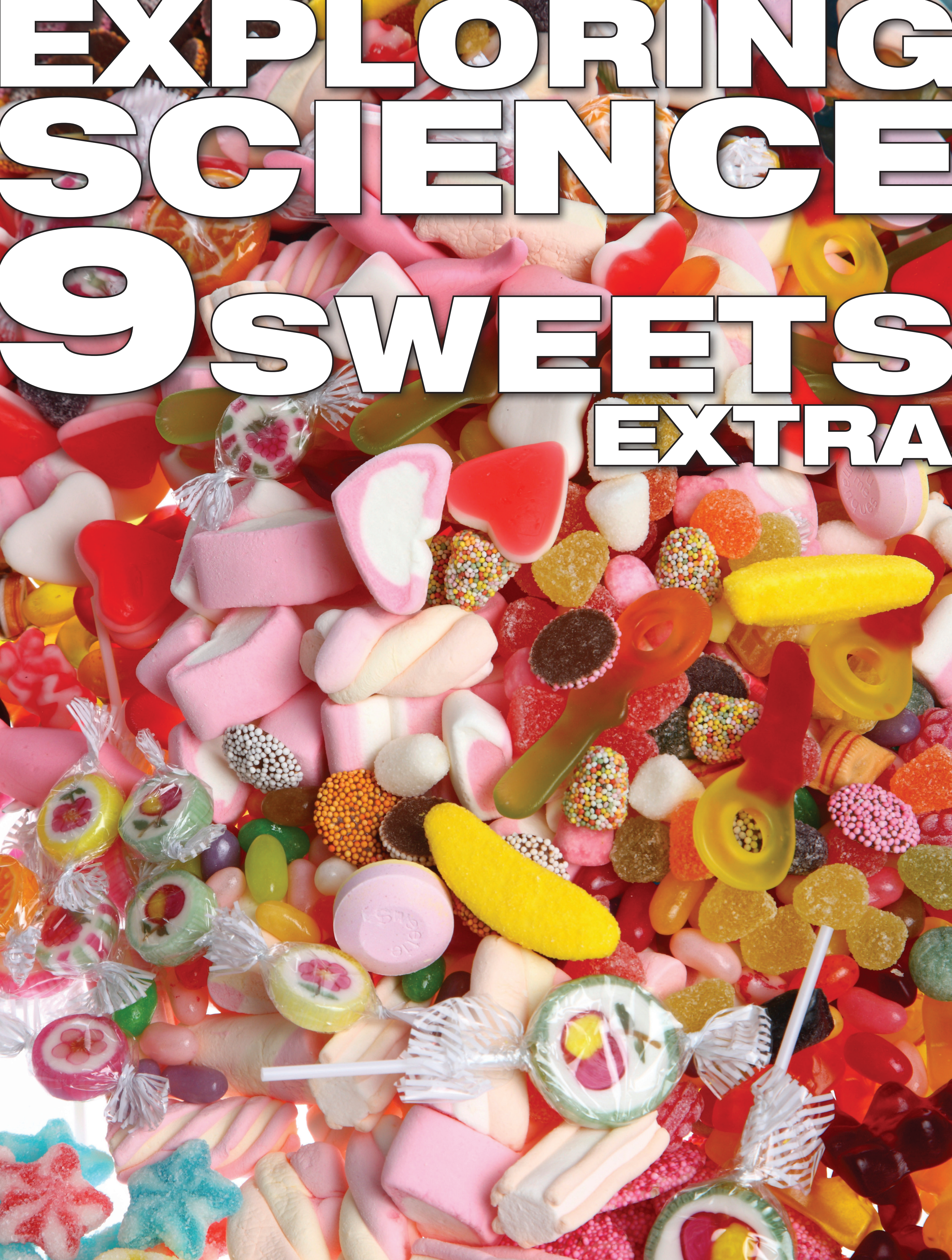
EXPLORING SCIENCE 9 SWEETS EXTRA



ALWAYS LEARNING

PEARSON

EXPLORING SCIENCE EXTRA

Introduction

Sweets. A treat close to many of our hearts but one that some of us may over-indulge in from time to time! With the vast quantities of sweets that some children manage to collect at Halloween, we thought that this would be an ideal opportunity to explore what's actually in the bags of goodies that children bring home.

You'll notice that we've had a bit of a make-over! With the publication of the new National Curriculum for Key Stage 3, we've been working hard to ensure that these changes are fully implemented in *Exploring Science*. This will allow teaching professionals to deliver the new National Curriculum using the familiar *Exploring Science* approach, safe in the knowledge that the changes have been thoroughly integrated into the course to allow for an easy transition. Of course, we would be doing ourselves and our users a disservice if this exercise was just one of 'window dressing' and so along with a familiar approach there is much that will be new, and which we're excited to tell you more about... soon. In the meantime, as a taster, we've introduced some of the new design elements from the new edition into this pack. We hope you like the changes and as always, we'd love to hear your feedback!

Did you know?

Do you use the Open-Ended Assessed Task in *Exploring Science*? Each unit has one of these activities at the end that can be used for summative assessment. You can assess the work using the assessment grids in the Assessment Support Pack or students can assess themselves using the 'Assess yourself!' sheets.

Our feedback has shown different ways in which teachers have adapted and used these activities, which we thought we'd share with you.

One way of running these activities is to get students to plan the activity, rather than actually do it. They come up with lists of things that they would include or do in the activity and reasons for their choices. For some activities this can be done orally, after groups of students have had a chance to discuss the problem. Students can then check their ideas against those on the 'Assess yourself!' sheet.

Another idea is to get groups of students working on the activity with 'face cards' next to them (smiley, neutral, sad). Students indicate how they are getting on by putting one of these cards uppermost. This will allow you to focus in on the groups that have sad faces showing and find out where they are going wrong and correct any misunderstandings. And another idea involves extending the use of the 'Assess yourself!' sheets. When students have completed their planning or the whole activity, they use the sheets to assess themselves. They then choose a statement for which they didn't give themselves a tick and write it down on an index card. They then find out the information that was required and write this on a card. The students can keep the cards to remind them of areas that they found difficult. If you scan the cards, it will give you a quick snapshot of what generally students found difficult in the unit.

We always enjoy hearing about how you have adapted activities in *Exploring Science*. So, keep all the ideas, suggestions and comments coming. You can contact us at:

www.pearsonschools.co.uk/exploringscienceextra

With best wishes for the Winter Term

Mark
Mark Levesley, Series Editor

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1 A HISTORY OF SUGAR

A Different forms of table sugar.

Sugar for life

Sugar is pure carbohydrate. Our bodies crave sugar – the energy in carbohydrate is quickly released in the body for use in all the processes that keep us alive.

We spoon sugar over cereal, add it to drinks, and use it to make many foods including sweets. We love sugar so much that, in 2011, the average consumption across the world was 24 kg per person per year.

Sweet beginnings

Centuries ago, most people used honey to sweeten their food because sugar wasn't available.

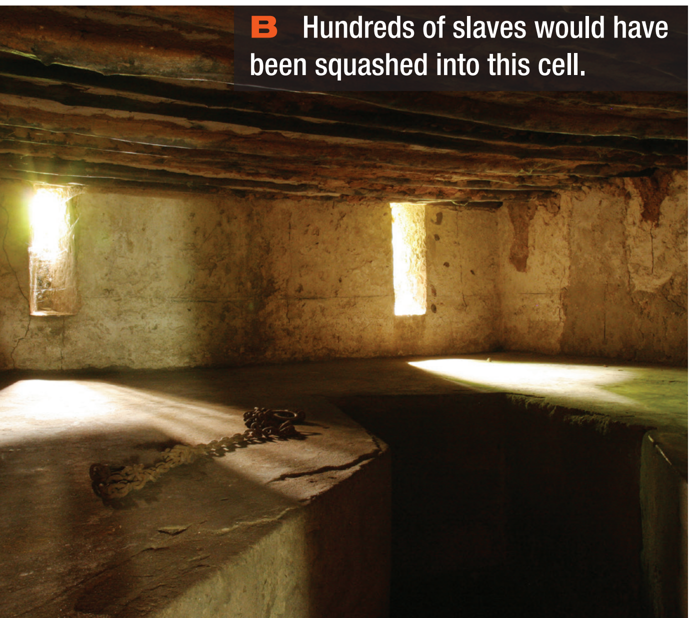
The first production of a sweet sugary substance took place in India nearly 3000 years ago, made from a local plant called sugar cane. Originally people would have just chewed the cane to get the sweetness, but then they started to boil the cane to make a syrup. The sugar syrup was cooled so it crystallised. Sugar crystals were much easier to transport than sugar cane plants.

Sugar became important in trading between India and other ancient cultures, including the Chinese, Arabians and Persians. Sugar eventually came to Europe when crusaders returned from their wars with the Arabs about 900 years ago.

FACT

The word 'sugar' comes the Arabic word *sukkar*, which originated from the Sanskrit (an ancient Indian language) *sarkara*. These names hint at how sugar was spread by trade between different peoples.

In the 1400s, Venice in Italy was the main sugar cane production area in Europe. This sugar was very expensive and only the very rich could afford it. Everyone else still used honey to sweeten their food.



B Hundreds of slaves would have been squashed into this cell.

About 250 years ago, a plant called sugar beet started to be used to make sugar. However, large-scale refining of sugar has only happened in the last 100 years. This has made sugar much cheaper, so we can all enjoy it.

Sweet problems

In the 1600s and 1700s, sugar cane was taken to the Americas by the Spanish and Portuguese. During the 1800s, large-scale sugar production in these areas led to the transport of millions of black African slaves to the Americas to work on sugar cane plantations owned by white people. Slavery was abolished by many countries during the 1800s.

2 SUGAR FROM PLANTS

Plants make sugar during photosynthesis, but usually the sugar is spread throughout the plant, and no part will taste very sweet. Plants break down sugar during respiration to release energy. They use this energy for all their life processes. A few plants store sugar for use at a later time, as an adaptation to their environment. Sugar cane and sugar beet are two of these plants. These are the plants that supply most of the sugar we eat today.

C Sugar beet at the end of its first year.

Sugar beet

Sugar beet is a broadleaved plant, closely related to beetroot. It grows well in rich moist soils in cool regions, such as in northern Europe. It has a two-year life cycle. In its first year, extra sugar from photosynthesis is stored in an enlarged root. If the plant is left in the ground over winter, everything above ground dies off. However, the underground root is protected from the weather. In the spring, sugar from the beet is used in respiration. This releases energy so the plant can make new leaves and a flower stalk. Once the flowers have been fertilised, and seed produced, the whole plant dies off. New plants will grow from the seed.

When sugar beet is grown as a crop, the roots are harvested at the end of the plant's first year, when the roots are full of sugar and before the first winter frosts.

D Sugar is extracted from the stalks (canes) of sugar cane plants.

Sugar cane

Sugar cane grows in tropical regions where it is warm and wet. The plant is very different to sugar beet, and has narrow leaves, like the grasses it is related to. It takes about 18 months after planting before a plant produces flowers. Like sugar beet, sugar cane stores sugar, so that it can release energy quickly to grow flowers at the right time. Unlike sugar beet, it stores its sugar in the stalk. Also the plant doesn't die after it has flowered.

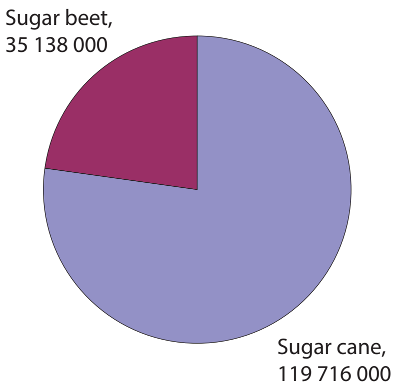
Sugar cane is harvested for making sugar by cutting the canes near to the ground. The roots are left to produce new stalks for another year. Both sugar beet and sugar cane have been bred over the centuries to increase the amount of sugar that they store, and so make them better sources of sugar.

FACT

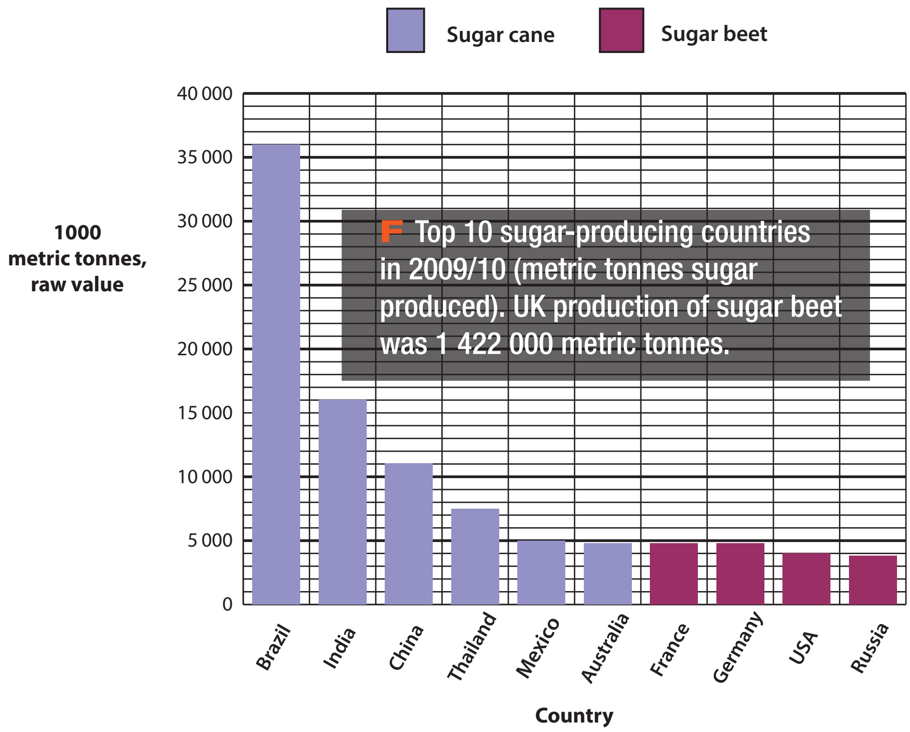
Some other grasses have a sweet taste if you chew a long stalk in summer. The grass plant is storing sugar in the same way as sugar cane, ready to produce flowers. (It's not a good idea to try this – the grass may have animal waste, fertiliser or weedkiller on it!)

3 SUGAR PRODUCTION

Sugar growing details



E Total world production of sugar crops in 2009/10 (in metric tonnes).



F Top 10 sugar-producing countries in 2009/10 (metric tonnes sugar produced). UK production of sugar beet was 1 422 000 metric tonnes.

Making sugar

The process of producing sugar is similar whether you use sugar cane or sugar beet.

Sugar cane is shredded into small pieces and crushed.

Sugar beet is sliced and shredded.

The waste plant material from sugar cane is burnt to heat the water for the dissolving process.

Plant pieces are sprayed with hot water to dissolve out the sugar. → Lime (calcium hydroxide) is added to make impurities clump together. → Juice is filtered to remove solids. → Juice is heated to evaporate water. This produces a super-concentrated syrup. → Syrup is spun in a centrifuge to spin out sugar crystals.

G The stages in producing sugar.

The only difference between the sugar crystals from the two crops is that crystals from sugar cane are brown (called 'raw sugar') and those from sugar beet are white. To produce white sugar from raw sugar, the raw sugar is mixed with more syrup, chemically cleaned again, then filtered and centrifuged. This is known as sugar refining.

H Raw sugar from sugar cane is brown and formed into large pieces.

4 MAKING SWEETS

All sweets contain a high proportion of sugar. However, they also contain many other ingredients that give them their flavour, colour and texture. All these ingredients must be safe for eating.

Flavour

The flavours for sweets can be produced artificially using chemicals. However, some chemicals can cause problems when eaten, particularly in children. So, many sweets now only use natural sources of flavour from fruits and other parts of plants. These flavourings include mint, vanilla, liquorice and cocoa.

I Seed pods from this orchid are used to produce natural vanilla flavouring.

Sometimes acids from natural sources are used to give a sharp tang to the sweet. These include citric acid and ascorbic acid from citrus fruits.

J Some of these colours are produced by mixing other colours together.

Colour

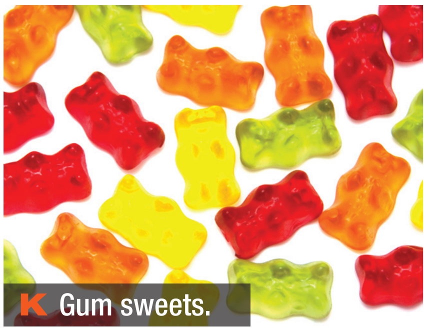
The bright colours of sweets make them very attractive. As with flavourings, colours produced chemically can cause problems when eaten. Many of these artificial colours are now banned for use in food. So, many sweets use only natural colours from plants and animals.

Even so, some people react badly to particular natural flavours and colours, and must avoid sweets containing these.

Texture

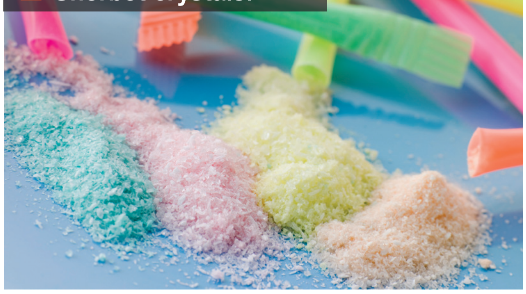
Jelly sweets may be made using starch to give a soft chewy consistency. The starch comes from plants such as potatoes and maize.

The harder chew in gum sweets often comes from gelatin. Gelatin is a mixture of proteins and is colourless and flavourless. Gelatin is produced by boiling the waste parts of animals that were killed for their meat. This means that some gum sweets are not suitable for vegetarians.



K Gum sweets.

L Sherbet crystals.



Marshmallows have a soft fluffy texture, made by whipping air into the gelatin to form a solid foam in the shape of the sweet.

Sherbet is made of sugar crystals mixed with citric acid and bicarbonate of soda (sodium hydrogencarbonate). When the crystals dissolve in your mouth, the acid and bicarbonate react to release carbon dioxide gas. It's the release of the gas that causes the 'fizz' that you feel.

5 OTHER USES OF SUGAR

M Soft fruits can be preserved by cooking with sugar.

Preserving food

Sugar is used to improve the flavour of many foods. However, it can also help to preserve fresh foods so that they can be kept for longer. This was particularly important in times when there were no fridges and freezers.

Microorganisms need moisture for growth. Fresh fruits and vegetables contain a high proportion of water. So microorganisms can easily grow on them and decay them. Jams and chutneys are made using fruit and vegetables and a lot of sugar. A high concentration of sugar draws water out of living cells, including microorganisms. This damages the cells and prevents them growing, and so stops the spoiling of the food.

Sugar will also absorb water from the air, so jams and chutneys must be sealed shut until they are used. Otherwise some microorganisms will start growing when the moisture content of the food is high enough. Sugar may also be used with salts to preserve meat, such as in making hams.

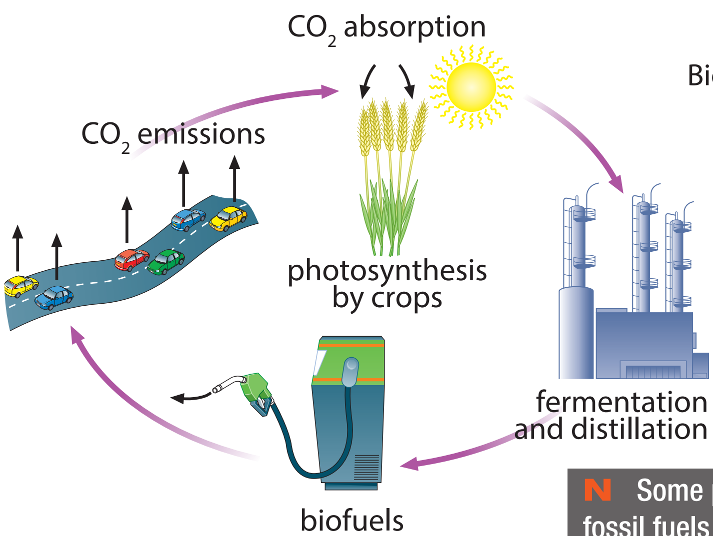
FACT

Honey was often used during the mummification of dead bodies in Ancient Egypt. The sugar in the honey had a preservative effect on the body.

Sugar has also been used to treat large open wounds, such as sores and ulcers. Reducing the water content of a wound reduces the growth of bacteria, helping it heal more quickly.

A biofuel source

Sugar is a good fuel for respiration in living organisms. However, the energy stored in sugar can also be released during combustion. Renewable sources of sugar could therefore replace non-renewable fossil fuels, such as oil. Usually the sugar is first converted to ethanol, which is a liquid and so easier to use in engines.



Bioethanol has been produced in Brazil for nearly 40 years, using waste plant material from sugar cane. It is mixed with petrol before it is used to power engines. Any plant material that contains a high concentration of sugar may be a good source of bioethanol. There are concerns, though, that replacing food crops with bioethanol crops could reduce the amount of food available in some places.

N Some people say that biofuels from crops are better than fossil fuels because the amount of carbon returned to the air by combustion is the same as the crop took from the air to grow.

Sweets

General note: Several of the following activities involve students handling sweets. At the start of each of these activities, remind students that they should not eat the sweets unless the activity is being carried out in hygienic conditions. You may also need to remind students that sweets should be regarded as occasional treats since the high levels of sugar that they contain can be harmful to health in the long-term. In the short term, foods containing high levels of sugar can be dangerous for those with diabetes.

Sweet adaptations

***Exploring Science* link: 7C**

This activity gives students an opportunity to practise their note-taking skills, and to use their notes to make comparisons between sugar cane and sugar beet.

Ask students to read the Student Booklet and make notes about sugar cane and sugar beet. They should organise their notes, for example, in a table, so that they can compare the life cycles of the two species. They should also take notes about the habitats in which the species live, and the way that the plants store sugar. They could extend their research using books or the internet. Some students may need help organising their notes in a useful way – suggest suitable headings for each set of notes. Skills Sheet 59 *Taking notes from science writing* provides support for this.

Students could use their notes to produce an illustrated poster of the adaptations of sugar cane and sugar beet to their environments, and to explain why they are now the main sources of table sugar.

Sherbet fizz

***Exploring Science* link: 7E, 7F, 9E**

This activity can be used during the discussion of neutralisation reactions in Topic 7Ee or in relation to evidence for reactions in Topic 7Fa.

Students can either make their own sherbet, or it can be prepared before the lesson by a technician. Please note that if students are to taste the sherbet, then the ingredients must be food grade (such as from a supermarket), and the sherbet must be prepared and tasted in hygienic conditions, such as in a food preparation area and not in a science lab.

The ingredients should be mixed in the following proportions: 6 teaspoons citric acid crystals, 3 tablespoons bicarbonate of soda, 4 tablespoons icing sugar. First mix the citric acid and bicarbonate of soda together, and crush the mixture to a fine powder in a mortar and pestle (or using the back of a large spoon against the side of the mixing bowl). Then thoroughly mix in the sugar. The mixture can be stored in a dry, well-sealed container until needed.

If students taste the sherbet, they should describe the sensation as the sherbet touches their tongue. They should then try to explain what has happened. They should be able to identify that the fizzing is evidence of a reaction, where a gas is given off. They should also realise that the reaction is triggered by moisture in the mouth. Alternatively add a spoonful of sherbet to water and ask students to describe what happens. Some students may develop their answers to explain that the reaction does not happen with the dry chemicals, but can only take place when the substances in the mixture are in solution.

If the topic of neutralisation is to be covered, students could mix a teaspoonful of citric acid and of bicarbonate of soda in separate beakers of water and test the pH of each solution. This will show that one is acidic and the other alkaline. Mixing the two together produces a neutralisation reaction, and the pH will become closer to pH 7. Students could test the gas produced to confirm that it is carbon dioxide.

This can be extended with more able students, or in relation to Unit 9E, by writing a word equation for the reaction, or even a balanced symbol equation for very able students:

citric acid + sodium hydrogencarbonate $\rightarrow$ sodium citrate + carbon dioxide + water

$C_6H_8O_7 + 3NaHCO_3 \rightarrow Na_3C_6H_5O_7 + 3CO_2 + 3H_2O$

You may need to explain that bicarbonate of soda is sodium hydrogencarbonate.

Safety note: Wear eye protection. Food grade ingredients must be used. Preparation must be carried out in hygienic conditions. Take account of students' medical conditions before tasting.

Resources (per group): Eye protection, c. 30 g food grade citric acid crystals, c. 45 g food-grade bicarbonate of soda (sodium bicarbonate), c. 60 g icing sugar, mortar and pestle, mixing bowl + spoon, beakers, water, pH indicator paper or solution.

A handful of energy

***Exploring Science* link: 7I**

This simple data analysis activity gives students the opportunity to collect data, manipulate it and use it to draw a bar chart. The chart can then be used to answer questions and draw conclusions. The data for this activity can be collected from sweet wrappers. Either provide students with a range of sweet wrappers, ask students to bring in a range of wrappers, or use internet research to provide the data. Suitable sites include http://www.calorieking.com.au/foods/portionwatch/index.php?action=viewcat&cat_id=10 - 91 and http://www.weightlossresources.co.uk/calories/calorie_counter/chocolate_sweets.htm. Manufacturers also provide nutrition information for their products on the internet, such as http://www.wrigley.com/uk/brands/skittles.aspx and http://www.smarties.co.uk/products/.

Ask students to record the amount of energy (in kJ) in each sweet item as well as in 100 g of the sweets. This can be done in a spreadsheet if preferred. If the value per 100 g is not available, then students should calculate the value, so that they can compare the energy in different sweets.

The energy per 100 g for a range of sweets can then be used to draw a bar chart, either by hand or by using the spreadsheet chart tool. Students should be reminded to label the chart axes correctly and to give the chart a suitable title.

The questioning can be extended by asking students to use their chart to calculate the energy content of sweets collected by a student who went trick-or-treating at Halloween (provide a sample bag of sweets for this). Alternatively, suggest the best sweets to take as emergency rations on an expedition, for use when someone needs a rapid dose of energy. More able students could consider not only the energy content of the sweets, but also their volume or mass, since they need to be carried until there is an emergency.

Resources (per group): range of sweet wrappers that show nutritional information, spreadsheet program.

Sweet diet

***Exploring Science* link: 8A**

The activity above for 7I could be adapted to consider whether sweets can be part of a 'healthy' diet. Students could record the amount of each food group contained in a range of sweets. Actual packaging may give details about a wider range of food groups than the internet, and so may be more useful for this activity.

As above, students should convert values to 'per 100 g' if not presented that way, so that they can compare different sweets more easily. They could use the data to draw separate bar charts for each food group, and use their charts to answer questions, such as which sweet contains the most/least of a particular food group. This could be extended further by comparing the charts with information on dietary reference values for the main food groups, such as in http://www.food.gov.uk/multimedia/pdfs/nutguideuk.pdf.

Students could then calculate how many sweets of a particular brand they would need to eat to take in 100% of the daily recommended value for a particular food group. The effect of this amount on the intake of other food groups could be considered (for example, if you eat enough sweets to get 100% of the recommended daily amount of carbohydrate, what proportion of the recommended amount of protein have you eaten?) Students could then draw conclusions about the value of sweets in a balanced diet, or use their findings to explain why some children are overweight and lacking important nutrients in their diet.

Resources: range of sweet wrappers that show nutritional information, spreadsheet program.

Sugar preserves

Exploring Science **link: 8C**

As an introduction to this practical activity, ask students what effect they think increasing amounts of sugar may have on the growth of microorganisms. Students may suggest that, as sugar is essential for respiration, increasing sugar may increase the rate of growth. Some students might note that sugar-based preserves, such as jams and chutneys, don't go mouldy very quickly when exposed to air but may do so after some time. Leave the question unanswered, but introduce Activity Sheet 1, which provides a method for the practical work. (The protocol in Activity Sheet 1 is based on a method from the *Practical Biology* website at http://www.nuffieldfoundation.org/practical-biology/preserving-food.) This activity will take about 15 minutes to set up. The tubes then need to be left at room temperature for 2–3 days, so that the solution in at least one of the tubes is noticeably cloudy. They should be left somewhere safe, so that they cannot be tampered with or knocked over during this time.

Students should find that the tube in which there has been least microbial growth is the one containing concentrated sucrose. The questions on Activity Sheet 1 should help students to make the association with the effect of microorganisms on the use of sugar in preserving foods. More able students may be able to link this to the effect of concentrated solutions on cells, drawing water out of the cell by diffusion and therefore making it more difficult for normal cell processes to continue properly.

Safety note: Tubes should not be opened after they have been stoppered with cotton wool. Any spills should be cleared immediately and the area cleaned with disinfectant. After the investigation, the cotton wool and contents of the tubes should be autoclaved and then disposed of. .

Resources (per group/student): 9 frozen peas, dilute sucrose solution (10% w/v), concentrated sucrose solution (20% w/v), distilled water, 3 test tubes + rack, forceps, non-absorbent cotton wool, marker pen, Activity Sheet 1. Disinfectant and wipes may be needed for clearing spills.

Sweet colour mixes

Exploring Science **link: 8E**

The chromatography practical investigations in the *Exploring Science Year 8* Topic 8Ed could be replaced with a similar investigation using sweets that have an outer colour layer over a harder 'shell', such as Smarties® or M&Ms®. The activity could be introduced by asking how students could find out if different manufacturers use different colour mixes to produce sweet coatings that appear to be the same colour. For example, do green sweets all use the same green colour? If students need a hint, point out that the colours are soluble in water, and this might be used to separate out constituent colours.

Skills Sheet 54 in the *Exploring Science Year 7 CHAP* provides guidance on how to set up a chromatography test – the ink spot method may be the easiest in this case. The spots of colour will need to be built up by repeatedly dampening a sweet, placing it in the middle of the filter paper, then allowing the spot to dry.

Ask students to formulate a hypothesis before they start the investigation. At the end of the investigation, make sure students compare their results with their hypothesis and that they draw a conclusion about the way colours on sweet coatings are produced.

Safety note: Remind students that they should not eat the sweets, as they have not been used in hygienic conditions.

Resources (per student or group): Coloured sweets (such as Smarties®, M&Ms® or Skittles®, although Smarties® tend not to work so well as the others) in a range of colours, 100 cm^3 beaker, filter paper, scissors, access to means of drying filter papers, Year 7 CHAP Skills Sheet 54.

Which is the red one?

***Exploring Science* link: 8K**

This activity develops the Unit 8K Exploring 3 task in the *Exploring Science Year 8 CHAP* on how colours appear to change in different colours of light. Different colours of a particular brand of sweet can be used, so as not to provide other visual cues from which colour could be guessed.

Before the lesson, prepare several boxes with lids (old shoe boxes are an ideal size) that have been painted black inside. Each box should be large enough to take a ray box, but leave space for the coloured sweets. Place a coloured filter between the ray box and sweets. A small viewing hole in the lid, above the sweets, will reduce the amount of white light entering the box. Use a different colour filter in each box, but lay out exactly the same colour sweets in the same pattern in each box.

At the start of the lesson, allow students 15–20 minutes to work in groups and explore for themselves the effect of coloured light on the apparent colour seen, using the Unit 8Ke Exploring 3 task.

Once students have completed their own exploration, challenge them to look at the sweets in each of the prepared boxes and answer appropriate to their level (you will need to tell them what colour each filter is). For example:

- (simple questions) Can you tell which is the red sweet in each of the boxes? If yes, how can you tell? If not, why not?
- (more challenging question, after looking at all the boxes) What pattern of sweet colours would you see in white light?

Students could continue to work in their groups to answer the questions. Encourage discussion between students in the group to produce a group answer. Then take answers from a spokesperson in each group and compare their choices. Expect more able students to explain their choices.

Safety note: Remind students that they should not eat the sweets, as they have not been used in hygienic conditions. Also remind pupils not to stare at light sources or to touch ray boxes when they are hot.

Resources (per group): ray box; coloured filters; coloured sweets (such as Smarties®, M&Ms® or Skittles®) in a range of colours or a range of other coloured objects. Optional: closed boxes with a viewing hole and hole for the ray box wire.

For the challenge: prepared boxes each with a different coloured filter, ray box and identical coloured sweets arranged in the same pattern.

Should there be sugar quotas?

***Exploring Science* link: 9C**

This activity looks at the relationship between government and farmers in relation to food quotas, by looking at a current issue on the reform of EU sugar policy, due in 2015.

Activity Sheet 2 covers some of the background and different points of view about government intervention, such as quotas and farming. The sheet can be used in several ways.

- In a simple literacy task students should read the text to identify the advantages and disadvantages of quotas and government intervention in controlling prices for food commodities such as sugar. Students should consider different points of view, including that of a farmer, a food manufacturer, the shopping customer and a government that needs to make sure that their country makes more money than it spends.
- Students could then use their findings to prepare a poster about the advantages and disadvantages of farming quotas.
- Alternatively, students could use their findings to prepare for a class debate on 'We believe that sugar quotas for the European Union should be scrapped.' Students could take one point of view and develop it by finding additional information on the internet, such as http://www.foodmanufacture.co.uk/Regulation/DEFRA-seeks-French-support-to-scrap-sugar-quotas and http://sugarcane.org/global-policies/policies-in-the-european-union/eu-sugar-policy. Other websites, including news sites, may offer better information as the EU Parliament debate progresses.

General information about the farming of sugar beet in the UK, including UK yields of sugar, can be found at http://www.ukagriculture.com/crops/sugar_beet_farming.cfm.

Resources (per student): Activity Sheet 2, Skills Sheet 41 (from *Exploring Science Year 7 CHAP*) *Debates and speaking*, Skills Sheet 60 (from *Exploring Science Extra Pack 3* Fireworks) *Arguments, facts and opinions.*

Sweet changes

***Exploring Science* link: 9H**

This series of demonstrations presents a range of impressive chemical reactions and physical changes related to sugar. These must be carried out by a teacher or technician with appropriate concern for safety. The most vigorous reactions could be replaced with the video alternatives suggested.

Before the demonstrations, discuss with students what evidence they could look for that would show that a reaction is taking place, such as the production of gas, a colour change or a temperature change. Students should also develop some criteria for judging whether one change is more energetic than another.

Allow students time after each demonstration to record their evidence and assess how energetic the change was. At the end of demonstrations, take examples from around the class to discuss the evidence, and to decide which reaction was the most energetic.

Students could also be encouraged to write word equations for the reactions they have seen.

(1) Screaming babies or dancing bears

Although the general advice is that chlorate/sugar mixtures should not be made in schools, this activity presents a safe but spectacular demonstration provided that certain safety precautions are adhered to. The activity must be carried out only by teachers who should practise it in advance. You should NOT be tempted to increase the scale of the operation.

Place a small amount of potassium chlorate, of about the same volume as the sweet that you will use, into a test tube that is supported by a clamp and stand. Heat the tube until the potassium chlorate has melted, then remove the heat source. Using long-handled tongs, add a gum/jelly sweet (e.g. Jelly Baby, Haribo Goldbear®) to the tube and push it into the chlorate. Stand well clear. The reaction vigorously releases gas and heat.

Safety: The safety advice from CLEAPSS® Supplementary Risk Assessment SRA01 (available through CLEAPSS or at: http://www.rsc.org/learn-chemistry/content/filerepository/CMP/00/000/828/cfns%20experiment%2069%20-%20the%20howling-screaming%20jelly%20baby.pdf) must be followed.

Alternatively, show students a video of the reaction, such as https://www.youtube.com/watch?v=txkRCIPSsjM.

Resources: eye protection (including for spectators), potassium chlorate, test tube, clamp + stand, Bunsen burner, long-handled tongs, gum/jelly sweet (e.g. Jelly Baby, Haribo Goldbear®).

Explanation: Potassium chlorate is an oxidiser, which oxidises the sugar (sucrose) in the sweet. In effect, the sucrose acts as a fuel. (This could be linked to the use, as biofuels, of plant materials that contain a lot of sugar.) The word equation for the reaction is:

sucrose + oxygen (from potassium chlorate) → potassium chloride + water + carbon dioxide

(2) Sherbet and water

Mix one spatula of citric acid with one spatula of sodium hydrogencarbonate in a test tube. (This is the basis for sherbet – see Sherbet fizz above.) Measure the temperature of the base of the tube using a temperature sensor or thermometer. Add about 2 cm^3 of water to the mixture. The mixture should fizz, and the bottom of the tube should be colder after the reaction.

Safety: Wear eye protection.

Resources: citric acid, sodium hydrogencarbonate, spatula, test tube, temperature sensor or thermometer, water, 10 cm^3 measuring cylinder.

Explanation: This is a neutralisation reaction between the acid and a base, which only takes place in solution. The reaction is slightly endothermic, taking in a little heat energy from the surroundings. The word equation for the reaction is:

citric acid + sodium hydrogencarbonate → sodium citrate + carbon dioxide + water

(3) Sugar and sulfuric acid

Half-fill a 100 cm^3 beaker with sucrose and add concentrated sulfuric(VI) acid to just saturate the sugar. After a delay of a minute or two the mixture goes black and begins to rise, producing sulfur dioxide and carbon monoxide. Do **not** touch the carbon mass formed unless gloves are worn. **Disposal:** Plunge the beaker and carbon into an excess of water when cool. The carbon is placed in the normal refuse.

Safety: Concentrated sulfuric(VI) acid is corrosive. Wear goggles or a face shield. Use a fume cupboard. Wear chemical-resistant gloves.

Alternatively show students a video of the reaction, such as: http://www.youtube.com/watch?v=pqi50sjJVc0&feature=related.

Resources: table sugar, tablespoon or equivalent, tall-form glass beaker, water, stirrer, about 50 cm^3 concentrated sulfuric acid.

Explanation: The sugar is dehydrated by the sulfuric acid, producing carbon and water. The heat of the reaction causes the water to turn to water vapour and steam.

The word equation for the reaction is:
sucrose + concentrated sulfuric acid → carbon + carbon dioxide + water

(4) Caramelisation

Place several tablespoonfuls of table sugar into a crucible (or small cooking pan) and heat over a high heat. Initially the sugar will melt, and then slowly turn brown. When you remove the pan from the heat and allow it to cool down, the liquid will solidify to a brown toffee. The hardness of the toffee will depend on the heat that the sugar reached before cooling – the higher the temperature, the harder the toffee. (A 'sugar' thermometer can be used to measure the temperature of the melted sugar.)

Safety: Take full precautions when heating the sugar, and place the pan on a heat resistant surface while it cools. **Do not** touch the toffee until fully cool, as sugar retains heat for a long time. Do not eat sugar or toffee.

Resources: table sugar, crucible (or small cooking pan), source of heat e.g. Bunsen burner, spoon, heat resistant mat.

Explanation: In this reaction, the sucrose molecules lose water from their structure and this causes a variety of other compounds to start to form, including 5- hydroxymethylfurfural.

(5) Diet cola and sugar-coated sweets

This well-known 'eruption' can be carried out using any diet cola and sugar-coated sweets. The best sweets for this have a slightly rough, rather than glossy, surface. Ordinary cola also works, but diet cola works better due to the aspartame. The demonstration is more impressive with a large bottle of cola. Note, however, that this is a physical change and not a chemical reaction, although the liberation of gas may make students think otherwise.

Remove the cap from the bottle and place the bottle on a flat surface. This should be done outside as the jet of liquid can reach a metre or so. Quickly add 4 or 5 sweets, then stand well back. The reaction starts almost immediately, shooting a jet of cola into the air.

Safety: This demonstration should be done outside, with everyone standing at least a metre away. **Do not** attempt to replace the cap of the bottle once the sweets have been added. Do not eat the sweets or drink the cola.

Resources: 2-litre bottle diet cola, 4 or 5 sugar-coated sweets (ideally with a dull surface, e.g. Mentos®).

Explanation: The rough surface of the sweets acts as a catalyst for the release of carbon dioxide that is dissolved in the carbonated cola. Also, as the sweets start to dissolve, this disrupts some of the bonds holding the water molecules in the cola together. The rapid expansion of the gas forces the liquid out of the narrow neck of the bottle with sufficient pressure to produce a fountain. This is a physical change, not a chemical reaction.

Expanding marshmallows

***Exploring Science* link: 9L**

In this practical activity, students use marshmallows to investigate the effects of pressure on the air bubbles in the sweet. Details of the student investigation, using a large plastic syringe and a mini marshmallow, are given on Activity Sheet 3. Alternatively, you could demonstrate this on a larger scale using large marshmallows in a vacuum jar.

Students are expected to explain what they see in terms of changing pressure in the air bubbles inside the sweet. Some students may need help with this explanation. They may also need reminding about atmospheric pressure.

Students should find that there is no change in the marshmallow when the end of the syringe is open. This is because the pressure around the sweet is equal, so there is no change in pressure in the bubbles in the sweet. When the end of the tube is closed and the syringe pushed in, the pressure around the marshmallow increases. This compresses the air in the bubbles in the sweet, and the sweet should look smaller. As the plunger is pulled out again, the pressure outside the sweet decreases. This causes the air in the bubbles to expand and the sweet should expand. This expansion will be more obvious in the teacher demonstration.

Safety note: Remind students that they should not eat the sweets, as they have not been used in hygienic conditions.

Resources (per student/group): large plastic syringe, mini marshmallow, Activity Sheet 3.

Sugar and microorganisms

In this investigation you will look at the effect of different sugar concentrations on the growth of microorganisms on peas. The peas have an invisible layer of microorganisms, which have come from the atmosphere.

Safety

Tubes should not be opened after they have been stoppered with cotton wool. If a solution is spilt in the recording stage of the practical, clear the spill immediately and make sure the area is cleaned with disinfectant. All materials must be properly disposed of at the end of the practical, as directed by your teacher.

Apparatus

9 frozen peas
dilute sucrose solution
concentrated sucrose solution
distilled water
3 test tubes + rack
non-absorbent cotton wool
marker pen

Method

A Use the marker pen to write your initials on each of the tubes. Then label one tube *water*, another tube *dilute sucrose*, and the third tube *concentrated sucrose*. Place the tubes in the rack.

B Place three peas into each tube.

C Carefully pour distilled water into the *water* tube until the tube is about half-full.

D Repeat step C for the other two tubes, using the correct solution for each tube. All three tubes should contain a similar amount of liquid.

E Plug each tube with cotton wool, and return the tubes to the rack. The tubes will need 2–3 days at room temperature before you check them again.

F After 2–3 days, look carefully at each tube. **Do not remove the cotton wool plugs from the tubes or tip the tubes**. Compare the appearance of the peas, and the cloudiness of each of the solutions. The cloudier the solution, the more microorganisms it contains. Record your results.

Recording your results

1 Display your results in a table. Use your table to answer these questions.

Considering your results/conclusions

2 Which solution contained the fewest microorganisms? Explain your answer.

3 Which solution contained the most microorganisms? Explain your answer.

4 Explain why one of the tests was with pure water.

5 Use your answers to 2 and 3 to explain why fresh fruit and vegetables are made into sweet jams and chutneys.

6 Suggest how a jam manufacturer could develop this method to produce a new jam that lasts longer without being spoiled (decayed) by microorganisms.

Sugar quotas

Farming is a business. Each year farmers plan what to grow so that they can make a profit. A farmer who grows crops may choose to grow different crops each year. What farmers choose to grow is affected by the price they expect to get for what they grow.

The market price for a crop is what people are prepared to pay for it. This price may vary each year, depending on how much crop is available and how much people want to buy.

For a crop such as sugar beet, the market price will depend on how much sugar is needed by the manufacturers to make all the foods that use it. It will also depend on how much sugar is grown in the country, and the amount that is imported (brought into the country) from other countries. If there is a lot of sugar, then the market price for sugar will fall. If it falls too low, then the farmer may get less for the sugar beet than it costs to plant, grow and harvest the crop.

Governments may try to control the price of a product, such as sugar, to protect farmers as well as manufacturers. The European Union (EU) Government controls the price of sugar in Europe in several ways.

- **Production quotas** limit how much can be grown in one year. This helps to make sure that there won't be more crop grown than is needed in one year and stops the market price for sugar beet dropping so low that farmers lose money.
- **Import quotas** limit how much sugar can be imported to the European Union from other countries without an added tax or import duty. Any more sugar imported beyond this quota is taxed so that it is much more expensive. This helps to make sure that manufacturers choose to buy and use sugar from Europe. It also restricts the import of sugar from sugar cane growing countries such as Brazil, Thailand or Australia, even if the world price for cane sugar is less than that for beet sugar.
- The **interventionist price** is the price that a government will guarantee to pay farmers for a crop. These prices are not affected by the amount of crop available. They aim to protect farmers from a market price that is too low. In years when the market price is good, the interventionist price is lower than the market price. In years when the market price is low, the government will lose money by paying farmers for the crops they can't sell.

These quotas and prices were agreed in the EU in 2006, when the EU was the world's second largest sugar exporter, producing more sugar than European manufacturers could use. Now, although the EU is still the third largest sugar producer in the world, it is also the second largest consumer of sugar, and Europe imports more sugar from other countries than it exports.

The EU Government is reviewing its sugar policy. Some countries in the EU, such as the UK, want to get rid of sugar quotas. They say that sugar prices have been forced too high by the quotas. They believe that, without quotas, food manufacturers will be able to buy more sugar. The manufacturers will then be able to make more products such as cakes, biscuits and drinks, which can be sold in countries such as China and India where they haven't sold much yet.

France grows more sugar beet than the UK but wants to keep the quotas. They say they need the quotas to protect their farmers at times when the market price is very low.

In 2015, the countries of the EU will need to decide again how much control they need over the production and importing of sugar.

Marshmallow

Marshmallows are a solid foam, containing many tiny bubbles of air. In this investigation you will use a marshmallow to investigate the effects of pressure on the air in the bubbles.

Apparatus

large plastic syringe
mini marshmallow

Method

A Remove the plunger from the syringe. Place the marshmallow into the tube of the syringe, and gently push it to the other end without squashing it.

B Replace the plunger and watch the marshmallow carefully while you gently push the plunger down the barrel until it nearly touches the marshmallow. Record any changes (if any) to the marshmallow.

C Watch the marshmallow carefully as you gently pull the plunger back out of the tube. Record any changes (if any) to the marshmallow.

D Place your finger or thumb tip over the end of the narrow end of the syringe. Then repeat step B. Record any changes (if any) to the marshmallow.

E Keeping your finger or thumb tip over the end of the syringe, repeat step C. Record any changes (if any) to the marshmallow.

Recording your results

1 Display your results in a suitable table.

Considering your results/conclusions

2 Compare your results with and without the end of the syringe closed. What happened to the marshmallow:
- **a** when you pushed the plunger into the tube?
- **b** when you pulled the plunger back out of the tube?

3 Try to explain any differences in terms of pressure.

