**teacher guide**

**Life in the Solar System 4:**

**Life under extreme conditions**

# Components

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| --- | --- | --- | --- |
|  | NAME | DESCRIPTION | AUDIENCE |
|  | *Life under extreme conditions*teacher guide | The guide provides information on how to use this resource. | teachers |
|  | *Searching for life in the Solar System*video | This video-podcast provides a brief introduction to the search for life beyond our planet. | students |
|  | *Extremophiles: Life at the limits*fact sheet | This fact sheet contains information about extreme environments and extremophiles. | students |
|  | *Life beyond Earth*fact sheet | This fact sheet highlights spacecraft and technologies used to search for life in the Solar System. | students |
|  | *Extreme life*worksheet | This two-part worksheet provides activities centred on extremophiles and the search for life in the Solar System. | students |

Purpose

To demonstrate that life exists under a wider range of conditions than was previously believed, and to use this as a context for elaborating on the search for life on other planets.

# Activity summary

Outcomes

Students will be able to:

* explain what is meant by extreme environments and extremophiles;
* describe characteristics of a number of extreme environments and organisms that inhabit them;
* explain how our knowledge of extremophiles influences methods used to search for life on other planets; and
* explain the potential for life to be found in places explored by space missions.

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| --- | --- |
| ACTIVITY | POSSIBLE STRATEGY |
| Students listen to a podcast and access two fact sheets while responding to questions posed in the worksheet. | individually or in pairs |
| Discuss with students questions in the worksheet and this guide. | teacher-led whole group |

# Technical requirements

The guide, fact sheets and worksheet require Adobe Reader which is a free download from www.adobe. com. The worksheet is also provided in Microsoft Word format. A modern browser (eg Internet Explorer 9 or later, Google Chrome, Safari 5.0+, Opera or Firefox) is required to view the video. A high quality MP4 version of the video is available by download from the SPICE website.

 The video-podcast contains closed captions.

# Notes for teachers

The video-podcast *Searching for life in the Solar System* provides a brief introduction to the primary concepts around the search for life beyond our planet.

The fact sheet *Extremophiles: Life at the limits* provides specific information about extreme environments and extremophiles (organisms uniquely adapted to take advantage of unique conditions).

The fact sheet *Life beyond Earth* provides information on spacecraft and technologies used to search for life on other planets in the Solar System.

Suitable discussion questions include:

* What are some characteristics of extreme environments and how do they differ from conventional environments on Earth?
* Which featured extremophiles are most likely to survive on Mars, Venus and Io?
* What types of extremophiles should scientists be looking for on Venus and Mars?

# References

## Extremophiles: life at the limits

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## Life beyond Earth

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# Image credits

## Extremophiles: life at the limits

* methane ice worm (NOAA, solarsystem.nasa.gov/ multimedia/display.cfm?IM\_ID=7123)
* alkaliphile *Anomoeoneis* (photo © D J Patterson, starcentral.mbl.edu/microscope/portal.php?pagetitle=asse tfactsheet&imageid=20150)
* Cleveland Volcano, Aleutian Islands, Alaska (NASA, [www.](http://www/) nasaimages.org/luna/servlet/detail/nasaNAS

~10~10~71790~177122:Ash-Plume-from-Cleveland-Volcano)

* snottite, subsurface bacteria in Cueva de las Sardinas,

Mexico (photo © 2003 Kenneth Ingham, used by permission, photos.i-pi.com/Caves/Sardinas/ Sardinas-2003-09-07/Overview//dscn2470.jpg)

* acidophile *Urotricha* (photo © L Amaral-Zettler and

D J Patterson, starcentral.mbl.edu/microscope/portal.php? pagetitle=assetfactsheet&imageid=923)

* halophile/alkaliphile *Surirella* (photo © D J Patterson, starcentral.mbl.edu/microscope/portal.php?pagetitle=asse tfactsheet&imageid=20149)
* psychrophile *Acanthocystis* (photo © Michele Bahr and

D J Patterson, starcentral.mbl.edu/microscope/portal.php? pagetitle=assetfactsheet&imageid=1001)

* thermophile *Halteria grandinella* (photo © D J Patterson, starcentral.mbl.edu/microscope/portal.php?pagetitle=asse tfactsheet&imageid=1331)
* lichen (photo by Paul Ricketts, DUIT Multimedia)
* tardigrade (photomicrograph by L Michalczyk and L Kaczmarek, used by permission courtesy of [www.tardigrada.net.](http://www.tardigrada.net/) All rights reserved.)

## Life beyond Earth

* Voyager spacecraft (NASA, nix.larc.nasa.gov/ info?id=PIA04495)
* Phoenix Landing Site (NASA/JPL-Caltech/University of Arizona, [www.nasa.gov/images/content/279794main\_](http://www.nasa.gov/images/content/279794main_) PhoenixOnGlobeWithText2.jpg)
* excavated trench (NASA/JPL-Caltech/University of Arizona/ Texas A&M University, [www.nasa.gov/mission\_pages/](http://www.nasa.gov/mission_pages/) phoenix/images/press/SS024IOF898355142\_12E50R1B2T1\_ full.html)
* delivering a sample to TEGA (NASA/JPL-Caltech/ University of Arizona/Texas A&M University, [www.](http://www/) nasa.gov/mission\_pages/phoenix/images/press/ SS011EFF897193286\_11BEEL1M1-scoop-bright-adj.html)
* Apollo 15 Saturn V launch in 1971 (NASA, grin.hq.nasa. gov/ABSTRACTS/GPN-2000-001115.html)
* Phoenix lander on Mars (NASA, [www.nasa.gov/](http://www.nasa.gov/) multimedia/imagegallery/image\_feature\_857.html)
* Phoenix arm (NASA, wiki.nasa.gov/cm/blog/Shana’s-Blog/ posts/post\_1213999748605.html)

## Searching for life in the Solar System (podcast)

* ‘Voyager spacecraft’ by NASA, nix.larc.nasa.gov/info?id=PIA04495
* ‘constellations’ by Paul Luckas
* ‘planet montage’ by NASA/JPL, photojournal.jpl.nasa.gov/catalog/PIA01341
* ‘spiral galaxies’ by NASA, ESA, and the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration, hubblesite.org/gallery/album/entire/ pr2006046a/
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* ‘Mars’ by NASA, ESA, and The Hubble Team (STScl/ AURA) NASA/STScl), hubblesite.org/gallery/album/ entire/pr2005034f/
* ‘Sputnik’ by NSSDC/NASA, nssdc.gsfc.nasa.gov/ planetary/image/sputnik\_asm.jpg
* ‘rocket launch’ by NASA, [www.nasaimages.org/luna/](http://www.nasaimages.org/luna/) servlet/detail/nasaNAS~5~5~20776~125772:Viking-1- Launch
* ‘Mars surface’ by NASA/JPL, grin.hq.nasa.gov/ ABSTRACTS/GPN-2000-001434.html
* ‘Viking 1’ by NASA, [www.nasaimages.org/luna/](http://www.nasaimages.org/luna/) servlet/detail/nasaNAS~5~5~23371~127351:Viking-2- Image-of-Mars-Utopian-Plai
* ‘boab tree’ by Paul Luckas
* ‘single cell organism’ by D J Patterson, starcentral.mbl.edu/microscope/portal.php?pagetitl e=collectiondetails&collectionID=166
* ‘rainforest’ by Paul Ricketts
* ‘volcanic pool’ by James Taylor, used under licence from Stock.xchng, [www.sxc.hu/photo/800999](http://www.sxc.hu/photo/800999)
* ‘Mars Odyssey’ by NASA/JPL, [www.nasaimages.org/](http://www.nasaimages.org/) luna/servlet/detail/nasaNAS~20~20~120598~227300: Odyssey-over-Mars--South-Pole
* ‘Mars Rover’ by NASA, [www.nasaimages.org/luna/](http://www.nasaimages.org/luna/) servlet/detail/
* ‘Mars globe’ by NASA/JPL, [www.nasaimages.org/](http://www.nasaimages.org/) luna/servlet/detail/nasaNAS~20~20~120476~227177: Global-Mosaic-of-Mars-Centered-on-V
* ‘Mars Victoria crater’ by Mars Exploration Rover Mission/Cornell/JPL/NASA, antwrp.gsfc.nasa.gov/apod/ap070703.html
* ‘Mars ancient river beds’ by Malin Space Science Systems/MGS/JPL/NASA, antwrp.gsfc.nasa.gov/apod/ap030205.html
* ‘Mars polar regions’ by NASA, ESA, and The Hubble Team (STScI/AURA), hubblesite.org/gallery/album/ entire/pr2005034f/
* ‘Mars frost’ by NASA/NSSDC, nssdc.gsfc.nasa.gov/ imgcat/html/object\_page/vl2\_p21873.html
* ‘Alvin submarine’ by OAR/National Undersea Research Program (NURP); Woods Hole Oceanographic Institute, [www.photolib.noaa.gov/](http://www.photolib.noaa.gov/) htmls/nur07549.htm
* ‘deepsea smoker’ by OAR/National Undersea Research Program (NURP); NOAA, www.photolib. noaa.gov/bigs/nur04506.jpg
* ‘Grand Prismatic Spring’ by National Park Service US, Department of the Interior,photographer Jim Peaco, [www.nps.gov/features/yell/slidefile/thermalfeatures/](http://www.nps.gov/features/yell/slidefile/thermalfeatures/) hotspringsterraces/midwaylower/Images/17708.jpg
* ‘Antarctica’ by Frank Wheatley
* ‘Saturn’ by Paul Luckas
* ‘Jupiter montage’ by NASA/JPL, grin.hq.nasa.gov/ ABSTRACTS/GPN-2000-000451.html

# Associated SPICE resources

*Life in the Solar System 4: Life under extreme conditions* may be used in conjunction with related SPICE resources to address the topic of life in the Solar System.

|  |  |
| --- | --- |
| DESCRIPTION | LEARNING PURPOSE |
| *Life in the Solar System*This learning pathway combines a number of SPICE resources to address the topic of the search for life in the Solar System. |  |
| *Life in the Solar System 1: Conditions for life*A presentation challenges students to think about where life is found. | Engage |
| *Life in the Solar System 2: Exploring environments*Students explore different environments to compare surface conditions and abundance of life. | Explore |
| *Life in the Solar System 3: Planetary atmospheres*Students compare atmospheric conditions on various bodies in our Solar System. | Explain |
| *Life in the Solar System 4: Life under extreme conditions*Life exists in extreme environments on Earth, which suggests that it may also be found in unknown environments in space. | Elaborate |

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Web: spice.wa.edu.au Email: spice@uwa.edu.au Phone: (08) 6488 3917

Centre for Learning Technology (M016) The University of Western Australia

35 Stirling Highway

Crawley WA 6009