World Science Day Project: Is there Life on Mars?

Guidance Notes for Lesson Delivery

The following lessons may be taught in sequence as a **full project** spanning a day's teaching if there is opportunity to set aside a '**Science Day**' to celebrate World Science Day 2014. In this instance it is suggested that:

- All **three suggested Starter activities** are undertaken to fully **engage** all pupils with the proposed study theme: Is there Life on Mars?
- Main Focus options 1 & 2 are both taught, each in a separate session during the day, guiding pupils through **Option 1** during a **morning** session followed by **Option 2** in the **afternoon** session. Each **plenary** will be used at the end of the focus sessions to **evaluate** understanding.
- Option 1 '**Research Project**' is to be taught **first** to fully engage and excite pupils about the concept of searching for life in our wider universe as well as considering human settlement on other planets, namely Mars.
- Option 2 '**Dead or Alive? Experiment**' may then follow Option 1, ensuring that pupils are equipped with knowledge and **critical thinking** from their research prior to engaging with the practical experiment, testing soil samples for possible signs of life. Pupils then further **explore** and **elaborate** upon the criteria for life and **explain** their findings.

Alternatively each Starter and Main Focus option may be **selected individually** for one teaching session.

National Curriculum teaching and learning expectations: KS2 focus

The following key attainment targets are taken from the Science Primary National Curriculum (2013-14) for KS2. We hope that KS1 teachers may use the guidance and resources provided by adapting suggested activities and outcomes accordingly.

Science - Earth & Space (KS2)

- Describe the movement of the Earth, and other planets, relative to the Sun in the solar system (Y5) *(statutory)*
- Find out about the way ideas about the solar system have developed (Y5) *(non-statutory)*
- Build upon learning about grouping and classifying living things (Y6) *(non-statutory)*
- Find out about the significance of the work of scientists (Y6) *(non-statutory)*
    - Research unfamiliar animals and plants from a broad range of other habitats (Y6) *(non-statutory)*
    - Recognise that soils are made from rocks and organic matter (Y3) *(statutory)*
- Linked with geography, explore different kinds of rocks and soils (Y3) *(non-statutory)*
- Work scientifically by observing rocks and explore how and why they might have changed over time (Y3) (Y6) *(non-statutory)*
- Explore different soils and identify similarities and differences between them; raise and answer questions about the way soils are formed (Y3) *(non-statutory)*

Lesson Activities - World Science Day: Life on Mars

Introductory Notes - Mars Exploration

- The **2014 World Science Day** theme is **'Peace and Development'**, highlighting the role of science and technology in daily life and future development and for the benefits of science worldwide.
- The not-for-profit organisation **Mars One** aims to establish **human settlement on Mars by 2024**.
- An astronaut's flight to Mars would take between seven and eight months one-way!
- **Mars** is the fourth planet from the sun in our Solar System. It is further away from the sun than the Earth and therefore it is very cold.
- It is often described as the '**Red Planet**' because of its reddish appearance, due to its 'rust-coloured' **dusty and rocky** surface, containing the mineral **iron oxide**. Dust in the atmosphere also often causes it to appear hazy.
- **Wind speeds** on Mars often reach up to 100 mph and cause dust storms which can cover the planet; dust particles in the atmosphere also cause the planet to have a reddish appearance.
- Mars' **atmosphere is very thin** which also contributes to how cold the planet is, with an average temperature of -55^{o}C.
- Mars does have **seasons** (caused by the tilt of the planet's axis which is at a similar angle to that of the Earth's axis) but it is extremely dry and there is never any rain. It is nearly always sunny on Mars and in the 'summer' season it can reach up to 27 ^{o}C at the equator.
- The atmosphere is made up of **95.3% carbon dioxide (CO_2)**, 2.7% nitrogen (N_2), 1.6% argon (Ar) and just 0.1% oxygen (O_2). There are also tiny amounts of other gases including carbon monoxide (CO), water vapour (H_2O), nitric oxide (NO), neon (Ne), xenon (Xe) and krypton (Kr).
- It is thought that in the past there was **surface water** present on Mars and the atmosphere was thicker. Mars is the only planet that has shown evidence that **water may have existed** on it.
- There are **polar caps** on Mars similar to those on Earth, but instead of containing frozen water the Mars polar caps contain mostly **frozen carbon dioxide**.
- Mars has **two moons**, Phobos and Deimos, which were discovered in 1877.
- It takes Mars 687 days to **orbit** the sun, during which time it travels 849,400,000 miles.
- The name 'Mars' meant **God of War** to the Romans; in Greek the planet is known as Ares.
- The first known records of Mars were by **Egyptian Astronomers** in the 2nd millennium BC.
- The tallest mountain known in the solar system is on Mars. **Olympus Mons** is a huge volcano, the largest in the solar system at 21km high and 600km in diameter. Some scientists believe it could still be active.
- Other important features of Mars include: the **Valles Marineris**, an extensive canyon on the equator; **Noctis Labyrinthus**, a vast maze of canyons and pits; and the **Martian Polar caps**, containing ice and dust layers which could hold clues to Mars' climate change during its lifetime.
- The **surface gravity** of Mars is only 37% of that on Earth, which means that you could jump three times higher on Mars than you could on Earth!
- Several **meteorites** that have fallen to Earth are known to have come from Mars. Scientists were able to study the debris and begin to understand the Martian planet even before space missions were launched. Since then there have been approximately **22 successful missions** to Mars!

1. Lesson Starters

Select or adapt starter suggestions to fit allotted lesson times.

1. [5+ mins.]

Introduce the concept of space exploration with **pupil discussion** about what scientists, astro-physicists and astronomers etc. may discover in space, or what they may be searching for.

- Pupils discuss with their **talk partner**, person next to them, or **small group**.
- Pupils take turns to **feed back** their ideas (collate on a whiteboard if you wish).
- What do they think they already know? What are their thoughts about space exploration? What would they like to find out more about? Do they think there is likely to be life elsewhere in the universe? If so where might it be?
- Does '**life**' only mean people (humans) or animals? What does the term '**Martian**' mean?
- Ask pupils to **consider whether they think there is (or was) life on Mars or not**. Take a **vote** (this could be an anonymous voting, depending on pupils or intentions). Supply pupils with a slip of paper and ask them to write YES or NO in 'secret', folding the slip up and placing in a bag or box to be looked at later; otherwise take a vote by show of hands and record as a tally. Analyse these results and also **re-take this vote to compare views at the end** of the lesson!

2. [5-10 mins.]

Ask pupils to **brainstorm** using dry-wipe boards or post-it notes. Ask pupils to write or draw the ideas they feel describe the concept of '**life on Mars**' or '**life in outer space**', and what the word '**Martian**' means.

- Share the **Mars related vocabulary** that pupils have generated.
- Use the **Printable Martian Vocabulary Cards provided** to stimulate discussion if required.
- Use **dictionaries** to extend discussion on what the words '**alien**' and '**life**' mean, e.g. something that is referred to as 'alien' may be something out of its original habitat, or 'foreign' - anything foreign to the environment in which it exists at the present moment.

3. [5 mins.]

Ask pupils to summarise the **essential variables** which need to be in place for **life** to develop and be sustained. Discuss areas of the Earth which are mostly habitable or uninhabitable, and why.

- Do people and/or other living things inhabit every part of our planet?
- Consider extreme habitats, such as desert or deep ocean; what life can be found here?
- What would scientists be looking for to find evidence of life in outer space?
- How has science helped us to understand the universe?

2. Main Focus - Option 1: Research Project

Inform pupils (or re-cap if already known/discussed during Starter session) that there is currently a **Mars mission** in operation whereby a sophisticated robotic rover named the '**Curiosity Rover**' is traversing the surface of Mars, collecting data through samples, measurements and photography.

This NASA program has been years in the making: The Curiosity rover was launched in November 2011 and landed on Mars in August 2012. It has been gathering evidence ever since!

- What might the Curiosity Rover be looking for? What do scientists hope to learn/discover?
- Show pupils images of the Curiosity Rover and its findings to date (via the internet).

Previously, in 1976, probes were landed on Mars which gathered soil samples and performed experiments. These probes were called **Viking I** and **Viking II**. Later, in 2004, NASA robots known as **Spirit** and **Opportunity** also explored Mars.

- In **groups**, pupils are to **conduct research** into the search for life on Mars:
  - Group pupils according to class size and necessary differentiation
  - Provide pupils with materials for research, including **reference books** if possible - use any of the key words highlighted throughout this guidance for internet searches
  - Remind pupils of how to conduct an **effective search** for information on the internet
  - Pupils require **access to the internet** via laptops, tablets or PCs
  - Paper for recording research - preferably a large A2 sheet per group, or A3 in pairs
  - Pens, pencils, paint and any other recording material you would like pupils to use

Recommended websites for information include the following:

http://mars.jpl.nasa.gov/msl/mission/overview/ - NASA official site - Mission Overview

http://www.nasa.gov/audience/forkids/kidsclub/flash/index.html#.VD5gtvldWkk - NASA Kids Club

http://mars.jpl.nasa.gov/explore/curiosity/#141 - an interactive experience with Curiosity Rover

http://www.mars-one.com/ - Mars One official site

http://cmex.ihmc.us/CMEX/data/Marslife/NLife.htm - a selection of websites about 'Life on Mars?'

http://news.bbc.co.uk/1/hi/sci/tech/4063181.stm - reports about the Opportunity discoveries (2004)

Direct pupils to include a range of information on their **research displays**, all of which will focus on the possibility of and search for life on Mars, including:

- **Facts** about Mars and a description of the planet, comparisons to Earth, early and recent **scientific discoveries** and efforts, **scientific developments** and important missions.

3. Main Focus - Option 2: Soil Sample Experiment

This session requires some preparation to set up the experiment - see Equipment sheet

Ask pupils if they can determine whether something is alive or not - what **criteria** defines the term '**living**' versus 'dead'? Remind pupils that Mars is currently considered to be a 'dead' planet, but scientists are continuing to explore whether Mars supported life in the past or not.

- Pupils turn to their **talk partner** or the person next to them, or discuss in **small groups**.
- Pupils take turns to **feed back** their ideas - **collate criteria** on a whiteboard or similar.

Next, watch the following video clip if possible:

https://www.youtube.com/watch?v=AfPjP8k0EG8 - NOVA - Mars, Dead or Alive (Part 1 of 5)

Stop the video clip at 0:2:20 (total length 0:9:25) and discuss points of interest from the clip. Also show images of the Curiosity rover, discussing how the rover's 'hand' collects soil samples:

http://mars.jpl.nasa.gov/msl/multimedia/images/ - NASA Images from the Mars Rover

Explain to pupils that they are going to imagine they are **scientists testing samples** from the surface of Mars; they will need to consider the criteria and characteristics for 'dead or alive' as discussed. Subtle but **fundamental points** they may need to include (which may need to be directed or added to pupil suggestions, considering age and ability level of pupils) are:

- Complex cellular organisation with the ability to **reproduce, replicate or divide**
- **Growth and reaction to stimuli** (hot/cold/water/touch/movement/vibration etc.)
- **Metabolic exchanges** such as **respiration** (breathing), exchange of gases or solids etc.

Ask pupils to form **groups** or **pairs** (based on existing class organisation for Topic sessions etc.) and invite one pupil per group to collect the necessary equipment (3 samples per group, A, B and C) - already set up *(see Equipment sheet for prep.)* Direct pupil experimentation as follows:

1. Explain that pupils have before them a selection of "Martian soil samples"
2. Pupils will need to **observe and check each sample** for signs of life or living material
3. They can view, smell, touch and listen (but NOT taste) and record their observations
    a. Pupils now discuss and make notes of **initial observations** for each sample A, B and C
4. Direct groups to **collect a cup of warm water** (hot tap water, less than 50°C in temperature)
    a. Direct pupils to **add a little water to sample A only** - observe and record data
    b. Next, direct pupils to **add a little water to sample B** - observe and record data
    c. Finally direct **as per above for sample C** - observe and record data
5. Now ask pupils to **pour the rest of their water into each sample**, covering all of the soil
6. Pupils should then **immediately observe and record** each of the three samples
7. Leaving the samples alone, pupils then discuss, compare and add further notes to their data
8. Approximately **10 minutes later** ask groups to **re-observe each sample** (sample B should be very active!)

4. Lesson Plenary

Option 1: Research Project - Plenary

Once pupils have reached the time limits you place on their independent Main Focus activity [25-30 mins. approx.] the plenary is ideal for pupils to **present, share and critique** their findings to their class, stating **evidence for or against life on Mars** and the **advancement of scientific developments [10-15 mins.]**.

Remind pupils of any **feedback and peer-assessment criteria** you have in place:

- Celebrate each others' work and, time permitting, re-**vote** (as per **Starter #1**) on whether pupils think there is, or was, life on Mars - discuss any differences/changes of opinion & why.
- Do pupils now have a different **view of what alien 'life' means**? What are their views of the scientific developments which bring us discoveries today? Explain and give evidence.
- '**3 stars and a wish**' technique - suggesting 3 things they see as positive about the work presented by each group and one suggestion for improvement.
- '**Feedback Sandwich**' technique - presenting one suggestion for improvement within two positive comments (positive - improvement - positive).
- Reinforce the **language of peer-assessment** - be **constructive** and **specific**, consider others' feelings, use well-constructed grammar/be polite! Also try to **give supporting scientific evidence** to ideas and criticisms.
- Ensure pupils know the meaning of '**constructive criticism**'!

Option 2: Soil Sample Experiment - Plenary

Pupils will demonstrate their knowledge and skills within the field of experimentation by **evaluating** and **presenting their findings** to the class, **assessing the chosen criteria** as well as potentially trying to **persuade** others of any theories they may have generated!

Remind pupils of the typical **structure** used when presenting **scientific findings**:

- Summarise a **statement of the problem** - what questions were being answered?
- Set out a **hypothesis** - a possible, testable solution for the problem
- List **materials and equipment** used during the experiment
- Describe the **procedure** or **method** as a step-by-step summary
- Present the **results** of the experiment (including graphs, data tables etc. where appropriate)
- **Explain the conclusions** reached and why the hypothesis has been accepted or rejected

Direct pupil discussion, allowing time for each group to feed back their observations from the experiment. Encourage pupils to lead their parts of the session (as a teacher would!).

- Which samples showed activity? Does activity demonstrate life? Explain that sample B contained yeast and sample C effervescent tablets - how might scientists tell the difference between living and non-living chemical change? Were their chosen criteria specific enough?

Printable Martian Vocabulary Cards

Use specific Mars related vocabulary as reference cards or activity and discussion prompts.

Mars	space	planet	life	alien	mission
Martian	dust	rock	gas	mineral	water
explore	investigate	scientist	sun	orbit	gravity
astronaut	meteorite	volcano	spacecraft	robot	organism
universe	temperature	tools	sample	analyse	data
solar system	development	reaction	chemical	conditions	probability

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Experiment Equipment List & Preparation

The following materials are required for the Soil Sample Experiment and **preparation before the session is essential**.

Equipment:

N.B. quantities and measurements given are based on x30 pupils in 15 pairs; adjust if in larger groups

- Small disposable cups (minimum x45)
- Jug(s) and cups for distributing warm water
- Markers etc. to label sample bags and cups or containers
- Approximately 1kg (40oz) clean fine sand (as used for sand pits etc.)
- Approximately 700g granulated sugar
- Approximately 70-80g (2.5oz) instant active dry yeast
- Effervescent tablets (x15) crushed and powdered
- Warm water (from the hot tap, less than 50°C) not too hot to kill the yeast (approx. 4 litres)
- x3 zip-lock bags ('gallon' or 4-litre capacity)
- Magnifying glasses, enough for 1 per pair or group

Preparation:

- Fill each of the large zip-lock bags with 1/3 clean sand each
- Label bags A, B and C
- Add x1 cup (approx. 230g) granulated sugar to all 3 bags of sand; close and shake
- Set aside one bag and label as **Sample A** - Sample A is now ready
- Add the 70+g yeast to one of the other bags of sand, closing and shaking well
- Label this bag with yeast as **Sample B** and set aside - Sample B is now ready
- To the last bag add the crushed, powdered effervescent tablets, closing and shaking
- Label this bag with effervescent tablets as **Sample C**
- All samples are now ready for the experiment

When you are ready to conduct the experiment with pupils, decide whether you wish to distribute the sample yourself in a more controlled or time-restricted environment. In this case all of the small disposable cups will need to be pre-labelled as sets of A, B and C. Just prior to the session the samples will need to be distributed from the bags into the cups, ready for testing.

Otherwise you may wish to keep all of the sample material in the large bags, asking pupils to come up one-at-a-time from their groups or pairs to collect a small amount of each sample, scooping the sample material out of the bags and labelling the cups themselves.