Science in Society

Should we send a human mission to Mars?

A debate on a controversial topic with scientific, ecological and ethical considerations.

Learning Outcomes in Focus:

Earth and Space:

8. **Examine** some of the current hazards and benefits of space exploration and **discuss** the future role and implications of space exploration in society.

   Examine: consider an argument or concept in a way that uncovers the assumptions and relationships of the issue.

   Discuss: offer a considered, balanced review that includes a range of arguments, factors or hypotheses: opinions or conclusions should be presented clearly and supported by appropriate evidence.

Nature of Science:

6. Conduct **research** relevant to a scientific issue, evaluate different sources of information including secondary data, understanding that a source may lack detail or show bias.
7. Organise and communicate their research and investigative findings in a variety of ways fit for purpose and audience, using relevant scientific terminology and representations.
10. Appreciate the role of science in society; and its personal, social and global importance; and how society influences scientific research.

Research: to inquire specifically, using involved and critical investigation.

Evaluate: collect and examine evidence **to make**

Organise: to arrange; to systematise or methodise.

Appreciate: recognise the meaning of; have a practical understanding of.

Other Skills

Public Speaking Critical thinking Collaboration and team work
Organisation Skills

Cross Curricular Links

As a formal debate, this activity can be run in collaboration with SPHE or English departments as a way of whole school involvement with Space Week.

Materials

Computers with internet access in class or at home.

Learning Intentions

Students will learn to:

1. Use a variety of sources of information to come to an informed opinion on a topical scientific issue with societal wide impacts.
2. Recognise the various ethical issues regarding human exploration of space.
3. Using information researched form a coherent and organised argument to be presented to a group.

Prior Learning:

1. Students may be familiar with comparative planetology (comparing the length of day, temperature, atmosphere and gravity of Earth and Mars).
2. Students may be familiar with the issue from media sources and projects such as NASA Mars Curiosity Rover and SPACE X projects.

Teacher Sheet

Starter Questions:

- What do we know about humans in space?
- When did the first humans visit space?
- Are there any humans in space now?
- Thinking about what we know about human biology, do we think the human body would find it easy in space?
- Compare Mars and Earth in terms of gravity, day length, temperature, atmosphere

Basic Mars Facts:
Mean radius: 3,390 km (about 53% that of Earth)
Mass: 6.42 x 10^{23} kg (or 642 sextillion kg, about 11% that of Earth)
Surface gravity: 3.71m/s^2 (about 38% that of Earth)
Average temperature of atmosphere: -63°C (cf 15°C for Earth)
Length of year: 687 Earth days
Length of day: 24hr 40mins

The following statements might be presented to students and they could be asked if they agree or disagree.

- We should colonize Mars to exploit its natural resources.
- We should colonize Mars to fulfil our pioneering nature.
- We should colonize Mars to experiment with new ways of living.
- We should colonize Mars as a backup planet.
- We should colonize Mars to learn the answers to important scientific questions.
- We need to sort out our own planet first!!!!

Student Activity

SHOULD WE SEND A HUMAN MISSION TO MARS?

- Depending on the Learning Outcome aims for the lesson, a teacher may decide to run a formal or informal classroom debate.
- Students may be asked to present their views in a variety of suitable formats.

Points for discussion

What is the difference between someone's opinion and a scientific judgement?

Why is it important to discuss with others your opinions and judgements?

Why is it important for humanity to develop laws around new technology or exploration?

What are the ethical considerations in sending a one way mission to Mars?

We asked some Science experts:

Dr. Niamh Shaw, *Artist and Physicist. She is passionate about science, engineering and performing! Niamh has taken part in simulated training missions to Mars in the Mars Desert Research Station (MDRS). This is a full-scale 'pretend Mars' facility in Utah that supports Earth-based research. This is to try and establish the technology, operations, and science required for human space exploration. Niamh's mission was almost 3 weeks in duration, in total isolation with limited water, power and food supplies, surrounded by terrain that is similar to Mars. She wonders how we would decide who or what kinds of people we would send to Mars:*

"If we are to create a new community on Mars, we need to consider the impact of this on our species as much as the technological need to explore new worlds. How will we live on Mars? How do we create new communities? How will we entertain ourselves, how will be bond? If we only send scientists we are limited to the type of community we will have. For example, artists can help us reflect, to make us think about the bigger questions about our existence. They can share the experience not only with the new community, but also people back home on Earth.

But, a trip to Mars is a tough journey and when we finally arrive after a long trip, we need the hardiest and the strongest of people to withstand the harsh conditions on such an inhospitable planet. There is no time to worry about community in these early days, we would need to building power generation facilities, oxygen factories. The types of people and how they will help the community on Mars will have a huge influence on how a human mission to Mars will succeed.

Laura Keogh *is a lawyer who specialises in Space Law. Space Law is concerned with things such as the use of satellites for peaceful purposes or the responsibilities of humans to explore space carefully and for the good of humankind. As more and more humans explore space it is becoming very important to have rules and regulations governing what we do in space, just as we have environmental laws or rules of the road.*

Here she outlines some of the International Space Law that applies to human exploration of Mars.

International space law provides for five key principles for exploration:

(1) exploration must be peaceful.

(2) exploration should be carried out for the benefit of all people and all countries.

(3) all countries should be allowed to explore, without discrimination toward any country.

(4) there should be freedom of scientific investigation.

(5) international cooperation should be encouraged.

Therefore, if we can send a human mission to Mars that complies with these principles (as well as all the other laws!), of course we should send a human mission to Mars!

Dr. Brigit Lucey and Professor Roy Sleator *are microbiologists researching in Cork Institute of Technology. Microbiologists can be involved in research into the human exploration of space. They study microorganisms in space. Microorganisms are the most widespread form of life on Earth. They can colonise almost any environment – very hot, very cold and very dry. Scientists focus on studying microbial life when studying extra-terrestrial life. Small and simple cells usually evolve first on a planet before larger organisms with millions of cells like humans!*

Prof. Roy Sleator *comments* "exploration is in our nature. We began as wanderers, and we are wanderers still. Like Everest, humans will eventually conquer Mars for no other reason other than "because it's there". There are many reasons to send a human mission to Mars. Earth has a growing population and dwindling natural resources. Climate change and other natural (and human caused) disasters may make the Earth no longer habitable; forcing humankind to seek shelter elsewhere. Mars exists at the edge of the habitable zone of our solar system. It may give us such a shelter and allowing humankind not only to survive, but to thrive.

He wonders if anything will be different for humans on Mars? "Humans have plundered the Earth of its natural resources. Our carbon footprint has changed our environment. It has triggered climate change and other natural catastrophes. Colonisation of Mars might mean refuge for humankind, but at what cost? Would old habits simply be brought with us to a new world – treating Mars in the same way that has damaged Earth? Far better for humankind to stay put and put out knowledge and expertise to reversing the damage done to Earth, rather than simply moving to a new world."

Dr. Brigit Lucey is quite positive about what technology can give us when thinking about sending humans to new planets. She wonders how we might overcome millions of years of evolution that has adapted our bodies to life on Earth,"with modern technology, it is becoming more possible that humans can colonise another planet. The length of a day on Mars is like that of planet Earth. It becomes extremely cold at night and at the poles. The daytime temperature is sometimes reported to be like fine summer’s day in Ireland. If we develop technology for Mars that would allow us to make oxygen, and if we could produce soil, we could have an artificial ecosystem there. We could control our environment so much that we wouldn’t need to generate any waste.

One of the problems, however, with existing in microgravity is that our bones become less dense and our muscles become less efficient – we are adapted to life on Earth, not Mars."

Wallace Arthur *is an evolutionary biologist. Evolutionary biology looks at the very origins of life, studying how life developed from a single common ancestor. An evolutionary astrobiologist would consider what this would mean for life in the universe. Here Professor Arthur considers a human mission to Mars…*

“Why do it? First, because it’s there, and it’s in our nature to explore. If we stop exploring, we stagnate. Second, because the Earth will not remain habitable indefinitely, we will need to embark upon interplanetary travel at some stage if we wish to outlive the Earth. The sooner we start the better. Third, people are better than machines at certain types of exploration. There is still a possibility that Mars has its own life forms. Humans on Mars might spot tell-tale signs that robot rovers miss.

However, human space-flight is fraught with problems, as we’re all aware from the shuttle disaster and the near-disaster of Apollo 13. The risks increase with the length of the journey. So, Mars missions will be far more dangerous than orbits of Earth or trips to the Moon. No-one should be coerced into such a risky venture. However, luckily, this is not an issue because lots of brave people queue up for the opportunity to go, notwithstanding the risks.”

Dr Andy Wheeler *is a Geologist in University College Cork. His main area of study is marine environments, especially mapping our sea floor and learning about the history of what life used to be like in prehistoric marine ecosystems. He wonders about the reasons we might send a human mission to Mars, and, perhaps if that effort is best spent at home here on Earth.*

Going to Mars is an unbelievably costly exercise. Could that money be better spent on fixing our own planetary problems? After all Mars is an incredibly inhospitable place and will never be an alternative to this planet, which is the only one we are adapted to survive on. Our future is here whether we like it or not and we should focus on conserving what we have. Earth has finite natural resources. The research and effort we would put into a Mars Mission would go a long way toward changing our lifestyles here on Earth.

Physicist Kevin Nolan, *a lecturer in IT Tallaght is an expert on Mars. He has written a book about the human fascination to learn about and explore the red planet. He believes exploration of Mars by humans is going to happen but must happen from a sustainable point of view:*

"In 1995 it was experts realised that the chances of life originating on Mars billions of years ago was about the same as on Earth. From then on, we have done robotic exploration of the Red Planet, which is still happening today. While we haven't found life there yet, we can in no way rule out the possibility of microbial life on Mars existing.

So, if we send people to Mars, while tempting, we will be sending people to another planet where there may be indigenous life.

The question is, if we find life there, do we leave the planet alone for that life to run its course uninterrupted; or do we explore the planet with the likely outcome being the obliteration of that life?

This question not only challenges our view on life on Mars - it challenges our value of all life. Does life on other planets, however sophisticated or simple, have a right to be left undisturbed; or are we entitled to affect it?

How we answer that question on Mars will "cast the die" on how we proceed from here as a space fairing civilization throughout the Galaxy and toward all planets harboring indigenous life."

Research Resources:

Direct students to the following websites:

www.esa.int

www.sciencenewsforstudents.org/article/preparing-trip-mars

www.sciencenewsforstudents.org/article/en-route-mars-astronauts-may-face-big-health-risks

Niamh Shaw documented her Mars training mission for headstuff.org:

https://www.headstuff.org/author/niamh-shaw/

Science News for Students

SPACE BRAIN HEALTH

En route to Mars, astronauts may face big health risks

NASA and other groups are examining hazards of traveling to the Red Planet

BY STEPHEN ORNES MAR 8, 2018 — 6:45 AM EST

Going into space brings the thrill of a new frontier and risks that scientists are racing to understand, from radiation to isolation.
RossellaApostoli/iStockphoto

This is the second of a two-part series on preparations for upcoming human space missions to the Red Planet.

Frank Borman was probably the first person to barf in space.

Borman was part of NASA's Apollo 8 mission, which lifted off a launch pad in Florida on December 21, 1968. Over the next six days, the mission made history as it circled the moon and returned home. But Borman, who led the mission, became queasy near the beginning.

"I threw up a couple of times," he recalled in an interview in 1999. Now 89, Borman is the oldest living U.S. astronaut.

"Nobody likes to throw up," he said. Still, he insisted, this space sickness "wasn't a big deal."

In space, gravity is so weak that it might as well not be there at all. The difference between "up" and "down" becomes meaningless. Astronauts can experience nausea and become disoriented. It happens a lot.

This famous image, called Earthrise, was captured by astronauts on the Apollo 8 mission on Christmas Eve, 1968.
NASA

Space sickness isn't the only side effect to accompany the thrill of leaving Earth. A 2015 NASA report identified 30 factors that could make astronauts sick and unable to do their jobs. And there may be more, it said. Until people visit Mars it will be difficult to fully predict what could go wrong.

"We want to make sure we can bring people back healthy, and safely," says astronaut Jessica Meir, who lives in Houston, Texas, and works for NASA. She has helped NASA design programs to train space travelers for the hazards of space.

Some of the known risks are extremely thorny. Along with space sickness, there is radiation — high-energy subatomic particles that will pass through an astronaut's skin, damaging cells inside and out. Space travelers' bones and muscles also can weaken as those body parts no longer have to constantly work against gravity. Blood and other fluids from the lower parts of the body can accumulate in upper body parts, including around the brain. One side effect: Astronauts may suffer hearing loss.

Space travel can even mess with the mind and mental health. For instance, astronauts travel in cramped quarters with other people. "If your relationships [with them] aren't going well, you start to isolate yourself from the rest of the crew," says Steve Kozlowski. He's a psychologist at Michigan State University, in East Lansing. On long-term space flights, astronauts have to collaborate on many tasks. If they don't work well together, those tasks may not get done correctly or on time. That, he says, can jeopardize the mission and lives of the entire crew.

Double Trouble

Today's astronauts visit the International Space Station. It orbits Earth 381 kilometers (237 miles) overhead. Getting there takes less than a day, and most crew members stay less than a year. A trip to the moon would take about 3 to 5 days. A future voyage to an asteroid could take many weeks. Missions to Mars might last about 3 years.

As astronauts' time in space increases, so do their health risks. And the most dangerous one facing those angling for Mars is well known, says Meir: radiation.

Life on Earth is protected from space radiation by a big, invisible, lopsided bubble. It's called the magnetosphere (Mag-NEE-toe-sfeer). It's the region around Earth dominated by the planet's magnetic field. Like a shield, the magnetosphere deflects most of the high-energy particles that stream toward Earth from the sun. Only the highest-energy particles will get through.

Space radiation also comes from galactic cosmic rays. These powerful bursts of energy come from deep space. Scientists are still looking for their source. Like solar radiation, galactic cosmic rays can damage the human body inside and out. Also like solar radiation, these rays are deflected by Earth's magnetosphere.

But a trip to Mars will take astronauts well beyond that protective magnetosphere.

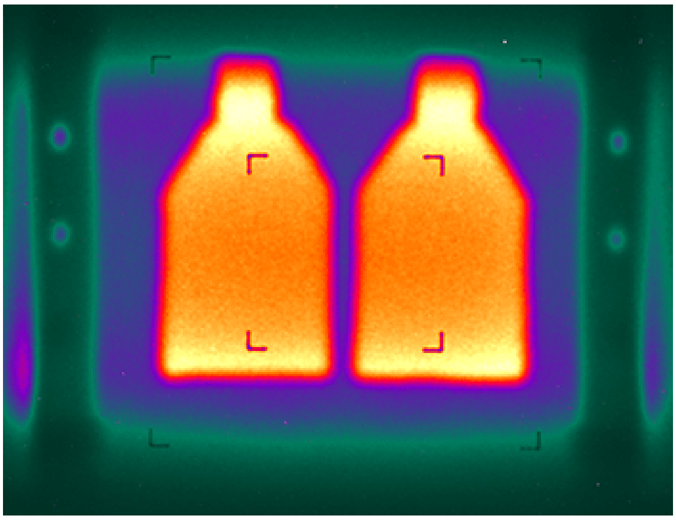
The magnetosphere includes two so-called *Van Allen belts*. "Once you traverse the Van Allen belts, which wrap around the Earth, there is no more protection," says engineer Lisa Carnell.

Carnell studies deep-space radiation at the NASA Langley Research Center in Hampton, Va. Her laboratory studies attempt to simulate deep space. They include firing high-energy lasers at targets, including ordinary objects and samples of human tissue. She also has conducted studies on the risk of space-radiation sickness, which can lead to symptoms ranging from nausea and vomiting to organ damage. (This is different from the regular space sickness due to weightlessness.)

Radiation may damage the cardiovascular system, which includes the heart and lungs. It also can damage the central nervous system, which includes the brain and spinal cord. So radiation may impair someone's ability to think clearly.

Galactic cosmic rays can shower astronauts with particles of many sizes. Carnell likens this radiation to invisible bullets fired from deep-space guns. "There are different types of guns and different types of damage they can do," she notes.

This photo was taken from the International Space Station. Those greenish lines are made of light and form from the interaction of radiation from the sun with Earth's magnetosphere.
NASA



These plastic bottles glow after being pummeled by ions from the Galactic Ray Simulator at Brookhaven National Laboratory in New York.
U.S. DOE, Brookhaven National Laboratory, NASA

Cosmic rays include small particles, which are parts of an atom. Those particles are like BBs. The simplest may be isolated protons or electrons. Bigger ones may include the cores of atoms of lithium, carbon or iron. Carnell likens these to rifle bullets.

In laboratory studies, she says, exposure to beams of these particles will cause cancer in mice. Scientists haven't seen evidence of higher cancer rates in astronauts. But astronauts have not yet remained in space for very long. And even those who have stayed up for months on the ISS are still protected by the magnetosphere.

Mars is far outside that protective bubble. Data collected by the Curiosity rover, which roams the Red Planet, finds that surface space radiation levels there are high. This suggests astronauts who go to Mars will face a high risk of cancer.

Space missions will have to protect astronauts from that radiation. Carnell says engineers are looking for many ways to do that. Each has pros and cons. One solution includes building space ships and space suits from thick materials that could shield the passengers. However, such a ship might be too heavy and expensive to launch. And those suits would be bulky.

Another solution would be to design and use new materials that deflect more radiation. But scientists need time and money to develop these materials. Organizations such as NASA are planning to send people to Mars in the next 15 years. SpaceX, a private company, wants to get people there by 2020. (In January 2018, the company sent the world's heaviest rocket — called Falcon Heavy — barreling toward the Martian neighborhood. It carried a sportscar.) A third solution might be to develop a medication that can block the harmful effects of radiation from inside an astronaut's body. Such a drug does not yet exist.

And, with medicine, there's another cause for pause. Astronaut urine is recycled for drinking water. Scientists would have to make sure any treatment for radiation is safe no matter where it ended up, every time it passed through a body.

"I don't think that we'll ever get to the point that we completely mitigate the risk," says Carnell. "So the ultimate goal is to reduce the risk as much as possible."

Brawn and brains

Astronauts face other health risks from space travel. Those include the loss of bone and muscle. Meir, the astronaut, says the International Space Station includes equipment that can help limit that. Onboard the ISS is the ARED. This stands for Advanced Resistive Exercise Device. The machine uses *vacuum tubes* to provide resistance to movements — as weights do in the gym.

Koichi Wakata of the Japan Aerospace Exploration Agency works out on the Advanced Resistance Exercise Device on the ISS.
NASA

Astronauts on the ISS work out with ARED two hours each day. This should cut muscle or bone mass, Meir says: "That's one of the big things we have solved."

The ISS has plenty of room for the ARED. The first spacecraft to Mars won't be nearly as spacious. So engineers are developing smaller exercise equipment for these craft. Exercise, after all, will remain a critical health issue for people travelling into deep space, Meir says.

Scientists planning for Martian missions also need to think about what goes on in an astronaut's head. Rachael Seidler is a kinesiologist (Kih-NEES-ee-OL-oh-gizt) at the University of Florida, in Gainesville. (Kinesiology is the study of how bodies move.) She has been investigating how space travel alters the brain.

Seidler and her team studied brain scans from 27 astronauts who had been in space. Fourteen had spent six months on the ISS. The rest had spent about two weeks on a space shuttle.

Living in space led to surprising changes. Seidler's team identified places in the brain where the amount of gray matter had either decreased or increased. Gray matter includes nerve cell bodies, which are like the control center for these cells.

Seidler doesn't think the decreases suggest astronauts are losing brain cells. Instead, she suspects that fluids — including those around the brain — move around freely in the *microgravity* of space. Those shifts may have caused some of the changes she observed.

"Your brain is kind of floating a little bit higher in the skull than it does on Earth," she explains. As a result, "There's a redistribution of fluids." That's one reason, she says, "If you look at photos of astronauts when they first go into space, they have this puffy-face look."

That also may help explain some symptoms seen in returning astronauts. The longer they had spent in space, the more dramatic the changes to their gray matter.

Upon returning to Earth, they often have difficulty with balance and hand-eye coordination. They can't drive a car for a few weeks, sometimes for months. They must undergo physical therapy to get used to gravity again.

Her team reported its results in December 2016 in *Nature Microgravity*.

Seidler says she wants to figure out if some of these effects are linked to the brain changes she's observed. This research could be useful for future missions, since going to Mars means more time in space and possibly more brain changes.

These experiments also may help scientists understand brain changes in the elderly. As people age, they may show symptoms similar to what astronauts experience upon returning to Earth: problems with balance and vision, for example.

In the lab, Seidler has been leading bed-rest studies. Her volunteers lie down on a bed for months at a time. During and afterward, the researchers record brain scans of each volunteer.

Participants in bed-rest studies have to remain lying down during all activities, even using a computer. Bed rest affects people in ways similar to weightlessness, making these studies an easy, and cheaper, way to study what happens to humans in space.
German Space Agency (DLR)

These show that bed-rest changes the brain in ways similar to what is seen in astronauts. No longer pulled toward the feet by gravity, the fluids in the bodies of bed-rest volunteers move around. Their brains may rise up in their bodies a bit, says Seidler. Bed-rest volunteers also can get the same face puffiness.

These results offer clues to how the brain changes as the brain and body experience the world differently than when just standing up.

Of course, the studies are tricky. They require finding people willing to lie around for months. Seidler is about to launch a study that will require people to lie down for 60 days. She is the first to admit it doesn't sound like fun. "The idea of maybe lying around in bed for a weekend sounds okay," she says. "But anything more than that sounds awful."

Space on Earth

Getting people to lie down isn't the only way to simulate space. Researchers do it right on Earth in specialized environments.

In January, Ryan Kobrick began a two-week stay at a two-story building in the Utah desert to see how much dust from the outside leaks to the inside as people come and go. Those studies could help scientists predict how dust on the moon or Mars might affect life away from Earth.

Kobrick is a former astronaut. Now he works as an engineer at Embry-Riddle Aeronautical University in Daytona Beach, Fla.

Meir, the astronaut, has participated in a NASA program called NEEMO. (NEEMO stands for NASA Extreme Environment Mission Operations.) In this project, a small group of researchers live and work together in Aquarius. It's an underwater research station in the Atlantic Ocean, some 5.6 kilometers (3.5 miles) off the Florida island of Key Largo. Experiences there are designed to mimic spaceflight. Crew members have to work together to complete tasks and solve problems.

Meir also participated in a simulation program with the European Space Agency. It's called CAVES (an acronym for Cooperative Adventure for Valuing and Exercising human behavior and performance Skills). Six crew members — including ones from Russia, China, Spain and Italy — spent two weeks together in a deep cave in Italy. They wore space suits and had to rely on each other as they performed various tasks. This included exploring and mapping unknown sections of the cave. Such exploration required working in teams to climb steep cliffs or *rappel* down. The team also observed and documented the organisms that found alive in the deep.

"It was the coolest experience of my life," Meir recalls. The caves looked like another planet and the views were extraordinary, she says. She saw spectacular formations made out of rock, never before seen by human eyes. "We were like characters in science fiction — like *The Hobbit* or *Lord* *of The Rings,"* she says.

The CAVES experience, Meir notes, showed the importance of building a crew for outer space that's made of people who get along.

Experience has shown that getting along is important for astronauts. "Persistent danger and stress can take a toll," says Kozlowski, the psychologist. "People can irritate you. If you dislike somebody, they can impede effectiveness."

Kozlowski has been studying participants in a NASA program called HI-SEAS (short for Hawaii Space Exploration Analog and Simulation). Participants live together in a small, dome-shaped habitat on the side of a Hawaiian volcano. The living conditions have been designed to mimic a mission to Mars.

Jessica Meir, featured in the PBS special Beyond a Year in Space, trains for interplanetary travel.
PBS/Beyond a Year in Space

Teamwork is key

In February 2018, the sixth HI-SEAS crew began its eight-month stay. Recruits will be isolated in the habitat for the entire time. While there, they will have to work together, cooking meals or exploring the barren terrain outside the habitat. When they leave the dome, they will don space suits. They will work, eat and sleep as if they're living on the Red Planet.

By day, crewmembers will answer surveys on how things are going. "They report on whether they've had conflicts with other people, or problems with their work," notes Kozlowski. His team will study these surveys to look at the mission from beginning to end. They want to identify the earliest signs of any conflicts. Reducing those tensions is essential to making Mars missions a reality.

Space travel requires that a diverse group of people get along and work together for periods of time. This image was taken on board the International Space Station in 2010, when a Space Shuttle crew visited.
NASA

Conflict was less of an issue during the 1960s, the era of the Apollo missions. Why? Those missions were short. The pioneers of space flight spent a week or less in orbit. Still, on missions short and long, astronauts have to cooperate to succeed.

Frank Borman's barfing experience on Apollo 8 is a perfect example. On that December day in 1968, fellow astronaut Jim Lovell came to Borman's aid. He helped clean up. "Lovell, as I recall, squirted it out the urine dump system or something," Borman recalled.

In 1985, astronaut Jake Garn also became nauseous on a space flight. (Garn, a senator from 1974 until 1993, was the first member of the U.S. Congress to go into space.) His queasiness didn't last long: He soon felt better and was able to do his job. But for a while it had been touch and go. After he returned from space, NASA jokingly established the "Garn scale" as a way to measure space sickness. (A comic strip from the time called him "Barfin' Jake Garn," but he never actually threw up.) The sicker you got, the higher your score on the Garn scale.

In an interview from 2005, Garn reflected on his famous bout of nausea in space. He said he had no regrets. Even with all its hazards and risks, Garn said no experience on Earth was comparable to getting away from it all in space.

"Believe me," he said, "I'd throw up every day just to go into space again."

See part 1: Preparing for that trip to Mars (https://www.sciencenewsforstudents.org/article/preparing-trip-mars) .

Power Words

(for more about Power Words, click here (https://www.sciencenewsforstudents.org/power-words-aid-stem-literacy))

Apollo missions NASA's third human spaceflight program eventually took humans to the lunar surface. Along the way, this program sought to develop the technologies needed for long-distance space travel. It got a big kick-start after President John F. Kennedy proposed in 1961 creating the national goal of "landing a man on the Moon and returning him safely to the Earth."

asteroid A rocky object in orbit around the sun. Most asteroids orbit in a region that falls between the orbits of Mars and Jupiter. Astronomers refer to this region as the asteroid belt.

astronaut Someone trained to travel into space for research and exploration.

barf Slang for vomit.

BBs A type of small pellets, usually made from steel, which are fired by shotguns and air rifles. They can ricochet off of hard surfaces, making their use dangerous in confined spaces.

behavior The way something, often a person or other organism, acts towards others, or conducts itself.

brain scan A technique to view structures inside the brain, typically with X-rays or a magnetic resonance imaging (or MRI) machine. With MRI technology — especially the type known as functional MRI (or fMRI) — the activity of different brain regions can be viewed during an event, such as viewing pictures, computing sums or listening to music.

cancer Any of more than 100 different diseases, each characterized by the rapid, uncontrolled growth of abnormal cells. The development and growth of cancers, also known as malignancies, can lead to tumors, pain and death.

cardiovascular An adjective that refers to things that affect or are part of the heart and the system of vessels and arteries that move blood through the heart and tissues of the body.

cell The smallest structural and functional unit of an organism. Typically too small to see with the unaided eye, it consists of a watery fluid surrounded by a membrane or wall. Depending on their size, animals are made of anywhere from thousands to trillions of cells.

component Something that is part of something else (such as pieces that go on an electronic circuit board or ingredients that go into a cookie recipe).

Congress The part of the U.S. federal government charged with writing laws, setting the U.S. budget, and confirming many presidential appointments to the courts, to represent the U.S. government interests overseas and to run administrative agencies. The U.S. Congress is made of two parts: the Senate, consisting of two members from each state, and the House of Representatives, which consists of a total of 435 members, with at least one from each state (and dozens more for the states with the biggest populations).

cosmic rays Very high-energy particles, mostly protons, that bombard Earth from all directions. These particles originate outside our solar system. They are equivalent to the nucleus of an atom. They travel through space at high rates of speed (often close to the speed of light).

element (in chemistry) Each of more than one hundred substances for which the smallest unit of each is a single atom. Examples include hydrogen, oxygen, carbon, lithium and uranium.

engineer A person who uses science to solve problems. As a verb, to engineer means to design a device, material or process that will solve some problem or unmet need.

fiction (adj. fictional) An idea or a story that is made-up, not a depiction of real events.

gravity The force that attracts anything with mass, or bulk, toward any other thing with mass. The more mass that something has, the greater its gravity.

gray matter One of two main types of tissue found in the brain and spinal cord. It consists mainly of nerve cell bodies.

habitat The area or natural environment in which an animal or plant normally lives, such as a desert, coral reef or freshwater lake. A habitat can be home to thousands of different species.

International Space Station An artificial satellite that orbits Earth. Run by the United States and Russia, this station provides a research laboratory from which scientists can conduct experiments in biology, physics and astronomy — and make observations of Earth.

iron A metallic element that is common within minerals in Earth’s crust and in its hot core. This metal also is found in cosmic dust and in many meteorites.

journal (in science) A publication in which scientists share their research findings with experts (and sometimes even the public). Some journals publish papers from all fields of science, technology, engineering and math, while others are specific to a single subject. The best journals are peer-reviewed: They send all submitted articles to outside experts to be read and critiqued. The goal, here, is to prevent the publication of mistakes, fraud or sloppy work.

laser A device that generates an intense beam of coherent light of a single color. Lasers are used in drilling and cutting, alignment and guidance, in data storage and in surgery.

liquid A material that flows freely but keeps a constant volume, like water or oil.

lithium A soft, silvery metallic element. It’s the lightest of all metals and very reactive. It is used in batteries and ceramics.

magnetosphere The region surrounding Earth (or another astronomical body) in which its magnetic field protects the planet from the solar wind.

Mars The fourth planet from the sun, just one planet out from Earth. Like Earth, it has seasons and moisture. But its diameter is only about half as big as Earth’s.

mass A number that shows how much an object resists speeding up and slowing down — basically a measure of how much matter that object is made from.

matter Something that occupies space and has mass. Anything on Earth with matter will have a property described as "weight."

microgravity Gravity that is a fraction of the force experienced at sea level on Earth.

molecule An electrically neutral group of atoms that represents the smallest possible amount of a chemical compound. Molecules can be made of single types of atoms or of different types. For example, the oxygen in the air is made of two oxygen atoms (O_2), but water is made of two hydrogen atoms and one oxygen atom (H_2O).

moon The natural satellite of any planet.

muscle A type of tissue used to produce movement by contracting its cells, known as muscle fibers. Muscle is rich in protein, which is why predatory species seek prey containing lots of this tissue.

NASA Short for the National Aeronautics and Space Administration. Created in 1958, this U.S. agency has become a leader in space research and in stimulating public interest in space exploration. It was through NASA that the United States sent people into orbit and ultimately to the moon. It also has sent research craft to study planets and other celestial objects in our solar system.

nausea Feeling sick to one's stomach, as though one could vomit.

nerve A long, delicate fiber that transmits signals across the body of an animal. An animal’s backbone contains many nerves, some of which control the movement of its legs or fins, and some of which convey sensations such as hot, cold or pain.

nervous system The network of nerve cells and fibers that transmits signals between parts of the body.

neuroscientist Someone who studies the structure or function of the brain and other parts of the nervous system.

orbit The curved path of a celestial object or spacecraft around a star, planet or moon. One complete circuit around a celestial body.

organ (in biology) Various parts of an organism that perform one or more particular functions. For instance, an ovary is an organ that makes eggs, the brain is an organ that makes sense of nerve signals and a plant's roots are organs that take in nutrients and moisture.

particle A minute amount of something.

persistent An adjective for something that is long-lasting.

physical (adj.) A term for things that exist in the real world, as opposed to in memories or the imagination. It can also refer to properties of materials that are due to their size and non-chemical interactions (such as when one block slams with force into another).

planet A celestial object that orbits a star, is big enough for gravity to have squashed it into a roundish ball and has cleared other objects out of the way in its orbital neighborhood. To accomplish the third feat, the object must be big enough to have pulled neighboring objects into the planet itself or to have slung them around the planet and off into outer space.

psychological An adjective that refers to how the human mind works, especially in relation to guiding actions and behavior.

psychologist A scientist or mental-health professional who studies the human mind, especially in relation to actions and behaviors.

radiation (in physics) One of the three major ways that energy is transferred. (The other two are conduction and convection.) In radiation, electromagnetic waves carry energy from one place to another. Unlike conduction and convection, which need material to help transfer the energy, radiation can transfer energy across empty space.

rappel To travel down a cliff or other near-vertical rock face by sliding along a rope while periodically kicking off against the surface with your legs.

Red Planet A nickname for Mars.

risk The chance or mathematical likelihood that some bad thing might happen. For instance, exposure to radiation poses a risk of cancer. Or the hazard — or peril — itself. (For instance: *Among cancer risks that the people faced were radiation and drinking water tainted with arsenic*.)

science fiction A field of literary or filmed stories that take place against a backdrop of fantasy, usually based on speculations about how science and engineering will direct developments in the distant future. The plots in many of these stories focus on space travel, exaggerated changes attributed to evolution or life in (or on) alien worlds.

sea An ocean (or region that is part of an ocean). Unlike lakes and streams, seawater — or ocean water — is salty.

silicon A nonmetal, semiconducting element used in making electronic circuits. Pure silicon exists in a shiny, dark-gray crystalline form and as a shapeless powder.

simulation (v. simulate) An analysis, often made using a computer, of some conditions, functions or appearance of a physical system. A computer program would do this by using mathematical operations that can describe the system and how it might change over time or in response to different anticipated situations.

stress (in biology) A factor — such as unusual temperatures, movements, moisture or pollution — that affects the health of a species or ecosystem. (in psychology) A mental, physical, emotional or behavioral reaction to an event or circumstance (stressor) that disturbs a person or animal's usual state of being or places increased demands on a person or animal; psychological stress can be either positive or negative.

survey (v.) To ask questions that glean data on the opinions, practices (such as dining or sleeping habits), knowledge or skills of a broad range of people. Researchers select the number and types of people questioned in hopes that the answers these individuals give will be representative of others who are their age, belong to the same ethnic group or live in the same region. (n.) The list of questions that will be offered to glean those data.

symptom A physical or mental indicator generally regarded to be characteristic of a disease. Sometimes a single symptom — especially a general one, such as fever or pain — can be a sign of any of many different types of injury or disease.

terrain The land in a particular area and whatever covers it. The term might refer to anything from a smooth, flat and dry landscape to a mountainous region covered with boulders, bogs and forest cover.

therapy (adj. therapeutic) Treatment intended to relieve or heal a disorder.

tissue Made of cells, any of the distinct types of materials that make up animals, plants or fungi. Cells within a tissue work as a unit to perform a particular function in living organisms. Different organs of the human body, for instance, often are made from many different types of tissues.

van Allen belts Two belts, an inner and outer one, surrounding Earth. They consist of cosmic rays — charged particles (electrons and protons). The belts extend from about 13,000 to 60,000 kilometers (8,100 to 37,300 miles) above the planet's surface. The high-energy particles, a type of radiation, vary over time and altitude and pose a health risk to exposed space travelers.

Readability Score:

7.1

Citation

Journal: V. Koppelmans et al. **Brain structural plasticity with spaceflight. (https://www.nature.com/articles/s41526-016-0001-9).** *Nature Micrograviy*. Vol. 2, December 19, 2016. doi:10.1038/s41526-016-0001-9.

Report: Lisa Carnell et al. **Evidence Report: Risk of acute radiation syndromes due to solar particle events (https://ntrs.nasa.gov/search.jsp?R=20160003870).** . NASA report. April 6, 2016.

Further Reading

Questions for 'En route to Mars, astronauts may face big health risks' (https://www.sciencenewsforstudents.org/questions/questions-en-route-mars-astronauts-may-face-big-health-risks).

Wordfind (https://www.sciencenewsforstudents.org/atom/4322).

Source URL: https://www.sciencenewsforstudents.org/article/en-route-mars-astronauts-may-face-big-health-risks

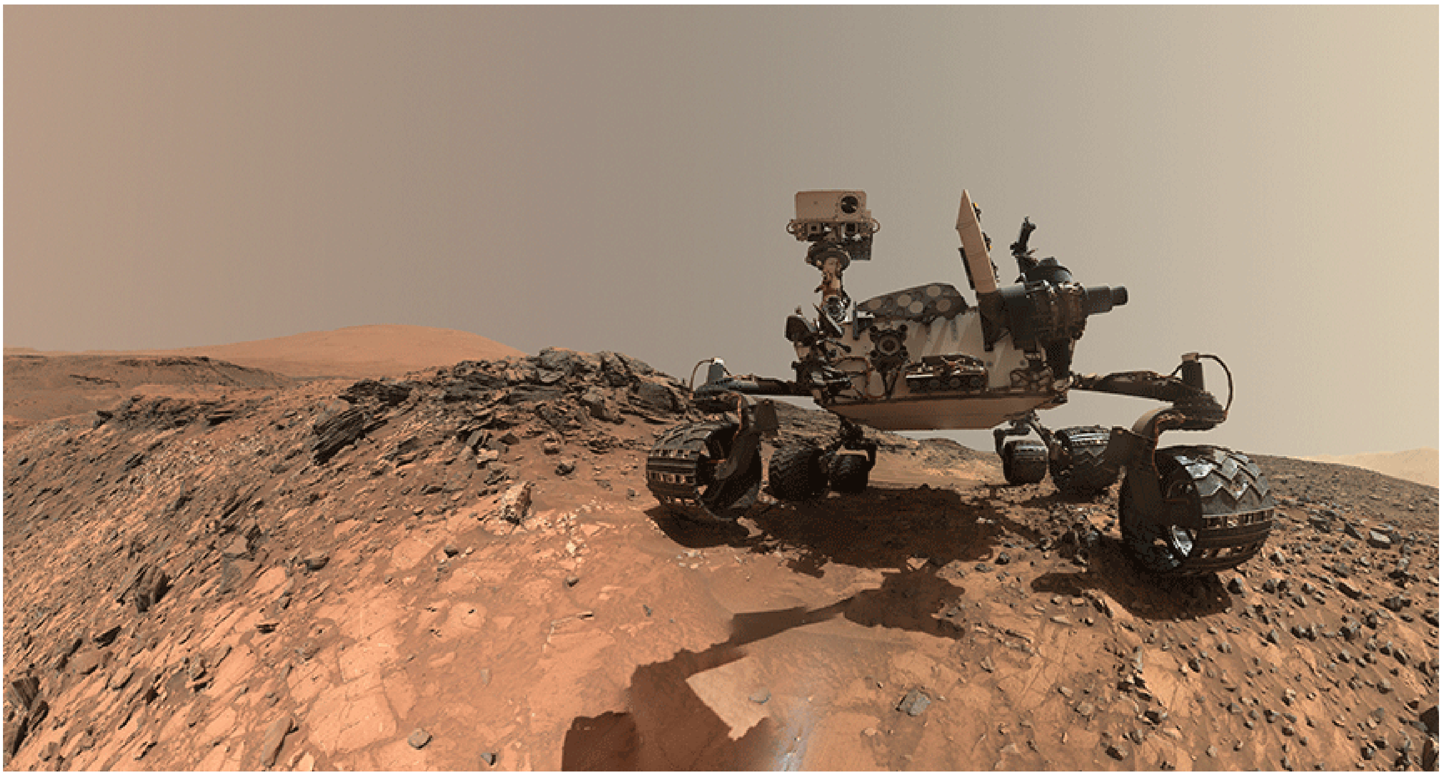
ScienceNews for Students

PLANETS SPACE

What the Curiosity rover has learned about Mars so far

While it has found no signs of life, its cameras and other tools have spied hints of water and habitable soils

BY **HELEN THOMPSON** AUG 5, 2017 — 7:21 AM EST



Curiosity has done a lot more than take selfies in front of Gale Crater, and with its mission extended through next fall, there's still more science to come.
MSSS, JPL-Caltech/NASA

August 5 marks the fifth anniversary of the Curiosity rover's 2012 landing on Mars. The little robot is by now an old pro at doing science on the Red Planet. And this Little Robot That Could has learned a lot.

Its mission had been simple. It was to look for signs that the planet might once have been habitable — for microbes, not for **Matt Damon (https://www.sciencenews.org/article/martian-entertaining-science-fiction-rooted-fact)** ! To do that, NASA sent the robot to Gale Crater. It's a huge impact basin with a mountain at its center. Curiosity has traveled across the crater, turning over rocks. Along the way, the robot collected evidence of ancient water, minerals, *organic* chemicals and other materials needed for life.

Curiosity was so successful that NASA has extended its mission through October 2018. After all, there's still plenty of interesting chemistry and geology to be done. As the robot continues to climb Mount Sharp at the center of the crater, it will explore three new rock layers. One is dominated by an iron mineral known as hematite (HE-mah-tyte). Another layer is mostly clay. The third contains plenty of sulfate-based salts.

What more could Curiosity dig up over the next year? Here are four mysteries it might solve (or at least find more clues to).

Are there remains of ancient life in the Martian soil?

Any signs of life would likely be microbial. Curiosity can take images of very tiny things with a tool known as the Mars Hand Lens Imager. To succeed at finding microfossils, however, those ancient cells would still have to be pretty big. What the rover might do instead is scan for the chemicals used to build such cells. And Curiosity can try that using its portable chemistry lab known as SAM (for Sample Analysis at Mars).

So far, SAM already has found a small *organic* molecule, meaning one with carbon in it. This ring-shaped chemical — chlorobenzene — turned up in ancient mud rock. Its discovery excited scientists. After all, chains of such molecules go into making things such as cell walls.

"We've only found simple organic molecules so far," says Ashwin Vasavada. He works at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif. There, this planetary scientist heads Curiosity's science team. Detective work in chemistry labs on Earth might point to whether bigger organic chemicals might degrade on Mars' surface into smaller ones, such as chlorobenzene.

How did Mars morph from wet and warm to cold and dry?

Studies have pointed to there once having been water on Mars. In fact, Gale crater once held a lake fed by rivers. Moreover, Curiosity's very first drilling sample detected chemicals that can form only in nonacidic environments that would comfortable for Earth-type life. Among those chemicals was calcium sulfate. The rocks also contained clays. These would have formed in water — and only water that was slightly salty.

Scientists with NASA have concluded that the Martian soil seems the most hospitable environment ever detected outside Earth.

But things didn't stay potentially cozy. Some 3.5 billion years ago, things changed.

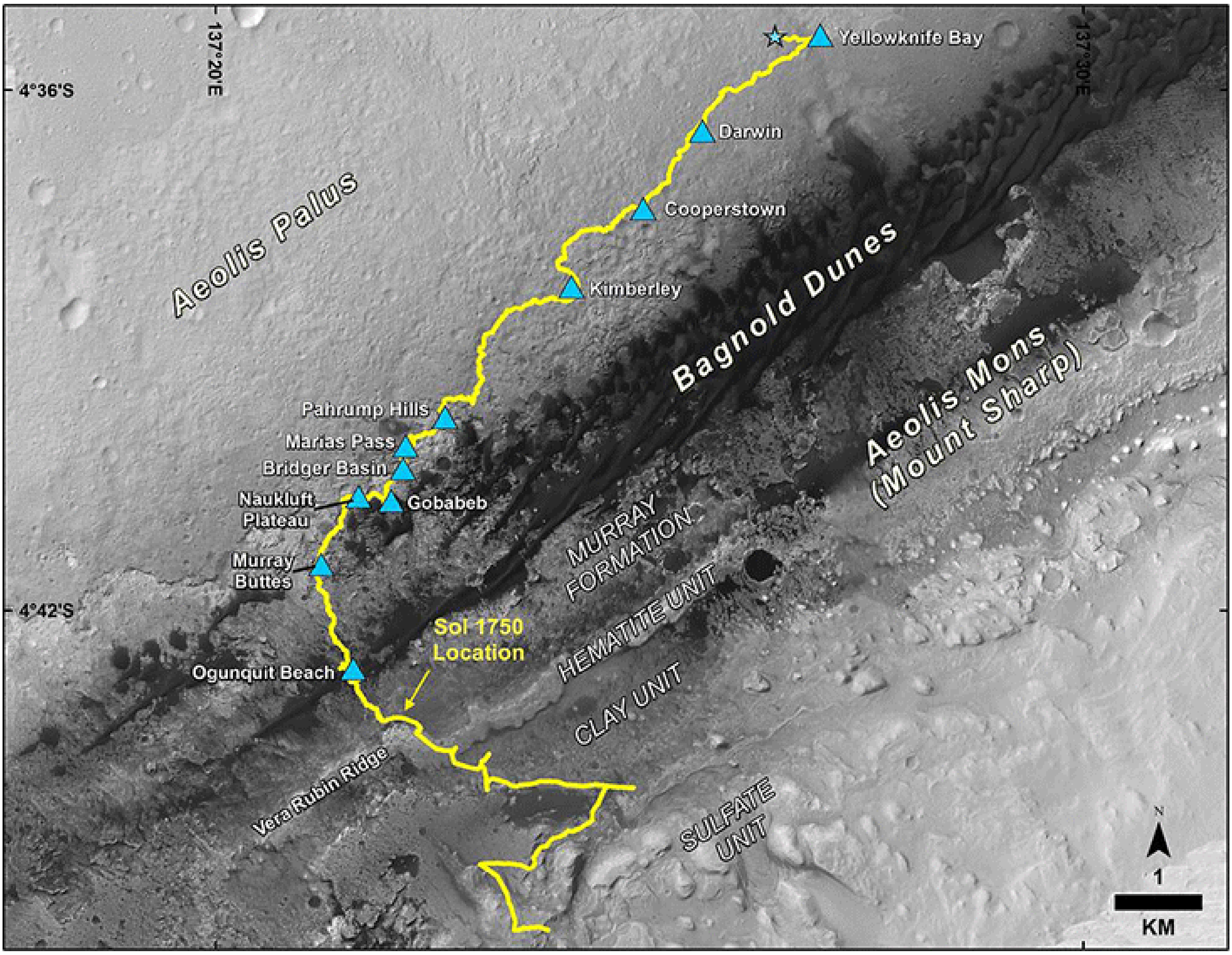
The going theory is that when Mars lost its protective magnetic field, particles from the sun began stripping away some of the Red Planet's atmosphere. (By the way, its atmosphere continues to erode today.) "That caused the climate to change from one that could support water at the surface to the dry planet it is today," explains Vasavada.

Curiosity has turned up a relatively high proportion of *heavy elements* in the Martian atmosphere. This supports the idea that lighter elements were once there but simply proved the first to go.

There's also a chance that as the rover hikes up Mount Sharp, it could capture regional evidence of the wet-to-dry transition in action. So far, Curiosity has investigated rocks from the end of the wet period. They pointed to the planet once having hosted surface lakes that lasted for millennia!

Rocky sites the rover is now approaching are younger. "Hopefully we'll be able to get some insight by looking at these rocks into some of the global changes happening," says Abigail Fraeman. She's a research scientist at JPL. Probing rock at the new sites might help uncover what types of changes made surface lakes a thing of the past.

(*Story continues after image*)



Curiosity has spent the last five years exploring an ancient lake bed. But now it's venturing into unknown territory in three new rock layers or units: hematite, clay and sulfate. Data from these areas could tell scientists what exactly makes up the units and how they fit into the history of Mount Sharp and Mars.
JPL-Caltech/NASA, Univ. of Arizona

Does Mars *really* have flowing water today?

Some mineral salts absorb water, then later release it as a liquid when they break down. The Curiosity team looked for the bursts of water that might result from such a process in Gale Crater. And it came up empty.

Two years ago, the Mars Reconnaissance Orbiter snapped images of shifting salt streaks. Those suggested Mars once had actively flowing water. These photos are the best evidence yet that Mars' liquid water might not be gone forever.

Mount Sharp also has such dark streaks. Curiosity takes pictures of them now and again. "It's something we keep an eye on," Vasavada says. If the streaks change in a way that might indicate that they're moving, the rover might drive over to look for water. Alas, so far the streaks have not changed.

What's the source of methane in Mars' atmosphere?

On Earth, microbes are big producers of methane gas. There is methane in the Martian air, too. But where it comes from is unclear. Atmospheric methane levels appear to vary over the course of a year. Changing temperatures or pressure might be behind these subtle fluctuations. Curiosity will continue to monitor methane levels. It also will collect more data, hoping to help pinpoint what's behind the annual ups and downs.

At the end of 2014, scientists detected a 10-fold spike in the methane in Mars' atmosphere. They now suspect that methane remains in the Martian air for only about 300 years. So, it's a relatively new addition. "That doesn't necessarily mean it's being actively created," Vasavada says. "It could be old methane being released from underground." (As minerals interact with water underground, they sometimes help create methane gas.) Mars' methane also might be the product of planetary dust particles as they break down on the planet's surface.

Another possible explanation: Life! "We have zero information to know whether that's happening on Mars, but we shouldn't exclude [life] as an idea," says Vasavada of methane-making microbes. Martian life is unlikely, he says, but it cannot be completely ruled out.

Power Words

(for more about Power Words, click [here (https://www.sciencenewsforstudents.org/power-words-aid-stem-literacy)](https://www.sciencenewsforstudents.org/power-words-aid-stem-literacy))

annual Adjective for something that happens every year.

atmosphere The envelope of gases surrounding Earth or another planet.

basin (in geology) A low-lying area, often below sea level. It collects water, which then deposits fine silt and other sediment on its bottom. Because it collects these materials, it's sometimes referred to as a catchment or a drainage basin.

calcium A chemical element which is common in minerals of the Earth's crust and in sea salt. It is also found in bone mineral and teeth, and can play a role in the movement of certain substances into and out of cells.

carbon The chemical element having the atomic number 6. It is the physical basis of all life on Earth. Carbon exists freely as graphite and diamond. It is an important part of coal, limestone and petroleum, and is capable of self-bonding, chemically, to form an enormous number of chemically, biologically and commercially important molecules.

cell The smallest structural and functional unit of an organism. Typically too small to see with the unaided eye, it consists of a watery fluid surrounded by a membrane or wall. Depending on their size, animals are made of anywhere from thousands to trillions of cells. Most organisms, such as yeasts, molds, bacteria and some algae, are composed of only one cell.

chemical A substance formed from two or more atoms that unite (bond) in a fixed proportion and structure. For example, water is a chemical made when two hydrogen atoms bond to one oxygen atom. Its chemical formula is H_2O. Chemical also can be an adjective to describe properties of materials that are the result of various reactions between different compounds.

chemistry The field of science that deals with the composition, structure and properties of substances and how they interact. Scientists use this knowledge to study unfamiliar substances, to reproduce large quantities of useful substances or to design and create new and useful substances. (about compounds) Chemistry also is used as a term to refer to the recipe of a compound, the way it's produced or some of its properties. People who work in this field are known as chemists.

clay Fine-grained particles of soil that stick together and can be molded when wet. When fired under intense heat, clay can become hard and brittle. That's why it's used to fashion pottery and bricks.

climate The weather conditions that typically exist in one area, in general, or over a long period.

compound (often used as a synonym for chemical) A compound is a substance formed when two or more chemical elements unite (bond) in fixed proportions. For example, water is a compound made of two hydrogen atoms bonded to one oxygen atom. Its chemical symbol is H_2O.

crater A large, bowl-shaped cavity in the ground or on the surface of a planet or the moon. They are typically caused by an explosion or the impact of a meteorite or other celestial body. Such an impact is sometimes referred to as a cratering event.

degrade To break down into smaller, simpler materials — as when wood rots or as a flag that's left outdoors in the weather will fray, fade and fall apart. (in chemistry) To break down a compound into smaller components.

element (in chemistry) Each of more than one hundred substances for which the smallest unit of each is a single atom. Examples include hydrogen, oxygen, carbon, lithium and uranium.

environment The sum of all of the things that exist around some organism or the process and the condition those things create. Environment may refer to the weather and ecosystem in which some animal lives, or, perhaps, the temperature and humidity (or even the placement of components in some electronics system or product).

erode Gradual removal of soil or stone, caused by the flow of water or the movement of winds.

field An area of study, as in: *Her field of research was biology*. Also a term to describe a real-world environment in which some research is conducted, such as at sea, in a forest, on a mountaintop or on a city street. It is the opposite of an artificial setting, such as a research laboratory.

fossil Any preserved remains or traces of ancient life. There are many different types of fossils: The bones and other body parts of dinosaurs are called "body fossils." Things like footprints are called "trace fossils." Even specimens of dinosaur poop are fossils. The process of forming fossils is called fossilization.

geology The study of Earth's physical structure and substance, its history and the processes that act on it. People who work in this field are known as geologists. Planetary geology is the science of studying the same things about other planets.

habitable A place suitable for humans or other living things to comfortably dwell.

heavy element (to astronomers) Any element other than hydrogen (or possibly helium).

hematite A reddish-brown to black iron-based mineral, it's the principle source of iron ore.

insight The ability to gain an accurate and deep understanding of a situation just by thinking about it, instead of working out a solution through experimentation.

iron A metallic element that is common within minerals in Earth's crust and in its hot core. This metal also is found in cosmic dust and in many meteorites.

lens (in optics) A curved piece of transparent material (such as glass) that bends incoming light in such a way as to focus it at a particular point in space. Or something, such as gravity, that can mimic some of the light bending attributes of a physical lens.

magnetic field An area of influence created by certain materials, called magnets, or by the movement of electric charges.

Mars The fourth planet from the sun, just one planet out from Earth. Like Earth, it has seasons and moisture. But its diameter is only about half as big as Earth's.

methane A hydrocarbon with the chemical formula CH_4 (meaning there are four hydrogen atoms bound to one carbon atom). It's a natural constituent of what's known as natural gas. It's also emitted by decomposing plant material in wetlands and is belched out by cows and other ruminant livestock. From a climate perspective, methane is 20 times more potent than carbon dioxide is in trapping heat in Earth's atmosphere, making it a very important greenhouse gas.

microbe Short for microorganism. A living thing that is too small to see with the unaided eye, including bacteria, some fungi and many other organisms such as amoebas. Most consist of a single cell.

millennia (singular: millennium) Thousands of years.

mineral Crystal-forming substances that make up rock, such as quartz, apatite or various carbonates. Most rocks contain several different minerals mish-mashed together. A mineral usually is solid and stable at room temperatures and has a specific formula, or recipe (with atoms occurring in certain proportions) and a specific crystalline structure (meaning that its atoms are organized in regular three-dimensional patterns).

molecule An electrically neutral group of atoms that represents the smallest possible amount of a chemical compound. Molecules can be made of single types of atoms or of different types. For example, the oxygen in the air is made of two oxygen atoms (O_2), but water is made of two hydrogen atoms and one oxygen atom (H_2O).

monitor To test, sample or watch something, especially on a regular or ongoing basis.

NASA Short for the National Aeronautics and Space Administration. Created in 1958, this U.S. agency has become a leader in space research and in stimulating public interest in space exploration. It was through NASA that the United States sent people into orbit and ultimately to the moon. It also has sent research craft to study planets and other celestial objects in our solar system.

orbiter A spacecraft designed to go into orbit, especially one not intended to land.

organic (in chemistry) An adjective that indicates something is carbon-containing; a term that relates to the chemicals that make up living organisms.

particle A minute amount of something.

planet A celestial object that orbits a star, is big enough for gravity to have squashed it into a roundish ball and has cleared other objects out of the way in its orbital neighborhood. The solar system now includes eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

pressure Force applied uniformly over a surface, measured as force per unit of area.

proportion The amount of a certain component of a mixture relative to other components. For example, if a bag contains 2 apples and 3 oranges, the proportion of apples to oranges in the bag is 2 to 3.

propulsion The act or process of driving something forward, using a force. For instance, jet engines are one source of propulsion used for keeping airplanes aloft.

Red Planet A nickname for Mars.

robot A machine that can sense its environment, process information and respond with specific actions. Some robots can act without any human input, while others are guided by a human.

salt A compound made by combining an acid with a base (in a reaction that also creates water). The ocean contains many different salts — collectively called "sea salt." Common table salt is a made of sodium and chlorine.

sulfate A family of chemical compounds that are related to sulfuric acid (H_2SO_4). Sulfates occur naturally in drinking water.

sun The star at the center of Earth's solar system. It's an average size star about 26,000 light-years from the center of the Milky Way galaxy. Also a term for any sunlike star.

Readability Score:
7.7

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Citation

Journal: K.S. Edgett et al. **Curiosity's Mars Hand Lens Imager (MAHLI) investigation (https://link.springer.com/article/10.1007%2Fs11214-012-9910-4).**
. *Space Science Reviews.* Vol. 170, September 2012, p. 259.

Further Reading

Learn about the Sample Analysis at Mars (SAM) instrument **here (https://mars.nasa.gov/msl/mission/instruments/spectrometers/sam/).**
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Learn more **here (https://www.nasa.gov/mission_pages/msl/news/msl20130718.html).**
about what Curiosity has learned about the changing atmosphere on Mars.

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