Photo Credit: Bonneville Salt Flats - Utah Bureau of Land Management;
Dunaliella salina - Microbewiki, Kenyon College
For more information visit http://astrobiology.nasa.gov/

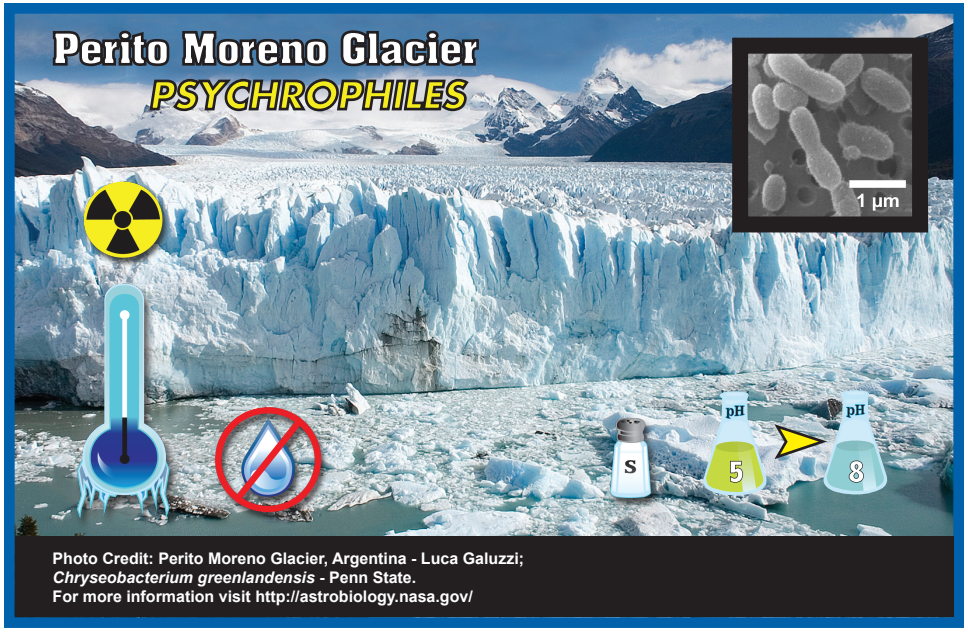

Photo Credit: Perito Moreno Glacier, Argentina - Luca Galuzzi;
Chryseobacterium greenlandensis - Penn State.
For more information visit http://astrobiology.nasa.gov/

Photo Credit: Algae flow patterns at Rio Tinto, Spain - Carol Stoker, NASA Ames Research Center;
Ferroplasma acidiphilum - Helmholtz-Centre for Infection Research.
For more information visit http://astrobiology.nasa.gov/

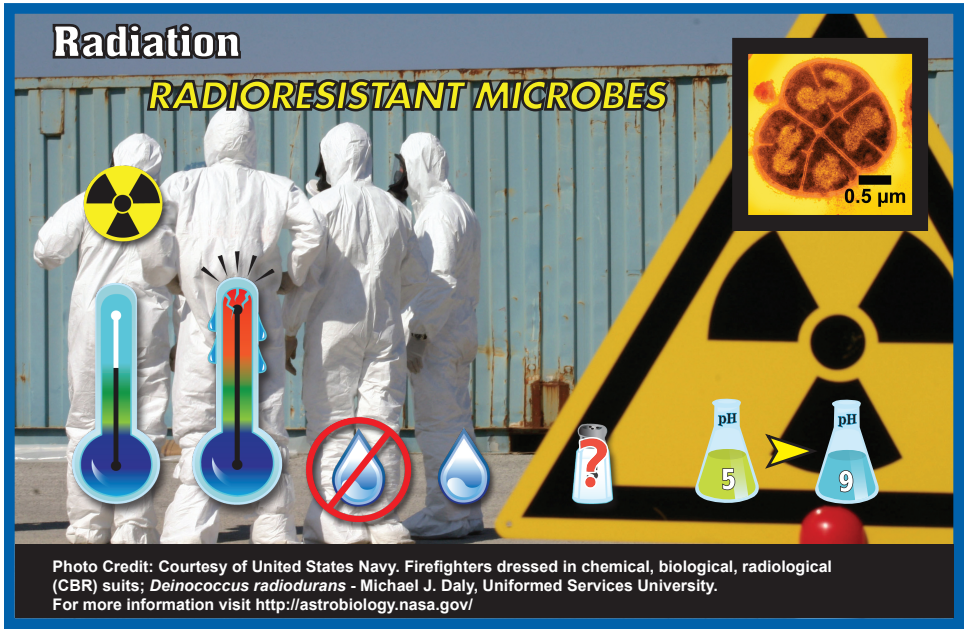

Photo Credit: Courtesy of United States Navy. Firefighters dressed in chemical, biological, radiological (CBR) suits; *Deinococcus radiodurans* - Michael J. Daly, Uniformed Services University.
For more information visit http://astrobiology.nasa.gov/

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Chryseobacterium greenlandensis is a very small bacterium. It has survived for up to 120,000 years within the ice of a Greenland glacier. It has been found nearly two miles below the surface.

EXTREME ABILITY

Psychrophiles are organisms the grow the best at temperatures below 15° C. To protect their DNA, some produce proteins that act as antifreeze. Not only can they survive in cold places, but many psychrophiles are also halophiles!

EXTREME ENVIRONMENTS

Psychrophiles have been found in arctic soils, deep ocean water, glaciers, snowfields, sea ice, and tundra. Scientists are trying to determine if Jupiter's icy moon Europa harbors cold-loving microbes.

EXTREME EXAMPLES

While many psychrophiles need cold temperatures to survive, some can survive in temperatures from -10 up to 37° C. That is as warm as your body temperature!

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Dunaliella salina is an algae that lives in salt ponds. To protect itself from sunlight, Dunaliella concentrates betacarotene in its cell wall. This gives it an orange or pinkish color.

EXTREME ABILITY

Halophiles coat themselves with a special protein layer. This layer allows only certain amount of salt into the cell. This layer also helps to seal in water.

EXTREME ENVIRONMENTS

Ocean water is about 3.5% salt. The water in salt ponds is typically 5 to 10 times saltier than ocean water. This means that a gallon of water from some salt ponds contains as much as 2.5 pounds of dissolved salt! D. salina has been flown into space and may survive the UV radiation of space. Most require temperatures between 0° - 35° C to survive.

EXTREME EXAMPLES

These salt lovers live in places like the Great Salt Lake in Utah, Owens Lake in California, and the Dead Sea between Israel and Jordan. Halophilic bacteria also occasionally grow on saltine crackers!

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The bacterium Deinococcus radiodurans is resistant to drying, ultraviolet light, and large doses of gamma-ray radiation.

EXTREME ABILITY

D. radiodurans can survive doses of radiation that are 500 times greater than the lethal dose for humans. It does not have a radiation shield, its DNA is damaged just like a humans. The difference is that it can repair its DNA much faster. *D. radiodurans* also has multiple copies, or backups, of its DNA.

EXTREME ENVIRONMENTS

Radioresistant fungi were found growing in the remains of the Chernobyl nuclear reactor. Scientists determined that the fungi were using energy from radioactivity to produce food. They can survive at temperatures between 30° - 95° C.

EXTREME EXAMPLES

D. radiodurans is listed in the Guinness Book of World Records as "the world's toughest bacterium." In addition to being resistant to radiation, this bacterium can also survive severe droughts, extreme cold, and strong acids.

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Ferroplasma acidiphilum extracts energy from iron. It "eats" the metal and leaves rust behind.

EXTREME ABILITY

Acids, such as the citric acid in lemons, taste sour. Even the word acid comes from the Latin word acidus meaning "sour." Acidophiles survive in very acidic environments where pH rarely rises above 3. When other organisms are exposed to such acidic conditions their DNA is damaged beyond repair.

EXTREME ENVIRONMENTS

These organisms are most commonly found in mine drainages, waste treatment plants, acidic hot springs, and some caves. Scientists think that the toxic clouds of Venus might harbor acidophiles. Acidophiles are found in temperatures between 30 – 92 ° C.

EXTREME EXAMPLES

Acidophiles play a role in acid mine drainage and in coal mining. They are used to recover minerals and to reduce sulfur levels.

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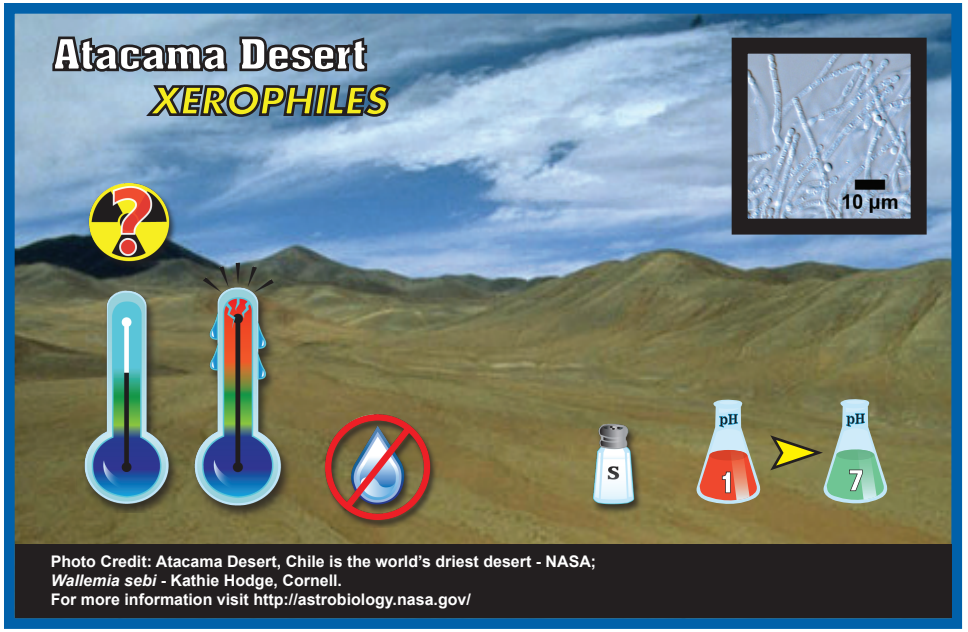

Photo Credit: Atacama Desert, Chile is the world's driest desert - NASA;
Wallemia sebi - Kathie Hodge, Cornell.
For more information visit http://astrobiology.nasa.gov/

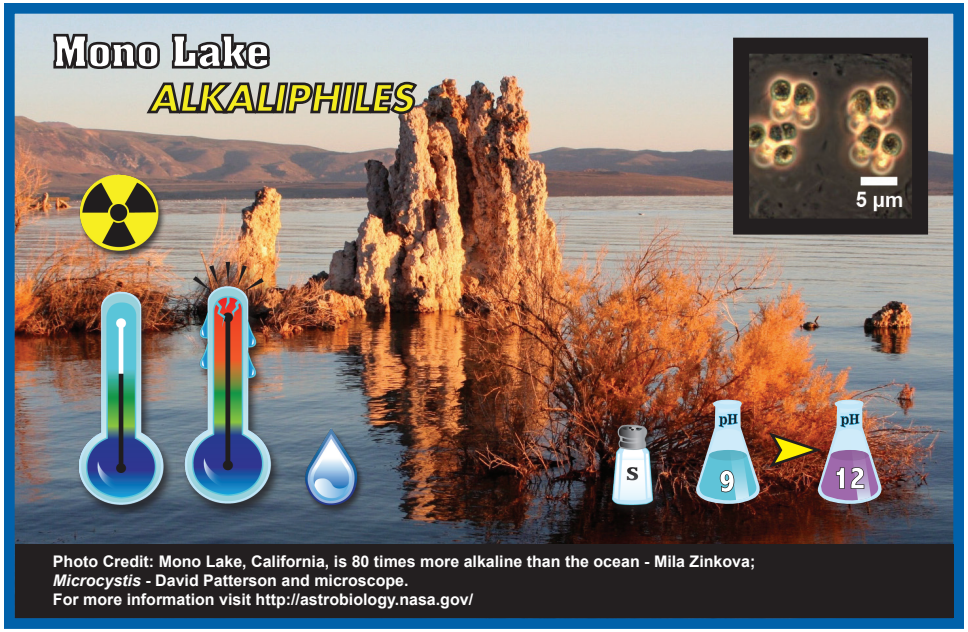

Photo Credit: Mono Lake, California, is 80 times more alkaline than the ocean - Mila Zinkova;
Microcystis - David Patterson and microscope.
For more information visit http://astrobiology.nasa.gov/

Photo Credit: Grand Prismatic Spring at Yellowstone National Park - Mila Zinkova;
Phormidium - Gilberto Benitez and microscope.
For more information visit http://astrobiology.nasa.gov/

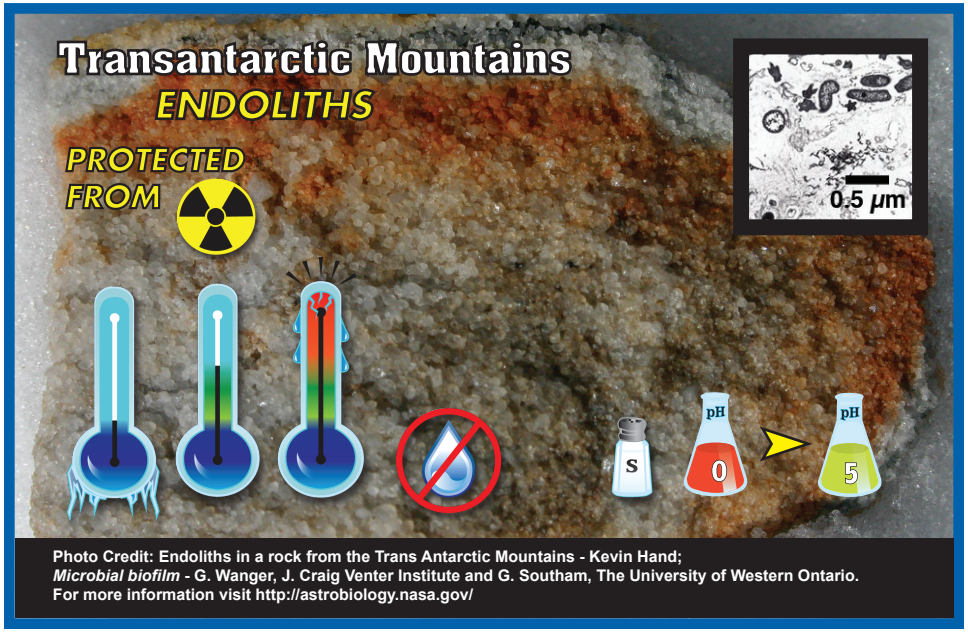

Photo Credit: Endoliths in a rock from the Trans Antarctic Mountains - Kevin Hand;
Microbial biofilm - G. Wanger, J. Craig Venter Institute and G. Southam, The University of Western Ontario.
For more information visit http://astrobiology.nasa.gov/

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Colonies of blue-green bacteria called Microcystis flourish in alkaline environments like Mono Lake, California seen on the front of this card.

EXTREME ABILITY
Most alkaliphiles would not be able to survive in drinking water (pH 7). Alkaliphiles love environments typically having pH values ranging from 9 to 11. These organisms have had to evolve a unique metabolism to get energy from their surroundings.

EXTREME ENVIRONMENTS
These microbes live in such places as soda lakes, caves, alkaline hot springs, deserts, and waste dumps from mines. Alkaliphiles can survive at temperatures between 4° - 93° C.

EXTREME EXAMPLES
Alkaliphiles are used in making paper and cleaning up spilled oil. They are also common ingredients in dishwashing detergent and laundry soap.

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Wallemia sebi is a mold that grows in places with very little water such as dried fruits, salted meats, and the evaporitic beds where sea salt is produced.

EXTREME ABILITY
Xerophiles can grow and reproduce in conditions with little water available. This group of organisms is named from the Greek words xeros meaning “dry”, and philos meaning “loving”.

EXTREME ENVIRONMENTS
Some live in pretty normal places like old food (nuts and jam especially), but others thrive in harsher conditions. Xerophiles can live in deserts where most creatures would dehydrate quickly! Xerophiles can survive at temperatures between 5 - 50° C.

EXTREME EXAMPLES
Many types of mold and yeast are xerophilic. Mold growth on bread is an example of food spoilage by xerophilic organisms. Xerophiles commonly live on food that has been dried for storage outside of the refrigerator.

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This community of microbes was collected more than one mile deep in a South African platinum mine. It contains star-shaped bacteria that had never been seen before!

EXTREME ABILITY
Endoliths are microbes that make their homes inside of rocks. They can live for hundreds of years by feeding on the traces of iron, potassium, and sulfur in their host rocks.

EXTREME ENVIRONMENTS
Rocks in deserts and on mountain slopes often contain endoliths. Some endoliths have been found within the Earth’s crust at a depth of nearly two miles. Endoliths can survive at temperatures between -15 - 140° C.

EXTREME EXAMPLES
Many scientists think that endoliths are good examples for the type of life most likely to be discovered living on Mars now or in the past. Harsh conditions on Mars may have driven them underground.
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Phormidium, a type of algae, loves the hot water baths at Yellowstone National Park. This thermophile can make the pools it lives in orange.

EXTREME ABILITY
These microbes have developed special proteins and enzymes that allow them to survive in a wide range of temperatures. Some even require temperatures around 60° C to exist at all.

EXTREME ENVIRONMENTS
These hardy microbes can be found in places like hot springs, crater lakes, peat bogs, and superheated hydrothermal vents on the sea floor.

EXTREME EXAMPLES
Thermus aquaticus, bacteria found in a Yellowstone hot spring, produce an enzyme that allows for quick DNA replication. This enzyme has revolutionized the biotechnology field.

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