



Overview

Age Range:

10-14

Lesson Time:

45 Minutes (including 2 videos)

Equipment Needed:

Computer

Projector

Topics Covered:

Biology (Life in extremes)

Astronomy (Mars surface conditions)

Activity Outline

An introduction to life found in extreme environments, exploring the kind of stresses we may find on Mars and how life can adapt to survive these.

Learning Outcomes

After completing this activity, pupils will:

- Understand that cells can change to adapt to extreme environments.
- Explain the function of a cell membrane.
- Assess how stresses on Mars might affect its habitability.

Background Material:

Slide 1 - Introduction

In this lesson we will be looking at microorganisms that can thrive under conditions which we would normally consider inhospitable for life.

Slide 2 – Objectives

Can be seen above in Learning Outcomes.

Slide 3 – What is an extreme environment?

An extreme environment is one that was previously believed to be unable to support life. Contemporary work within the fields of microbiology and astrobiology has shown that in many cases this was a false assumption. Extreme environments are under harsh conditions such as extreme temperatures both high and low, high salinity, extreme acids or bases and even a lack of available nutrients.

Slide 4 – Examples of Extreme Environments on Earth

The study of extremely survivable organisms on Earth, such as tardigrades (also known as water bears) is often linked with the study of habitability of environments on other celestial bodies of the Solar System. Life that can survive in extreme environments is generally classed as an *extremophile* or an *extreme-tolerant organism*. An extremophile grows very well in extreme environments, and actually requires their harsh conditions to grow. An extreme-tolerant organism can survive in extreme environments but grows better in less harsh conditions.

There are many examples of extreme environments here on Earth. An example of two environments which may seem superficially different are a tundra and a desert, but these two environments are both considered to be extreme and in quite similar ways. They both exhibit extreme temperatures, though at opposite extremes of Earth's temperatures. Both environments also have limited availability of nutrients and drinkable water.

Many environments here on Earth, therefore, are an excellent opportunity for study, allowing us to approximate environments elsewhere in the Solar System. These areas are often referred to as Planetary Field Analogue sites due to their analogous nature to extra-terrestrial environments.

In the majority of cases, the kind of organisms which are the most adaptable, and therefore the most likely to survive (or even thrive), are the simplest.

Slide 5 – What are cells made of?

This is why we turn our attention to single celled organisms (microorganisms), the simplest form of life on Earth. Let's get a basic understanding of a cell: this diagram is of an animal cell, and labelled on the diagram are three elements of a cell that will be important for this discussion. We have the cytoplasm, which is the liquid contained within the cell; the nucleus, which is where the majority of the DNA is contained and lastly the cell membrane, which is holding everything together.

Slide 6 – Cell membrane importance

It's easy to imagine the cell membrane to be a lot like a bag or a plastic film, but it's actually semi-permeable. This means that it will allow some things in, such as nutrients and water, but resist other things from entering. Our skin is also semi-permeable, which is why if your fingers are in water for an extended period of time, they will wrinkle. It's also why some compounds can be toxic even to the touch.

Adaptations to the cell membrane are one of the key deciding factors for whether or not a microorganism can survive in a given environment.

Slide 7 – Semi-permeable membrane video

Here is a video illustrating one way in which semi permeability can work: <https://youtu.be/JTU8A-kzxRM>

Video background information: In this video we have used a jam jar with a tight mesh placed over the top. When the jar is turned upside down, air pressure will stop the water from pouring out. Larger objects, such as a pencil, are unable to pass through the mesh and are therefore 'resisted' by the 'membrane', whereas a smaller object like a toothpick is able to pass through into the 'cell' and is not 'resisted'.

Slide 8 – What might happen to cells under Mars-like conditions?

From what you know about the planet Mars, what do you think would happen to a cell on the Martian surface? Please discuss in groups.

(Allow time for group discussion)

(Take answers)

A cell may be affected by many of the conditions on Mars. Students might mention that the cell could freeze due to the low temperatures, be hit by high levels of radiation, or affected by low pressures or salt concentrations found on the Martian surface.

Slide 9 – Egg Membrane Experiment

Here is a video of an experiment using de-shelled raw eggs as an analogue for a cell and subjecting them to different extreme environments: <https://youtu.be/DddOzinHalM>

Video background information: With a de-shelled egg, the analogue works as such: the yolk represents the nucleus, the conalbumin represents the cytoplasm and the membrane of course represents the cell membrane. The aim of the experiment is to observe the effect of different extremes on the simulated cell and to see if the membrane would be capable of resisting the negative impacts of these conditions. The membrane did not resist low temperatures and froze through; therefore, it is possible to infer that the failed high temperature condition would not have been resisted and would have cooked through. The membrane also showed a partial resistance to the salt.

Slide 10 – What happened? Why?

What did you observe in that video? Discuss in your groups and feedback.

(Allow time for discussion)

(Take answers)

Slide 11 – How do you think this might affect habitability?

The eggs may not have resisted these conditions, but life has evolved on Earth that is capable of resisting these environments and greater extremes.

With what you have learnt, please discuss in groups whether you believe it would be possible for life to survive on the surface of Mars.

(Allow time for group discussion)

(Take answers)

Slide 13 - Review

From this lesson, students should be able to answer the following questions:

- What can cells do to adjust to an extreme environment?
- Why is a cell membrane important?
- How could the extreme conditions on Mars affect cells?