I BET YOU DID'T KNOW...

One of Saturn's moons may be a home for extra-terrestrial life

Dr Katharine Pemberton, Fellow of PSTT College, links **cutting edge research** with the **principles of primary science**

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Have you ever wondered if there is life on other planets? The idea of extra-terrestrial aliens has formed the basis of numerous films and stories. The discovery that conditions on one of Saturn's moons may be able to support life makes us wonder what else could be living in our Solar System. But what do you think aliens would need to have to survive?

What do living things on earth need to survive?
Where do most living things get their energy?
What raw ingredients do they need to build their bodies?

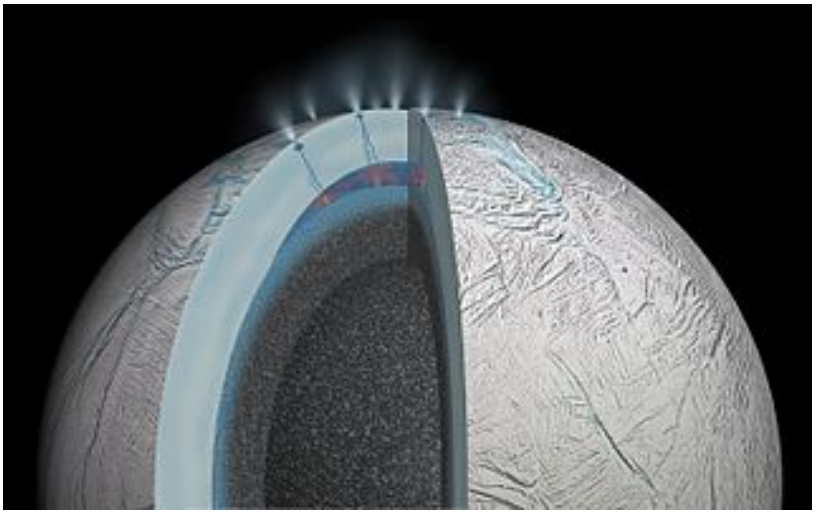
All living things need a source of energy. Animals, fungi and some bacteria get their energy from the food they eat. Most plants, algae and other bacteria get their energy from the sun. Through photosynthesis they create the complex carbon-based molecules needed for life. However, some bacteria and another group of single-celled organisms called Archaea' do not need the sun and can get their energy directly from chemicals in a process called *chemosynthesis*. This has been seen in deep-sea 'cold seeps' and 'hot hydrothermal vents' where chemosynthetic cells form the lowest level of the food chain and support extensive food webs. Hydrothermal vents are plumes of super-heated water from deep in the Earth's hot crust that are rich in dissolved minerals. Cold seeps are areas on the ocean floor where fluids rich in hydrocarbons filter through the ocean bedrock. Hydrocarbons are compounds in which the main components are hydrogen and carbon.

Have you seen any of the bizarre creatures that can be found in the deep-sea?
Can you explain some notable features?
How do you think this helps them survive at the depths of the ocean?

Images beamed back to earth from the space probe Cassini have shown that one of Saturn's moons, Enceladus, has a rocky core, surrounded by a salty ocean encased in a layer of ice. Spurting out through cracks in the ice are gigantic jets of chemicals (Figure 1). The plumes are so big that they can reach 49km away from Enceladus' surface.

You could compare the moon to an egg, where the shell is the ice, the white is the ocean and the yolk is the core or children could create models of the moon using different colours of modelling clay to represent the layers of rock, water and ice. Older pupils could make scale models (the diameter of Enceladus is 504.2km) and use pipe cleaners or cocktail sticks to represent the jets of chemicals.

Figure 1. Artist's impression of possible hydrothermal activity on Enceladus, showing the plumes.



Can you imagine a fountain that reached 49km into the sky?
How big is the tallest building on Earth?
How high is the tallest mountain?
At what height do scientists think the Earth's atmosphere ends?
You could replicate a geyser using cola and Mentos sweets – details are provided in the Teacher Guide.

Using a scientific instrument attached to Cassini, researchers have found hydrogen gas within the plumes. Hydrogen is the most abundant chemical element in the universe, but it is the presence of this gas as molecular hydrogen (H_2), that suggests conditions may exist to support life on Enceladus. The tricky problem is to work out the source of the hydrogen found in the plumes. It may be produced in hydrothermal vents and that would suggest that there could be life on Enceladus now. However, there are other possible sources of the gas. Where else could the hydrogen have come from? Is it being produced now, or could it have come from stores of the gas that were created years ago?

How can you prove where something comes from when you cannot visit the moon itself?

To try and tackle the problem, the researchers measured concentrations of hydrogen and other chemicals in the plume and the rate at which they are being ejected. Table 1 gives details of the possible sources of hydrogen (either stored on Enceladus or produced from hydrothermal vents). Scientists worked out that it is most likely that the hydrogen they measured came from the hydrothermal vents.

The *rate* of something tells you how much takes place in a given amount of time. For example, the rate at which a tap water flows is a measurement of the volume of water that comes out of the tap in a given amount of time, e.g. ml per minute. You could investigate rates by trying the investigation described in the Teacher Guide.

According to the authors, the measured concentration of hydrogen and its ratio to other chemicals, suggest that it is being produced now on Enceladus and that of the two possible means of production, the most likely is reactions at hydrothermal vents. Where the oceanic water meets the rocky core of the moon, chemical reactions can occur as the minerals and organic compounds in the surface get broken down. These compounds could be mixed together in way that leads to hydrogen production. Calculations show that these processes could generate enough hydrogen to

explain the high measurements in the plume. So, if the hydrothermal vents do indeed exist, could the associated chemical soup be supporting chemosynthesis and extra-terrestrial food webs? That question cannot yet be answered. "It could be life, Spock, but not as we know it."

Table 1: Possible sources of molecular hydrogen measured in the plumes erupting from Enceladus.

Hydrogen source	Is this a likely/possible source?
Hydrogen stored on Enceladus	
1. *within the ice shell*	No: it would be too volatile to have lasted until now – it would have quickly reacted with other chemicals.
2. *trapped within other molecules*	No: the ratio of hydrogen to other gases is wrong.
3. *within the ocean*	No: there does not appear to be enough hydrogen in the sea to support measured rates.
4. *produced from chemical reactions when the moon was formed*	No: the ratio of hydrogen to helium is too low and when the moon was formed, it would have been too hot and too small to trap enough hydrogen to support measured rates.
Hydrogen being produced now	
1. *radiolysis – the splitting of water in the rocky core using energy from radioactive decay*	No: the rates of radiolysis are too low to support measured rates of hydrogen production.
2. *reactions at hydrothermal vents*	Yes: chemical reactions at the surface of the core could mix mineral and carbon- based compounds with seawater to produce molecular hydrogen.

The research paper that generated this work was:

Cassini finds molecular hydrogen in the Enceladus plume: Evidence for hydrothermal processes. By J. Hunter Waite,[1,2] Christopher R. Glein,[1] Rebecca S. Perryman,[1] Ben D. Teolis,[1] Brian A. Magee,[1,3] Greg Miller,[1] Jacob Grimes,[1] Mark E. Perry,[4] Kelly E. Miller,[1] Alexis Bouquet,[1,2] Jonathan I. Lumine,[5] Tim Brockwell,[1] Scott J. Bolton,[1] Science 356 (6334), 155-159 (2017)

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