Is there life beyond Earth?

with Dame Dr Maggie Aderin-Pocock

Royal Institution Christmas Lectures Activities

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In this year's CHRISTMAS LECTURES from the Royal Institution (Ri) supported by CGI, Dr Dame Maggie Aderin-Pocock will take us on an epic voyage through time and space.

Scientists in 2025 detected the 'strongest hint yet' of biological activity outside our solar system on exoplanet K2-18b, sparking growing excitement about the real possibility of extraterrestrial life. In this series of lectures, Maggie sets out on a journey to find it.

Life Beyond Earth

Aimed at KS3, this resource will prompt pupils to consider what conditions are required for, and can be monitored by scientists to predict, life beyond Earth. Pupils will use extremophiles on Earth as examples to consider life on other planets and how they may thrive in varied conditions.

Learning Objectives

- To learn what factors/conditions make Earth habitable and how scientists can use this knowledge in their search for extraterrestrial life
- To learn how the discovery of extremophiles can redefine what we understand to be habitable conditions
- To consider extremophile characteristics and what planetary conditions they could survive on

Definitions

- **Exoplanets –** Planets located outside of our Solar System
- **Extremophiles –** Organisms that grow optimally in extreme conditions
- **Mesophiles –** Organisms that grow optimally in non-extreme conditions
- **Extremotolerant mesophiles –** Organisms that can survive in extreme conditions
- **The Goldilocks Zone –** Also called the **'Habitable zone'**. The orbit area around a star that is not too hot and not too cold to sustain the conditions required for life to exist (such as liquid water)

What is required for life to exist?

Earth is home to a huge diversity of life – from complex multicellular organisms like animals and plants to microscopic bacteria and fungi. This abundance differentiates Earth from the rest of the known universe. Despite scientists having identified thousands of exoplanets within our galaxy, and the estimates suggesting there could be trillions more throughout the observable universe, Earth remains the only planet that is confirmed to support life.

Activity 1 – What conditions do the following organisms need to survive? What conditions are not essential for survival but might be useful? Why are these conditions important for the organisms?

Use some of the ideas below and add your own:

- Oxygen/air
- Water
- Gravity
- Soil
- Sunlight
- Warmth
- Food/nutrients

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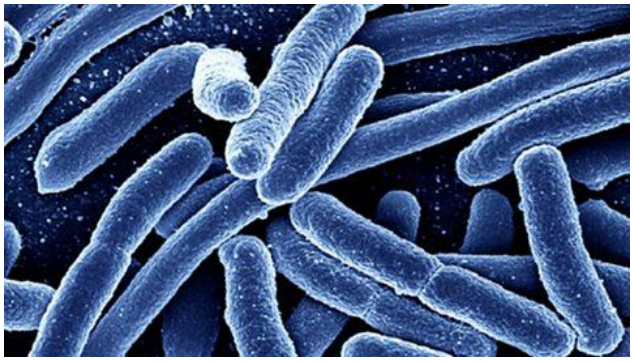

What do scientists look for on planets when searching for life?

When looking for other planets that may support life, scientists look at what makes Earth habitable. These conditions work together to create a habitable environment where life can develop:

- **Water –** Almost all life processes depend on water in liquid form. Most of the chemical reactions that happen inside living cells can only take place when water is present.
- **Energy sources –** All life requires energy to grow, move and reproduce. Light energy is used on Earth for photosynthesis.
- **Protection from excessive radiation –** The atmosphere around Earth protects life from harmful UV radiation which can damage critical molecules for life such as DNA.
- **Chemical elements –** Living things are built primarily from carbon, hydrogen, nitrogen, oxygen, phosphorus and sulphur.

Looking at a star and its orbiting planets, scientists can calculate the 'Goldilocks zone'. This is the distance a planet has to be from its star to potentially have the essential characteristics to support life.

What do you think these creatures need to live?

These are all **extremophiles** – organisms that grow optimally in extreme environments. These places have conditions that would be unsuitable for most life – extreme temperature, pressure, or pH for example.

Extremophiles have been found in a wide variety of environments:

- Hot springs with temperatures over 100C
- (Sub)glacial areas in the Arctic with temperatures as low as -20C
- Deep ocean trenches with high pressure and no sunlight
- Underground acidic lakes

With extremophiles showing that life can survive in what was once considered 'uninhabitable' areas, scientists have to reconsider their criteria for life beyond Earth. Living things on exoplanets may look very different to what the majority of life looks like here.

Activity 2 – Who can live where?

You have 12 extremophile Top Trumps and 6 fictional exoplanet Top Trumps. Can you match the extremophile to an exoplanet that it might be able to live on? What extra information might you need about the extremophile or about the planet?

Extra questions you can consider:

- What would humans need to survive on one of these planets? Would current space suits be enough?
- What do you think are the most useful adaptations that the extremophiles have? Can they be ranked?
- What do you notice about the extremophiles? Compare the bacteria and archaea to the eukaryota – what are the differences and why?

Optional Extension

Scientists have discovered over 6000 exoplanets, mostly in the Milky Way, using various telescopes and techniques. NASA keep a catalogue where you can learn more about every confirmed exoplanet.

Make a fact-file for an exoplanet that you find interesting. Here are some facts about confirmed exoplanets to get you started:

K2-18b

- Super-earth that is almost 9 times bigger than Earth
- Scientists potentially detected DMS (dimethyl sulfide) and DMDS (dimethyl disulfide) in the atmosphere which could be signs of life!

Proxima Centauri b

- Almost the exact same size as Earth
- The closest exoplanet that we know about – only 4 light years away from Earth

HD 189733 b

- Gas giant just bigger than Jupiter but much hotter – temperatures could be over 1000C!
- The planet looks blue to our telescopes but that comes from silicate particles in the atmosphere.

Trappist 1e

- Sits in the middle of its stars habitable zone so liquid water could exist on the surface
- Tidally locked so the same face of the planet is always pointed at the star. One side is always daytime and the other is always night

Kepler 16b

- Gas giant of a similar size to Saturn with no solid surface
- Orbits 2 stars!

55 Cancri e

- Rocky planet twice the size of Earth
- 65 times closer to its star than the Earth is to our Sun. So hot the rocks melt and there would be an ocean of lava

HD 40307g

- Super-earth, nearly 7 times bigger than Earth
- You would fall faster on this planet as there is stronger gravity