SUSTAINABLE STORIES AND SOLUTIONS FOR OUR PLANET

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

CENTRE *for* INDUSTRY EDUCATION COLLABORATION

CHEMICAL INDUSTRIES ASSOCIATION

synthomer

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INTRODUCTION

The future holds many challenges for young people, and to secure the future of children across the world and decrease the burden on our planet, we need to move towards more sustainable development.

This publication introduces specific sustainability issues and impacts for primary children aged 9-11 years. All activities are linked to the English National Curriculum for Science, with a focus on the upper key stage two programme of study incorporating substantive and disciplinary knowledge.

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 develop an awareness of vocabulary linked to current environmental issues. A glossary provides a comprehensive list of key environmental vocabulary introduced here, then used throughout the activities. Children are encouraged to return to their original ideas after completing each activity to compare their definitions, make amendments each time, and reflect upon the learning that has taken place.

MAIN ACTIVITIES

Polymer manufacture provides the context for learning about sustainability practices in industry. Knowledge of polymers goes beyond the key stage two curriculum so children will be introduced to them simply as an 'important ingredient'.

There are four main activities, which introduce children to a range of different challenges within the context of sustainability. These include the sustainability of:

- ingredients used to make less harmful emulsions
- monitoring microbe growth to ensure product safety
- ingredient selection to produce durable products which use less heat and material to make.

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 discussions and problem solving. Children should be encouraged to develop their own ideas and questions, methods of recording, drawing conclusions and making recommendations.

Questions for thinking are included for each activity and should be asked as a 'drip-feed' throughout the activity.

POWERPOINT PRESENTATIONS

A presentation accompanies the main activities. These build one company's story to enrich and contextualise the children's learning of sustainability. Children will learn and find out about how scientists and engineers are striving to find solutions to sustainability issues.

Each presentation concludes with a STEM Careers profile collectively featuring a range of scientists and engineers working at the company. These aim to highlight real-world jobs and inspire pupils to make connections between their classroom learning and the exciting range of STEM career opportunities available to them.

In addition to the PowerPoint presentations, teachers may wish to make links with industry via local companies and/or their 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 ***www.stem.org.uk/stem-ambassadors.***

SUMMARY OF ACTIVITIES

THEME	SUMMARY OF ACTIVITIES	APPROXIMATE TIME TAKEN
Introductory activity 1: 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)
Introductory activity 2: 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)
1 Mixing ingredients	Children explore how oil and water behave when they are mixed together, predicting outcomes and testing different stirring devices. They go on to observe how adding an emulsifier to the mixture is a more sustainable way to help oil and water stay mixed for longer.	1 hour
2 Monitoring microbes	Children dab their fingers onto agar plates before and after cleaning their hands, then grow their samples to observe how many bacteria are revealed. This activity is designed to prepare children for a more in-depth investigation in Activity 3.	1 hour plus daily observation time over two weeks
3 Who has the cleanest classroom?	Children use the skills learned in Activity 2 to test various classroom surfaces to model how scientists work in industry to ensure products are clean and safe for customer use. They discover that good hygiene prevents waste, helping products last longer instead of needing to be replaced.	1 hour plus daily observation time over two weeks
4 A bit of a stretch	Children design an investigation to discover which type of rubber or plastic is best for making stretchy protective gloves, learning that durable, flexible materials help reduce waste. They will use measuring equipment to record how each material stretches.	1–1.5 hours

SAFETY GUIDANCE

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 ethics. 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.

INTRODUCTORY ACTIVITY 1: PREPARATORY SURVEY

1 HOUR, PLUS 15 MINUTES 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?

INTRODUCTORY ACTIVITY 2: ENVIRONMENTAL VOCABULARY

30 MINUTES + 15 MINUTES 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 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 environment 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

1. MIXING INGREDIENTS

1 HOUR

In this activity, children explore how oil and water behave when they are mixed together, predicting outcomes and testing different stirring devices. Children go on to observe how adding another liquid (called an emulsifier) to the mixture can help oil and water stay mixed for longer.

TYPE OF ENQUIRY

Problem solving

OBJECTIVES

Be able to give reasons, based on evidence from comparative tests, for the uses of everyday materials.

To carry out investigations making careful observations.

SCIENCE VOCABULARY

mix, mixture, liquid, separate, ingredient

RESOURCES

(per group of four, unless otherwise stated)

- **Activity Sheet 4**
- 3-6 x 1-litre beakers, measuring jugs or similar size transparent containers
- 3+ stirring devices with varying levels of efficiency e.g. 1-2 stirring devices from each of the following:
  - Low efficiency: wooden coffee stirrer, pencil, spoon, straw
  - Moderate efficiency: fork, manual hand whisk, coil whisk
  - High efficiency: rotary hand whisk, press whisk, milk frother, electric whisk,[1]
- 3 x 500 ml water (1500 ml in total)
- 3 x 40 ml cooking oil (120 ml in total)
- 5 ml washing up liquid (emulsifier)
- pipette, teaspoon, or syringe
- stopwatch

NOTE:

Quantities of the oil and water have been carefully considered, taking care to limit the amount of oil used for clean-up and resource cost purposes. The amounts specified keep oil use to a minimum whilst still allowing for good scientific investigative process.

1 To reduce resource cost and adult supervision requirements, only one electric whisk is needed per class.

SAFETY GUIDANCE

If using an electric whisk, it must be checked by the teacher before use and used on a stable surface. Children should operate the whisk under close adult supervision, with clear instructions to keep fingers, hair, and loose clothing away from the moving beaters.

Remind children to use whisks gently, limiting contact with the jug/container to avoid breakages.

To dispose of oil, it can be treated as food waste. Put it into a strong plastic bag containing absorbent material (e.g. sand, newspaper, a clean nappy, cat litter), tie the plastic bag and place it in the bin.

PRIOR KNOWLEDGE/EXPERIENCE

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

ACTIVITY NOTES

Part 1

Present children with water and oil and ask what will happen if they are mixed together. Following small group discussion, ask children to share their ideas. Some may be aware that oil and water do not mix; they are known as immiscible liquids.

Groups make up three+ samples of oil and water (one for each stirring device they will test), adding the 40 ml of oil first each time and observing what happens when the 500 ml of water is added. They will see that the oil moves above the water.

Children may ask why this happens. The explanation goes beyond the primary curriculum, so teachers should use their judgement to decide whether to elaborate. A primary friendly explanation is that 'for its size' oil has less mass (or 'stuff' in it) than the same amount of water, so it floats on top of the water.

Children now explore the stirring devices, to find out how well each mixes the oil and water. Allow time for them to consider the criteria for a good stirring device, e.g. the longest lasting mixture or the shortest time taken for the ingredients to become fully mixed.

Note: The more stirring devices children try, the greater the range of results they will have to compare.

Encourage children to make reasoned predictions about how each stirring device will affect the mixing. They may describe the properties of the stirring devices, such as the type and thickness of the stirrer's material or the speed at which they stir/mix.

On testing the stirrers, children should discover that the milk frother or electric mixer create the longest lasting mixtures.

The class share and discuss their results in relation to their predictions and attempt to generalise the properties required for a 'good' stirrer.

Children should conclude that when water and oil are stirred, they create a temporary mixture; and the better they mix, the longer the mixture lasts before separating.

Part 2

Read the letter (**Activity Sheet 4**) to the class from a scientist at the real company Synthomer, to introduce the 'Sustainable Ingredients' challenges. In this first challenge, Synthomer explain that some ingredients they use don't stay mixed for long and they would like them to stay mixed for longer. They've heard that an ingredient called an emulsifier will help and invite children to find out if this is the case.

Explain that Synthomer do not mix oil and water but have asked the class to use these liquids because they have the same properties as the ingredients they use and are safe to use in the classroom. Tell children that you will provide an emulsifier, washing up liquid, for their investigation.

Children will now use two fresh samples of oil (40 ml) and water (500 ml) and select an appropriate stirring device. The existing samples which the children have just mixed can be used to reduce resources needed but some time will be needed to allow them to settle first. Before collecting their sample of emulsifier, groups plan their stirring method and how they will record their observations.

A child from each group collects a 5 ml pipette of the emulsifier and adds it to one of their two samples. Both samples should then be mixed using their chosen device. Groups compare both samples, looking at how well and for how long, each sample is mixed. They discuss the results of their observations and verbally share their findings with the class. Some of the Questions for thinking can be used to guide discussions. The class share their observations with each other.

TOP TIPS

When using the manual hand whisk, if children struggle with the standard one-handed whisking method, encourage them to rub back and forth with the handle of the whisk between the palms of their hands.

To ensure the class includes the full range of stirring devices you have provided, provide each group with a sub-set to test and allow time for each group to share their results with everybody at the end.

Stirring for 30 seconds and allowing 30 seconds for the mixture to settle produces good results.

Photographs taken at agreed intervals can be a good way of comparing the appearance of the mixtures.

Measuring jugs can be purchased cheaply from low-cost homewares stores,[2] or 2-litre pop bottle can be collected, cut to size, and 100 ml increments marked on the side in permanent marker.

Provide a tray and/or paper towel to provide a surface to store stirrers in between uses to help reduce the post-activity clean-up.

If resources allow, children compare the top one or two stirrers identified in their earlier investigation to see which performs best, or ask each group to try a different stirrer, ensuring that broader range of the stirrers is tested.

At the end of the lesson, include children in the oil disposal process by discussing the absorbent materials you will use (**refer to safety guidance on page iv**) and how keeping oil out of the school drainage system prevents drain blockages.

Plenty of warm soapy water will be needed to clean up the jugs and stirrers which have been in contact with the oil.

2 1-litre measuring jug 50p from Dunelm and ASDA (correct at time of publication)

BACKGROUND INFORMATION

This information is to support the teacher's knowledge of the subject only. It should not be used in the classroom.

Polymers are a family of materials we encounter in lots of everyday items from clothes to cars. They can occur naturally (such as silk) or be manufactured and are often called 'plastics' (such as disposable coffee cups). They can be liquids or solids (including powders) and can be made to have different properties such as being flexible, brittle, stretchy, transparent, opaque, biodegradable and much more; to make them fit for purpose. Many products are made from or include polymers, like polythene used for food packaging, nylon used to make clothing, and the ingredients used to make the glue we use at home and school. Some polymers act as the 'glue' in paints; others are used to make strong and flexible gloves.

Making polymers requires heat to help the ingredients to change into a new product (or 'react'). When the ingredients change, a lot of heat is generated. Companies have dedicated teams of scientists and engineers who work out how to reduce the impact of their products on the environment by:

- using less heat
- finding ways to recover heat from reactions
- reducing the amount and type of waste products that can be harmful to the environment
- improving the durability of their end products.

These companies also help their customers to find ways to use heat when they mix the polymers to make their products. One example is a polymer that has been designed so the customer (company making gloves) needs **a third less** energy; as the gloves can now be made thinner than before, whilst having the same important properties of strength and elasticity.

Emulsifiers are an important addition in the mixing/changing process. They ensure that the ingredients mix evenly throughout the whole vessel, resulting in the reaction taking place evenly throughout the vessel. Poor mixing results in poor reactions and can have safety and environmental impact, with poor material produced that could need to be disposed as waste.

QUESTIONS FOR THINKING

- Why are the oil and water separate?
- Can you think of any other liquids that do not mix?
- How did the different stirrers affect how long the oil and water stayed mixed together?
- How does the stirring speed affect the mixing process?
- What effect did the washing up liquid have on the mixture?
- Can you think of any other liquids that you mix together at home? What do you think will happen when you mix them?
- Can you think of any liquids and solids that can be mixed? What happens to them?

USING THE PRESENTATION

Before beginning part two of this activity, share slides 2 and 3 of the PowerPoint presentation with children to introduce the idea of different ingredients being made and used by different companies.

Following part two, revisit presentation slide 2 and introduce one company that carries out this kind of work; Synthomer, which is an example of Company B. They buy emulsifiers from Company A to make their product, which other companies then buy from them. Slide 4 shows children the equipment Synthomer uses to mix emulsifiers with other liquids to make their important ingredient (or 'product'). This piece of equipment is called a feed vessel and works like a blender which you might find in a kitchen. It mixes ingredients evenly, to ensure the mixture has a consistent texture. The creamy white colour at the top shows where the separate ingredients are becoming mixed.

Slide 5 shows an industrial scale reactor. It works in a similar way to the feed vessel but it is much larger, meaning larger volumes of ingredients can be added to make larger volumes of product. Inside the reactor, temperature, mixing speed, and the order ingredients are added can be controlled using automated computer programs, to ensure the same recipe and process is followed each time. To support development of science capital, encourage children to make connections between the industrial stirring machines to items in their daily lives which work in similar ways. They may suggest items such as whisks, coffee frothers and food blenders.

To conclude the lesson, use the STEM Careers slide at the end of the presentation to highlight real-world jobs in STEM to further nurture children's science capital. Share Susana's career profile to inspire pupils by helping them make connections between their classroom learning and the science that is used in exciting jobs.

INDUSTRY LINKS AND AMBASSADORS

Scientists and engineers working in a wide range of industry sectors can be asked to bring photographs or videos of reactors/industrial stirrers in action or types of stirring required for different purposes. Pictures and videos of 'bad' mixing, where batches or liquids have been spoiled or resulted in solid lumps, would also be worthwhile, and are often very memorable for children! Photographs or real samples, where safe to do so, of emulsifiers or other ingredients used to make products will enhance children's understanding.

STEM CAREERS

Susana, pictured here with a jar of Synthomer's important ingredient, is a scientist who works as a team with fellow scientists and other colleagues at Synthomer to develop ingredients that are more sustainable by being less harmful to the environment and safer for people. Susana loves her job because she feels she is contributing to a better world.

Activity Sheet 4

Dear scientists,

At Synthomer, we make important ingredients that go on to be used in materials that need to be stretchy, strong, and bendy. Rubber gloves, food packaging, and glue are all examples of where our ingredients are used.

We want our ingredients to be more sustainable, so when we make them, we think about (i) how to mix them, (ii) how to use less heat and less material, (iii) using ingredients which are safe for people and the environment, and (iv) ensuring our ingredients are stretchy enough for our customers to use in their products.

We would like your help to improve the way we make our ingredients the best they can be. Please can you help us solve these problems:

We need to mix ingredients that don't stay mixed for long naturally. We've heard using an emulsifier will help them stay mixed for longer. Can you find out if using an emulsifier makes a difference?

We want to test our ingredients to make sure microbes cannot grow inside them. Can you recommend a way for us to do this?

A customer wants to use our important ingredient to make protective gloves which are stretchy. Can you test some different materials to see which one is the most stretchy, and how all the other materials compare?

We look forward to hearing from you with the results from your investigations.

Yours sincerely

M. Pandey

Manisha Pandey
Scientist

2. MONITORING MICROBES

1 HOUR PLUS A WEEK OF 10-MINUTE DAILY OBSERVATIONS OVER TWO WEEKS

Children dab their fingers onto agar plates before and after cleaning their hands, then grow their samples to observe how many bacteria are revealed. This is a skill building activity designed to prepare children for a more in-depth investigation in Activity 3 so please complete this first. If children are sufficiently skilled, this activity can be skipped.

This activity requires additional resources, preparation time, and access to suitable materials. If children are already confident in the relevant practical skills, it can be omitted. To help reduce costs or preparation demands, you may wish to work with a local secondary school science department, university, or local company, which may be able to provide materials, facilities, or advice.

TYPE OF ENQUIRY

Comparative test

OBJECTIVES

Plan different types of scientific enquiries to answer questions. (UKS2 Working Scientifically)

Describe how living things are classified into broad groups according to common observable characteristics and based on similarities and differences, including microorganisms.

(Y6 living things)

SCIENCE VOCABULARY

microbe, microorganism, bacteria, germ, clean, dirty, grow, nutrient, food source, living thing

RESOURCES

(per group of four, unless otherwise stated)

For the introductory activity:

- Access to soap and water for whole class handwashing
- Hand sanitiser (enough for the class to clean hands once)
- 3 sterile Petri dishes with agar solution (+1 Petri dish for class control sample)[3]
- tape for sealing Petri dishes e.g. medical tape[4]
- permanent marker pen or stickers to identify each person's fingerprint
- **Activity sheet 4, Activity Sheet 5** (optional)
- Protective gloves (if needed see safety guidance for further details)

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3 20 disposable Petri dishes £3.00 from Philip Harris. 10 agar Petri dishes £19.72 exc. VAT from Breckland Scientific. Prices correct at time of publication. Alternatively, you can make your own, see guidance on page 18.

4 Medical tape is available from pharmacies or supermarket first-aid supply section

AGAR PLATES – ADVANCE PREPARATION GUIDANCE FOR TEACHERS

If purchasing pre-made agar plates:

- Check the supplier's advice on shelf life, this can differ significantly.
- Check storage requirements, some require refrigeration whilst others advise against it.

A lower cost alternative to buying agar plates is to make your own. This is a straightforward process but you will need to factor in the following:

- Time is required to prepare these in advance.
- Care is needed to ensure plates remain sterile throughout the preparation process.

To make approximately 30 agar plates, you will need:

Equipment	Ingredients
Anti-bacterial surface cleaner and cleaning cloth Microwave Kettle Microwave-safe glass measuring jug 30 sterile petri dishes Cling film	900 ml boiled water 3 tsp agar agar powder ½ plain beef stock cube 1 tsp sugar

INSTRUCTIONS:

Use an anti-bacterial surface cleaner to prepare a clean surface big enough to lay out enough petri dishes to make your planned number of agar plates.

Microwave the microwave-safe glass measuring jug (2 minutes) to sterilize.

Pour the boiled water into the glass jug. Add the agar agar powder, plain beef stock cube, and sugar to the jug. Stir until completely dissolved.

Place the agar mixture into the microwave (full power, 2 minutes). Keep a close eye on the mixture to make sure it does not boil over.

Let the mixture cool for 1 minute before removing it from the microwave. Take extra care when removing, the bowl and agar mixture will be hot.

Pour the mixture into the petri dishes and cover with clingfilm to prevent any germs from the surrounding area getting into the cooling mixture.

Leave the mixture for 1hr to cool and solidify.

Check the mixture has cooled fully before removing the cling film and placing the lid onto the dishes. Do not put the lids on until the mixture has cooled, this will cause condensation to become trapped, making observation difficult.

NOTE:

Time to make: 20 minutes + 1 hour cooling time

Agar plates can be stored for up to 4 weeks in a refrigerator at 4°C until ready for use.

Homemade agar plates work just as well as factory-made plates but may look different, as the colour and surface texture can vary.

SAFETY GUIDANCE

The agar solution is safe to touch. Children with skin sensitivities should wear protective gloves for this activity and wear them for a short while prior to doing the finger dab to enable exposure to microbes. Over a break or lunch time would work well.

Some agar powder packages are labelled 'may contain traces of nuts' so please check the packaging carefully.

Once sealed, Petri dishes **MUST NOT** be reopened. Growing microorganisms releases invisible spores and can lead to respiratory irritation. The dishes should be disposed of in their sealed condition at the end of the investigation.

CLEAPSS recommend carrying out activities using agar plates with support from a secondary school partner for safe disposal. For more information, please visit the CLEAPSS website and search for the term 'agar plates'.

PRIOR KNOWLEDGE/EXPERIENCE

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

ACTIVITY NOTES

Revisit the letter from the company scientist **(Activity Sheet 4)** and explain that Synthomer use regular testing to keep their ingredients free from infection caused by bacteria, a group of tiny living things known as microorganisms. It is important that Synthomer keep their ingredients infection free so they are safe for their customers to use and they don't have to throw away infected products, like we might throw away mouldy bread.

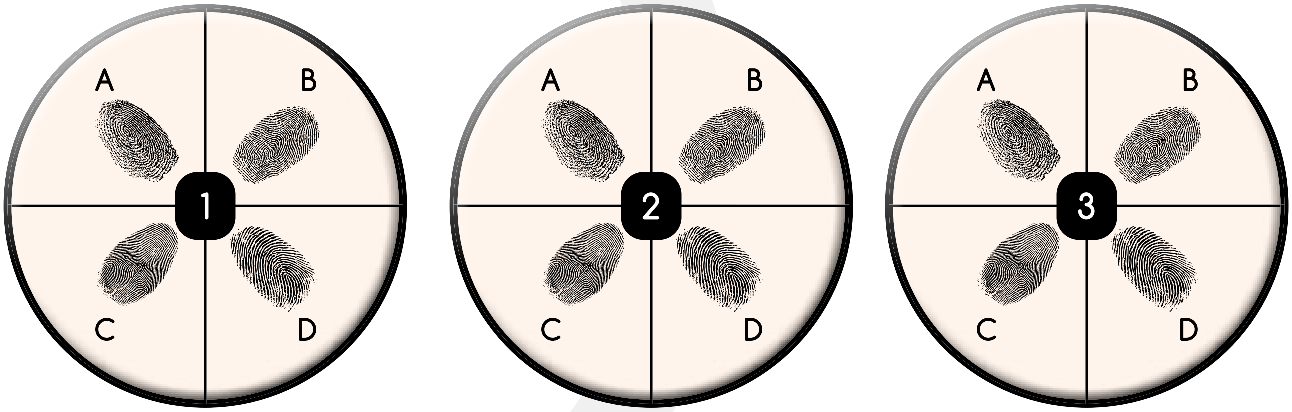
Children will prepare for Activity 3 by carrying out a finger dab test and learning how to monitor microbe growth using an agar plate. When bacteria grow on the plates, they form small spots called colonies which make the otherwise invisible bacteria easier to observe and compare.

A control agar plate should be set-up which children use for comparison; a sterile Petri dish containing agar solution which is sealed without coming into contact with any other surfaces.

In groups, children use a sticker or permanent marker to indicate where they will place their fingerprint on the base of three agar plates as follows:

- Plate 1 – Unwashed hands
- Plate 2 – Hands then washed with soap and water
- Plate 3 – Hands then cleaned with hand sanitiser

Each child will place a fingerprint in each of the three plates. They should use the same finger to place their print in each of the agar plates.



Unwashed hands

Hands washed with soap and water

Hands washed with hand sanitiser

Place the lids on the Petri dishes and seal with tape. Leave the agar plates to develop in a dark place at room temperature (20-25°C). Microbe growth should be visible after 2-3 days.

Over the next fortnight, take approximately ten minutes each day to monitor the agar plates. A photo or sketch diary would enable children to compare the plates based on microbe growth. **Activity Sheet 5** can be used for this purpose, or children can create their own record, e.g. counting the number of individual microbe colonies they can see to generate numerical data for comparison.

Observations are likely to reveal that different types of microbes are present. Children may notice that they have grown microbe colonies which differ in size, colour, and number. They may also see that colonies can grow at different speeds; some spread out and cover the plate, perhaps merging with other colonies, whilst others remain isolated and small. These differences occur because different types of bacteria will be growing and like other living things, different species behave differently.

The **Questions for thinking** (below) support the development of children's higher order thinking skills. The information provided below is included to provide support in scaffolding children's responses:

Microbes grow on agar plates because agar is a jelly-like substance that contains water and nutrients, which gives tiny living things such as bacteria and fungi the food and moisture they need to multiply. As they reproduce, they form visible groups called colonies. These colonies can be different colours, such as white, cream, yellow, orange, pink or even green, depending on the type of microbe. Different growth patterns can often be observed on different agar plates because the microbes that land on them come from different places, for example, hands before washing, hands after washing, or surfaces around the classroom.

Cleaning hands with soap or using hand sanitiser usually reduces the number of microbes, so fewer colonies are likely to grow on the agar. Colonies can also be different shapes and sizes; some may be small and round, while others may spread out in fuzzy or uneven patterns. Some microbes grow faster than others because they have different needs and life cycles. To find out the names of the microbes, scientists would need to carry out further investigations in a laboratory, such as using microscopes, special tests, or comparing them with known samples, as this cannot be done just by looking at the agar plate.

TOP TIPS

Some of the bacteria growing can be similar in appearance to mould, which children may be more familiar with. To avoid future misconceptions, a short conversation around the differences between bacteria and mould will support children to recap (or introduce them to) grouping and classifying microorganisms in their year 6 living things topic. Bacteria are simple living things which can live on their own and grow by splitting in two. Some are helpful (like bacteria in the stomach) while others can make us ill. Mould is a type of fungus and grows in a network of fine threads; it spreads by releasing spores into the air.

QUESTIONS FOR THINKING

- Why do the microbes grow?
- Did all agar plates grow microbe colonies? Why?
- What conditions did you grow your microbe colonies in?
- What different colour colonies can you see?
- How many different microbe colonies are in each agar plate?
- Can you find similar growth patterns across different agar plates?
- Has cleaning hands with soap or using sanitiser reduced the number of microbes?
- Are the microbe colonies different shapes or sizes?
- Did some microbe colonies grow faster than others?
- How might scientists find out the name of different microbes?
- Background information

This information is to support the teacher's knowledge of the subject only. It should not be used in the classroom.

An agar plate is a shallow Petri dish filled with a jelly-like substance called agar which is made from seaweed. Agar gives microorganisms the nutrients and water needed to grow, and the plates are used by scientists to see what microorganisms are growing in different environments.

USING THE PRESENTATION

Ingredients which cause less harm to the environment, used by companies like Synthomer, are prone to infection caused by bacteria. Before Activity 2, share the slides to show how lab testing is carried out to ensure products are free from infection.

To conclude the lesson, use the STEM Careers slide at the end of the presentation to highlight real-world jobs in STEM to nurture children's science capital. Share Vaishali's career profile to inspire pupils by helping them make connections between their classroom learning and the science that is used in exciting jobs.

INDUSTRY LINKS AND AMBASSADORS

A scientist, university student who works in a lab setting, or secondary school biology lab technician would be an excellent choice of ambassador to visit the classroom to help you enrich this activity. They may be able to demonstrate some of the practices for ensuring clean working conditions in the lab and bring photographs and equipment to show children. Depending on their working environment, they may even be able to supply and grow the agar plates for you.

STEM CAREERS

Vaishali studied microbiology at university and has worked at many companies which make medicines. She works with very tiny living things which cannot be seen with the naked eye, so she uses a microscope to observe them. At Synthomer, Vaishali makes sure that the paints, glue, and gloves are infection free and safe to use. She helps to make the world a better and safer place by reducing the use of harmful ingredients in their products.

Activity Sheet 5

	Control	Unwashed hand	Washed hand	Hand cleaned with hand sanitiser
Day ___				
Day ___				
Day ___				

3. WHO HAS THE CLEANEST CLASSROOM?

1 HOUR PLUS A WEEK OF 10-MINUTE DAILY OBSERVATIONS OVER TWO WEEKS

Children use the skills learned in the Monitoring microbes activity to test various classroom surfaces to model how scientists work in industry to ensure products are clean and safe for customer use. This activity builds upon the skills-focused task in Activity 3, which should be completed first.

TYPE OF ENQUIRY

Comparative test

OBJECTIVES

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

Describe how living things are classified into broad groups according to common observable characteristics and based on similarities and differences, including microorganisms. (Y6 living things)

SCIENCE VOCABULARY

microbe, microorganism, bacteria, germ, clean, dirty, grow, nutrient, food source, living thing

RESOURCES

(per group of four, unless otherwise stated)

- 4+ sterile Petri dishes with agar solution
- 4+ sterile swab sticks
- tape for sealing Petri dishes e.g. medical tape
- permanent marker pen or stickers to label each sample
- 2+ copies of **Activity Sheet 6** (optional)
- access to sink for hand washing

The agar plates will need to be sourced or prepared in advance of the lesson by an adult. See Activity 2 (page 9) for information on this preparation.

NB: If purchasing pre-made agar plates, please check the supplier's advice on shelf life (which can differ significantly) and storage requirements (some require refrigeration whilst others advise against it).

SAFETY GUIDANCE

Some agar agar powder packets are labelled 'may contain traces of nuts' so please check the packaging carefully.

Once sealed, Petri dishes should not be reopened. Growing microorganisms release invisible spores and can lead to respiratory irritation. The dishes should be disposed of in their sealed condition at the end of the investigation.

CLEAPSS recommend carrying out activities using agar plates with support from a secondary school partner for safe disposal. For more information, please visit the CLEAPSS website and search for the term 'agar plates'.

PRIOR KNOWLEDGE/EXPERIENCE

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

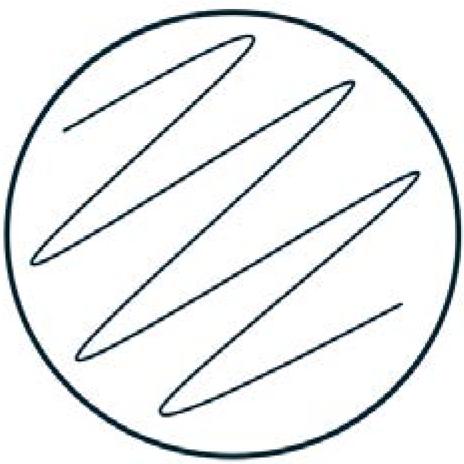
ACTIVITY NOTES

In Activity 3, children developed their microbe growth monitoring skills. They will now carry out a comparative investigation. Explain that Synthomer's processes and products need to be free from bacteria to keep their ingredients infection free and safe for their customers to use.

Children should be encouraged to ask their own questions for investigation, such as:

- Which teacher has the cleanest classroom?
- Which group has the cleanest table?
- Which class has the cleanest cloakroom?
- How clean is the route to my classroom? (E.g. touching door handles and/or the surfaces they contact from the school gate to their desk.)

Once a question is selected, children make predictions based on their observations and existing knowledge of the locations/items selected for testing.



Children then take swabs of their chosen locations by rubbing a sterile swab stick onto the surface and then rubbing the swab across the surface of the agar solution as shown here:

With swabs taken, Petri dishes are sealed with tape and placed in a dark place at room temperature (20-25°C), such as a shady corner of the classroom or inside a cupboard. Limit exposure to cold temperatures and UV light from any windows.

Children may choose to record their findings using **Activity Sheet 6** or using a sketch or photo diary. Ten minutes per day for a fortnight is recommended for daily monitoring.

At the end of the monitoring period, children review the results they have collected to draw conclusions using their results and evidence. They consider the challenge they were set in the Synthomer letter and create a short report outlining their method for testing different surfaces to check for the presence of microbes. Children should consider what places like Synthomer might do if the swab of a surface showed signs of infection and how they might ensure strict cleaning procedures. After a short discussion, share how, if a company like Synthomer found signs of infection on a surface or in a product, they would stop using that area and product straight away, throw away any affected materials, and carry out a deep clean using strong cleaners that kill germs. After cleaning, they would test again to make sure the germs are gone and investigate how the problem happened so it doesn't happen again. To prevent this, workers follow strict cleaning rules, wear protective clothing, clean equipment frequently, keep records, and regularly test surfaces to make sure everything stays safe and clean.

Children may also discuss their own experiences of places cleaning procedures are used such as classrooms, the school kitchen, and medical settings.

QUESTIONS FOR THINKING

Some sample answers have been provided but other similar answers from the children will also be acceptable.

- What is a microbe?
  - *A microbe is a tiny living thing, such as a bacterium or fungus, that is so small you need a microscope to see it.*
- Where do microbes come from?
  - *Microbes are found naturally all around us: in the air, water, soil, and on our bodies. Microbes spread when we touch things.*
- How can we tell if things are really clean?
  - *Things may look clean, but most microbes are too small to see, so the only way to be sure is to clean them properly.*
- If microbes are everywhere, why can't we see them?
  - *We can't see most microbes because they are much smaller than our eyes can detect.*
- How can we clean things properly?
  - *We can clean things properly by washing with anti-bacterial cleaning products like soap or detergent; rubbing well and rinsing so microbes and dirt are removed.*

USING THE PRESENTATION

To conclude the lesson, use the STEM Careers slide in the presentation to highlight real-world jobs in STEM to nurture children's science capital. Share Guy's career profile to inspire pupils by helping them make connections between their classroom learning and the science that is used in exciting jobs.

INDUSTRY LINKS AND AMBASSADORS

A scientist or university student who works in a lab setting would be an excellent choice of ambassador to visit the classroom to help you enrich this activity. They may be able to demonstrate how they test different materials for microbe growth and bring photographs and equipment to show children. Depending on their working environment, they may even be able to supply and grow the agar plates for you.

STEM CAREERS

Guy studied to become an engineer at university and his first job was helping factories improve processes to be safer and use less fuel, water and materials.

He has had different jobs linked to safety and sustainability over 30 years working in 4 different countries and visiting many others, helping sites find better ways of working.

Guy often talks to people using his computer, which helps save fuel and waste by only travelling when he has to.

Activity Sheet 6

Hand cleaned with hand sanitiser			
Washed hand			
Unwashed hand			
Control			
	Day ___	**Day ___**	**Day ___**

4. A BIT OF A STRETCH

1-1.5 HOURS

Children design an investigation to discover which type of rubber or plastic is best for making protective gloves which need to be stretchy. They will use measuring equipment to record how each material stretches.

TYPE OF ENQUIRY

Comparative test

OBJECTIVES

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

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

SCIENCE VOCABULARY

material, property, properties, stretch, stretchy, brittle, measure, force

RESOURCES

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

- 2 small (approx. 51 mm) G-clamps[5]
- range of force meters
- metre rule or tape measure
- device with camera function (optional)
- **Activity Sheet 7** (optional)
- selection of materials (20 cm lengths work well), **must include:**
  - nitrile rubber (e.g. disposable nitrile glove)

  may also include:
  - HDPE plastic (e.g. disposable HDPE glove, single use carrier bag)
  - LDPE plastic (e.g. 'bag-for-life' carrier bag, sandwich bags, bin liners. cling film)
  - vinyl plastic (e.g. disposable vinyl glove)
  - latex rubber (e.g. balloon[6], marigold gloves)

Note that children may ask for additional equipment depending on their independent planning ideas.

5 4 pack of 51mm mini G-clamps £7.99 from Amazon. Price correct at time of publication.
6 Balloons made of other materials, e.g. metal-look plastic, can also be incorporated.

SAFETY GUIDANCE

Some materials will snap easily when stretched. This results in very little recoil and are therefore unlikely to pose an injury risk. Whilst snapping will probably occur, children should be discouraged from intentionally trying to snap the materials.

Remind children regularly to keep their faces away from the materials as their focus will be on taking force or length measurements.

Check to see whether any children have latex allergies before making latex available for testing.

PRIOR KNOWLEDGE/EXPERIENCE

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

In key stage 1, children will have learned about everyday materials, differentiating between an object and the material it is made from. Children will be able to name a variety of everyday materials, including plastics, describing their physical properties.

Children should also be able to identify the suitability of everyday materials for their specific uses and have an awareness that the shapes of solid items can be changed by squashing, bending, twisting, and stretching.

ACTIVITY NOTES

Revisit the letter from the scientist working for Synthomer (**Activity Sheet 4**). Explain that they make ingredients which other companies use to make their products. One customer wants to use the Synthomer ingredient to make protective gloves, like those worn by healthcare workers. They would like children to test different materials to see which are the most suitable to use for gloves.

Ask children if they can think of other properties that Synthomer's customers would like their gloves to have. In addition to stretchy, they may think of durability, and gloves that will not snap easily.

Provide samples of the materials for children to discuss and share any experiences or knowledge they have relating to their properties and uses of the materials. The materials should be pre-cut so children do not see the objects they have been taken from.

Children now plan their investigations. They can be left to do so independently, or offered suggestions to aid their planning, such as:

- pulling a material to observe how far it will stretch
- measuring the stretch with a ruler and comparing the stretched and original length
- using a force meter to measure the force required to stretch each material.

Here is an example of how each material can be tested:

Children use a small G-clamp to hold material samples firmly on a classroom table.

A second small G-clamp grips the other end of the material, so that it can be stretched easily.

A force meter is attached to the free-moving G-clamp to take a force measurement.

A results table will be needed to collate the measurements taken during the investigation. Children can design their own or use the table provided on **Activity Sheet 7** can be used.

G-clamp attached to table

2. G-clamp attached to material

3. Force meter attached to G-clamp

4. Measuring stretched material with ruler

When data collection is complete, ask children to evaluate their investigation method. Did it go to plan? What did they do well? What could they do better? They should also review their results and form an appropriate conclusion. Which material will they recommend to Synthomer's customer to make their protective gloves?

Once the investigation is over, children can be shown the objects the materials were taken from. This will help children to understand that the materials have real-world uses and help to reduce misconceptions which commonly occur around objects, materials, and properties.

TOP TIP

It can be tricky to read the force meter or get a distance measurement with materials that snap so have spares of the testing materials to enable children to repeat their test.

A device with a camera function is useful when trying to measure stretchiness. Children can record a video as they stretch the material samples, then re-watch and pause to observe from a still image. This will improve accuracy in taking measurements.

QUESTIONS FOR THINKING

- Why does the material for safety gloves need to be stretchy?
- Can you name any other materials that are stretchy?
- Which other items need to be stretchy to do their jobs properly?
- Which objects would not do their job properly if they were made from stretchy material?

USING THE PRESENTATION

After the children have carried out their investigation, use the slides to share examples of products made by companies like Synthomer, and how products are tested. Slide three shows an elongation test in progress, which is similar to the activity carried out by the children. Slide four shows how products are tested for thickness.

To conclude the lesson, use the STEM Careers slide at the end of the presentation to highlight real-world jobs in STEM to nurture children's science capital. Share Orlagh's career profile to inspire pupils by helping them make connections between their classroom learning and the science that is used in exciting jobs.

INDUSTRY LINKS AND AMBASSADORS

Scientists and engineers in industry, such as those working at Synthomer, work hard to make their products more sustainable. They make ingredients for other companies to produce gloves which use less material and remain durable.

An industry ambassador could initiate this classroom activity by introducing this challenge to children and showing them a range of plastic and rubber samples that are stretchy or brittle. They might show a video of elongation tests carried out in a lab or factory setting. 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 test products to ensure they are of the best quality to sell to their customers. Finally, the ambassador could discuss the children's results and ask for their recommendations.

STEM CAREERS

Orlagh works in sustainability for Synthomer. She checks how the company treats the Earth, how it treats people and if it follows good rules. Orlagh uses her computer to make charts and look at big reports to track how the company is doing and compares it to other big companies.

Activity Sheet 7

Material	Stretch (cm or N)	Observations

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:

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