COUGH SYRUP

A science investigation pack for teachers of 9–11 year olds

CENTRE *for* INDUSTRY EDUCATION COLLABORATION

Supported by the Gatsby Charitable Foundation

Contents

Introduction

AGE RANGE

The activities in this book give upper Key Stage 2 children the opportunity to explore some of the processes that are followed by the pharmaceutical industry in the production of new medicines. The activities can be adapted to suit the needs of the children, staff and planning requirements of the school. They may also be modified for use in lower Key Stage 2.

CONTEXT

The activities are based on the development of a new cough syrup. Having discovered an active ingredient that will relieve the symptoms of a cough, a fictitious pharmaceutical company wishes to manufacture a syrup containing the new ingredient. The new ingredient is produced during the fermentation of a particular micro-organism. They contact the children and request that they carry out some further research and development on their behalf.

The children work to identify the best conditions for growing micro-organisms to produce the active ingredient, the most effective and efficient way to collect it and the ideal consistency for the syrup to be administered.

The children also need to consider economic factors involved in production and the commercial importance of effective branding for the new product.

ACTIVITIES

The activities take approximately 5 hours to complete and can be covered in 3-4 half day sessions. They should be completed in the order given as they follow a process from initial research through development to production of the final product. Intermediate products resulting from the children's investigations are referred to in subsequent activities. However, each activity could be easily adapted as a stand-alone lesson. Ideally, children should work in groups of 4. As all of the activities involve the measuring of liquids, additional adults would support learning and skills development.

ACTIVITY SUMMARY

Title	Description	Timing
1 Investigating food sources for microbes	Children adopt the role of scientists working on behalf of a pharmaceutical company to develop a new cough syrup. They investigate a range of food sources for cultivating yeast. This information about growing conditions can then be used to grow a micro-organism for extraction of an active ingredient.	1 hour 30 minutes
2 Investigating the effect of temperature on microbial growth	Children investigate how the growth of a micro-organism is affected by temperature.	1 hour 30 minutes
3 Filtration	Having grown the yeast, children find the best method of separating the growth medium from the micro-organisms. The effectiveness of filters is investigated using a flour and water mix.	1-2 hours
4 Viscosity testing	Children investigate the effect of altering the ratios of specific ingredients on the viscosity of the resulting syrups. The aim is to find the best consistency of a cough medicine.	1 hour 30 minutes

Curriculum Coverage

The following **National Curriculum** (for England) areas are supported by this work:

Working Scientifically Upper Key Stage 2
Planning different types of scientific enquiries to answer questions, including recognising and ontrolling variables where necessary
Taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate
Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs
Using test results to make predictions to set up further comparative and fair tests
Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations
Identifying scientific evidence that has been used to support or refute ideas or arguments
States of Matter (Y4)
Compare and group materials together, according to whether they are solids, liquids or gases
Observe that some materials change state when they are heated or cooled, and measure or research the temperature at which this happens in degrees Celsius (°C)
Animals, including Humans (Y4)
Describe the simple functions of the basic parts of the digestive system in humans
Properties and Changes of Materials (Y5)
Compare and group together everyday materials on the basis of their properties, including their hardness, solubility, transparency, conductivity (electrical and thermal), and response to magnets
Know that some materials will dissolve in liquid to form a solution, and describe how to recover a substance from a solution
Use knowledge of solids, liquids and gases to decide how mixtures might be separated, including through filtering, sieving and evaporating
Give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials, including metals, wood and plastic
Demonstrate that dissolving, mixing and changes of state are reversible changes
Explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible, including changes associated with burning and the action of acid on bicarbonate of soda.
Living Things and their Habitats (Y6)
Describe how living things are classified into broad groups according to common observable characteristics and based on similarities and differences, including micro-organisms, plants and animals
Maths (Key Stage 2)
Interpret and present discrete and continuous data using appropriate graphical methods, including bar charts and time graphs **(Y4 Statistics)**

Solve comparison, sum and difference problems using information presented in bar charts, pictogram, tables and other graphs **(Y4 Statistics)**

Complete, read and interpret information in tables, including timetables **(Y5 Statistics)**

Use all four operations to solve problems involving measure [for example, length, mass, volume, money] using decimal notation, including scaling **(Y5 Measurement)**

Complete, read and interpret information in tables, including timetables **(Y5 Statistics)**

Solve comparison, sum and difference problems using information presented in a line graph **(Y5 Statistics)**

Computing (Key Stage 2)

Use search technologies effectively, appreciate how results are selected and ranked, and be discerning in evaluating digital content

Select, use and combine a variety of software (including internet services) on a range of digital devices to design and create a range of programs, systems and content that accomplish given goals, including collecting, analysing, evaluating and presenting data and information

English (Y5/6)

(Spoken Language)

- Listen and respond appropriately to adults and their peers
- Ask relevant questions to extend their understanding and knowledge
- Use relevant strategies to build their vocabulary
- Articulate and justify answers, arguments and opinions
- Give well-structured descriptions, explanations and narratives for different purposes, including for expressing feelings
- Maintain attention and participate actively in collaborative conversations, staying on topic and initiating and responding to comments
- Use spoken language to develop understanding through speculating, hypothesising, imagining and exploring ideas
- Speak audibly and fluently with an increasing command of Standard English
- Participate in discussions, presentations, performances, role play, improvisations and debates
- Gain, maintain and monitor the interest of the listener(s)
- Consider and evaluate different viewpoints, attending to and building on the contributions of others
- Select and use appropriate registers for effective communication

Retrieve, record and present information from non-fiction **(Y5/6 Reading – comprehension)**

Provide reasoned justifications for their views **(Y5/6 Reading – comprehension)**

Plan their writing by identifying the audience for and purpose of the writing, selecting the appropriate form and using other similar writing as models for their own **(Y5/6 Writing – composition)**

Noting and developing initial ideas, drawing on reading and research where necessary **(Y5/6 Writing – composition)**

Selecting appropriate grammar and vocabulary, understanding how such choices can change and enhance meaning **(Y5/6 Writing – composition)**

Using further organisational and presentational devices to structure text and to guide the reader [for example, headings, bullet points, underlining] **(Y5/6 Writing – composition)**

The material is aimed at 9-11 year old, though the activities can be modified for use with other age groups and their associated learning objectives.

1. Investigating food sources for microbes

1.5 hour activity

Children adopt the role of scientists working on behalf of a pharmaceutical company to develop a new cough syrup. They investigate a range of food sources for cultivating yeast. This information about growing conditions can then be used to grow a micro-organism for extraction of an active ingredient.

TYPE OF ENQUIRY

- Fair test
- Observation over time

OBJECTIVES

- To plan different types of scientific enquiry including recognising and controlling variables where necessary.
- To record data and results using scientific diagrams and tables
- To report and present findings from enquiries including conclusions, causal relationships and explanation of and degree of trust in results in oral and written forms.
- To develop their understanding of micro-organisms as living things

SCIENCE VOCABULARY

Micro-organism	Ingredients	Change
Investigation	Fair test	Factor
Compare	Improve	Evaluate
Results		

RESOURCES

(per group of 2-4 children, unless otherwise stated)

- Activity sheet 1
- Activity sheet 2 (one per child)
- 4 sachets dried yeast
- 300 ml warm water (approximately 50°C, e.g. in Thermos flask)
- 5 ml sugar
- 5 ml salt
- 5 ml flour
- 5 ml lemon juice
- 4 small plastic drinks bottles
- 4 balloons or air-locks available from brewing outlets

- 100 ml measuring cylinders or suitably graded bottles
- Measuring spoons or teaspoons
- Blank sticky labels

PRIOR KNOWLEDGE/EXPERIENCE

Children should have had opportunities to set up simple practical enquiries, comparisons and fairs tests. They should be able to recognise when a fair test is necessary and help to do some of the planning required for this.

ADVANCE PREPARATION

Place sugar, salt, flour and lemon juice in separate labelled containers so that children can collect them easily when needed. Sugar and salt may be confused if care is not taken.

Provide water at about 50°C. By the time the children have measured and transferred the water it will have cooled to about 40-45°C. If thermometers are available, the exact temperature can be recorded after the bottles are set up.

INTRODUCING THE TOPIC

Introduce the topic of medicine by asking the children to think about medicines they have taken. Ask for ideas about who makes medicines and what kinds of processes are important in developing new ones. How do the companies know that their medicines will help to make sick people well? Posters that introduce medicines in a child friendly format are available from the Association of the British Pharmaceutical Industry website, www.abpischools.org.uk.

Give each group some real boxes that have contained medicine bottles. These can be obtained from pharmacies. Ensure the boxes are empty and contain no trace of medicine. Identify that each medicine has an active ingredient. Explain that this is the substance that works on the cause of the illness to make the patient better. Many active ingredients are derived from plant sources. You could illustrate this by reminding children that dock leaves can be rubbed on nettle stings to ease the stinging. The substance that does this may be extracted from the dock leaves and could form the active ingredient in an ointment. Although many illnesses are caused by micro-organisms, some active ingredients are derived from others. Penicillin, an antibiotic, is an example of this, as it is produced by a type of mould. The story of Alexander Fleming could be introduced in literacy as a piece of non-fiction writing, to illustrate the work of scientists.

ACTIVITY NOTES

Read the letter from Medivelop Ltd (Children's sheets) and ask children for their initial thoughts and ideas.

Discuss with children the first requirement: finding the most effective method of producing the active ingredient. In an industrial setting, this would be the primary manufacturing stage.

A possible introduction to the investigation would be to smell freshly baked bread or a yeast extract jar and talk about the contribution that yeast has made to these products. In bread the fermentation produces a gas that makes the bread rise, and in yeast extract the yeast itself adds flavour. There are different types of yeast, just

like there are different types of plants, and different types of yeast are used for different purposes. Other micro-organisms also produce useful by-products, e.g. yogurt.

Some micro-organisms produce substances that will kill other micro-organisms. If they can do this without harming the patient, they can be used in medicines. Many tests will be carried out throughout the development of a new medicine. From the very beginning safety is of greatest importance. In the first stages of this investigation we are going to use yeast because it is safe and easy to grow in the classroom and can be used to investigate optimum growth conditions.

Yeast is a one celled micro-organism that grows by reproducing itself and dividing into two. To grow, it needs the right conditions, the same as animals and plants do. Ask the children for suggestions as to what these may be: food, oxygen, water and warmth are needed, whereas light is not.

Organise the children into working groups of four. Their task is to find the conditions in which the yeast will be most productive.

Show the children the resources that will be available and allow each group time to consider how the problem can be investigated. Ask each group to explain how they think the investigation might be carried out. This first investigation can be used as an opportunity to model how to conduct a fair test.

Here is one possible investigation, though children may suggest suitable variations to this:

- Label four identical containers or small pop bottles each with one of sugar, salt, lemon juice and flour and also the name of the group.
- Add the same quantity (by volume) of food to the bottles using a teaspoon or measuring spoon. A clean spoon must be used each time.
- Add 1 sachet or 1 heaped teaspoon of dried yeast to each bottle.
- Top up each with an equal volume of warm water to about ⅓ full and place a balloon over the open neck of the bottle or add an airlock if used.
- Observe each of the mixtures and record initial observations. There should be frothing in the sugar mixture quite soon after setting up.
- Leave the bottles in a warm place where they can be easily observed. As the yeast feeds on the sugar and produces carbon dioxide, the children will observe the balloons inflating.

Note: Don't stress the importance of temperature at this point as children will investigate this next.

Balloons will inflate with the carbon dioxide produced. The production of gas can also be demonstrated by the bubble of air passing through the water in an air-lock.

The children should make observations every ten minutes and record their findings in a table (Children's sheets).

Encourage the children to observe the bottles carefully and record information about what is happening. This can be done by using digital cameras and sequencing the images or by drawing diagrams and adding accurate label descriptions.

Examples of children's recording are provided to illustrate the minimum amount of information that should be gathered.

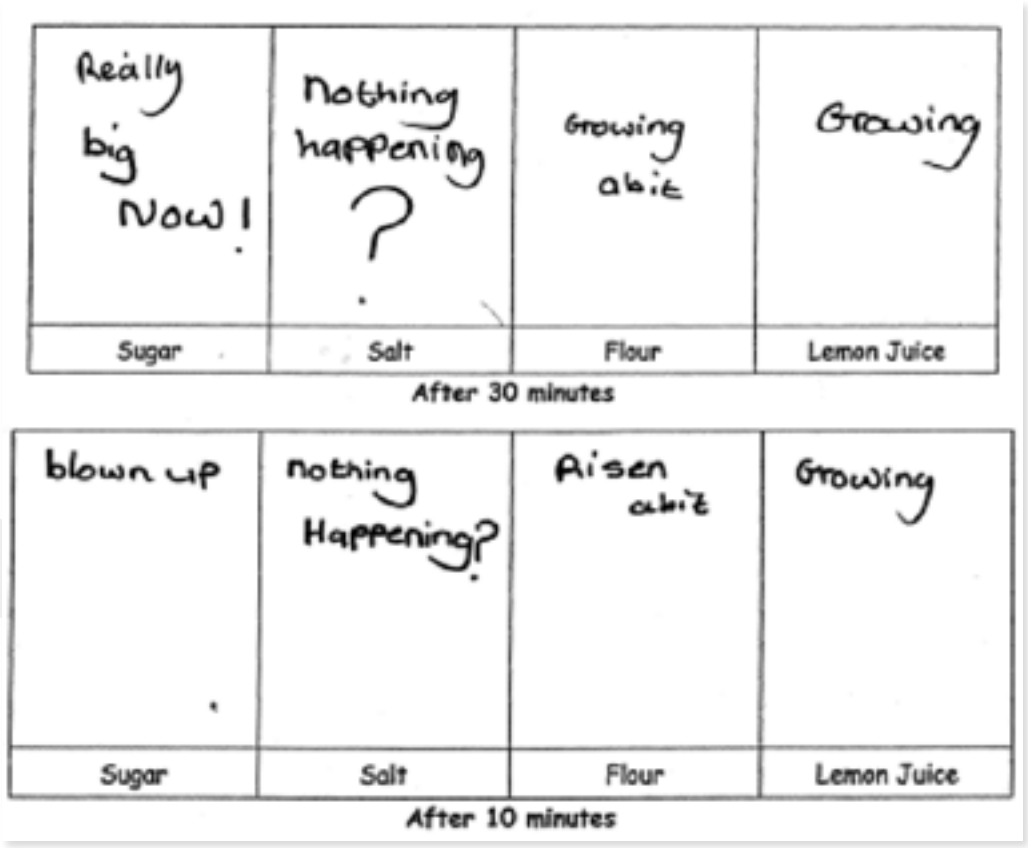


Figure 1

The information recorded in **Figure 1** is limited and does not provide evidence for what the child is claiming.

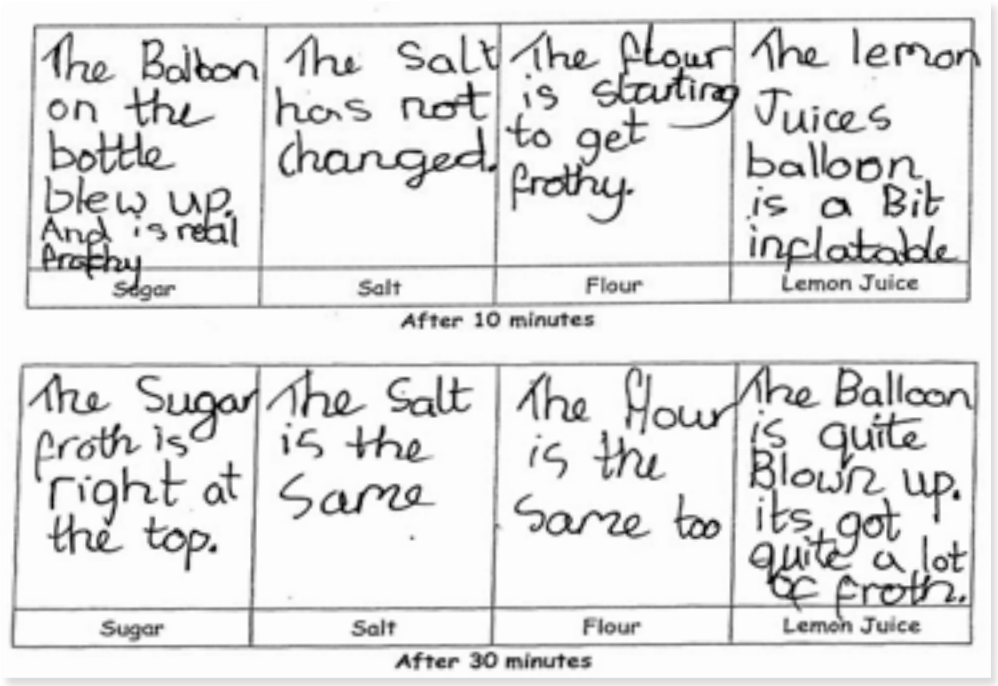


Figure 2

In **Figure 2** more information is given specifically about the contents of the bottle and the balloon. These observations will provide evidence to support the conclusion made.

In between observations, children could begin to think of a marketing campaign for the new medicine. The samples of packaging, shown when introducing the topic, can be a starting point for this. Advertising a product needs careful wording to attract buyers, as well as safety messages and warnings.

They should avoid existing brand names but could think about the kind of names used and how these portray a certain brand image. An opportunity exists here for links with design technology and English.

Each group should find that the solution containing the sugar caused the balloon to inflate most. There may be some partial inflation of the balloons from the solutions containing the flour and the lemon juice as these contain starch and sugar for the yeast to feed on but it will be noticeably less. The salt solution should not produce any inflation. Leave the solutions to settle so that the yeast forms a layer at the bottom. The yeast in sugar solution should have increased and so form a thicker layer. After approximately 30 minutes the children should look at the data they have collected and discuss what conclusions can be drawn from it.

Ask each group to present their findings to the whole class. The questions for thinking can be used to stimulate discussion, and to encourage the use of appropriate vocabulary.

Explain that, as yeast is a living micro-organism, it needs to feed. As it feeds on the sugar, it produces a gas called carbon dioxide. It is this gas that inflates the balloon. Flour will not harm the yeast but salt in the water would. This could be investigated by repeating the conditions for growth with sugar and salt in the same bottle.

EXTENSION

The children have been told that the gas produced by yeast is carbon dioxide. Although they have no reason to doubt your word, can they think of any way to demonstrate this? This would be very challenging work and would depend on children having a high level of knowledge. One way may be to carefully pour the gas from the balloons over a tea light placed in a shallow container to extinguish the flame. Carbon dioxide being heavier than air will sink to the bottom of the container. This does not necessarily prove that the gas is carbon dioxide, and not some other heavier than air gas, but it reduces the possibilities and encourages creative thinking.

Further investigations could be carried out to explore the effect that using artificial sweetener in place of sugar would have.

QUESTIONS FOR THINKING

- Have all the balloons expanded?
- Have they all expanded to the same size?
- If not, what may account for the variation?
- What caused some of the balloons to inflate?
- What conclusions are the children able to draw from their investigation?
- How can the most yeast be grown in the shortest time?

- How would the new cough syrup be packaged?
- What would be a good name for a new cough syrup?

SAFETY GUIDANCE

- Basic advice about medicines not being taken unless prescribed should be given.
- Children should wash their hands carefully after handling the bottles of yeast

INDUSTRY LINKS AND AMBASSADORS

The development and manufacture of medicines is a lengthy and expensive process which can be broken down into three stages.

- **Research and development (R&D)** includes the identification of a potential treatment and the research needed to develop the idea into a new drug.
- **Primary manufacture** is the manufacture of the 'active ingredient'. An active ingredient is the part of a medicine that has a beneficial effect and usually comprises a small part of the whole medicine.
- **Secondary manufacture** is the incorporation of the active ingredient into a form which can be taken or applied.

Some active ingredients are produced using 'chemical technology' which is combining substances to create the active ingredient. However, this investigation mimics the R&D stage of producing an active ingredient using 'biotechnology'. A real life example of this would be the cultivation and extraction of penicillin to make an antibiotic.

CROSS CURRICULAR LINKS

English: Opportunities to use spoken language to develop understanding through speculating, hypothesising, imagining and exploring ideas. Also, links to writing whereby pupils identify audience and purpose, as well as selecting the appropriate form, especially if considering ways to market their medicine.

Mathematics: Opportunities to practice taking and recording measurements and performing simple calculations

Design and Technology: Opportunities to design packaging for the medicine.

Medivelop Ltd

Dear Researchers,

Here at Medivelop Ltd we work with many companies that are as committed as we are to producing medicines of the highest quality.

We have discovered an active ingredient that soothes coughing. This ingredient can be made from the liquid produced when a particular micro-organism is grown.

To help us to use this discovery we would like you to carry out some further research and help us to develop a new cough medicine.

We require you to carry out the following investigations:

- Find the most effective method of growing the micro-organism to produce the active ingredient.
- Find the most efficient way to collect the active ingredient.
- Produce the final product in the form of a syrup containing the active ingredient. This should be soothing when swallowed and pleasant to take.

We also require you to provide ideas and samples of possible names and packaging designs that will quickly identify the product to consumers.

When conducting your research please consider the cost of production, how to keep the medicine the same each time and the need to produce the medicine in large quantities. Remember that it is very important to keep careful records of everything that you do.

Please report to me directly when your research is complete.

Yours sincerely

Dr. J Brown

Director of Research and Development

Medivelop Ltd

2. Yeast Growth Recording Sheet – Food Type

Look closely at the bottles containing the solutions you made. Draw or write about your observations for each of the foods you placed in the solution.

Sugar	Salt	Flour	Lemon Juice

After 10 minutes

Sugar	Salt	Flour	Lemon Juice

After 20 minutes

Sugar	Salt	Flour	Lemon Juice

After 30 minutes

2. Investigating the effect of temperature on microbial growth

1.5 hour activity

Children set up a fair test to investigate how the growth of a micro-organism is affected by temperature.

TYPE OF ENQUIRY

- Fair test
- Observation over time

OBJECTIVES

- To plan different types of scientific enquiry including recognising and controlling variables where necessary.
- To record data and results using scientific diagrams and tables
- To report and present findings from enquiries including conclusions, causal relationships, and explanation of and degree of trust in results in oral and written forms.
- To use test results to make predictions to set up further comparative and fair tests.
- To develop their understanding of micro-organisms as living things.

SCIENCE VOCABULARY

Micro-organism	Ingredients	Change
Investigation	Fair test	Factor
Compare	Improve	Evaluate
Results	Temperature	

RESOURCES

(per group of 4 children unless otherwise stated)

- Activity sheet 3 (one per child)
- 3 sachets dried active yeast
- 300 ml warm water (approx 50°C, can be stored in a Thermos flask)
- Cold, iced water
- 100g sugar
- 3 balloons
- 100 ml measuring cylinders or suitably graded bottles
- 3-4 small plastic pop bottles
- 1 litre jugs

- 3-4 plastic spoons
- 3-4 plastic containers
- 2-litre ice-cream tubs, or similar
- Blank sticky labels
- 1 thermometer -10°C to 110°C

PRIOR KNOWLEDGE/EXPERIENCE

Children should have had opportunities to set up simple practical enquiries, comparisons and fairs tests. They should be able to recognise when a fair test is necessary and help to do some of the planning required for this.

ADVANCE PREPARATION

This investigation should be carried out using a range of water temperatures (at least 3) between 10°C and 50°C. Children can prepare different temperatures by mixing warm and cold water.

During the experiment, it will be possible to maintain the temperature of the water in each container for a longer period of time by sitting them in a larger container half filled with water. Put the warm bottles in a water bath at 55-60°C and the cool bottles in a water bath at 10°C cooled with ice. By doing this, the warm water will take longer to cool down, the cold water longer to heat up, and a more constant temperature will be maintained.

ACTIVITY NOTES

Introduce the session by discussing the findings of the previous lesson. Ask children to discuss in their groups the conclusions they reached.

- Which type of food promotes the most yeast growth?
- How do we know this?

Remind children that yeast is a living micro-organism that feeds, and that sugar is the best food source.

- What else might have an impact on the amount of yeast growth?
- What other conditions may affect the growth rate?
- What else could we change that may affect growth?

The investigation outlined here is to find the optimum temperature for maximum growth. Children may choose to investigate the best amount of food or volume of water to promote growth. Increasing the concentration of sugar will speed up growth provided that the solution is not too concentrated. Increasing the water volume will make little difference. Starting off with more yeast will establish growth more quickly.

Look back at the conditions for growth of living things. Encourage children to think about the temperature of the liquid in which the micro-organism is grown.

They need to find the conditions in which the yeast will be most productive. They have already investigated the effect of different foods, and they now need to find the best temperature for the growth medium.

Dried yeast becomes active when it is re-hydrated. If food is available, it will then

grow. At a certain size each cell will split into two. The number of cells will double about every twenty minutes as long as there is food available and the temperature does not become too low or too high. The children need to find out which temperature is most effective for promoting growth.

Provide each group with the resources on the list.

After looking at the equipment available, give each group time to discuss how they will carry out their investigation. Having been shown how to conduct an investigation in the first activity, allow flexibility of approach and let children make decisions about how the experiment will be undertaken. When the group is in agreement, and has explained how to proceed, the children should assemble their chosen equipment and begin.

Ask children to discuss how they will decide at which temperature the yeast is most active. Some may suggest repeating the use of balloons because they will have learned that more activity means more carbon dioxide. Some may suggest simple observation (photographs could be taken every ten minutes with a digital camera to keep a record of the data), and some may suggest measuring the height of the foam produced or the depth of the layer of yeast when the mixture settles. Give children the opportunity to use their own ideas as the effectiveness of the different methods can be discussed during the plenary.

Some groups may still need guidance and those children can be directed towards the following approach:

- Label three identical containers or small pop bottles with one each of cold, room temperature, warm and also the name of the group.

Note: labels should be placed as high up the bottle as possible if water baths are being used.

- Add equal quantities of sugar (about 2 teaspoons) to each bottle.
- Add equal quantities of yeast (1 sachet or heaped teaspoon).
- Prepare a range of water temperatures. Water baths may be needed to maintain the temperatures. Higher temperatures are more difficult to maintain.
- Top up the bottles to ⅓ full with the same volume of each temperature of water.
- Place balloons over the open necks of the bottles and swirl to mix the contents thoroughly.

The children need to observe each of the mixtures and record their initial observations. They should make observations every ten minutes and record their findings using Activity sheet 3. Figures 3-5 below are examples of this recording.

Children may also wish to design their own tables for recording information.

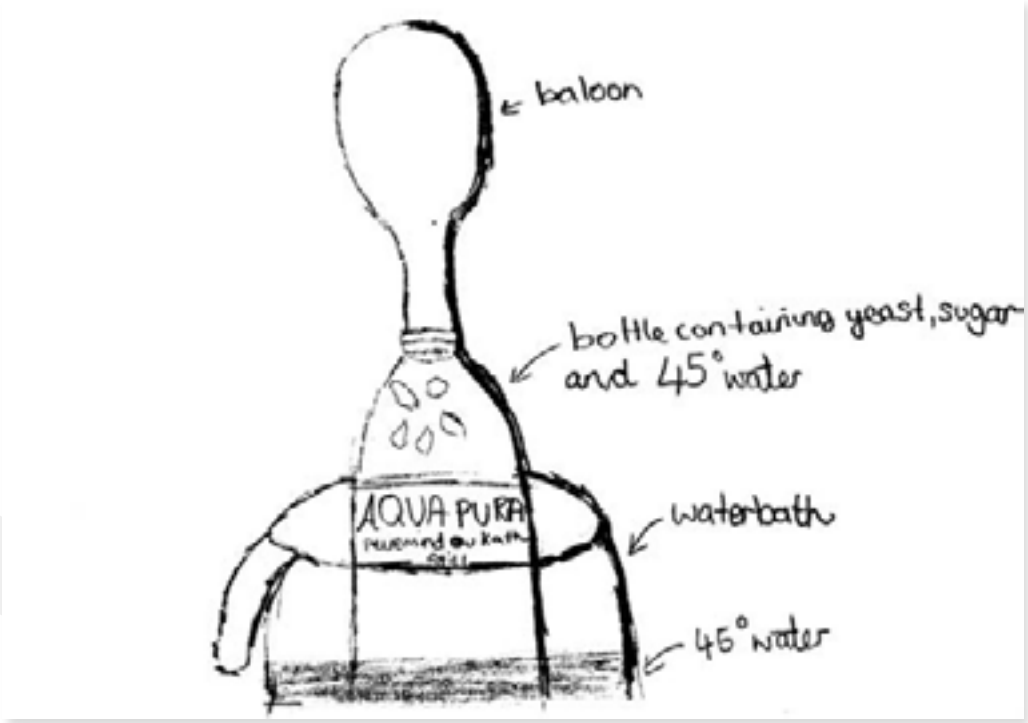


Figure 3

In **Figure 3** information is provided about the contents and temperature of the bottle as well as recording the resulting inflation of the balloon.

The diagrams produced will vary according to ability but accuracy is the important factor.

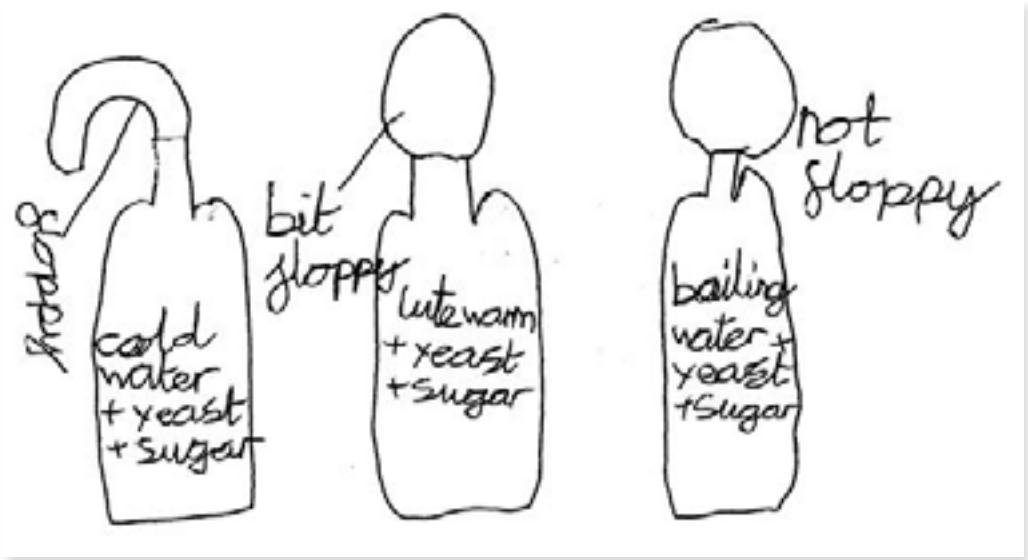
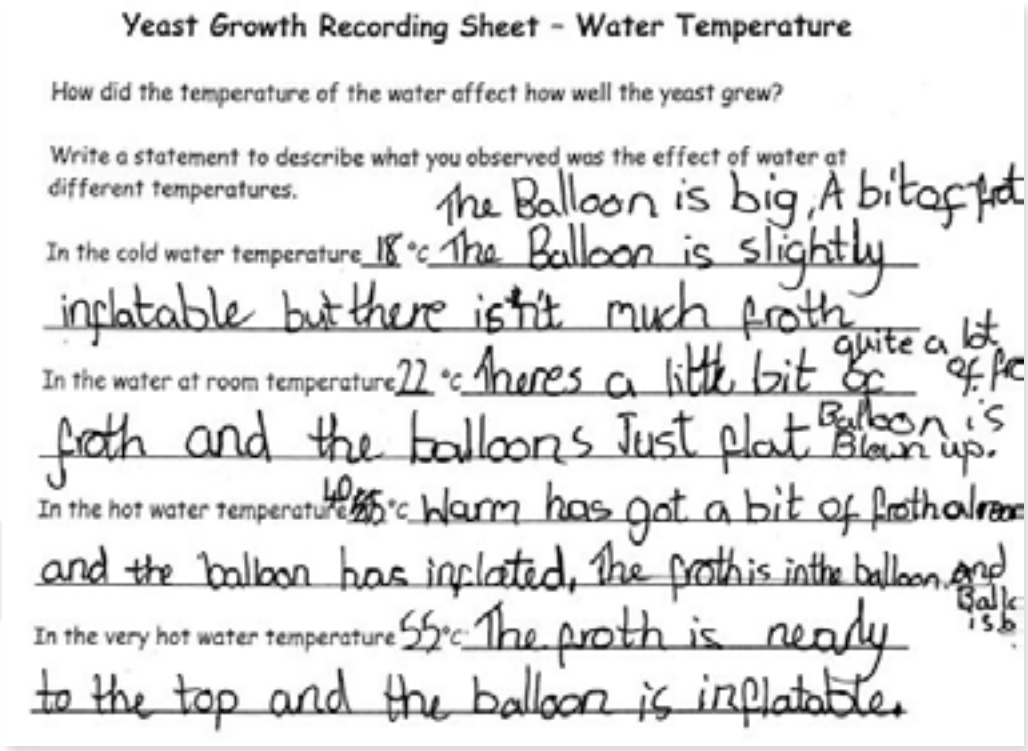


Figure 4

In **Figure 4** there is a comparative representation of the carbon dioxide collected in the balloons but the information about the water is inaccurate stating the warmest water as 'boiling'. The temperature was in fact 47°C. There is a teaching point here about the use of standard measures.



Yeast Growth Recording Sheet – Water Temperature

How did the temperature of the water affect how well the yeast grew?

Write a statement to describe what you observed was the effect of water at different temperatures.

The Balloon is big, A bit of froth

In the cold water temperature 18 °C The Balloon is slightly inflatable but there is a bit much froth

In the water at room temperature 22 °C theres a little bit of froth and the balloons just flat quite a lot of fro Balloon is Blown up.

In the hot water temperature 40 45 °C Warm has got a bit of froth and the balloon has inflated, the froth is in the balloon and Ball is b

In the very hot water temperature 55°C The froth is nearly to the top and the balloon is inflatable.

Figure 5

Figure 5 provides accurate information in the statements. This could be improved by adding a detailed labelled diagram as in Figure 3 and adding extra diagrams as in **Figure 4**. Each group should find that the yeast in the warm solution was more productive than the others. This indicates greater growth.

After approximately 30 minutes the children should look at the data they have collected and discuss what conclusions can be drawn from it. Relate this to plants growing more quickly when it is warm but remind the children that plants also die when it is too hot. There is a maximum temperature above which the yeast cells will die. It would not be possible for the higher temperatures to be maintained in classroom conditions. A demonstration could be set up using very hot water, 80+°C at a maintained temperature. It will require temperatures in excess of 100°C to kill all of the yeast cells but no growth will be observed.

Re-read the Medivelop Ltd letter. With the information they have gathered from their investigations into food source and temperature, children can begin to draft the first part of their report to Medivelop Ltd on the optimum conditions needed to produce the active ingredient required.

EXTENSION

Simple airlocks of the type used in brewing could be attached to the bottles and a count of bubbles per minute could provide continuous data for graphing. Using this method to investigate what happens when the sugar concentration increases should produce a steady increase in growth rate until the solution becomes too concentrated.

Research how the effect of food sources and temperature on growing yeast is used in food production. For example, the need to keep bread dough at a certain temperature in order for it to rise or the fact that it does not continue to rise

because the cooking temperature kills the yeast. When bread dough is mixed, a small amount of sugar is added to the yeast to start it growing. Make different types of bread in the classroom using a bread maker. Ensure that health and safety policies are followed at all times.

Ask children to carry out research into yeast and how it is used. What other common uses can they find for yeast or carbon dioxide? They could present their findings in the form of a poster or a presentation.

QUESTIONS FOR THINKING

- What was the effect of temperature on the growth of the micro-organism?
- Why does an increase in temperature increase growth?
- What would happen if the water became too hot?
- If different groups used different methods of measuring and recording, did any methods have any advantages?
- Were some more accurate than others? If using a measurement that gave a numerical value such as measuring the height of foam produced, this could be used to produce a line graph.

SAFETY GUIDANCE

60 °C is the maximum temperature for water used by primary aged children.

INDUSTRY LINKS AND AMBASSADORS

Like the previous activity this one mimics some of the research and development that would be needed at an early stage when developing a new medicine that has an active ingredient derived from a micro-organism. Manufacturers need to find out not only under what conditions the micro-organism will grow but what conditions will allow it to grow as fast as possible and produce the most active ingredient. This makes the production of the medicine as cost effective as possible.

CROSS CURRICULAR LINKS

English: Opportunities to use spoken language to develop understanding through speculating, hypothesising, imagining and exploring ideas. Also, links to writing whereby pupils identify audience and purpose, as well as selecting the appropriate form.

Mathematics: Opportunities to practice taking and recording measurements and performing simple calculations.

3. Yeast Growth Recording Sheet – Water Temperature

How did the temperature of the water affect how well the yeast grew?

Write a statement using your observations to describe the effect of water at different temperatures.

In the cold water temperature __ °C _____

_____

In the water at room temperature __ °C _____

_____

In the warm water temperature __ °C _____

_____

Use the space below to draw and label diagrams of what is happening in the bottles.

3. Filtration

1.5 hour activity

Children are asked by a pharmaceutical company to test several materials to determine which is the most effective filter. They are encouraged to plan and carry out a fair test to determine how effective the different materials are at removing flour from a mixture of flour and water considering both the time taken to filter the liquid and also how much of the flour was removed from the sample.

TYPE OF ENQUIRY

- Fair test

OBJECTIVES

- To use knowledge of solids, liquids and gases to decide how mixtures might be separated, including through filtering, sieving and evaporating.
- Give reasons, based on evidence from comparative and fair tests for the particular uses of everyday materials.
- To report and present findings from enquiries including conclusions, causal relationships and explanation of and degree of trust in results in oral and written forms.

SCIENCE VOCABULARY

Micro-organism	Ingredients	Change
Investigation	Fair test	Factor
Compare	Improve	Evaluate
Results	Filter	Filtration
Scale		

RESOURCES

(1 per group of 4 unless otherwise stated)

- Activity sheet 4 (1 per child)
- 400 ml water
- 60 ml flour
- Plastic jug or container
- Transparent containers – marked at the 50 ml level
- Measuring cylinders
- Funnels
- Spoons
- Timer (stop clock)

- Various materials that could be used as a filter such as:
    - Filter paper
    - Paper towels
    - Cotton wool
    - Kitchen roll
    - Felt
    - Cotton
    - Tights

PRIOR KNOWLEDGE/EXPERIENCE

Children should have carried out fair tests and had opportunities to make decisions about what observations to make. They should have had experience of evaluating their own investigations and making suggestions as to how they could be improved.

ADVANCE PREPARATION

The filtering process can be very slow as the pores become blocked by the flour. Collecting the first 50 ml to come through makes the process more manageable. To do this the collecting cups need to be marked at the 50 ml level. This preparation can be done by the children as it is an opportunity to practice measuring skills. Pour a measured 50 ml of water into each cup and accurately mark the level using a permanent marker pen. Funnels and collectors can be made by cutting plastic bottles in half and upturning the neck into the base.

ACTIVITY NOTES

Read the letter from Medivelop Ltd again and remind children that they are investigating the processes that are used when making some medicines. They are modelling these processes in each of their investigations. During the previous lessons, they looked at how a micro-organism could be cultivated to maintain optimum growth. Discuss the fact that the active ingredient is in the liquid in which the micro-organism lives. The next step in the process is to suggest ways of getting the active ingredient out of the liquid. This is still part of the primary manufacturing stage.

The purpose of this activity is to find the most effective and efficient way to separate the micro-organism from the liquid in which it is cultivated; this should be done by testing different materials as filters.

Explain that rather than using the liquid from the yeast, which in a commercial environment may be expensive to produce, they are going to use a mixture of flour and water to represent the micro-organism and growth solution.

When carrying out their investigation, they will need to consider several criteria to judge the effectiveness of their method. The question that we are trying to answer is: Which material will make the most efficient filter? The following factors need to be considered.

- How clear is the filtrate? (The filtrate is the liquid that remains when it has passed through the filter.)
- How long did the filtration take?
- Could the process be replicated on a larger scale?

Allow the children time to discuss which materials they are going to test as filters and how the investigation is going to be carried out. When they are in agreement, they should collect the equipment and materials they will need.

Each group should try to test four different materials to find the most effective filter. If resources are limited they may test two, and then share their findings with the class. Try to ensure that each material is tested by at least two groups so that comparisons can be made, or allow repeat tests to be carried out by the groups.

The following guidelines are provided for children who might need more support.

- Choose the materials that you think will be the best filters.
- Place the material in a funnel or upturned bottle and hold it over a marked cup to collect the water.
- In a different cup mix one heaped teaspoon of flour with 100 ml water.
- It is important that you stir the mixture just before it is poured.
- Pour the suspension through the filter and collect the liquid that comes through.
- Start the clock when you start to pour the liquid and stop it when the liquid has reached the mark.
- Repeat this for each of the filters mixing a new suspension each time.

After pouring the liquid into the filter, children should record how long it takes for the filtrate to be collected. The time taken can be shown in the form of a bar chart using Activity sheet 4.

When the filtration is complete, a test must be devised to assess the clarity of the filtrate (and therefore the effectiveness of the filter). This may be done by straightforward observation or by placing the filtrate in front of a dark background and placing them in order of clarity. A torch could be used to light up the filtrates. Torch light will highlight any particles in the liquid and make it easier to judge how cloudy it is. If appropriate ICT resources are available, light sensors may be used for increased accuracy and to produce quantifiable results that can be presented in a bar chart or, if comparing time and clarity, a scatter graph. There are many programs available for analysing and presenting data.

The groups should be given time to discuss results and decide whether they are able to draw any conclusions from their investigation. They should then present their findings to the rest of the class and be prepared to answer questions from their peers on their methods or results. This could be done as 'hot seating' where one child is the research scientist and the class ask him/her questions about his/her work. Questions from the teacher may prompt children's thinking.

The results of the filtration test need to be reported back to Medivelop Ltd and suggestions made about how the active ingredient can be extracted from the filtrate. As the active ingredient is produced by the micro-organism, it will be contained in the growth liquid that remains when the micro-organism has been filtered out.

EXTENSION

Could the best filter material be adapted for use on a larger scale?

Repeat the investigation using the chosen filter with a larger quantity of mixture and larger apparatus.

Can children think of examples from other industries where filters may be used?

What other methods can be used for separating a solid from a liquid?

Evaporation may be suggested but this is not appropriate in this case as the active ingredient would be left behind with the solid. Allowing the solid to settle and siphoning off the liquid is a possibility. Industry can use a centrifuge to spin the mixture so that the solid sinks more quickly or sometimes special liquids can be added to make the solid form clumps which are heavier and sink more quickly.

QUESTIONS FOR THINKING

- Which material was the most efficient filter?
- Do efficient and effective mean the same thing?
- Was one material noticeably quicker at filtering out the flour particles?
- Was the filtrate clearer with the slower or faster filters?
- Which material gives the best combination of speed and effectiveness?
- Why do you think this is?
- How can the company get the ingredient they need out of the liquid?

INDUSTRY LINKS AND AMBASSADORS

Like the previous two activities, this one mimics one of the initial phases of research and development in the production and extraction of the active ingredient in a medicine. However, this is only one stage of a process which can take up to 12 years from initial research to the launch of a new product.

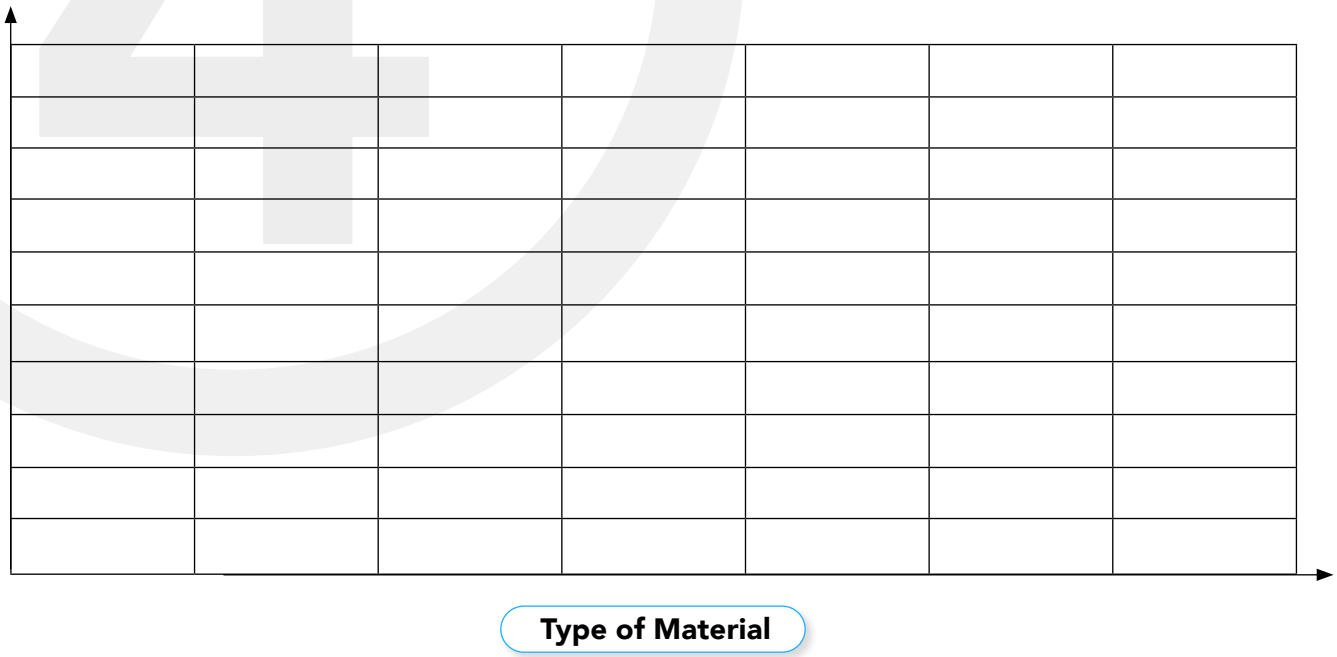
CROSS CURRICULAR LINKS

English: Opportunities to use spoken language to develop understanding through speculating, hypothesising, imagining and exploring ideas. Also, links to writing whereby pupils identify audience and purpose, as well as selecting the appropriate form.

Mathematics: Opportunities to practice taking and recording measurements and performing simple calculations

4. Filtration Investigation

Create a bar chart to show the time taken for each material to filter 100 ml of water and flour suspension/mixture.



Type of Material

What conclusions can you draw from the information in the bar chart?

Does the material that took the longest time to filter produce the clearest filtrate?

4. Viscosity testing

1.5 hour activity

Children investigate the effect of altering the ratios of specific ingredients on the viscosity of the resulting syrups. The aim is to find the best consistency for a cough medicine.

TYPE OF ENQUIRY

- Comparative testing

OBJECTIVES

- Compare and group together everyday materials on the basis of their properties
- Give reasons, based on evidence from comparative and fair tests for the particular uses of everyday materials.
- To report and present findings from enquiries including conclusions, causal relationships and explanation of and degree of trust in results in oral and written forms.

SCIENCE VOCABULARY

Viscosity	Observe	Measure
Investigation	Data	Changes
Compare	Improve	Evaluate
Results	Ingredients	

RESOURCES

(per group of 4 children, unless otherwise stated)

- Activity sheet 5 (1 per child, optional)
- 50 ml liquid glucose (available from most supermarkets or pharmacists)
- 50 ml glycerine
- 50 ml water
- 20 ml measuring cylinder
- Small containers
- Plastic spoons or stirrers
- Measuring spoons
- Pipettes
- Blank sticky labels
- For the viscosity testing (depending on the test chosen)
    - 3-4 marbles
    - 1 plastic funnel

- 1 stop clock
- 1 30 cm length of dowel marked in centimetres
- 1 30 x 20 cm board (or other smooth surface)

PRIOR KNOWLEDGE/EXPERIENCE

Children should have experience of taking and recording measurements. They should have had opportunities to describe and explore a range of mixtures and understand that mixtures of liquids can be made up of different amounts and types of liquids. An understanding of ratio and average is helpful but not essential.

ADVANCE PREPARATION

Consider that children are likely to need three or four identical containers per group plus any measuring cylinders and jugs. The utensils used for measuring the liquids are suggestions and can be substituted with what is available.

When mixing ingredients, containers with firmly fitting lids are ideal as they can be shaken. If lids are not available, make sure containers have a wide enough mouth to allow for vigorous stirring.

Liquid glucose is very difficult to pour and is very sticky. Children may need assistance to pour a measured amount accurately or they may use measuring spoons.

ACTIVITY NOTES

Discuss the meaning of viscosity and explain that it is the correct word to describe the 'runniness' of a liquid.

Encourage discussion about how runny a medicine would need to be, based on children's own experience. Make reference to familiar liquids such as water, oils, shampoo or washing up liquid. Polymers are added to these products to produce the correct consistency.

A cough syrup needs to be of the correct consistency to coat the inside of the throat instead of going straight into the stomach.

Show children the three ingredients that could be used to produce a syrup to carry the active ingredient in the medicine they are producing (liquid glucose, glycerine and water). Make sure children know they have to devise and record a recipe for the syrup they produce in this activity to make the final product. In the pharmaceutical industry, this would form part of the secondary manufacturing stage.

None of the three liquid ingredients individually has the desired viscosity, so the children will need to devise a way of mixing the liquids in different combinations and proportions to achieve the best result. Stress the need to measure accurately and to label and record each combination. Ask children why, in a commercial environment, it is vital that the recipe be systematically recorded and reproduced so that it is identical each time. Relate this to other products they may be familiar with such as tomato ketchup or toothpaste. Ensure that children understand the importance of potential customers knowing that a product will be as they expect each time they buy it.

Discuss with children the need for quality control and constant sampling in all forms of manufacturing. More information about the industrial production of liquids can be found in the CIEC resource Runny Liquids.

Allow each group time to discuss the task and to produce ideas about how the viscosity of a syrup could be tested. Discuss ideas and ask groups to consider any advantages or disadvantages of the suggestions that are put forward.

There are several ways that children may decide to test viscosity.

- They may pour a measured amount of each liquid into a 'bunged' funnel and time how long it takes for all of it to run through, when the bung is removed.
- They may use a 'spoon' test, scooping a measured amount of each liquid and observing or timing how long it takes to pour or drop from the spoon.
- A similar method is to measure and mark a length (between 5 and 10 cm) on to separate pieces of dowel, dip the dowel into the liquid up to the measurement and then transfer it straight to a measuring jug. The run off of liquid can then be measured. The more viscous the liquid, the more will be picked up by the dowel.
- Time how long it takes an object, such as a marble, to sink through a measured amount of each liquid.
- Time how long it takes for a measured amount of the liquid to spread out to fill a circle.
- Measure the length of time it takes the liquid to run down an angled slope.

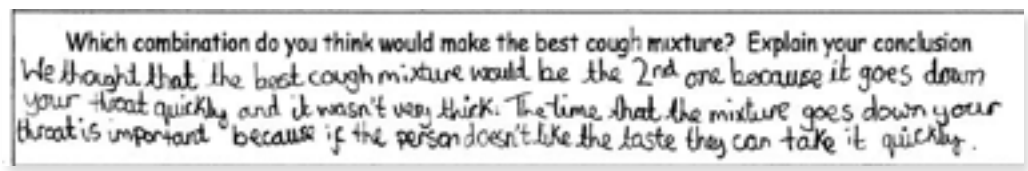
When the merits of each method of investigation have been discussed, each group should decide how to carry out their test and collect their resources. Each group should design a recording sheet and have it approved before beginning their investigation. Alternatively use Activity sheet 5.

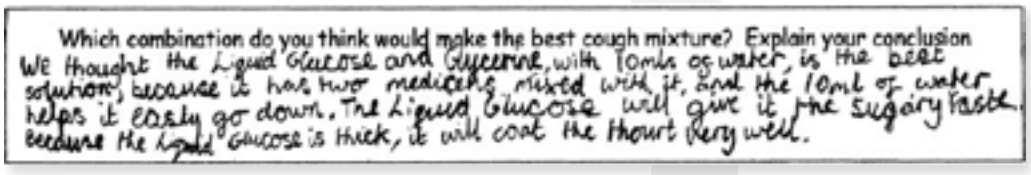
Children do not need to test large quantities. A total of 50 ml of any of the liquids combined is enough to obtain results. This may be measured out using a spoon, a pipette or a measuring cylinder, depending on what the children decide to do and the resources available.

Remind the children that they need to combine two or more of the ingredients in measured amounts, testing and recording each combination until they arrive at what they consider to be the ideal viscosity for their medicine. Once a sample has been tested and recorded it can be changed to dilute or thicken and then retested, as long as the changes are recorded.

Each group should discuss how successful their investigation was.

In the examples below two different groups of children have a completely different perception of what the best liquid will be like. In the first example the focus is on swallowing quickly to avoid the bad taste. In the second example the children understand that the medicine needs to stay in contact with the throat to be most effective.


Which combination do you think would make the best cough mixture? Explain your conclusion
We thought that the best cough mixture would be the 2nd one because it goes down your throat quickly and it wasn't very thick. The time that the mixture goes down your throat is important because if the person doesn't like the taste they can take it quickly.


Which combination do you think would make the best cough mixture? Explain your conclusion
We thought the Liquid Glucose and Glycerine, with 10ml of water, is the best solution, because it has two medicines mixed with it, and the 10ml of water helps it easily go down. The Liquid Glucose will give it the sugary taste. Because the liquid Glucose is thick, it will coat the throat very well.

An opportunity should then be given to present their findings to the whole class and the outcomes discussed. A comparison could be made between the final syrup that each group has produced. Ask what other ingredients may need to be added before the medicine goes into production. If needed, prompt children to think about flavouring and colouring to make the medicine more palatable and more visually appealing.

This is also an opportunity to discuss the effects of glucose on tooth decay and obesity. They have used glucose (a form of sugar) as one of the ingredients, but many medicines are now sugar free. Introduce the idea that scientists have developed an alternative to glucose to sweeten medicines because of these issues.

EXTENSION

In what other instances is the viscosity of a liquid important?

Ask children to think about, discuss and research this question. Oil for lubrication of machines is an obvious example. On an industrial scale, it is also a consideration for the petrochemical industry and any company that has to move liquid from place to place. Chocolate manufacturers need to move liquid chocolate around a site. Molten glass and metal are moved around while at a very high temperature. Discuss examples that may be familiar to children, for example sucking a milkshake through a straw, squeezing toothpaste from a tube. Why is viscosity important in ice cream sauces or tomato ketchup?

QUESTIONS FOR THINKING

- What problems did they encounter?
- How were they resolved?
- How would a company check that their mixture was always exactly the same?
- Why is it important that the mixture is always exactly the same?

CROSS CURRICULAR LINKS

- **English:** Opportunities to use spoken language to develop understanding through speculating, hypothesising, imagining and exploring ideas. Also, links to writing whereby pupils identify audience and purpose, as well as selecting the appropriate form.
- **Mathematics:** Opportunities to practice taking and recording measurements

5. The Right Thickness - Testing Viscosity

Mix different combinations of the three ingredients – you don't have to use all three each time – and record your observations. Take care to measure the amount of each ingredient accurately and include your measurements in your recording. If you have chosen a way to measure the viscosity, include your measurement of that too.

Codename / Ingredients			
Water			
Glycerine			
Liquid Glucose			
Result			

From your results, which combination do you think would make the best cough mixture?

Explain your conclusion

CIEC offers support for the teaching of science across the primary age range and beyond. This support includes CPD programmes, bespoke in-school CPD, interactive websites for teachers to use with their pupils, and a wide range of downloadable resources which encourage collaborative, practical problem solving. For more information, please visit our website:

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