Lesson 1: Microplastics and degradation

Introduction:
This lesson tool can be adapted to your own style of teaching. It has been designed to help you enhance and refresh your existing lesson plans for the topics of B1 6 degradation and C1 5.2 biodegradable plastics. The lesson is practical and easy to set up. It helps students develop their data analysis skills and skills in writing up scientific experiments. It also helps students understand the theory in context with the real local and global issue of marine and beach litter.

Curriculum links:

Curriculum link:	Students should understand:	Students should be able to:
B1.6.1a	• Living things remove materials from the environment for growth and other processes; these are returned to the environment in wastes and when organisms die and decay	• Describe how plants and animals return materials to the environment. • Describe the role of microorganisms in decay
C1.5.2c	• Many polymers are not biodegradable: so they are not broken down by microbes and this can lead to problems with waste disposal.	• Evaluate the impact of polymers on the environment and identify possible solutions
C1.5.2d	• Plastic bags are being made from polymers and cornstarch so that they break down more easily. • Biodegradable plastics made from cornstarch have been developed	• Evaluate information about the ways in which crude oil and its products are used.

Learning points:
Different materials break down in different ways. The same degradation methods can be found on land as in the marine environment.

1. **Photodegradation** – This is the only natural process which breaks down plastic. Plastic is made up of long polymer chains, tangled together, making the object strong. Components of sunlight (infra-red and ultra-violet radiation) cause the long polymer chains to react with oxygen from the air and break down into shorter chains. As more of the plastic molecules react and break down, there are fewer long chains holding the object together- it becomes brittle and breaks into smaller and smaller pieces, though it never completely disappears.
2. **Erosion** –Litter made from materials like glass get buffeted about by the wind, water and other forces. Glass is made out of molten sand. If left for a long time these forces will completely disintegrate the glass into tiny glass grains that mix harmlessly with sand on the ocean floor.
3. **Biodegradation** – Natural materials such as plants, animals and their derivatives (e.g. natural fabrics- cotton, silk, wool etc; untreated timber; paper) are broken down by specific organisms which have evolved (adapted) to exploit a specific niche. These are broken down by two types of decaying organism:
   a. Detritivores e.g. on land: earthworms, maggots, millipedes and woodlice; in the ocean: sea cucumbers and sea worms like *Osedax mucofloris* (literally meaning "Bone-eating snot-flower"). This first stage of decomposition begins the chemical breakdown and increases the surface area of the material for the second type of organism to get to work.
   b. Decomposers – these bacteria chemically break down natural materials into the constituent nutrient components which can be used by other organisms for growth, completing the life cycle.

Resources required:

- Glass bottle
- Clear plastic trays with lids
- Cigarette Butt
- Biodegradable plastic bag
- Plastic bottle
- Fishing line
- Plastic bag
- Apple core & orange peel
- Pre prepared worksheets (optional)
- The Green Blue "Time to Degrade" poster
- "Before" photos of litter items for comparison at results stage.
- Sea water*

**this can be collected from a local beach or created in the lab using 35g sea salt per litre of tap water*.

Method:

- Place the litter items in trays of salt water on a windowsill. Ensure photos are taken of any supplementary items at the beginning of the experiment for comparison at the end.
- The experiment will require at least a month to achieve noticeable results.
- *Set up the experiment with students at the end of a lesson and then get them to monitor the items every week.*
- ***OR** Set up the experiment in advance and involve the students at the analysis stage.*

Predictions

- How will each item break down?
- Which process will it use?
- How long will it take?
- What results might students see?

Optional worksheets are included in the toolkit

Results

- Compare observations at start/finish of experiment
- In particular, note the differences between the two bags- plastic & corn starch.

Optional worksheets are included in the toolkit

Conclusions

- Which items broke down most quickly?
- Did any items completely degrade? Why?
- How long would it take for these items to break down completely? *See Green Blue poster in toolkit*
- Opportunity to reflect on the impact of plastics on the environment
- What can be done to reduce the amount of plastics created? (limiting use will limit production; what alternatives are there to frequently used plastic objects- particularly those designed for single use)

Extensions

1 What might the constraints be on this experiment? Why might the experiment not yield the same results as in a real ocean environment?
   - Not enough sunlight on window sill for photodegradation to happen, or lids reduced amount of light reaching the litter
   - If you used a sea water replica solution it might be that the microorganisms found in sea water were not present so biodegradation could not occur
   - Low levels of oxygen due to the lids
   - No wave action as haven't been moved

2 Which bag is better, and why? Biodegradable packaging is made in a range of different ways. The consumer needs it to be strong and long-lived enough to fulfil its purpose, but then breakdown completely as quickly as possible. Can this be achieved? For homework, students could research different kinds of biodegradable packaging and its advantages/disadvantages and debate the topic in a future lesson. Thoughts could include:
   - Products with short term life with biodegradable contents e.g. dog waste bags, food/ garden waste bags (prevents fossilisation of waste)
   - Weather impact- carrying heavy supermarket shopping in the rain?
   - Specific contents- carrying goldfish from pet shop?
   - Mix of plastic/cornstarch- cornstarch component breaks down quickly, what happens to the plastic component?
   - Where is corn for cornstarch grown? What else could the land be used for?

3 Which environment causes fastest breakdown of which materials? Compare items' breakdown rates in salt water, fresh water and terrestrial (buried underground) environment.
   - Compare the same item in each break-down scenario to ensure fair test.
   - Find a location in the school grounds to bury your chosen items and mark their positions before returning a month later to see what has happened
   - What is different about the three environments? Chemical composition, bacterial/detritivore composition