THE PROPERTIES OF MATERIALS
and their everyday uses

Science background for teachers

VOCABULARY

Words to describe properties: Hard, soft, strong, weak, tough, brittle, stiff, rigid-flexible, absorbent, waterproof, magnetic, non-magnetic, wear and tear, smooth, rough, transparent, opaque, translucent

Names of a variety of materials: wood, metals – copper, tin, steel, gold, silver, aluminium, chrome, plastic – polythene, polystyrene, PVC, fabrics – cotton, silk, polyester, wool, acrylic, foam, glass, rubber

Children need to have experience of, and explore as many different materials (substances) as possible in order to make sense of their world. Understanding how materials behave in their natural state and under certain conditions will help them to understand why objects are made of specific materials. Some properties are easily observable features, such as transparency, which they explore as younger children, others are less obvious and need to have tests carried out on them.

In carrying out comparative tests on different materials, children develop an understanding of suitability for different purposes. They then begin to develop the skills themselves to choose the best materials for certain tasks. When testing materials for properties, precise vocabulary becomes important because children (and adults) sometimes confuse scientific terms, which they use in a general way in their everyday speech.

Hardness Resistance to scratching and pressure. Hardwood does not mark as easily as softwood.

Strength Amount of force needed to break a material usually by pushing or pulling down.

Toughness Resistance to breaking by cracking, opposite to 'brittle'.

Stiffness Amount of force needed to change the shape of a material, opposite to flexible.

Elasticity Ability to return its original shape when a force is removed eg rubber band.

Plasticity Ability to retain the new shape when a force is removed eg plasticene.

Absorbency Ability of a material to soak up a liquid.

Waterproof Resistance to liquids, repels water.

A material can be described in a variety of ways for example it may be strong but brittle, and the combination of its properties may determine its use. The property of a material can change according to how the material is treated; clay is very different once it has been fired, rolled up newspaper is very different to a sheet of newspaper.

SKILLS

- Recognising and carrying out a fair test, repeating a procedure.
- Measuring length with a degree of accuracy.
- Constructing a bar graph.
- Careful observation.
- Working cooperatively.
- Recording carefully.
- Use of ICT for graph drawing.

Key ideas and activities

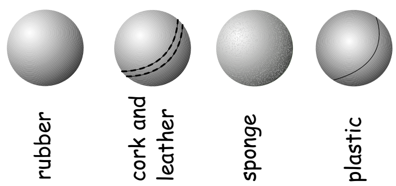
Younger children should have spent time experiencing some testing of the simple properties of materials. The activities offered here try to build on that experience and give the opportunity to develop the skills of investigating, whilst tackling the testing of properties. Certain materials have properties that are appropriate for specific uses and by comparing these, the idea is introduced that whilst some materials are reasonable for the use, others might do the job better.

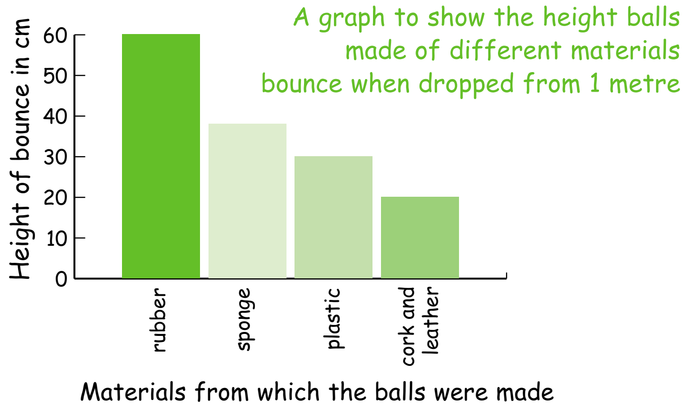
Some materials can be changed in shape, a property suited to specific uses

(a) Balls are made from a variety of materials **Investigate**

Which is the bounciest ball? Look at balls made from a variety of materials and discuss the different uses and properties, including sizes. The children can decide what they want to test eg, 'the bounciest football', 'the bounciest small ball'. What do they think 'bounciest' means? A ball that bounces the highest, or one that bounces for the longest time? The possibilities and variables are numerous, so they need to be made more specific. This is where the children learn to plan. The results will make a good bar graph.

Graphing package





Choose balls that are the same size. How high did they bounce?

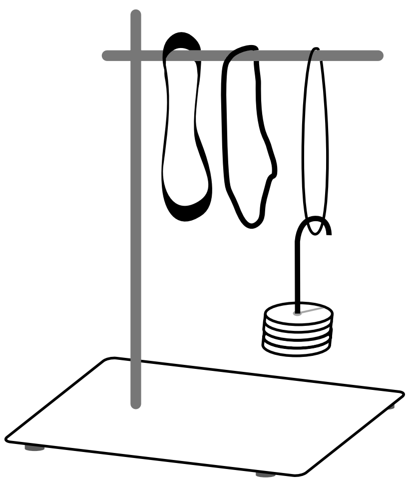
(b) Elastic bands **Investigate** elastic bands with older children.

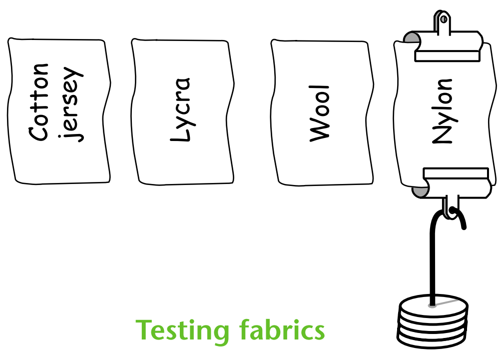
Stretching them to their breaking point is too dangerous! Try comparing different thicknesses of the same band circumference with a fixed weight eg 500 gram. Carry out this experiment on the floor. Hold the band and weight against a ruler to see which stretches the most.

Safety!

- Goggles should be worn when testing elastic bands.
- Care should be taken when using 'scratching' tools.
- Care should be taken when using weights.
- Great care should be taken and children closely supervised when using hot wax.

Testing different thicknesses of rubber bands with weights



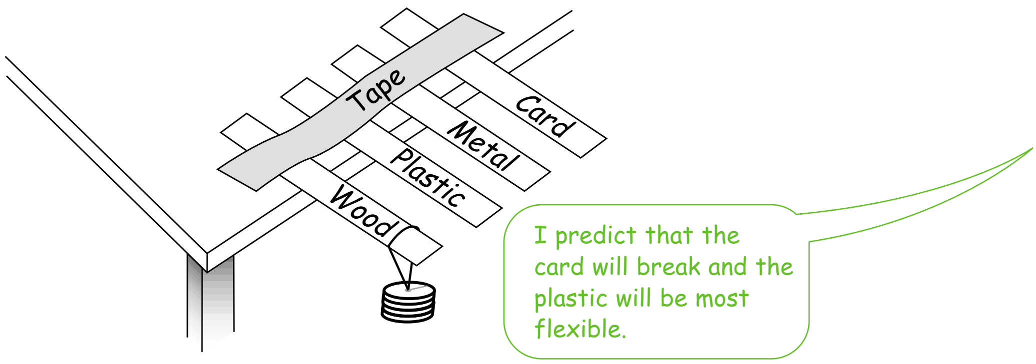


Testing fabrics

(c) Stretchy materials Sometimes we want a material (fabric) to have some elasticity because of the garment it will be used to make, for example, a pair of tights. Different fabrics can be tested for this, but pupils must remember that we want the fabric to return to its original shape and size. Strips of fabric can have weights hung onto them. What length is the fabric at the start? To what length does it stretch? What length does it return to? Use bulldog clips to support the weights or cut a hole in the fabric to hang the weights through.

Spreadsheets

(d) Flexibility Some usually rigid materials need to be able to 'give' a little and not break, to accommodate different situations for example a bridge carrying heavy traffic. Different materials can be tested eg identical lengths of wood, plastic, metal (use rulers) and card to **investigate** how much they will bend by hanging weights from string onto the end or sticking weights on the top with Blu-Tack®. Since the intention is not to break all your material samples, use a light weight and **investigate** 'which material bends the most using a 100 gram weight?' Measure the distance that each ruler bends. Another consideration is the way the material is formed. A card tube, for example, is less flexible than the same card unrolled. Children can **investigate** one material in different forms. Cut the card from both sides of a cereal packet to test the card flat, rolled the long way, the short way and folded zig-zag, then put the weights on the top.

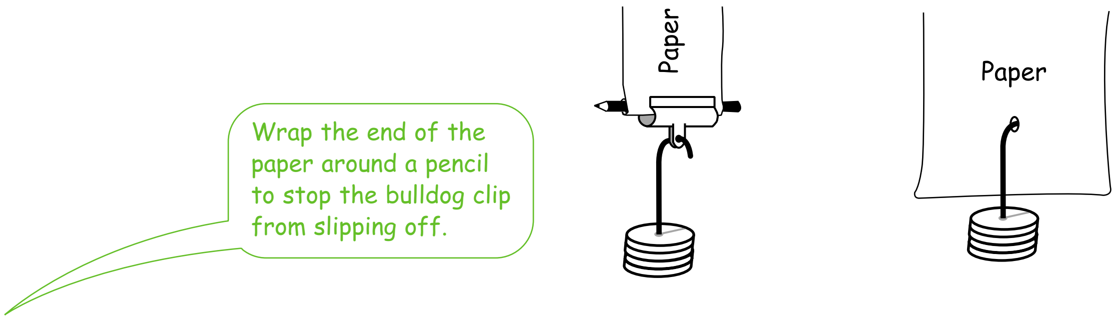


Comparing everyday materials for strength

Most materials need to be strong. They need to withstand the forces of pulling or pushing without breaking or tearing and withstand 'wear and tear' if they are materials to be made into clothing.

(a) The strongest paper Papers are made of different qualities, young children may have carried out the simple test for the best drawing paper. This is another one for younger children. Paper is often used for wrapping parcels and needs to be flexible and strong. **Investigate** Which type of paper is strong? Can they think of a way to test the strength of paper? Collect sheets of different types of paper and make them the same size. Make a hole in each sheet not too near the edge and hang a weight carrier onto it. Carefully add weights until it tears. A sheet of A4 computer paper held 650 g before tearing.

Tip If weight carriers are not available use a strong bulldog clip with a pot attached to it by thread going through the hole. Clip this to the sheet of paper and gradually add weights to the pot. The bulldog clip sometimes slips off the paper, so wrap the end of the paper around a pencil and the bulldog clip will grip this.



Make a bridge with paper Older children can try making a bridge using different types of paper and putting weights on the top. What happens if the paper is folded into a concertina shape?

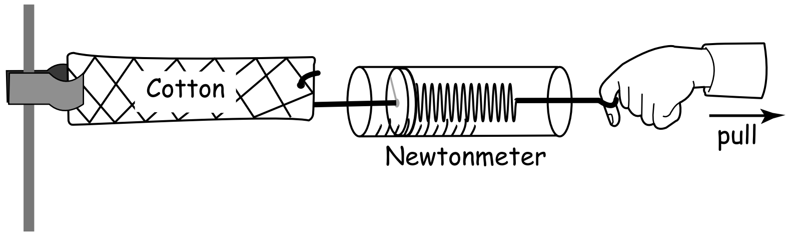
(b) Testing threads Many fabrics are made from woven or twisted threads and their strength is important. Strings and ropes made from such fibres may hold heavy weights, peoples' lives may depend on their strength. **Investigate** the strength of threads by suspending weights from equal lengths of threads and seeing the weight they will hold until they break.

Tip Weight carriers can be used, but threads are surprisingly strong, a length of cotton held 1100 g, polyester and nylon will hold much more. Try tying the threads to the leg of a table turned on its side, tie a small, light plastic bucket (plasticene tub) to the thread being tested and gradually add weights. The container allows large weights to be added. Threads may also be tested using a newtonmeter, (forcemeter), but it is less accurate as it is often difficult to see exactly where the thread breaks because the spring returns too quickly.

(c) Testing fabrics for strength Fabrics used for items such as work clothes, sheeting, bags etc need to be strong to withstand being pulled around, for example by your friends! The strength of fabrics can be tested in various ways, similar to the testing of threads. See if the children can suggest ways in which this might be done. Equal strips of fabric can have a newtonmeter attached to the end. As it is pulled, the force will register on the scale to the point where the fabric tears. As fabric tears slower than thread breaks, this method works quite well.

Tip Alternatively, by using a pot as the container or a weight carrier, the weights can be hung through a hole in the fabric until it tears (some fabrics are very strong and can take many weights, use thin fabric strips). **Investigate** 'Which is the strongest fabric?' You may discuss with the children whether it is fair to include 'elastic' fabrics in this test that also have the 'stretch' property.

Slowly pull the newtonmeter to see how much force it takes to tear the fabric.

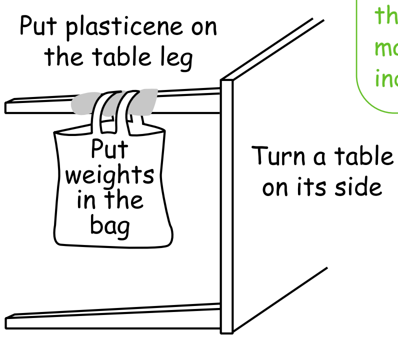


(d) **Hard wearing fabric** Clothes must withstand the wear and tear that comes from sitting on the floor or playground tumbles, (who has had tears in their trouser knees?) rather like friction wear. Discuss this with the children and see if they can think of a way to test this. If you stick a piece of coarse grade sandpaper onto a wood block and rub this onto fabric you can count how many times you can rub before the fabric shows wearing or a hole. Choosing the same child to rub makes it fairer, although a little tiring!

(e) **Which is the best carrier bag?** **Investigation** for older children. Children bring in a collection of carrier bags. What do we mean by the best? The strongest? Handles that don't mark your fingers or both? Bags may be tested, by hanging them over a pole (or the leg of a table turned on its side). Weights are then carefully put into the bags (they take a lot, supplement with bricks). The 'best' bag will carry the heaviest load. A separate **investigation** may be carried out to test for handles that don't mark your fingers but older children can deal with both variables at once. Whilst testing for strength, put plasticene on the pole where the handles are to be hung. The handles cut into the plasticene as the bag becomes heavier. The amount the handles cut into the plasticene can be measured. The results can then be discussed. Which is the bag that is the strongest but marks your hands the least? Is there a compromise to be made?

The best bag holds the most weights, and makes the smallest indent in the plasticene.

Make the plasticene about 3 cm thick. How deep do the handles dig in?

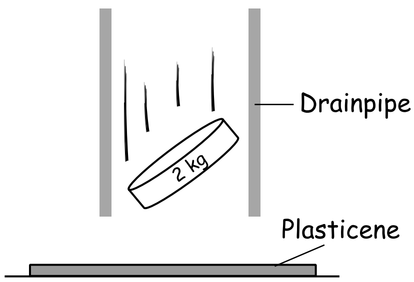


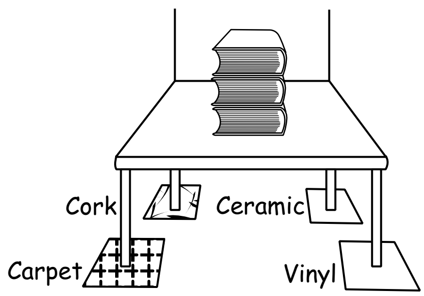
Comparing everyday materials for hardness

(a) **The scratch test** This test, which is used on different rocks (see Rocks and Soils section) can also be used on other materials such as different woods or different types of hard flooring such as vinyl, linoleum and tiles. Discuss with the children the fact that flooring must withstand scuffs and scratches from shoes and scraping chairs and see if they can devise a test. Scratching can be done with a variety of objects from fingernails to metal nails on samples of the material to be tested. Discuss with the children the difficulty of measuring how hard to scratch. If the same child scratches each material as hard as possible it helps to make the test fair. Children will often come up with this conclusion themselves.

Investigate Which is the hardest wood?

(b) Denting test If you drop a metal weight on to a piece of flat plasticene it will leave a dent. What will it do to the floor? There are often notices in halls where there is a wooden floor about wearing stiletto heels. There are a variety of variables here for older children to consider apart from the material that is to be tested, the different weights, the different heights they may be dropped from and the different surface area of the weight. Drop weights through a wide drainpipe or cardboard tube for safety, onto squares of different types of flooring, cork, vinyl, carpet, wood and ceramic. Furniture often leaves marks on carpets and flooring, so you could test four pieces of flooring. Place different flooring under the four legs of a classroom chair and weight the seat of the chair with books or bricks. Leave for a few days then look to see if there are any marks.





Tip Ask the children to bring in samples of flooring from home since parents often keep 'off cuts' or try to get old samples to keep from a local builders merchant or DIY store.

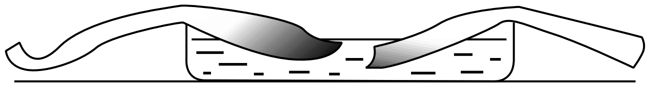
Comparing everyday materials for absorbency

Kitchen paper and disposable cloths are common items in most kitchens these days for doing many jobs, especially mopping up spills, but are all makes of paper as good as each other? Are some materials better than others? When carrying out these tests the children must consider how much water to use, the size of the material, how many pieces/wipes they use. A pipette or syringe dispenses accurate, small quantities of liquid, which can be coloured with vegetable dye for some of these tests.

(a) Mopping up Young children might drop a small, measured quantity of water onto a tray and put sheets of paper onto the top until it is all absorbed. Alternatively, drop measured quantities onto the paper. **Investigate** which is the best kitchen paper?

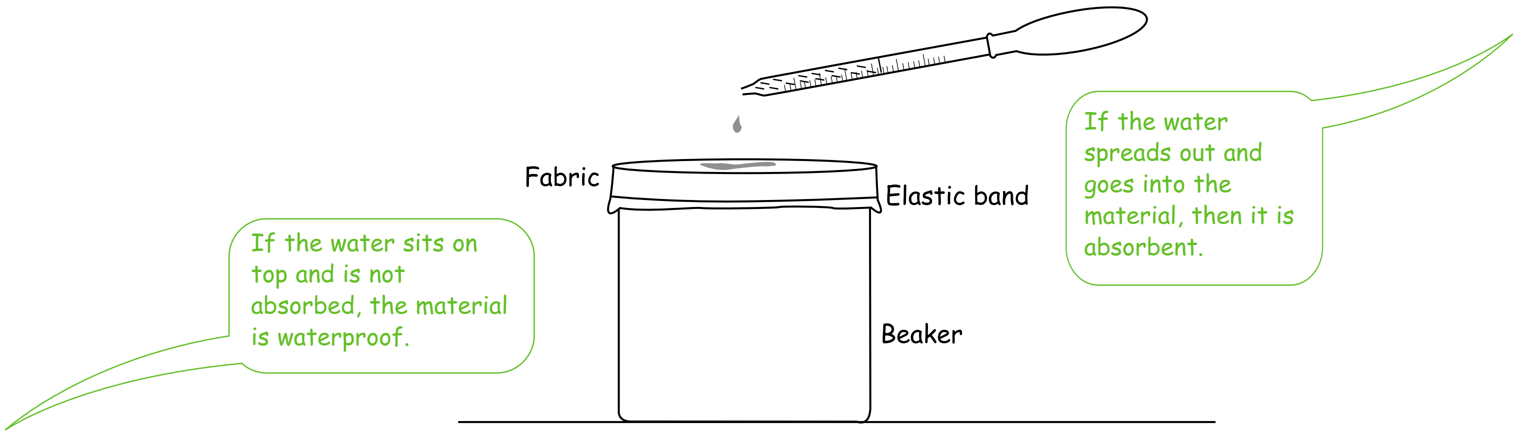
(b) Which material absorbs water the fastest? Lay thin strips of equal lengths of different materials (include a waterproof strip) into a shallow tray. Pour coloured water into the tray, measure how fast and how far up the fabric it is absorbed. Discuss the different reasons why absorbent materials may need to be used.

Put thin strips of fabric in a dish of coloured water



(c) Absorbent building materials It does not always occur to children that 'hard' materials like wood and stone can absorb water. The knowledge of this fact is particularly important in understanding how building materials (or their toys!) need protection from the wet. Children can test a variety of materials eg plastics, metals, different types of wood and bricks for their absorbent property. Young children can put small objects eg tennis ball, wooden brick etc into very shallow dishes of coloured water to observe if any water is absorbed. Older children can use a dropper to measure out 5 cm^3 into each dish. Stand small pieces of material of the same size in the dishes eg cork, wood, metal and plastic to observe and time any absorption that might take place. If accurate scales are available, a quantitative and 'fair test activity' could be to **investigate** which is the most absorbent brick or wood. Compare different types of bricks or wood of the same size, weigh before and after immersing in water (see also Rocks and Soils section). A bar graph can be constructed showing the volume of water absorbed by each type of wood.

(d) Waterproofing If materials do not absorb water at all they are said to be waterproof, a property that can be very useful for example in clothing, packaging and housing. A very simple activity for younger children is to drop water onto a variety of materials as in the 'absorbency' activity, to see if they absorb or repel the water. Older children can stretch pieces of cloth across jars to make them taut and using a dropper, drop water onto the cloth. The number of drops and the time they stay on the cloth before being absorbed, if at all, can be measured. Making the absorbent material 'waterproof' can then be tried with older children, by waxing it.



Batik The ancient craft of dying material using a wax resist could be done as an art activity. Molten wax is applied onto cotton through a special tool called a tjanting or painted with a brush. The cloth is then dyed and when it is dry, the wax is ironed out. Where the wax has been applied, the dye does not penetrate, so a pattern is formed. This is an extension of the wax drawing and wash technique often used with younger children.

(e) Make a waterproof hat/bag A design technology activity.

Comparing everyday materials for magnetism

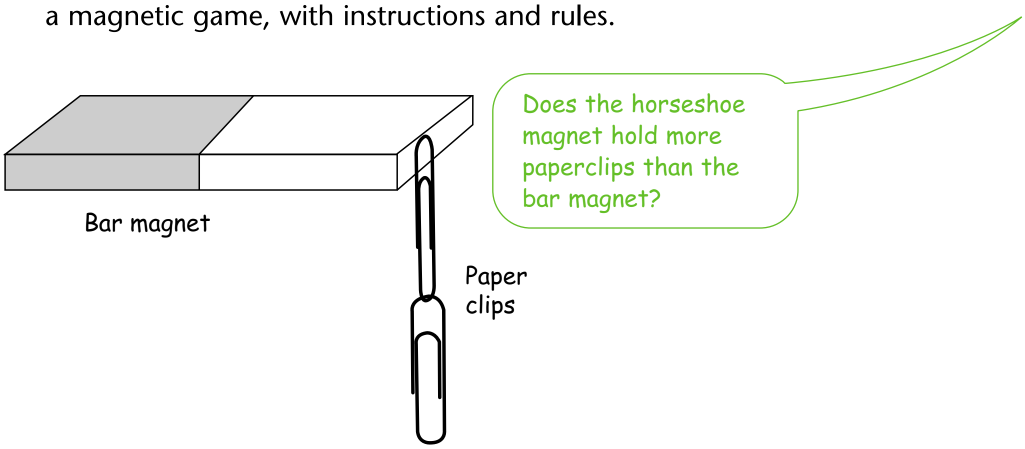
Branching database

(a) Is it magnetic? Younger children may carry out a simple classification activity to see which materials are magnetic.

(b) Will magnets work through all materials? This can be a simple classification activity or **investigate** which materials magnets work through the best? Does thickness matter?

(c) Which is the best magnet Using different types of magnets get the children to plan and **investigate** this.

(d) Make a magnetic game A design technology activity to make a magnetic game, with instructions and rules.



MATERIAL FACT FILE

To 'round off' and consolidate this work, or as an introduction or research for older children (homework) here are some suggested 'pencil and paper' activities:

(a) Choose a large object with many materials and functions eg a bicycle, room in a house, outside of the house and get the children to construct a chart of the materials used, the function and properties of the material. For less able children provide a copy of the sheet at the end of the chapter.

(b) Choose a material with many different uses and properties such as aluminium, write them down or let the children research for themselves and match a particular property to a specific use eg flexible, lightweight – aluminium foil. Non-corrosive, lightweight- bicycle frame. For less able children provide a copy of the sheet at the end of the chapter.

Star* Poetry by Michael Rosen

Bag Words A poem that plays with words, what are bags made of?

Scary Sausage-fingers That's what carrier bags do to your fingers if you have lots of shopping.

Night-time Kitchen Which is the most important material in the kitchen? See page 10.

Rubber Dubber Rubber is 'elastic' and used for making bouncy balls, what else is it used for? See page 10.

Bag Words

Today we are learning about bags.

If a paper bag is made of paper
is a handbag made of hands?
is a sandbag made of sand?

An air bag is full of air
so I suppose a plastic bag
is full of plastic.

A carrier bag carries,
so a sick bag is sick.

I know what mailbags
look like
but what do bags of fun
look like?
And can you pack the bags
under your eyes?

I know who let the cat
out of the bag
but who put it in?
I just hope there aren't any cats
in the bags under your eyes!

I've heard there's a
bag of nerves
and a
bag of bones.
Why not put them
in together
with some blood, muscles and skin
and you could have
a bag of person?

All this I understand
But why do people
keep saying
'It's in the bag'?

What's in the bag?
The cat?
The sick?

And while I think about it
which bag is 'it' in?
One of those bags of fun, perhaps?

Shouldn't they say
what they mean
and instead of saying
'It's in the bag'
couldn't they say
what they are talking about
like
'The hand is in the handbag'
or
'The cat is in the bag of nerves'.

And then we'd all know
what they're talking about.

Scary Sausage-fingers

Hey!
Psst!
I got a trick.
Do you want to know my trick?
I'll tell it to you.

It's called Scary Sausage-Fingers.

I'll tell you how you do Scary
Sausage-Fingers.

You walk into a room
with Scary Sausage-Fingers,
you hold up your hands
and go:
"Look at me! I got Scary Sausage-Fingers!"
and everyone'll go, 'YAAAA!!!'

But first you've got to
make
Scary Sausage-Fingers

You go to the supermarket - without a bag.
You do loads and loads of shopping
You put it all into the bags
they give you
You carry it all home.

As you walk along
the handles of the bags
cut into your hands.

It's agony.

But you don't give up.

You walk on home.

The bags still cutting into your hands.

It's double-agony.

You get home
You drop the bags.

Now you've got
Scary Sausage-Fingers,
Big, fat, puffy fingers
with little narrow white bits
in the joints in between
the sausages.
So you rush into where
everyone's sitting quietly
having a nice time
and you hold up your hands
in the air and shout,
'Look! Scary Sausage-Fingers!'
and everyone'll go,'YAAAA!!!'

RS•C

lightweight

expensive to produce

soft, easy to mould and shape

can be mixed with other metals to make it stronger

good thermal conductor

it does not rust

good electrical conductor

Match the Aluminium Facts

Rotary driers

Aluminium foil

Bicycle frames

Saucepans

Electrical cables

Window frames

Toothpaste tubes

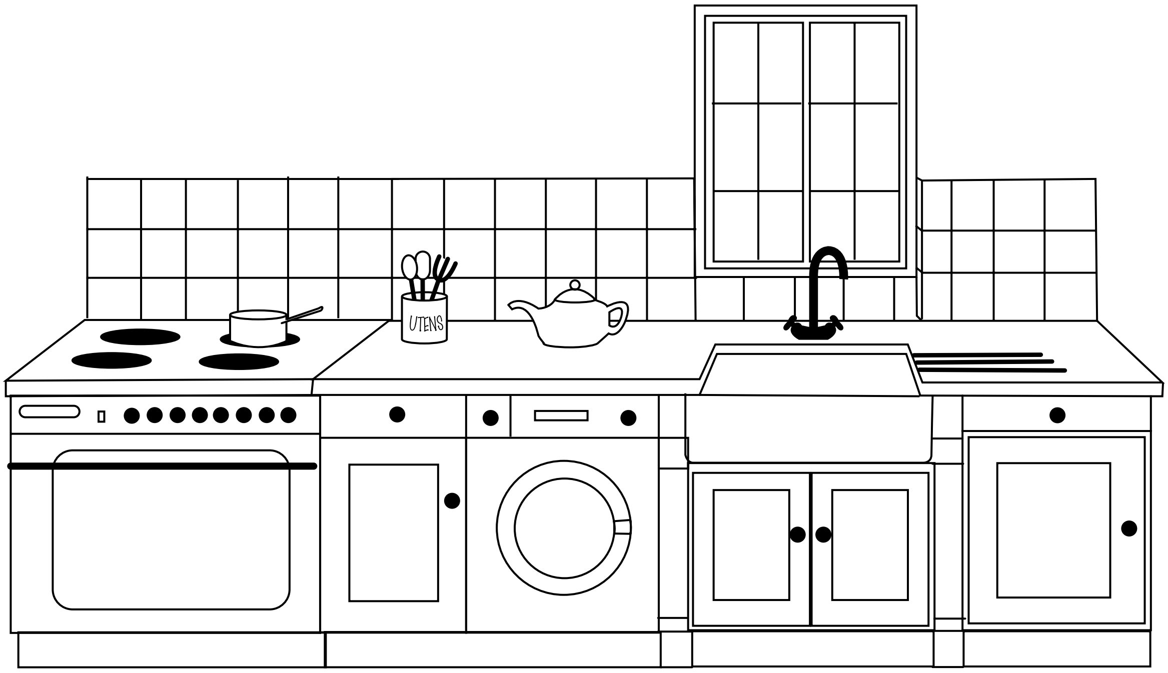
Mirrors

Watering cans

Milkbottle tops

Aircraft

abpi



Object	Material	Property	Use related to the property of the material
teapot	ceramic	rigid, waterproof resistant to hot liquids	holding hot liquids

Object	Task	Material	Why was it chosen?
sink	holding water, washing things	stainless steel	waterproof, strong, tough, easy to clean

INTRODUCTION

This book is not intended to be a scheme of work, but is a manual of ideas, activities and investigations about the science of materials for teachers to use with primary children. They may add to or offer an alternative to those already being carried out in schools. All the activities have been trialled, although in accordance with good practice should be tried by the teacher before using them with a group of children.

Each chapter begins with scientific background knowledge appropriate for the concepts covered in that section and these are intended to help the non-specialist teacher. There is a suggested vocabulary to introduce to children and a list of science skills.

Key ideas or learning intentions are followed by a variety of activities described in some detail. These are intended to help children to develop an understanding of the concepts by taking part in a practical activity themselves or watching a demonstration. Each set of activities may be targeted at a particular year group. Some ideas however, begin with activities for younger children and continue with those for older children, in order to develop the concept further. Extension ideas are often offered for more able children. The intention is for teachers to select activities that best suit their children, school and classroom circumstances.

Opportunities for the use of ICT to enhance the teaching and learning experience have been indicated where appropriate.

The activities section always includes a list of safety considerations, and in some cases additional reference is made to this within the section. It is a good idea to get into the habit discussing the hazards and risks involved with the whole class, especially for situations which maybe particularly hazardous.

Teachers should be aware of the useful guide 'Safe Use of Household and Other Chemicals' (Leaflet L5p) produced by the CLEAPSS School Science Service. However teachers should be aware that this is only available to subscribers to CLEAPSS.

Cross-curricular links

Where possible, links to other areas of the curriculum have been made and in all cases there are references to the Numeracy Strategy and the non-fiction Literacy Strategy for England and Wales. In addition, poems from the star* project have been included. This project on Science, Technology and Reading is funded by The Design Council, Esso and the Royal Society of Chemistry, with support from the Institute of Physics and the Association for Science Education. These poems have been given literacy references in number form only for the age of the children for whom the science activities are appropriate. This and other curriculum information can be found detailed on the following website; www.chemsoc/networks/LearnNet/thats-chemistry.htm

star* Project

Science, Technology and Reading is the star* project and includes a unique collection of poems especially written for it by Michael Rosen. The poems deal with specific scientific concepts in an everyday context and where appropriate, some have been included in this book. They are intended as an exciting introduction to a science lesson, offering the concept in its everyday context, a requirement of the Programme of Study for Science in the National Curriculum. In addition, they offer an opportunity to take a cross-curricular approach, by being referenced to the National Literacy Strategy, where they may also be used.

Literacy

Poetry and stories star* poems have been selected and included for all of the chapters. In addition, other poems and stories have been suggested in the resources section on pages xvii-xx, to link particular scientific concepts with the language curriculum.

Non-fiction Throughout the primary school, children are expected to experience non-fiction writing, which will often have a cross-curricular theme with a specific genre. Some suggestions have been made for this and is dependent on the suggested activities in the chapter and the age of the children carrying them out.

INVESTIGATIONS AND SCIENTIFIC ACTIVITIES

Most of the ideas presented may be carried out in a variety of ways.
These include demonstrations by the teacher, investigative and explorative activities and part or whole investigations.
Practical activities such as researching a topic, illustration (eg following instructions for crystal growing), observation, surveys, learning skills (using a thermometer), and handling secondary data are not investigations. They are valuable scientific activities, which may carry specific, skills-based learning intentions. Most of the time, however, they can be incorporated into investigative and explorative activities where pupils are encouraged to make increasingly more choices and decisions for themselves. This is a valuable way of learning scientific and key skills, and building children's confidence to eventually carry out a full, independent investigation.
Investigations involve a set of scientific skills such as identifying a problem or need, planning the process and equipment, carrying out the task, observing and recording results and concluding from the results. This is time-consuming, so children should experience it when it is most appropriate, not all the time. Suggestions for investigations have been made in the book where they are particularly suitable.
Not all investigations are of the type where variables are the focus. Scientists carry out a variety of investigations where the skills of planning, carrying out the task, recording results and concluding are needed. Whilst the investigation must be carried out in a scientifically 'fair' way, changing maybe one variable, the focus maybe on another skill, depending on what is appropriate eg pattern finding. Children should experience a varied diet of investigations. The following give examples of other different investigation types:

(1) **Classifying and identifying,** eg which materials are magnetic? What is this small creature, its name and type?

(2) **Exploring.** Observations of an event over a period of time, eg germinating seeds or the development of frog spawn.

(3) **Pattern seeking.** Observing, measuring, recording, then carrying out a survey to see if there is a pattern, eg do tall people have the longest legs?

(4) **Making things or developing systems.** This maybe a combined science/technology investigation, eg designing and making a traffic light system.

(5) **Investigating models,** eg does the mass of a candle increase or decrease when it burns?

Many non-investigative activities may be turned into investigative ones if it is appropriate to do so by changing the task title. For example an illustrative activity such as making carbon dioxide using Alka-Seltzer and water can be made into an investigation by posing the question, 'Does the amount of Alka-Seltzer used affect the amount of carbon dioxide made?'

This type of activity presents opportunities for information collecting and handling using ICT.

ORGANISATION

The classroom organisation of science activities depends on a variety of factors, including the number and ages of the children in the class, the size of the room, number of adults helping, the available resources and the specific activity being carried out. Clearly one teacher and thirty 10 year old children, carrying out a 'burning materials activity' is not advisable for many reasons, not least of all the safety factor. For activities like this, it is advisable to carry them out in small, closely supervised groups where the children work in pairs. A classroom assistant or parent helper is very useful, even if not essential, for times like this.

The current pressures of curriculum delivery tend to dictate whole class teaching, which is probably what will happen for most science activities, especially with older children. Class rules about moving around, collecting, sharing and using equipment need to be established for science, as for any other practical subject. Children participate and learn best when they work in very small groups of two or three, but this could be part of a larger group of six, working at one table, who share a tray of equipment.

It is not always necessary for all the children to do all the same activities when dealing with a key idea in science. Differentiation dictates that some children will not be able to do this anyway. If, for example, children are testing materials or looking at factors affecting a scientific process such as dissolving they do not all need to do all the same tests. It is better to do two tests really well, where scientific skills are developed, than attempt to rush through more. The important factor would then be the plenary session at the end, which would bring all their ideas together in a whole class discussion and group presentation. This also addresses various aspects of the language curriculum.

DIFFERENTIATION

It is generally accepted that most children will be able to carry out a simple whole investigation independently by the time they leave primary school. Some, however, will not.

Children gradually develop the skills to do this and investigations can be differentiated not only by changing the task but also by the amount of teacher input that is given.

For example, an investigation into the factors that affect dissolving may be differentiated in many ways:

(1) Limit the number of factors that are investigated for less able children.

(2) When investigating each factor, some children may plan, choose apparatus etc for themselves, others may need help for all or some of this.

(3) You may wish to use the investigation as an opportunity to focus teach a skill to a group of children, such as improving their results chart or teaching them how to draw a line graph.

Helping in any part of an investigation does not negate its value or mean that the investigation cannot be assessed. Children may do a part investigation independently and receive help with the rest. For example, a child may need help planning an investigation, but be able to carry out the task and record results independently. It may not be possible to assess a complete investigation for some children.

(4) Some investigations are not appropriate for all the class eg investigating the saturation point of a solid in water, but may be used as an extension activity for some able 9-10 year old children.

TABLES, CHARTS AND GRAPHS

Charts and graphs help to make sense of a list of measurements and enable children to visually see the results of their scientific investigations. It also helps them to see the effect that variables have on each other. They need to develop the skills of reading and constructing charts and graphs.
There are conventions for tables, charts and graphs, all of which should be given clear, appropriate headings.
Tables should be drawn in column form. The left-hand column is for the **independent variable,** which is the one you choose and change, and the right-hand column is for the **dependent variable,** which is the one you observe and measure.
Any units used should be in the column heading not in the column.
There can sometimes be confusion about plotting variables on a graph and deciding which variable goes on which axis. The **independent variable**, which is chosen by the experimenter, goes on the horizontal or **'x'** axis, and the **dependent variable**, which are the readings to be made, go on the vertical or **'y'** axis.

In the science activities in this book, most of the graphs used are bar charts or line graphs.

(a) **Bar charts** are used when the **independent variable** is not numerical. The bars can be in any order, equal width and should not touch. Lines, paper strips and materials etc can be used instead of bars.

(b) **Column graphs** are very similar to bar charts but are used when **either or both variables** are whole numbers, the second variable being discreet numbers and not continuous. The columns should be in order of increasing or decreasing size.

(c) **Histograms** are for continuous survey data (any number) where the data has been grouped in numbers, eg weight, 0-10 kg, 10-20 kg, 20-30 kg. This is represented as a column similar to a column graph, but the columns are touching.

(d) **Line graphs** are also for continuous data where two variables are used eg time and temperature of dissolving. The points of the data are marked with an 'x' and the 'best fit' line or curve drawn through the points. Usually in science the points are not individually joined up, although this is common practice in other subjects. The units used are part of the axis label and not next to the data numbers. More than one line can be drawn on a graph, if the same two variables are used, to compare a third variable eg rate of evaporation of different liquids. Colours can be used to differentiate the lines.

(e) **Pie charts** are used for survey data as an alternative to Venn diagrams, column graphs, histograms and bar charts. There should be no more than six categories in order to avoid it becoming too complex, with the data key next to the chart. The sections should be in rank order beginning at '12 o'clock.'

Many graphs and charts can be produced using ICT packages.

STANDARD UNITS OF MEASUREMENT

These are the metre, m, the unit of length; the kilogram, kg, the unit of mass; the second, s, the unit of time; and the cubic metre, m^3, the unit of volume. As the use of litres is common in everyday life children should know both.

1 litre = 1 dm^3

1 ml = 1 cm^3

1 dm^3 = 1000 cm^3

The unit of temperature used is the degree Celsius (°C) which is **not** a standard unit.

HEALTH AND SAFETY

Any situation in school is potentially dangerous and the ultimate responsibility rests with the employer. However there is an expectation that the employee will behave in a certain way as to minimise the risks. All schools should have a school safety policy, which includes references to science activities to which teachers should adhere. In addition, most local authorities belong to CLEAPSS (Consortium of Local Education Authorities for the Provision of Science Services) and follow their guidelines. They recommend the use of the ASE booklet 'Be Safe' which offers advice for most primary science activities and are extremely helpful if additional advice is needed. (The telephone number and website is at the end of this section). However advice is only available to subscribers.

All countries in the UK make specific reference in their curriculum documents to children of all ages recognising the hazards and risks to themselves and others when taking part in a science activity. This therefore means that this awareness needs to be taught, together with strategies for dealing with specific hazards. Practical activities of any sort where children are moving about and using equipment are potentially hazardous and all such activities should be preceded by a brief discussion with children. Specific situations where risks are greater and particular strategies are used, such as the wearing of goggles will also need discussion with the children. It might also be a good idea to get them to design their own safety symbols to put in the margins of their work to highlight the need for safe working, and to use them regularly when they are needed.

All the activities in this book can be carried out safely in schools. The hazards have been identified and any risks from them reduced to insignificant levels by the adoption of suitable control measures. However, we also think it is worth explaining the strategies that are recommended to reduce the risks in this way.

Regulations made under the Health and Safety at Work Act 1974 require a risk assessment to be carried out before hazardous chemicals are used or made, or a hazardous procedure is carried out. Risk assessment is your employers responsibility. The task of assessing risk in particular situations may well be delegated by the employer to the head teacher/science co-ordinator, who will be expected to operate within the employer's guidelines. Following guidance from the Health and Safety Executive most education employers have adopted various nationally available texts as the basis for their model risk assessments. These commonly include the following:

Safeguards in the School Laboratory, 10th edition, Association for Science Education, 1996

Topics in Safety, 2nd Edition, Association for Science Education, 1998 (new edition available in 2001)

Hazcards, CLEAPSS, 1998 (or 1995)

Laboratory Handbook, CLEAPSS, 1997

Safety in Science Education, DfEE, HMSO, 1996

Hazardous Chemicals Manual, SSERC, 1997.

If your employer has adopted one or more of these publications, you should follow the guidance given there, subject only to a need to check and consider whether minor modification is needed to deal with the special situation in your class/school. We believe that all the activities in this book are compatible with the model risk assessments listed above. However, teachers must still verify that what is proposed does confirm with any code of practice produced by their employer. You also need to consider your local circumstances. Are your students reliable? Do you have safety glasses for everyone?

Risk assessment involves answering two questions:

How likely is it that something will go wrong?

How serious would it be if it did go wrong?

How likely it is that something will go wrong depends on who is doing it and what sort of training and experience they have had. In most of the publications listed above there are suggestions as to whether an activity should be a teacher demonstration only, or could be done by students of various ages. Your employer will probably expect you to follow this guidance.

Teachers tend to think of eye protection as the main control measure to prevent injury. In fact, personal protective equipment, such as goggles or safety spectacles, is meant to protect from the unexpected. If you expect a problem, more stringent controls are needed. A range of control measures may be adopted, the following being the most common. Use:

- a less hazardous (substitute) chemical;
- as small a quantity as possible;
- as low a concentration as possible; and
- safety screens (more than one is usually needed, to protect both teacher and students).

The importance of lower concentrations is not always appreciated, but if solutions are suitably dilute they are classified as irritant rather than corrosive.

Throughout this resource, we make some reference to the need to wear eye protection. Undoubtedly, chemical splash goggles, to the European Standard EN 166 3 give the best protection but children are often reluctant to wear goggles. Safety spectacles give less protection, but may be adequate if nothing which is classed as corrosive or toxic is in use. It is recommended that corrosive or toxic materials are **not** used in primary schools.

CLEAPSS

Teachers should note the following points about CLEAPSS:

At the time of writing, every LEA in England, Wales and Northern Ireland (except Middlesbrough) is a member, hence all their schools are members, as are the vast majority of independent schools, incorporated colleges and teacher training establishments and overseas establishments.

Members should already have copies of CLEAPSS guidance in their schools.

Members who cannot find their materials and non-members interested in joining should contact the CLEAPSS School Science Service at Brunel University, Uxbridge, UB8 3PH. Tel: 01895 251496, fax: 01895 814372, email: science@cleapss.org.uk or visit the website http://www.cleapss.org.uk.

Schools in Scotland have a similar organisation, SSERC (Scottish Schools Equipment Research Centre), 2nd Floor, St Mary's Building, 23 Hollyrood Road, Edinburgh EH8 8AE. Tel: 0131 558 8180.

Chemicals used in this book

Chemical	Hazard
Aluminium potassium sulfate	**None**
Borax (sodium tetraborate decahydrate)	**None**
Dilute hydrochloric acid 0.5 mol dm^{-3}	**None**
Iron(III) oxide	**None**
Iron filings	**None**
Plaster of Paris (anhydrous calcium sulfate)	**None**
Poly Vinyl Acetate (PVA) glue	**None**
Sodium hydrogen carbonate	**None**
Universal Indicator solution	**None**

Hazard and risk in teaching

Discuss with children the hazards of an activity – what might go wrong? Then discuss the risks – how likely is it that something would go wrong? How many people could be affected? How badly would each be affected? (One hand chopped off would be a big problem; a minor cut on a hand would be a small problem; a class set of minor cuts on hands would be a medium problem). Then discuss the control measures – how can we make it less likely that something does go wrong?

The word 'danger' can be used when you want to talk generally, but to be precise then hazard, risk, etc are the correct terminology.

So, as an example, for elastic bands, the hazards might be :

(a) Breaking, thus dropping a heavy load on your toe;

(b) Breaking, contracting and flicking something into your face or eye;

(c) Being misused to fire pellets at each other.

The chance of (a) actually happening may be zero (if you are not using heavy loads). Or considerable if you are! The number of people affected may depend on whether the whole class is doing this or just one group. How serious the injury might be would depend on the type of shoes being worn, how heavy your load really is, etc. Whether it will drop onto toes or not may depend on whether there is a bin underneath to keep toes out of the way (a control measure). The chance of (c) happening will depend on many factors such as the control exercised by the teacher and the normal behaviour of the class.