***Exploring life in extremes and beyond the Earth!*** ****

**Astrobiology education kit: Instructions**

Your education kit has most of what you need to demonstrate some basic ideas in astrobiology.

However, you will need to obtain: water, some empty water bottles, a kettle to make hot water, some sugar, iodine solution, some hand lenses

This kit is made for about 5 groups of four people, but you can use it for any number in a class. Some of the items (such as hand lenses) must be shared between groups, but you could augment the kit with items available in your school.

**Kit content**

***In each kit you will find:***

*5 x Dimple tile*

*Small bag starch granules*

*Small bag yeast*

*Small bag sand*

*Small bag Alka seltzer (crushed)*

*2 x Empty dropper bottle for water and iodine solution*

*10 x Balloons*

*2 x Vinegar sachets*

*3 x Salt sachets*

*20 x UV Beads*

*3 x UV key rings*

*5 x 10 ml syringe*

**Detection of life experiment**

*In the kit: dimple tile, starch granules, yeast granules, sand, alka seltzer (crushed), empty dropper bottle for water, dropper bottle for iodine, small hand lenses*

**This experiment is about the characteristics of life, how we can identify life and what the implications might be for the search for life elsewhere.**

This demonstration will show that some chemical reactions can appear to show ‘activity’ and yet are not life. To determine whether something contains life we often need more than one life detection method. This activity could occur around a discussion on the characteristics of life or a discussion on the chemistry of living things. A good space mission context is to talk around the problems that the Viking Lander on Mars had in detecting life (it detected oxygen gas evolved from soil which is thought to have been caused by chemical ingredients in the soils like hydrogen peroxide reacting with nutrients that were added to the soil to test for life). The discussion can include how an active chemical reaction can easily confuse us into thinking we have found life.

For each group, prepare a dimple tile with each of the following in a separate dimple:

Starch powder

Yeast granules

Sand

Alka seltzer

Fill your empty dropper bottles with water.

Ask each group to add three or four drops of water to each of the four components. What do they see? (Remember not to identify what is in the wells!).

The starch powder will be unreactive and show no obvious signs of activity.

The yeast granules will swell and may show signs of some gas bubbles.

The sand will show no signs of activity.

The alka seltzer will fizz as if it is some sort of active metabolic process.

This test can be followed with a discussion to identify which wells contain active life. The discussion might focus on the apparent activity of the alka seltzer well.

Now ask each group to add a drop of iodine solution to each well. In contact with sugars (carbohydrates) the iodine will go purple. The relatively inactive starch will go purple, the yeast granules will go purple, but neither the sand or alka seltzer go purple.

The discussion can then revolve around the results: the starch was very inactive with water, but with iodine is clearly of biological origin. The yeast was suspected of being biological and is shown to be with iodine. The sand is inert with water and with iodine, it is not biological. The surprise is alka seltzer, which fizzed like active life with water, but contains no sugars – it must be a chemical reaction showing how chemistry can sometimes lead us to make conclusions that something is life when it is not.

**Extremophiles and the limit of life**

*In the kit: Yeast granules, balloons, vinegar sachets, salt sachets*

*You will need to find empty water bottles, two for each group and some sugar.*

**This experiment is about looking at the limits of life, how the growth of life is influenced by its environment and what sorts of physical conditions might limit life.**

Get each group to fill their water bottles to about one third full with water. Add in about two or three tablespoons of sugar (food for the yeast to become active). Add in your extreme condition of choice. For example, one group could do salt (add in about three sachets of salt), one group could do vinegar (add about two sachets of vinegar) and one group could be a control group that adds nothing. The two remaining groups can take part in the experiments with the three groups above or do additional extremes (see below).

Add yeast to the bottles (about a tablespoon or equivalent) and then place a balloon over the top of the bottle. Now wait (it helps for people to hold the bottles to warm up the yeast and make it more active). The yeast will start to metabolise producing carbon dioxide which will cause the balloon to inflate. However, extreme salinity and acid (salt and vinegar, respectively) will slow down the reaction and not so much gas will be produced. The balloons will not inflate as much.

*Note:* You don’t need to do salt and vinegar. You could do cold temperatures (in a bucket of ice) or hot temperatures (in a bucket of warm water) to explore temperate range or any other extremes you can think of.

During and after the experiment you can engage in discussions about the requirements for life, the effects of extreme conditions for life, implications for life elsewhere and the dependence of growth and metabolic process on the environment.

**UV radiation and damage to life**

*In the kit: UV Beads and UV key rings*

**This experiment is specifically focused on radiation as a damaging agent for life. Ultraviolet radiation in sunlight in particular can limit the ability of life to grow.**

Ultraviolet radiation is damaging to life since it interacts with organic molecules and causes damage to them or makes them change chemical characteristics. It can damage important molecules such as DNA by breaking the strands or it can cause proteins to unfold or ‘denature’.

In this simple experiment you will shine UV radiation onto the UV beads provided (note that the levels of UV radiation produced by the keyring are negligible and not damaging. However, obviously you should discourage people from deliberately shining the UV into eyes, particularly at short distances).

The beads you have been provided with change colour under UV radiation because of complex chemical reactions between the plastic and UV radiation. As plastics are made of hydrocarbons like you and me (but obviously our hydrocarbons are in a different form) they are a good analogue for how UV radiation has enough energy to drive active chemistry in complex carbon compounds.

You can accompany this experiment with a discussion about how life might protect itself against UV radiation (tanning), why life on a planet like Mars with no ozone shield might experience more UV radiation and why this might be damaging, and why the ozone hole on Earth is a concern.

**Pressure and the limits to life**

*In the kit: 10 ml syringe*

*You will need to make some hot water (not scolding) using a kettle.*

**This experiment is to demonstrate that pressure can influence the boiling point of water and the availability of liquid water for life.**

If we reduce the pressure on water, we find the boiling point drops. On Mars, where the pressure is 6 millibar (compared to the Earth where it is 1 bar), it is exactly on the triple point, which means that water will turn from solid directly into gas, bypassing liquid altogether (sublimation). This simple experiment is to demonstrate that as we reduce pressure, the boiling point is reduced, with consequences for water on Mars (there are no large bodies of water on its surface since the pressure is so low, water is either as ice or it will tend to boil away).

Ask each group to take their syringe and partially (about a third of the way) fill it with hot water (make sure the water is not scolding!) by placing the tapered end in water and withdrawing the plunger. When it is about a third full they should take the syringe, place their finger over the tapered end and gently pull the plunger back further As the pressure in the syringe drops, the water will start to bubble – it is boiling!

This simple experiment can be accompanied by the discussion on the phase diagram of water, effects of pressure on boiling point, implications for Mars and implication for life on the surface of a place like Mars at low pressure (no liquid water means that life cannot be active as water is a requirement for life).

***Acknowledgements: We thank Chris Carr and the National Space Centre for their help and inspiration in putting this kit together***