Lesson Plan

NEUROHEADWAY

Neuroscience Into Education

Life in Extreme Environments

Teachers' Notes

Slide 1 – Title Slide

Slide 2 – Introduction

- We're going to explore the most unlikely life forms on Earth, living in extremely hostile environments where, before the use of today's technology, we never would have imagined finding living organisms.
- We will then examine the implications this has on the search for life elsewhere in the universe. Just a few decades ago, it seemed only a pipe dream, but as we discover more and more organisms that can thrive in harsh conditions, the search becomes ever more worthwhile.

Slide 3 – Tardigrades (Water Bears)

- These are surprisingly poorly known creatures
- Tardigrades, also called water bears, are tiny (0.5mm long) animals that inhabit virtually every environment on earth. They are able to survive extreme conditions such as volcanoes, the Antarctic, high altitudes, and the crushing pressure at the bottom of the ocean.
- They can even survive the vacuum of space.
- The reason for their resilience is their ability to revert to **Tun** form. They become like a compact cellular fortress in which they tuck in their legs and head and dehydrate themselves, putting them into a temporary stasis.
- In one experiment, scientists brought Tardigrades out of their Tun form after 30 years. They were alive, healthy, and even able to reproduce.
- There are thousands of species of Tardigrades, and more are being discovered all the time. All you need is a low-power microscope.

Slide 4 – Hydrothermal Vents

- These super-hot, bottom of the ocean vents spew out chemicals at scalding temperatures. Yet they can support whole ecosystems that were never believed to exist before they were directly observed.
- The temperatures of the water coming out ranges from 60 to 400 degrees C. Water boils at 100 ◦ C, but because they are at the bottom of the ocean and extremely high pressure, the water can stay liquid in those conditions.
- The deepest are at 5000m below sea level.
- The range and diversity of life around them is astounding – there is much more life here than the rest of the deep sea ocean.

- Life is possible through a process called **Chemo-Synthesis**, where the organism converts the chemicals in the water into energy. Before this discovery, we thought that all life relied on the Sun to survive, yet we now know this is not true. These organisms live in complete darkness, enduring pressure 1000 times that on the surface.
- Some scientists think that the first life on Earth could have originated around a hydrothermal vent, billions of years ago! And that this could be the ancestor to all life on earth.

- *Highlight how 'alien' looking some of these organisms in the pictures are, will get the imaginations flowing*!

Slide 5 – Blood Falls

- These eerie red waterfalls in the Antarctic are one of the last places you'd expect to find life, but scientists have discovered a below-the-ice reservoir of salt and iron rich water that, while lacking in oxygen, is teeming with microbial life.
- This gives hope to the search for life on Jupiter's moon Europa, as a possible habitat for below-ice life. If these blood-falls microbes can survive with no oxygen, and below freezing temperatures on our planet, why couldn't they elsewhere in the solar system?

Slide 6 – Atacama Desert

- This desert in Chile is similar to Mars's environment, so much so that scientists test equipment that is going to be used on Mars in the future here. It is also used to film movies set on the planet.
- Though it is almost completely devoid of water and extremely hot, microbial life has been found by digging just a few feet into the Earth.
- While there is almost certainly no life on the surface of Mars, the Atacama Desert demonstrates that life underground is very possible. *The European Space Agency's EXO Mars Rover, due to land on the planet in 2020, is equipped with a drill capable of penetrating 6 feet underground. What will we find?*

Slide 7 - Activity sheet

Slide 8 – Pitch Lake

- Pitch Lake is a hot pool of liquid tar. Noxious gasses bubble to the surface, and its absence of water or oxygen makes it very hostile.
- Plant life has been swallowed up and spat out hundreds of years later, in perfect condition.

- More microbial life has been found in the depths of the tar, challenging the notion that Saturn's moon Titan is too hostile to support life; their make-up is very similar.

Slide 9 – Titan and the Huygens Lander

- The Cassini space probe reached Saturn in 2005, ejecting the Huygens Lander so it could land on its largest moon, Titan. Huygens' 2-hour descent to the moon revealed shows an impressive landscape – huge mountains set against an orange sky. Its thick, smog-like atmosphere of nitrogen and methane would be deadly to humans, but it is entirely possible that microbial life may exist here.
- *There is a video from Huygens' camera that documents its entire descent, worth showing to the pupils.*
    - https://www.youtube.com/watch?v=HtYDPj6eFLc
    - Clear views start from about 2 minutes in.

Power point Example

NEUROHEADWAY

Neuroscience Into Education

LIFE IN EXTREME ENVIRONMENTS

In this lesson we're going to take some time to look at how life finds a way to thrive in the harshest of territories on our home planet, and what implications that has on our search for extra-terrestrial organisms.

This may demonstrate how life elsewhere in the universe is not only possible, but probable.

TARDIGRADES (WATER BEARS)

- Tardigrades, also called water bears, are tiny (0.5mm long) animals that inhabit virtually every environment on earth. They are able to survive extreme conditions such as volcanoes, the Antarctic, high altitudes, and the crushing pressure at the bottom of the ocean.
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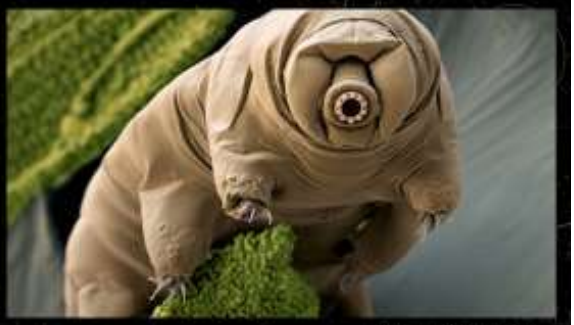
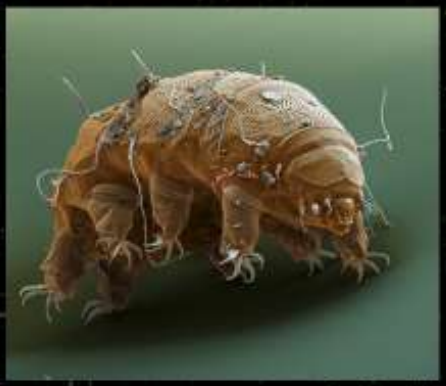


Eye of Science/Science Source



Eye of Science/SPL

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HYDROTHERMAL VENTS

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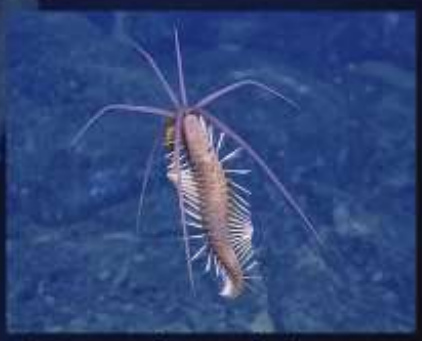
- This is possible through a process called **Chemo-Synthesis**, where the organism converts the chemicals in the water into energy. Before this discovery, we thought that all life relied on the Sun to survive, yet we now know this is not true. These organisms live in complete darkness, enduring pressure 1000 times that on the surface.

A **Purple Holothurian** going about its day at the bottom of the ocean.

Many scientists believe that the first life on Earth (and all life's common ancestor) originated around a hydrothermal vent, billions of years ago!



The rare **Squidworm Polychaete.**

All images by Ocean Exploration Trust

BLOOD FALLS

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National Science Foundation/Peter Rejcek

Teachers Evaluation and Handouts

What conditions are required for life and where might they exist in the Solar System?

Now that we have covered the planets, dwarf planets, moons, asteroids and comets of the Solar System let's consider what is required for life.

Firstly, let's think about what we know about life on earth. Answer these questions

What are the most extreme areas on earth that life exists?

Hint: Think of the extremes of temperature, pressure and amount of water

Encourage the pupils to use their imagination to think of the most extreme places on earth. Get them to think of places they have been, for example on holiday (mountains, caves, very hot countries) and tell them to think of even more extreme places than those. They may not get all of these, but that is fine. The point is to get them to think of a few. You can given them an example if they are struggling. We will come back to the last one (Pitch lake, which has implications for searches for life on Titan)

Location	**Why is it extreme?**
Deserts	High temperatures, low water (can be 40 – 50 ° C)
Antarctic	Cold - temperatures can be as low as -60 °C.
Bottom of the ocean	there is very high pressure, and darkness (no sunlight)
Very high mountains	Low amounts of oxygen, high amounts of ultra-violet radiation from Sun
Underground in dark caves	Cold, no sunlight, often full of toxins
Very hot volcanic springs	Very Hot temperatures, water can be acidic or alkaline, or very salty
"Pitch lake": pools of hot, liquid tar	No water, oxygen. Poisonous gas, hot.

What are the basic requirements of life on earth (use your answers above to guide you)? Give examples of where these might be found on earth and elsewhere in the Solar System.

Basic requirement	**Example on earth**	**Where else in the Solar system?**
Water in liquid form	Over much of earth's surface	No detection of any water flowing on the **surface** of any planet or moon
	Oceans	Could be oceans below the surface of Europa (moon of Jupiter) or Enceladus (moon of Saturn).
	Below the hot and dry desert surfaces	No water on the surface of Mars, but there might be below
Energy	Sunlight - over much of the surface and the upper parts of the Oceans	All of the planets and moons get sunlight, but at orbits beyond earth, this is low.
	Heat from hot water - (hydrothermal vents)	Could be hydrothermal vents in the possible under surface oceans of Enceladus or Europa
Chemical elements	The 4 basic chemical elements required for earth are carbon, nitrogen, oxygen and hydrogen. The earth is rich in all. It is thought that about 25 elements are essential, but the 4 above are the absolute essentials	We need oxygen to breath, but we have seen in the slides that oxygen is not always necessary on earth for simple, microbial life. All of the planets have similar chemical elements to what we find on earth.