

on Earth—and Beyond

An Astrobiologist's Quest

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The Hubble Space Telescope is able to photograph distant galaxies, such as the barred spiral galaxy NGC 1672.

Introduction

Are We Alone?

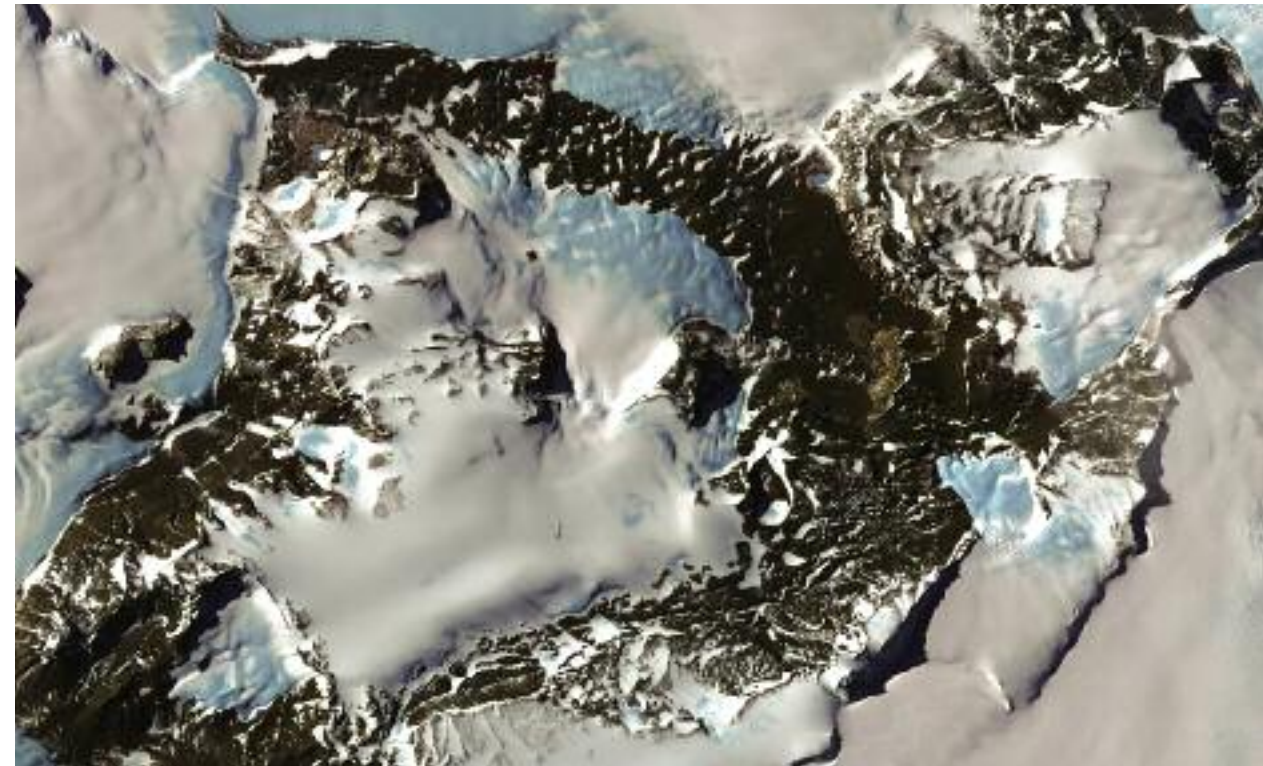
Biology is the study of life on Earth, but astrobiology is the study of life in the universe. Astrobiologists seek to answer the question: does life exist beyond Earth?

We haven't discovered any aliens yet. However, astrobiologists are looking carefully at planets such as Mars, moons such as Europa, and distant solar systems for signs of life. Astrobiologists like Dr. Chris McKay of the National Aeronautics and Space Administration (NASA) also study extreme environments on Earth to better understand how life might survive the extreme environments on other worlds. Chris's research takes him to places such as Antarctica, the Atacama Desert in Chile, Russia's Siberia, and Africa's Sahara Desert. What types of creatures live in these harsh environments? How do they survive?

Could similar life be waiting beyond Earth?

Between a Rock and a Cold Place

The Dry Valleys, Antarctica



The Antarctic Dry Valleys (the dark patches in this satellite photo) are the largest ice-free areas in Antarctica.

Can life survive in a very cold, dry place?

At the very bottom of the globe, in a land of ice and snow, there are great curving valleys of bare earth: Antarctica's Dry Valleys. It's a harsh place. In April, the beginning of the Antarctic winter, the sun goes down and doesn't come up again until September. For months the Dry Valleys are locked in frozen darkness. There isn't a single scraggly weed or tiny insect. The Dry Valleys are almost as lonely as outer space.

Lack of rainfall, less than 4 inches (10 centimeters) of snow per year, and temperatures of minus 29°F (minus 34°C) make the Dry Valleys a frozen desert.

Yet the Dry Valleys fascinate astrobiologists like Chris McKay. “The Dry Valleys are like Mars,” explains Chris. “Both are cold and dry. It hardly ever snows in the Dry Valleys, and when it does, the air is so cold that very little snow ever melts. Mars is even colder and drier.”

Chris set off to visit the Dry Valleys in January 2005, during the Antarctic summer. Just getting to such a remote spot was an adventure.

Journey to the Bottom of the Earth

To reach the Dry Valleys, Chris flew from San Francisco, California, to New Zealand. In New Zealand he boarded an Air Force cargo plane to McMurdo Station in Antarctica. The cargo plane had no reclining seats or meal service. No windows either. “It was eight hours of being cramped and cold, and so noisy you had to wear earplugs,” Chris later recalled.

Chris and seven other scientists took many boxes of equipment to Antarctica. They didn’t have to bring everything, however. The scientists had special cold-weather clothing and camping gear from the National

Chris’s team boards a cargo plane for the flight from New Zealand to Antarctica.



★ *Chris's research site*
Along the edges of Antarctica are huge ice shelves (thick, floating platforms of ice). The Ross Ice Shelf, near McMurdo Station, is the size of France. The Antarctic Dry Valleys are also nearby.

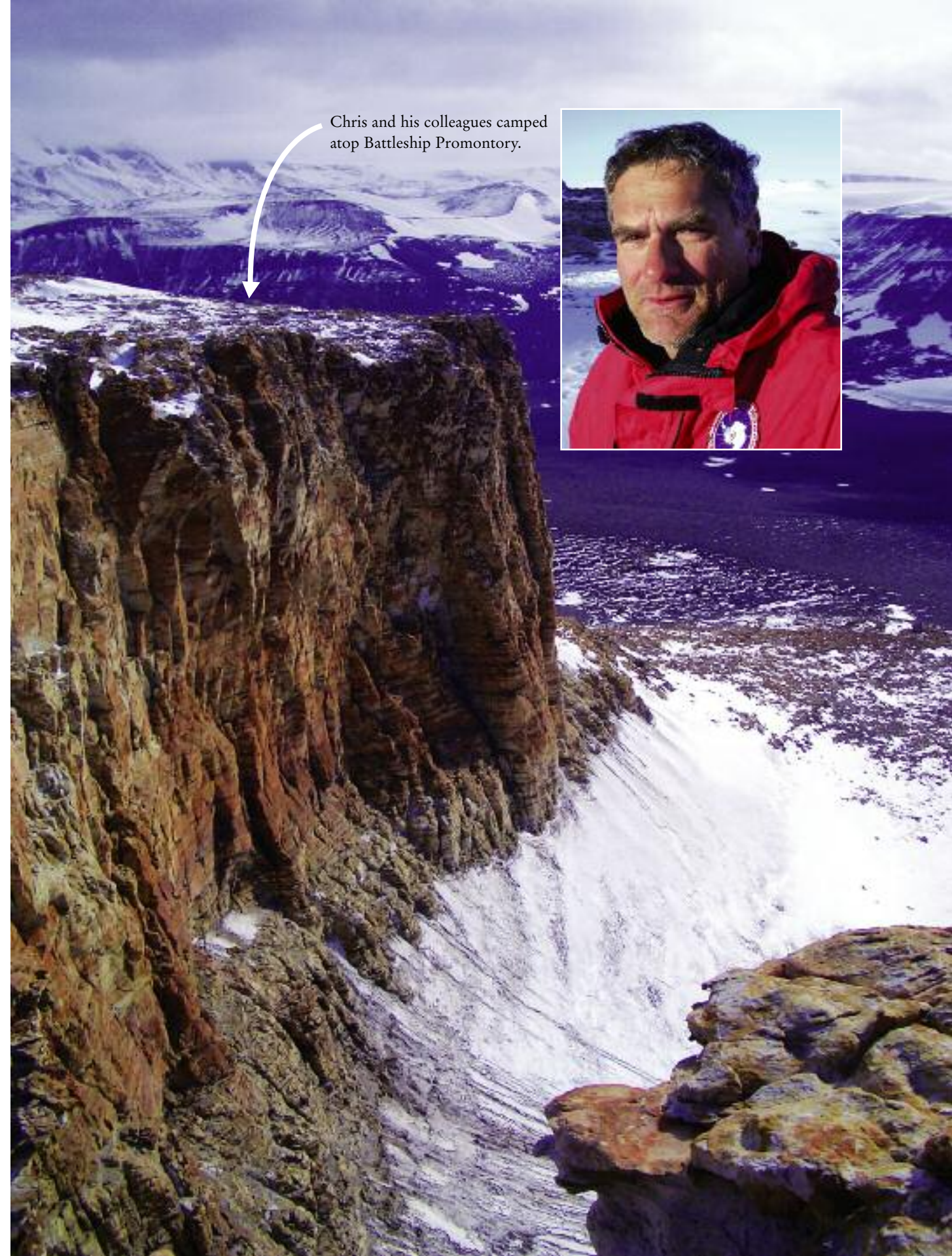


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Science Foundation, an agency that coordinates American research in Antarctica. They didn't have to pack food either. Chris and the other scientists went shopping at McMurdo Station's "supermarket": a big metal hut full of groceries.

After stuffing two helicopters with camping gear, equipment, food, and water, the scientists flew to the Dry Valleys. They landed atop a giant lump of sandstone called Battleship Promontory. It would be their home for the next two weeks.

Helicopters carried the scientists, their supplies, and their equipment 100 miles (160 kilometers) from McMurdo Station to the Dry Valleys.



Chris and his colleagues camped atop Battleship Promontory.



Scientists have found seal mummies in the Dry Valleys. Some of them are thousands of years old.

Little Green Men

Early on his first morning in the Dry Valleys, six-foot-six-inch Chris wormed his way out of his extra-long sleeping bag. There was plenty of light outside. The sun is up twenty-four hours a day during the Antarctic summer. However, the sun's rays didn't give off much warmth. Even during the summer the Dry Valleys were as cold as Montana in winter.

Chris dressed quickly and made his way through the scientists' tent camp. The chilly wind cut like a razor, even through down-filled clothing.

The camp was a little "tent city." There was a science tent, a kitchen tent, a toilet tent, and the "suburbs" (the sleeping tents). Solar panels powered the kitchen tent, fondly nicknamed Café Battleship. Chris treated his companions to pancakes with canned cherries on top. Cleaning up was easy. The scientists just wiped everything with paper towels and let the dishes freeze. Nothing rotted or spoiled in the cold, dry air.



Chris serves pancakes inside Café Battleship.

This is the camp on Battleship Promontory. At the end of the trip, helicopters flew out every piece of trash and human waste.





This is the view from Chris's tent. In 2005 there was more snow than usual.

Chris has been making these camping trips to Antarctica for twenty-five years. He knows there are creatures hidden in the Dry Valleys that can survive some of the world's worst weather. Their secret? They live *inside* rock.

“Solid” rock isn't always solid. Many rocks are honeycombed with little spaces, or pores, that seem like huge caverns to super-small creatures called microbes. Microbes (also called microorganisms) are the tiniest of all living things. They are so small that they can't be seen without a microscope.

After breakfast Chris headed to the nearby sandstone cliffs. He examined the sandstone carefully. Chris spotted little blotches on the rock. A colony of microbes was living in pores just under the surface. With a hammer and chisel he carefully chipped off a chunk of rock to

take back to his lab at NASA. On previous visits Chris had drilled tiny holes into the sandstone and attached sensors. The sensors measured the light and moisture inside the rocks year-round. Chris's sensors showed that the microbes hidden in the rocks survived on tidbits of summer sunlight and a few drops of snowmelt.

Looking carefully, Chris also spied a wet spot on the rock. “When that happens there are microbes cheering, ‘Yeah! Wet snow!’” Chris later explained. “They are living in little rock greenhouses. They ‘wake up’ for a few days in the summer, when the sun is shining and a little moisture seeps down through the pores in the rock. They grow a little and then go back to sleep for the rest of the year.”

Chris chipped off another rock sample. Just under the rock's surface was a thin green line—a minute “forest” of microbes (cyanobacteria and fungi). These microbes were real survivors. “If life exists on Mars, it might look something like that,” Chris later explained. “Those little green critters are the best Martians we have. And everyone knows Martians are little and green!”

Snowmelt reaches the microbes that are hidden inside the rock.



A closer look at the small dark patch exposes cyanobacteria and fungi.

A shelter of rock or dirt would be very important for any Martian life. The atmosphere on Mars is too thin to block dangerous radiation from the sun. If any life exists on Mars, it would need to be shielded from solar radiation by rock or soil. But microbes hiding inside rocks or underground aren't easy to find. So Chris used the Dry Valleys as a testing ground for microbe-detection machines.

What Is Life?

You'd think the answer is easy. Living things eat (take in energy) and give off waste, right? But a car "eats" gasoline and gives off heat and exhaust gases. A car isn't alive.

Let's add the ability to reproduce. A car can't make baby cars.

That doesn't work either. A fire eats wood and oxygen and gives off heat, carbon dioxide, and smoke. It can reproduce, too. A single spark can grow into a whole new fire.

Let's add the ability to evolve. Fire can't do this. Fire is fire. But all species of living things—from bacteria to bean plants to bears—evolve. They adapt over time in response to changes in their environment. So now we have it: a living thing eats, gives off waste, reproduces, and evolves.

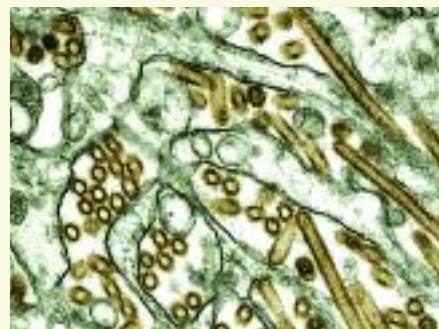
Sorry, but there is one major glitch: viruses. Viruses are very small, very simple microbes. They cause many human diseases, including AIDS and the common cold. Viruses take in energy, give off waste, and evolve. Flu

viruses evolve so quickly that scientists must develop new flu vaccines every year to fight the latest version of the virus.

But viruses can't reproduce by themselves. A virus must invade the cell of a living thing (such as a bacterium, plant, or animal) and hijack the cell's machinery to make more viruses.

So is a virus just a fancy bit of chemistry? Or is it possible for something to be half-alive?

Scientists are still arguing over these questions. There's no easy answer. That's life!



The gold circles and rods are the deadly H5N1 "bird flu" virus.



These are valleys on Mars. The average temperature on Mars is minus 80°F (minus 60°C), but the temperature can reach 70°F (20°C) during the Martian summer.

Machines for Mars and Beyond

The team brought a gas chromatograph, a spectrometer, and four types of ultraviolet (UV) lasers to test in the Dry Valleys. Each machine used a different technique for sensing hidden microbes. The gas chromatograph sensed gases given off by microbes. The spectrometer looked for the kind of light absorbed by microbes. The UV laser sensed the "glow" given off by microbes when the UV laser shone on them.

At least that's what was *supposed* to happen. But the gas chromatograph didn't work at all, despite hours of tinkering. Of the six machines Chris and the other scientists brought to Antarctica, only two, the spectrometer and one UV laser, were good at finding microbes. Even recording test results was difficult. The ink froze in Chris's pen!

Chris was pleased that two machines worked. Science is all about testing new things and ideas. Sometimes things work out, and sometimes they don't.

A spectrometer or UV laser may travel on a future NASA mission. The machines may land on a planet that—like the Dry Valleys—seems too cold and too dry for life. Yet “little green men” might surprise us.

Chris can't wait to find out. He's been wondering what's out there ever since he found a dusty old telescope and pointed it into the night sky.

Kevin Hand, Robert Carlson, and Henry Sun test a spectrometer on rock containing hidden life.



Chris phones home via satellite. The blue squares provide solar power for the scientists' equipment.