CoCoBioMater Bag

Booklet

ROYAL SOCIETY OF CHEMISTRY

Friends of Cotteridge Park

DISCOVER MATERIALS

Welcome to your CoCoBioMater Bag Booklet

Notes to Parents and Carers

This booklet is an introduction to materials science and how to make bioplastics. It intended to be an activity that you can take part in together and learn together through making.

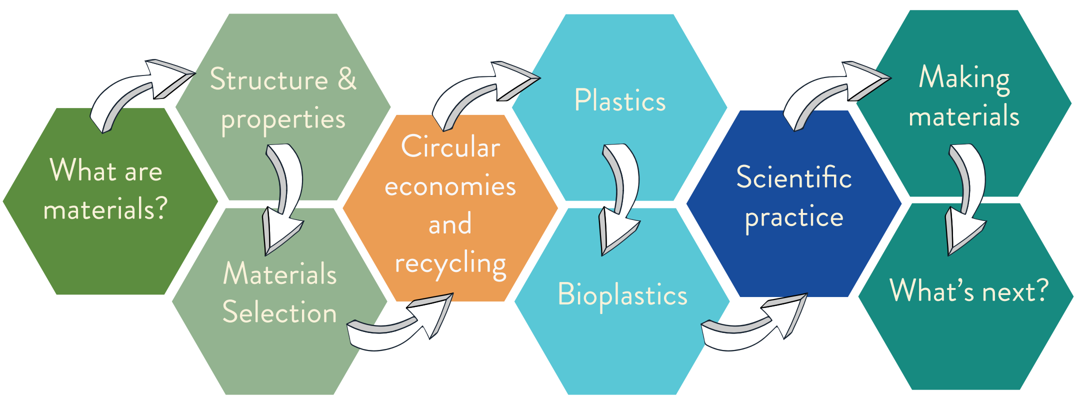
We appreciate that you may not feel like a scientist so please do not do anything that you are not comfortable with and contact the following email address if you have any questions (c.a.hamlett@bham.ac.uk) or post any questions on the Padlet page.

The purpose of this activity is to introduce scientific thinking where children learn to plan and do their own experiments.

They do not need to follow the example recipe given in this booklet taken from www.materiom.org – they could simply make a jelly and put sprinkles inside it as long as they plan what they are doing and think how they can make it different the next time they make it.

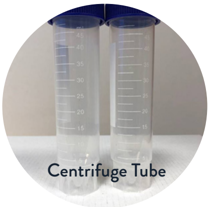
> Part of the example recipe for making bioplastics may involve boiling water– please make sure that you supervise children when they are doing this.

Booklet Overview



CoCoBioMater Bag Contents

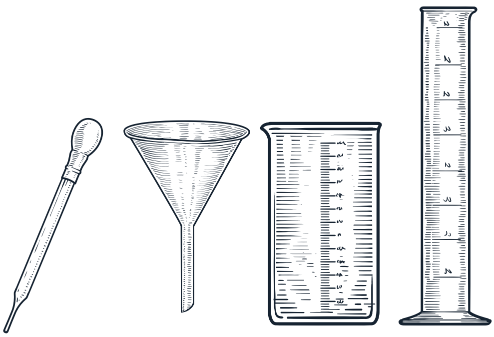
Lab book
Sharpie pen
Fridge magnet
Discover Materials pens
Materials Scavenger Hunt sheet
Recycling scavenger hunt sheet
Microscope lens


Centrifuge Tube


Spatula

Lab equipment
500ml beaker
100ml beakers
100ml measuring cylinder
25ml measuring cylinder
Pestle and mortar
Funnel
Spatulas
Plastic screw top jars
Silicone mould
50ml plastic centrifuge tubes
Square petri dishes
Universal indicator paper 1 book
Pipettes
Optional:
Oven tray (used as a spill tray)


Square petri dish



Chemicals (for example recipes)
Sodium alginate
Vinegar

Examples of dry additives to include in your bioplastics such as e.g. egg shells, dried coffee grounds (available at the Shed in Cotteridge Park) or even glitter

What are materials?

A material is the stuff that an object is made from. Material choice is really important when making something. Here are some examples of materials and there are many more.

plastic toys

ceramic pots

metal cogs & gears

Why not have a look at things around the home and outside and have a think what materials they are made from and why?

Think about why the material an object is made of might be important. What if a teapot was made of chocolate? Do you think this is the right material? Would the heat from hot water melt the chocolate?

Can you name any other types of materials?

Have a go at our Materials Scavenger Hunt

Structure and properties of materials

Choosing the right material depends on the properties and structure of that material.

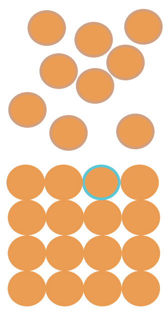
What is the structure of a material?

The structure of a material can mean many things.
It can mean the atomic structure, which is how the smallest building blocks in materials science known as atoms are put together.

There at 118 different types of atoms and these can be found in the Periodic Table. The structure of a component can also affect its properties.

Atoms can either be disordered like balls scattered in a pit or neatly stacked together like food tins on a shelf.

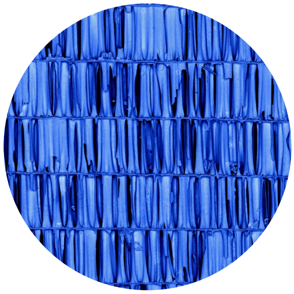
Periodic Table from www.rsc.org/periodic-table



There is also the **microstructure**, which is what a material can look like under a microscope. This structure can also affect its properties.

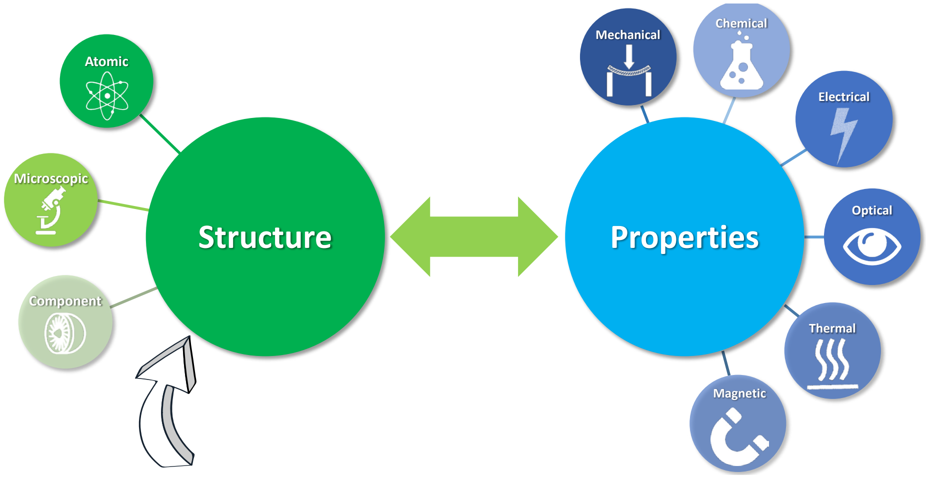
snow

mobile phone



cuttlefish bone

Properties of materials



We have thought about the structure of a material.
Now let's consider the properties of a material.

Mechanical properties

Describe how a material responds to forces such as being stretched, hit or dropped.
Some mechanical properties are **toughness** (how much force is needed to break the material) and **ductility** (how easy a material is to stretch)

LEARN MORE ABOUT MECHANICAL PROPERTIES

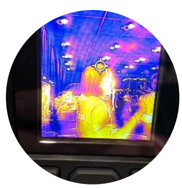
EXPERIMENT AT BY MAKING AND BREAKING BEAMS OF MATERIALS

Chemical properties

How a material reacts with other chemicals (e.g. iron rusts when it is in contact with oxygen and water -corrosion)

Thermal properties

How materials responds to heat. Such properties include how much a materials expands when it is warmed up (thermal expansion) or how well heat can pass through the material (thermal conductivity).



Other properties include **magnetic properties** - how a materials responds to a magnet, **optical properties** (what a material looks like), **electrical properties** (how well a material conducts electricity) and wettability (how easily a liquid spreads on a material).

Materials Selection

You might chose to make clothes like a t-shirt out of soft, easy to wash fabrics such as cotton and not heavy, stiff sheets of metal - unless you are a medieval knight!

Why not think about what objects around you are made from and why they are made from certain materials.

DOWNLOAD OUR MATERIALS SCAVENGER HUNT ACTIVITY TO EXPLORE THE MATERIALS AROUND YOU AT HOME

By learning how materials behave materials scientists can develop new materials or learn how to use existing materials in new ways to help solve global issues.

CHECK OUT THE DISCOVER MATERIALS VIDEO OR EXPLORE OUR YouTube PAGE AND WEBSITE WWW.DISCOVERMATERIALS.CO.UK

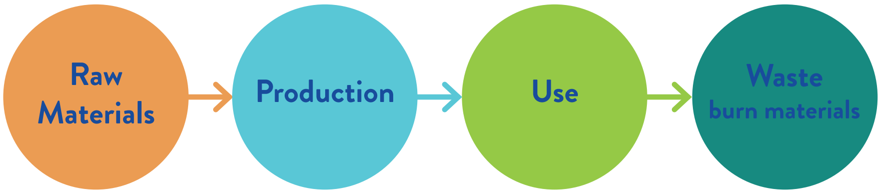
Note your material observations

Circular economies and recycling

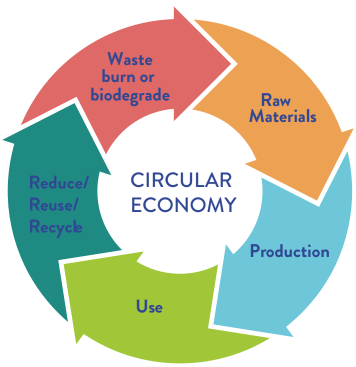
When you no longer want to keep a toy or some packaging what do you do with it? Do you throw it away? Recycle it? Give it away?

Whatever you do with it is part of the life cycle of the material and it is very important to think of this when selecting what material to make something out of in the first place.

If it simply thrown away, and burnt to make energy, it can no longer be used as a material and brand new material has to me made. This is known as a linear economy and means that more crude oil is needed to make plastics or more metal ore is needed and these processes can be very bad for the environment!



Recycling and reuse is a very important part of extending the lifetime of material which means that no new material has to be made and that is much better for the environment.



The problem with traditional plastics is that if they are not biodegradable (meaning they do not decompose naturally) so if are simply thrown away they can break up into smaller and smaller pieces (microplastics) and stay around for many many centuries.

EXPLORE THE SEPARATING MATERIALS RECYCLING ACTIVITY

YOU CAN EXPLORE OUR RECYCLING SCAVENGER HUNT

AND ACTIVITY SHEET

Plastics v Bioplastics

The use of traditional plastics (those made from crude oil) is a huge global issue especially when we think of sustainability and pollution. However, these are, in fact, fantastic materials as they can be made into any shape imaginable, can be melted at (reasonably) low temperatures and are cheap to produce.

These fantastic properties enable plastics to be used in huge quantities and this can be a huge problem for the environment because people and companies have used plastics in a very wasteful way. This has lead to pollution, waste and the phenomenon known as 'microplastics' (tiny pieces of plastics that are too small to see without a powerful microscope) even being found inside animals.

Bioplastics and circular economy

The plastics that most people think of (such as the polypropylene used to make plastic milk bottles) are made from crude oil. Bioplastics are made from natural, biodegradable resources such as alginates (from seaweed) and can include additional inclusions (such as egg shell).

Things to explore

NATIONAL GEOGRAPHIC ARTICLE EXPLORING BIOPLASTICS

TALK BY ZOE POWELL BEST ABOUT BIOPLASTICS AND THE CIRCULAR ECONOMY

Making bioplastics

Polymers are the building blocks that make up many of the materials that we use every day (including us!) and they can be thought of as long, spaghetti-like strands.

When you make slime you start off with PVA glue, this is full of polymer chains but when you add the activator it sticks some of these chains together (this is called 'cross linking) and the mixture becomes more like a slime than a runny glue. If you have really long polymer chains this cross linking can make them form harder plastics.

You may have tried this at CoCoMAD but if you want to make slime you can mix PVA glue with a little bit of activator (contact lens solution) and sodium bicarbonate and mix it. The mixture will become less runny and more slimy and you can even add other things in - have a look at this video to see how we made spooky slime for Halloween!
https://youtu.be/ID1LglKPH20

SLIME RECIPE

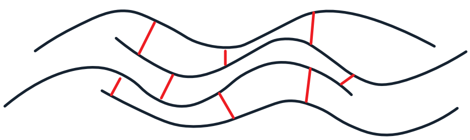
- PVA glue (base) and sodium bicarbonate
  (about 1 teaspoon for every 250 ml of PVA glue)
  Use as much or as little as you like
  (it depends on how much slime you want!)
- Contact lens solution (activator)
  It must contain boric acid / borax
- Anything to jazz up your slime e.g. glitter or food colouring (additives)
- Bowl
- Spoon
- Pots to keep your slime in

What's going on?

Cross-linking – polymer molecules are the building blocks that make up plastic materials and can be thought of as long strings or spaghetti. These 'strings' can slide past each other (and the polymer solution flows) but they can be made to stick together by adding certain ingredients and this is known as cross-linking and makes it very difficult for the string-like polymer molecules to slide past each other and so the liquid get thicker and thicker until a solid forms.

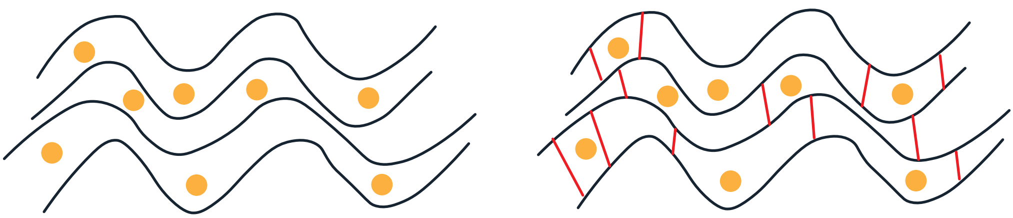
If you cross link a polymer solution with other powders in (such as egg shell or glitter) then the polymer molecules can trap the powders in which makes different materials.

Not cross-linked
The long chains move easily



Cross-linked
The long molecules are locked in place

When you add inclusions (such as glitter or egg shell) the long polymer chains cross-link and trap the inclusions keeping them inside your bioplastic.



Note your observations

Being a good scientist

1 They have an idea about what they want to test and what might happen (**hypothesis**)

2 They then plan a set of experiments by changing one thing at and write this down in their lab book.
They also think if there is anything dangerous about the experiment and what they can do to stop themselves being hurt

3 They then carefully **measure** each ingredient and record how they mix them. This will have been thought about in their planning. They also record what happens.

4 They make really good notes in their lab book about :

- What they did
- How much of each ingredient they used
- What happened

They do this so that others can do the same experiment and repeat the awesome science that has been discovered.

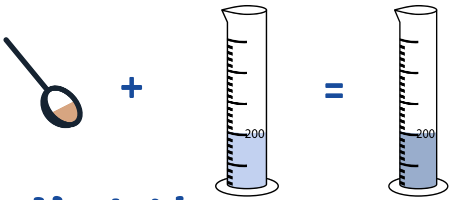
Measuring

For liquids you can write down the number of cups used, in this box, we have provided measuring cylinders so you can measure how much of a liquid you use in units called millimetres (mm).

For powders this may be in the number of spoonfuls used (but make sure you write down what kind of spoon that was used). Because not everyone will use the same spoon it is more useful to write down the mass of the powder (but at home you may not have kitchen scales that can measure only a few grams). When you mix a solid and a liquid the solid might seem to disappear – this kind of mixture is known as a **solution** (think about mixing sugar into water).

If you can still see the solid it is known as a mixture and if the powder is floating around in the liquid it is known as a **suspension**.

When you make a **solution** it is important to know how much of the solid (solute) has been dissolved in the liquid (the solvent) to make the solution and this is known as the **concentration**.



Solution = 1g of powder mixed with 200ml (0.2l) of liquid.
The liquid has concentration of 5g/l

Variables

Once you have made a bioplastic you can then make a different one by changing one thing about the recipe. Whatever you change is known as a variable and it is important to only change one variable if you want to find out how that variable affects the bioplastic (if you change two things at once you cannot say which is the important one).

There are lots of variables include the amount of a powder (mass), the volume of liquid used, the concentration of solutions, temperature, humidity (how much moisture is in the air).

Grinding Powders

A **pestle and mortar** is a great way for grinding up powders and is often used for grinding spices for cooking. All you need to do is to put your ingredients in the pestle and grinding it with the mortar under it becomes a powder. The longer you grind it the smaller the powder particles become. Be careful not to grind your fingers.
Hint: make sure you grind dry solids otherwise they won't make nice, flowing powders.

Planning your experiment

Use your notebook to write down what variables you will change (this could be the mass of a powder or any other powders (such as egg shell or glitter) that you are going to put in.

Making materials

Making your bioplastic

In your CoCoBioMater Bag you will find the ingredients to make a bioplastic based on sodium alginate (which is a chemical found in seaweeds).
This recipe is taken from the Materiom website (**https://materiom.org/recipe/60**).

Ingredients:

-Vinegar 5-10 ml
-Water 200 ml
-Sodium alginate 4 grams (One spatula full is ~0.3g of sodium alginate)

Inclusions (the recipe in the link above uses 15g of eggshell but feel free to experiment with the eggshell) or even try a different type of inclusion.

Equipment

Grinder (pestle and mortar), stirring spoon, container for mixing (500 ml beaker), a mould, scales (or spoon for measuring)

Think about what you want your material to do? Do you want to make it tougher? More bendy? More sparkly?

Have a think about how you could change your recipe (add more cross linker, what inclusion to add?) then plan your experiment and make at least three different recipients and change the amount of only one ingredient - how does this affect the final material?

When you plan your experiment you must remember to think about safety - speak to your parent or caret as they may be able to spot risks that you cannot see (this is part of being a great scientist).

You could make a few different materials and keep them in the square petri dishes (and use the Sharpie pen to write on the dish what each material is) and then we can test them

Remember to visit us in Cotteridge Park over the summer holidays to show us your materials and test them using our testers.

Method

This is an example method of making a bioplastic using sodium alginate (that is supplied in the CoCoBioMater Bag).

Step 1) Prepare the alginate solution

The day before you need it prepare a 2wt%* alginate solution by mixing 200ml of water with 4 grams of sodium alginate. Leave the alginate solution to hydrate for 24 hours.

***2wt% means that 2% of the weight of the solution if from the solid powder that was added e.g. a 2wt% solution would be made up of 98ml water (which weighs 98g) and 2g of powder.**

Notes

Step 2) Prepare the inclusions

If you want to mix in anything else then it works best if they are dry powders (such as coffee grounds, eggshell). If you want to dry out powders then it is recommended to put them in the oven at a low temperature (less then 80°C) for a few hours. You can also grind up the powder using the pestle and mortar provided (the longer you grind it the smaller the particles will be).

- A description of how to prepare the eggshell is described here (**https://materiom.org/recipe/60**).

Notes your observations

Step 3) Make the composite

Mix the eggshell*with 20g of hydrated 2% alginate solution. Stir gently until they mix completely avoiding the incorporation of bubbles.

Notes your observations

Step 4) Set the composite

- Put the composite (made in step 3) in a mould and then gently pour the vinegar onto it and it will start reacting and coagulating.
  (Coagulating is where the liquid starts to thicken up and become more solid.)
- Leave it react for 15 minutes and then try to separate the mix from the mould gently in order to leave space for the vinegar to penetrate the sides (use the spatula).
- Wait for an hour and then take the sample out of the mould and turn it around to allow the vinegar to reach the other side of the biocomposite.

Notes your observations

Step 5) Drying

Take it out of the mould, rinse it under tap water (to clean the vinegar off) and leave it to dry.
Once it is dry write down what it looks like (or even take a photo), what does it feel like and how does it behaves (does it break easily?)

You can then make more biocomposites and try changing the variables

Now you have made your bioplastic what is it like?

Is it bendy? Crumbly?

What does it look like?

If you have changed one bit of the recipe from your first attempt what effect has that had?

What's next?

Share photographs of your bioplastics on our online Padlet page (and see what other people have made or even bring along your bioplastic to show our materials scientists who will be by **'The Shed' in Cotteridge Park on Friday 29th July and Tuesday 23rd August (1030-1230)** and they can even help test your bioplastic to see how strong it is and even what it looks like under a microscope!

Explore the Discover Materials Website:

www.discovermaterials.co.uk

RECYCLING PANEL DISCUSSION

CAREERS PANEL DISCUSSION

CAREERS IN MATERIALS SCIENCE AND ENGINEERING

Padlet page

We have videos and extra help on a Padlet page (a kind of electronic noticeboard). Use this page to ask us questions and to share photos of your awesome bioplastics.

Thanks for taking part in our CoCoBioMater Bag project please leave us your feedback

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