# Get the message?

**Secret messages or ciphers have been used throughout history to disguise communications for many different reasons. In this bulletin we will explore a variety of ways in which you can encrypt and decode messages and outline the links to Curriculum for Excellence.**

Once learners have explored the different methods of concealing and revealing their own messages, they could suggest applications for use in class. For instance: to decode a punchline to a joke, find the answer to question, a clue to a treasure hunt or the answer to an "escape room" type challenge.

## Cracking the Code

### The Caesar Wheel Cipher

This is one of the earliest known ciphers, it is a simple substitution cipher and named after the Roman emperor Julius Caesar – apparently he used this method to send encrypted messages to his generals.

One larger and one smaller circle of paper or card – each with 26 sections marked on their outer edge (Figure 1) are placed together so they can rotate easily (a paper fastener is ideal to join the two circles together). For a template visit Bletchley Park | How to Make a Caesar Wheel.

Write the letters of the alphabet A-Z around the outside of the larger wheel (one letter in each section) then repeat for the inner circle, but this time use lower case a-z.

To produce a code you need to pick a "key" – this will allow your code to be deciphered by your partners – to select a key rotate the inner disc so that you match up two different letters. The choice is yours – for example you might line up A and f – like we have.

Now write your message, substituting the letters in your words for the corresponding letters on the inner

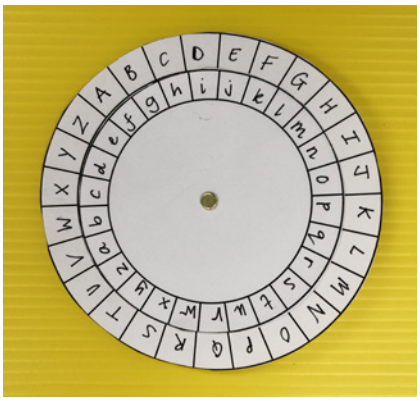

**Figure 1** - Caesar Cipher Wheel.

wheel. You could leave a space between each word when you write your message.

To decode the message your partner will need an identical copy of the wheel (or be able to access yours) and you will need to share the key i.e. the unique pairing you used to create the code – once they have the key they can decipher your message.

Can you read this message using the A = f key? The wheel in Figure 1 is set up for decoding this message.

**mjqqt kwtr xxjwh**

There are lots of ways to substitute one letter for another, substitute letters for numbers or even symbols. You could add extra sections onto the wheels to allow you to include punctuation marks or include a symbol to indicate a space. Learners could easily come up with their own ideas – the important thing is to be able to share the method for decoding the message with others. Remember not to leave the letters lined up on your wheel if you want to keep the message a mystery to those without the key!

When thinking about breaking codes in real life situations we often think about wartime applications – one of the most famous places in the UK is probably Bletchley Park. Although their work was kept secret for many years, the code breakers working at Bletchley Park (including Alan Turing) were able to decipher many messages, including those encoded by the German's Enigma machine. The Bletchley Park code breakers have been credited with shortening the Second World War by a number of years and their work enabled a leap forward in modern computing. The Bletchley Park website has a range of learning resources and offers a virtual tour Bletchley Park | Learning.

Another very useful method of encryption and one that can be replicated easily in the primary classroom, is Morse Code. This famous code replaces letters in the alphabet with a sequence of dots and dashes (Figure 2). By constructing a simple circuit with a switch and bulb (or buzzer) learners can send messages to each other (Figure 3). Morse Code was developed by Samuel Morse and Alfred Vail – the first message being sent in May 1844.

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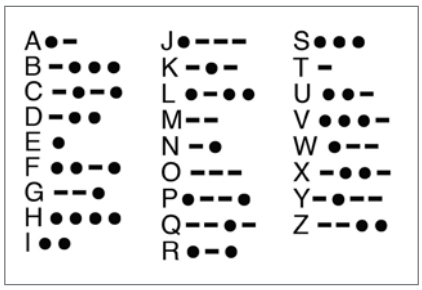


**Figure 2** - Morse Code + letters (image: bp.blogspot.com).

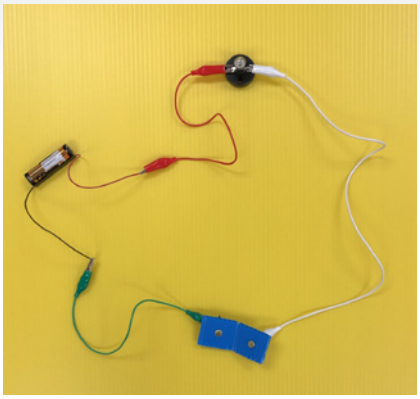

**Figure 3** - Circuit, including a simple switch, for sending Morse Code messages.

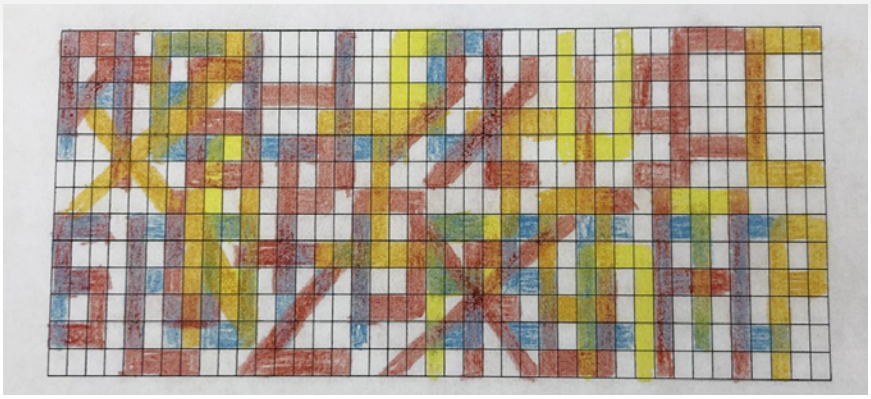

**Figure 4** - A mystery message – can you read it?

Morse Code has been used in wartime communications and military campaigns, as well as in shipping and transportation. RMS Titanic used Marconi wireless to send messages via Morse Code. The Primary Science Teaching Trust (PSTT) have a book and resources based on Titanic Science | Primary Science Teaching Trust. Here you will also find some videos SSERC produced to support this resource.

Encryption methods are used in everyday life to make our interactions and transactions secure and confidential – whether you are browsing the web, shopping on-line, withdrawing cash from an ATM, using a credit card, storing photos and videos, making a call, sending a message or using social media – encryption will be used to try to make these transactions as safe and secure as possible (How the modern world depends on encryption - BBC News).

## Filter Fun

One way of using light in a creative way is to make a mystery message that can only be read using a coloured filter. At first glance the paper seems to show many different colours – it is hard to see any message (Figure 4). However, once a piece of red cellophane, or a filter, is placed over the paper the message is revealed (Figure 5).

How does this work? The message is written in blue and then disguised with red based pigments (red, pink, orange) in a pattern designed to break up the outline of the message. When the red filter is placed over the paper red light passes through the filter, but other colours – like blue – do not. Blue light from the message does not pass through the red filter and appears darker – thus revealing the hidden words! Watch the video on SSERC TV **here** to show you how to make this type of mystery message.

**You need:**

- Blue colouring pencils (for the message).
- Red, pink, orange, yellow pencils (to disguise the message).
- A piece of red cellophane – you could try using sweet wrappers or try colouring a small piece of transparent plastic using a marker pen.
- Paper – we found it easier to use squared paper to write and disguise the message.

First, experiment on a small scale to find out which combinations of colours work best with your filter or cellophane.

Once you are ready write your message in blue colouring pencil – try using the lines of the grid to help you (Figure 6). Now disguise the message using red, orange, pink and yellow colours. Make sure you break up the outline of the message with >>

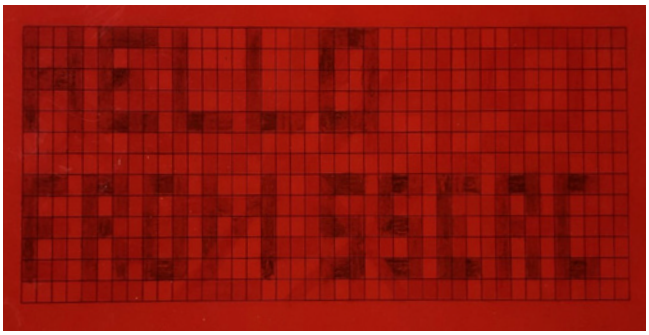

**Figure 5** - Message revealed with a red filter - Hello from SSERC!

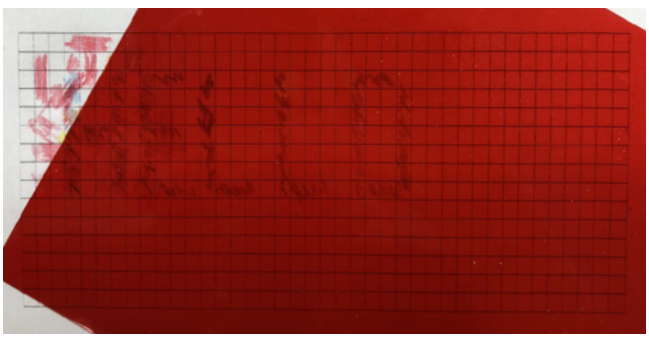

**Figure 6** - A grid helps to break up the letters of the message.

**Figure 7** - Tray with sand, tealight and metal tin.

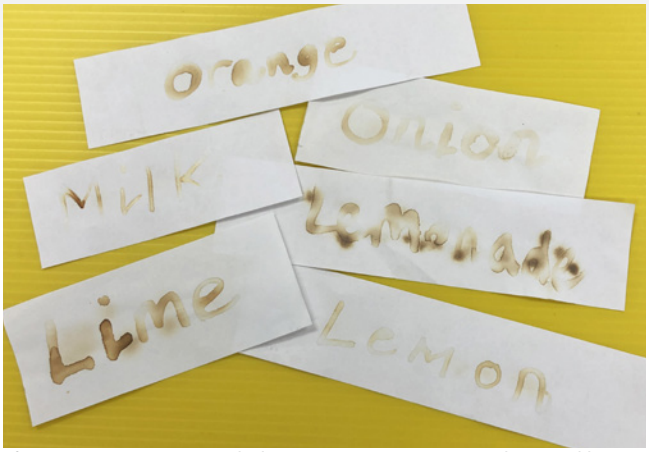


**Figure 8** - Messages revealed, written in orange, onion, lime and lemon juice, lemonade and milk.

a mix of lines and shapes, you can even write letters over the top of the blue letters in red, pink, orange and yellow to really obscure the original message. It can help to leave parts of the sheet uncoloured. Be aware that photocopying the disguised message doesn't always result in a successful outcome.

Provide a red coloured filter or piece of cellophane for the recipient to use to read your message. We found that writing the message in blue and covering it with red based colours worked best, using a red filter to reveal the message. Feel free to try other colour/filter combinations but always try out on a small scale to make sure your combinations of colours work before embarking on a massive missive!

## Chemical Correspondence

A few other ideas for secret messages rely on some principles of chemistry and link with CfE Sciences, specifically the materials organiser. In this activity we explore the properties of materials and use chemical changes to reveal a message using different "inks".

## Juicy Jottings

This activity has been around for a long time, but it is still amazing to see it in action!

**You will need:**

- A small volume (around 20 ml) of a range of liquids – for example milk, lemon juice, lime juice, distilled white vinegar, lemonade, water.
- Cotton buds, fine paintbrush, toothpick, a clean twig or feather - to use as a pen.
- Strips of paper – standard photocopying paper works well.
- Tealight and lighter.
- Metal tray with a layer of sand.
- Small metal tin e.g. a 142 g tomato puree tin emptied and washed out. We cut the top and bottom of the tin off and made sure there were no sharp edges.

Cut the strips of paper so they are slightly narrower than the diameter of the tin you are using – ours measured 21 cm x 4 cm. This means that oxygen can still reach the flame even when you hold the paper over the tin.

Take a strip of paper and write a short message using one of your inks. You can use a cotton bud, fine paint brush, a clean twig or feather as a pen. Make a separate message using each ink. You might want to write on the corner of each piece of paper the ink that you used, so that you can compare the different results. Use a different cotton bud for each ink or wash your "pen" between inks.

Leave the message to dry – once the ink is dry the message should be hard to read. Watch a video clip of this activity here.

To reveal the message, place the tea-light on the sand filled tray, light it and place the tin on top – to act like a funnel (Figure 7). Make sure the wick of the tealight is long, we found it best to use a new tealight. If the tealight wick was too short it took a very long time to reveal the message.

Hold the paper by the edges so that the part of the paper with the message on is over the heat given off by the flame. Before too long the message will appear, as the paper you marked starts to turn brown in the heat of the flame. Learners might wish to write a "fake" message in pencil and write the hidden message between the lines in the invisible ink – only to be revealed when heated. We experimented with different liquids and found that those liquids that are acidic produced a good result (Figure 8). Using water alone did not produce any result. You can see this activity in action here.

The acidic liquids damage the cellulose fibres of the paper. When the paper is placed in the heat of flame the damaged parts change >>

colour before the undamaged paper fibres – thus revealing the message (Figure 9). This change is an irreversible chemical reaction.

See our additional safety advice for heating and burning. We found the use of the small tin meant that the paper did not ignite easily, plus the coating of the tin keeps the metal cool.

## Red Cabbage Reveal

Many chemistry fans will know that red cabbage acts as an indicator – changing colour when coming into contact with chemicals of differing pH. This change in colour can be used to reveal a secret message and learners can explore and make predictions while finding out about more about the chemicals around us.

Make up some "invisible ink" to use to write a message. We suggest trying some of the following as separate inks – lemon juice, lime juice, vinegar, milk, water, bicarbonate of soda mixed with water or transparent liquid soap.

Write a message using your chosen ink onto paper – you can use a cotton wool bud, fine paintbrush, clean twig or feather to write your message. Leave the message to dry.

Make up some red cabbage indicator by adding hot water to finely chopped red cabbage leaves and leave to cool – you will find the water goes a deep purple colour. Strain off the liquid. You will need to use the indicator fairly quickly as it will start to smell quite unpleasant after a day or two, however you can freeze the indicator for use later. We have a video clip explaining how to prepare red cabbage indicator here.

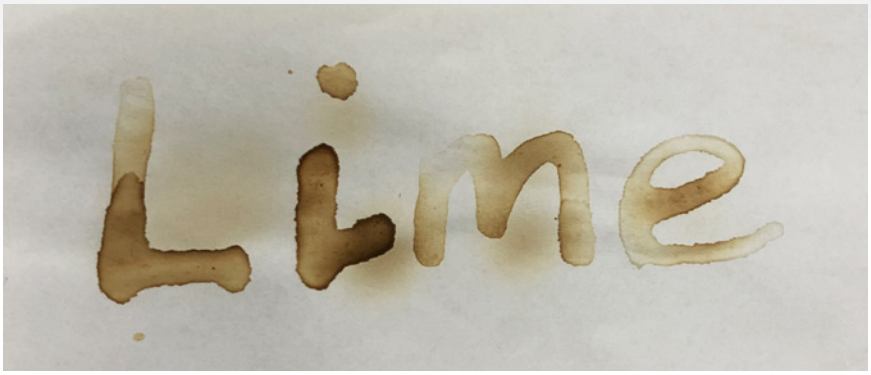


**Figure 9** - Message written in lime juice, revealed with the heat from a tealight.

Take your secret message and paint the indicator over the surface – you should see the message appear in a different colour against the purple background (Figure 10). The colour of the message depends upon the pH of the liquid used. We got the best results using inks made of either lime juice, milk or bicarbonate of soda (we mixed a teaspoon of bicarbonate of soda with 20 ml of water). Learners might observe a difference in the colour revealed, depending on whether the liquid "ink" was acidic or alkaline.

### Safety advice

When investigating with indicators ensure any household chemicals provided are safe to use – avoid bleach, washing soda, dishwasher and washing tablets/gels/powders and oven cleaners.

## Curcumin Code

Another idea for a secret message, linked to chemistry, uses turmeric as an indicator. Curcumin is the key chemical component in turmeric – its chemical structure alters when in acidic and alkaline solutions. In acidic solutions it retains the familiar yellow colour, but when in contact with alkaline solutions (above pH8) it appears red or orange (Figure 11).

To write the message we used bicarbonate of soda mixed with water (to make an alkaline solution of sodium hydrogen carbonate) >>

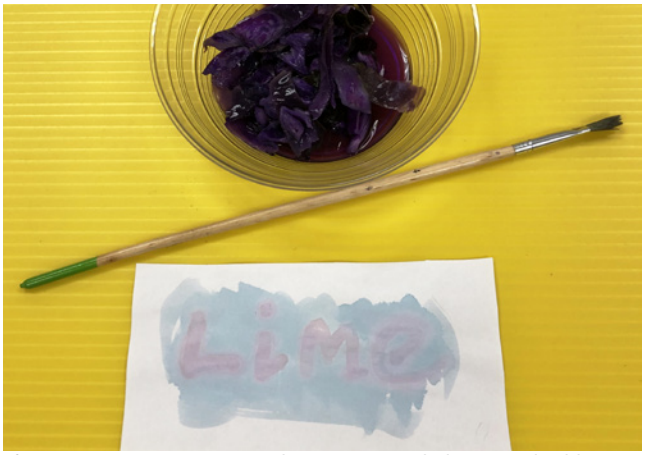


**Figure 10** - Message written in lime juice revealed using red cabbage indicator.


**Figure 11** - Message written in bicarbonate of soda and revealed using turmeric.

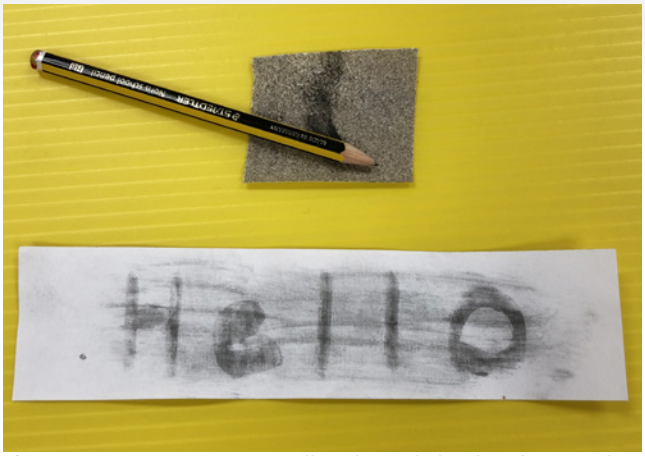


**Figure 12** - Message written in milk and revealed with carbon powder from a pencil.

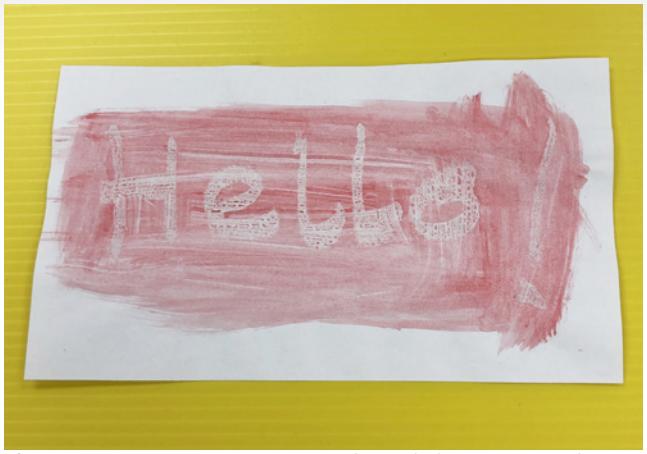

**Figure 13** - Message written in wax and revealed using water colour paints.

as the ink. You could use a cotton wool bud or paintbrush to write the message.

Curcumin is insoluble in water, so a small volume of alcohol is required to form a solution. Care is needed when using alcohol in the primary classroom. We used surgical spirit (obtained from a local pharmacy).

**Safety advice**
Undiluted Surgical spirit is flammable and so should not be used near any source of ignition e.g. a flame. Surgical spirit is also harmful if swallowed, so the age, stage and maturity of the learners should be taken into account if you are planning to carry out this activity. Check the label on the bottle. Close adult supervision is required and the surgical spirit should always be stored away from learners, in a safe place to prevent unauthorised access and away from sources of heat. Please contact SSERC if you need any further advice.

We used half a teaspoon of powered turmeric and added a teaspoon of surgical spirit to form a solution, then we added four teaspoons of water to the solution to dilute the alcohol and reduce the hazard.

Brush the turmeric solution over the paper to reveal the message. Learners might like to try using lemon juice as an "ink" next, explaining any differences in the results. Rinse any of the unused turmeric solution down the sink with plenty of water. You can watch a video clip of this activity here.

## Milky Message

Using full-fat or semi-skimmed milk write a message on plain paper using a paint brush or cotton wool bud. Let the message dry completely. Once the message is dry, take some sandpaper and rub it over the sharpened end of a pencil, allowing the graphite (carbon) powder to fall onto the paper. Gently rub the graphite powder over the message to reveal the writing using a cotton wool ball or paper towel (Figure 12). The water evaporates from the milk as it dries, leaving some of the fat content behind on the paper, the fine graphite powder sticks to these areas and reveals the hidden message - you can watch this activity **here**.

## Waterproof Words

This message uses paraffin wax to waterproof sections of paper. When water-colour paint is applied to the paper the parts coated in wax resists the water and the message is revealed.

Use a white candle or tealight to write a message on a sheet of paper. Paint over the surface of the paper with watercolour paints to reveal the message (Figure 13) - you can see the message revealed here.

The wax makes the paper resistant to water – learners might like to suggest other materials that are waterproof and could research the work of inventors like Charles Macintosh – the Primary Science Teaching Trust (PSTT) has a free to download resources based on the work of this Scottish inventor.

## Make your Mark

Take two pieces of paper (we used two pieces of A5 white paper) dip one of the pieces of paper into a bowl of cold water. Place the wet piece of paper underneath the dry piece of paper. Leaning on a hard surface use a pencil to write your message on the dry paper.

Discard the top piece of paper and allow the wet paper to dry out – the message will no longer be visible. When you are ready to reveal the hidden message, dip the paper back into the water and the message will appear as the water saturates the original indentations made by the pencil - you can watch this happening here.

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**Safety advice for heating and burning materials**

- Heating and burning materials can provide opportunities for learners to observe and explore chemical change at first hand. However, there are certain precautions that you should consider when planning this type of activity.
- Always take into account the age, stage, maturity and experience of the learners and provide appropriate adult supervision at all times.
- Check that surroundings are clear of obstructions and the activities take place well away from flammable materials - for example artwork on walls.
- Ensure there is a clear route to the fire exit.
- Learners should stand up when heating materials so that they can move away from the area safely.
- Learners should have long hair tied back and loose clothing tucked in.
- Learners should not walk around with hot or burning materials or lean across areas where heating or burning is taking place.
- Use a tealight as a source of heat – tealights are much more stable than a candle.
- Heating and burning activities should take place over a metal tray of sand to enable learners to place burning items safely onto this non-flammable surface. Make sure the sand tray is large enough to allow pupils to place the burning/heated samples on the sand.
- An adult should light the tealights and always store matches or lighters away from learners.
- Check location and operating instructions for classroom fire extinguisher.
- Ensure that materials are not heated directly under heat sensors – ask for advice when planning the activity.
- If burning materials as part of an investigation do not burn synthetic fibres – as harmful fumes may be produced.
- Only heat or burn small pieces of the material being investigated. You should use tongs to hold the material.
- Allow materials to cool before clearing up. Do not touch hot equipment or objects. Be aware that metal tongs may not appear hot.
- Ensure you and the learners know what to do if a burn to the skin is sustained.

**CfE Experiences & Outcomes**

- Through creative play, I explore different materials and can share my reasoning for selecting materials for different purposes - *SCN 0-15a*.
- Through exploring properties and sources of materials, I can choose appropriate materials to solve practical challenges - *SCN 1-15a*.
- By contributing to investigations into familiar changes in substances to produce other substances, I can describe how their characteristics have changed - *SCN 2-15a*.
- I have collaborated in activities which safely demonstrate simple chemical reactions using everyday chemicals. I can show an appreciation of a chemical reaction as being a change in which different materials are made - *SCN 2-19a*.
- By exploring reflections, the formation of shadows and the mixing of coloured lights, I can use my knowledge of the properties of light to show how it can be used in a creative way - *SCN 2-11b*.
- I can recognise a variety of materials and suggest an appropriate material for a specific use - *TCH 1-10a*.
- I can recognise basic properties and uses for a variety of materials and can discuss which ones are most suitable for a given task - *TCH 2-10a*.
- I can compare aspects of people's daily lives in the past with my own by using historical evidence or the experience of recreating an historical setting - *SOC 1-04a*.