POTATOES TO PLASTICS

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

CENTRE for INDUSTRY EDUCATION COLLABORATION

ROYAL SOCIETY OF CHEMISTRY

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biome bioplastics

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INTRODUCTION

Potatoes to Plastics has strong links to the science programme of study for Y5 and could be used to deliver, or reinforce, the materials strand of the science National Curriculum.

It shows that science can be used to provide solutions to real world problems such as pollution, waste disposal and over reliance on fossil fuels.

It has the potential to increase children's science capital both by increasing their awareness of the relevance of science to their own lives and by providing biographical information about real scientists. This shows that scientists are 'ordinary' people with a variety of interests beyond the work that they do rather than special people who spend their lives in laboratories wearing white coats and goggles.

FIRST SECTION

The first section of the resource is based upon newspaper style articles which have been written about scientists in the Green Chemistry Centre of Excellence, some of whom acted as STEM ambassadors during the pilot of these activities. These articles could be used for stand-alone activities in a literacy lesson which, as well as meeting literacy objectives, would have the potential to raise children's science capital.

SECOND SECTION

The second section comprises three practical lessons which can either be carried out with ambassador support or by the class teacher. The first activity takes children through the steps needed to extract starch from potato peel. The second lesson leads children through the steps needed to turn the extracted starch into bio-plastic. Although this can be done with ordinary cooking equipment, it is even more exciting if laboratory equipment is used. This can be achieved if working with an ambassador from a local university or perhaps with secondary school teachers, as part of a transition project.

The final activity in this section gives children the opportunity to plan an investigation and to explore the properties of the bio-plastic they have made. This will give them opportunities to ask and answer their own questions. It will also lead to discussion about the scientific process, as the results of their investigations give rise to further questions. For example, could they change the recipe, or could they test for strength and waterproofing?

FINAL SECTION

The third, and final, section of the resource gives children an overview of the wide range of processes that have been developed by scientists to address a variety of environmental problems. It comprises a set of cards which showcase nine different 'waste problems' created by manufacturing processes and the corresponding 'green solution' which scientists have developed. Three card games are described which, when followed by the appropriate discussion, will increase children's awareness of the range of solutions that scientists have developed.

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CHILDREN'S SHEETS

Any activity sheets needed by children are included at the end of each section. These include optional vocabulary cards which can be used to support children to recount what they have done using appropriate scientific language. In the second section there are also instruction sheets which, as well as being used in class, can be shared on the school website or sent home as paper copies so that children can repeat the activity with their families. As well as being an engaging optional homework activity this has the potential to reinforce learning and to raise the science capital of the whole family.

STEM AMBASSADORS

STEM ambassadors are people who are currently working in science, technology, engineering or maths either in universities or within industry. They are volunteers who have received some training so that they are ble to share their experiences with school children.

To find out how to become an ambassador or to find out if one is available in your area to support you with Potatoes to Plastics contact:

https://www.stem.org.uk/stem-ambassadors/local-stem-ambassador-hubs

Ambassadors have different areas of expertise so you will need to let them know what is required when requesting ambassador support to ensure that you are put in touch with someone who has relevant experience.

SUMMARY OF ACTIVITIES AND CURRICULUM COVERAGE

ACTIVITY	SUMMARY	CURRICULUM COVERAGE
1. Scientists Today: Reading biographies	Children read articles from the publication *'Scientists Today'* about the life and work of living scientists	• To ask relevant questions to extend their understanding and knowledge (English) • Understand that scientists come from a wide range of backgrounds and do a wide range of jobs
2. Scientists Tomorrow: Writing biographies	Children write articles based on the publication *'Scientists Tomorrow'* about their future selves as a scientist	• To realise that they could choose a career in science when they are older and that studying science opens doors to a wide range of jobs • Write clearly, accurately and coherently, adapting their language and style in, and for, a range of contexts, purposes and audiences (English)
3. Ambassador Interviews	Children interivew a STEM ambassador about their experience of being a scientist	• To listen and respond appropriately to adults and their peers (English) • To ask relevant questions to extend their understanding and knowledge (English) • Maintain attention and participate actively in collaborative conversations, staying on topic and initiating and responding to comments (English)
4. Extracting starch from a potato	Children extract starch from a potato using a variety of processes including filtration, sedimentation (settling) and evaporation	• Explore reversible changes including evaporating, filtering and sieving • Use knoweldge of solids, liquids and gases to decide how mixtures might be separated, including through filtering, sieving and evaporating
5. Making plastic from potato starch	Children use the extracted potato starch to make bio-plastic by mixing it with some other ingredients and heating it	• Explore changes that are difficult to reverse, for example, burning, rusting and other reactions • Explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible
6. Testing the bio-plastic	Children ask and answer their own questions as they plan and carry out an investigation into the properties of the bio-plastic	• Plan different types of scientific enquiry to answer questions including recognising and controlling variables where necessary • Report and present findings from enquiries
7. Science solutions card games	Children will be introduced to 3 different card games. These use one set of cards which showcases the range of green solutions that scientists have developed to address environmental problems	• Explore examples of human impact (both positive and negative) on environments, for example the negative effects of population and development, litter or deforestation (Y4 Science) • To realise that science can develop solutions that can lead to a more sustainable future • To become aware of the range of products that can be created from waste materials that have been developed by scientists • Talk about the problem of waste products which need to be disposed of and describe how science has the potential to provide possible solutions to some of these difficulties

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LINKS TO THE KS2 SCIENCE PROGRAMME OF STUDY

Year 5: properties and changes of materials

Statutory requirements

Pupils should be taught to:

- Know that some materials will dissolve in liquid to form a solution.
- Use knowledge of solids, liquids and gases to decide how mixtures might be separated, including through filtering, sieving and evaporating.
- Explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible.

Notes and guidance (non-statutory)

Children should explore reversible changes, including evaporating, filtering, sieving, melting and dissolving recognising that dissolving and melting are different processes. Pupils should explore changes that are difficult to reverse, for example, burning, rusting and other reactions, for example, vinegar with bicarbonate of soda. They should find out about how chemists create new materials.

Children might research and discuss how chemical changes have an impact on our lives, for example, cooking, and discuss the creative use of new materials.

CROSS CURRICULAR LINKS

English: pupils can develop their oral skills by recounting the stages of making a plastic from potato peel, and explaining what they have done clearly and concisely. They will also need to read and follow instructions to extract potato starch and make bio-plastic. They will need to extract information from a non-fiction text when reading the scientists' biographies. They will plan, execute and evaluate their own writing based on the science biographies they write about themselves.

Mathematics: links to using a range of equipment to measure volumes of liquid ingredients, and to weigh dry ingredients.

Design and Technology: If the plastic is used to make a simple product (such as a fridge magnet) pupils will develop their understanding of product design which will include them evaluating their own ideas and products and making suggestions to improve their work.

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1. SCIENTISTS TODAY: READING BIOGRAPHIES

1 HOUR

This activity has been designed to develop cross curricular links with science during an English lesson.

Children read articles from the publication *'Scientists Today'* about the life and work of living scientists.

They discuss the vocabulary that has been chosen to describe the scientists and their jobs. Children talk about what the article does and doesn't tell them about the scientists. If they have the opportunity to meet a scientist, they should plan questions to ask.

TYPE OF ENQUIRY

Secondary Research

OBJECTIVES

To ask relevant questions to extend their understanding and knowledge (English)

TO BE ABLE TO

Understand that scientists come from a wide range of backgrounds and do a wide range of jobs.

VOCABULARLY

(this will vary depending upon the article read)

palaeontologist	science	laser
non-fiction	biography	passion
chemistry interview	university	spectroscope
historian	substance	chemistry
treatment	recovery	

RESOURCES

Activity Sheets 1-6 may be printed out for small groups of children to work on or displayed on the interactive white board.

PRIOR KNOWLEDGE/EXPERIENCE

Children should be familiar with different forms of non-fiction text. They should be aware that writers and journalists make choices about what information to include and what vocabulary to use.

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ACTIVITY NOTES

Begin by explaining to the children that they are going to read about a real scientist. Ask them to think about what they already know about scientists, and to discuss this with a partner before sharing with the whole class. What sort of people are scientists? Where do they work? What do they do? What are they like? Listen out for stereotypes but do not challenge them at this stage. Notice if children have a tendency to use 'he' exclusively in their descriptions.

Children now read *'Scientists Today'.* Different groups could work on different biographies or you may choose to work as a whole class to read one biography on the interactive white board.

Ask children to summarise what they now know about the scientist that they have read about. If different groups have read different biographies, they might report to the rest of the class about 'their' scientist.

Ask children to 'think, pair, share' about how the scientists that they have read about differ from their initial descriptions. Are they surprised by any of the differences? Were there less or more similarities than they expected?

Challenge children to think about the choices that the writer has made when writing about the scientist. What words have they chosen? Why do they think that they have chosen those words? What does the article tell them about the scientist? What does it leave out?

If you are working with an ambassador, and the children will therefore meet a scientist, ask them to work in pairs to think of things they would like to know and to write questions on post-it notes. Tell the children that they will be meeting the scientists and work as a group to decide which of the questions it would be appropriate to ask them when they visit. Support them to consider the best way to frame their questions and to elicit the information that they want. If possible email the questions to the ambassadors prior to the visit to enable them to think about their answers.

QUESTIONS FOR THINKING

- What sort of people work as scientists?
- Where do scientists work?
- What do scientists do?
- How many different jobs do scientists do?
- What branch of science would you like to work in?
- Are you surprised by anything you found out about the scientist that you have read about?
- Are there any differences between the scientists you thought about and the scientists you read about?
- What would you like to know about these scientists?
- What questions are you going to ask them?

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Activity Sheet 1

Scientists Today

Andy Maneffa

Our scientist this week is researching ways to make healthier sweets, although he admits that they will probably not be so healthy that your mum asks you to eat them instead of your Brussel sprouts! He told ***Scientists Today*** that his work includes reading a lot about the work that other scientists have done as well as doing practical experiments. He enjoys helping other people to understand the science that he has done.

When we interviewed him he admitted that he didn't always want to work with food but was interested in a completely different branch of science. When he was younger he was fascinated with dinosaurs and had wanted to be a palaeontologist.

Balancing work, rest and play leads to a healthy lifestyle

Andy has always enjoyed an active lifestyle. He plays football with the other scientists in his department at York University and enjoys walking, hiking and going to the gym.

At home he often cooks and enjoys rustling up healthy meals.

He also realised at an early age how important it was to study science at school if he wanted to do a job like this. He went on to study science at University and has never looked back.

Did You Know...

Andy was born on Christmas Day. He says that makes him feel special, but he never had a party with his friends on his actual birthday!

Scientists Today: Personality Profile

Each week we give our scientist a personality test. This is what we found out about Andy...

Andy is passionate about sharing information and knowledge about science with as many people as possible. He is an excellent communicator and good at putting facts in a way that people understand. He is also very diplomatic which means that he is good at helping people get along together. He is good at understanding different subjects and is able to collect lots of different ideas together.

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Activity Sheet 2

Scientists Today

Jenny Lewis

Our scientist this week uses a special machine called a spectrometer. She told ***Scientists Today*** that this helps her to detect tiny amounts of substances. She went on to explain that the amount of each substance is so tiny that it cannot be smelt or seen, so the spectrometer is the only way that scientists can tell that they are there.

Scientists Today wanted to know why Jenny needed to do this. "*Well, it is quite complicated"* she explained *"But the information that I collect is used to make some of the machines that they use in hospitals even better."* She smiled as she added *"It's very satisfying to know that I'm helping doctors to find the correct treatments for people and help cure their illnesses."*

Glad to have studied science at school

Jenny told ***Scientists Today*** that she sometimes wonders what would have happened if she hadn't chosen to study science when she was at secondary school.

"You know, if I had made a different choice then, I would not have been able to go on to study science at university and would not be able to do this important work!" she explained.

Did You Know...

Jenny has a wide range of hobbies. She enjoys reading both fiction and non-fiction books.

She also enjoys ballet, skiing, diving and sailing. Phew! She made us feel tired just thinking about all of those activities. We wonder how she finds time to go to work?

Scientists Today: Personality Profile

Each week we give our scientist a personality test. This is what we found out about Jenny...

Jenny is very organised, good at paying attention to the details and quick to spot and correct mistakes. She is creative and practical and this, combined with her ability to spot when something is not quite right, means that she is good at building and making things. She likes to help people build their skills and helps them to understand things.

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Activity Sheet 3

Scientists Today

Annie Hodgson
Schools Liaison and Outreach Officer

Our scientist of the week teaches science to university students. "The type of science I specialise in is called chemistry," she told ***Scientists Today***. "Chemists are interested in what things are made of and also mixing together different ingredients to make new products. This can be as common as mixing ingredients to make a cake or as exciting as developing a new medicine" she explained.

Scientists Today asked Annie if her work involved a lot of explosions. *"Everyone always thinks that"* she laughed. *"No, science is not really about explosions, it is about finding out more about the world and also making useful things, such as shampoo, paint or medicines, that can make our lives better."*

Beaver Scout Leader shares science with York scouts

A little bird tells us at ***Scientists Today*** that Beaver Scouts in the York area particularly enjoy pack meetings when their leader plans activities for them based around science.

"It is really exciting when we get to do experiments and find things out" enthused one Beaver (aged 7). *"It's made me think that I would like to be a scientist when I grow up!"* Of course their leader is none other than our own scientist of the week Annie Hodgson, so it is no surprise that she has given York Beavers such exciting experiences. You would think that with being a full time scientist and a busy scout leader Annie would not have time for anything else, but you would be wrong! She also finds time to sing and play the violin in her spare time.

Scientists Today: Personality Profile

Each week we give our scientist a personality test. This is what we found out about Annie ...
Annie is confident and creative. She is happy working alone but also very good at listening to other people and working in a team. She has a strong sense of honesty and is willing to speak out if she thinks anything is not fair. She is passionate about sharing her knowledge with everyone from school children to other scientists.

Activity Sheet 4

Scientists Today

Liz Fear

Our scientist this week works at the cutting edge of medical research.

She is working on ways to improve the accuracy of Nuclear Magnetic Resonance (NMR) which doctors use to look inside people's bodies.

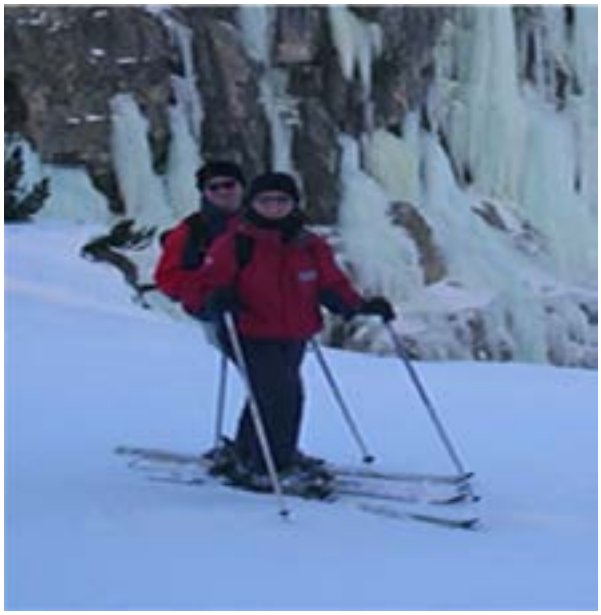
Being able to look in more detail inside people's bodies will help doctors to diagnose illness earlier and more accurately. This will mean that life-saving treatments can be offered more quickly.

Liz has a son who is 6 and a daughter who is 4.

Scientist swaps ski slopes for exciting medical research

Liz told ***Scientists Today*** that before she took on her current role as a research scientist she worked for several years as a ski guide in Italy.

She lived there for 16 years and speaks fluent Italian. As energetic as ever she continues to enjoy yoga and walking.



Scientists Today: Personality Profile

Each week we give our scientist a personality test. This is what we found out about Liz …
Liz is very organised and conscientious and is good at paying attention to the details which can make the difference between success and failure. She likes to help people, and is good at listening to them to find out what their needs are. She is also good at explaining science to people who are not scientists (from school children to politicians). She works well in a team and can get people to work together effectively.

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Activity Sheet 5

Scientists Today

Avtar Matharu
Scientist and Lecturer

Our scientist this week is determined to make the world a better place and believes that science is an important way to do this.

Avtar told ***Scientists Today*** that he is able to use his skills as a scientist to find ways to make useful products from materials that would be thrown away and which would pollute our beautiful planet.

He also works with science students at the University of York to teach them how they can use science to make our lives more sustainable. He told ***Scientists Today*** that his students chose to study science when they were at school so that they had the right qualifications to study at university.

Today's Scientist tells us that cooking is like science!

Everyone at ***Scientists Today*** was curious when Avtar told us that cooking is like science! He explained that no-one ever eats in a science lab, as this is not allowed.

However, Avtar explained that just like scientists, all cooks try out new ingredients and test their ideas. They then observe and compare the results to see, for example, whether beans cook better with or without salt in the water.

Did You Know...

Avtar was born in Nairobi in Kenya

Scientists Today: Personality Profile

Each week we give our scientist a personality test. This is what we found out about Avtar ...
Avtar has a very strong sense of right and wrong and this is why he is careful to only use his science on projects that he believes will make the world a better place for everybody. He is excited by new ideas and loves finding out new things and thinking about the world in new ways. He also likes working with people from lots of different backgrounds and from around the world; which is important in the team he leads.

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Activity Sheet 6

Scientists Today

Jiajun (Alice) Fan
Researcher

Our scientist of the week is working to discover ways to turn waste materials, like straw, into useful things.

Scientists Today wanted to know how scientists can do this. Alice explained, *"First, we use microwaves to turn the straw into sugars or oils. Next, we feed these to bugs, and they make useful ingredients for example that are used in sun screen."*

Alice explained that microwave radiation is very useful. It is not only good at heating your food, but can be used to break down wood, straw, and seaweed through heating them up to high temperatures, where they turn into charcoal, liquids/oil and gas, in a similar way to how coal is made. But rather than taking millions of years this takes a few minutes.

This is an environmentally friendly way to make these very useful ingredients.

Adventurous life in a scientist's spare time

Alice told ***Scientists Today*** that she has always enjoyed being outdoors. When she was a child she helped her grandad grow vegetables on his farm. She loved climbing trees and was good at climbing high. She also enjoyed catching insects and finding out about them.

Today she enjoys travelling to different countries around the world and loves snorkelling, where she explores underwater worlds and seeing the ocean life hidden beneath the waves.

Scientists Today: Personality Profile

Each week we give our scientist a personality test. This is what we found out about Alice ...
Alice is very curious and is always asking questions. She wants to know how the world is made and always wants to find out more. She is motivated by a strong sense of wanting to help others and to make the world a better place by finding solutions to problems such as pollution. Alice is good at explaining complicated ideas in a way that other people can understand.

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2. SCIENTISTS TOMORROW: WRITING AUTOBIOGRAPHIES

1 HOUR

This activity has been designed to develop cross curricular links with science during an English lesson.

Children write an article about themselves as scientists using the same template as the *'Scientists Today'* biographies. They think about science that they have already done as well as science that they might hope to do in the future.

OBJECTIVES

To realise that they could choose a career in science when they are older.

To begin to recognise that studying science opens doors to a wide range of careers.

TO BE ABLE TO

Write clearly, accurately and coherently, adapting their language and style in, and for, a range of contexts, purposes and audiences (English).

VOCABULARLY

scientist	science	career
non-fiction	biography	

RESOURCES

Activity sheet 7

PRIOR KNOWLEDGE/EXPERIENCE

Children should be familiar with different forms of non-fiction text. They should be aware that writers make choices about what information to include and what vocabulary to use.

ACTIVITY NOTES

Read *'Scientists Tomorrow'* and explain that it has been written by a primary school pupil who is both thinking about the science that they have already done and the science that they might do in the future.

Encourage children to think about things that they have in common with this pupil and ways that they are different. In pairs ask children to think about some of the science that they have done in school. What could they write about in their own biography? Ask them to make notes for their own biography.

As a class, ask children to think of as many possible science-based careers as they can. Emphasise that many aspects of life need scientists to develop improved products. For example, products used by hairdressers and the bob sleighs used in the winter Olympics were developed by scientists. Farmers know the best way to plant their crops and car manufacturers know the best shape to build a car because of the work of scientists. Where possible, give examples based upon the children's known interests.

In pairs, ask children to consider what branch of science they would be most interested to work in. Ask them to add to their biography notes.

Support children to start writing their own *'Scientists Tomorrow'* biographies.

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QUESTIONS FOR THINKING

- In what ways are you the same as this scientist of tomorrow? In what ways are you different?
- How many different jobs do scientists do?
- What branch of science would you like to work in?

Activity Sheet 7

Scientists Tomorrow

Lee Cheng

Our scientist this week tells us that he enjoys science most when it is hands on and practical.

"I really enjoy the experiments that we do in school" explained 11 year old Lee Cheng. "*But then we have to write everything down and sometimes I get a bit bored with that side of things."*

However, there was one time when Lee was not bored by the writing. *"It was when a toy manufacturer wrote to our class and asked us to investigate the best ingredients to make bubbles"* Lee enthused.

"When we had worked out the best recipe we wrote a letter explaining what we had done to the managing director. That seemed much more interesting."

Love of sport and science is a winning combination!

Lee told ***Scientists Tomorrow*** that he plans to specialise in sports science when he grows up. *"Did you know that athletes and other sports people rely on scientists to help them to perform their best?"* he asked. *"Some scientists are experts in the food that is needed to give athletes the most energy possible from their food!"* Lee hopes to work in football.

Scientists Today: Personality Profile

Each week we give our scientist a personality test. This is what we found out about Lee...

Lee loves sport; especially football. He is in the school football team and was very proud to score the winning goal against North Lane Primary School! He also likes finding out about things and likes reading non-fiction books. Lee lives with his Dad and little sister Su. They have two dogs called Buster and Bart.

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3. AMBASSADOR INTERVIEWS

1 HOUR

Children have the opportunity to interview ambassador(s) about their job, career path, school days, etc using questions that they formulated as part of the *'Scientists Today'* activity.

OBJECTIVES

To listen and respond appropriately to adults and their peers (English).

To ask relevant questions to extend their understanding and knowledge (English).

TO BE ABLE TO

Maintain attention and participate actively in collaborative conversations, staying on topic and initiating and responding to comments (English).

ACTIVITY NOTES

Ensure that there is time during the ambassador visit to sit down with either the whole class, or with small groups of children to answer the questions that they have planned.

FOLLOW UP ACTIVITY

Following the ambassador interviews children could use the information collected to write an extension to the *'Scientists Today'* article.

4. EXTRACTING STARCH FROM POTATO PEEL

1-2 HOURS

This activity will need to be carried out at least three days prior to using it to make bio-plastic.

Children experience a novel application of sieving, filtering and evaporation as methods of separating a solid mixed with a liquid. They will discover that useful substances can be extracted from 'waste' materials by separating starch from potato peel. They will experience both reversible and irreversible changes as they recognise that the starch can be mixed back with the water, but cannot be returned to the potato.

TYPE OF ENQUIRY

Observing changes over time.

OBJECTIVES

Explore reversible changes, including evaporating, filtering and sieving.

TO BE ABLE TO

Use knowledge of solids, liquids and gases to decide how mixtures might be separated, including through filtering, sieving and evaporating.

SCIENCE VOCABULARY

solid	liquid	mixture
evaporate	sediment	filter
mixture	mix	reversible
irreversible	'green'	extract

RESOURCES

Per pair of children

- About 100g of potato peel (school caterers, local restaurants or chip shops may well be willing to provide potato peel free of charge)
- 2 x 1 litre jug
- Petri dish, saucer or plate
- Pop sock or leg from a pair of old tights
- All groups will also need access to a means of pureeing or grating the potato peel eg. a cheese grater or an adult can use a food processer or blender
- Activity sheet 8 (optional)
- Activity sheet 9. This can also be shared with families either on the school website or by sending copies home

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PRIOR KNOWLEDGE/EXPERIENCE

Children should have had opportunities to follow step by step instructions in the correct chronological order. They should be able to pour liquids carefully in order to decant the liquid from the sediment.

ACTIVITY NOTES

This activity will need to be carried out at least three days prior to using the starch to make plastic.

Activity sheet 8 may be used at this stage to assess and, if necessary, reinforce the vocabulary used in this and the following activity.

Begin by explaining that some materials are made up of lots of different 'ingredients' or substances. For example, you might give the example of a water melon or pumpkin which has flesh, seeds and skin which can be separated from each other.

Tell children that not all ingredients are visible like the seeds in a melon, but can often be invisible to the human eye. You could demonstrate this by showing children how salt or sugar cannot be seen once dissolved into water although we know that it is there and it can still be tasted. Explain that scientists are able to find these hidden ingredients and take them out or 'extract' them.

Explain that 'Green Scientists' are scientists who find ways to use waste which would otherwise end up in rubbish tips. Today the children are going to find out how Green Scientists are able to extract a hidden ingredient, called starch, from potato peel. Tell them that the potato peel is a waste product that would otherwise be thrown away. Starch is a substance which has many uses, as they will soon find out.

The next stage should be carried out by an adult. The potato peel will have to be broken down finely with at least an equal amount of water using a food processor or blender. Alternatively, if whole potatoes are being used children can use a potato grater to break it down. This allows children to work more independently, although the potato will be broken down less finely.

The resulting puree is a mixture of water and solids that have been broken down very finely. The more finely the potato peel is broken down at this stage the more starch the children will be able to extract.

The puree will need to be poured into the foot of a pair of tights. Children can take turns to squeeze the tights to obtain as much liquid as possible. When they are sure that they can squeeze no more liquid from their potato mixture, the remaining solids can be disposed of. Ideally they should be placed in a compost heap.

The children will be left with a cloudy mixture. Explain to them that the cloudiness is caused by tiny particles of solid suspended in the water. These are the particles of solid which were small enough to be squeezed through the holes in the tights along with the water.

Within a few minutes, they will notice that the solids begin to sink to the bottom of the jug. They can be told that when solids separate out of a mixture in this way, it is called a sediment. The cloudy mixture will need to be left for about ten or fifteen minutes before the next stage can take place.

Once the water is clear it can be carefully poured away leaving the potato starch at the bottom of the jug. Separating sediment from a liquid is one way that scientists separate materials. If there is a lot of mud or other impurities mixed in with the starch, water can be added and the mixture stirred and allowed to settle again to allow some of the dirt to be washed away.

Encourage the children to notice the properties of the solid particles that they have separated from the mixture. They may comment that they look and behave like 'ooblek' made from mixing cornflour and water. You could point out that cornflour is starch that has been extracted from corn and that potato starch and corn starch can be used in similar ways.

The potato starch can be put in a petri dish or saucer, to allow the remaining water to evaporate. Within a day or two you should be left with a fine white powder which can be used in the next activity to make plastic.

A copy of the instruction sheet could be sent home with children or it could be shared on the school website as an optional activity to share with families. As well as reinforcing the learning this has the potential to raise the science capital of the whole family.

QUESTIONS FOR THINKING

- What does the potato peel look like before and after it has been blended?
- Is the 'stuff' that we squeeze from the tights a gas, a liquid, a solid or is it a mixture?
- Where did the potato starch come from?
- How did we separate the potato starch from the rest of the potato?
- Could we put the starch back in the potato?
- Can you describe the wet potato starch?

SAFETY GUIDANCE

Please use the following health and safety information to produce your own risk assessment for this activity.

- Prior to this activity, check for individuals who may be allergic to potatoes
- Teachers should operate the blender or food processor
- If using a grater children will need clear guidelines how to do this safely

Activity Sheet 8 Vocabulary

solid	liquid
evaporate	sediment
mixture	mix
irreversible	reversible
opaque	clear
heat	measure
viscous	filter
extract	

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Activity Sheet 9: Instructions for extracting starch from a potato

You will need:

- Potato peel or old potatoes (about 100g)
- The foot from an old pair of tights or a pop sock
- A jug or bowl (it will need to hold about a litre of liquid)
- A food processor, blender or liquidiser
- Saucer or plate

1. An adult uses the food processor or blender to blitz the potatoes with about 500ml water until the potato is broken down very finely. Alternatively, you could grate them very finely. You should now have a 'slurry' of potato and water.
2. Pour this mixture into the foot of the tights. Hold over a jug or bowl and squeeze out as much liquid as possible. When no more liquid can be squeezed from the tights the potato solids can be disposed of (ideally on a compost heap).
3. The liquid that has been squeezed from the potato will be very cloudy. This is because the particles of starch that were in the potato are so fine that they were squeezed through the holes in the tights along with the water. The rest of the potato was made up of particles that were too big to fit through the holes so they were left behind in the tights. The method of separating materials is called ***filtration.***
4. Leave the cloudy liquid to stand for between 10 and 15 minutes. You will notice that water gradually clears as the particles of starch sink to the bottom of the container. This is called ***sedimentation.***
5. Once the potato starch has settled the water can be very slowly poured away. The wet potato starch can now be left in a flat container, such as a saucer, so that the rest of the water will be removed by evaporation. Putting the container in a warm place, such as an airing cupboard, above a radiator or on a warm windowsill, will speed up this stage which may take two to three days.

SAFETY GUIDANCE

Adult supervision will be needed when using a knife or grater.

Make sure that children understand the expectations for safe use.

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5. MAKING PLASTIC FROM POTATO STARCH

1-2 HOURS

This activity is similar to cooking, and therefore requires similar high levels of adult supervision. It is an ideal activity for transition to secondary school - this making use of secondary school staff and facilities; or for working alongside a STEM ambassador.

Children will experience how materials can be changed to make useful new materials and products. They will witness how mixing ingredients together and applying heat leads to an irreversible change to the potato starch that they extracted in the previous activity.

TYPE OF ENQUIRY

Observing changes over time.

OBJECTIVES

Explore changes that are difficult to reverse, for example, burning, rusting and other reactions.

TO BE ABLE TO

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

SCIENCE VOCABULARY

solid	liquid	mixture	translucent
mix	heat	change	measure
irreversible	viscous	opaque	

RESOURCES

For a class of children, working in 8 groups. Adapt quantities for smaller or larger classes, if necessary.

- 25-50g potato starch
- 20-30 ml white vinegar
- 8 x Petri dish, saucer or plate
- 2-3 bottles of different colours of food colouring (2-3 ml per group is required)
- 30-40 ml glycerine
- Safety glasses for all participants
- 8 x 50ml measuring cylinders
- 16 x pipettes
- 8 x glass or plastic beakers (see safety guidance below)
- 8 x lolly sticks for stirring
- Activity sheet 10 (1 per group). This can also be shared with families either on the school website or by sending copies home
- Activity sheet 11 (1 per pair)
- Activity sheet 8 (optional)

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For teachers/ambassadors

- Hot plate and magnetic stirrer or small saucepan, spoon and access to a hob
- If children have been given plastic beakers to do the mixing and a hot plate is being used a glass beaker will be needed for each group
- Some examples of bio-plastic made earlier. (It is strongly recommended that the adult has already carried out this activity before introducing it to the class so should have some samples at this stage)
- Digital weighing scales which can weigh to +/- 0.5g (if these are not available ingredients can be measured using teaspoons and pipettes)

PRIOR KNOWLEDGE/EXPERIENCE

Children should have had opportunities to follow step by step instructions in the correct chronological order.

PRIOR DISCUSSION

Before starting the main activity remind children that many everyday materials are made up of various ingredients. Show them the potato starch and ask them to spend two minutes in their pairs, reviewing how they extracted it from potato peel. Listen in to one or two conversations and check that they have realised that the starch was always present in the potato.

Ask each group in turn to offer a step in the process, perhaps recording each on the whiteboard or flipchart paper. Hopefully they will state something similar to the following:

- Breaking down the potato peel and mixing it with water
- Filtering the rest of the potato solids from the water and starch
- Leaving the starch to fall to the bottom of the container
- Pouring the water away from the starch.

ACTIVITY NOTES

Working in groups of four and following the instructions (Activity sheet 10) children measure and mix together 3g of potato starch, 30ml water, 2ml of glycerine and 2ml of white vinegar. 3g potato starch is about 1 teaspoon and this will be accurate enough if no digital scales are available. A drop or two of food colouring can be added at this stage.

At this point, explain that the exact quantities of each ingredient are not critical for this recipe. However, ambassadors can give one or two examples of process that they have carried out where precise measurement has been vital. Children particularly enjoy hearing about mishaps – so please share any stories where imprecise measurements have caused mayhem!

The mixture now needs to be heated to change it into plastic. An adult will need to carry out this stage for each group. Make sure that everyone is wearing safety goggles during the heating process. If not using a magnetic stirrer, keep stirring all the time. Attention should be drawn to the way that the mixture gradually changes consistency and becomes more 'viscous'. It will be necessary to explain to children that viscosity is a way of talking about the thickness or runniness of a liquid.

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The adult should highlight that the mixture becomes translucent (an opportunity to ask children what this means). They should also be told that, even though it is made from food ingredients, the potato plastic will not be edible as a completely new material has been made! Once the mixture is bubbling and completely translucent it can be taken from the heat.

The liquid should now be poured into a petri dish, saucer or other shallow container, and spread into a thin layer. It can then be left somewhere warm to harden. This may take two to three days. You may wish to experiment at this stage as spreading the mixture at different thicknesses will have different results. It can, for example, be spread very thinly, over a sheet of cling-film.

Pairs of children can be given Activity sheet 11 and asked to number them in the right order. Then they should use them to recount how they extracted starch from a potato and made it into plastic. One or two children can be selected to recount the stages to the rest of the class, and supported in the use of the correct scientific vocabulary.

Since the heating stage is fairly quick, children may be interested to watch each other's mixture being heated when they are not sorting the *'Stages of making bio-plastic cards'*.

If they have not already been shown samples of bio-plastic the children can be shown some examples that have already hardened.

A copy of the instruction sheet could be sent home with children or it could be shared on the school website as an optional activity to share with families. As well as reinforcing the learning this has the potential to raise the science capital of the whole family.

QUESTIONS FOR THINKING

- What does the mixture look like before you heat it?
- How does it change when you heat it?
- How does it change when you leave it for a couple of days?
- Do you think that you could get the potato starch back out of the bio-plastic?
- Explain why you think that.

HEALTH AND SAFETY GUIDANCE

Please use the following health and safety information to produce your own risk assessment for this activity.

- The mixture will be very hot during the heating stage. Only an adult should carry out this part of the activity.
- Safety goggles should be worn throughout the procedure.
- Children should be warned that although it is made of food ingredients, bio-plastic is not edible.
- Glass beakers will need to be used if the mixture is being heated using a hot plate. Most children of this age, if given clear guidelines, should be able to use glass beakers appropriately for the mixing stage. However, if there are any concerns children can be given a plastic beaker and the contents transferred into a glass beaker. Alternatively, a saucepan might be used for this stage.

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Activity Sheet 8: Vocabulary

solid	liquid
evaporate	sediment
mixture	mix
irreversible	reversible
opaque	clear
heat	measure
viscous	filter
extract	

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Activity Sheet 10: Instructions for making plastic from potato starch

You will need:

- Potato starch
- White vinegar
- Glycerine
- Water
- Plastic or glass beaker (see safety notes)
- Stirring rod or spoon
- Petri dish or saucer

1. Weigh out **3g of potato starch.**
2. Measure **30ml of water, 2ml of glycerine and 2ml of white vinegar.**
3. Mix all of the ingredients together in a beaker. Using the stirring rod or spoon stir the mixture so that all of the ingredients are combined and there are no lumps.
4. With adult help, transfer the mixture into a glass beaker if a magnetic hot plate is to be used or saucepan. Watch the liquid being heated and stirred all the time, looking for bubbles and the change from an **opaque** to a **translucent** liquid. It should also become much more **viscous** (thick, rather than runny).
5. Watch as the adult carefully pours the mixture into a petri dish or saucer and spreads it out using the spoon or stirrer.
6. Leave the plastic in a warm place to harden.

SAFETY GUIDANCE

Adults will need to take responsibility for all the stages from heating to pouring and spreading the mixture. The liquid will remain hot for some time after removing it from the heat source and could burn if it came into contact with skin.

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Activity Sheet 11: Stages of making bio-plastic from potato peel

• Pour the liquid carefully from the container so that it now contains just the wet starch.
• Weigh out 3g of potato starch. Add 30ml of water, 2ml of glycerine and 2ml of white vinegar. Stir the mixture.
• Blend the potato peel with plenty of water.
• Heat the liquid, stirring all of the time until it bubbles and changes from opaque to translucent. It will become much more viscous (thick).
• Pour the liquidised potato into the foot of a pop-sock. Then squeeze as much liquid from it as possible. Leave the liquid to settle for about 15 minutes. This is called sedimentation.
• Leave the wet potato starch in a warm place to let the water evaporate from it. You will then be left with a dry white powder.
• Tip the hot liquid plastic carefully into a dish and smooth it out.

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6. TESTING THE BIO-PLASTIC

1-2 HOURS

Until now children have not been able to make many choices as they have been following precise instructions to extract the starch and turn it into plastic. Now they will have the opportunity to ask, and answer, their own questions and to plan an investigation. Following a request from a company that specialises in sustainable products, they will think about possible uses for the finished bio-plastic. They will then test it to see if it is suitable for that purpose or whether it would need further research and development (for example to increase its durability).

TYPE OF ENQUIRY

Fair test

OBJECTIVES

To plan a test to assess the suitability of the bio-plastic for a specified purpose.

TO BE ABLE TO

Plan different types of scientific enquiriy to answer questions including recognising and controlling variables where necessary. Present findings from enquiries, including conclusions, casual relationships and explanations of the degree of trust in results, in oral and written forms.

SCIENCE VOCABULARY

test	investigate	results
plan	fair	

RESOURCES

Activity sheet: Letter

Several samples of bio-plastic for children to test and compare.

Any other resources needed will depend upon the investigations carried out by the children. It is therefore a good idea to give children an opportunity to plan their investigation in advance of the activity to give time to collect the necessary equipment together. However, you will need several samples of the bio-plastic so that children can compare how they perform under different conditions.

PRIOR KNOWLEDGE/EXPERIENCE

Children should have had experience of planning and carrying out various investigations. In particular, experience of observing over time and carrying out fair and comparative tests. They should also have experience of presenting their findings in a variety of ways including graphs, tables, photographs and letters.

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ACTIVITY NOTES

Show children the letter from ReNEWables. Encourage them to work in pairs to discuss possible uses for the plastic.

Invite them to consider what properties the plastic would need if it were to be used for different purposes. For example, if it is to be used as a disposable bag it would need to be bio-degradable but it would also need to be relatively strong. If it was to be made into a bottle it would need to be waterproof.

Explain to children that they will be testing the bio-plastic to find out if it has the required characteristics. Children can then work in small groups (of no more than four) to decide which characteristic they will be testing, and how they are going to test it. At this stage you may find the ***CIEC online planning tool*** useful. This could first be used for a whole class demonstration of how it works before groups of children use it to plan their own line of enquiry.

Once children have planned their investigation they will need to decide what equipment they will need so that it can be collected together in advance.

It may well be that the investigations will take place over a period of time, for example to find out how quickly the material bio-degrades.

Once children have gathered the data ask them to work in their groups to consider how best to present their findings to ReNEWables UK. This could include tables, graphs and photographs. However, these will also need to be accompanied by a letter which will draw conclusions about what the results mean in terms of the products future potential as well as any suggestions for future tests that could be carried out by the children.

Take this opportunity to talk about the scientific process with children and how, once tests have been carried out, further questions are raised and which in turn lead to more tests. For example, if the plastic is not strong enough scientists might consider adding a new ingredient to find out if that helps to make it stronger.

It is unlikely that there will be any more time available in class to try out different ingredients. However, it is possible, especially if they have already made bio-plastic at home, that some children may wish to try out some different mixtures with their families.

QUESTIONS FOR THINKING

- What products could be made from bio-plastic?
- What properties would the product need?
- How will you test the bio-plastic?
- What will you measure?
- What will you change?
- What will you keep the same?
- How will you show your findings?
- What do your results tell you?

Patricia Moynes

Research and Development

ReNEWables UK

c/o CIEC, Department of Chemistry

University of York

York

YO10 5DD

29th October 2018

Dear Children

I hear that your class has been extracting starch from potato peel and using it to make bio-plastic. Here at ReNEWables UK we are very interested in developing this plastic to make a useful product which will reduce the use of fossil fuels.

Have you any ideas about what products we could make from bio-plastic? Please can you test the samples that you have made to see whether it has the necessary properties for the product that you have in mind?

I would be grateful if you could send your findings to me at the above address.

Best wishes

P. Moynes

Patricia Moynes
Head of Research and Development

7. SCIENCE SOLUTIONS CARD GAMES

30-40 MINUTES

Children play a card game where they collect sets of cards based upon a raw material, the product that is made from it, the 'waste problem' that is left over and the 'green solution' of a product made from the waste.

OBJECTIVES

Explore examples of human impact (both positive and negative) on environments, for example the negative effects of population and development, litter or deforestation (Y4 Science).

To realise that science can develop solutions that can lead to a more sustainable future.

To become aware of the range of products that can be created from waste materials that have been developed by scientists.

TO BE ABLE TO

Talk about the problem of waste products which need to be disposed of and describe how science has the potential to provide possible solutions to some of these difficulties.

SCIENCE VOCABULARLY

landfill	product	waste material
raw material	solution	

RESOURCES

- Activity sheet 12 (one per group)
- Science Solutions Cards (separate download)

PRIOR KNOWLEDGE/EXPERIENCE

Children should have had opportunities to play games which require them to take turns and follow simple rules.

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GAME ONE (GO RECYCLE)

20 MINUTES

Look at the pictures and writing at the top of each card. This is the name of the raw material from which the different products are derived and is the name of the set. The aim of the game is to collect as many sets as possible. A product set comprises the Raw Material, the Product, the Waste Problem and the Green Solution. The Fossil Fuel card must be removed from the pack for this game.

Activity sheet 12 is placed so that it is visible to all players.

Deal out the cards so that every player has seven cards. The remaining cards are placed face down on the table. The dealer then starts by asking another player if they have any cards in a particular set. For example, they might ask "Mia, do you have any cards in the potato set?"

If Mia has any of the cards that she has been asked for she hands them over. The player who asked the question can then ask someone else if they have any cards in a set. However, if the person who has been asked does not have the card they say "Go Recycle" and the player who asked the question takes a card from the top of the stock pile.

Play then passes to the left, and the next player may ask opponents for cards from a named set. Players try to remember who has asked for which card as this lets them know what sets their opponents hold and therefore which cards it is worth asking them for.

Once a whole set is collected it is placed face up in front of the player who collected it.

Play continues until all of the sets have been completed. The winner is the player who has the most sets.

GAME TWO (OLD FOSSIL)

20 MINUTES

Activity sheet 12 is placed so that it is visible to all players.

The aim of the game is to collect pairs of cards that are in the same set and to avoid being left with the Fossil Fuel card at the end of the game.

To begin with all of the cards are dealt and players place any pairs that they can make face down in front of them (if they have three from a set only two are paired up in this way).

The dealer then spreads out their cards (ensuring that the fronts cannot be seen by the other players), and offers it to the person on their left who takes a card. If it matches a card that they already have they pair it up and place it face down before offering their hand to the next player to take a card.

Play continues to pass to the left in this way until all cards have been paired up. The player who is left with the Fossil Fuel card is declared the 'Old Fossil' and is the loser.

GAME THREE (MEMORY PAIRS)

30 MINUTES

For this you will just need the categories 'Waste Problem' and 'Green Solutions'

Place all cards face down on the table.

Take turns to turn two cards over at a time. If the matching 'Waste Problem' and 'Green Solution' cards are turned over they are kept by the player who then has another turn.

Play continues until all matching pairs have been collected.

The winner is the player who has collected most pairs.

FOLLOW UP ACTIVITY

20 MINUTES

(For all card games)

Children are not expected to remember any of the facts on the cards. The main aim is for them to realise the wide range of solutions provided by science.

Ask them to work together to think of as many reasons as possible why it is a good idea to use waste products to make new materials. Reasons might include:

- Saves sending rubbish to landfill
- They are cheaper than fossil fuels
- It can use less toxic substances than traditional methods (see example for the bio-board made from wheat straw or the eco-wax from maize)
- It can help producers stay in business (such as the orange producers in Brazil) as it gives them another product to sell.

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Activity Sheet 12: Science Solutions Overview

Raw Material	Product	Waste	Green Solution
 orange	 orange juice	 orange peel	 limonene
 potato	 chips, roasted, mash	 potato peel	 plastic
 wheat	 bread, cakes, pasta	 straw	 bio board
 oil seed rape	 vegetable oil	 rape straw	 energy
 maize	 corn oil, sweetcorn, pop corn	 maize straw	 eco wax
 cocoa beans	 chocolate	 cocoa bean husk	 packaging
 coffee beans	 coffee	 coffee grounds	 oils (used in fuels and soap)
 food crops	 food	 food waste	 fuels and fertiliser
 pea plants	 peas	 vines	 thickening agent

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