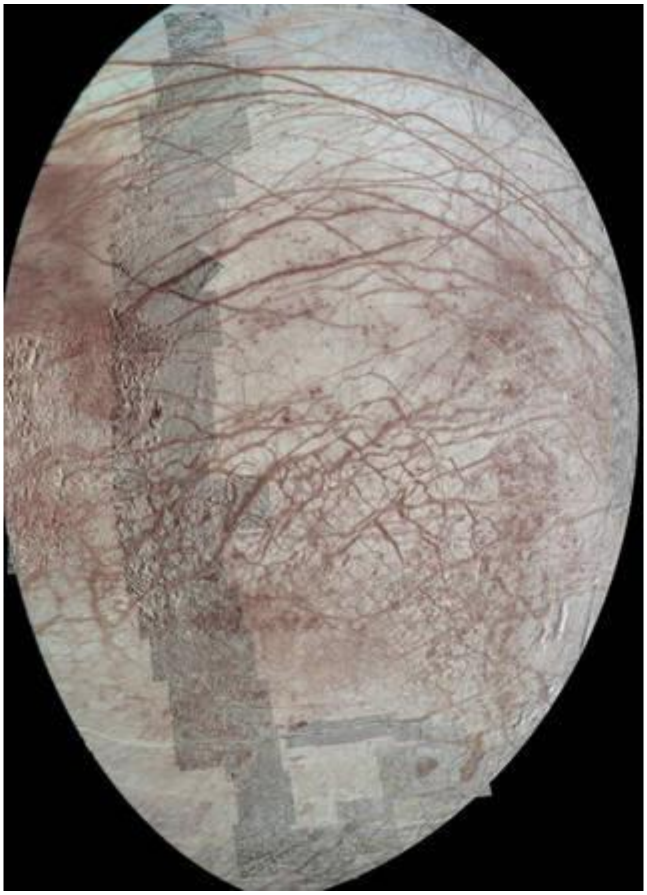
A Window into Europa's Ocean Right at the Surface



This illustration of Europa (foreground), Jupiter (right) and Io (middle) is an artist's concept.

Credits: NASA/JPL-CalTech

Full image and caption



This view of Jupiter's moon Europa features several regional-resolution mosaics overlaid on a lower resolution global view for context.

Credits: NASA/JPL-Caltech/University of Arizona

Full image and caption

If you could lick the surface of Jupiter's icy moon Europa, you would actually be sampling a bit of the ocean beneath. A new paper by Mike Brown, an astronomer at the California Institute of Technology in Pasadena, Calif., and Kevin Hand from NASA's Jet Propulsion Laboratory, also in Pasadena, details the strongest evidence yet that salty water from the vast liquid ocean beneath Europa's frozen exterior actually makes its way to the surface.

The finding, based on some of the best data of its kind since NASA's Galileo mission (1989 to 2003) to study Jupiter and its moons, suggests there is a chemical exchange between the ocean and surface, making the ocean a richer chemical environment. The work is described in a paper that has been accepted for publication in the Astronomical Journal.

The exchange between the ocean and the surface, Brown said, "means that energy might be going into the ocean, which is important in terms of the possibilities for life there. It also means that if you'd like to know what's in the ocean, you can just go to the surface and scrape some off."

Europa's ocean is thought to cover the moon's whole globe and is about 60 miles (100 kilometers) thick under a thin ice shell. Since the days of NASA's Voyager and Galileo missions, scientists have debated the composition of Europa's surface. The infrared spectrometer aboard Galileo was not capable of providing the detail needed to identify definitively some of the materials present on the surface. Now, using the Keck II Telescope on Mauna Kea, Hawaii, and its OSIRIS spectrometer, Brown and Hand have identified a spectroscopic feature on Europa's surface that indicates the presence of a magnesium sulfate salt, a mineral called epsomite, that could have formed by oxidation of a mineral likely originating from the ocean below.

Brown and Hand started by mapping the distribution of pure water ice versus anything else. The spectra showed that even Europa's leading hemisphere contains significant amounts of non-water ice. Then, at low latitudes on the trailing hemisphere-the area with the greatest concentration of the non-water ice material-they found a tiny, never-before-detected dip in the spectrum.

The two researchers tested everything from sodium chloride to Drano in Hand's lab at JPL, where he tries to simulate the environments found on various icy worlds. At the end of the day, the signature of magnesium sulfate persisted.

The magnesium sulfate appears to be generated by the irradiation of sulfur ejected from the Jovian moon Io and, the authors deduce, magnesium chloride salt originating from Europa's ocean. Chlorides such as sodium and potassium chlorides, which are expected to be on the Europa surface, are in general not detectable because they have no clear infrared spectral features. But magnesium sulfate is detectable. The authors believe the composition of Europa's ocean may closely resemble the salty ocean of Earth.

Europa is considered a premier target in the search for life beyond Earth, Hand said. A NASA-funded study team led by JPL and the Johns Hopkins University Applied Physics Laboratory, Laurel, Md., has been working with the scientific community to identify options to explore Europa further. "If we've learned anything about life on Earth, it's that where there's liquid water, there's generally life," Hand said. "And of course our ocean is a nice, salty ocean. Perhaps Europa's salty ocean is also a wonderful place for life."

The work was supported, in part, by the NASA Astrobiology Institute through the Icy Worlds team based at JPL, a division of Caltech. The NASA Astrobiology Institute, based at NASA's Ames Research Center, Moffett Field, Calif., is a partnership among NASA, 15 U.S. teams, and 13 international consortia. The NAI is part of NASA's Astrobiology program, which supports research into the origin, evolution, distribution and future of life on Earth and the potential for life elsewhere.

Last Updated: July 31, 2015

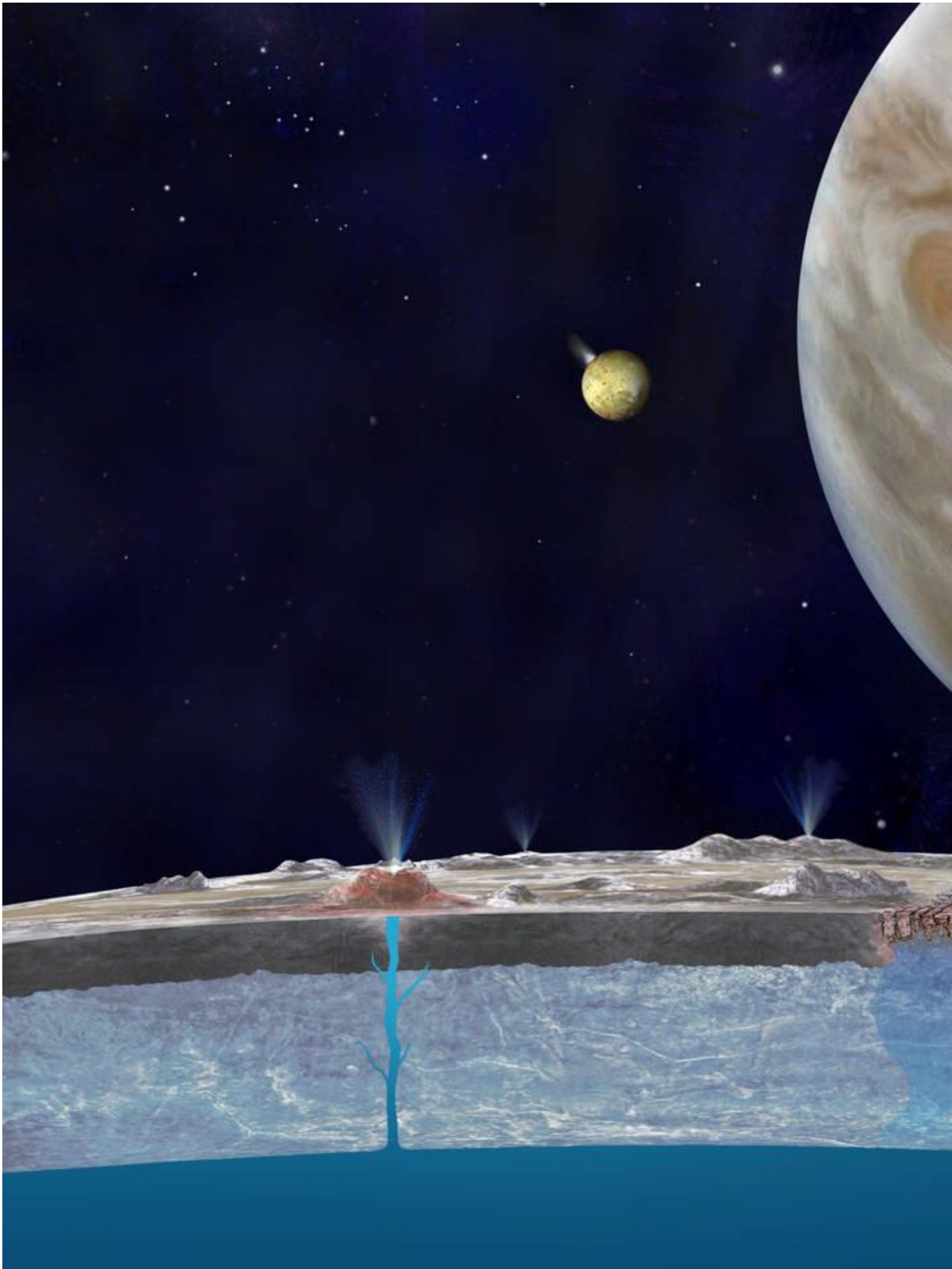
Editor: NASA Administrator

Tags: Astrobiology, Europa (Moon), Jupiter, Moons, Solar System

Astrobiology

March 6, 2013

Taste of the Ocean on Europa's Surface



Based on new evidence from Jupiter's moon Europa, astronomers hypothesize that chloride salts bubble up from the icy moon's global liquid ocean and reach the frozen surface where they are bombarded with sulfur from volcanoes on Jupiter's innermost large moon Io. The new findings propose answers to questions that have been debated since the days of NASA's Voyager and Galileo missions. This illustration of Europa (foreground), Jupiter (right) and Io (middle) is an artist's concept.

Image Credit: NASA/JPL-Caltech

Last Updated: July 31, 2015

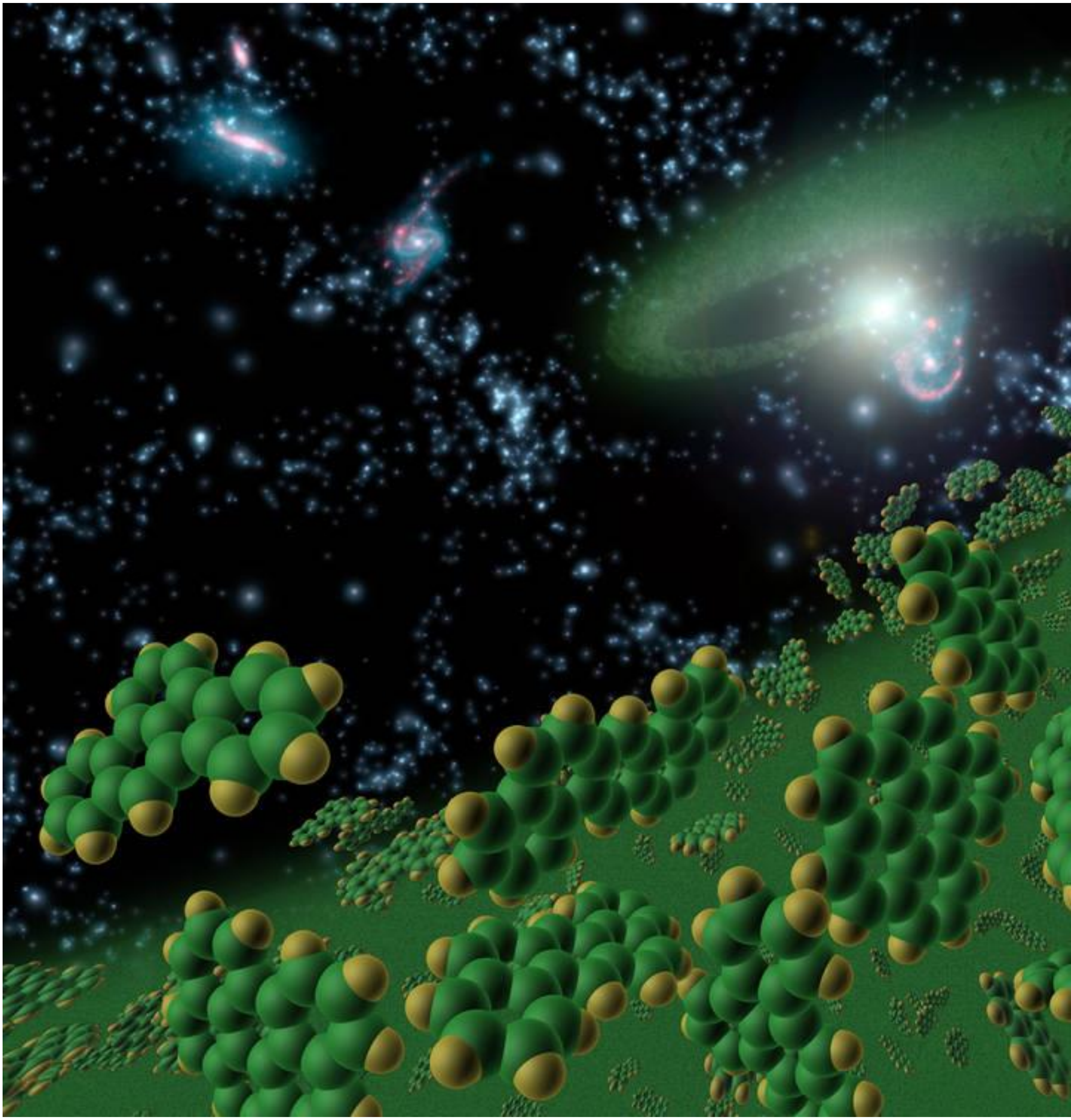
Editor: NASA Administrator

Tags: Astrobiology, Europa (Moon), Moons, Solar System

Spitzer Telescope

March 24, 2008

Ingredients for Life



This artist's conception symbolically represents complex organic molecules, known as polycyclic aromatic hydrocarbons, seen in the early universe. These large molecules, comprised of carbon and hydrogen, are among the building blocks of life. NASA's Spitzer Space Telescope is the first telescope to see polycyclic aromatic hydrocarbons so early-10 billion years further back in time than seen previously. Spitzer detected these molecules in galaxies when our universe was one-fourth of its current age of about 14 billion years. These complex molecules are very common on Earth and form carbon-based materials are not burned completely. They can be found in sooty exhaust from cars and airplanes, and in charcoal broiled hamburgers and burnt toast. Polycyclic aromatic hydrocarbons are pervasive in galaxies like our own Milky Way, and play a significant role in star and planet formation.

Image Credit: NASA/JPL-Caltech/T. Pyle (SSC)

Last Updated: Dec. 16, 2015

Editor: NASA Administrator

Tags: Astrobiology, Spitzer Space Telescope, Universe