NFER Classroom

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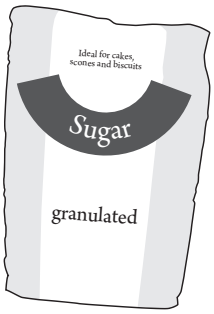

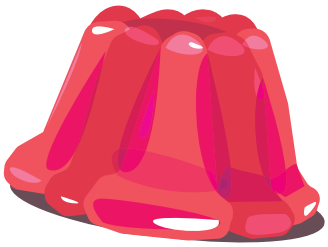

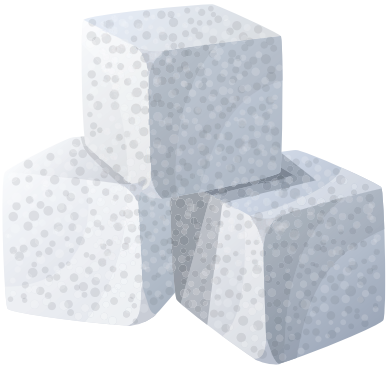

Lesson plan on investigative science

Dissolving

Dissolving

Pupils performed less well in the TIMSS test when assessed on dissolving in a practical context. Lessons 1 and 2 provide teachers with classroom activities to teach pupils about dissolving through observation, prediction, carrying out a fair test and evaluation.

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Lesson plans

Lesson 1

Does the size of sugar affect how quickly it dissolves in water?

Lesson 1 objective - to investigate if the size of sugar grains affect how quickly the sugar dissolves.
Skills – observation, design and evaluating

Prior knowledge

Understanding

For this lesson pupils should already be familiar with the concept that some materials mix and combine with water, and that this change is called dissolving. They should be aware that some materials dissolve, e.g. sugar, salt, while others do not, e.g. rice, sand.

Skills

Pupils are going to be making observations and designing a fair test. They are then going to be evaluating their findings. In order to do this, they should understand what a fair test is – a test in which only one variable is changed and the other variables are kept the same, in order to compare the results. They should have had some experience at identifying control variables (variables that are kept the same during the investigation) so they are able to apply their understanding to this task.

Definitions

The definitions below may be helpful for this lesson:

Dissolve – when a solid mixes and combines with a liquid to form a liquid mixture (solution)

Soluble – a material that dissolves in a solvent (such as water)

Solvent – a liquid, such as water

Solute – a solid material that has dissolved e.g. in salty water the solute is salt, and the solvent is water.

Solution – a liquid mixture consisting of a liquid (solvent) and a dissolved solid (solute)

Equipment required

1) Printouts of the worksheets, or a way of displaying the worksheets, e.g. on a whiteboard.

2) Each group will need:

- a magnifying glass
- beaker
- stopwatch
- stirrer
- teaspoon
- 1 sugar cube
- 1 tsp of icing sugar
- 1 tsp of caster sugar
- 1 tsp of granulated sugar

3) The teacher needs access to a kettle. (The investigation works better using warm water rather than cold water straight out of a tap as the sugar will dissolve faster.)

Pupils should work in groups of 3-5. Each group should have access to the range of equipment they require for the task – ideally they would be able to choose this for themselves from a central area, however if this is unfeasible the groups could each be provided with a box of equipment.

Links to everyday life

In this lesson, pupils will be exploring which type of sugar dissolves fastest. Most pupils will have had some experience of dissolving solids in water – either in school or at home. The teacher should discuss with the pupils their everyday experiences of dissolving solids. You could use the familiar examples to prompt discussion about their experience and explore their understanding of dissolving in the real world:

- dissolving solutes in water, e.g. sugar and salt
- water soluble paints such as powder paints and how they can be used in art and design
- opportunity to link to dissolving in biology, e.g. the acids in sugary / fizzy drinks can dissolve the enamel in your teeth, leading to tooth decay. Could show pictures of tooth decay on a projector
- discuss the way that some buildings are made of limestone which can be dissolved by the acid in rainfall and that this effect can wear down buildings / statues
- opportunity to introduce the idea that some substances are insoluble in water but are soluble in other solvents, e.g. introduce the idea that nail polish is not soluble in water but is soluble in acetone. Therefore nail polish remover cannot be made of water but can be made of acetone.

Identifying misconceptions

Pupils may have a misconception about what happens to a solid when it dissolves. It is important pupils recognise the solid has not 'disappeared' or 'vanished' but is still in the liquid; it has just combined with the particles in the liquid to become part of the liquid. This is not a permanent change. No new materials have formed, and the solid can be recovered from the solution.

The statements below can be used during the introduction of the lesson to gauge what pupils already know about dissolving, and provide some good discussion points from which misunderstandings and misconceptions can be addressed. A printout of the statements is provided which can be copied and cut into cards. Alternatively the statements could be written on a whiteboard. Ask the pupils in pairs or small groups to discuss whether they agree or disagree with each statement. If provided with cards with the statements on, the pupils could sort them into True / False / Not sure categories. If the statements are on a whiteboard, write the overall consensus of the class after pupils have discussed in their pairs or groups. Review their thoughts in the plenary and discuss any misconceptions. The answers for each statement are provided below.

- **When you dissolve sugar in water, the sugar disappears.**

  (False – this implies the sugar is no longer there, however it has mixed with the water becoming soluble in solution and therefore it appears to have disappeared as you can no longer see it.)

- **Only some solids can be dissolved in water.**

  (True – only some solids are soluble, e.g. sugar, salt, coffee; many others are insoluble, e.g. rice, pasta, paper, chalk.)

- **When sugar is dissolved in water you cannot get the sugar back.**

  (False – dissolving is a reversible change; you can get sugar back by evaporating the water.)

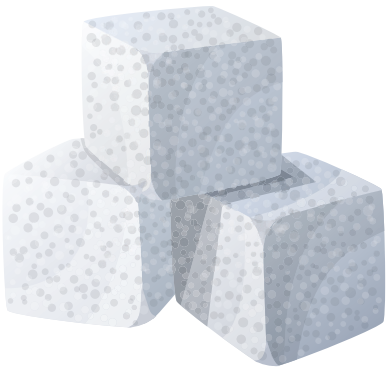
- **You can change how quickly a substance is dissolved in water.**

  (True – you can affect the rate of dissolving by stirring, shaking, heating etc.)

- **Dissolving is the same as melting.**

  (False – dissolving is when a solid mixes with a liquid to form a solution of the two materials. Melting is when one material changes from a solid to a liquid as it is heated.)

Note down pupils' ideas. During the plenary come back to any misconceptions and see if these have changed or developed.



Lesson 1

Introduction for the task

The aim of this lesson is for pupils to understand that the size of a solid (in this case sugar granules) affects the rate of dissolving (i.e. the smaller the granules the quicker they will dissolve).

Give out the cards with the statements (see Identifying misconceptions on page 5) or display the statements on a whiteboard and ask the pupils to decide if each statement is true, false or they are not sure. They could photograph the sorted cards, or photograph the whiteboard showing their decisions. This can then be compared to any changes in their decisions at the end of the lesson (see Plenary).

Next, tell the pupils they are going to be carrying out an investigation to find out if the size of sugar granules affects the time it takes for the sugar to dissolve in water. Show the pupils the four different types of sugar they will be testing. Ask the pupils which sugar has the smallest granules.

Ask pupils if they think it will make a difference if they try and dissolve different sizes of sugar granules in water.

Explain that a sugar cube is actually made of the same size granules as granulated sugar, but that they are all stuck together. Do they think that this will make a difference to how quickly it dissolves? Discuss this and see if they can come up with some explanations so they are then ready to move onto the experimental task.

Task

Allow a pupil from each group to collect the equipment they will need for the task. Alternatively make sure each group is provided with a box with the equipment listed on page 4.

Tell the pupils they are going to design an investigation to find out if the size of sugar will affect how quickly it dissolves in water. First they need to predict which of the four sugars will dissolve most quickly. Suggest they use the magnifying glass to look at each sugar. They should then write down their prediction with a reason why. This could be a whole class activity recording their predictions on a whiteboard, so they can return to their predictions after they have carried out the investigation.

Tell the pupils they can only use equipment they have been given and warm water. Tell them you have the warm water which they can collect as needed. (Have a large container of warm water to hand – around 40°C, and a kettle to keep topped up – you may like to have a thermometer to keep a check on the temperature.)

Ask the pupils what is the variable they are going to be changing in this investigation? (the type of sugar)

Ask the pupils what is the variable they are going to measure? (the time it takes the sugar to dissolve)

Get the pupils to discuss in their groups how they are going to carry out their investigation. What are their control variables? How are they going to carry out their test with each sugar? Give each group a planning sheet. When you are happy each group has given sufficient thought to their plan, and you have checked it is workable, the group can get started with carrying it out.

Ask each group to record their results. When they have done this, they can then write a conclusion and see if their prediction matched their findings. If pupils finish early ask them to think about how they could display their results.

Discussion

Which type of sugar dissolved the fastest? Why?

Which type of sugar dissolved the slowest? Why?

Did pupils find a pattern relating to the size of the sugar granules and how quickly they dissolved? Can they suggest a reason for this? This can lead into a discussion about surface area – if a solid is broken into lots of tiny little pieces, then more of it is in contact with the water which helps it dissolve more quickly.

What happened to the temperature of the water as pupils were doing the investigation? Why might this affect their results? If the water had cooled down this might affect how quickly something dissolves. If the temperature is not exactly the same for dissolving each type of sugar they cannot compare the results and the test may not be fair.

Do they think anything else may affect how quickly a solid dissolves? (e.g. how quickly you stir, how long you stir for).

At the end of the discussion ask them to go back over their plans. Ask the pupils to evaluate their investigation. Was it as fair as it could be? Could they have improved it in any way?

The aim of this lesson is for pupils to understand that the size of a solid affects the rate of dissolving

Plenary

Ensure all pupils have understood what a fair test is and can recognise if their own test was fair and any problems they encountered as a group.

Recap the key words relating to dissolving – solution, solute, solvent.

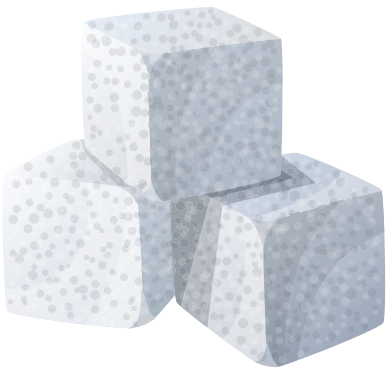
Return to the statement cards (or look at the photographs taken showing how the statements were sorted). Do they still agree with their decisions? Are there any they would change? Discuss the explanations for why pupils have identified each statement as true or false or not sure and address any misconceptions to ensure pupils have a solid understanding of the concept of dissolving.

Recap that the size of the sugar granule affects how quickly it dissolves in water – the smaller the sugar granule the faster it will dissolve in water. See if any pupils remember this is linked to the surface area of the solid. Explain that therefore it is better to use sugar granules rather than sugar cubes if you put sugar in a cup of tea.

Extension

If there is time at the end of the lesson, ask pupils to discuss in their groups what variables they could change if they were investigating how quickly just one type of sugar dissolves. (Examples include water temperature, rate of stirring, volume of water, mass of sugar.)

Once they have come up with a list of different variables ask them to think about how each variable will affect the time taken for the sugar to dissolve and why. Ask them to record their answers on the printout. Tell the pupils they will be using their ideas from this discussion in the next lesson where they will be dissolving a different solid.



Lesson 2

How can you make jelly most quickly?

Lesson 2 objective – to compare the effects of two variables on how quickly jelly dissolves.
Skills – predicting, doing and evaluating

Prior knowledge

Understanding

For this lesson pupils should have a solid understanding of the process of dissolving. They may be aware that different variables may affect how quickly a material dissolves. From the extension activity in lesson 1, they may be able to identify some of these (e.g. temperature, time stirred for). Pupils should have an understanding, from the previous investigation, that the size of the solid (surface area) affects how quickly it dissolves with smaller pieces of solid dissolving more quickly.

Skills

Pupils should be familiar with making predictions and giving an explanation for their prediction based on prior scientific knowledge. In this lesson they will be using their understanding and predictions in the extension activity from the previous lesson, to make an informed prediction for this task. Pupils should have a good understanding of fair testing and of identifying the variable to change and variables to keep the same. They will be developing this skill in this lesson to look at several variables, so need to be secure in their understanding of fair testing. They will also need to use their knowledge of fair testing to evaluate a plan that has clear errors.

Note for Teacher

Surface area is a measure of how much exposed area an object has. One way of increasing the surface area of an object is to break it up into smaller pieces, which increases the exposed area of the object.

Therefore breaking a block of jelly into small pieces will increase the surface area of the jelly.

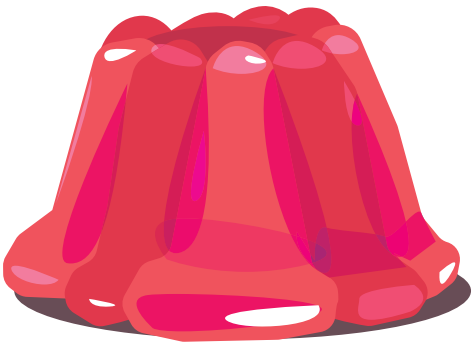
Definitions

The definitions below may be helpful for this lesson:

Fair test – when one variable is changed and the other variables are kept the same allowing you to compare the results.

Variables – the different factors in an investigation that may affect the results.

Control variables – the factors in an investigation that are kept the same each time.



Equipment required

1) Printouts of the group planning sheet.

2) A way of displaying the plan to evaluate, and the class data collection sheet.

3) Each group will need:

- a beaker
- jelly cubes to be cut up into different size pieces (if there are vegetarians in the class then be sure to use vegetarian jelly)
- stirrer
- stopwatch
- (hand) hot water
- scissors

4) The teacher needs access to a kettle.

Pupils should work in groups of 3-5. Each group should be provided with a box of the equipment they require for the task. Care needs to be taken with the hot water to dissolve the jelly – the water should be as hot as possible without burning. The teacher should pour the water at each table to avoid pupils carrying beakers of water around the classroom.

Links to everyday life

Opportunities to discuss when you want things to dissolve quickly in everyday life:

- Making fruit juice. When making sweetened orange juices you add sugar to warm water and the juice of the orange. The drink is then stirred at a warm temperature. The sugar dissolves into the solution faster because it is stirred and at a warm temperature.

- Making hot chocolate, cocoa and coffee using instant granules. In all three cases the product has been ground down into small granules. This means that there is a large surface area which helps them to dissolve quickly in hot water.

Identifying misconceptions

Pupils may have some misunderstandings about why a fair test is important. They should understand that a fair test allows comparisons to be made. If you are changing more than one variable it is not possible to make valid comparisons unless every combination is tested. The first part of the lesson, evaluating the given plan, will provide the opportunity to address any misconceptions relating to carrying out a fair test to collect valid results.

Pupils may have some misunderstandings about why a fair test is important. They should understand that a fair test allows comparisons to be made.

Lesson 2

Introduction

Tell the pupils that they are going to investigate making jelly. Briefly describe how jelly is made for those unfamiliar with making jelly. Explain that the jelly cubes are added to hot water and that the jelly cubes dissolve into the water. After completing this stage of the experiment, the students put the jelly mixture into the fridge to set.

The aim of their investigation is to find the fastest method for **dissolving** the jelly. They are going to be looking at three variables – the size of the jelly, the amount of water and if the mixture is stirred. The context could be that you want to make jelly as quickly as possible for a party. You have lots of other things to get ready and you do not want to be taking up your time dissolving jelly.

Tell them some children have written out a plan to test the three variables, but you are not sure if their plan is a good investigation. Pupils need to look at this plan and think about why it is not a good way of finding out which variables make jelly dissolve most quickly. They will be evaluating the plan and improving it to design their own investigation which will give results they can compare to come up with a conclusion.

The pupils will then carry out their own investigation in groups. They will record their results and at the end should be able to conclude what variables will give the fastest method for dissolving the jelly.

Task

Give each group a sheet with the 'Plan for discussion of unfair test', or display on a whiteboard. After reading it through, ask some questions to get pupils thinking about why this is not a good investigation. Tell them they need to think about how they could improve the plan, and that they can also use their own knowledge of what they learned about dissolving in the last lesson.

The following are question prompts that could be used (the answers are given in brackets):

What are the variables they are changing in this investigation? (size of jelly, amount of water and if they stir the mixture)

Will the children be able to compare if using small pieces of jelly is better than a whole cube? Why? (yes, they could compare the results from the first two columns of the plan because they are only changing the size of the jelly but they are keeping the amount of hot water the same and stirring both for the same amount of time)

Will the children be able to compare how long you should stir for, or is it better to just leave and not stir? Why? (no, because in the test that they did not stir they changed the amount of water as well, so they won't know if any differences in the time to dissolve are because of using less water, or leaving to dissolve)

What have these children forgotten about in their plan? (they're not keeping anything the same – there are no control variables so the test is not fair)

Why is it important to have control variables? (to make sure the test is fair so you can compare the results and know if the one variable you are changing is having an effect)

What did we find out last week about the size of the pieces and how quickly it dissolves? (that smaller pieces dissolve more quickly)

If we know this already, what size of jelly would be best to use in your investigation? (it would be best to use the smaller pieces of jelly, so that you can see if other variables affect how quickly the jelly dissolves)

How can we compare the other two variables of stirring and amount of water? (you would have to compare all of the combinations of variables and in each test you would only change one thing)

Tell the pupils that some groups will need to investigate stirring and others will investigate the amount of water. You will need to coordinate the groups so you have at least one group with each of the following:

	variable to change	control variable
Group 1	stirring and not stirring	using 300 ml water
Group 2	stirring and not stirring	using 200 ml water
Group 3	amount of water (300 and 200ml)	stirring
Group 4	amount of water (300 and 200ml)	not stirring

More groups means you will get more data for each test, which will provide comparisons for reliability of the data.

The control variable across all the groups will be they all use jelly cubes cut into 8 small pieces. Ask the pupils to give a prediction about what they think will be best – more or less water, stirring or not stirring. Discuss the reasons behind their predictions.

Give each group a planning sheet for their investigation and a box of the equipment they may use. When you have checked their planning sheet they can carry out the tests.

The table below shows how each planning sheet should be filled in.

Group:	Group 1	Group 2	Group 3	Group 4
Variable we are going to change	Stirring or not stirring	Stirring or not stirring	Amount of water (200 and 300ml)	Amount of water (200 and 300ml)
Variable to keep the same	Jelly cube cut into 8 pieces			
Other variables to keep the same	1) Use 300 ml water 2) Water temperature 3) The beaker	1) Use 200 ml water 2) Water temperature 3) The beaker	1) Stir for 1 minute 2) Water temperature 3) The beaker	1) Do not stir 2) Water temperature 3) The beaker
What we are going to measure	The time it takes for the jelly to dissolve.			
How we are going to measure	Should include: start timing when the water has been added to the jelly. If stirring, then start with the timer. Stop timing when the jelly has dissolved. Record the time taken.			

Lesson 2

Display the data collection sheet, so each group can record their results and you can discuss together as a class.

Discussion

What do the results show us? Was it better to stir or not to stir? Was it better to use more or less water?

Do these results support your predictions about what you thought would happen?

If you want to dissolve jelly in the fastest time, what is the best way to do this from the evidence we have so far? (expected pupil responses – use small pieces, stir it, use more water)

What variables were difficult to keep the same each time? (expected pupil responses – the temperature of the water, the speed at which the mixture was stirred)

How could this experiment be improved to get more reliable results? (expected pupil response – repeat the experiment and calculate an average of your results)

Can we tell from this experiment if increasing the amount of water or stirring the jelly mixture has a greater effect on the rate of dissolving? Why are we able to do this? (expected pupil response – because we have compared each variable we changed against the same control variables)

Why would you not want to add too much water to the jelly mixture even if it dissolves faster with more water? (expected pupil responses – the jelly might not have as much flavour, the jelly might not set / be too runny)

Extension

Ask each group to come up with a method for dissolving jelly even faster than any of the methods they have used in this activity. Pupils can only use the equipment they have been provided in the lesson. If pupils are having trouble thinking of what they could do, get them to think about the variables they found that speeded up dissolving and see if they can adjust these variables to speed it up even more (e.g. cut the jelly cube into even smaller pieces, stir more vigorously, stir for longer).

Then ask the pupils to carry out their new method and time how long it takes to dissolve the jelly.

Collect the results from the different groups and discuss why the different methods take different amounts of time.

Plenary

Ensure pupils are confident with the main variables that affect the rate of dissolving (volume of solvent, rate of stirring, temperature of solvent, mass of solute).

Check that pupils appreciate the difficulties in comparing investigations in which you change multiple variables in the same experiment and that if you are testing more than one variable in the same investigation you must test each possible combination.

Confirm that pupils can identify the conditions that lead to faster dissolving times.

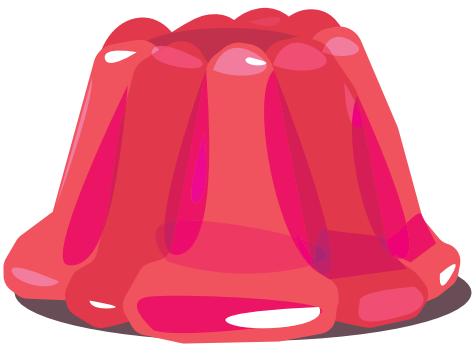
The aim of the investigation is to find the fastest method for dissolving the jelly

Resources

Links to some useful resources on dissolving:

Video demonstrating dissolving of nail varnish in propanone:
www.bbc.co.uk/education/clips/zx7w2hv

Video demonstrating dissolving of a sugar cube:
www.youtube.com/watch?v=hydUVGUbyvU



Lesson printouts

Dissolving lesson 1

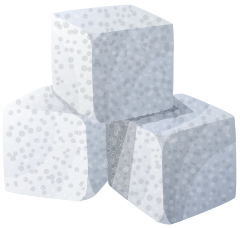
Does the size of sugar affect how quickly it dissolves in water?

Aim: To investigate if the type of sugar affects how quickly it dissolves.

Identifying misconceptions

When you dissolve sugar in water, the sugar disappears.
Only some solids can be dissolved in water.
When sugar is dissolved in water you cannot
get the sugar back.
You can change how quickly a substance is
dissolved in water.
Dissolving is the same as melting.

Look at the four different types of sugar using the magnifying glass.



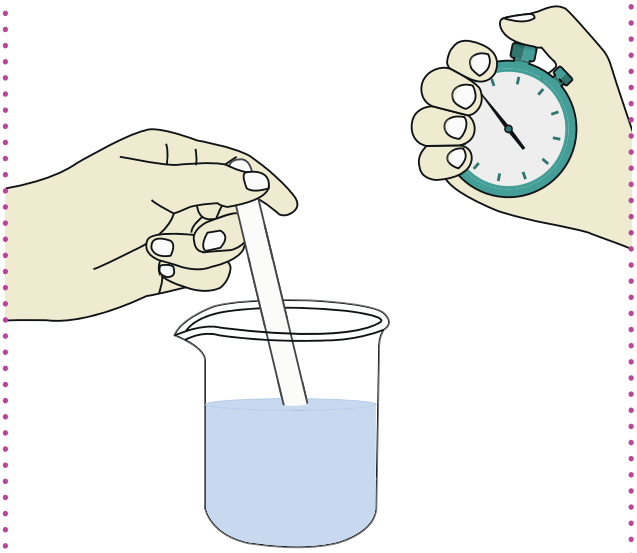
You can draw them and make notes here.

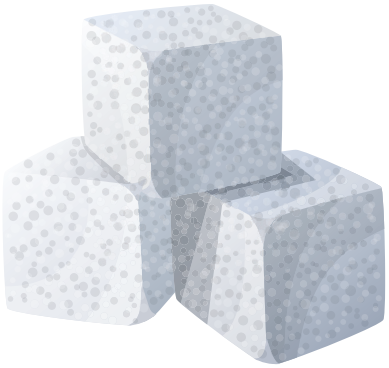
Prediction

Which type of sugar do you think will dissolve in the water the fastest? Why?

Equipment for investigation

- ◯ warm water (collect from your teacher)
- ◯ beaker
- ◯ stopwatch
- ◯ stirrer
- ◯ teaspoon
- ◯ 1 sugar cube
- ◯ 1 tsp of icing sugar
- ◯ 1 tsp of caster sugar
- ◯ 1 tsp of granulated sugar





What is the variable you are going to change?	
What is the variable you are going to measure?	
What variables are you going to keep the same? List them here.	

Results

Record your results in the table below.

Type of sugar	Time taken for sugar to dissolve (s)
Sugar cube	
Granulated sugar	
Caster sugar	
Icing sugar	

Conclusion

Which sugar dissolved fastest?

Which sugar dissolved slowest?

Can you write a conclusion for your investigation? What is it about the type of sugar that affects how quickly it dissolves?

Evaluation

In what ways did you make sure your investigation was a fair test?

If you did it again, would you change anything in how you did it? Think about what went well and what you could improve.

Extension

If you only used one type of sugar in this investigation (e.g. granulated sugar) what variables could you change to investigate their effect on the time it takes for the sugar to dissolve?

Variable 1:

Predict how it will affect the time taken to dissolve:

Variable 2:

Predict how it will affect the time taken to dissolve:

Variable 3:

Predict how it will affect the time taken to dissolve:

Dissolving lesson 2

How can you make jelly most quickly?

Aim: to compare the effects of two variables on how quickly jelly dissolves, developing skills of prediction, carrying out a fair test and evaluation.

Plan for discussion of unfair test

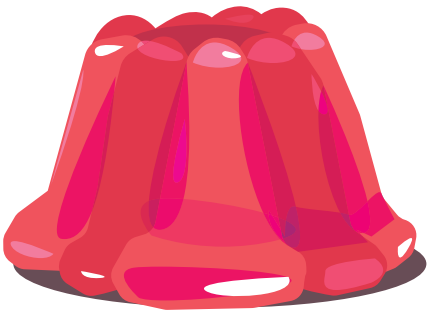
Some children are deciding how to make jelly quickly.

They need to dissolve the jelly in hot water and then put it in the fridge to set.

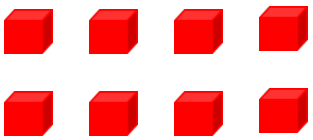
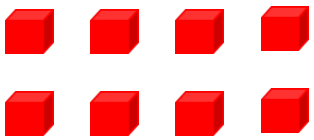
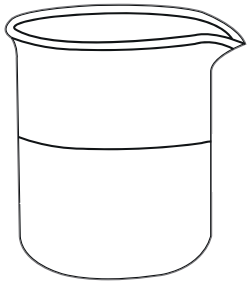
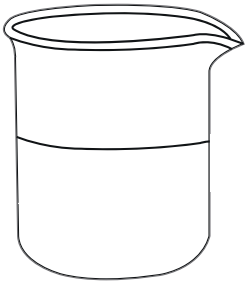
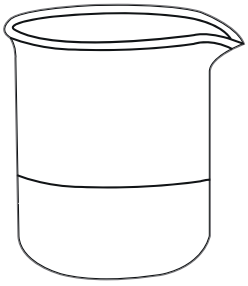
They want to dissolve the jelly in the fastest time.

They decide to investigate three variables:

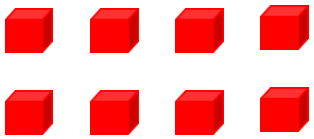
- size of jelly
- amount of water
- stirring the mixture



This is their plan:

Use a whole jelly cube	Use a jelly cube cut into 8 small pieces	Use a jelly cube cut into 8 small pieces
		
Put in 300 ml hot water	Put in 300 ml hot water	Put in 200 ml hot water
		
Stir until dissolved	Stir until dissolved	Leave to dissolve
Record time	Record time	Record time

Group planning sheet for task

Variable we are going to change	Circle one: Amount of water 300ml and 200ml Stirring or not stirring
Variable to keep the same	Jelly cube cut into 8 pieces 
Other variables to keep the same	1) 2) 3)
What we are going to measure	
How we are going to measure	Describe what you are going to do
Predict what you think will happen. Give a reason why.	

Class data collection sheet

Jelly cubes cut into 8 small pieces.

Each group should write their results in the two boxes they have investigated.

	300ml water	200ml water
Stirring		
Not stirring		

Extension

Using only the equipment you have been given, design a different method for dissolving the jelly cube which is quicker than the methods you have used so far.

How long (in seconds) did your method take to dissolve the jelly?

How did this method compare to your previous investigation?