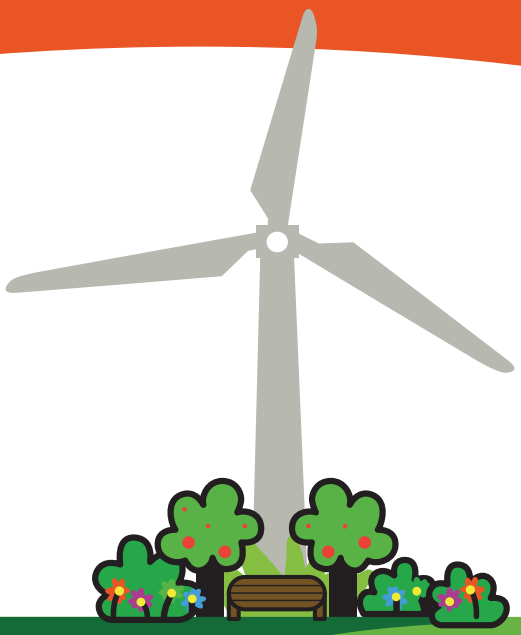
urban science



Plastics

Schools investigate how plastic impacts on the quality of the environment. Students explore how plastic has become a common part of everyday life and a range of ways plastic pollution can be addressed.

A curriculum linked learning module for students aged 13-15 to develop competences in working scientifically.

Learning challenge:

Plastic pollution has become one of the world's most urgent environmental problems. The rapidly growing demand and production of plastic products has to contend with our inability to both understand how to utilise them during their whole life cycle and how to deal with plastic waste at the end of its productive life. Discarded plastic objects are often made up of plastic materials that cannot be recycled together. They need expensive and uneconomic processing. After recycling, the resulting 'new' plastic is often of a lower quality for which there is limited use.

Plastics are found across all environments and often in the form of small fragments. Plastic waste is now found in seas, oceans, soil and even in our most remote and wild places such as forests and glaciers. Plastic pollution is a threat to all ecosystems, and particularly for the survival of marine biodiversity. Turtles, seabirds and whales die because they mistake plastic for food. However, the conundrum is that it can be a brilliant resource: strong, light and flexible. How can we best ensure that it is used wisely and that we look at its whole life cycle? For these reasons many UK schools are considering becoming plastic free. This module can be used to guide students through the complex science issues and towards making informed plastic choices.

This learning module can be used flexibly within the curriculum to support key knowledge about chemistry and develop working scientifically competences. The learning links with the Sustainable Development Goals and provides a broader context for student learning. It is suitable for adapting as a STEM activity or Eco Club.

www.urbanscience.eu

Co-funded by the Erasmus+ Programme of the European Union

To deliver this module we recommend:

- Start with one or both of the Stage 1 activities to generate interest and context about how humans deal with waste compared to nature.
- Elicit current student understanding in Stage 2 and discuss students views and opinions.
- Stage 3 is the practical challenge where students gather data and make conclusions.
- In Stage 4 you will find suggestions for sharing and presenting results.

Subject

Biology	Chemistry	Physics	Raising Attainment
	✓		✓

Programme of Study reference

1. Chemistry	Chemical and allied industries • life cycle assessment and recycling to assess environmental impacts associated with all the stages of a product's life. • the viability of recycling certain materials.	2. Working scientifically	Students successfully completing this module will have had the opportunity to access these statements: 1c,1d,3ai,3aii,3aiii,3av,3avi,3avii. See Annex 1 for full statements.

Sustainable Development Goals

All Urban Science modules try to 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' and in addition focus on education for sustainable development and global education - SDG 4.7. Support and resources here

http://www.teachsdgs.org/

This module has strong links to SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation, SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable, SDG 12: responsible consumption and production and SDG 14: life below water.

Activities Overview

Stage 1	Time (mins)	Resources needed
Introduction	10 mins	None required
How Many Questions?	20 mins	None required
Everyone is Talking About It	20 mins	Student Sheets 1 and 2
Plastic Around Us	10 mins	None required

Stage 2	Time (mins)	Resources needed
Share and Tell	10 mins	None required
PlayDecide Game	35 mins	Access to PlayDecide website
Plastic Conversion	35 mins	Student Sheets 3, 4 and 5
Target Board Evaluation	10 mins	Student Sheet 6
What is in the Bag?	5 mins	None required

Stage 3	Time (mins)	Resources needed
Plastic Science Fair	60 mins	Refer to each experiment

Stage 4	Time (mins)	Resources needed
Presenting Results	60 mins	None required

Health and Safety: please refer to the guidance provided on the Urban Science website before commencing the module.

http://www.urbanscience.eu/uk/learning-modules/health-and-safety/

STAGE 1 - Houston…we have a problem

Inquiry based learning stage

Stage 1 - Initiating and eliciting	✓	**Stage 2 - Defining and responding**	
Stage 3 - Doing and making		**Stage 4 - Communicating, presenting and evaluating**	

Learning objectives

1. Students are able to make observations and question their findings.
2. Students are able to research a topic.
3. Students can make links between different topics to deepen their understanding.

Learning outcomes

1. Students make observations in their community.
2. Students ask questions about their observations.
3. Students research information about plastic waste.
4. Students use creativity and imagination to create their own plastic journal.

Overview of lesson

In the first stage students are asked to gather evidence on our approach to plastic waste and collect information about the issue. The teacher asks students to keep a logbook/journal where they collect their ideas on particular aspects of the problem. There is an option to use plastic waste to create their own journal. We recommend this activity as it gives students an opportunity to more fully understand the unique properties of plastic material.

Lesson structure

Introduction:

We start this topic showing an inspirational clip from David Attenborough's 'The Blue Planet – the dangers of plastics in our oceans'

https://www.bbc.co.uk/programmes/p05q49hq

After watching the video, it is important that students talk about the issues. This problem can appear overwhelming so the following activity can be used to stimulate conversations and then students go on to reflect and explore how they can take action.

Main 1: How many questions?

In pairs or small teams, students are invited to write down as many questions as they can about the video. At the end of a given time limit the question writing must stop. The questions are counted to see who has the most questions. The students with the longest list of questions read their questions out. No two questions must be the same and players may challenge any they think are repeated in different words. The 'winners' are those that have achieved a given target, for example 10 questions or who have listed the most questions.

Main 2: Everyone is talking about it

In this activity students create a 'plastic' journal which they use over the course of the entire module.

For their first entry, we have provided some suggestions below. It is important to have some articles and websites ready in advance to avoid misconceptions and bias. Student Sheet 1 contains a summary of contemporary UK sources on this issue.

Journal suggestions:

- Their first reflections and thoughts.
- Press and journal articles.
- What are the issues?
- What are the solutions?
- Ideas for the plastic challenge corner.
- Key words and glossary.
- Data and graphs.

Making a journal

This can be done in the session or set as a project before the start of the module, or even as something to do as a homework task during the module itself. See Student Sheet 2 for full details.

Main 3: Plastic around us.

Ask students to focus their attention during a 24-hour period on:

- the objects they use every day and the materials they are made of.
- plastic waste in the spaces they visit.
- the different types of plastic they come across during the day

Students write notes in their journal to record their findings.

Students write a brief photo report in their journal about an 'interesting piece of plastic waste', the place and the date they found it, a short description and a hypothesis about why the object came to be found outside.

Optional – Over the next two months note the changes in their plastic object. Pay particular note to changes in colour, size and shape.

Plenary: The messy wall

Students who have previously completed an Urban Science module will be used to setting up a 'messy wall'. We are suggesting calling this one 'the plastic challenge corner'.

Student Sheet 1 - references and sources of information

Websites

www.wrap.org.uk/content/plastics-industry-recycling-action-plan-pirap

WRAP have summarised the issues effecting the industry. Students need to have this perspective to understand how to make effective change.

www.practicalaction.org/schools/plastics-challenge/

As brilliant pack of resources from Practical Action.

www.bbc.co.uk/newsround/42810179

Superb analysis of the problem and a good video.

www.bbc.co.uk/news/business-47161379 - How to solve the plastic packaging paradox

Aimed at adults but a good summary of the issues.

www.edu.rsc.org/feature/whats-in-a-bag/3010854.article

What's in a bag. We have included an activity linked to this article for a homework activity (stage2). This is a great introduction to the life cycle analysis of a product. Currently part of the English GCSE chemistry specification.

http://www.infoplease.com/science/science-projects/science-projects-beginners-what-kind-trash-bag-breaks-down-fastest

What kind of trash bag breaks down the fastest

Video links

Blue Planet -David Attenborough – there are a number of clips freely available from this BBC series. This is the one that kicked off a change in attitudes across the globe.

http://www.bbc.co.uk/programmes/p05q49hq

Surfers Against Sewage are a passionate group of campaigners who also now have a focus on issues related to plastics alongside sewage! Some brilliant videos and background information.

http://www.sas.org.uk/plastic-free-schools/

WWF 'Plastic Pollution'– a good introduction to the issue.

http://www.youtube.com/watch?v=IA9O9YUbQew

Citizen science

www.bigcompostexperiment.org.uk/about/links

www.chemistryworld.com/opinion/fighting-plastic-waste-with-the-power-of-citizen-science/4011560.article

www.bigcompostexperiment.org.uk

Further ideas

www.edu.rsc.org/resources/green-plastics/296.article

This activity introduces students to green chemistry, the need to change to a more sustainable society and the issue of fossil fuels versus bioplastics. Students access a range of experiments that exemplify these principles and are not normally available in schools. This is a great set of activities that need to be developed with a local university /HEI. The link describes how to access and apply for funding.

Student Sheet 2 - making a 'plastic' journal using polypropolene waste

We have been inspired by this site but there are loads more on Instagram and Pinterest.

www.babbledabbledo.com/design-for-kids-recycled-handmade-journals/

- Create your stash of paper, or if binding at the end of the project, your 'plastic problem' journal pages.
- Find a source of polypropylene plastic waste that will fit the edge of your book. You may also want to find a piece big enough for a front sheet…it isn't that hard. It will also be useful to have a cutting board and a cutting wheel to cut your plastic sheets.

Method 1. Stapling

Staple the sheets together using a heavy-duty stapler. Then cut a strip of polypropylene that fits this edge. Put in a few more staples to attach it all together.

This Photo by Unknown Author is licensed under CC BY-SA

Method 2. Hole punch and fasteners. (sometimes called 'brads')

Make two holes using a heavy-duty punch. Either make a strip as in method 1 or create circles that will give strength to the punched holes. Put the fasteners through the paper and the plastic. There are really fancy ones with glass jewelled inserts. There is a lovely idea to use what they call a 'brad' at the back of a journal to fasten some ribbon that then wraps around your book to close it. Obviously, this can be used in any of these methods.

This Photo by Unknown Author is licensed under CC BY-NC-ND

Method 3. Bull dog clips

Taking advice from the link above, it is really important to score the edge to make sure it can easily open. As we are using polypropylene material, take care when doing this. It is tough to cut. Bind using bull dog clips which are very versatile and come in many colours, styles and sizes.

This Photo by Unknown Author is licensed under CC BY-NC-ND

Method 4 Book rings.

These are readily available from office stationers. This definitely needs a full size polypropylene cover to give it strength. The beauty of this is that the book can become very thick if needed.

This Photo by Unknown Author is licensed under CC BY-NC-ND

Method 5. Rubber band and stick

You need a thick rubber band and a stick (a pencil would do). Punch two holes at the sides. With your large rubber band and with the back facing you, put the band through each hole. With the front facing, put a stick through each end of the rubber band. Again, investigate how your polypropylene plastic waste can be used to reinforce the hole either by adding a strip or circles around the holes.

Why is polypropylene plastic waste useful for this task? See

www.thoughtco.com/what-is-polypropylene-820365.

How do you find and identify Polypropylene?

www.owlcation.com/stem/How-plastic-is-really-recycled

STAGE 2 - Plastic Problems: digging deeper

Inquiry based learning stage

Stage 1 - Initiating and eliciting		**Stage 2 - Defining and responding**	✓
Stage 3 - Doing and making		**Stage 4 - Communicating, presenting and evaluating**	

Learning objectives

1. Students are able to distinguish between facts and opinions.
2. Students are able to express their own views and justify them.
3. Students can interrogate a range of opinions.

Learning outcomes

1. Students research and analyse a range of viewpoints.
2. Students test evidence for themselves.
3. Students question evidence to reach conclusions.
4. Students have an understanding of life cycle assessment and recycling as regards plastic products.

Overview of lesson

In this session students dig deeper into the issues surrounding plastic use in the UK and further afield. Two activities are offered: the online PlayDecide game and the conversion activity. Both have been chosen to allow students to scrutinise this complex, often controversial topic, in ways that push them to discuss, argue and cooperate to find solutions. The PlayDecide game activity may take more than one session and may be more suitable for a number of sessions in a STEM Club. The conversion activity, although not a typical STEM activity, may fit better into a more traditional time slot.

Lesson structure

Introduction: Share and Tell

Students update each other on their individual discoveries from the last session, and from their work at home. They add any new information to the plastic challenge corner.

It is useful to set the scene for the next few sessions here. Students are to learn more about the contentious issue of plastic use and waste. This is in preparation for a school science fair on the topic. Then they will be looking at their school, local and national policies, and actions they may wish to take.

Main 1: The PlayDecide game

This activity uses the PlayDecide website. PlayDecide enables people to explore a topic in-depth in an informal and informative way. The game element really helps explore thoughts and opinions that would be difficult to get to and express in other ways.

A game exploring plastic pollution has been created for this module. Full instructions and information can be found at:


www.playdecide.eu/playdecide-kits/167658

Main 2: Plastic Conversion

Plastic conversion presents information and the issues in the form of an exhibition. This is a complex topic and students following this approach will also benefit from having such 'an exhibition' on display. It will help them as they reflect on the issues over the next few weeks.

Students scrutinise facts and issues about the plastic problem via an exhibition (Student Sheet 3). For this option they could also look at their plastic challenge corner. Their task is to convert an aspect of the exhibition into another format.

Their task is to then present their knowledge of plastic in a tableaux (see www.dramaresource.com/tableaux/ for details about tableaux). Each group takes a format card (see Student Sheet 4) and an information card (see Student Sheet 5); these could be randomly selected or allocated as appropriate.

They are given 30 minutes to complete the task and then they present this to the rest of the group.

Plenary

Reflecting

The exhibition lists a number of options for taking action. Working with the same group they take time to discuss their preferred options (brainstorm and list these), before moving onto the target board evaluation below.

Although two options are given for students to scrutinise the information on plastics, the end point of reflecting on some priorities for action is the same.

Target board evaluation

As a class, students use the target board evaluation to identify their priorities taken from their 'action strategies' (see Student Sheet 6).

Then, with the target board technique, students identify the priority resolutions: the centre of the target is equivalent to a 'very important' action, the external ring 'not at all important'. The target board, with all positioned actions, will be hung in the plastic challenge corner.

The learning from this session and the proposed homework activity (see below) will form the basis for their activity in the next session - It's a Wrap. In some settings it may be wise to introduce this ahead of the next session to set the scene and to allow students to make informed choices.

Homework

What is in a bag? This activity scaffolds life-cycle analysis with key questions. It will require students to use sources beyond the article for research. It is necessary to sign up to the RSC site to access their resources, however, these are well researched and risk assessed activities.


http://www.edu.rsc.org/feature/whats-in-a-bag/3010854.article?utm_source=EiC519&utm_medium=resource&utm_campaign=compostablebags

Student Sheet 3 - Exhibition - Plastic Facts

The History of Plastics

The first synthetic plastic - plastic made entirely from man-made materials - was created over 100 years ago.

It was called Bakelite and was invented by Belgian chemist Leo Baekeland in the early 1900s.

Many think Bakelite was the start of plastics as we know them today.

https://www.bbc.co.uk/newsround/42810179

What are the most common types of plastics in use?

- Polyethylene Terephthalate (PET) - used in water bottles and plastic trays.
- High Density Polyethylene (HDPE) - used for milk cartons and shampoo bottles.
- Low Density Polyethylene (LDPE) - plastic carrier bags and bin liners.
- Polypropylene (PP) - margarine tubs and ready-meal trays.

Most commonly used plastics

	What is it used for?	Next life	Ease of recycling
Polyethylene Terephthalate (PET) 1	Soft drink bottles, food packaging such as punnets	Used to make more PET products	Easy
High Density Polyethylene (HDPE) 2	Milk cartons, cleaning products, yoghurt pots, soap dispensers	Garden furniture, pipes and more milk cartons	Easy
Polyvinyl Chloride (PVC) 3	Pipe fittings, window fittings, thermal insulation, car parts	Used to make more PVC products	Difficult
Low Density Polyethylene (LDPE) 4	Food bags, shopping bags, magazine wrapping	Bin liners, plastic furniture and floor tiles	Manageable
Polypropylene (PP) 5	Margarine tubs, microwave meal trays, fibres and filaments for carpet, wall coverings, vehicle upholstery	Clothing fibres, food containers, speed humps	Easy
Polystyrene (PS) 6	Some yoghurt pots, takeaway boxes, plastic cutlery, protective packaging, insulation	As more packaging	Difficult
Other 7	This includes other forms of plastic including composites, such as salad bags and crisp packets	Goes to landfill	Very difficult

Recyclable

Recyclable at specialist points

Not easily recyclable

Source: https://www.which.co.uk/reviews/recycling/article/how-to-recycle-in-the-uk-ajwEz4p63Qs6

Student Sheet 3 - Exhibition - Plastic Facts (continued)

Recycling common plastics (1)

- The 4 main plastic types have the greatest recycling demand and are easier for recycling facilities to handle than other polymers.
- As it's airtight and rigid, yet flexible, PET is the most commonly used, and particularly useful for packaging food and drinks.
- While polystyrene (used for takeaway boxes, cups and food packaging) and PVC (used for food packaging and drainpipes and guttering), are technically recyclable, it's much more difficult to recycle these.

http://www.which.co.uk/reviews/recycling/article/how-to-recycle-in-the-uk-ajwEz4p63Qs6

Recycling common plastics (2)

- Bags that are crinkly and airtight, such as salad bags or crisp packets, are made of composite plastics that are almost impossible to recycle.
- To stop gases escaping from them, these plastics have been developed with multiple polymers layered on top of each other.
- It makes them completely airtight – ideal for storing foods that would otherwise soon go stale or wilt.
- But the layers make them very hard to recycle. This plastic is usually labelled as 'other', and has to be put into general household waste.

http://www.which.co.uk/reviews/recycling/article/how-to-recycle-in-the-uk-ajwEz4p63Qs6

The scale of plastic waste in the UK (2016) – all sectors (1)

- In that year an estimated 1.53 million tonnes of plastic waste were reported.
- This was up by 24% since 2010 and 13% since 2014.
- The service sector was the largest single contributor with 53%.
- Households contributed just over 8%. This data is based on waste streams that are categorised as 'plastics wastes'(only) and exclude the plastic content of other mixed waste streams such as the general 'Households and similar wastes' stream.

UK House of Commons briefing – 'Plastic Waste'
www.commonslibrary.parliament.uk/research-briefings/cbp-8515/

Student Sheet 3 - Exhibition - Plastic Facts (continued)

The scale of plastic waste in the UK (2016) – all sectors (2)

- The coverage of UK data on plastic waste has been questioned by some organisations.
- A report for WWF calculated that total plastic waste generation in the UK in 2014 was around 4.9 million tonnes.
- This could increase to around 6.3 million tonnes by 2030.
- Plastic packaging made up two-thirds of plastic waste in 2014 (3.3 million tonnes).

WWF 'a plastic future'
www.wwf.org.uk/sites/default/files/2018-03/WWF_Plastics_Consumption_Report_Final.pdf

What happens to UK plastic waste? (1)

In 2016

- 91% of plastic waste which was sent to treatment went to 'recycling and other recovery'.
- 9% to landfill.
- The amount of plastic waste going to landfill fell from 122,400 tonnes in 2012 to 53,400 tonnes in 2016.

UK House of Commons briefing – 'Plastic Waste'
https://commonslibrary.parliament.uk/research-briefings/cbp-8515/

What happens to UK plastic waste? (2)

….the coverage of this data has been questioned.

- The WWF-UK report calculated recycling rates for single use plastics, based on the amount of waste produced, not just the share going to 'treatment 'of any kind (landfill, recycling, incineration etc.).
- They estimated recycling rates of 29% for 2018 and projected a rate of 37% for 2030 based on estimates of all plastic waste.
- Estimated landfill rates in 2018 were 48% with 22% going to energy recovery.

UK House of Commons briefing – 'Plastic Waste'
https://commonslibrary.parliament.uk/research-briefings/cbp-8515/

WWF 'a plastic future'
www.wwf.org.uk/sites/default/files/2018-03/WWF_Plastics_Consumption_Report_Final.pdf

Plastic packaging waste UK

- Official estimates of the UK's plastic packaging waste recycling rate are given below.
- The recycling/recovery rate has increased in each year and are now more than double the minimum target of 22.5%.
- The data on the amount of packaging waste produced are industry estimates.

Million Tonnes

	Produced	Recovered or Recycled	% Recycled / Recovered
2012	2.55	0.64	25.2%
2013	2.26	0.71	31.6%
2014	2.22	0.84	37.9%
2015	2.26	0.89	39.4%
2016	2.26	1.02	44.9%
2017	2.26	1.04	46.2%

Source: UK statistics on waste - February 2019 update

Alternative estimates of plastic waste recycling

Eunomia, (for WWF) estimates:

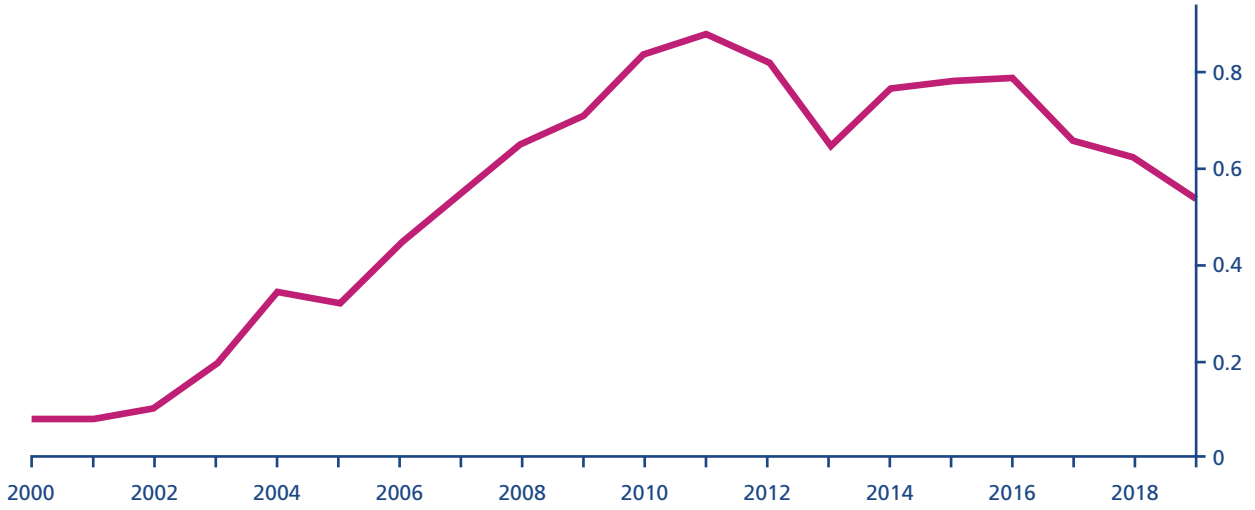
- That the actual volume produced was around 3.5 million tonnes in 2015 with a possible range of 3.1-3.9 million tonnes.
- Their central estimate is more than 50% above the figure used in the Government statistics for 2015- 2017.
- Around two-thirds of this waste is collected by local authorities, mainly from households.
- Their calculation includes an estimate of plastics in the general household waste stream.
- With this highest estimate of waste produced the resulting recycling rate falls to 23-29% in 2015.

Student Sheet 3 - Exhibition - Plastic Facts (continued)

Exports of plastic waste (1)

- In 2019 the UK exported 0.5 million tonnes of plastic waste.
- The amount exported increased rapidly in the decade to its 2011 peak of almost 0.9 million tonnes.
- The chart shows that it has generally fallen since then.
- The 2019 level was the lowest for over a decade

UK Plastic Waste Exports - *Million Tonnes*



Source: uktradeinfo.com

Exports of plastic waste (2)

- Much of the expansion of waste exports went to China/Hong Kong and these exports accounted for more than 80% of the total in 2005 to 2012.
- They fell in importance after 2013 but were still the largest single destination in 2017 with 37% of the total.
- The decision by China to ban imports of certain types of waste for recycling from 2018 saw UK exports to China fall by 97% between 2016 and 2019.
- In 2019 the most important export destinations were Turkey (19%), Hong Kong (12%), the Netherlands (9%), Malaysia and Poland (both 7%).

Student Sheet 3 - Exhibition - Plastic Problems (continued)

What is the problem with plastics? - Recycling issues (1)

… the problem with plastic is that most of it isn't **biodegradable.**

- It doesn't rot, like paper or food, so instead it can hang around in the environment for hundreds of years.
- Each year, 400 million tonnes of plastic is produced and 40% of that is **single-use** - plastic we'll only use once before it's binned.
- Examples of single-use plastic are carrier bags, drinks bottles and crisp packets.

http://www.bbc.co.uk/newsround/42810179

What is the problem with plastics? - Recycling issues (2)

… not all plastic can be recycled.

- This might be because of the way it is made up or because it is too expensive or difficult to do.
- Some coffee cups, for example, have a waterproof plastic lining which can make them difficult to recycle.
- Every day seven million cardboard coffee cups are thrown away but only one in 400 are recycled.

http://www.bbc.co.uk/newsround/42810179

What is the problem with plastics? – Climate change

- It might come as a surprise, but plastic is a big problem for the environment even before it pollutes our rivers and oceans. Plastic is a major **contributor to climate change**.
- That's because chemicals derived from fossil fuel production are used to make almost all plastics - more than 99% of them.
- So the more plastic we make, the more of these petrochemicals we need. And the more petrochemicals we need, the higher the demand for gas, oil and even coal. The same fuels driving dangerous climate change.

https://friendsoftheearth.uk/plastics/how-is-plastic-made

Student Sheet 3 - Exhibition - Plastic Problems (continued)

What is the problem with plastics? Ocean pollution (1)

- More than eight million tonnes of plastic enters the world's oceans each year and most of that escapes from land.
- It can be blown into the sea from ships and beaches, or carried there by river. Some also gets flushed down the toilet.
- Experts think that by 2050, the amount of plastic in the ocean will weigh more than the amount of fish in the ocean.

http://www.bbc.co.uk/newsround/42810179

What is the problem with plastics? Ocean pollution (2)

- All animals, whether they live on land or in the sea, can be hurt by plastic.
- They can get trapped in bigger items such as carrier bags or food packaging.
- Birds, fish and shellfish can mistake plastic for food when it has broken down in to smaller pieces.
- One in three sea turtles, and around 90% of seabirds, have eaten it.
- They can't digest plastic so their stomachs can become full, meaning they don't have room for actual food.
- Each year 100,000 animals in the sea are killed by plastic.

http://www.bbc.co.uk/newsround/42810179

What is the problem with plastics? Ocean pollution (3)

- They're created by currents in the ocean which carry the waste and bring it together.
- One of the most famous is the 'Pacific Garbage Patch' between California and Hawaii.
- These are known as 'trash islands' or 'garbage patches'.

http://www.bbc.co.uk/newsround/42810179

Student Sheet 3 - Exhibition - Plastic Problems

What is the problem with plastics? Micro plastics (1)

Microplastic pollutants are bits of plastic less than 5mm in size.

Typically, microplastics are thought to come from a number of sources, such as:

- car tyres
- paints on buildings and road markings
- plastic pellets used to make plastic products
- clothing

The risks to human and environmental health are unknown and urgently need investigating. But we do know these microplastics are escaping into the sea and potentially entering the food chain. They've been found in seafood, drinking water and even human stools.

http://www.bbc.co.uk/newsround/49935723

What is the problem with plastics? Micro plastics (2)

- Vehicle tyres are made of a mixture of synthetic materials, including different types of plastic, that shed during driving.
- They are responsible for the greatest proportion of microplastic pollution entering EU surface waters, according to a report by Eunomia for Friends of the Earth .
- Every time we wash our clothes, microplastics drain out with the water and slip through the sewage system into our waterways.

http://www.bbc.co.uk/newsround/49935723

Student Sheet 4 - Format Cards

Tableaux – present your information via 'still images' using your bodies.	**A song; you will be asked to sing it.**
A spider diagram or mind map.	**Pictures or drawings.**
Graphs and numbers.	**A poem of any type.**

Student Sheet 5 - Information Cards

The history of plastics (more research might be needed – clue billiard balls!).	**What are the most common types of plastics in use and how are they recycled?**
Current UK plastic waste data from government and WWF perspective.	**Where does our plastic waste go?**
Recycling issues.	**Plastic problems in the oceans and climate change.**

Student Sheet 6 - Target Board Evaluation

Use the target board below to evaluate your priorities for taking action.

- the centre of the target is equivalent to a “very important” action.
- the external ring “not at all important”.

The target board, with all positioned actions, will be hung in the Plastic Challenge Corner.

STAGE 3 - It's a Wrap: plastic problem planning

Inquiry based learning stage

Stage 1 - Initiating and eliciting		**Stage 2 - Defining and responding**	
Stage 3 - Doing and making	✓	**Stage 4 - Communicating, presenting and evaluating**	

Learning objectives

1. Students are able to plan and carry out an investigation.
2. Students can use primary and secondary data to understand an issue.
3. Students can recognise and consider limitations in their method.
4. Students can apply their scientific knowledge to a local context.
5. Students are able to communicate their ideas and work effectively in a team.

Learning outcomes

1. Students co-operate with each other by taking part in activities that lead to a whole class science fair.
2. Students plan and carry out surveys to collect primary data via a citizen science challenge.
3. Students interrogate secondary data to find trends and patterns of change.
4. Students make recommendations based on their research.
5. Students assess environmental impacts associated with all the stages of a plastic product's life.
6. Students have an understanding of the viability of recycling plastic materials.

Overview of lesson

The group are now plastic literate. Students will use this knowledge and understanding to plan and deliver a 'plastic fair' for their school community. We have suggested packaging as a focus as it is an issue that they are likely to encounter on a daily basis. We have included a range of experiments and activities that could provide the basis for such an event. There are also ideas for whole school citizen science opportunities, and a space for them to share their creativity via their journals. Some students may also want to devise their own experiments to describe the plastic challenge, this will depend very much on the time available and their curiosity. Those listed here can be adapted and they all contain the required health and safety information.

Lesson structure

Introduction

Discuss the findings of the 'What's is in a bag' homework exercise (set last session).

Review their action priorities from their 'target boards'. Ask students to reflect on these in the context of the following practical session. How can we:

- Produce plastics for packaging that are biodegradable?
- Reduce our dependence on fossil fuels?
- Make change happen and communicate this to others?

Main

Introduce the notion of a 'plastic science fair' in order that their work can be disseminated to others in their school community. This module is aimed fully at the 14-16 GCSE chemistry student. As such the experiments are carefully curated to ensure they are fully risk assessed. As a result, it is harder for a student's own ideas to be acted on. However, looking for alternatives to fossil fuels as a basis for plastic wrapping is a good start.

It's a wrap – plastic science fair
Students prepare for the science fair. It is good if students take the opportunity to deliver this event to staff and governors of their school, not just to other students. We have included a citizen science project and early results for this show a lack of knowledge across all ages.

www.bigcompostexperiment.org.uk/blog/your-results-so-far.

In this version of a science fair students share their knowledge with others and invite participants to join in practical experiments and surveys. They can then add their views and comments to their plastic challenge corner. They do not necessarily need to create their own experiments as in some science fair events. We recognise the time constraints on schools, however, it is possible to adapt any of these activities if students wish to be more creative.

1. **Can we create biodegradable plastic wrapping materials?**
   a. Making plastics from potato starch: In this activity students make plastic from potato starch and investigate the effect of adding a 'plasticiser' on the polymer that they make.

      www.edu.rsc.org/resources/making-plastic-from-potato-starch/1741.article

   b. Making 'plastic glue' from milk: Here students make their own plastic 'glue' from milk.

      www.edu.rsc.org/resources/developing-a-glue/459.article

2. **The citizen science survey.** This group describes the BBC Inside Science Big Compost experiment and shows how the whole school community can get involved www.bigcompostexperiment.org.uk. The aim of this project is to investigate the role and effectiveness of biodegradable and compostable packaging. Although predominately a composting project, it also makes firm links with packaging. Ideally students enrol on the project and take part, this gives participants to the fair and these students opportunities to take their learning outside.
3. **Making eco-friendly slime – just for fun.** It is less clearly related to the plastic issue, however, it does show how to make a polymer from food products www.bbc.co.uk/newsround/45563215. Many online videos describe how to make slime from PVA glue. Unfortunately, this approach creates a non-biodegradable plastic product. These take a very long time to break down and the residue is often washed into water courses.
4. **PlayDecide game.** A group demonstrates playing their PlayDecide game (see Stage 2). If time is short the cards can be displayed and explainers can describe the main features and how to play.
5. **Journal show and tell.** The student journals describing their learning are on show. Participants are encouraged to take their learning from these journals and the other activities and put it into the plastic challenge corner. See plenary below.

Plenary: Plastic Challenge Corner

Students add participant results to the plastic challenge corner.

STAGE 4 - Plastic Problem action

Inquiry based learning stage

Stage 1 - Initiating and eliciting		**Stage 2 - Defining and responding**	
Stage 3 - Doing and making		**Stage 4 - Communicating, presenting and evaluating**	✓

Learning objectives

1. Students are able to communicate their results.
2. Students can apply a range of communication techniques.

Learning outcomes

1. Students select an appropriate communication technique.
2. Students present their results using their chosen technique.
3. Students critique the work of others.

Overview of lesson

In this lesson students think about how to communicate the results of their study on the plastic problem. Our aim in this module has been to encourage the student's actions from one of personal responsibility to that of campaigning for more widespread system change. Here we introduce some national and international campaigns on the issue alongside some strategies so that their actions are effective and successful.

Lesson structure

Introduction

Describe and outline the main features of current campaigns on this issue. The first two are technically very good as regards campaigning about the plastic problem.

http://www.rethinkplasticalliance.eu/about-us/

- this is an alliance of the main EU campaigns.

https://friendsoftheearth.uk/plastics

This site is probably useful for teachers. It links up to some fascinating sources of information on environmental issues from parliamentary legislators and where to find out about environmental law.

www.field.org.uk/the-top-15-useful-environmental-websites-in-the-uk/

The discussion should then centre around how to present their results and how to organise a successful and effective campaign. Greenpeace have an interesting article here about how and why they have been successful in creating systematic change.

http://www.greenpeace.org.uk/about-greenpeace/how-we-create-change/

Main

Here is a generic list of some activities that students could undertake after reflecting on the lessons learned.

- **Poster** - create a poster campaign communicating your results and making recommendations for their plastic free community.
- **Film** - create a 5-minute film communicating to the school leaders and governors about how you carried out your research and the results.
- **Presentation** - deliver a 5-minute presentation for the school leadership team and governors.
- **Report** - write a report laying out your recommendations and evidence.
- **Other** - add your own suggestion.

Annex 1 - Key Stage 4 Working Scientifically Statements

Through the content across all three disciplines, students should be taught so that they develop understanding and first-hand experience of:

1. **The development of scientific thinking**
    a. the ways in which scientific methods and theories develop over time.
    b. using a variety of concepts and models to develop scientific explanations and understanding.
    c. appreciating the power and limitations of science and considering ethical issues which may arise.
    d. explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments.
    e. evaluating risks both in practical science and the wider societal context, including perception of risk.
    f. recognising the importance of peer review of results and of communication of results to a range of audiences.

2. **Experimental skills and strategies**
    a. using scientific theories and explanations to develop hypotheses.
    b. planning experiments to make observations, test hypotheses or explore phenomena.
    c. applying a knowledge of a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments.
    d. carrying out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.
    e. recognising when to apply a knowledge of sampling techniques to ensure any samples collected are representative.
    f. making and recording observations and measurements using a range of apparatus and methods.
    g. evaluating methods and suggesting possible improvements and further investigations.

3. **Analysis and evaluation**
    a. applying the cycle of collecting, presenting and analysing data, including:
        i. presenting observations and other data using appropriate methods.
        ii. translating data from one form to another.
        iii. carrying out and representing mathematical and statistical analysis.
        iv. representing distributions of results and making estimations of uncertainty.
        v. interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions.
        vi. presenting reasoned explanations, including relating data to hypotheses.
        vii. being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.
    b. communicating the scientific rationale for investigations, including the methods used, the findings and reasoned conclusions, using paper-based and electronic reports and presentations.

4. **Vocabulary, units, symbols and nomenclature**
    a. developing their use of scientific vocabulary and nomenclature.
    b. recognising the importance of scientific quantities and understanding how they are determined.
    c. using SI units and IUPAC chemical nomenclature unless inappropriate.
    d. using prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano).
    e. interconverting units.
    f. using an appropriate number of significant figures in calculations.