LONGMAN

Exploring Science Extra

How Science Works

Chocolate 1

ALWAYS LEARNING

PEARSON

1 Exploring Science Extra

Introduction

Welcome to the first *Exploring Science Extra* pack, in which we are having a look at everyone's favourite … chocolate. This pack includes a Student Knowledge Booklet and a Teacher's Guide that outlines some suggested activities on the theme of chocolate. Some of these activities are supported by Activity Sheets.

The idea behind *Exploring Science Extra* is to provide additional resources for schools using *Exploring Science*. The activities are intended to inspire and stretch students, and to take them slightly outside of the standard curriculum areas, whilst still developing the key scientific skills needed for Key Stage 3 Science and beyond.

Each of the activities is linked to a unit from *Exploring Science*, making the pack easy to incorporate into your teaching.

Let us know what you think of the pack! Tell your rep or contact us through the website. We've got lots of further packs in the pipeline and in our next one we'll be looking at the Olympics.

Did you know?

We're often asked whether Exploring Science can do 'such-and-such' and often the answer is 'yes' … it can just be a little difficult to try to find if you're a new user. Sometimes the answer is 'no', in which case we'll do our best to help out, and if necessary create something new. In each *Exploring Science Extra* pack we'll highlight an area of Exploring Science that you might not know about or might not have explored.

Alongside this pack, we've got some new materials for you. Many schools love our End of Unit Tests but some have said that for low ability students they can be a bit demoralising. So, we've created some low ability End of Unit Tests at Levels 2 – 5, which you'll find available with this pack. You can also download them from our new *Exploring Science Extra* website: http://www.pearsonschoolsandfecolleges.co.uk/Secondary/GlobalPages/ExploringScienceExtra/ExploringScienceExtra.aspx

Enjoy the pack and the new resources. And do get in touch with us to let us know your thoughts, and any suggestions you may have for *Exploring Science*.

With all good wishes for a chocolate-filled Easter,

Mark

Mark Levesley

Series Editor

LONGMAN

Exploring Science Extra

How Science Works

Chocolate 1

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1 The history of chocolate

Where's it from?

Cocoa trees are native to Central America and the Amazon region of South America and have been farmed there for thousands of years. Cocoa beans were taken from pods on the trees, dried and ground, and used to make a cocoa drink. There was no sugar, so the drink was flavoured with spices. The word 'chocolate' comes from *xocoatl*, the ancient Aztec name for this drink meaning 'bitter water'.

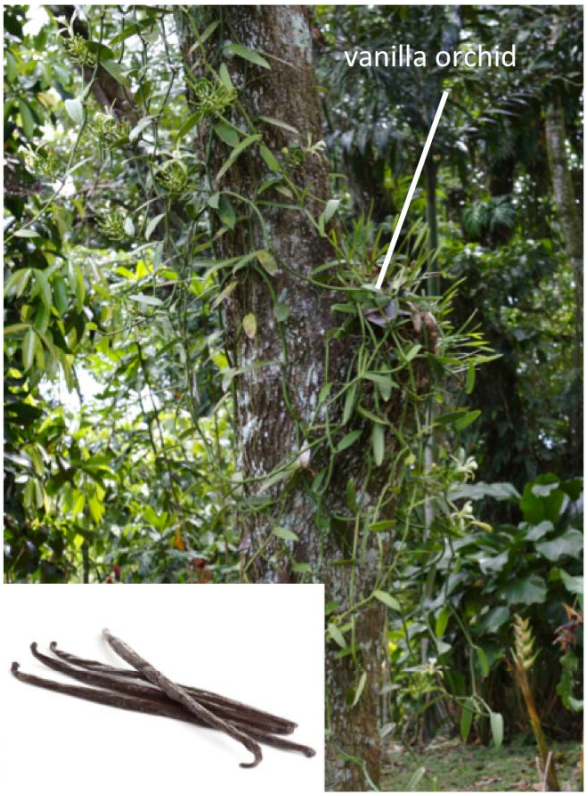
The ancient peoples of South and Central America called cocoa the 'food of the gods'. Only the elite were allowed to have it. They said it gave them health, wisdom and power.

A *Cocoa beans are found in pods that grow on the trunk and branches of cocoa trees* (Theobroma cacao).

How did cocoa become chocolate?

In 1492, after visiting the area, Christopher Columbus took cocoa beans back to Spain but nobody was interested in them. Hernando Cortez, who conquered part of Mexico in 1519 is credited with experimenting with the drink by adding sugar. The Spaniards developed the mix of cocoa, sugar and vanilla that makes what we recognise as chocolate.

The Spanish kept chocolate a secret from the rest of Europe for over 100 years.



B *Vanilla flavouring comes from the pods of the vanilla orchid.*

Chocolate bars

Until the mid 1800s cocoa was still only used to make drinks or desserts. The development of a steam engine to speed up the bean-grinding process made it much quicker and cheaper to make cocoa powder. Many more people could afford to buy it.

In 1847 an Englishman developed the first process for making chocolate bars. Further developments took place in Switzerland. The first milk chocolate was developed in 1875, new production methods in 1879 made much smoother chocolate, and in 1913 the first chocolates filled with other confections were made.

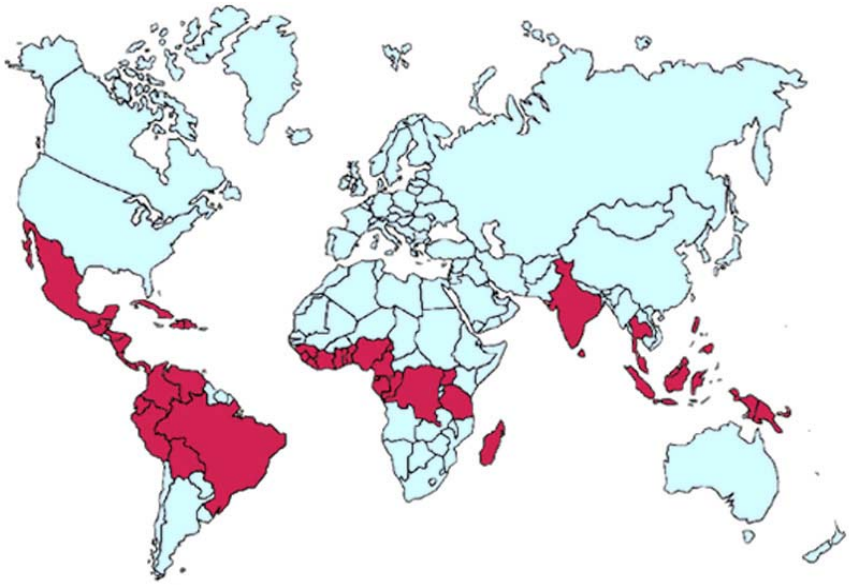
Today, over £50 billion worth of chocolate is bought each year and demand is growing.

2 Growing cocoa

Growing cocoa

Cocoa trees only grow well between 20° north and south of the Equator, and up to about 300 m above sea level. They need to be shaded from full sunlight by taller trees. They need plenty of water and rich well-drained soils, as well as hot, humid air. All these conditions means that cocoa trees only grow well in a few places.

Today, nearly three-quarters of the world's cocoa grows in the West African countries of Ghana and Ivory Coast.



C *Countries of the world where cocoa is grown.*

Different varieties

There are three main varieties of cocoa.

- Forastero has good disease resistance and mild but limited range of flavour. Large plantations grow this.
- Criollo has a fruity flavour, but produces a smaller crop and is more likely to suffer from diseases.
- Trinitario was produced by breeding the other two varieties together. It is more resistant to disease than Criollo and has a better flavour than Forastero.

The flavour of the cocoa depends varies and depends on the variety of cocoa grown, the conditions where it grows, and how the beans are dried and processed.

Cocoa growing problems

The humid conditions that cocoa trees need are also good for pests and disease. Witches' broom is a fungal disease that has reduced the production of cocoa in Brazil by 80%. In West Africa, cocoa trees are attacked by black pod rot (a fungus), swollen shoot virus and insect pests. Cocoa pod borer is a major pest in South East Asia.

Chocolatiers mix different proportions of beans from these varieties to produce different flavours of chocolate

Large plantations can afford fertilisers, pesticides and fungicides to help their trees grow well. However, many growers in Africa are poor farmers with small farms. They cannot afford the expensive chemicals, so their trees produce a much smaller amount of cocoa beans.

The average global harvest of about 450 kg of cocoa beans per hectare could be increased to 1500 kg per hectare using modern farming techniques with more chemicals and machinery without planting more trees.

Climate change could make it even more difficult to find the right conditions to grow cocoa trees in the future.

3 Making chocolate

Fermenting the beans

The cocoa pods ripen a few at a time throughout the year. The ripe pods are cut off the tree, split open and the beans and sticky white pulp are removed.

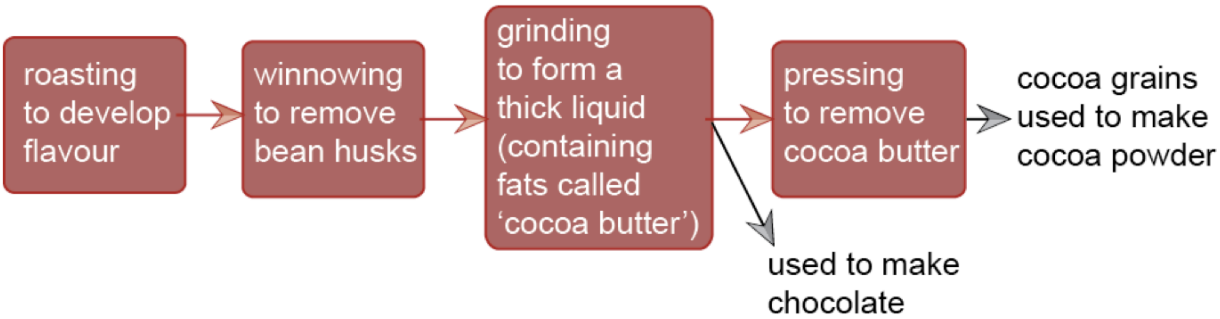
The beans and pulp are piled up and fermented to develop the flavour. During the process, microbes break down the pulp into a liquid, which drains away. The beans are then dried, often outside in the sun.

At this stage the beans are sold to buyers for chocolate-making companies.

D *Cocoa beans drying in the sun.*

Processing the beans

The beans go through many stages of processing at the chocolate-making factory before they are used for making chocolate.



Making chocolate

- Dark chocolate is made by mixing the thick chocolate liquid with sugar, vanilla and sometimes other flavours.
- Milk chocolate is the dark chocolate mix with added milk.
- White chocolate is made from cocoa butter mixed with sugar and flavourings.

E *Different types of chocolate.*

To make dark and milk chocolate, the mixture is passed through rollers to break down the cocoa grains and produce a smooth texture. In a final step, called 'conching', the chocolate mixture is slowly mixed and pressed to produce an even smoother texture.

F *Tempered chocolate has a shine.*

The chocolate is then 'tempered', which means it is heated so that it melts and then allowed to cool slowly while still being stirred. This produces a glossy solid chocolate that snaps as you bite it and melts smoothly in your mouth. The tempered chocolate is poured into moulds to set as chocolate bars or sweet cases.

4 From the factory to us

Why is chocolate wrapped?

Cocoa butter easily absorbs strong flavours around it. So the main wrapper around chocolate is to prevent this happening. Metal foil makes a good barrier but metal is getting more expensive and so plastic film is often used instead, because it is cheaper.

Plastic is also used to make the trays in boxes of chocolates so that they don't bump and damage each other when the box is moved.

Many wrappers also tell you what the product is, and what it contains. As metal foil cannot be printed on easily, a printed paper wrapper or box is usually added outside a foil wrapper. Some plastics can be printed, so only one wrapper is needed.

Boxes of chocolates often have several wrappers. Some are there just to make the product look 'special'. But this means there is more packaging to throw away. The UK creates about 1 million tonnes of waste plastics each year, which goes to landfill.

Some companies are replacing plastic with thick paper wrappers which are easier to recycle, and safer for the environment.

Foil wrapper

Paper wrapper

Plastic wrapper

Cardboard box and plastic tray

G *Chocolate comes packaged in many different type of wrapper..*

What's in chocolate?

Chocolate is mainly cocoa grains, cocoa butter and sugar. Milk chocolate also contains some milk. This means that the main nutrient groups in chocolate are fat and sugar. You will find information about the nutrients in chocolate on the packaging.

Some nutrients can be bad for you if you eat too much. The amounts of these nutrients are shown on chocolate wrappers (see Figure H).

Although chocolate contains a lot of saturated fat, the fat in cocoa butter is not a health problem because it comes from a plant. However, the large amount of sugar means that eating a lot of chocolate is not healthy.

Chocolate contains several mineral salts that you need to stay healthy, including salts containing copper, magnesium, potassium and iron. Milk chocolate also contains calcium.

Calories	Sugars	Fat	Saturates	Salt
245	26.5g	13.9g	8.6g	0.11g
12.2%	29.4%	19.9%	43.2%	1.79%

H *The amounts of some nutrients in 8 chunks of a milk chocolate bar.*

There are many other compounds in chocolate, some of which are thought to change the way we feel. Some people think it makes them feel more awake and alert.

Don't give chocolate to a dog or cat. This is because one compound in chocolate, called theobromine, is poisonous to them.

1 Chocolate

Safety

Unless chocolate is prepared in hygienic conditions, it should not be tasted. Students using chocolate in investigations in the science lab may need frequent reminding of this.

It's a matter of taste

***Exploring Science* link: 7D**

This activity gives students the opportunity to plan and carry out an investigation linked to their study of variation in Topic 7D. Activity Sheet 1 supports this work and full details on how to run the activity are found on the sheet.

This is a good context in which to cover the development of scientific questions for testing in investigations. The Activity Sheet provides some guidance, but the opportunity to draft and discuss suitable questions as a class would be valuable. The Activity Sheet also focuses on how to convert potentially qualitative data to quantitative variables that can be analysed more effectively.

An interactive map of cocoa flavours from around the world can be found on the allchocolate website (http://www.allchocolate.com/enjoying/map), which could be used to introduce the idea of why different chocolate manufacturers are able to produce such a wide range of chocolate flavours.

Resources (for the investigation): a selection of different chocolates (e.g. white/dark/milk, from different manufacturers, or different estate chocolate); access to a food preparation area to prepare the chocolate in appropriately hygienic conditions; Activity Sheet 1.

The state of chocolate

***Exploring Science* links: 7F and 7G**

Chocolate is a useful material for investigating the effect of heat on changes in state and in the properties of a material. The melting point of a chocolate bar is usually around 34 °C and it melts easily in lab conditions. The physical changes of melting and solidification (Topic 7G) can be investigated using the gentle melting method below. Alternatively, the class could be split into two groups, one group using the gentle melting method and the other heating the chocolate more vigorously, to compare reversible and irreversible changes (Topic 7F).

If practical work is carried out in the science lab, remind students not to taste or eat the chocolate.

Gentle melting method: Students should use heating apparatus to heat a beaker of water to a gentle simmer. An evaporating basin should be placed on top of the beaker, so that the chocolate is heated by steam from the hot water. Two chunks of a standard chocolate bar should be placed in the basin and stirred continuously so that its temperature rises slowly. This could also be done as a teacher demonstration, using a pan and heatproof bowl to melt the chocolate in a food preparation area. The bowl should be large enough to sit on the pan without touching the hot water.

Vigorous melting method: Students should place two chunks of a standard chocolate bar into an evaporating basin and heat it directly over a Bunsen burner. The chocolate should be stirred to avoid burning, although it should be heated to a higher temperature than with the gentle method. An irreversible change will occur that changes the texture, making it more lumpy. This is known in cookery as 'seizing', and is when the cocoa grains start to separate from the cocoa butter.

Temperature is an important factor in the 'tempering' of chocolate to produce the smooth brittle chocolate cases for filled chocolates, and for chocolate bars. Instead of practical work, students could research the conditions needed using the search term 'temper chocolate'. They should write a short report, using no more than 50 words.

Resources (per group/student): evaporating basin; two chunks of a standard chocolate bar; Bunsen burner; tripod and gauze mat; beaker of tap water; stirrer.

Resources for teacher demo: heatproof bowl, pan, tap water, heat source, stirrer.

1 Chocolate

Chocolate energy

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

Explain to students that expeditions often carry chocolate as their 'emergency rations' because it is a good source of energy. However, as expeditions can only carry a limited amount of supplies, they need to select the best type of chocolate for this; the highest amount of energy for a given mass.

Students should use the data on energy content of different kinds of chocolate on Activity Sheet 2. Ask students to analyse the data so that they can compare the different kinds of chocolate and decide which would be the best to take on an expedition. They will need to convert the values to something that they can compare, such as kJ per 100 g. Some values are in kcal only, so these will first need converting to kJ using the conversion factor 1 kcal = 4.18 kJ.

Resources: Activity Sheet 2; calculator or computer with spreadsheet program.

Chocolate nutrients

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

Collect the wrappers of a range of chocolate bars, including from dark, milk and white chocolate bars, as well as from different manufacturers. Ask students to collate the nutritional information from each of the bars into a spreadsheet. Additional information on the vitamin and mineral content of chocolate can be found from websites using the search terms 'chocolate nutrition'. The data can then be analysed in a variety of ways.

- The data could be compared with Table C on page 11 of the Y8 Student's Book, to identify what proportion of the recommended daily amount of each nutrient is supplied by different kinds of chocolate.
- Different kinds of chocolate could be compared to identify general differences in nutrients between them.
- Different manufacturers could be compared to see how the nutrient content of similar products differ.

Resources: wrappers from a range of chocolate bars (including dark, milk and white).

Environmental packaging

***Exploring Science* link: 8F**

Ask students to work in pairs to consider how environmentally friendly the packaging in a box of chocolates is. Ask them to develop a set of criteria by which they could judge how ‘environmentally friendly’ different boxes for chocolates were. Their criteria could take the form of question such as:

- Is all the packaging necessary?
- What is the purpose of each part of the packaging?
- Could other, more environmentally friendly materials be used instead?
- Could the packaging be made easier to recycle?

The section on packaging in the Student Booklet can provide some starting points for this work. Pairs of students should then join up and work together in groups of four or six, agreeing a set of criteria. These can then be shared with the class. If time and resources allow, old chocolate boxes could be examined using the agreed criteria.

Alternatively, show students a chocolate box and ask them to design new packaging that will have less of an environmental impact. Students should draw their packaging and label their drawings to show the features that make their new packaging better than the original packaging. For more able students, ask them to consider not just how the materials can be reduced or recycled, but also the environmental impact of their production.

Resources: (optional) boxes/containers from assorted chocolates collections.

Chocolate's melting point

***Exploring Science* link: 8I**

Cocoa butter forms different crystalline structures depending on how it is treated as it cools. The chocolate we buy is usually 'tempered', which is produced by stirring molten chocolate as it slowly cools and solidifies. This activity gives students the opportunity to investigate the effect of different treatments on the melting point of chocolate. Activity Sheet 3 supports this work and full details on how to run the student part of this activity can be found on the sheet.

Safety

If practical work is carried out in the science lab, remind students not to taste or eat the chocolate.

You may need to tell students who are struggling with working out what sort of chart or graph they need to draw, that time should be displayed on the *x* axis and temperature should be drawn on the *y* axis. They should draw straight lines to join the points for each kind of chocolate.

The 'treated' chocolate needs preparing at least one day in advance. If the chocolate bar is in a sealed wrapper, place it somewhere warm (e.g. on a radiator) to melt gently. Otherwise, break the chocolate into a bowl and melt it gently while stirring over a pan of boiling water. Place the melted chocolate into a food fridge to cool it quickly. (Do not use a fridge containing chemicals.) When it is set, let it warm to room temperature and break it into small enough pieces to fit into a boiling tube before the lesson. The 'untreated' chocolate should be broken into similarly small pieces.

Tempered chocolate melts at around 34 °C, while chocolate that has been cooled quickly after melting is likely to melt at between 17 and 23 °C. Although students may produce different values to these, they should see a difference between the chocolates.

Resources (for preparation): chocolate bar(s) (sufficient to prepare one set of grated 'treated' chocolate and one set of grated 'untreated' chocolate for class use; heatproof bowl; water; heat source (e.g. Bunsen burner or cooker hob); spoon; fridge (in food prep room); large cheese grater.

Resources (per student or group): hot water (no more than 50 °C); beaker; grated chocolate, some treated and some untreated; thermometer; boiling tube; stopclock; Activity Sheet 3.

Producing enough cocoa

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

Students could use the content in the Student Booklet as a comprehension exercise, to help them develop their skills in writing longer answers. This could be linked to work in Topic 9c on farming and increasing yield by using chemicals such as pesticides, fungicides and fertilisers, as well as improving varieties of cocoa trees to increase the amount of beans produced.

Ask students to use the Student Booklet and Topic 9C in the Student Book to produce their own 3- or 4-mark question with a mark scheme. These can then be exchanged with another student to test out the question and mark scheme. They should then comment on how the question and mark scheme could be improved.

Chocolate melting point activity reproduced here courtesy of the Nuffield Foundation

1 Chocolate

New packaging materials

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

Using the stimulus material in the Student Booklet, and their own research, ask students to investigate how the packaging of chocolate bars has changed over the last 100–200 years. This could be organised as a whole class activity with groups of 5–7 students researching a particular set of decades and printing out pictures and typing up information cards. The cards can then be used to create a timeline.

Students should not only identify the materials that have been used to make the wrappers, but also try to discover why they changed. This should help them to identify the various purposes of packaging (e.g. protection, advertising). Some of this information can be found on the websites of the major chocolate manufacturers.

They could then extend the task by trying to predict how chocolate bar packaging might develop in the future. They should explain their predictions.

Chocolate fuel

***Exploring Science* link: 9I**

Scientists have been investigating the possibility of using waste from the chocolate-making process as a substrate for bacteria. The bacteria growing on the substrate produce hydrogen, which could be used as fuel to replace some uses of fossil fuel.

Ask students to find out more about this research (such as using the web page http://environment.about.com/od/renewableenergy/a/chocolatefuel.htm).

They could then work in small groups to draw up a table to show the benefits, drawbacks and implications of this idea.

The activity could be developed to give students an opportunity to think about and discuss the ethics of developing 'green' fuels from waste products.

1 It’s a matter of taste

The way we experience tastes involves our noses, taste buds on our tongues, and different areas for sensing and remembering things in our brains.

Different people prefer different flavours. For example, some people prefer sweet foods, others prefer salty or savoury foods. Are these differences in what people like because people taste the same flavour in different ways? Or is it maybe because of memories associated with those flavours when we first tasted them? Or is there another reason?

You have the opportunity to plan and carry out an experiment to test what affects people's sense of flavour using different kinds of chocolate.

Choosing the right question

You need to choose a good scientific question to investigate. This question needs to be one that you can test with a scientific experiment that produces good data that you can study and draw conclusions from.

A question such as 'Do certain chocolates taste nicer than others?' is not a scientific question. It asks what people think and cannot be answered using an experiment – different people may have different ideas of what 'nice' means.

A question such as 'Do people respond to the same flavours in the same way?' is a better question because you can test this question more scientifically. For example, you could give people a range of chocolates of different sweetness and ask them to place them in order of sweetness.

Try writing a good scientific question for each of these investigations:

- whether everyone responds to the same flavour in the same way
- whether the same person responds to the same flavour in different ways at different times
- whether a person's mood affects their response to a flavour
- whether a person's sense of taste is linked to their other favourite foods.

Then choose one of the questions to plan as an investigation.

Deciding how to take measurements

You will have to ask the people you test to answer a question about what they are tasting. This question will generate the data that you will analyse.

Choosing a question that allows a range of answers will give you better data for analysis. For example, you could ask each person 'On a scale of 1 to 5, 1 being very bitter and 5 being very sweet, what grade would you give this chocolate?' This will give you more data than just asking 'Is this chocolate bitter or sweet?'

Using numbers for the grade makes the results *quantitative*, which means they are easier to manipulate (such as by taking averages of groups) and to present in tables, charts or graphs.

It is often a good idea to take repeat measurements for each test (though you will need enough chocolate to do this!). You can then average the results to reduce the effect of differences that happen by chance.

1 It’s a matter of taste

Making the test fair

In a fair test all the variables are controlled apart from the *independent variable* (the variable you are interested in changing, which in this case is the type of chocolate). The variable you measure, the *dependent variable*, is each person's response.

Many factors affect people's responses in a test situation, particularly sight and smell. For example, colouring a food blue often puts people off a food, even if they know it's their favourite. You will need to think of how to avoid these factors.

Safety

Always, when using food in a science situation, you must consider how and where to prepare the food for the test in a way that is safe. Cutting up chocolate where someone has recently been using chemicals is not safe! It is best to work in a food preparation area and follow all the rules about the safe preparation of food.

You should also check that none of the people in the test have an allergy to chocolate (or milk if you include milk chocolate). If they have, it is not safe for them to take part.

Recording your results

The best way of presenting your results will depend on what data you collect. In most cases a table will help you organise the results in a way that helps you to identify any pattern in the results.

The independent variable (type of chocolate) is qualitative. If the measured variable (person's response) is quantitative, then you will also be able to present your results as a bar chart. This may also help you identify any pattern in the results.

Considering your results/conclusions

Use your results to draw a conclusion for your investigation. Remember to refer back to your original question when you do this. Have your results answered your original question? If so, what is the evidence for this in your results?

If you can, try to use your science knowledge to explain your conclusion. In this case, you would talk about how the taste buds and brain respond to flavour.

Evaluation

At the end you should evaluate your investigation. Here are some questions you could consider in your evaluation.

- Did the results help you answer your question well? If not:
    - was this because your question was not a good scientific question?
    - or was it because you didn't collect good enough data to answer your question?
- How could your original question be improved to make it easier to answer with a scientific investigation?
- How could your method for asking people be improved, in order to collect better data?

2 Chocolate energy

The table shows the mass and energy content of a range of chocolate bars.

Convert all the values to kJ/100 g of chocolate so that you can compare the energy content of the chocolate in each bar. Note: 1 kcal = 4.18 kJ.

Use your results to decide which chocolate would be the best for use as 'emergency rations' on an expedition, that is the chocolate that contains the highest amount of energy for the same mass.

Chocolate	Mass of chocolate bar (g)	Energy content
milk chocolate bar A	75	1654 kJ
diet chocolate bar B	60	998 kJ
dark chocolate bar C	200	1050 kcal
milk chocolate bar D	75	2270 kJ
white chocolate bar E	100	580 kcal
milk chocolate bar F	100	2340 kJ
dark chocolate bar G	75	390 kcal
white chocolate bar H	60	345 kcal

3 Chocolate’s melting point

The chocolate in a chocolate bar, chocolate shape (such as an Easter egg) or surrounding a soft centre is 'tempered' chocolate. This means that it has been treated in a particular way to make it crisp and brittle when you bite it. It also gives it a shiny surface.

If chocolate is treated in other ways, these properties change. This is because the cocoa butter in the chocolate forms a different structure depending on how it is treated. The melting point of the chocolate may also change.

In this investigation you will measure and compare the melting points of chocolate from the same bar. Some of the chocolate will have been melted and then chilled rapidly to solidify it before you use it.

Safety

Do not taste the chocolate, as it has not been prepared in hygienic conditions.

Apparatus

hot water (no more than 50 °C)
beaker
grated chocolate, some treated and some untreated
thermometer
boiling tube
stopclock

Method

A Pour some hot water into a beaker.

B Place 1 cm depth of grated, untreated chocolate into a boiling tube (enough to cover the bulb of the thermometer when the chocolate melts).

C Place a thermometer into the tube and measure the temperature.

D Place the tube into the hot water and start the stopclock. Use the thermometer to slowly stir the chocolate.

E Measure the temperature of the chocolate every 15 seconds for 5 minutes. Record each temperature.

F Repeat steps 1–5 with the treated chocolate.

Recording your results

G Draw a table to display your results.

H Use your table to draw a graph or chart that best displays the results for both kinds of chocolate.

Considering your results/conclusions

I Use your graph to decide whether the two kinds of chocolate had the same or different melting point.

J Explain your decision.

Activity courtesy of the Nuffield Foundation