Life In the Extreme

About The Activity

Participants are each given one of 14 examples of extremophiles -- organisms found in some of the toughest conditions on Earth. They sort themselves into groups according to the various preferences of their organisms. Finally, they discover that all known life on Earth requires liquid water to survive and grow.

Topics Covered:

- All life that we have found on Earth needs liquid water to survive.
- Life is found in a variety of extreme environments on Earth.
- Science is using these facts to explore the possibility of life beyond Earth.

Participants:

This activity works best with a group of at least 10 participants so that each person gets a card. With more participants, they can form "colonies." With fewer participants, this activity can be a simple sorting game spread out on a table. Ages 7 to adult will enjoy this activity at different levels.

Location and Timing:

This activity can be used before star parties, indoors or out, with scout troops and youth groups, in the classroom, at club meetings, and even for a general presentation. Participants will need to be mobile. It can run 5 to 15 minutes.

Materials Needed:

- 14 Extremophile Cards
- (Optional) Presenter's Cue sheet

Included in This Packet	Page
Detailed Activity Description	2
Materials and Set Up	5
Background Information	5
Master Copies	7

© 2011 Astronomical Society of the Pacific www.astrosociety.org
Copies for educational purposes are permitted.
Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Detailed Activity Description

Life In the Extreme

Leader's Role	**Participants' Role (Anticipated)**
To Say: Who thinks there might be life elsewhere in our galaxy? *–or--* What kinds of worlds do you think aliens might live on? To get some clues to these questions, scientists are studying organisms that survive in extreme environments right here on Earth to see all of the amazing ways life has adapted on our planet. This broadens the kinds of planets we are looking at where life might exist. If aliens exist, they might look very different from us and live in different environments. Let's see what kinds of organisms they are finding here on Earth. Everyone take a card. *To Do:* Hand out the Extremophile Cards to your visitors.	I do! Worlds like Earth?

© 2011 Astronomical Society of the Pacific www.astrosociety.org
Copies for educational purposes are permitted.
Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Leader's Role	Participants' Role (Anticipated)

Presentation Tip:
If there are more than 14 visitors, have them form "colonies" of organisms around each card. If there are fewer than 14, you can run the activity with as few as 10 of the cards. With just 1-4 participants, have them sort all of the cards together.

The first few times you use this activity, it might be useful to have the Presenter's Cue sheet to remind you of the categories.

Alternative activity for small groups: If there are only a few participants, use the small environment cards also titled "Life in the Extremes" and found in the Media and Resources bag or online here:
http://astrobiology.nasa.gov/nai/education-and-outreach/products-and-resources/life-in-the-extremes-trading-cards/

Visitors can try to pair the large organism cards with the environments described on the smaller cards. Again, you can sort them by many categories, laying the small cards out one at a time. Or allow them to explore the cards on their own and make their own categories.

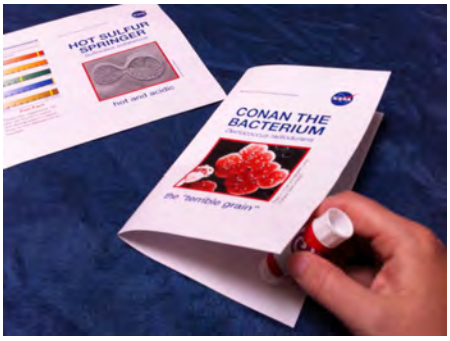
© 2011 Astronomical Society of the Pacific www.astrosociety.org
Copies for educational purposes are permitted.
Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Leader's Role	Participants' Role (Anticipated)
To Say: What are some of the organisms you all have? Great. Now look on the back. There you will find information about your organism's environment. To start with, who has an organism that likes a hot environment? If your organism likes it really hot, come over to my left side. Everyone else to my right. *To Do:* Sort the groups 3-5 times in this fashion. After each sorting, ask a participant to tell about their organism. Younger groups usually have shorter attention spans, but ages 10 through adult like running through this more times. Use categories such as Hot, Cold, and Acidic, or organisms that like Sunlight, Darkness, and High pressure. *To Say:* Which of your organisms can live without water? Come over here. Ahh! Interesting. Did you know that every single living organism we've discovered on Earth needs liquid water to survive, grow, and reproduce? That has some interesting implications for our search for aliens. When we look for possible habitable planets, we are actually looking for planets with evidence of liquid water. Did you know that there are other worlds right here in our Solar System that likely have liquid water on them? *To Do:* Either show the group the Watery Worlds banner or direct them to telescopes showing Jupiter's moons or Mars as examples of potentially watery worlds. The front of the Presenters Cue Card also has images of possible watery worlds in our Solar System with more information on the back.	Snottites! Penguins… No one goes to that side

© 2011 Astronomical Society of the Pacific www.astrosociety.org
Copies for educational purposes are permitted.
Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Materials

What do I need to prepare?



- If you are using the pre-printed cards, there is nothing to prepare.
- If you are printing your own cards, you will need to fold each 1-sided piece of paper in half and glue the halves together to create 2-sided cards. See example, right.
- You may want to have the Presenter Cues nearby if you ever need help thinking of categories.

Background Information

What is an Extremophile? (from Microbial Life Educational Resources)
http://serc.carleton.edu/microbelife/extreme/extremophiles.html

An extremophile is an organism that thrives under "extreme" conditions. The term extremophile is relatively anthropocentric. We judge habitats based on what would be considered "extreme" for human existence. Many organisms, for example, consider oxygen to be poisonous. While oxygen is a necessity for most life as we know it, some organisms flourish in anoxic environments. We call them extremophiles... but that is only one perspective. If they could think, what would they think of our environment?

Types of Extremophiles
(adapted from NASA's Astrobiology Institute)
http://astrobiology.nasa.gov
There are many different classes of extremophiles that range all around the globe, each corresponding to the way its environmental niche differs from moderate conditions. These classifications are not exclusive. Many extremophiles fall under multiple categories.

Acidophile: An organism with optimal growth at pH levels of 3 or below. That's as acidic as lemon juice. They are mostly found in mines and caves. Venus has toxic clouds that may be the perfect environment for something that loves acidic environments, though we have not discovered any life there yet. *Examples found in this activity: Hot Sulfur Springer, Iron Eaters, Snottites*

© 2011 Astronomical Society of the Pacific www.astrosociety.org
Copies for educational purposes are permitted.
Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Alkaliphile: An organism with optimal growth at pH levels of 9 or above; that is, the least acidic (most basic) environments. They can be found in caves, some hot springs, and waste dumps and are used in making paper and recovering spilled oil. *Examples: Rushing Fireberry, Spirulina*

Barophiles: These microbes thrive under high pressure. Most are found on the ocean floor. Most have a waxy cell layer that protects them against crushing pressures and very cold temperatures. *Examples: Pompeii Worm, Rocky Lichen, Yeti Crab, Water Bear*

Endoliths: This broad category of organisms makes their home inside of rocks. They can live for hundreds of years by feeding on minerals such as iron, potassium, and sulfur in their host rocks. Many scientists think that endoliths are a good candidate for the types of life most likely to be discovered living on Mars now or in the past. *Example: Endolith*

Polyextremophile: An organism that qualifies as an extremophile under more than one category. *Examples: Conan the Bacterium, Water Bear*

Psychrophile: An organism capable of survival, growth or reproduction at temperatures of -15 °C (5°F) or lower for extended periods. These can be found on Earth in very cold temperatures, such as frozen soils, permafrost, polar ice, cold ocean water, and in or under alpine snowpack. Scientists are trying to determine if Jupiter's icy moon Europa harbors cold-loving microbes. *Examples: Penguins, Water Bear, Watermelon Snow, Wood Frogs*

Radioresistant: Organisms resistant to high levels of ionizing radiation, most commonly ultraviolet radiation, but also including organisms capable of resisting nuclear radiation. They have been found in nuclear reactors, using the radioactive energy to produce food. *Examples: Conan the Bacterium, Water Bear*

Thermophile: An organism that can thrive at temperatures between 60–80 °C (140 – 176 °F) they have developed special enzymes and proteins that allow them to survive in a broad range of temperatures. *Examples: Conan the Bacterium, Hot Sulfur Springer, Strain 121, Water Bear*

Xerophile: An organism that can grow in extremely dry, desiccating conditions; such as the soil microbes of the Atacama Desert. They can even grow in dried foods such as nuts. *Examples: Rocky Lichen, Water Bear, Watermelon Snow*

© 2011 Astronomical Society of the Pacific www.astrosociety.org
Copies for educational purposes are permitted.
Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Opening Questions

- Who thinks there might be life elsewhere in our galaxy?
- What kinds of worlds do you think aliens might live on?

To get some clues to these questions, scientists are studying organisms that survive in extreme environments right here on Earth. Here are some examples. (Hand out cards.)

Categories (Sort participants 3 to 5 times)

Who has an organism that likes:

COLD • **HOT** • **HIGH PRESSURE** • **DARK** • **ACIDIC**

Who has an organism that can live without **WATER**

Every single organism that we've discovered on Earth requires water to survive, grow, and reproduce.

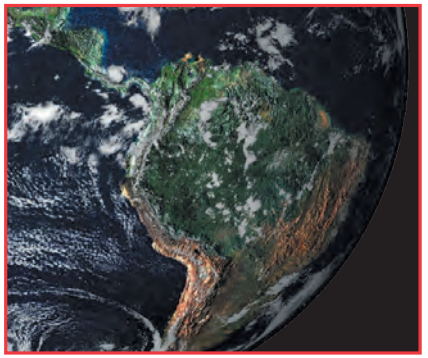
That gives us a clue when we are looking for life on other planets. Do you think a planet with liquid water might be a good place to search for alien life? That's where we're looking!

Even in our own Solar System, there are other watery worlds, including some of the moons of Saturn (Enceladus) and Jupiter (Europa and Ganymede). And Mars probably had water on its surface in the past. Saturn's moon Titan does not have water, but it does have lakes of methane and a cloudy atmosphere. We haven't found conclusive evidence of life yet, but we are looking.

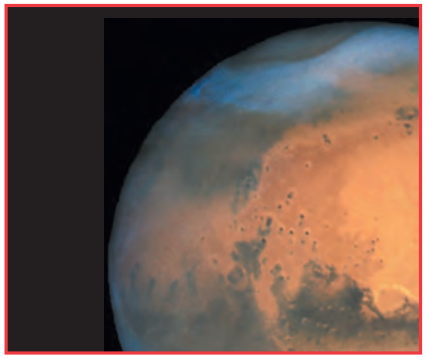
National Aeronautics and Space Administration

Extrememe Organisms

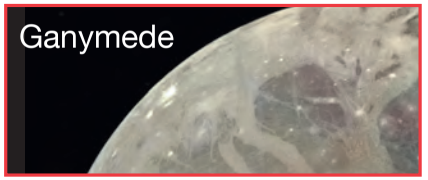
Extreme Environments

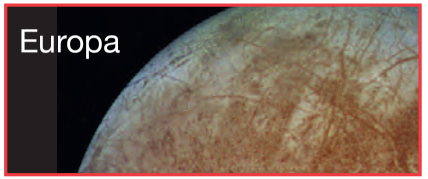


Earth



Mars





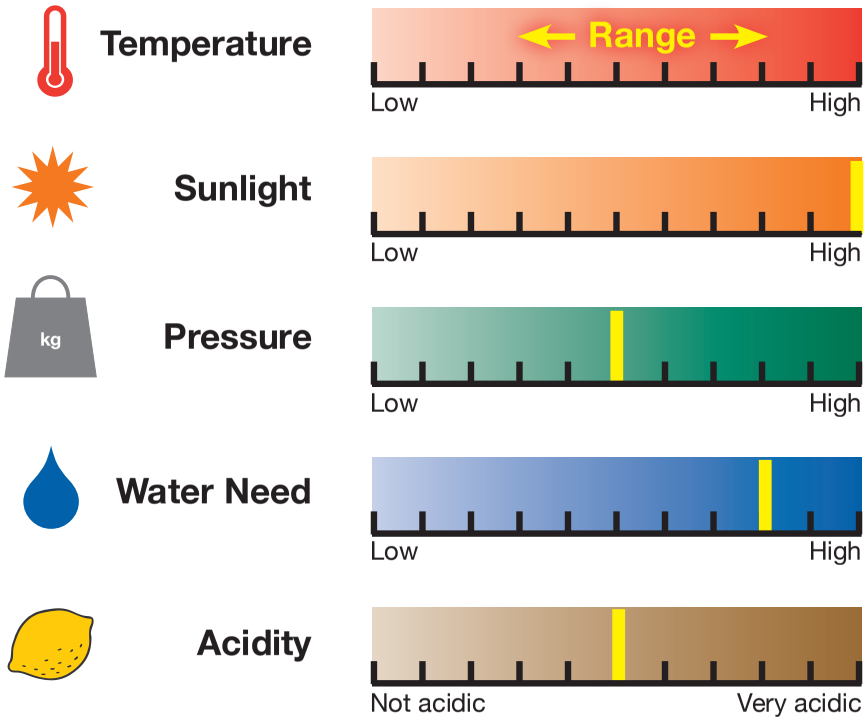
Jupiter's moons

Saturn's moons

NASA x6

Conan the Bacterium Environment

Conan is so tough, it can even survive high levels of radiation.



Can be found

Fun Fact

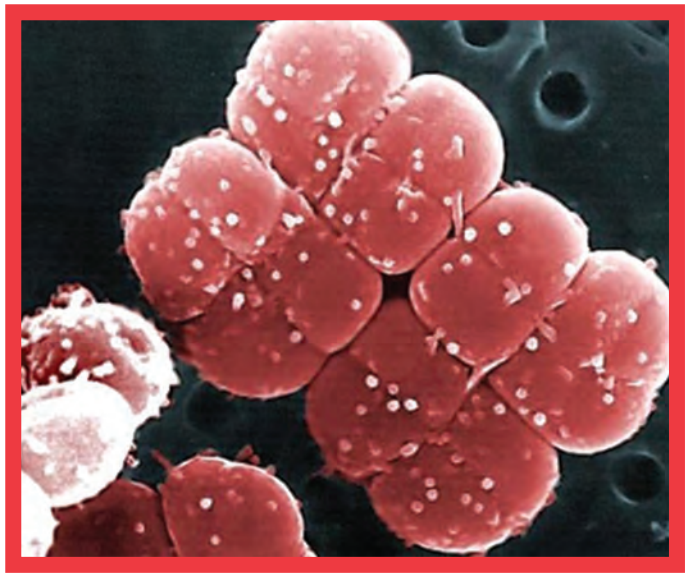
Deinococcus radiodurans is listed as the world's toughest bacterium in The Guinness Book Of World Records.

www.nasa.gov

National Aeronautics and Space Administration

CONAN THE BACTERIUM

Deinococcus radiodurans



Peggy A. O'Cain and Margaret C. Henk, Louisiana State University

the "terrible grain"

Hot Sulfur Springer Environment

These tough organisms eat sulphur and are found in volcanoes and mudpots.

Temperature

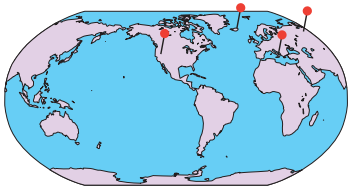
Sunlight

Pressure

Water Need

Acidity

Can be found



Fun Fact

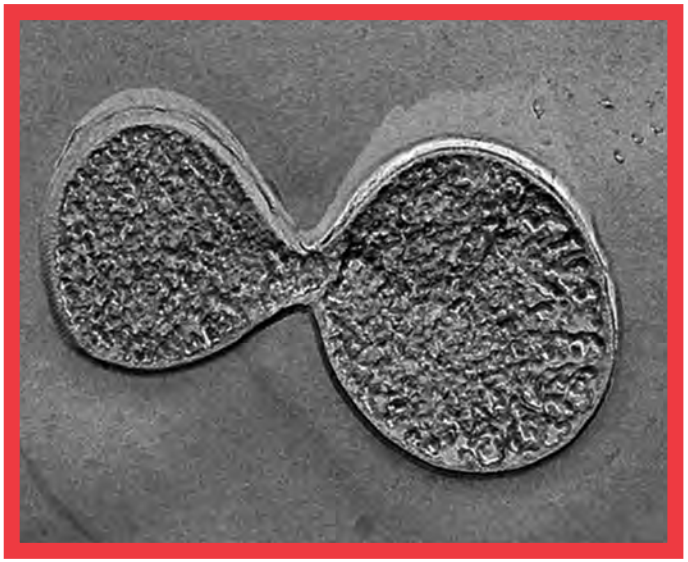
These tiny organisms can also be found in some hot spring spas in Japan. They're not dangerous to humans.

www.nasa.gov

National Aeronautics and Space Administration

HOT SULFUR SPRINGER

Sulfolobus solfataricus



Sonja-Verena Albers

hot and acidic

Iron Eaters Environment

This organism “eats” iron and leaves behind rust.

Temperature

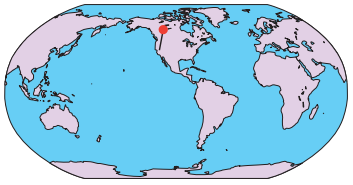
Sunlight

Pressure

Water Need

Acidity

Can be found



Fun Fact

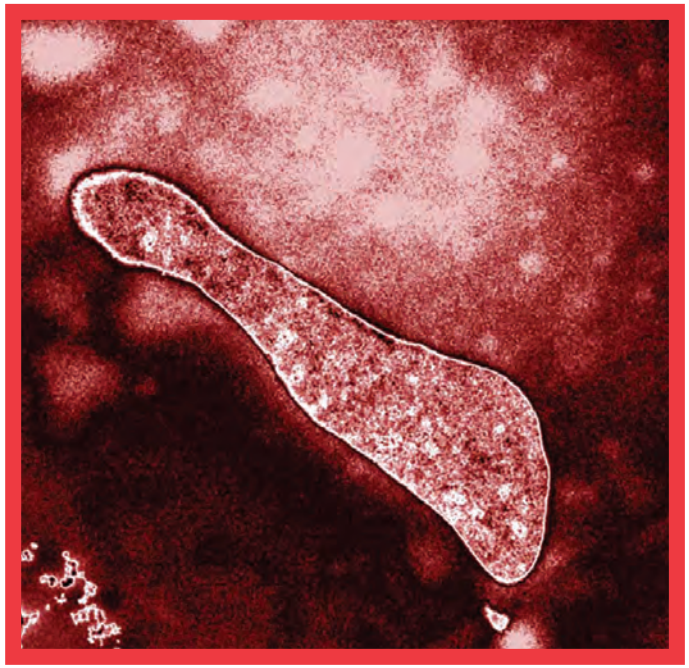
Early conditions on Earth would have been perfect for these acid-loving organisms.

www.nasa.gov

National Aeronautics and Space Administration

IRON EATERS

Ferroplasma acidiphilum

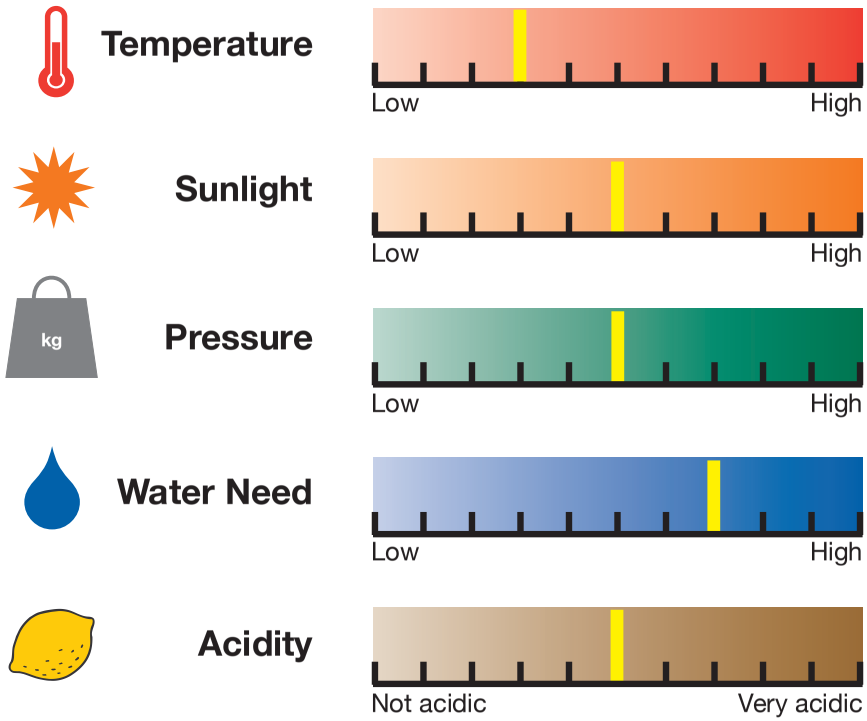


Indumathy Jayamani

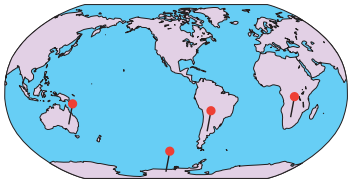
acidic miner

Penguins Environment

Many penguins live in large groups to keep warm.



Can be found



Fun Fact

To get around in their environments, penguins swim and surf the waves and use their bellies as toboggans on land.

www.nasa.gov

National Aeronautics and Space Administration

PENGUINS

Spheniscidae

Stan Shebs

swimming birds

Pompeii Worm Environment

These worms can become about 13cm (5in) long and live on black smokers at the bottom of the ocean.

Temperature

Sunlight

Pressure

Water Need

Acidity

Can be found

Fun Fact

What looks like hair on the worm's back is actually colonies of bacteria, insulating the worm from the very hot temperatures.

www.nasa.gov

National Aeronautics and Space Administration

POMPEII WORM

Alvinella pompejana

University of Delaware

hot tail, cold head

Rocky Lichen Environment

These tough organisms can freeze and then revive when temperatures increase.

Temperature

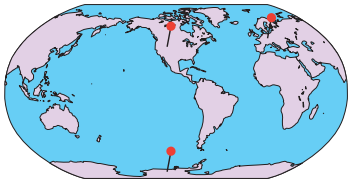
Sunlight

Pressure

Water Need

Acidity

Can be found



Fun Fact

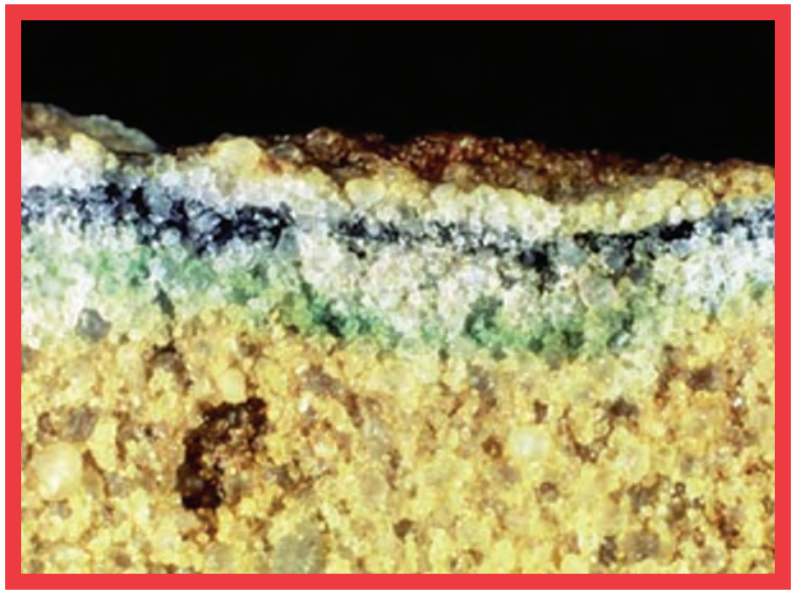
Rock-dewlling organisms have been found as deep as we are able to drill into the Earth. Even 7 km (4 miles) under the ocean floor, these tough organisms are thriving!

www.nasa.gov

National Aeronautics and Space Administration

ROCKY LICHEN

Endoliths



NASA

hidden in the rock

Rushing Fireberry Environment

The hotter the better for this organism.
It can survive in steaming volcano pools.

Temperature

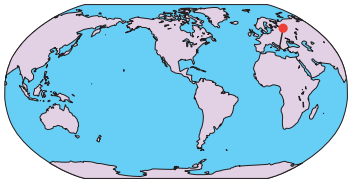
Sunlight

Pressure

Water Need

Acidity

Can be found



Fun Fact

This tiny organism gets the rushing part of its name from the fact that it is able to double the number of organisms in less than 37 minutes.

www.nasa.gov

National Aeronautics and Space Administration

RUSHING FIREBERRY

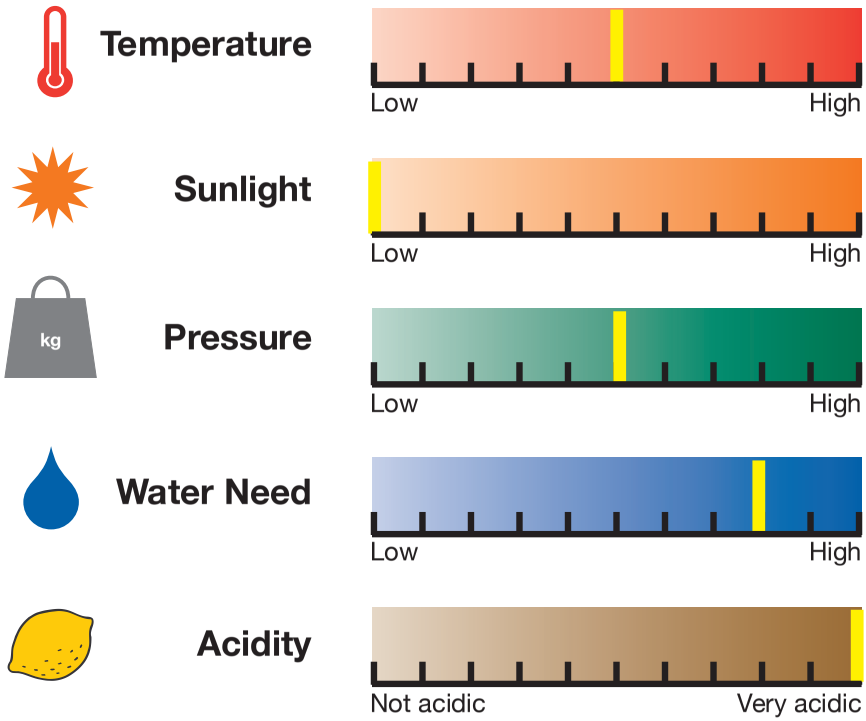
Pyrococcus furiosus

ArchiMeDes

hot multiplier

Snottites Environment

Snottites get their energy from sulfur in the water, not from sunlight.



Can be found

Fun Fact

These bacteria are so acidic, that one drop has been known to eat through clothes and cause third-degree burns on researchers.

www.nasa.gov

National Aeronautics and Space Administration

SNOTTITES

Single-celled bacteria

slimy cave drips

Spirulina Environment

This organism is nicknamed Spirulina after its spiral shape.

Temperature

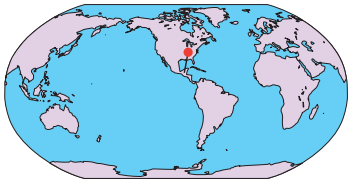
Sunlight

Pressure

Water Need

Acidity

Can be found



Fun Fact

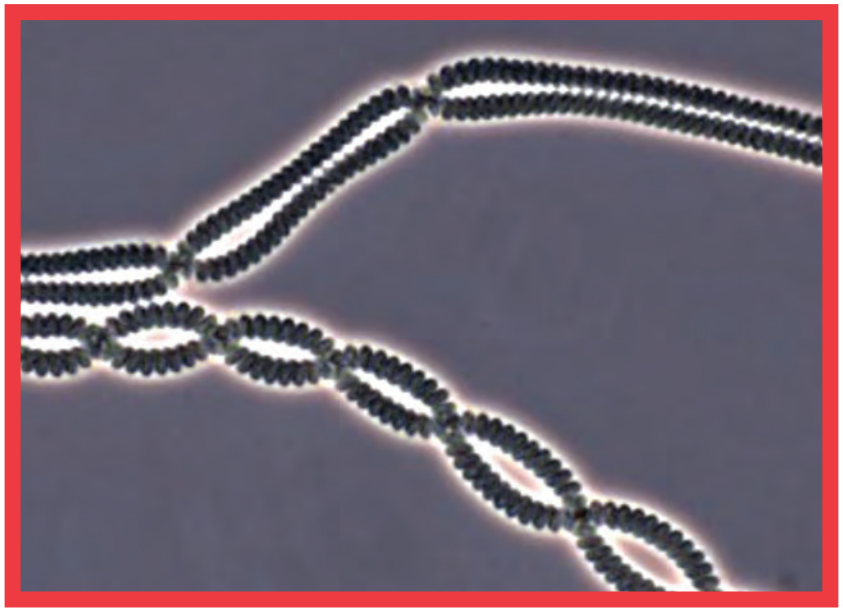
The Aztecs used Spirlunia as a food source until the 16th century.

www.nasa.gov

National Aeronautics and Space Administration

SPIRULINA

Arthrospira maxima



Globe Pequot Press

blue green algae

Strain 121 Environment

Strain 121 eats iron from the hydrothermal vents at the bottom of the ocean.

Temperature

Sunlight

Pressure

Water Need

Acidity

Can be found

Fun Fact

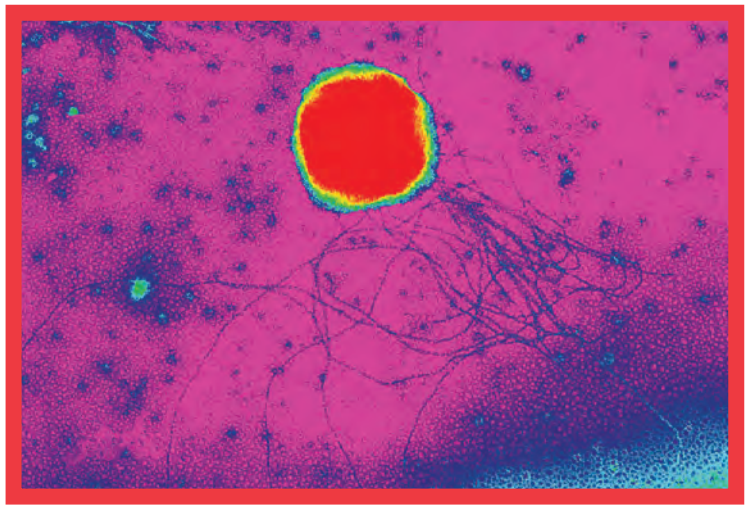
Prior to the 2003 discovery of Strain 121, a fifteen-minute exposure to these temperatures was believed to kill all living organisms.

www.nasa.gov

National Aeronautics and Space Administration

STRAIN 121

Geogemma barossii



hotter than hot

All About Water Bears

These tough organisms have been exposed to the vacuum of space for 10 days and still survived!

Temperature

Sunlight

Pressure

Water Need

pH (acidity)

Can be found

Fun Fact

The Water Bear can actually hibernate without water for at least 10 years. Once it gets a drop of water it wakes up, good as new.

www.nasa.gov

WATER BEAR

Tardigrade

the survivor

Watermelon Snow Environment

Sunlight helps the algae turn the snow into water that it can use to grow.

Temperature

Sunlight

Pressure

Water Need

Acidity

Can be found

Fun Fact

This algae actually smells like fresh watermelon! For many years hikers thought it was a mineral causing the reddish color.

www.nasa.gov

National Aeronautics and Space Administration

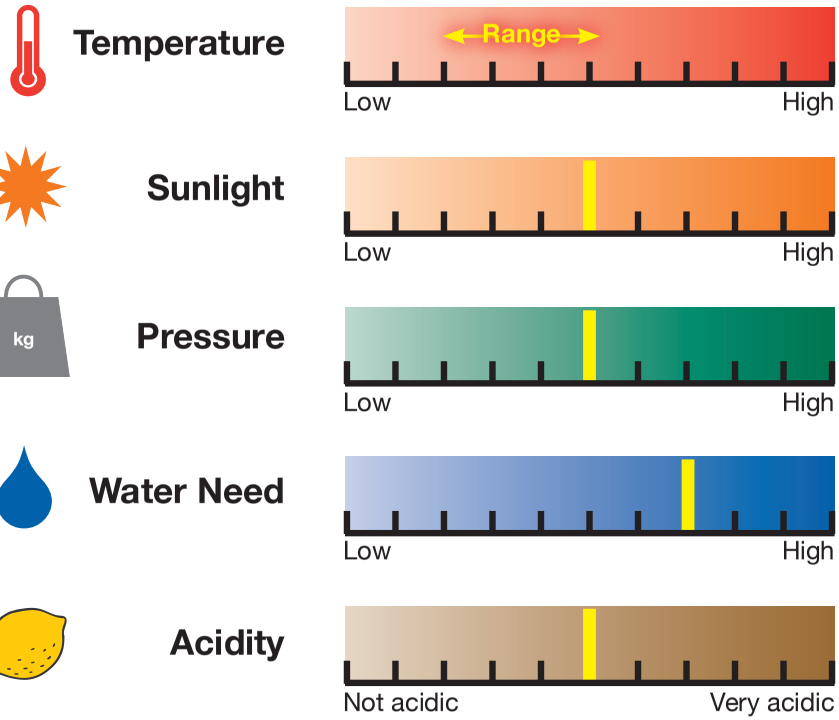
WATERMELON SNOW

Chlamydomonas nivalis

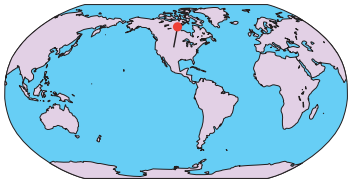
Will Beback

snow algae

Wood Frogs Environment



Can be found



Fun Fact

These frogs survive cold temperatures by hibernating in a frozen state. When the weather warms, they thaw and resume their lives.

www.nasa.gov

National Aeronautics and Space Administration

WOOD FROGS

Rana sylvatica

freezing frogs

Yeti Crab Environment

Bacteria coat the hairs of the crab and eat many of the toxic minerals in the environment.

Temperature

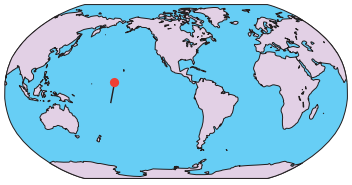
Sunlight

Pressure

Water Need

Acidity

Can be found



Fun Fact

The Yeti Crab lives on the deep, dark ocean floor where sunlight never reaches and is completely blind.

www.nasa.gov

National Aeronautics and Space Administration

YETI CRAB

Kiwa hirsute

Census of Marine Life

furry lobster