teacher guide

Life in the Solar System 4: Life under extreme conditions

Components

	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.

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.

Activity summary

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.

CC 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

- Astrobiology Magazine (2008). *Extreme life*. Retrieved July 9, 2008 from NASA Astrobiology Portal http://astrobio.net/news/Topic5.html
- California Academy of Sciences (2008). *Extreme life*. Retrieved July 11, 2008 from http://www.calacademy.org/exhibits/xtremelife/life_on_earth.php
- Gross, Michael (1998). *Life on the edge: Amazing creatures thriving in extreme environments*. New York: Plenum Trade Press.
- Jönsson, K. Ingemar (September 29, 2008). *Tardigrades in space (TARDIS)*. Retrieved August 12, 2008 from http://tardigradesinspace.blogspot.com/2008/09/space-tardigrades-stood-test.html
- Microbial Life (micro*scope) (2008). *Extreme habitat.* Retrieved December 16, 2008 from http://starcentral.mbl.edu/microscope/portal.php?pagetitle=habitatnav&next=136
- Northup, Diana et al. (2008). *Sulfur cave microbial ecology – Cueva de Villa Luz*. Retrieved September 11, 2008 from http://www.caveslime.org/VillaLuz/
- Rothschild, Lynn (2002). *Life in extreme environments: The Universe may be more habitable than we thought*. Retrieved July 7, 2008 from http://www.spaceref.com/news/viewnews.html?id=463
- Sancho, Leopoldo G. et al. (2007). Lichens survive in space: Results from the 2005 LICHENS Experiment. *Astrobiology, 7* (3): 443-454. Retrieved July 21, 2008 from the Liebert Online database.
- Science Education Resource Center at Carleton College (2008). *Microbial life*. Retrieved July 10, 2008 from http://serc.carleton.edu/microbelife/index.html
- Wharton, David A. (2002). *Life at the limits: Organisms in extreme environments*. Cambridge: Cambridge University Press.

Life beyond Earth

- NASA (2008). *NASA's Mars Exploration Program*. Retrieved July 23, 2008 from http://mpfwww.jpl.nasa.gov/
- NASA (2008). *Phoenix Mars Lander: Exploring the Arctic Plain of Mars*. Retrieved July 17, 2008 from http://www.nasa.gov/mission_pages/phoenix/images/press/phx-20090102.html
- NASA History Division (2009). *Space Science*. Retrieved January 9, 2009 from http://history.nasa.gov/tindex.html#11
- *NASA National Space Science Data Center (2009). Planetary Missions: Chronology of lunar and planetary exploration*. Retrieved January 16, 2009 from http://nssdc.gsfc.nasa.gov/planetary/chrono.html
- NASA Science (2008). *Planets missions*. Retrieved July 23, 2008 from http://nasascience.nasa.gov/planetary-science/mission_list
- NASA, Jet Propulsion Laboratory, California Institute of Technology (2009). *Voyager The Interstellar Mission*. Retrieved January 23, 3009 from http://voyager.jpl.nasa.gov/
- Space.com (2008). *Phoenix Mars Lander: Digging for secrets of the Martian Arctic*. Retrieved July 22, 2008 from http://www.space.com/missionlaunches/phoenix-mars-lander-special-report.html
- The University of Arizona (2008). *Phoenix Mars Mission: Uncovering the mysteries of the Martian Arctic*. Retrieved July 17, 2008 from http://phoenix.lpl.arizona.edu/mission.php
- University of Colorado at Boulder (2009). *Cassini-UVIS Mission to Saturn and Titan*. Retrieved January 17, 2009 from http://lasp.colorado.edu/cassini/index.shtml

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=assetfactsheet&imageid=20150)
- Cleveland Volcano, Aleutian Islands, Alaska (NASA, 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=assetfactsheet&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=assetfactsheet&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. 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_PhoenixOnGlobeWithText2.jpg)
- excavated trench (NASA/JPL-Caltech/University of Arizona/Texas A&M University, 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.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/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/
- 'Carboniferous world' © Walter Myers, used under licence. All rights reserved. www.arcadiastreet.com/cgvistas/
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- 'Percival Lowell' used by permission from Lowell Observatory Archives
- 'Mars canals' used by permission from Selden Ball at Wilson Lab, Cornell University
- 'Mars' by NASA, ESA, and The Hubble Team (STScI/AURA) NASA/STScI), 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/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/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?pagetitle=collectiondetails&collectionID=166
- 'rainforest' by Paul Ricketts
- 'volcanic pool' by James Taylor, used under licence from Stock.xchng, www.sxc.hu/photo/800999
- 'Mars Odyssey' by NASA/JPL, www.nasaimages.org/luna/servlet/detail/nasaNAS~20~20~120598~227300:Odyssey-over-Mars--South-Pole
- 'Mars Rover' by NASA, www.nasaimages.org/luna/servlet/detail/
- 'Mars globe' by NASA/JPL, 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/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/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

Acknowledgements

Designed and developed by the Centre for Learning Technology, The University of Western Australia. Production team: Leanne Bartoll, Alwyn Evans, Bob Fitzpatrick, Trevor Hutchison, Paul Luckas, Paul Ricketts, Jodie Ween and Michael Wheatley, with thanks to Roger Dickinson, Jenny Gull and Wendy Sanderson.

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