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1. Plants Use Sixth Sense for Growth Aboard the Space Station

Although it is arguable as to whether plants have all five human senses – sight, scent, hearing, taste and touch – they do have a unique sense of gravity, which is being tested in space. Researchers with the Japan Aerospace Exploration Agency will conduct a second run of the Plant Gravity Sensing study after new supplies are delivered by the sixth SpaceX commercial resupply mission to the International Space Station. The research team seeks to determine how plants sense their growth direction without gravity. The study results may have implications for higher crop yield in farming and for cultivating plants for long-duration space missions.

The investigation examines the cellular process of formation in thale cress, or Arabidopsis thaliana, a small flowering plant related to cabbage. The genetic makeup of thale cress is simple and well-understood by the plant biology community. This knowledge allows scientists to easily recognize changes that occur as a result of microgravity adaptation.

Understanding the cellular processes in plant development may translate to better knowledge of cellular processes in the human body. Since thale cress is considered a model organism for biological research, there are genetic similarities that may reveal insights into our health. Specifically, this could impact medical science since research teams may gain a better understanding of mechanisms of diseases affected by gravity, such as osteoporosis and muscle loss.

In the Plant Gravity Sensing study, scientists examine whether the mechanisms of the plant that determine its growth direction – the gravity sensor – form in the absence of gravity. Specifically, the research team analyzes how concentrations of calcium behave in the cells of plants originally grown in microgravity when later exposed to a 1g environment, or gravity similar to that on Earth. Plant calcium concentrations have been shown to change in response to temperature and touch and adapt to the direction of gravity on Earth.

“Plants cultivated in space are not experienced with gravity or the direction of gravity and may not be able to form gravity sensors that respond to the specific direction of gravity changes,” said Hitoshi Tatsumi, Ph.D., principal investigator of the Plant Gravity Sensing investigation and associate professor at Nagoya University in Nagoya (present address: Kanazawa Institute of Technology), Japan.

Researchers use a centrifuge in the Cell Biology Experiment Facility in Kibo, the Japanese Experiment Module, to monitor the plants’ response to changes between microgravity and a simulated 1g condition. The research team does this to determine if the plants sense changes in gravitational acceleration and adapt the levels of calcium in their cells.
Scientists hypothesize that the process in which amyloplast—particles within the plant cell that store and synthesize starch for energy—distributes and assembles occurs in the direction of gravitational pull. Once the amyloplast settles, it activates mechanisms within the plant’s cells, including an increase in calcium concentrations. These mechanisms form the molecular structure in the cell that stimulates gravity sensing for growth. The unknown here is whether or not the gravity sensing components actually assemble in microgravity to determine direction of plant growth.

If the study hypothesis is proven true, it may be possible to modify plant gravity sensing mechanisms on Earth or to cultivate healthy plants for consumption on future deep space missions or conceivably on other planets. The plant’s gravity sensor may be regulated for growth in either a low or high magnitude of gravitational acceleration.

“We may design plants that respond to gravity vector changes more efficiently than wild ones,” said Tatsumi. “These plants will recover from collapse by winds or flood more rapidly than wild ones. Thus, the agricultural output of the designed plants will be greatly increased, which may solve, in part, the shortage of crops in the near future.”

It makes “sense” why researchers are interested in thale cress and what it may reveal off the Earth for the Earth. Research aboard the space station may illuminate the mystery of a plant’s “sixth sense,” literally turning plant gravity sensing research on its head.

Source: NASA
Using archival data from the Japan-led Suzaku X-ray satellite, astronomers have determined the pre-explosion mass of a white dwarf star that blew up thousands of years ago.

The measurement strongly suggests the explosion involved only a single white dwarf, ruling out a well-established alternative scenario involving a pair of merging white dwarfs.

"Mounting evidence indicates both of these mechanisms produce what we call type Ia supernovae," said lead researcher Hiroya Yamaguchi, an astrophysicist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "To understand how these stars explode, we need to study the debris in detail with sensitive instruments like those on Suzaku."

The researchers analyzed archival observations of a supernova remnant named 3C 397, which is located about 33,000 light-years away in the constellation Aquila. Astronomers estimate this cloud of stellar debris has been expanding for between 1,000 and 2,000 years, making 3C 397 a middle-aged remnant.

The team made clear detections of elements crucial to weighing the white dwarf using data from Suzaku's X-ray Imaging Spectrometer. The observation, made in October 2010 at energies between 5,000 and 9,000 electron volts, provided a total effective exposure of 19 hours.

Infrared data from NASA's Spitzer Space Telescope provided insight into the amount of gas and dust the expanding remnant has gathered up as it drives into interstellar space. The observations, from April 2005, indicate 3C 397 has swept up a mass some 18 times greater than the original white dwarf. As a result, the team concludes that shock waves have thoroughly heated the remnant's innermost parts.
Most low- and medium-mass stars similar to the sun will end their days as white dwarfs. A typical white dwarf is about as massive as our sun yet roughly the size of Earth. This makes white dwarfs among the densest objects scientists know of, surpassed only by neutron stars and black holes.

"White dwarfs remain stable as long as they never tip the scales too closely to 1.4 solar masses," said team member Carles Badenes, an assistant professor in the Department of Physics and Astronomy at the University of Pittsburgh in Pennsylvania. "White dwarfs near this limit are on the verge of a catastrophic explosion. All it takes is a little more mass."

Until recently, astronomers thought the most likely way for a white dwarf to gain mass would be as a member of a close binary system with a normal sun-like star. By accumulating matter from its companion, the white dwarf can, over millions of years, nudge itself closer to the limit and explode. The companion stars are expected to survive, but astronomers find scant evidence for them, suggesting the need for an alternative model. In the merger scenario, the blast is triggered by a pair of lower-mass white dwarfs, whose orbits tighten over time until they eventually merge and explode.

"We can distinguish which of these scenarios is responsible for a given supernova remnant by tallying the nickel and manganese in the expanding cloud," said Goddard astrophysicist Brian Williams. "An explosion from a single white dwarf near its mass limit will produce significantly different amounts of these elements than a merger."

The team also measured iron and chromium, which are produced in all type Ia explosions, as a way to standardize their calculations.

The study, which was published March 12 in The Astrophysical Journal Letters, is part of a continuing program of Suzaku research aimed at helping astronomers better understand the diversity of type Ia supernovae, an important class of stellar explosion used in probing the distant universe. This finding shows that at least some type Ia supernovae must have surviving stellar companions, and the team emphasizes that the search for these stars should continue.

Launched on July 10, 2005, Suzaku was developed at the Japanese Institute of Space and Astronautical Science (ISAS), which is part of the Japan Aerospace Exploration Agency (JAXA), in collaboration with NASA and other Japanese and U.S. institutions.

Source: Spaceref.com
New NASA data find the snowpack in the Tuolumne River Basin in California's Sierra Nevada -- a major source of water for millions of Californians -- currently contains just 40 percent as much water as it did near this time at its highest level of 2014, one of the two driest years in California's recorded history. The data were acquired through a partnership with the California Department of Water Resources, the San Francisco Public Utilities Commission and the Turlock and Modesto irrigation districts.

In its first springtime acquisition of the year, NASA's Airborne Snow Observatory quantified the total volume of water contained within the Tuolumne River Basin snowpack on March 25. The observatory data revealed that the amount of water in the mountain snowpack on that date was 74,000 acre-feet, or 24 billion gallons. This is about 40 percent of the maximum snow water content the observatory measured near this time last year, which was 179,000 acre-feet. This is the third year of Airborne Snow Observatory operations.

The Tuolumne Basin is a water supply for the Turlock and Modesto irrigation districts and the Hetch Hetchy Regional Water System, which serves San Francisco and neighboring communities. The observatory's first-ever wintertime acquisitions in mid-February and early March measured volumes of 82,000 acre-feet and 112,000 acre-feet (62 percent of last year's peak), respectively.

In contrast to data released today by California's Department of Water Resources on snowpack percentage at the state's snow courses (marked locations where manual snow measurements are made), Airborne Snow Observatory data instead provide the actual volumes of water in the mountain snowpack.

In normal years, snowfall supplies about 70 percent of California's annual precipitation, melting in the spring and early summer. The greater the snowpack water content, the greater the likelihood California's reservoirs will receive ample runoff as the snowpack melts to meet the state's water demand in the summer and fall.

Airborne Snow Observatory Principal Investigator Tom Painter of NASA's Jet Propulsion Laboratory in Pasadena, California, said the NASA data give water managers near-real-time information on how much water they can expect to flow from the mountains during California's ongoing drought, now in its fourth and most intense year.

"A mountain's snowpack is like a giant TV screen, where each pixel in the image varies but blends together with the others to make up a picture," said Painter. "For the past century, we've estimated mountain snowpack by looking at just a few pixels of the screen -- that is, a few sparse ground measurements in each watershed basin. During an intense drought like this one, most of the pixels on the screen are blank -- that is, they're snow-free. NASA's Airborne Snow Observatory is able to measure the snowpack in every pixel of the screen that still has snow, and put together a complete picture of how little actual snow there is."

Hetch Hetchy Reservoir operator Adam Mazurkiewicz said Airborne Snow Observatory data are allowing the reservoir to move into a new era of water knowledge. "This information is being used to improve modeling estimates of future water runoff," he said. "Improvements in runoff forecasting will guide more efficient
system operations and water usage, not just in the drought years that we are currently experiencing, but also in future times of flooding and even normal conditions.”

“It looks from our snow courses and pillows that statewide, we have about half or less of the lowest April 1 snowpack on record,” said Frank Gehrke, chief of the California Cooperative Snow Surveys. “Airborne Snow Observatory data on snow water volume don't represent newly-found water; rather, they provide a new ability to inform our constituents how much water is there and how its volume is changing week to week.”

The California Department of Water Resources currently uses a combination of manual surveys of Sierra Nevada snow courses and data from electronic sensors planted in the ground called snow pillows. While these methods are highly accurate, the snow courses and pillows are sparsely located, and the available data do not allow water managers to know exactly how much water presently lies in the mountain snowpack.

As of this date, four of six snow pillows in the Tuolumne Basin are already lacking snow, providing no direct assessment of the remaining snowpack in the basin. Statewide, 88 of the 123 total snow pillows are snow-free. Normally at this time of year, snow accumulations are at their peak, and the vast majority of these pillows still have snow.

Painter points out that while the current snow water volumes in the Tuolumne Basin are dire, the snowfall season is not absolutely over, as April can bring large snowfalls to the Sierra Nevada. However, current projections by the National Weather Service suggest below-average to average precipitation for the next 30 days (http://www.cnrfc.noaa.gov/climoForecasts.php).

NASA’s Airborne Snow Observatory was originally created to test a new method of estimating Earth's snowpack water content, a critical part of our planet's water cycle and a key component of the Earth system that may be influenced by climate change.

The Airborne Snow Observatory combines a scanning lidar instrument with an imaging spectrometer flown aboard a King Air aircraft to uniquely and completely measure snow depth and relectivity of the snowpack across a growing number of mountain basins in the Sierra Nevada and Colorado River Basin. The total volume of water in the snowpack (snow water equivalent) is computed using densities from ground-based measurements and modeling.

The data, acquired approximately weekly during snow season, are used as inputs to improve operational and research hydrological models. The reflectivity of the snow pack -- that is, how bright or dirty the snow pack is -- provides information on how fast it will melt as it absorbs solar radiation. The data are also used to provide information on vegetation and soil cover, forest growth, ecosystem and water cycle impacts of forest fires such as California's recent King and Rim Fires, and rock fall events.

Airborne Snow Observatory data for the Tuolumne River Basin are updated weekly and are available through the spring on the mission's website: http://aso.jpl.nasa.gov.

NASA uses the vantage point of space to increase our understanding of our home planet, improve lives, and safeguard our future. NASA develops new ways to observe and study Earth's interconnected natural systems with long-term data records. The agency freely shares this unique knowledge and works with institutions around the world to gain new insights into how our planet is changing.

For more information about NASA's Earth science activities, visit http://www.nasa.gov/earth.

Source: NASA
The Night Sky

Friday, April 3

This evening the full Moon shines in Virgo with Spica well to its lower left, as shown here. Much closer to the Moon is fainter Gamma Virginis (Porrima), a close telescopic double star.

A barely total eclipse of the Moon happens before or during dawn Saturday morning for the western half of North America. The farther west you are the better. It happens during Saturday evening for Australia and the Far East. This eclipse is barely total for only about 5 to 12 minutes, depending on how you define the exact edge of Earth's blurry-edged shadow.

Mid-eclipse is at 12:00 April 4th UT (GMT). The partial phases of the eclipse begin at 10:15 UT and end at 13:45 UT. For maps, timetable, and more, see the April Sky & Telescope, page 50, or the version online: Saturday's Total Lunar Eclipse.

Can't see the eclipse from where you are? Griffith Observatory in Los Angeles will run a live webcast from 5:00 a.m. to 9:30 a.m. Eastern Daylight Time (9:00 to 13:30 April 4th UT). The Virtual Telescope Project will also webcast the eclipse, starting at 6:00 a.m. EDT (10:00 UT). So will Slooh, starting at 6:00 a.m. EDT (10:00 UT).

Saturday, April 4

The Moon is still essentially full this evening, much closer now to Spica as shown above.

Sunday, April 5

Are you keeping watch on Venus and the Pleiades? They're drawing closer together day by day in the western twilight. This evening the Pleiades are about 7° above Venus in the darkening blue. The little cluster will pass less than half that distance to Venus's right on April 10th through 12th.

Monday, April 6

After dark, the Big Dipper high in the northeast is tipping over now as if to dump water into the dim Little Dipper's bowl, which is swinging up far below it.

Tuesday, April 7

As dawn brightens on Wednesday morning the 8th, look south for Saturn glowing near the waning gibbous Moon.

Source: Sky & Telescope
ISS Sighting Opportunities

For Denver:

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Sighting information for other cities can be found at NASA’s [Satellite Sighting Information](#)

**NASA-TV Highlights**
*(all times Eastern Daylight Time)*

**Friday, April 3**

2 p.m., NASA TED Talk with Dr. Bryan Duncan: Air Quality – A Tale of Three Cities (all channels)

**Monday, April 6**

11:45 a.m., ISS Expedition 43 Educational Event with the Smithson Valley High School in Spring Branch, Texas and Expedition 43 Commander Terry Virts of NASA and European Space Agency Flight Engineer Samantha Cristoforetti (all channels)

2 p.m., NASA TED Talk with Dr. Paul Newman: A Story of Ozone (all channels)

**Tuesday, April 7**

1 p.m., Live NASA Science Update: Our Solar System and Beyond: The Search for Water and Habitable Planets (all channels)

Watch NASA TV on the Net by going to the [NASA website](#).

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Space Calendar

- Apr 03 - Comet 86P/Wild Perihelion (2.264 AU)
- Apr 03 - Asteroid 2015 CW13 Near-Earth Flyby (0.035 AU)
- Apr 03 - Asteroid 5725 Nordlingen Closest Approach To Earth (1.655 AU)
- Apr 03 - Asteroid 4037 Ikeya Closest Approach To Earth (1.845 AU)
- Apr 03 - Asteroid 3709 Polypoites Closest Approach To Earth (4.384 AU)
- Apr 04 - Total Lunar Eclipse
- Apr 04 - Comet P/2004 R1 (McNaught) At Opposition (0.940 AU)
- Apr 04 - Comet C/2013 C2 (Tenagra) Closest Approach To Earth (8.202 AU)
- Apr 04 - Asteroid 2015 FB34 Near-Earth Flyby (0.058 AU)
- Apr 04 - Centaur Object 10199 Chariklo Occults UCAC4-268-158928 (14.9 Magnitude Star)
- Apr 04 - Asteroid 2015 EQ7 Near-Earth Flyby (0.087 AU)
- Apr 04 - Asteroid 2102 Tantalus Closest Approach To Earth (2.137 AU)
- Apr 05 - Comet 169P/NEAT At Opposition (2.903 AU)
- Apr 05 - Comet C/2014 XB8 (PANSTARRS) Perihelion (3.011 AU)
- Apr 05 - Comet P/2004 FY140 (LINEAR) At Opposition (3.078 AU)
- Apr 05 - Comet P/2006 F1 (Kowalski) Closest Approach To Earth (3.946 AU)
- Apr 05 - Asteroid 2015 FK120 Near Earth Flyby (0.015 AU)
- Apr 05 - Asteroid 2011 GK44 Near-Earth Flyby (0.064 AU)
- Apr 05 - Asteroid 2015 EE7 Near-Earth Flyby (0.099 AU)
- Apr 05 - Asteroid 30440 Larry Closest Approach To Earth (1.588 AU)
- Apr 05 - Asteroid 1740 Paavo Nurmi Closest Approach To Earth (1.938 AU)
- Apr 05 - Asteroid 73769 Delphi Closest Approach To Earth (3.968 AU)
- Apr 05 - 5th Anniversary (2010), STS-131 Launch (Space Shuttle Discovery, ISS)
- Apr 05 - 25th Anniversary (1990), 1st Pegasus Rocket Launch
- Apr 05 - Franklin Chang-Diaz's 65th Birthday (1950)
- Apr 06 - Comet 88P/Howell Perihelion (1.359 AU)
- Apr 06 - Comet C/2012 F3 (PANSTARRS) Perihelion (3.457 AU)
- Apr 06 - Asteroid 2015 FN33 Near-Earth Flyby (0.025 AU)
- Apr 06 - Asteroid 4957 Brucemurray Closest Approach To Earth (1.196 AU)
- Apr 06 - Asteroid 4103 Chahine Closest Approach To Earth (1.810 AU)
- Apr 06 - 50th Anniversary (1965), Intelsat 1 Launch (1st Commercial Communications Satellite)

Source: JPL Space Calendar
When NASA's new Space Launch System (SLS) launches on its first flight, it will be doing some serious multi-tasking. Not only will Exploration Mission-1 test the performance of SLS and its integration with the Orion spacecraft – the agency plans to use its massive lift capability to carry nearly a dozen nano-satellites to conduct science experiments beyond low Earth orbit.

NASA's newest rocket will launch Orion on an uncrewed test flight to a distant retrograde orbit around the moon. Tucked inside the stage adapter -- the ring connecting Orion to the top propulsion stage of the SLS -- will be 11 self-contained small satellites, each about the size of a large shoebox.

"NASA is taking advantage of a great opportunity to conduct more science beyond our primary focus of this mission," said Jody Singer manager of the Flight Programs and Partnerships Office at the Marshall Space Flight Center in Huntsville, Alabama. "While this new vehicle will enable missions beyond Earth orbit, we're taking steps to increase the scientific and exploration capability of SLS by accommodating small, CubeSat-class payloads."

About 10 minutes after Orion and its service module escape the pull of Earth's gravity, the two will disconnect and Orion will proceed toward the moon. Once Orion is a safe distance away, the small payloads will begin to be deployed, all at various times during the flight depending on the particular missions.

These CubeSats are small nano-satellites designed to be efficient and versatile. The masses of these secondary payloads are light -- no heavier than 30 pounds (14 kilograms) -- and will not require any extra
power from the vehicle to function. They will essentially piggyback on the SLS flight, providing what otherwise would be costly access to deep space.

"We are expanding the capabilities of this particular SLS test flight," said Joseph Pelfrey, deputy manager of the Exploration and Space Transportation Development Office at Marshall. "The rocket will be the strongest ever built by NASA and we want to take advantage of that design. Flying secondary payloads is something we plan to do for missions to come and provide the science community an opportunity they haven't had before."

The dispensers on the adapter ring will be built with commercially available materials. No pyrotechnic devices will be a part of the payloads and each will be ejected with a spring mechanism – similar to opening a lid on a toy jack-in-the-box.

The principal investigators and engineers for the payloads will work with the secondary payload integration team to develop mission-specific requirements and verify interfacing and safety requirements are met. Multiple organizations at NASA Headquarters in Washington are soliciting inputs for the available EM-1 secondary payload slots, and three have already been selected for further development: Near-Earth Asteroid (NEA) Scout, Lunar Flashlight and BioSentinel.

Both NEA Scout and Lunar Flashlight involve Marshall engineering and science teams, while BioSentinel is managed by NASA's Ames Research Center in California.

NEA Scout, using solar sail propulsion, will fly by a small asteroid, taking pictures and making observations that will enhance the current understanding of the asteroid environment and will yield key information for future astronauts exploring an asteroid.

"A solar sail works best when deployed in deep space and SLS will get us there," said Les Johnson, principal investigator for NEA Scout at Marshall. "It will take us out of Earth orbit and to interplanetary space -- where we need to be to deploy the solar sail. It's a perfect ride to begin our mission."

NASA's Lunar Flashlight will scout for locations on the lunar surface that are rich in resources that, once broken down into their component molecules, could be used in future exploration, such as building materials, propellant, oxygen and water. Lunar Flashlight will use a large solar sail, similar to the NEA Scout sail, to reflect sunlight and illuminate the moon's permanently shadowed craters and then the science instruments will measure the surface water ice.

BioSentinel will use yeast to detect, measure, and compare the impact of deep space radiation on living organisms over long durations beyond Low-Earth Orbit, which will help us understand the effects of the deep space environment on biological systems as we plan to send humans farther into space than ever before. The BioSentinel mission will be the first time living organisms have traveled to deep space in over 40 years and the spacecraft will operate in the deep space radiation environment throughout its 18-month mission.

Exploration Mission-1 will serve as a proving ground for the integrated Orion spacecraft and SLS, allowing designers to steadily move forward with development of the vehicle and prove the systems' ability to carry and deploy experiments yielding invaluable science results.

Secondary Payloads Fact Sheet

Source: NASA

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**Aurora in the Backyard**

**Explanation:** How will cows survive on the Moon? One of the most vexing questions asked about space, scientists have spent decades debating this key issue. Finally, after extensive computer modeling and over a dozen midnight milkings, engineers have designed, built, and now tested the new Lunar Grazing Module (LGM), a multi-purpose celestial bovine containment system. By now, many of you will not be surprised to be wished a Happy April Fool's Day from APOD. To the best of our knowledge, there are no current plans to launch cows into space. For one reason, cows tend to be large animals that don't launch easily or cheaply. As friendly as cows may be, head-to-head comparisons show that robotic rovers are usually more effective as scientific explorers. The featured image is of a thought-provoking work of art named "Mooooonwalk" which really is on display at a popular science museum.

**Image Credit & Copyright:** Robert Nemiroff (Michigan Tech. U.)