SUSTAINABLE STORIES AND SOLUTIONS FOR OUR PLANET

A science investigation pack for teachers of 9–11 year olds

CENTRE for INDUSTRY EDUCATION COLLABORATION

Thomas Swan
Chemical manufacturing since 1926

innospec

JM Johnson Matthey
Inspiring science, enhancing life

CONTENTS

INTRODUCTION

The future holds many challenges for young people and our current model of development is placing an increasing burden on the planet. In order to secure the future of children all over the world, we need to make a decisive move towards sustainable development.

This publication will introduce and develop some of the issues and impacts of sustainability for primary aged children aged 9-11 years. All activities are linked to the English National Curriculum for Science, with a focus on the Year 5 programme of study for science content and the full upper key stage two programme of study for working scientifically.

Given that young children will become the next generation of adults; it is important that they are educated about sustainability issues so they can take positive action to help preserve their future in a changing world.

There are many definitions of sustainability. One of the most frequently used is taken from Our Common Future, also known as the Brundtland Report (1987):

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

In simple terms, sustainable development means meeting the needs of all people now – without having a negative impact on the needs of people living in the future.

INTRODUCTORY ACTIVITIES

In the two introductory activities, children consider their own motives behind sustainability as well as develop an awareness of vocabulary linked to current environmental issues. A glossary provides a comprehensive list of all key environmental vocabulary introduced here, then used throughout the activities. Children are encouraged to return to their original ideas to compare their definitions, make any final amendments and reflect upon the learning that has taken place.

MAIN ACTIVITIES

There are thirteen main activities, which introduce children to a range of different challenges within the context of sustainability. These include: the sustainability of common materials such as metal, plastic and fabrics, the sustainability of personal care products such as soap and shampoo, the sustainability of food and energy sources, and the sustainability of fuel. The investigative approach provides opportunities for children to explore the varied roles of scientists and engineers in practical ways, allowing the development of key skills including discussion and problem solving. It is intended that children be encouraged to develop their own ideas and questions, methods of recording, conclusions and recommendations. The Questions for thinking included within each activity should be asked as a 'drip-feed' throughout, even though they are written towards the end of each set of teachers' notes.

POWERPOINT PRESENTATIONS

A presentation accompanies many of the main activities. They have been created to help children develop a deeper understanding of our impact on the planet and encourage them to weigh up different opinions and evidence for themselves. Empowering young people to take responsibility for their own future is not only desirable: it is a crucial feature of their education.[1]

Each presentation extends the sustainability message to include wider environmental issues such as the environmental impact of personal hygiene products and the impact of the choices that we make, vehicle emissions and air pollution, single-use plastics and the importance of recycling, the environmental impact of washing and replacing items of clothing, alternative diets and an awareness of our carbon footprint, our use of fossil fuels and the development of renewable sources of energy.

The final slides of each presentation contain a short company case study to embed the children's learning of sustainability into real life industrial contexts. This is what makes this publication unique in that, for every problem posed within the original main activity, children will learn about one company's solution and find out about how scientists and engineers are striving to find answers to sustainability issues.

In addition to the PowerPoint presentations, teachers may wish to make links with industry via local companies and company websites. STEM Ambassadors are volunteers from a wide range of science, technology, engineering and mathematics related jobs across the UK. They offer their time and enthusiasm and can be found via the STEM Learning website at ***https://www.stem.org.uk/stem-ambassadors***

[1] Our Common Future (the Brundtland Report): United Nations through Oxford University Press, 1987.

SUMMARY OF ACTIVITIES

THEME	SUMMARY OF ACTIVITIES	APPROXIMATE TIME TAKEN
1a Preparatory survey	A survey is carried out by each child to ascertain their thoughts about sustainability as well as their understanding of the impact of their own behaviour in actively bringing about change. Children are encouraged to question family members and compile an overview of current attitudes towards sustainability.	30 mins (+ 30 mins discussion)
1b Environmental vocabulary	Children are challenged to create a 'big-book' style environmental dictionary which will help others in their school to learn about important environmental issues. They suggest definitions for a list of words provided and then refer to the glossary and return to the task to make amendments as they learn more about environmental issues in subsequent activities.	30 mins (+ 15 mins after each activity)
2a. A Sustainable Fuel Story	For teacher use only. A quick-start overview of the story of sustainable fuel to support teachers' understanding of how sustainable fuel is created. Not intended for use in the classroom but to enhance the teacher's ability to share this story in a child-friendly way with their class as they carry out the sequence of activities in the classroom.	-
2b. Sustainable fuel: Electricity to gas	Children observe what happens when an electric current is passed through water, seeing how the combined hydrogen and oxygen in liquid water are released as gases. Developing an understanding that this process is reversible.	30 mins
3 Sustainable fuel: Main beam	An opportunity to investigate the relationship between the brightness of a bulb and the number of cells in an electric circuit.	1 hour
4 Sustainable fuel: Lumpy challenge	Exploration of three types of sugar dissolving in water, to consider whether there is a relationship between surface area of sugar and rate of dissolving.	1 hour
5 Sustainable fuel: Increasing surface area	Children investigate the properties of different grinding materials to find out which are better at grinding sugar cubes into more finely milled granules or powder.	1-1.5 hours
6 Teams of STEM professionals	To enhance children's understanding of STEM careers, information about a team three scientists working on fuel cells is presented in a variety of formats, including game cards, written information, and a map to locate each scientist in the team	1 hour
7 Sustainable materials: Which soap?	Children carry out a sequence of three investigations to research the environmental benefits of using a solid, as opposed to a liquid cleaning product, while developing their science and maths understanding through practical activities.	1.5–2 hours including regular observations over about 4 weeks

THEME	SUMMARY OF ACTIVITIES	APPROXIMATE TIME TAKEN
8 Sustainable materials: How much shampoo?	Children discuss the importance of using just the right amount of shampoo; as not enough will not wash the hair effectively but too much is a waste of shampoo. They investigate how much shampoo is the 'best' amount.	1–1.5 hours
9 Sustainable materials: What type of packaging?	Children discuss the importance of minimising the quantity of raw materials that we use to make single use packaging. They then explore a range of possible packaging materials before finding out about an innovative solution that one company is developing. They then test different types of paper as potential packaging for soap and shampoo bars.	1.5–2 hours
10 Sustainable materials: which metal?	Children investigate how metals can corrode when exposed to substances in the environment and that rusting is one type of corrosion. They are introduced to the properties and uses of precious metals and consider how one company uses these to reduce the amount of dangerous gases emitted by high numbers of vehicles on our roads today.	2–3 hours (+ ongoing observations)
11 Sustainable materials: which plastic?	Children are challenged to identify and name unknown plastics by observing what happens when samples are placed in different liquids and when a force is applied. They learn about the impact that plastics can have on the environment and why it is important to recycle plastic items. They consider how one company supports a recycling scheme to reduce the amount of U-PVC that is usually used once and sent to landfill sites.	1–2 hours
12 Sustainable methods of cleaning: which washing product?	Groups of children plan and carry out their own fair test to investigate how effective different commercial washing products are at removing stains from fabric. They will consider how one company has developed an ingredient for a new washing product which washes clothes more effectively than ever so that we do not have to wash or replace them more than we need to.	2–3 hours
13 Sustainable sources of food: how can we grow oyster mushrooms?	Children consider the benefits of following a more sustainable diet as an alternative to obtaining meat from animals as a source of protein. They are challenged to grow a crop of oyster mushrooms as a sustainable food source before learning about one company's solution to producing protein-rich food in a sustainable way.	1–2 hours (+ ongoing observations)
14 Sustainable sources of energy: which plant material?	Children consider the need for renewable energy and how this can be less harmful to the environment than burning fossil fuels. They are challenged to carry out two investigations for a fictitious company in order to find a sustainable plant-based source of fuel. They learn about a real company's solution to producing energy for electricity from natural, sustainable sources such as plants.	1–2 hours

SAFETY GUIDANCE

To avoid short circuiting the battery, ensure the carbon electrodes do not touch each other, and that the wires are connected to electrodes before connecting to the battery. Do not leave the cell running for extended lengths of time. Once the children have clearly seen the bubbles, disconnect the wires from the battery before the electrode at the end of the demonstration.

It is important that schools refer to their own health and safety policies when planning, testing and evaluating all practical science activities for themselves. Resources and expectations must be age appropriate and investigations must be supervised by responsible adults at all times.

CLEAPSS is an advisory service providing support in practical science and technology. If at all possible, schools should ensure they have membership with CLEAPSS annually and this will enable them to access important ideas, guidance and safe practical ethic. This will also guide schools in how to correctly 'risk assess' their own practical sessions.

Disclaimer: CIEC assumes no liability with regard to injuries or damage that may occur as a result of using the information contained in the 'Sustainable Stories and Solutions for Our Planet' publication lesson plans.

1a. PREPARATORY SURVEY

1 HOUR, PLUS 15 MINS AFTER EACH ACTIVITY

A survey is carried out by each child to ascertain their thoughts about sustainability as well as their understanding of the impact of their own behaviour in actively bringing about change. Children are encouraged to question family members and compile an overview of current attitudes towards sustainability.

TYPE OF ENQUIRY

Survey / Researching using secondary sources

OBJECTIVES

Recording data and results of increasing complexity (UKS2 Working Scientifically)

Reporting and presenting findings from enquiries, in oral and written forms such as displays and presentations (UKS2 Working Scientifically)

SCIENCE VOCABULARY

Generations, positive, negative, impact, environment.

RESOURCES PER CHILD

- Photocopy of **Activity Sheet 1:** Survey plus additional copies to take home
- Pencil or pen

PRIOR KNOWLEDGE / EXPERIENCE

Children will have had experience of asking and answering simple questions to gather information or opinion.

ACTIVITY NOTES

Explain to the children that they are each going to complete a short survey which contains questions about looking after the Earth and our environment. Discuss with them that this is not a test, it is just to collect their ideas and that there are no right or wrong answers. Discuss with children that they all might have their own ideas and opinions about the questions they are being asked so that it is very important to answer honestly and with as much detail as they can.

Children should be aware that the teacher can read the questions aloud to them, if appropriate and explain any words or questions they do not understand without providing ideas for their answers. If a child is unable to respond, they should write ***'I do not know'.*** The accuracy of spellings is not important at this stage and there could be a time limit of thirty minutes for completion of the questionnaire, although some children might not need the full amount of time.

Once the survey has been completed, it would be interesting for children to compare their ideas and opinions. Children might also take copies of the survey home for family members to complete and then a wider range of responses can be compared, with a focus on differences and similarities across generations.

Activity Sheet 1: Survey

Complete this survey as honestly as you can. It would be interesting for you to ask family members too. Compare your answers with what other people think.

1. How important do you think it is that we look after the Earth and make sure that it is left in a good state for future generations?

2. Why do you think this?

3. What things do you know about that can have a harmful effect on the Earth?

4. What things can we do to help the Earth?

5. What do you do at school/work to help look after the Earth for future generations?

6. What do you do at home to help look after the Earth for future generations?

7. What else do you think you could do?

8. What changes could you make to your own behaviour to help to look after the Earth for future generations?

9. What jobs do you know about where people make a positive impact on the environment?

10. What jobs do you know about where people are causing damage to the environment?

11. If you were Prime Minister, what rule or law would you introduce to help us to look after the Earth?

1b. ENVIRONMENTAL VOCABULARY

30 MINS + 15 MINS AFTER SUBSEQUENT ACTIVITIES

Children are challenged to create a 'big-book' style environmental dictionary which will help others in their school to learn about important environmental issues. They suggest definitions for a list of words provided and then, later, refer to the **Glossary** and return to the task to make amendments as they learn more about environmental issues in subsequent activities.

TYPE OF ENQUIRY

Grouping and classifying things / Researching using secondary sources

OBJECTIVES

Recording data and results of increasing complexity (UKS2 Working Scientifically)

Reporting and presenting findings from enquiries, in oral and written forms such as displays and presentations (UKS2 Working Scientifically)

SCIENCE VOCABULARY

See full vocabulary list contained in the activity on **Activity Sheet 2**

RESOURCES

per child

- Photocopy of **Activity Sheet 2**: Environmental vocabulary
- Later reference to **Activity Sheet 3**: Glossary
- Pencil or pen

PRIOR KNOWLEDGE / EXPERIENCE

Children will have had experience of asking and answering simple questions to gather information or opinion.

ACTIVITY NOTES

Show children the newspaper headline on **Slide 9** of presentation '**Sustainable materials: which plastic?'** (also shown below):

> Dictionary names 'single-use' as the phrase of the year
>
> There is a rising concern of how much plastic we use once and then throw away. This year has seen huge numbers of businesses pledging to phase out single-use plastics from their operations. Some governments are preparing to ban plastic straws, cotton buds, and other single-use plastics…

Discuss the information provided and describe how, each year, several dictionary companies compile a list of new and popular words that reflect the times we are living in. They have named 'single-use' as the phrase of the year and say that this phrase has been used four times as much over the past twelve months as it has ever before.

Explain to children that they are going to create a 'big-book' style environmental dictionary which will help other children in their school to learn about important environmental issues. There are so many new words and phrases that have appeared in our language over recent years, it is important that young people have a good understanding of what they mean.

Share the list of words on **Activity Sheet 2**. Ask if children can suggest definitions, without carrying out any initial research. They should write their ideas directly onto the sheet under each word provided.

Explain that they will return to the task on completion of the activities in this publication. It will be interesting to see how much additional detail children can include in order to improve their final definitions for the finished dictionary.

Children may also wish to compare their final definitions with those provided in the **Glossary** (**Activity Sheet 3**).

Activity Sheet 2: Environmental Vocabulary

Do you know what the words or phrases in the list below mean? Write your ideas under each word provided. You can return to the task later to make any changes or improvements.

acid rain	electric vehicle	going green	recycle / re-use
carbon footprint	emissions	greenhouse gases	pollution
climate change	environmental impact	landfill	precious metals
degradable	fossil fuels	microplastics	single-use
eco-friendly	global warming	non-renewable	sustainable

Activity Sheet 3: Glossary

acid rain	Water droplets that are acidic due to pollution in the air
carbon footprint	The total amount of carbon dioxide or methane gas you produce per year in your everyday life
climate change	The changes in different environments (temperature, rainfall, cloud cover etc) as a result of global warming
degradable	Able to break down in the environmental naturally, or rot away over time
eco-friendly	Least harmful to the environment
electric vehicle	Vehicle with an electric motor powered by electricity from batteries
emissions	Created, given out or flowing from
environmental impact	Any change to the environment, either positive or negative
fossil fuels	A natural, non-renewable fuel, such as coal or gas, formed millions of years ago from the remains of living things
global warming	The processes that cause the average temperature of the Earth to rise
going green	Changing the way you live to help the environment for the better
greenhouse gases	Gases in the air that trap heat from the Sun, so the hot gases stay close to the Earth
landfill	Getting rid of waste material by burying it
microplastics	Very tiny pieces of plastic that pollute the environment
non-renewable	A fixed amount that cannot be replaced
recycle / re-use	To make something new out of something that has been used before To use for the same or a different purpose, something that has been used before
pollution	Any gas, liquid or solid that makes the Earth dirty, poisonous or unhealthy for living things
precious metals	Natural metals of high value that do not react compared to other metals
single-use	Designed to be used once and then thrown away or destroyed
sustainable	To keep it going or available for future generations

2a. A SUSUTAINABLE FUEL STORY

This information is for teacher use only. It is not intended to be used in the classroom, but to enhance the teacher's ability to share this story in a child-friendly way with their class as they carry out the sequence of activities in the classroom.

ELECTRICITY TO GAS

Children may already have come across the idea that water is made up of hydrogen and oxygen, but understand little about this, other than coming across the expression H_2O. This demonstration is intended to show children that electricity can be used to get hydrogen and oxygen gases from water.

This is a reversible process, of quite a different kind to those children will have come across before (such as getting salt and water back from salty water or 'brine').

Hydrogen fuel cells use hydrogen gas to get electricity. This is a more sustainable process than burning fossil fuels such as natural gas, coal, and oil.

Scientists and engineers across the world are designing and building hydrogen fuel cells to run electric vehicles. These vehicles are better for our planet than those which burn fossil fuels found in petrol and diesel.

MAIN BEAM

Hydrogen fuel cells are very thin so to achieve a high enough voltage to move heavy vehicles such as buses, scientists layer many fuel cells on top of each other, just as children would add additional cells into a circuit in investigating how to make a bulb shine brighter.

LUMPY CHALLENGE AND INCREASING SURFACE AREA

Companies like Johnson Matthey make ingredients called catalysts to add to the layers of fuel cells, to speed up the hydrogen production in the fuel cell. When the catalyst has been made, it is filtered from water, resulting in a 'cake' that is then dried to remove the last of the water. This leaves large lumps of catalyst.

These catalyst lumps need to be ground, or milled, into a very fine powder. This fine powder is made into a 'suspension' in a liquid, which is spread thinly onto fuel cell membranes. The fine powder has a high surface area to speed up the production of hydrogen, in the same way that finer sugar dissolves more quickly or effectively.

TEAMS OF STEM PROFESSIONALS

Many different STEM professionals are involved in the research, development and production of these fuel cells, and often live in different parts of the country, and potentially different parts of the world. They share their expertise to enable the final products to be used in our electric vehicles.

2b. SUSTAINABLE FUEL:
ELECTRICITY TO GAS

30 MINS

Children observe what happens when an electric current is passed through water, seeing how the combined hydrogen and oxygen in liquid water are released as gases. Seeing this process and understanding that it is reversible is central to children learning about the work of scientists in making hydrogen fuel cells for electric vehicles.

TYPE OF ENQUIRY

Observing changes over time

OBJECTIVES

Demonstrate that changes of state are reversable changes. (Y5 materials)

Explain that some changes result in the formation of new materials, and that this kind of change is not usually reversable. (Y5 materials)

Make systematic and careful observations (non-statutory)

SCIENCE VOCABULARY

change of state, liquid, gas

RESOURCES

For adult demonstration only

- **Activity Sheet 4**
- **PowerPoint presentation:** Electricity to gas
- 1ltr transparent jug or beaker
- 15 cm x 15cm card (enough to cover the top of measuring jug)
- 2 carbon rods[2] (fixed to card - see diagram in activity notes)
- 2 crocodile clip wires
- Sticky tape (to secure wires and card)
- 9v zinc chloride PP3 battery[3]

SAFETY GUIDANCE

To avoid short circuiting the battery, ensure the carbon electrodes do not touch each other, and that the wires are connected to electrodes before connecting to the battery. Do not leave the cell running for extended lengths of time. Once the children have clearly seen the bubbles, disconnect the wires from the battery before the electrode at the end of the demonstration.

[2]Ensure these are purchased from a reputable science education supplier, such as Philip Harris. At the time of publication, a pack of 10 costs £11.15 +VAT and P&P. Alternatively, borrow the equipment from a local secondary school.

[3]9v PP3 batteries must be used, and purchased from a reputable education supplier, such as Philip Harris. Typical price at the time of publication is 65p - £1.00 from a wide range of suppliers.

For comprehensive safety guidance regarding use of batteries in the classroom, the CLEAPSS guidance document Batteries for practical circuit work has up to date advice[4]

PRIOR KNOWLEDGE/EXPERIENCE

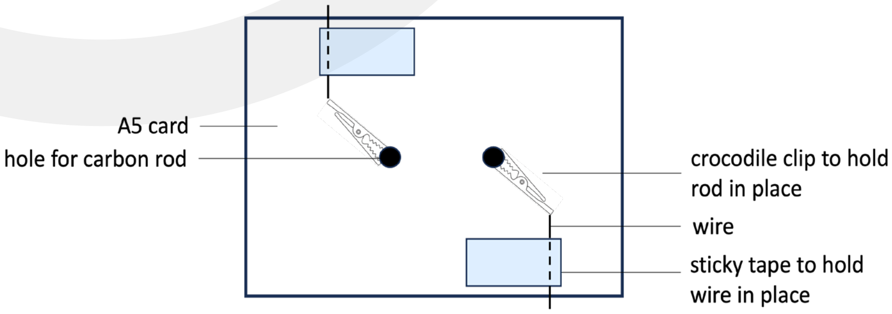
Children should have observed changes in state of water from liquid to gas and been introduced to the idea that this process is reversible (evaporation and condensation). They should also have been introduced to the idea that some changes result in the formation on new materials.

ACTIVITY NOTES

Start by reading the letter from Emily Nesling, scientist at Johnson Matthey (**Activity Sheet 4**) to the class to introduce the Sustainable Fuel challenges.

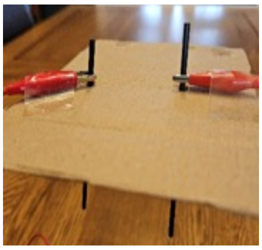
Carry out the Electricity to gas demonstration. You can construct the equipment before the lesson or with the class watching, as it is quick to assemble.

Making your carbon rod holding device:



The demonstration:

1. Fill a transparent jug three-quarters full with water.



2. Add the carbon rods through the holes in the card, ensuring they do not touch.
3. Attach a crocodile clip to a carbon rod, securing it with sticky tape to the card.
4. Repeat for the second rod and wire.

5. Attach the crocodile clips at the other end of each wire one to the battery terminal.
6. Observe the rods in the water.

Note: You will need to wait 5-10 minutes to see small bubbles forming.

[4] For comprehensive safety guidance regarding use of batteries in the classroom, the ***CLEAPSS*** guidance document ***Batteries for practical circuit work*** has up to date advice.

Children should see bubbles of gas gathering at each of the carbon rods. Oxygen gathers at one rod, and hydrogen gathers at the other.

Use the Electricity to gas presentation to explain to children how the demonstration relates to work scientists and engineers are doing to generate electricity from hydrogen.

Explain that fuel cells go through many stages of computer design and modelling before the final product is made. A prototype, or full-scale model, is made and tested to find out whether the modelled design works, then it is mass manufactured in a factory. Scientists and engineers make decisions together about how successfully tested prototypes will be manufactured on a large scale.

QUESTIONS FOR THINKING

- What do you see happening?
- What do you think the bubbles are?
- Why do you think that?
- Are the bubbles different at each rod?
- What states of matter can you see in this activity?
- Where is the electricity coming from?
- Where are the gas bubbles come from?
- Do you know any other changes of state which are reversible?
- Do you know any irreversible change of state where new materials are made?
- Do you know of any other renewable ways of getting electricity?

USING THE PRESENTATION SLIDES

Explain that fuel cells go through many stages of computer design and modelling before the final product is made. Scientists and engineers then make decisions about how they will be manufactured on a large scale. A prototype, or full-scale model, is made to check the design works, then the design is mass manufactured in a factory.

BACKGROUND INFORMATION

This information is for teacher use only. It is not intended to be used with children, as most of the science is beyond the Key Stage 2 curriculum.

Electricity can be used to get hydrogen and oxygen gases from water. This is a reversible process, and hydrogen fuel cells use hydrogen gas to generate electricity. This is a more sustainable process than burning fossil fuels such as natural gas, coal, and oil.

Scientists and engineers design, test and build fuel cells and their component parts, for use in electric vehicles. Electric vehicles which use electricity generated from sustainable sources, are much better for the environment than those which burn fossil fuels found in petrol and diesel.

The electricity generated from this type of fuel cell is clean which makes it better for our planet than using fossil fuels.

INDUSTRY LINKS AND AMBASSADORS

Ambassadors visiting the classroom could bring examples of the equipment used in the workplace to separate water into hydrogen and oxygen. This process is called 'electrolysis' but this language is not needed in the primary classroom, when more important primary science vocabulary is being introduced to children. Videos and images are an effective way to show items which are too big or unsafe to bring into the classroom.

Video conferencing could also be used so children get to see a scientist working in their lab and have their questions answered.

This electrolysis is safe to carry out in the primary classroom. Visiting lab-based scientists developing hydrogen fuel cell technology, or engineers working at a manufacturing plant would provide an opportunity to see the process of electrolysis in practice in a real-world context.

STEM CAREERS

Dan is a project manager at Johnson Matthey and is responsible for working out how fuel cells can be made in large quantities and whether they have the right machines and equipment.

You can learn more about Dan and STEM careers linked to sustainable fuel in **Activity 6.**

Activity Sheet 4

Johnson Matthey
Inspiring science, enhancing life

Dear Scientists,

We are designing and making fuel cells that offer a more sustainable way of generating electricity for running electric vehicles.

We have asked your teacher to show you our plan for using water to get electricity. Then we'd like your help with some problems we are facing:

- We have created a fuel cell, but it doesn't generate enough electricity to power the car headlights and make them shine brightly enough. Please can you investigate this to help find a solution?
- To make our fuel cells work better, we have been testing an ingredient used to coat the fuel cells that speeds up electricity generation to run vehicles.

Currently, this ingredient is in big lumps, and we think smaller pieces might help make everything work faster. Could you investigate this please, with ingredients you have access to?

- If you discover that smaller pieces will help, we'd also like some ideas on how to make the big lumps smaller.

We look forward to hearing from you with solutions to our problems.

Yours sincerely,

Emily Nesling

Emily Nesling

Scientist

3. SUSTAINABLE FUEL: MAIN BEAM

1 - 1.5 HOURS

Children construct a simple electric circuit with a lightbulb and investigate how they can make the light shine more brightly.

TYPE OF ENQUIRY

Problem solving

Comparative/fair tests

OBJECTIVES

Associate the brightness of a bulb with the number and voltage of cells used in a circuit. (Y6 Electricity)

Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary. (UKS2 Working Scientifically)

SCIENCE VOCABULARY

cell, wire, voltage, bulb

RESOURCES

(per group of four, unless otherwise stated))

- **Activity Sheet 4**
- **PowerPoint presentation:** Main Beam
- 3 AA 1.5v zinc carbon or zinc chloride batteries
- 3 single AA battery holders
- 4 crocodile clip wires
- Bulb in holder
- Data loggers OR
- Lux meter app on tablet or similar (optional)
- Kitchen roll inner cardboard tube (optional)

SAFETY GUIDANCE

Zinc chloride or zinc carbon batteries must be used.

For comprehensive safety guidance regarding use of batteries in the classroom, the CLEAPSS guidance document Batteries for practical circuit work has up to date advice.

PRIOR KNOWLEDGE/EPERIENCE

Children should have had some experience of setting up simple practical enquiries, comparative and fair tests.

TOP TIP

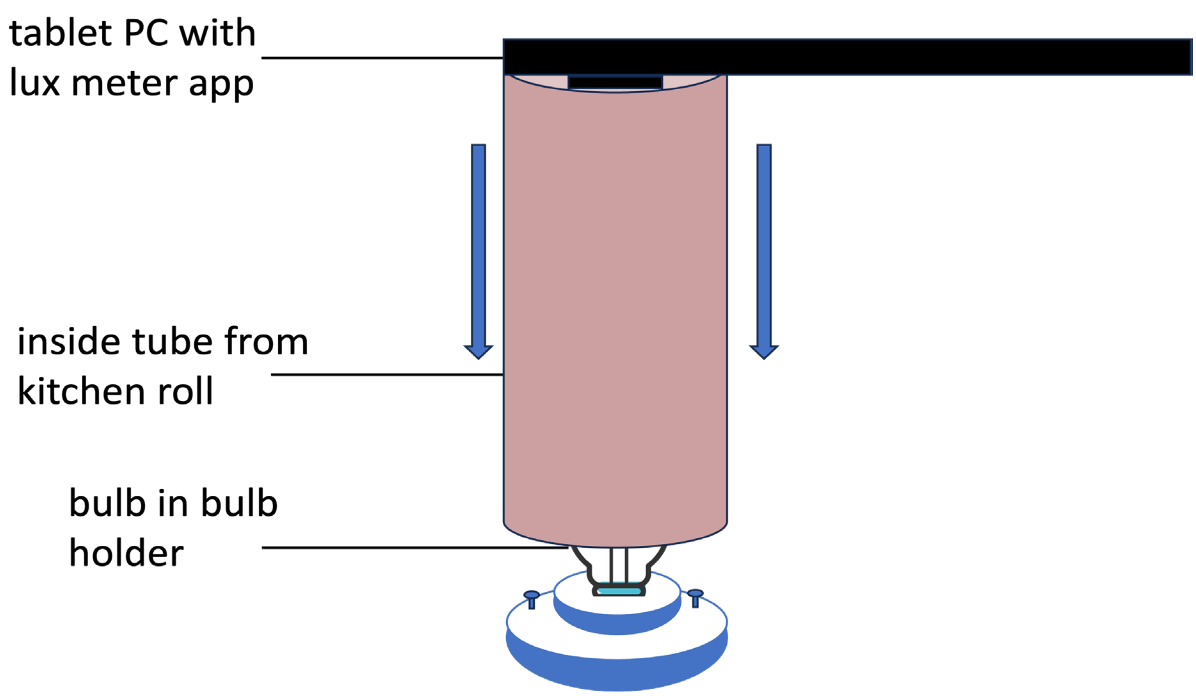
The activity requires children to construct a simple circuit, so depending on the children's confidence in building circuits, it may be worthwhile exploring circuits ahead of the main activity to refresh their memories about how they work.

ACTIVITY NOTES

Re-visit **Activity Sheet 4**; the letter from scientist Emily Nesling, who is developing fuel cells to find more sustainable ways of generating electricity for electric vehicles. The letter asks for children to help Emily find out how she can make a car's headlights shine more brightly.

Children construct a simple circuit containing one AA cell and a bulb. The bulb will light but will not be very bright. Following a period of exploration with one cell, children should be given access to additional 1.5v cells (up to 3 per group – maximum of 4.5v) to continue their investigation to find out if adding more cells to their circuit will increase the brightness of the bulb.

As more cells are added to the circuit, the bulb will be visibly brighter but using data loggers with light sensors or a lux meter app will enable groups to measure the brightness and generate data for use when reporting their findings. Placing the inside tube from a kitchen roll over the bulb ensures an accurate measurement of the light from the bulb without ambient light affecting readings.



The data collected will support children's explanations of their results. Groups can decide how to collect, record and present their observations, measurements and findings.

Use the Main Beam presentation to explain to children that some applications need higher voltages than others, so scientists need to find ways to increase the voltage generated using fuel cells. For instance, vehicles carrying heavier loads such as buses and lorries, require more fuel than vehicles carrying lighter loads such as cars and motorbikes.

Hydrogen fuel cells are very thin, so scientists layer many cells on top of each other to generate higher voltages. Similarly, adding more cells to a circuit increases the brightness of a bulb.

The diagram on the presentation slide shows the various 'slices' which make up a hydrogen fuel cell. All of these 'slices' are extremely thin so that lots of cells can be grouped together and fit inside a car leaving enough room for people.

QUESTIONS FOR THINKING

- How can we get the bulb to shine more brightly?
- How did increasing the voltage/number of cells affect the brightness of the bulb?
- Why did higher voltage/more cells mean the bulb could shine more brightly?
- Why is it important for hydrogen fuel cells to be used instead of burning fossil fuels to get electricity?

INDUSTRY LINKS AND AMBASSADORS

If you can find a scientist with relevant expertise who can visit your classroom, you could ask them to provide some added motivation to your class by setting the initial challenge to the children either in person or by personalising the letter on **Activity Sheet 4**. You could also ask them to bring along some sample fuel cells to show the class, parts of the fuel cell, or images and videos showing the cells in use either in a lab test or in real vehicles.

If you live near to any companies involved in hydrogen fuel cell development or production, you may even be able to arrange a visit to their site to meet the STEM professionals working to develop this exciting technology and see it first-hand.

4. SUSTAINABLE FUEL:
LUMPY CHALLENGE

1 HOUR

Children explore different types of sugar dissolving in water, to discover the relationship between surface area of the sugar and speed of dissolving.

TYPE OF ENQUIRY

Comparative/fair tests

Problem solving

OBJECTIVES

Know that some materials will dissolve in water to form a solution. (Y5 materials)

Compare and group together everyday materials based on their properties. (Y5 materials)

Take measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate. (UKS2 Working Scientifically)

SCIENCE VOCABULARY

liquid, dissolve, solution

RESOURCES

per group of 4, unless otherwise stated

- **Activity Sheet 4**
- 3 transparent cups or similar containers
- Water
- Measuring jug or cylinder (at least 100ml)
- 30-50g granulated sugar
- 30-50g caster sugar
- A few sugar cubes
- Teaspoon
- Stopwatch

TOP TIPS

Children should be given access to a small amount of the different sugars and a teaspoon to enable them to practice measuring their own amounts precisely. They should also be given free access to water, to select the quantities they use.

Each group can use different sized cups/containers, as long as those used within a group are the same.

PRIOR KNOWLEDGE/EXPERIENCE

Children should have had some experience of setting up simple practical enquiries and comparative tests.

If children have misconceptions about the difference between melting and dissolving, try the activity ***In the Melting Pot*** from the CIEC A Pinch of Salt publication to enable children to investigate and find the difference for themselves.

ACTIVITY NOTES

Revisit the letter **(Activity Sheet 4)** to present the 'lumpy challenge'.

Tell the children that you are providing different types of sugar to help them plan and carry out this investigation. Ask them to explain the differences between the sugars and plan an investigation to find out the differences in the time taken for each type to dissolve.

Provide support, as appropriate for each group, to ensure they work in a systematic way, keeping variables the same, other than the type of sugar. Wherever possible, give children autonomy and time to make mistakes, leading to deeper learning.

During a plenary discussion discuss how they might improve their investigations if there was tike to do so. Point out that this is true for professional scientists too, who refine their investigations in the light of experience. Encourage children to notice a pattern in the relationship between the size of the grain and the speed with which it dissolves.

Ask children to think about how they will share their results with Emily in clear and concise manner. For example, scientists often replace lengthy prose with photographs, diagrams, tables, chart and graphs.

BACKGROUND INFORMATION

This information is for teacher use only. It is not intended to be used in the classroom.

Companies like Johnson Matthey make ingredients called catalysts to add to the layers of fuel cells, to speed up the hydrogen production in the fuel cell. When the catalyst has been made, it is filtered from water, resulting in a 'cake' that is then dried to remove the last of the water. This leaves large lumps of catalyst.

These catalyst lumps need to be ground, or milled, into a very fine powder. This fine powder is made into a 'suspension' in a liquid, which is spread thinly onto fuel cell membranes. The fine powder has a high surface area to speed up the production of hydrogen, in the same way that finer sugar dissolves more quickly or effectively.

EXTENSION OR HOME-BASED ACTIVITIES

Ask children if they have any experiences with other materials that dissolve, such as salt.

You could ask children to be on the lookout for any other examples of dissolving they come across and report back to the class, perhaps collecting examples on a display or a page in a floor book.

Encourage children to plan and carry out their own dissolving activity at home, perhaps testing out granulated sugar in different liquids like vinegar or sparkling water. An adult could supervise a safe investigation into whether the temperature of a liquid affects how quickly sugar cubes dissolve. Water below 50°C is safe for children to handle.

QUESTIONS FOR THINKING

- Where has the sugar gone?
- How could we get the sugar back?
- What are the benefits of a smaller surface area?
- Does the size of the grains affect the total surface area?

INDUSTRY LINKS AND AMBASSADORS

An ambassador from a local company could initiate the activity, by introducing the challenge to the children and showing them a sample of an unground ingredient of any kind that they would go on to mill into a finer powder (e.g. pigments used in paints). The ambassador could outline their job and explain the skills required to carry out their role, explaining that scientists and engineers in industry often need to find solutions to problems such as this. Finally, the ambassador could discuss the children's results and ask for their recommendations.

INDUSTRY LINKS AND AMBASSADORS

Hellen is a senior scientists who works for Johnson Matthey. She uses special computer programs and powerful computers to make models, learn about how ingredients called catalysts work, and how to make better ones. These important ingedients are used to make lots of our everyday products, including fuel cells.

You can learn more about Hellen and STEM careers linked to sustainable fuel in **Activity 6.**

5. SUSTAINABLE FUEL:
INCREASING SURFACE AREA

1 - 1.5 HOURS

In this activity, children investigate the properties of different grinding materials to find out which are better at grinding sugar cubes into more finely milled granules or powder.

TYPE OF ENQUIRY

Comparative tests

Problem solving

OBJECTIVES

Compare and group together everyday materials based on their properties. (Y5 materials)

Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary. (UKS2 Working Scientifically)

Taking measurements, using a range of scientific equipment, with increasing accuracy and precision. (UKS2 Working Scientifically)

Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results. (UKS2 Working Scientifically)

SCIENCE VOCABULARY

material, property, hard, soft, brittle, mass, volume

RESOURCES

- **Activity Sheets 5 and 6**
- 3 small tough plastic/cardboard containers with lids e.g. 500ml food storage tubs or 40g Pringles containers
- Cup of sugar cubes

Range of spherical grinding materials, hard and soft, and of different sizes e.g. 1 or 2 materials from each of the following:

- hard - marbles, ball bearings, large beads
- soft - polystyrene balls, Smarties, cheese ball crisps
- 3 foil cases (e.g. mince pie case)
- Funnel (optional)
- 10-25ml measuring cylinder (optional)
- Ice-cube tray (optional)

For the class

- Digital scales (which can measure accurately to the gram)
- **Activity Sheet 4**

TOP TIPS

Use containers with enough space for the grinding materials and sugar cubes to move around.

Ensure containers are durable, as heavier grinding materials will break flimsier containers.

This activity can be very noisy so you may prefer to carry out the shaking outside, in a space away from other classrooms, or even plan for one group out at a time to carry the activity. Ensure anyone with noise sensitivities has ear defenders available to use.

SAFETY GUIDANCE

Ensure lids are tightly sealed before shaking, and that one hand is on the lid during shaking. Extra care should be with any materials which are particularly heavy such as ball bearings and marbles.

Spherical items pose a slipping hazard if dropped, so clear away dropped items immediately.

PRIOR KNOWLEDGE/EXPERIENCE

Children will have set up simple practical enquiries and comparative tests. They will have had experience of measuring mass and volume accurately to the nearest 1g or 1ml. They will have created tables of results and used these to create bar charts.

ACTIVITY NOTES

Please note, this is a follow-on activity from the Lumpy challenge so please complete the activities in sequence to support children's understanding.

Use the letter (**Activity Sheet 4**) to explain to children that scientists would like them to carry out a shake test using sugar cubes and a range of spherical grinding materials. This might include marbles, wooden beads, ball bearings, polystyrene balls, Smarties, and cheese ball crisps. The aim is to break down the lumpy sugar cubes into small pieces, increasing their surface area. The scientists will use this information to decide how best to grind their ingredients.

Give groups time to examine the samples and to discuss the properties of the materials. Ask each group to choose three grinding materials and explain the reasons for their choice of type, quantity, and size of materials. They should aim to select three materials which vary in hardness.

Children plan how they will control as many variables as possible in this comparative test. They can use the Post-It Planning Template (**Activity Sheet 5**) for support in the planning phase by generating a list of variables that they could change and observe/measure. In the case of this investigation, they may think of considering how to control variables such as amount of grinding material used, number of shakes and the duration or method of shaking.

They must also decide how they will measure the amount of ground ingredient produced. One idea to do this is to separate the grinding material from the ingredient, remove any unground ingredient (cubes), collect the ground ingredient, and measure and record its mass (g) or volume (ml).

To measure mass, the ground ingredient can be poured from the container into foil case and placed on a digital scale which will measure accurately to the nearest gram.

To measure volume, children pour the ground ingredient through a funnel into a measuring cylinder. Results may be recorded in a table, bar chart, or other appropriate format. An example recording sheet is provided in **Activity Sheet 6.**

Groups can repeat the process to test further grinding materials to discover how well each one performs, including observations of the fineness of the ground material. Remind children of their findings from Activity 4 where they investigated different kinds of sugar.

Example data set using 10 sugar cubes and 200 shakes per grinding material:

Grinding material	Mass (g)	Volume (ml)	Ground ingredient coarse or fine?	Observations
none (control)	6	7.5	coarse	Clean sample. Ground sugar is powdery with some lumps.
polystyrene balls	3	3.5	medium	Clean sample. Ground sugar is mostly powdery with a couple of lumps.
cheese ball crisps	-	-	-	Sample heavily contaminated. No visible ground sugar to separate from the fragments of cheese ball crisps.
wooden beads	4	4	coarse	Sample is contaminated with fragments of wood which have chipped off. Ground sugar is powdery with some lumps.
smarties	5	6	fine	Sample contaminated with fragments of smarties and difficult to separate sample from grinding material. Ground sugar is powdery
ball bearings	7	10	extremely fine	Clean sample. Ground sugar has the appearance of flour.
marbles	13	15	extremely fine	Clean sample. Ground sugar is powdery.

TOP TIPS

Groups will have tested a variety of grinding materials between them. An ice cube tray or divided paint tray is a good way to ‘pool’ all the class samples for easy visual comparison.

Polystyrene balls and marbles give the largest measurable difference between the amount of ground material produces and how visually coarse/fine the material is.

Smarties and cheese ball crisps are good materials to use to demonstrate brittleness of certain solids. Grinding materials need to be durable and not break apart during the process. Both the Smarties and the cheese balls start to disintegrate. This contaminates the ground sugar making it unusable.

The cheese balls cushion the impact of the cubes against the side of the container often resulting in no ground material at all to measure.

QUESTIONS FOR THINKING

- Why did some grinding materials work better than others?
- What are the properties needed for a grinding material to be more effective?
- What ingredients do you have at home which may have been ground?
- What other materials might be good at grinding ingredients?
- Are there any ingredients you have at home that you would not want to be ground?
- How are ingredients packaged to stop them being ground?

INDUSTRY LINKS AND AMBASSADORS

Ambassadors could explain to the children the methods used in industry to grind materials. Bringing photographs of equipment, pre and post grinding samples of the ground materials and the ceramic beads used for grinding in the plant and laboratory would make the lesson more engaging and memorable.

The ambassadors could respond to questions from the children or give feedback on the quality of the class investigation methods and results.

Emily is a membrane scientist at Johnson Matthey and works in a lab, where she tests catalyst recipes together with new membranes to find out how well they work together in real life.

Emily tries a couple of new catalyst-membrane combinations every month. If Emily is lucky, she finds one combination from about every ten she tries

You can learn more about Emily and STEM careers linked to sustainable fuel in **Activity 6.**

Activity Sheet 5

We could change

We could measure/observe

We will change

We will measure/observe

We will keep these the same...

When I change...

What will happen to?

I think that ______________________________

because ______________________________

Activity Sheet 6

Grinding material	Mass (g) or volume (ml)	Coarse or fine?	Observations

6. SUSTAINABLE FUEL:
TEAMS OF STEM PROFESSIONALS

1.5–2 HOURS

PLUS 4 WEEKS OF OBSERVATION

Children are presented with information about three members of a team of scientists. These three people work in different parts of the country, but the role of each is important to the others, to create new fuel cells for use in vehicles. The information is presented in a variety of formats, including game cards, written information, and a map to locate each scientist in the team, to enhance children's understanding of STEM careers.

OBJECTIVES

To use different contexts to maximise pupils' engagement and motivation to study science

To check that a text makes sense, discussing understanding and exploring the meaning of words in context (UKS2 reading comprehension)

Asking questions to improve understanding (UKS2 reading comprehension)

SCIENCE AND OTHER KEY VOCABULARY

STEM (Science, Technology, Engineering, Maths), collaborate, problem-solving, university, qualification, degree

RESOURCES

(per child or per group of four, unless otherwise stated)

- Set of career cards
- **Activity Sheets 7 and 8**
- **PowerPoint presentation:** What job do I do?

ACTIVITY NOTES

Children learn about a 'STEM' team in a science company. They are introduced, via card games, to three scientists who all have different specialisms outlined below. Carry out one or more of these games, depending on the time available. After the game(s), share the presentation, revealing the card 'combination' for each STEM professional.

Once the card games are completed, share **Activity Sheet 7** with the children either on the screen or in hard copy. Read the information together or in groups. Give each group a copy of **Activity Sheet 8**. Ask the children to do any combination of the following:

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[5] The science curriculum for England (2014)- Page 3, programmes of study: key stages 1 and 2. In several sections of the non-statutory guidance, it is suggested that children work scientifically by considering the work of real scientists (pages 12, 27, 28, 30, 31, 32).

[6] ***Download or purchase from CIEC*** at £8.15 for a class set. (Sustainable fuel career cards)

- Place the picture card of each person in the box on the map, near where they work.
- Write information in the box on the map about each person and what they do.
- Add information outside the boxes, around the map, about how they work together as a team. Use two different colours to add the information – one colour representing what you know, and one colour representing your thoughts. Think about what connects them, how they might communicate, why they might be based in different parts of the country.

THE CARDS

Each set of cards is based around three employees from a science company called Johnson Matthey. For each employee there are six cards comprising of the following:

- Name and photograph
- Job title and 'What do you do in your job?'
- 'What are your qualifications?'
- 'What do you need to be good at in your job?'
- 'What did you enjoy at school?'
- 'What are your hobbies?

GAME ONE

The aim is to encourage children to think about what different jobs might entail, and what sort of people might do certain jobs. There are a variety of ways that you could introduce this activity. For example, you could give children the job title cards and ask them to imagine what those jobs might involve before asking them to match the job titles to the photographs and names.

At this point children are likely to point out that it is not possible to tell; it is valuable to give them the opportunity to articulate this idea, as there is much evidence that, despite what we believe, gender and other stereotypes are deeply embedded in all of us from a young age.

You could support them to talk about their understanding by asking questions such as:

- Can you explain why you think that it would be this person?
- Does everyone agree with that?
- What makes you think that?
- Could it be this person?

Ask children what they think that these people might have enjoyed at school. Then look at the 'What did you enjoy at school?' cards and see if it is similar to what they guessed. Can they think of anyone in their class who likes the same things as this person? Do they like any of the same things as these people?

As long as children are engaged and there is a good level of discussion, keep adding cards or people. You may choose to end the session by using the PowerPoint presentation (see notes below) to show children which cards match with which people. However, it is important that children still understand that their suggestions are valid, even if they turn out not to match the reality as there is no way of telling for sure who does which job.

Show children all the 'What do you do in your job?' cards and the 'What did you enjoy at school?' cards. Challenge them to see if they can match them up. (In some cases there are clear links between early interests and current career, in others there are none, so this should give rise to some discussion).

Give out the 'What are your hobbies?' cards. Do they think that older people still like doing the things that they enjoyed when they were at school? Can they match these cards to the ones that they already have?

Use the PowerPoint presentation (see notes below) to see if they have correctly matched the three sets of cards. Again, ensure children understand that all their suggestions are valid as it is impossible to be completely sure which people have which hobbies.

GAME TWO

Show children all the 'What do you do in your job?' cards and the 'What did you enjoy at school?' cards. Challenge them to see if they can match them up. (In some cases there are clear links between early interests and current career, in others there are none, so this should give rise to some discussion).

Give out the 'What are your hobbies?' cards. Do they think that older people still like doing the things that they enjoyed when they were at school? Can they match these cards to the ones that they already have?

Use the PowerPoint presentation (see notes below) to see if they have correctly matched the three sets of cards. Again, ensure children understand that all their suggestions are valid as it is impossible to be completely sure which people have which hobbies.

GAME THREE

The cards can be used as a stimulus for children to make their own sets of career cards. Challenges could include:

- Making a set of cards for their future selves. Children could make more than one set; encourage them to think of a range of possibilities. For example, you could discuss that they may have more than one career during their adult lives. If their dream job is not in STEM consider the possibility that there may be a connected STEM career; for example, once they have retired as a premiership footballer, they may consider a job a sports psychologist or nutritionist! The sets of cards made by different children in the class could be used as the basis for a display which encourages children to consider the range of options that are open to them. Encourage children to find out what sorts of choices they will need to make to fulfil some of the ambitions on the cards.
- Making a set of cards for famous scientists both past and present. However, be aware of the danger of these being almost exclusively white, able-bodied males and ensure that people from a diverse range of backgrounds are included. Eg. Stephen Hawkins, Rosalind Franklin, Marie Curie, Maggie Aderin-Pocock and Katherine Johnson. Visit the ***Famous Scientists website*** for examples of famous black scientists.
- Making a set of cards for scientists and engineers that they have met. If they have been on a CCI visit this might include people from the industry that they visited. Alternatively, it could include visitors into school or family members or family friends. If there is the opportunity, children could interview potential subjects or, if this is not possible, allow them to use artistic license to fill in missing facts such as what their subject liked doing at school.

QUESTIONS FOR THINKING

Questions have been added to the appropriate sections above. In addition, you may like to ask:

- Do you know anyone who has a job using science? Is it different to these jobs?
- Do you know anyone who has gone to university? What did they study? What job do they do now?
- What do you know about going to university?
- Some people become apprentices instead of going to university. Do you know what an apprentice is? Do you know how this is different to going to university.

INDUSTRY LINKS AND AMBASSADORS

This activity provides a good opportunity to link with a broad range of STEM careers in industry. If possible, connect with ambassadors who have been to university as well as others who are or have been apprentices, and ask them to share reasons for their choices and what their time as an apprentice or student was like, e.g. 'a typical day' as a student/apprentice.

Request STEM ambassadors well in advance, who can visit your classrooms in person or virtually to discuss their experiences.

STEM CAREERS

The aim of this activity is to introduce children to 'scientists' who have developed their careers in different directions. Johnson Matthey employs a high number of chemists, but as with many science-based companies, employs other scientists (such as Hellen, a physicist) and a wide range of engineers (chemical, mechanical, electrical etc).

Activity Sheet 7
Teams of STEM Professionals

Hellen is a senior scientist who works for Johnson Matthey in Billingham, Northeast of England. She uses special computer programs and powerful computers to make models, learn about how ingredients called catalysts work, and how to make better ones. These important ingredients are used to make lots of our everyday products, including fuel cells. Hellen works with other scientists to improve or discover new catalysts that help the environment by making fuel and air cleaner. Hellen creates many models for these ingredients every week. Every few months, she finds a really good model and sends this to scientists who work with Emily to make real catalysts.	Catalysts are ingredients used in fuel cells and other things. Catalysts are powders when first made.
Emily is a membrane scientist and works in Swindon in the Southwest of England, about 260 miles from Hellen. Emily works in a lab, where she tests Hellen's recipes together with new membranes to find out how well they work together in real life. Emilyn tries a couple of new catalyst-membrane combinations every month. If Emily is lucky, she finds one combination from about every ten that Hellen sends her. Emily is then very excited about this, and sends the design that works to Dan.	Membranes are special kinds of filters, that are thin, soft and flexible (bendy).
Dan is a project manager and he works in Royston in the Southeast of England, about 120 miles from Emily. As a product manager, Dan is responsible for working out whether the combination of Emily's membrane and Hellen's catalyst recipe can be made in large quantities (thousands of kilogrammes a year!) and whether they have the right machines and equipment to combine the ingredients and make millions of fuel cell products. Dan tries two new recipes a year and then other people in the team help decide whether they are going to make it, as they need to build a lot of new equipment which takes 2 - 3 years to do. Only two new products will be made every year.	Fuel cells are made up of many layers of catalyst and membrane. The very fine catalyst powder is mixed with a liquid and looks like ink, so it can be spread over the membrane.

Activity Sheet 8
STEM Team Map

7. SUSTAINABLE MATERIALS: WHICH SOAP?

1.5–2 HOURS

PLUS 4 WEEKS OF OBSERVATION

Children carry out a sequence of three investigations to investigate the environmental benefits of using a solid, as opposed to a liquid cleaning product, while developing their science and maths understanding through practical activities. After an initial class input of about 30 minutes the first two activities will be ongoing over a period of four weeks and will take up to an hour over that period in 5–10 minute slots once or twice a week. The final activity will take about 30 minutes.

TYPE OF ENQUIRY

Carrying out comparative and fair tests

Observation over time

OBJECTIVES

Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary (UKS2 working scientifically)

Estimate volume – for example, using $1cm^3$ blocks to build cuboids including cubes and capacity using water (Y5 measurement)

Convert between different units of metric measure – for example, gram and kilogram, litre and millilitre (Y5 measurement)

SCIENCE VOCABULARY

Mass, volume, liquid, solid, shampoo

RESOURCES

per group of 4, unless otherwise stated

Activity 1:

- Unused 100g bar of soap
- Unused 500 ml bottle of hand wash
- Record of the price of both items (if not at hand this could be checked online)

Optional

- 100g play dough
- 10 x small beakers that will hold at least 50ml liquid

Activity 2:

- 5 slices of fresh white bread
- 5 new sealable bags
- Access to hand washing facilities and both soap and hand wash
- Access to hand sanitiser

Activity 3:

- playground chalk
- trundle wheel or large measuring tape

SAFETY GUIDANCE

Mould can produce many microscopic spores which are breathed in and can exacerbate conditions such as asthma. The bags of mouldy bread should remain sealed at all times and be placed together within another bag for disposal.

PRIOR KNOWLEDGE / EXPERIENCE

Children will have compared and grouped materials together, according to whether they are solids, liquids or gases.

They will have set up simple practical enquiries, comparative and fair tests.

ACTIVITY NOTES

Introduction: Show children the image on **presentation slide 2** and ask children to identify which is the odd one out and, most importantly, ***why***. An important aspect of an activity like this is that there are very few possible wrong answers but a large number of possible correct answers. There are some suggestions included in the presentation notes and children may come up with more once they realise that you are genuinely interested in all of their responses and are not just looking for a single 'correct' answer.

Ask: Can they think of other products that come in different forms? For example, they might suggest clothes washing products which are typically either liquid or powder (although in the past this too was a solid bar), shampoo which is starting to be sold as a solid bar as well as a liquid, and bubble bath which is sometimes sold in solid bars as well as liquid in bottles.

MAIN ACTIVITY 1: HOW LONG DOES SOAP LAST?

This activity will take at least 4 weeks, including observations over time. It is carried out concurrently with activity 2. Show children a bottle of hand wash and a bar of soap. Ask them to talk about the similarities and differences between the two products and possible advantages and disadvantages. Ask them to weigh the bar of soap and to make a note of the volume of handwash contained in the bottle. Ask children to work out how much of each product there would be if it were to be divided into 10 equal portions. Children who need more support may find it helpful to pour 500 mls of water into 10 containers and to divide 100g of (play)dough into 10 equal portions so that they can see that one tenth is 50ml and 10g respectively. If you have a record of the price of each item, children could also be supported to calculate the price of a tenth of each product.

Leave the handwash in a location where it will be regularly used for a set period of time (at least a fortnight, or until it is used up if that is sooner). Swap it for the bar of soap and leave it for the same period of time. Alternatively, if there are two wash basins which get an equal amount of use the two products can be used concurrently.

At the end of the period, weigh and measure the remaining amount of each product to calculate how much has been used. Remind children that each 50 ml of liquid equates to one tenth of the total quantity. Whereas for the solid one tenth equals 10g. Children can use this information to work out how long each product would last if the usage remains constant and how much each would cost per week. They could use a calculator to do this.

Discuss which product is cheaper to use and which one lasts longer. Children should be able to tell you that the bar of soap is longer lasting and more economical than the handwash.

MAIN ACTIVITY 2: DOES A BAR OF SOAP CLEAN YOUR HANDS AS WELL AS LIQUID HAND WASH?

This activity will take at least 4 weeks, including observations over time. It is carried out concurrently with activity 1.

The activity is best done after a playtime, before children have washed their hands. To prevent contamination it is vital that the slices of bread is only touched by one person until it is sealed in the bag. The bags should not be opened again at any point.

Remind children of good hand washing technique. The four children in each group handles and seals a slice of bread in an appropriately labelled transparent bag after doing one of the following:

- Child 1 cleans their hands using a bar of soap.
- Child 2 cleans their hands with hand wash.
- Child 3 cleans their hands with hand sanitiser
- Child 4 does not clean their hands.

The last slice of bread is sealed in a bag without anyone handling it.

All five bags are left for up to a month in a warm, dark place. Ensure that the bread does not get so hot that it dries out otherwise mould will not grow at all.

One would expect to see very little, if any, mould growing on the untouched bread, minimal growth on the two slices handled by children who have washed their hands and a significant amount of mould on the slice handled by the child who had not washed their hands. Children may be surprised to see that although hand sanitiser reduces the amount of mould on the bread, there is still more than on the bread handled by children who washed their hands. As well as helping children to understand the importance of regular hand washing, this activity should show that solid and liquid forms of soap are equally effective.

However, as with all science experiments, there may be anomalies. In this case, for example, if a child sneezed while handling the bread, or if their sleeves came in contact with it there might be more mould than expected on one of the 'clean' slices. Because the activity has been carried out by more than one group there is a good chance that the collated class results will show what you are expecting. This provides a good opportunity to compare results, for finding and considering the reasons for anomalies, and emphasising the reasons why experiments are repeated many times, i.e. it is not unusual for these kinds of unexpected results to occur.

MAIN ACTIVITY 3: WHY USE SOLID PRODUCTS?

Explain to children that the transport of products such as medicine, food and personal care products including soap and shampoo has a major impact on the environment. ***In the UK in 2019***, domestic transport was responsible for emitting the equivalent of 122 metric tonnes of carbon dioxide. Transport is the largest emitting sector of greenhouse gas emissions and produced over a quarter of the UK's total emissions that year. Anything that manufacturers can do to reduce the amount of transport can help to reduce these emissions.

Remind children of the data collected during Activity 1 and remind them that the solid soap lasted much longer than the liquid soap because one of the major ingredients in liquid soap is water. When we use a solid product we add the water at the point of use, thus saving the use of fossil fuels to transport the water in liquid soap (hand wash).

Show children **presentation slide 3** and explain that this shows how much more space is needed to transport liquid rather than solid soap.

FACT CHECK

The difference in the amount of transport required is even more than this once the two products are packaged. This is because liquids need more substantial packaging than solids. We will address this issue in a later activity.

Tell children that the average size of an HGV lorry is 25 metres by 3 metres. Challenge children to draw at least one rectangle of this size on the playground. If space allows, ask them to draw 6.5 such rectangles to help them visualise the difference in the amount of transport needed depending upon whether the product is in solid or liquid form.

Finish by explaining to them that scientists, such as the ones working at Innospec, continue to work on ways to address environmental problems and one way that they are doing this is to find ways of making solid instead of liquid products. For example, until recently shampoo was only available as a liquid product. However, in recent years scientists have been developing ways to make a solid shampoo which is as effective as a liquid one.

BACKGROUND INFORMATION

Research shows that on average people use about 2.3g of liquid soap every time they wash their hands and about 0.35 g if they are using a solid product. Solid soap has also been shown to be as effective as liquid soap at removing microbes from the skin. However, solid soap needs more hot water to create a lather and also needs more raw material such as vegetable oil than liquid soap. Nevertheless, by the time transport costs, packaging and increased usage is taken into account it is estimated that the carbon footprint of liquid handwash is approximately 25% greater than solid soap.

EXTENSION OR HOME-BASED ACTIVITIES

Children could be challenged to look at liquid personal care products in their own homes and when out shopping. Ask them to see if the manufacturers make any claim about the 'eco-friendliness' of their products. Do the children always agree with the claims made?

QUESTIONS FOR THINKING

- Are solid products such as soap and shampoo as effective as liquid products?
- What are the benefits of liquid products?
- What are the benefits of solid products?
- Why is it important to reduce the amount of fossil fuels that we use for transportation?
- How does the manufacturer persuade one to buy a particular product?
- In what ways do they claim that it is beneficial to the environment?
- Is there any information that is missing that the children think should be included?

INDUSTRY LINKS AND AMBASSADORS

Scientists in industry, such as those employed at Innospec, are constantly working to produce better personal hygiene products. This is why we so often see words such as 'new' and 'improved' emblazoned on familiar items. Some of the changes made are to improve the customer experience or to make a product more effective. For example, a new toothpaste formulation (recipe) may claim to make your teeth whiter or reduce plaque more effectively than a previous formulation.

Scientists also take the environmental impact of a product into consideration alongside customer experience. For example, early formulations of shampoo bars were bought by people keen to reduce packaging and transport costs and for convenience when travelling. However, because they were not as effective or pleasant to use as liquid shampoo people rarely bought a second bar. Since then, scientists have experimented with different ingredients and processes to produce a solid bar which is as good as liquid shampoo.

The next job of the industry will be to persuade consumers to trust these new products, and that will be a job for their marketing teams.

If you find an ambassador with relevant expertise, ask them to talk to the children about any innovations their company has carried out. For example, what has the impact of the innovations been on the products' efficacy and/or the environment? Encourage ambassadors to bring samples for children to handle and see for themselves how the product is different to the previous versions.

CROSS CURRICULAR LINKS

English: Children draft, edit and produce scripts and poster advertisements for solid formulations of soap and shampoo, explaining their benefits. This creative thinking has excellent links with the genre of persuasive writing in the English curriculum.

Mathematics: Children solve problems involving the relative sizes of two quantities where missing values can be found by using integer multiplication and division facts. They can solve problems involving the calculations of percentages [for example, of measure e.g. 15% of 360].

Design and Technology: Children design new packaging for soap and shampoo bars, selecting from and using a wide range of materials as well as evaluating their functional properties and aesthetic qualities.

PSHE: Children learn what improves and harms their local, natural and built environments and develop strategies and skills needed to care for these (including conserving energy).

8. SUSTAINABLE MATERIALS: HOW MUCH SHAMPOO SHOULD WE USE?

1–1.5 HOURS

Children discuss the importance of using just the right amount of shampoo; as not enough will not wash the hair effectively but too much is a waste of shampoo. They investigate how much shampoo is the 'best' amount.

TYPE OF ENQUIRY

Carrying out fair and comparative test

OBJECTIVES

Compare everyday materials on the basis of their properties including their solubility (Y5 materials)

Know that some materials will dissolve in liquid to form solution (Y5 materials)

Build a more systematic understanding of materials by exploring and comparing the properties of a broad range of materials (Y5 non statutory guidance)

Take measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate (UKS2 Working Scientifically)

Plan different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary (UKS2 Working Scientifically)

SCIENCE VOCABULARY

Foam, volume, liquids, strength, ratio, waste, dissolve

RESOURCES

per group of 4, unless otherwise stated

- Access to water
- 3 empty plastic 500ml pop bottles
- Syringe or pipette (ideally to measure to the nearest 1ml)
- 500ml measuring jug
- 20ml shampoo
- Permanent marker pen
- **Presentation: How much shampoo?**

Optional

- **Activity Sheet 9**

SAFETY GUIDANCE

Shampoo is safe for home use so is low risk. However, in the unlikely event that a child gets some in their eye, rinse their eyes with plenty of clean tepid water.

PRIOR KNOWLEDGE / EXPERIENCE

Children will have had experience of measuring volume accurately to the nearest 1ml. They will have created tables of results and used these to make graphs.

TOP TIP

A period of exploration before tackling an activity is likely to lead to the children working more productively than if tackling it 'cold'. The activities described in the Fun with Foam section of the CIEC resource The Science of Healthy Skin would work well for this.

www.york.ac.uk/ciec/resources/primary/science-of-healthy-skin/

Alternatively, the fun with foam activities could be used to consolidate or revist the learning sometime after the main lesson.

ACTIVITY NOTES

Introduction: Show children the images on **Presentation slide 2** and ask them if they know what concentrated means. Explain that if a liquid is concentrated it contains less water which means that it can fit into a smaller bottle. Customers need to use a smaller amount of the concentrated product to get the same results as with the 'normal' product. Liquids which can be concentrated include fruit drinks, personal hygiene products such as shampoo and household cleaning products such as washing up liquid or fabric conditioner. Explain that making a more concentrated liquid is another way to reduce transport and packaging costs, because the same amount of 'cleaning power' will fit into a smaller sized container.

TOP TIP

Ideally children should be given as much independence as possible to organise themselves to carry out practical activities., However their ability to do this will depend upon several factors including levels of maturity and past experience. They are more likely to be successful if they are given set roles within the group; and you may find the CIEC role badges useful for this.

www.york.ac.uk/ciec/resources/primary/skills-for-science/#role-badges

It is also valuable to let children make mistakes when they set up their investigations, even when it is obvious to you that it is not going to work. If adults step in too quickly to give advice, children are less likely to learn for themselves than if they have an opportunity to evaluate their own work and plan how they would do things differently next time. In the long term this is likely to lead to more maturity and independence than if we provide too much scaffolding.

MAIN ACTIVITY:

Show children **Presentation slide 3** which has a letter from Innospec asking for their help. The letter uses language which children may need help unpicking (such as 'optimum amount of lather', 'recruiting scientists' and 'fossil fuels'). This is in order to more closely represent the language that would be used in a letter from industry as children respond maturely to this. Children are then asked to work in groups of 4 to devise a test to find out the optimum amount of shampoo needed. This is a challenging investigation for children to plan. They will need to find out how they can tell which amount of shampoo is effective given they cannot wash their hair in the classroom. Children might choose to measure the effectiveness of the shampoo for cleaning something else, such as hands or a piece of soiled cloth for example. Alternatively, they might decide to measure the amount of foam created by a fixed amount of shampoo in a measured volume of water.

This may seem like more time than is available in a busy curriculum for a single lesson. However, such time is well spent, and the learning is likely to be deeper than several different lessons which are more prescriptive. Moreover, not every child in the class will be doing exactly the same thing (a bugbear of many work scrutinies and OFSTED reports). Time for class discussion and evaluation will mean that children will learn from each other's investigations and mistakes as much as they do from their own.

Once children have had a go at designing and trying out their own investigations you could share the instructions on **Activity Sheet 9** with them. It contains a modified description of the process used by the scientists at Innospec to measure the volume of foam produced by different products. Children could compare their own method with the Innospec approach.

If children's results and explanatory letters are sent to ***ciec@york.ac.uk*** they will receive a response from the company.

TOP TIP

Provide as many resources as possible for children. However, if they are given time to plan this activity a day or two ahead of carrying it out that will give time for more resources to be gathered, including those that you hadn't anticipated that they would need. It will also mean that you can share the task of providing materials with the children. For example, if one group suggest comparing different brands of shampoo, they can all bring in samples from home.

BACKGROUND INFORMATION

This activity gives an interesting opportunity to show children that it is not only solids (such as salt and sugar) which can be dissolved in liquids. Liquids, such as shampoo and household cleaning products, can also be dissolved in liquids.

The amount of minerals dissolved in tap water varies across the country. Hard water contains relatively high amounts of minerals such as calcium whereas soft water has relatively little dissolved minerals. The relative hardness of the water affects the quantity of product needed to create a foam with more being needed when using hard water.

EXTENSION OR HOME-BASED ACTIVITIES

Children may be surprised to learn that the water used in different parts of the country makes a difference to how much product is needed to make enough foam. If they live in a hard water area (most areas in the UK) you will be able to demonstrate this by repeating the activity with a sample of water that has been boiled and cooled, as this removes some of the minerals (which is why kettles tend to 'fur up' with mineral deposits). If they live in a soft water area you could use some mineral water to represent hard water and demonstrate the difference.

Ask children to look at packets of products that they use in the home including cleaning products, food and personal care products. Ask them to look for any advice about the amount to be used or portion size. They could discuss how well they think that most people follow this guidance.

QUESTIONS FOR THINKING

- Why is it important to use the right amount of shampoo?
- What happens if we don't use enough shampoo?
- What happens if we use too much shampoo?

INDUSTRY LINKS AND AMBASSADORS

If you are able to find a scientist with relevant expertise who can visit your classroom, ask them to bring a range of portable lab equipment they use to carry out the same tests that children have done in the classroom. Images showing the equipment in use, or of larger equipment that can't be taken out of the lab, would be useful for children to see alongside the real equipment.

CROSS CURRICULAR LINKS

English: Write a covering letter to explain their findings, to send to Innospec to accompany their results.

Maths: Select the best method(s) to present their results, and produce appropriate tables or graphs.

Activity Sheet 9

How to find the amount of shampoo needed to create the best amount of foam:

1. Add 100ml of water to a 500ml pop bottle

2. Add 1ml of the shampoo to be tested, using a syringe or pipette

3. Put the lid on

4. You now need to swirl the liquid around in the bottle at the same speed for 2 minutes. Don't shake it too much or the whole bottle will fill with foam and you won't have anything to measure!

5. Put the pop bottle down, and 30 seconds later measure the height of the foam (not including the liquid)

6. Repeat this 3 times and take the average of the 3 foam heights.

The research team is looking for at least 100ml of foam. If there is not enough foam with 1ml of shampoo try again with 2ml. If there is more than 200ml try again with less.

9. SUSTAINABLE MATERIALS: WHICH PACKAGING?

1.5–2 HOURS

Children discuss the importance of minimising the quantity of raw materials that we use to make single use packaging. They then explore a range of possible packaging materials before finding out about an innovative solution that one company is developing. They then test different types of paper as potential packaging for soap and shampoo bars.

TYPE OF ENQUIRY

Carrying out fair and comparative test

OBJECTIVES

Compare everyday materials on the basis of their properties (Y5 materials)

Know that some materials will dissolve in liquid to form a solution, and describe how to recover a substance from a solution. (Y5 materials)

Build a more systematic understanding of materials by exploring and comparing the properties of a broad range of materials (Y5 non statutory guidance)

Take measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate. (UKS2 Working Scientifically)

Plan different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary (UKS2 Working Scientifically)

TOP TIP

When planning your lesson, where possible, it is a good idea to choose just one content knowledge and one working scientifically objective to focus on depending upon the learning needs of your class. This will enable you to focus your support on the learning objectives rather than trying to teach them all at the same time.

Any recording done by the children should reflect the learning objectives that you have chosen; for example if the Working Scientifically focus is to 'take measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate' this should be what is recorded. Other aspects of the investigation can be done orally.

SCIENCE VOCABULARY

paper, dissolve, undissolved, change, soluble, property

RESOURCES

per group of 4, unless otherwise stated

- A selection of empty packaging including different types of plastic, card, metal and cellophane (or show **Presentation slide 2**).
- **Activity Sheet 10** Optional: create a set of cards
- 3 x squares of at least two types of soluble paper such as Solvy or Super Solvy (at least $10cm^2$)
- 2-3 squares of other paper samples, e.g. brown paper, tissue paper, cellophane, greaseproof paper, polythene or crepe paper. (NB: Exact $10cm^2$ size squares reduces the number of variables children need to consider controlling. A range of sizes could be offered, if preferred.)
- translucent beakers or clear plastic cups (200 ml or larger)
- Small pieces of soap (these could be cut from a larger bar or the bars from hotel rooms would work well)
- Access to somewhere to wash hands
- **Activity Sheet 11** (optional scaffolding for children)
- **Presentation: Which packaging?**

SAFETY GUIDANCE

Ensure that all packaging materials are clean and that there are no sharp edges.

Any spills should be wiped up promptly to prevent slipping.

PRIOR KNOWLEDGE / EXPERIENCE

Children will have compared and grouped materials together, according to whether they are solids, liquids or gases.

They will have set up simple practical enquiries, comparative and fair tests.

ACTIVITY NOTES

Introduction: Show children either the image on **presentation slide 2** or the packaging samples you have provided. Ask them to talk about the different materials they can see and their different properties. Discuss each material's properties that have led to them to be used as packaging materials.

Activity Sheet 10 starts with a matching excercise, which can be done be drawing connections on the sheet, or by matching pre-prepared cards. Ask children to see if they can match the materials cards to the product cards. Ask them to consider what different properties have to be taken into consideration when choosing packaging materials and whether some products are trickier to package than others.

Explain that all of this packaging has been developed by scientists to solve different problems and challenges. Scientists continue to explore and develop exciting ways to overcome new challenges, including reducing our environmental impact. Show the video clip on **presentation slide 3** which shows how important it is to reduce our use of packaging materials such as plastic. This is because recycling is of limited impact when addressing the problem of waste.

MAIN ACTIVITY:

Distribute the paper samples and invite children to describe them, their properties, their similarities and differences. The children consider each material's use(s) based on their own experience of different kinds of paper.

Share the letter (on **Presentation slide 4**) from Innospec which asks for the children's support to find a material that could be used to wrap shampoo bars.

Give children time to work in their groups to plan their tests and to consider how they will report their findings to Innospec.

They may find it helpful to use the table on **Activity Sheet 11**. However, depending upon the confidence of the children you may decide to let them decide for themselves (i) how many tests to conduct and (ii) how to present their findings.

If children's results and covering letters are sent to ***ciec@york.ac.uk*** they will receive a response from the company.

BACKGROUND INFORMATION

You may be interested to read about some of the innovations that are in the pipeline to reduce the environmental impact of personal hygiene products such as soap and shampoo.

EXTENSION OR HOME-BASED ACTIVITIES

Remind children of the phrase 'reduce, reuse, recycle' and ask them if they can explain why it is more important to reduce and reuse rather than recycle.

Challenge them to find a product or packaging that is currently single use and to see if they could design an innovative new product which could be used instead.

QUESTIONS FOR THINKING

- Why is it more important to reduce and reuse rather than recycle?
- Where does single use plastic go?
- How can scientists help us to tackle environmental problems?
- What can we do to tackle environmental problems?

INDUSTRY LINKS AND AMBASSADORS

There is a branch of science known as Green Chemistry. Green chemists focus their research on finding innovative ways to tackle environmental problems such as waste and pollution. You can find out more about one such science solution in the CIEC publication Potatoes to Plastics. If you were able to find a Green Chemist to come into your classroom they would be able to tell your children about the work that they do and the difference that they make.

www.york.ac.uk/ciec/resources/primary/potatoes-to-plastics

CROSS CURRICULAR LINKS

English: Children write persuasive texts to help people understand the benefits of using a solid shampoo in a soluble wrapper.

Design Technology: Children explore and evaluate the range of packaging that is currently used for personal care products.

Activity Sheet 10

paper	wood
tin	glass
card	fabric
plastic	waxed paper
apples	toy doll
bar of soap	toothpaste
sugar	flour
polystyrene	polythene
fizzy drink	cake
sandwich	hot drink
cooked pizza	shampoo
biscuits	washing powder
chocolate	milk

Activity Sheet 11

Sample code	Flexibility	Weight	Strength	Water solubility
A				
B				
C				
D				
E				
F				

We recommend sample ___ because

10. SUSTAINABLE MATERIALS: WHICH METAL?

2–3 HOURS

Children discuss the properties of a range of everyday materials before focusing their attention on different types of metal and their uses. They investigate how metals can corrode when exposed to substances in the environment and that rusting is one type of corrosion. Children are introduced to the properties and uses of precious metals and consider how one company uses these to reduce the amount of dangerous gases emitted by high numbers of vehicles on our roads today.

TYPE OF ENQUIRY

Observing changes over time / Carrying out comparative and fair tests

OBJECTIVES

Give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials, including metals, wood and plastic (Year 5 Properties and changes of materials)

Explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible, including changes associated with burning and the action of acid on bicarbonate of soda (Year 5 Properties and changes of materials)

Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary (UKS2 Working Scientifically)

SCIENCE VOCABULARY

materials, metal, precious metals, sustainable, corrode, rust, catalytic converter

RESOURCES

per group of 4, unless otherwise stated

Activity 1:

- 1 set of metal discs or testing strips from an educational supplier or a range of objects made from different metals, e.g. steel paper clips, fine steel wool pads, steel washers, copper plated coins, iron nails, aluminium foil
- 4 shallow containers, such as saucers or petri dishes containing water
- Magnet

- Industry sustainability story: Presentation

Activity 2:

- 4 fine steel wool pads
- Resources requested from individual groups might include mild white vinegar or salt
- **Activity Sheet 12:** grid photocopied onto clear acetate sheet
- 4 pairs of disposable non-latex gloves
- 4 shallow containers, such as saucers or petri dishes containing water
- 4 safety glasses (if using acidic solutions)
- Industry sustainability story: **Presentation**
- 4 lab coats or aprons

PRIOR KNOWLEDGE / EXPERIENCE

Children will have compared and grouped materials, focusing on similarities and differences.

ACTIVITY NOTES

Introduction: Start with a game, in which the teacher names an object (e.g. bag) and the children suggest materials from which it could be made. The game is a great way for children to think about how the same object can be made from different material, such as a bag, which can be made out of paper, plastic or fabric, and also how an object can be a composite of materials, such as scissors which can have metal blades and plastic handles.

Progress to focusing on objects made from different types of metals, for example: kitchen foil or drinks cans are commonly made from aluminium, electrical wiring is often made from copper, scissors and cutlery can be made from stainless steel. Ask how many metals the children can name and then discuss why different types of metal are useful for different things.

Presentation Slide 1: Ask children if they think metal is a sustainable material. This means that the availability of metal 'meets our current needs without having a negative effect on the needs of future generations'. Explain that, once manufactured, metal can be recycled and used repeatedly. Many people believe that non-renewable resources used to make metals, like minerals and fossil fuels, are not being used-up because the metal can be used again, and this makes it sustainable. Children discuss whether they agree with this or not.

Presentation Slide 2: Introduce children to the idea of *precious* metals and explain that these are naturally occurring metals of high value. Discuss that many properties of precious metals do not change under different conditions, for example, they can be shaped without losing toughness and, even at very high temperatures, they do not corrode or rust. Because of this, precious metals are often used to make jewellery. Common precious metals are gold, silver and platinum. Encourage children to research and name any other, lesser known, precious metals.

Ask children to consider how the environment can affect some metals, such as the damage caused when metals corrode. Discuss how corroded metals change, often in colour, and become weaker. Explain that rusting is a type of corrosion and think about different examples of some types of metals rusting such as car bodies and exhaust systems, nails, screws, metal gates, etc. Children could carry out a 'rust hunt' around the school, listing the rusting objects and (possibly) what they are made from. This will aid the process of making predictions about which materials may rust, based on their knowledge of everyday objects.

Note: the teacher might wish to check that there are, or even 'plant', rusty things to find prior to the hunt.

MAIN ACTIVITY 1: WHICH METALS RUST?

The original activity and comprehensive background information can be found in Activity 1 of: ***http://www.ciec.org.uk/pdfs/resources/water-for-industry.pdf***

Provide small groups of children with a range of objects made from different metals or commercial test discs/strips (see resources above).

Children could place the metal objects in shallow containers, such as saucers or petri dishes, with just enough water poured in to almost cover each object. Over several days, children should observe carefully which objects start to show signs of rust and which do not. They could use a magnet to identify metal items that contain iron or steel.

Children should observe signs of the reddish-brown iron oxide that we know as rust on objects made from iron or metals that contain iron – such as steel. They should begin to form conclusions that both air and water are needed for this to happen. See **Background Information below**.

MAIN ACTIVITY 2: RUST DETECTIVES

To learn more about the corrosion of iron and how salt affects rusting, visit Activity 6 of: ***http://www.ciec.org.uk/pdfs/resources/pinch-of-salt.pdf***

Once the children have discovered that several metals do corrode over time, and that the term 'rust' is only used for iron and its alloys, such as steel, and that this is due to a reaction with oxygen in the air and water, they should be encouraged to develop further questions about rusting. Examples include:

- Can iron and steel rust where there is little or no water?
- Does pollution in rainwater speed up rust?
- Do the salty roads in winter or salt spray from the sea make cars rust faster?
- Can I prevent iron or steel from rusting?

Children then plan and carry out a test to answer one of these questions. They should choose a good test material from the previous activity (such as fine steel wool pads) and give reasons for this choice. They could compare a control pad with either one dampened with water, one with saltwater or one with a mixture of water and mild white vinegar (acid). They could examine the pads at regular intervals such as each day over the period of a week and take photographs and measurements of changes over time.

One method of measuring the rusting is to hold a centimetre square grid (on an acetate sheet or tracing paper) above each pad and count the number of squares through which rusting is visible. A square grid is provided on **Activity Sheet 12** for this purpose. Children may have other ideas, such as taking a sequence of photographs, or collecting rust that they shake or scrape off their test material or observing colour changes of the liquids in each container.

BACKGROUND INFORMATION

Corrosion is the damage caused to materials such as metal and stone when they react to substances in the environment. Stone statues can be damaged by harmful gases in the air, or when they are transformed and carried in 'acid' rain.

'Rusting' is the term given to the corrosion of metals containing iron, e.g. steel, when in contact with water and air. The metal reacts with the oxygen in the air to form a metal oxide. It is impossible to stop corrosion, but it can be controlled.

Precious metals are unique in many ways. They are relatively non-reactive, so they will not rust or explode when exposed to different substances or high temperatures.

The eight precious metals are gold, silver, platinum, palladium, rhodium, ruthenium, iridium and osmium. Gold and silver are probably the best known for their use as high value currency, silver wear and jewellery.

In recent years, silver has seen an increased demand for industrial uses, mainly photography, photovoltaic (solar) cells and batteries as well as medicine (wound dressings, creams, and as an antibiotic coating on medical devices) and hygiene (clothing additives and colloidal silver in after shaves). Gold is used in electronic components because of its high conductivity and resistance to corrosion. While the use of gold has decreased in dental applications, some new markets such as catalysts and pharmaceutical drugs have emerged.

Small amounts of platinum, palladium and rhodium are used in catalytic converters and electronic devices (only a few grams per car). However, the total volume of car sales is large and increasing, as the global economy continues to improve. With a rising need to reduce pollution by promoting electric vehicles, platinum and palladium may also be needed in hybrid cars.

EXTENSION OR HOME-BASED ACTIVITIES

Discuss with children how it is important to recycle objects made from metal. Recycling is better for our environment as it uses much more energy to extract metals from the ground than it does to recycle them. Metal can be re-melted and reshaped into new products many times. Explain how even rusted metal can be recycled and reused once the oxygen has been removed.

A fun way to see how corrosion can be removed is to investigate what happens to old coins when they are rubbed with acidic substances, such as vinegar, lemon juice or even cola. Children should investigate with different types of coins to see whether some metals corrode more or less than others, for example copper coins can be made shiny again, while silver coins are visually unchanged.

Remind children that our coins do not technically 'rust' as they are not made from iron, however, the metal does corrode over time, and show a dull colour, due to contact with oxygen and water.

QUESTIONS FOR THINKING

- Why do we make so many objects from metal?
- What are precious metals and how are they useful to us?
- Do you agree that metal is a sustainable material? Why do you think this?
- Why is it important to recycle objects made from metal?
- Why do you think steel wool pads are a good test material for rusting?
- Why do we not make expensive jewellery from iron or steel?
- Which material would you choose for a pipeline? Why?
- Why do we paint steel bridges?

SAFETY GUIDANCE

Children should be particularly careful when handling metal objects and fine steel wool because they may have sharp edges or corners. They should protect their eyes from acidic solutions, such as vinegar, by wearing safety glasses and refrain from rubbing their eyes during investigations. They should also protect their clothes with lab coats or appropriate aprons. Encourage children to wear disposable non-latex gloves and wash their hands thoroughly to avoid any skin irritations. After completing the investigations, children should clean up responsibly.

INDUSTRY LINKS AND AMBASSADORS

Ambassadors visiting the classroom could bring samples of metals and metal equipment and talk about how metal is used on site or for important industrial processes. The ambassador can discuss the sustainability of metal in terms of how metal is made, used, reused or recycled on their sites and to give examples where alternative materials to metal are used.

To enable children to explore one company's use of precious metals to solve the problem of dangerous car emissions polluting our atmosphere, teachers and children should follow the slides on the presentation **Sustainable materials: which metal?** and engage in discussion points and activities to develop a further understanding of industrial contexts.

CROSS CURRICULAR LINKS

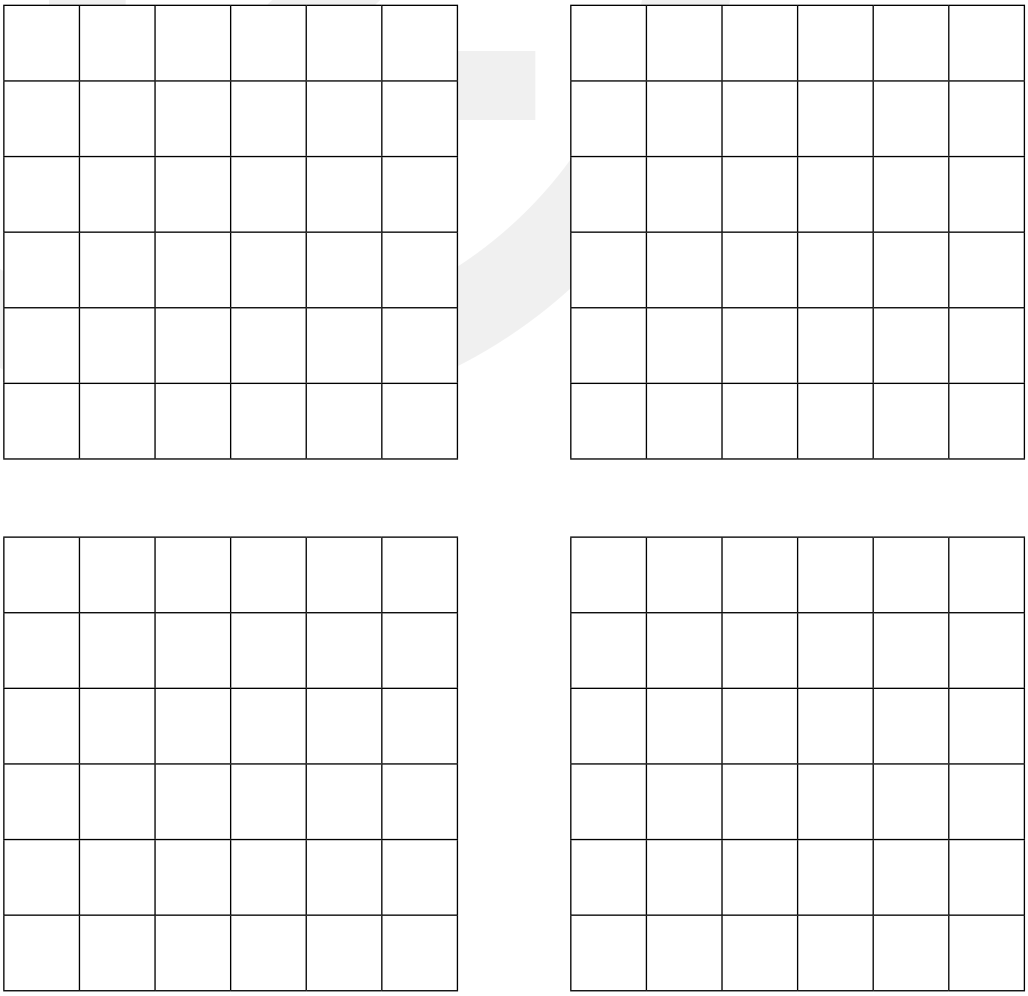
Mathematics: There is an opportunity to measure and compare the area of rusting / corrosion using grids.

PSHE: to research, discuss and debate topical issues, problems and events that are of concern to them and offer their recommendations to appropriate people; to learn that they have different kinds of responsibilities, rights and duties at home, at school, in the community and towards the environment; to continue to develop the skills to exercise these responsibilities.

Activity Sheet 12

The grids are for measurement of the area rusted on steel wool pads or similar metal objects.

Photocopy the grids onto clear acetate sheets to use.



Each square on the grid has an area of one square centimetre.

(When printing this page do not check the box "fit to page")

11. SUSTAINABLE MATERIALS: WHICH PLASTIC?

1–2 HOURS

Children discuss the properties of a range of everyday materials before focusing their attention on different types of plastic and their uses. They are challenged to identify and name unknown plastics by observing what happens when samples are placed in different liquids and when a force is applied. Children learn about the impact that plastics can have on the environment and why it is important to recycle plastic items. They consider how one company supports a recycling scheme to reduce the amount of a certain type of plastic that is usually used once and sent to landfill sites.

The original activity and comprehensive background information can be found on pages 3-6 of ***http://www.ciec.org.uk/resources/plastics-playtime.html.***

TYPE OF ENQUIRY

Grouping and classifying things / Carrying out comparative and fair tests

OBJECTIVES

Give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials, including metals, wood and plastic (Year 5 Properties and changes of materials)

Use and develop classification keys and other information records to identify, classify and describe materials (UKS2 Working Scientifically)

SCIENCE VOCABULARY

plastic, properties, single-use, fossil fuels, non-renewable, landfill, recycling, non-degradable

RESOURCES

per group of 4, unless otherwise stated

- **ONE OF EACH FOR WHOLE CLASS:** example plastic objects, e.g. Christmas card packaging (PVC), milk carton (polythene), yoghurt pot/hot drinks cup lid (polystyrene), pizza base/insulated foam cup (expanded polystyrene)
- 1 x 1-litre measuring jug (or bowl of similar capacity)
- 1 teaspoon
- **Activity Sheet 13:** Identifying Plastics Key
- 1 small bowl of salt
- Plastics pieces – 1 sample of PVC, polythene, polystyrene and expanded polystyrene cut to approximately 8cm x 1cm. The strips are then numbered 1 to 4 with a permanent marker.
- 4 safety glasses and 4 pairs of disposable non-latex gloves
- Industry sustainability story: **Presentation**

Important note: *As it is not certain that an object is made from a specific plastic it is imperative that the* ***teacher checks the identity and tests*** *selected items before presenting the activity to the children. Often, the recycling number or code is printed on everyday plastic objects. Teachers are looking for: 2 (HDPE) or 4 (LDPE) for polystyrene, 3 (PVC or V) for PVC and 6 (PS) for each type of polystyrene, however expanded polystyrene will be the foam version. Do not share this information with children until the end of the activity.*

PRIOR KNOWLEDGE / EXPERIENCE

Children will have compared and grouped materials, focusing on similarities and differences.

ACTIVITY NOTES

Introduction: A game of 'Jeopardy,' where the answer is provided and children work in small groups to suggest what the question might be, would be a fun starter activity to recap what they already know about a range of everyday materials. For example, the teacher says, 'The answer is wood,' and the children must phrase their response in the form of a relevant question, such as 'Which material comes from trees?' or 'What can a pencil, desk and drum sticks be made from?' Finish the game with the answer of 'plastic' and discuss the various questions suggested by the class.

Discuss how there are many different types of plastic and that each one is useful for different things. Ask the children to name as many different types of plastic as they can and collect responses. Refer to Lesson 1: 'which metal?' and consider how we know of metals in everyday use but often struggle to identify different types of plastic. Children may be familiar with names of plastics in specific contexts such as shopping with polythene bags or sitting on bean-bags filled with polystyrene beads.

Discuss how many types of plastic begin with the prefix 'poly' and can have very tricky long names so are often abbreviated. Give the examples of polythene (or polyethylene) (PE), polystyrene (PS), polypropylene (PP), polyethylene terephthalate (PET) or polyvinyl chloride (PVC).

Ask children if they think plastics are sustainable materials. Discuss how plastics are made from materials found in fossil fuels which are non-renewable and so will eventually run out. Children might also talk about how plastic is often thrown away after one use and can end up in landfill sites or as litter pollution. Focus the discussion on how important it is for us to consider the sustainability of the products we use and how plastics can be reused and recycled. It is important that we can sort plastic items by type and ensure that they are not just used once and then thrown away.

Show four everyday plastic objects (see Resource list for suggestions) and explain that each object is made from a different type of plastic, with different properties. Challenge children to suggest how we can identify each type of plastic in order to help us make decisions about plastic recycling.

Children could attempt to name the examples provided because of the colour or texture and similarity to objects that they already know. They should begin to realise the difficulty in identifying plastics simply by appearance, and the idea of investigating different properties can be introduced.

MAIN ACTIVITY 1: SINK FLOAT TEST

Children work in small groups and are given four samples of plastic (numbered 1-4) to represent each of the example objects. Explain to children that they should half fill a jug with water and place each sample piece under the water before letting it go. They should observe and record which samples of plastic float and why they think this might be (the pieces of polythene and expanded polystyrene will float).

Children should then add salt to the water, a teaspoon at a time, stirring after each addition, then observe and record which plastic sample begins to rise and which sample stays at the bottom of the jug and why they think this has happened. (The piece of polystyrene will begin to rise and will float after 2-3 teaspoons of salt have been added. The piece of PVC will stay at the bottom.)

Explain to children that by observing what a plastic sample does when placed in various liquids, different types of plastic can be identified, and this technique can be used to sort plastics during the recycling process.

MAIN ACTIVITY 2: CREASE TEST

Using the same samples (removed from the water), children should attempt to fold a crease in each of the four plastic pieces. They should observe and record whether each sample either snaps, creases or shows signs of stress whitening (the plastic becomes white along the line of stress where the material structure is altered).

For reference only, the results are usually:

- Snaps – thick PVC, expanded polystyrene
- Crease – polythene
- Creases with stress whitening – polystyrene, thin PVC and some polythene

Using their own results, groups should have enough information to use the classification key provided on **Activity Sheet 13** to identify and name each of the unknown plastics. They should then relate this information to which type of plastic each of the example objects are made from so that they can be appropriately recycled.

EXTENSION OR HOME-BASED ACTIVITIES

Discuss with children that, in order to identify the type of plastic that an object is made from, it would be impractical to see whether it floats or sinks or can be creased! Ask if anyone knows of another way to help us to identify which plastic an object is made from. Explain that many plastic items that can be recycled have a symbol like the one shown here.

Show lots of examples of plastic items (or children could be challenged to find these in the home) and allow time for children to locate this information and work out what the abbreviations or numbers might mean. They should then use what they have found out to sort and group a range of different plastic items according to plastic type. It would be interesting for children to find out which materials and types of plastics can be recycled near to where they live.

1 PETE	polyethylene terephthalate	Water bottles, soft and fizzy drink bottles, pots, tubs, oven ready trays.
2 HDPE	high-density polyethylene	Toys, picnic ware, household and kitchenware, cable insulation, carrier bags, food wrapping material.
3 V	polyvinyl chloride	Window frames, drainage pipes, medical devices, blood storage bags, flooring, vehicle interiors and seat coverings, fashion and footwear, packaging, cling film, credit cards.
4 LDPE	low density polyethylene	Squeeze bottles, toys, carrier bags, insulation, tank linings, heavy duty sacks, general packaging, gas and water pipes.
5 PP	polypropylene	Bottle caps, cereal liners, lunch boxes, ketchup bottles, packing tape, straws.
6 PS	polystyrene	Toys and novelties, rigid packaging, refrigerator trays and boxes, cosmetic packs, CD cases.
7 OTHER	other types of plastics	Baby bottles, water cooler bottles, car parts.

Source: ***https://www.bpf.co.uk/sustainability/plastics_recycling.aspx***

QUESTIONS FOR THINKING

- How can you tell plastics from other materials?
- Are all plastics the same? What similarities and differences have you noticed?
- Do you know the names of any plastics?
- Can you find out why many names of plastics begin with 'poly'?
- Why do you think so many things are made from plastic?
- Why is it important to recycle items made from plastic?

SAFETY GUIDANCE

Safety glasses should be worn during the 'crease test', as small pieces may splinter off the plastics when under stress. The option of wearing gloves would prevent cuts from sharp edges. Dispose of the pieces of plastic by recycling them if possible – do not pour down the sink.

INDUSTRY LINKS AND AMBASSADORS

Ambassadors visiting the classroom could bring samples of plastics and plastic equipment to show the children and talk about how plastics are used on site or for important industrial processes. It is interesting to discuss the sustainability of plastics in terms of how plastics are made, used, reused or recycled in industry, and to think about alternative materials to plastics.

To enable children to explore one company's solution to the problem of many plastic items ending up in landfill and the uncertainty of recycling plastics, such as PVC, teachers and children should follow the slides on the presentation Sustainable materials: which plastic? and engage in discussion points and activities to develop a further understanding of industrial contexts.

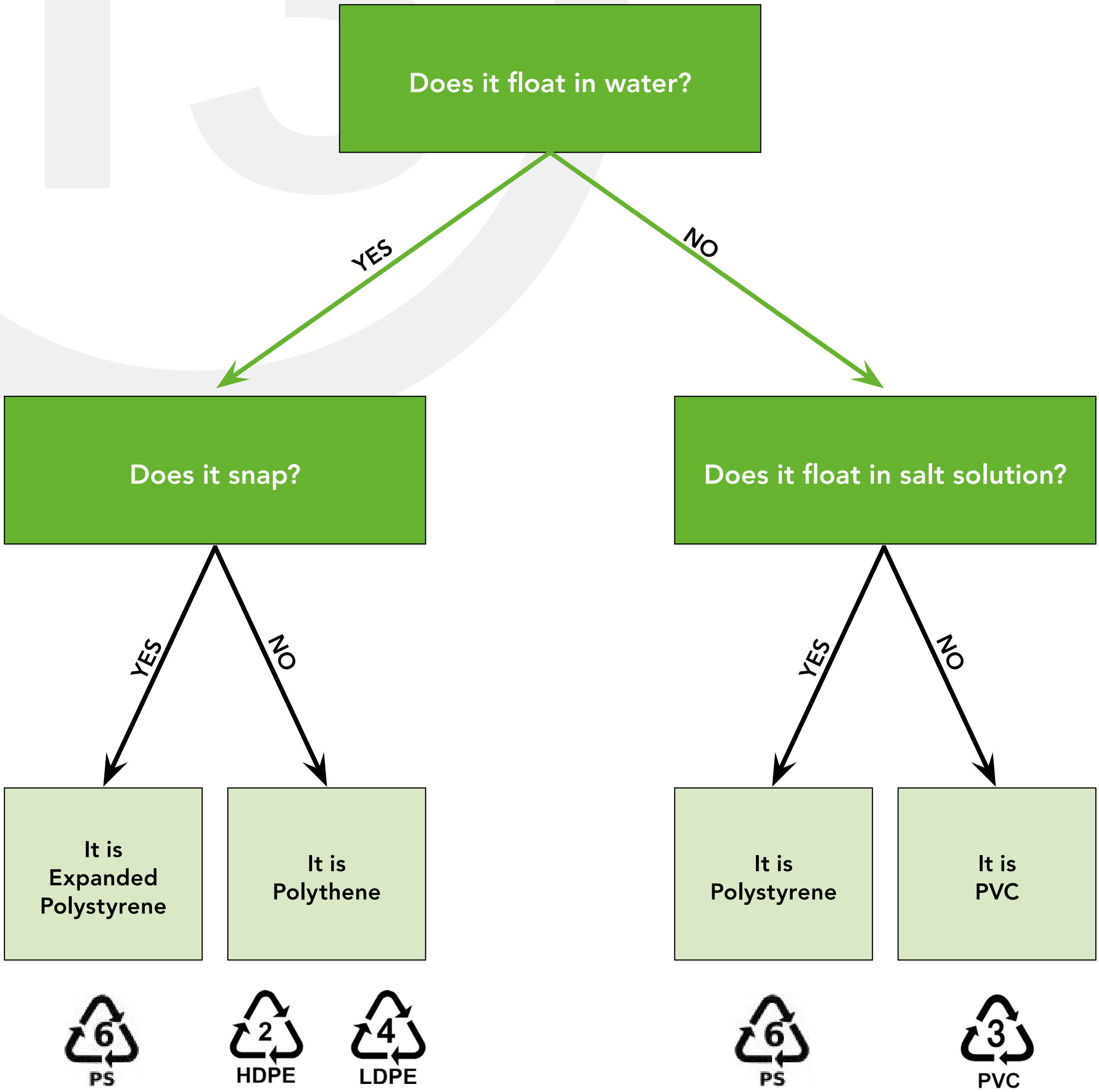
CROSS CURRICULAR LINKS

Mathematics: complete, read and interpret information in tables and graphs. Develop keys and other information records to identify, classify and describe.

PSHE: to research, discuss and debate topical issues, problems and events that are of concern to them and offer their recommendations to appropriate people; to learn that resources can be allocated in different ways and that these economic choices affect individuals, communities and the sustainability of the environment across the world.

Activity Sheet 13

Identifying Plastics Key



12. SUSTAINABLE METHODS OF CLEANING: WHICH WASHING PRODUCT?

2–3 HOURS

Children think about the amount of clothing that they own and discuss different types of clothing for different purposes. They reflect upon how frequently clothing is washed and the impact this might have on the environment. Groups of children plan and carry out their own fair test to investigate how effective different commercial washing products are at removing stains from fabric. They complete the activity by considering how one company has developed an ingredient for a new washing product which washes clothes more effectively than ever so that we do not have to wash or replace them more than we need to.

The original activity and comprehensive background information can be found in the 'What's in washing products?' activity at ***http://www.ciec.org.uk/kitchen_concoctions/***.

TYPE OF ENQUIRY

Carrying out comparative and fair tests.

OBJECTIVES

Give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials including metals, wood and plastic (Year 5 Properties and changes of materials)

Demonstrate that dissolving, mixing and changes of state are reversible changes (Year 5 Properties and changes of materials)

Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary (UKS2 Working Scientifically)

SCIENCE VOCABULARY

fabric, landfill, variable, fair test, greenhouse gases, carbon footprint, global warming

RESOURCES

per group of 4, unless otherwise stated

- Samples of clothing / different types of fabric (common washable fabrics include cotton, denim, linen, nylon, polyester and lycra),
- 1 teaspoon
- 1 thermometer
- 1 measuring jug
- 4-6 stained samples of white polyester or cotton
- **Activity Sheet 12:** grid photocopied onto clear acetate sheet
- Small samples of three different brands of commercial washing product (powder and liquid and an eco-friendly product),
- Source of warm water (up to 40oC),
- 1 timer
- 1 large bowl
- 4 pairs of disposable non-latex gloves and 4 safety glasses
- **Activity Sheet 14:** Post-it planning template
- Two colours of post-it notes
- Industry sustainability story: **Presentation**

Note: pre-prepared fabric samples could be the same size for fair testing. Stain the samples in advance with the same amount of food – do not use foods that stain severely such as tomato sauce. Good examples to include are margarine or mincemeat.

PRIOR KNOWLEDGE / EXPERIENCE

Children should have opportunities to set up simple practical enquiries, comparative and fair tests. They should be able to recognise when a fair test is necessary and contribute to some of the planning for this.

ACTIVITY NOTES

Introduction: Ask children to think about the amount of clothing that they own and the different types of clothing for different purposes. Children might have a uniform and PE kit for school, clothes for casual wear, special occasions, hobbies, seasonal clothes as well as warm coats, anoraks, jackets, body warmers, not to mention different types of shoes! Allow children time to explore and discuss a range of different types of fabric and which are used for different types of clothing. They might also like to look at labels on the clothing that they are wearing to identify fabric type.

Discuss how often clothing needs to be washed. For some children this might be every time an item has been worn or just when the clothing becomes dirty. Think about how most homes now have automatic washing machines and that modern detergents are considered essential for cleaning clothes. Explain that washing powders, liquids and capsules help break up dirt and stains so that we can wear our clothes repeatedly, rather than throwing them into the rubbish bin and ending up in landfill.

MAIN ACTIVITY

Discuss how washing products need to wash our clothes more effectively than ever so that we do not have to rewash or replace our clothes more than we need to. Also by washing clothes at much lower temperatures, we can use less energy. Explain to children that they will be planning and carrying out their own fair test investigation to find out how effective different commercial washing products are at removing stains from fabric.

Each group will be given samples of stained fabric and three different types of washing product (powder, liquid and eco-friendly). Children need to think about how they will test each washing product to observe or measure how well it removes the stain.

Children might like to use the generic **Post-It Planning Template (Activity Sheet 14)** for support in the planning phase by generating a list of variables that they could change and observe/measure. In the case of this investigation, they will be changing the 'washing product' to see how this affects the visibility / size of the stain OR the time taken to remove the stain.

Children should be aware that variables they control could include; the cause of stain, size of stain, type of fabric, size of fabric, amount of washing product, amount of water, temperature of water, number of rubs, time that the fabric remains in the washing solution, number of rinses to fabric after washing, etc.

Groups should spend time making decisions about the equipment they will use, how they will carry out their tests and make careful observations or measurements, as well as the best way to record the test outcomes. Visibility of stain could be an observation based on a 'visibility scale' determined by the children. Size of stain could be obtained by measuring the length of the stain with a ruler or placing a transparent cm^2 grid on top of the fabric **(Activity Sheet 12**) and calculating the area of stain remaining under each test condition.

Children might decide to include a control sample of stained fabric to compare the outcomes of different tests with the original stained material. They can also take photos or make annotated drawings and notes to assist them in the recording process. Once the washing investigations are complete, give children time to discuss and make decisions about their results and, ultimately, formulate an answer to their original enquiry question: Which washing product is the most effective at removing stains from fabric?

EXTENSION OR HOME-BASED ACTIVITIES

Children will be interested to research the phrase 'fast fashion' and learn about the increasing demand on clothing companies to deliver frequent new collections inspired by catwalk looks or celebrity styles. They should consider how 'fast fashion' can lead to negative environmental impact, water pollution, the use of toxic chemicals and increasing amounts of fabric waste.

In attempt to combat the problem of 'fast fashion', children might be interested in finding out about commercial products that protect and prolong the lifespan of fabrics, such as Scotchgard™. They could investigate this by 'protecting' clean samples of cotton or polyester with suggested substances such as glue, hair spray or vegetable oil. They could then drip staining liquids such as a diluted food colouring or a flavoured fruit drink onto the fabric and observe how well the substances offered protection.

QUESTIONS FOR THINKING

- Why do you think there are so many different types of washing products available to buy?
- What do you think a good washing product should be able to do?
- How can washing our clothes have a negative effect on the environment?
- How well do you think your group controlled variables and carried out fair washing tests?
- If you were repeating the washing tests, what would you do differently and why?
- What other question would you like to investigate?

SAFETY GUIDANCE

Prior to this activity, check for individuals who may be allergic to ingredients in any of the washing products or foods used to stain fabrics. On the back of many packets for example washing powder, you will find the words 'Danger', 'Keep out of reach of children' or a hazard warning label. Giving the children only minimal quantities of a sample, will reduce risks to an acceptable level, and the products can be used by children safely. Disposable or rubber gloves (non-latex may be required by some children) should be worn to prevent any allergic reactions children may have. As an additional precaution, children might wear safety glasses to prevent the rubbing of washing products into their eyes and warned not to eat or taste any of the products provided. When performing washing tests, hot water from a kettle or water heater should be cooled before use to no more than 50oC and a thermometer used to test this. Care should be taken to avoid splashing water on the skin, even at this temperature, ensuring that any spills are cleaned up immediately and hot water dispensed carefully by an adult.

For more comprehensive safety guidance, provided by CLEAPSS, please log in and go to: ***http://primary.cleapss.org.uk/Resource-File/P005-Investigating-soaps-and-detergents.pdf***

INDUSTRY LINKS AND AMBASSADORS

Links can be made with the washing powder and detergent industry via local companies and company websites. STEM Ambassadors are volunteers from a wide range of science, technology, engineering and mathematics related jobs across the UK. They offer their time and enthusiasm and can be found via the STEM Learning website at ***https://www.stem.org.uk/stem-ambassadors***

Industrial leaders such as Unilever, Procter and Gamble, and Croda provide speciality ingredients for household products including laundry and fabric care. The scientists at these companies are continuously investigating new ways to improve cleaning performance. Each company will have a team of marketing experts whose job is to tell customers about the benefits of choosing their products over others. Children could watch the video clip, 'Marketing the Mixture', at ***http://scienceofhealthyskin.org.uk/foam6.htm*** and have a go at some marketing for themselves!

To enable children to explore one company's solution to the environmental impact of washing clothes, teachers and children follow the slides on the presentation **Sustainable methods of cleaning: which washing product?** and engage in discussion points and activities to develop a further understanding of industrial contexts.

CROSS CURRICULAR LINKS

English: pupils could draft, edit and produce scripts and poster advertisements for the washing product that performed most favourably in their tests. This kind of creative thinking has excellent links with the genre of persuasive writing in the English curriculum.

Mathematics: pupils will use a range of equipment to measure and compare volumes of water and washing products, temperature of water and time taken to remove stains. There is also an opportunity to measure and compare the area of the stains using grids.

Design and Technology: pupils could design new packaging for new and improved washing products. They will select from and use a wide range of materials as well as evaluate their functional properties and aesthetic qualities.

PSHE: pupils will learn what improves and harms their local, natural and built environments and develop strategies and skills needed to care for these (including conserving energy).

Activity Sheet 14: Post-it Planning Template

We could change

We could measure/observe

We will change

We will measure/observe

We will keep these the same...

When I change...

What will happen to?

I think that ______________________________

because ______________________________

13. SUSTAINABLE SOURCES OF FOOD: HOW CAN WE GROW OYSTER MUSHROOMS?

2–3 HOURS + DAILY OBSERVATIONS

Children learn about the importance of maintaining a healthy and balanced diet and how we should choose the right amount of different types of food from different food groups. They consider the benefits of following a more sustainable diet as an alternative to obtaining meat from animals as a source of protein. The activity culminates in the children being challenged to grow a crop of oyster mushrooms as a sustainable food source before learning about one company's solution to producing protein-rich food in a sustainable way.

TYPE OF ENQUIRY

Observing changes over time

OBJECTIVES

Identify that humans, including animals, need the right types and amount of nutrition, and that they cannot make their own food; they get nutrition from what they eat (Y3 Animals including humans)

Describe how living things are classified into broad groups according to common observable characteristics and based on similarities and differences, including micro-organisms, plants and animals (Y6 Living things and their habitats)

Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs (UKS2 Working Scientifically)

SCIENCE VOCABULARY

nutrients, carbohydrates, protein, fungi, livestock, climate change

RESOURCES

Commercially available oyster mushroom growing kit (cost at time of publishing is around £5 to £10). To keep costs to a minimum, the whole class might grow oyster mushrooms from one kit. If you wish to try and grow oyster mushrooms without a growing kit, a comprehensive guide and list of equipment can be found at: ***https://grocycle.com/how-to-grow-oyster-mushrooms/.***

Industry sustainability story: **Presentation**

PRIOR KNOWLEDGE / EXPERIENCE

Children will know the importance of eating the right amount of different types of food.

ACTIVITY NOTES

Introduction: Discuss with children how eating the right amounts of different types of food provides a range of nutrients to the body and helps us to maintain a healthy diet. Consider different food and drink choices in terms of what children believe to be healthy and unhealthy for us.

Recap how our food and drink can be categorised into five main groups and that food from each group should be eaten in different amounts over a day, or even a week. The teacher could show an image of a healthy plate or food pyramid to illustrate how most of what we eat should come from the two biggest groups: fruit and vegetables, and carbohydrates such as potatoes, bread, cereal, rice and pasta. Discuss how we should eat moderate amounts of protein such as beans, meat, fish and eggs in addition to food and drink from milk and dairy products. The smallest amount of food should come from food high in fat or sugar.

Focus the discussion on how the global population is increasing, so to ensure that there is enough food for future generations, it is important to consider the 'sustainability' of the diets we eat. This means that the impact the production of the food, such as amount of land and water used and the emission of greenhouse gases, has on the environment is limited.

Explain how, with sustainability in mind, many people believe that a healthy diet today should include lots of plant-based foods, especially if the fruits and vegetables we eat are those that are in season and grown locally. Another example of food that can be grown is the oyster mushroom – which is not a plant but a type of fungi from the group of living things that includes microorganisms such as yeasts and moulds. The oyster mushroom is considered to be an extremely healthy, sustainable, source of food, rich in protein and with high levels of vitamins.

MAIN ACTIVITY: GROW YOUR OWN OYSTER MUSHROOMS

The simplest way for children to grow their own oyster mushrooms in the classroom is for them to use a commercially available oyster mushroom growing kit. These can be obtained relatively cheaply using an internet search or from a local garden centre. The kits should contain everything you will need, including the growing material (a special compost), mushroom spawn and detailed instructions. The mushrooms often take two to four weeks to grow and then the process can be repeated twice more in order to harvest three crops of oyster mushrooms from the same batch.

Children should be encouraged to keep some form of oyster mushroom growth journal or record of measurements and observations over an extended period. They could include scientific diagrams; photographs or time lapse video as well as written explanations. Through their own observations, they should develop an awareness of the three main phases of growth:

1. **Inoculation:** Oyster mushroom spawn is mixed with a material such as straw, sawdust, wood pellets, cardboard or coffee grounds. This is called a substrate material and it provides the spawn with essential nutrients for it to grow. The mixture is placed into a suitable container with small holes so that air can come in and out.
2. **Incubation:** The spawn will grow and spread out across the growing material. When the container is placed in a warm (20-24oC) dark room, such as a cupboard or boiler room, the spawn will eat its way across the food. After 10-14 days, they will grow a full web of white, root-like threads.

3. **Fruiting:** Once the spawn has spread, it is important to expose it to new conditions in order for the mushrooms to grow. This includes: shaded, low level light, fresh air, humidity (spray with water) and cooler temperatures. Small pins will begin to emerge, which grow out of the container into full size mushrooms.

EXTENSION OR HOME-BASED ACTIVITIES

Ask the children if they have any further questions they would like to find answers to as a result of growing oyster mushrooms. They might be interested in finding out what would happen to the growth of mushrooms in different conditions and set up further investigations by changing the original environment in which they have been grown.

QUESTIONS FOR THINKING

- Why do you think it is important to eat different amounts of different types of food each day or week?
- Which plant-based food do you enjoy eating?
- Can you explain whether a mushroom is an animal, plant or something else?
- Why is it important to eat food that has been grown locally?
- What do you think to the idea of 'Meat free Monday'? Why do you think this?

SAFETY GUIDANCE

Some fungi are very poisonous so make sure you obtain the spawn from a reliable source – do not be tempted to gather your own from the countryside. Before and after working with mushrooms, spawn or growing material, ensure that children follow strict hygiene rules by cleaning their hands well with hot soapy water and wiping down all surfaces they are working on with a cleaning spray. Children should not eat during the activity or handle items such as notepads.

We do not advise cooking and eating the mushrooms you have grown. If you decide to, you should follow the guidelines in The ASE booklet Be safe! (4th edition), which has a safety code for food hygiene. In addition to this, the 1990 Food Safety Act can be found online.

INDUSTRY LINKS AND AMBASSADORS

Links can be made with the food industry via local companies and company websites. STEM Ambassadors are volunteers from a wide range of science, technology, engineering and mathematics related jobs across the UK. They offer their time and enthusiasm and can be found via the STEM Learning website at ***https://www.stem.org.uk/stem-ambassadors***

Ambassadors visiting the classroom could bring real samples of food products and their packaging as well as relevant resources to show the various stages of growing alternative plant or fungi-based sources of food. Children might enjoy having a go at 'taste testing' to see whether they can identify alternative versus original products (once dietary/religious restrictions have been confirmed). To enable children to explore one company's solution to the search for more sustainable sources of food, teachers and children should follow the slides on the presentation **Sustainable sources of food: how can we grow oyster mushrooms?** and engage in discussion points and activities to develop a further understanding of industrial contexts.

CROSS CURRICULAR LINKS

Mathematics: measure, compare, add and subtract lengths (m/cm/mm); mass (kg/g); volume/capacity (l/ml)

PSHE: to research, discuss and debate topical issues, problems and events that are of concern to them and offer their recommendations to appropriate people; learn that they have different kinds of responsibilities, rights and duties at home, at school, in the community and towards the environment; to continue to develop the skills to exercise these responsibilities

14. SUSTAINABLE SOURCES OF ENERGY: WHICH PLANT MATERIAL?

2–3 HOURS

Children learn about what fossil fuels are and how they are used, in particular to make electricity. The discussion focusses on the need for renewable energy and how this can be less harmful to the environment. Children are challenged to carry out two investigations for a fictitious company in order to find a sustainable plant-based source of fuel. They will then learn about a real company's solution to producing energy for heating and electricity from natural, sustainable sources such as plants.

The original activity and comprehensive background information can be found on Activity 2 of ***http://www.ciec.org.uk/pdfs/resources/renewables-dont-run-out.pdf***.

TYPE OF ENQUIRY

Observing changes over time / Carrying out comparative and fair tests

OBJECTIVES

Compare and group together everyday materials on the basis of their properties (Y5 Properties and changes of materials)

Give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials (Y5 Properties and changes of materials)

Explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible, including changes associated with burning and the action of acid on bicarbonate of soda (Y5 Properties and changes of materials)

Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations (UKS2 Working Scientifically)

SCIENCE VOCABULARY

crude oil, fossil fuel, non-renewable, carbon dioxide, climate change, burn, compressing

RESOURCES

per class

- 1 large bowl of each: straw, hay, wood shavings/chips
- 1 bucket of sand or water (emergency use)
- timers – 1 per child or pair if possible
- 3 clear sealable plastic bags
- safety glasses
- 3 metal baking trays/roasting tins or similar
- 1 safety lighter (teacher use)
- **Activity Sheet 15** (letter from company)

RESOURCES

per group of 4, unless otherwise stated

- Access to straw, hay, wood shavings/chips Note: the plant material must be completely dried
- 1 x 500g food can or 1 x 1kg weight
- Access to push meters of different scales if possible
- **Activity Sheet 14:** Post-it planning template
- 1 x 1000ml jug and 1 circular disc of thick card measured to fit inside of the jug
- Access to weighing scales
- Two colours of post-it notes
- Industry sustainability story: **Presentation**

PRIOR KNOWLEDGE / EXPERIENCE

Children will have had some experience of setting up simple practical enquiries, comparative and fair tests.

ACTIVITY NOTES

Introduction: Activity Sheet 15 is a letter which introduces the children to a fictitious company and forms the context to both activities in this lesson. Discuss with the children why the company might want to find an alternative fuel to crude oil. Explain that this is a thick, yellowy-black liquid found naturally by drilling down through rocks on land or off-shore. Because it burns very well it is considered to be one of the world's most important fuel sources.

Presentation slide 2: Continue the discussion to include how crude oil is called a fossil fuel because it was formed from the remains of animals and plants that lived millions of years ago before the dinosaurs. Over many years, the remains were covered by layers of mud. Heat and pressure from these layers helped the remains turn into what we call oil.

Explain to children that crude oil is a non-renewable fuel as it takes millions of years to form and will eventually run out. (**Presentation slide 3**) Fossil fuels also release carbon dioxide gas into the air when it is burned, and this can contribute towards climate change. Discuss how it is important that we find new, environmentally friendly, sources of fuel for things like heating and making electricity.

Focus the discussion on how the population of the world is increasing, so to ensure that there will be enough energy for future generations, it is important to consider the 'sustainability' of the sources we use.

MAIN ACTIVITY 1: WHICH PLANT MATERIAL BURNS BEST?

Firstly, children are going to generate ideas for how they can compare samples of straw, hay and wood shavings/chips to find out which plants are best for the company to burn in their boiler. Each group should discuss what being 'best' means, e.g. burns for the longest, brightest flame etc. Post-it planning template (**Activity Sheet 14**) can be used to generate ideas at this stage, before collating suggestions as a whole class. The best aspects of each group's plans can be combined to provide the teacher demonstration.

The children can be involved in several aspects of the practical activity, such as: measuring equal amounts of plant material, emptying the measured material into a metal tray ready for testing, photographing and filming the process, measuring and recording close observations such as the duration of burning, flame type, smoke produced etc., creating a commentary.

The amount of ash and burnt material can be collected and, once cool, could be put into a clear plastic bag and used for display purposes. It could also be weighed and compared to the weight of the plant material at the start. Discuss why there may be a difference and what has happened to the plant material during the burning, i.e. an irreversible change.

SAMPLE BURNING RESULTS

hay	Takes time to ignite, smoulders rather than burns, produces a lot of smoke, and does not burn out completely.
straw	Burns readily, produces little smoke, quickly burns itself out, and leaves very little ash.
wood shavings/ chips	Ignite readily, produce little smoke, burn slowly but steadily and leaves ash.

Ask groups of children to consider what their findings tell them, and which burning properties would be attractive to a company. They will hopefully conclude that the company would be looking for a plant material that burns slowly and cleanly with little smoke and produces small amounts of ash.

MAIN ACTIVITY 2: WHICH PLANT MATERIAL CAN BE STORED MOST EASILY?

Each group is given samples of the straw, hay and wood shavings/chips to observe and handle. Children should think about how large quantities of plant material would take up a lot of space and so would be inefficient to transport and store. They should refer back to the original letter and discuss why many deliveries by lorry would not be an environmentally friendly solution to the problem.

Small groups should explore the effect of compressing the dried plant material, e.g. How can we reduce the space (volume) it takes up? Does compressing change the weight? Does it make it easier to transport? Could the compressed material be used for anything else?

Using the questions above, small groups of children should plan their test and choose resources needed to carry it out. The post-it planning template (**Activity Sheet 14**) can be used to help limit the independent variable to one (the plant material) and maintain fair test conditions. Dependent variables to consider include the amount of plant material, the method of compressing, length of time of compression, the method of measuring compression.

The following process provides one possible way to investigate the changes taking place and suggested method of collecting data:

1. Fill a jug with plant material up to the 1000ml line (be careful not to compress any of the material).
2. Place the circular card disc on top of the plant material and ensure that it lies exactly on the 1000ml measurement line (you might need to add more plant material or remove some).
3. Weigh the filled jug.
4. Compress the material using weights (a heavy food can will work well) or by pushing down an agreed force using a push-meter for an agreed amount of time.
5. Remove the weights/stop pushing and note the new volume of the plant material using the scale on the jug.
6. Re-weigh the jug.

Each group should report their findings on the compression of the dried plant materials, explaining what they have found out with respect to mass and volume, and possibly density – when material is squashed to make it smaller, it weighs the same but becomes more dense.

Discuss the idea that reducing the volume of the plant material by compressing it will reduce the number of vehicles required to transport it. By producing briquettes, small compressed packs of material, it is easier to handle and transport and will be in a form that can be used easily when adding to the boiler.

Children should combine their findings from the compression investigation with their observations made during the burning activity, and then make final decisions regarding which plant material would make the best sustainable source of fuel for the company.

EXTENSION OR HOME-BASED ACTIVITIES

Children might like to draft and produce a letter to the company in order to make their final recommendations. They could include data and results from their investigations in an appropriate format as additional evidence to support their conclusions.

Children might also be interested to research other forms of renewable energy and how these are created. They could look for solar powered items around the home, such as calculators, garden lights or roof panels. They may live near to wind turbines and could find out more about what they are and what they do.

QUESTIONS FOR THINKING

- How do the plant materials compare to the most common fuels; gas, electricity, coal and oil?
- Can the waste products be used for other purposes? (e.g. ash can be used to manufacture concrete and be used as fertilizer.)
- What problems could there be in transporting enough dried plant material to the company to keep the boiler going?
- What difficulties might there be with storing large quantities of plant material on site?
- Why might it be more convenient to convert fuel to electricity and supply it through a cable rather than burn the fuels on site?

SAFETY GUIDANCE

The burning investigation is a teacher-led practical activity and the following safety precautions must be taken:

Carry out the activity in the open-air (middle schools may have a fume cupboard) or liaise with the local secondary school. Only burn small samples of plant materials and have a bucket of sand or water close by for use as an extinguisher, if necessary. Only supervising adults should extinguish flames, not children. The teacher should wear safety goggles and have long hair tied back. Be aware of the weather conditions so that the children are not downwind of the activity and are out of the way of any smoke produced or any material which may get blown about. Check for children who may have allergies to plant material and ensure that children who have asthma have ready access to their inhalers.

For more comprehensive safety guidance, provided by CLEAPSS, please log in and go to: ***http://primary.cleapss.org.uk/Resource-File/P018-Investigating-burning.pdf***

INDUSTRY LINKS AND AMBASSADORS

Ambassadors visiting the classroom could talk about how they produce heat and electricity for their site, what targets they have set themselves and what they are doing to be more environmentally friendly. Children will be interested to hear about job roles including Environmental Officer. Some companies have introduced initiatives such as: electric vehicles for staff, energy saving lighting installed in all offices as well as using landfill gases as a source of energy. Some companies have won awards or special recognition for aspects of sustainability and it is important for the children to hear stories of positive environmental impact.

To enable children to explore one company's solution to the search for more sustainable sources of food, teachers and children should follow the slides on the presentation **Sustainable sources of energy: which plant material?** and engage in discussion points and activities to develop a further understanding of industrial contexts.

CROSS CURRICULAR LINKS

English: identify the audience for and purpose of the writing, select the appropriate form and use other similar writing as models for their own. Plan their writing by noting and developing initial ideas, drawing on reading and research where necessary.

Mathematics: estimate, compare and calculate different measures.

PSHE: learn what improves and harms their local, natural and built environments and develop strategies and skills needed to care for these (including conserving energy); learn that resources can be allocated in different ways and that these economic choices affect individuals, communities and the sustainability of the environment across the world.

Activity Sheet 15

Dear Scientists

Our company makes ingredients used in many different products, ranging from soap and body wash to kitchen cleaners. We want to ensure our products do as little damage to the environment as possible and would like your help with this.

We were wondering if we could burn dried plants instead of crude oil in our boiler to produce steam for heating and making electricity for use on our site.

Things we think we could burn, available from local companies, include straw, hay and wood shavings but we are not sure which one would be best to use.

The oil we currently use is delivered to us by pipeline with little or no disruption. We are worried that we would need very large quantities of plant material and we do not have enough room to store it on site.

Also, we would need many lorries every day to bring the plant materials on to our site. This will be very expensive for us and result in a lot of extra traffic on the roads.

We would like you to carry out some tests and provide us with evidence to help us make some difficult decisions. Any extra research you can do would also be very useful to us.

Yours faithfully

Susan Carlton
Environmental Manage

CIEC offers support for the teaching of science across the primary age range and beyond. This support includes CPD programmes, bespoke in-school CPD, interactive websites for teachers to use with their pupils, and a wide range of downloadable resources which encourage collaborative, practical problem solving. For more information, please visit our website:

www.ciec.org.uk

or contact:

Centre for Industry Education Collaboration
CIEC Department of Chemistry
University of York
York
YO10 5DD

01904 322523

ciec@york.ac.uk

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Authors – Nicky Waller, Jane Winter and Mackayla Millar
Editor – Joy Parvin

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