Science opportunities in a Church restoration project

A teacher resource developed by Dr Katy Hewis working in collaboration with Holy Trinity Church Messingham and Messingham Primary School. This resource was commissioned through a project funded through the Heritage Lottery Fund Grants for Places of Worship scheme – GP-15-02463.

The activities were piloted with Y5 and Y6 children.

Stone - Causes of deterioration

Teachers' notes

What's it all about

Stone used in heritage buildings such as Holy Trinity Church will weather and deteriorate over time. The environment, together with the climate, can cause great changes. The stone is porous and moisture transport causes salts within the stone to dissolve, move and recrystallize. Consequently, effects such as efflorescence (salting on the surface of the stone) and subflorescence (salts crystallising just under the surface of the stone and causing the surface to break away) can be seen.

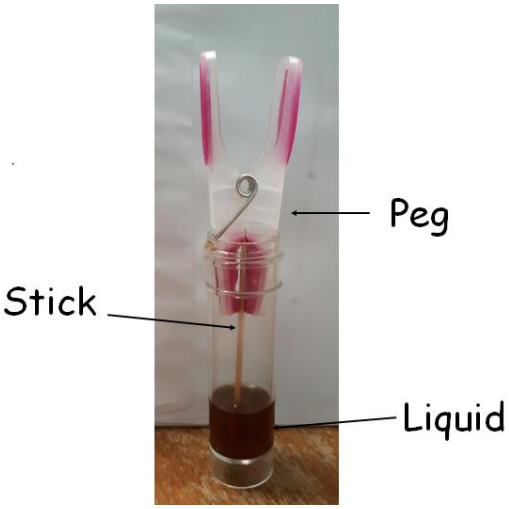
In these activities children will:

- Investigate dissolving and recrystallization of sugar.
- Observe the surface tension of water by balancing water drops on a penny.
- Construct 'stone' walls of sugar cubes and test them for durability when exposed to 'flooding and rainfall'.

Activity 1 – Growing sugar crystals

You will need:

- White sugar
- Brown sugar
- Clear plastic cups
- Plastic spoons
- Plastic bowls
- Plastic jugs
- Hot water (hand hot i.e. around 40 – 50 deg C)
- Cocktail sticks
- Clear plastic tubes
- Clothes pegs
- Filter paper (e.g. coffee filter papers)
- Plastic funnels



What to do:

1. Children to work on tables of 4 – 6.
2. Place a bowl of white sugar on one half of the tables and a bowl of brown sugar on the other half.
3. Each child to have a plastic cup and a spoon.
4. One jug of hot(ish) water between 4 children.
5. Children to pour water into the cup until it is half full.
6. Children to add a spoonful of sugar to the cup and stir until no sugar is seen.
7. Repeat until no more sugar will dissolve and there is undissolved sugar at the bottom of the cup. This is now a SATURATED SOLUTION.
8. One plastic jug, funnel and filter paper on each table.
9. Each child to pour their solution carefully into the filter.
10. Wait until the clear liquid has filtered through.
11. Each child to have a clear plastic tube, a cocktail stick and a peg (See illustrations above.)
12. Each child to pour the filtered sugar solution into the plastic tube.
13. Grip the cocktail stick in the jaws of the peg and place the peg into the tube so that it acts as a stopper and the cocktail stick is positioned vertically in the tube and with around 1cm or so into the solution.
14. Leave the tubes of solution in a place where they will not be disturbed.
15. In several days small sugar crystals should grow on the cocktail stick. In time these should increase in size. If not see *Troubleshooting* notes below.

What is happening?

Sugar is a soluble substance which means it will dissolve in water. A known amount will dissolve in water at a certain temperature. Roughly 200g of sugar will dissolve in 100ml of water at 20 deg C. As temperature increases more sugar will dissolve so that about 490g sugar will dissolve in 100ml of water at 100 deg C. When as much sugar as possible is dissolved in a known amount of water and there is undissolved sugar left at the bottom of the solution then the solution is said to be **saturated**. If this saturated solution is then heated up and more sugar added till no more will dissolve this solution is said to be **supersaturated**. A supersaturated solution is very unstable in that it will take very little

for the solution to crystallise immediately. E.g. handwarmers that crystallise by clicking a small metal disc within the pack. A supersaturated solution of sugar can also be crystallised by dropping a single crystal of sugar into the solution. This is called 'seeding'.

Troubleshooting

I don't have any clear plastic tubes

Use clear plastic cups instead. In this case it may be difficult to suspend a cocktail stick into the solution. Another option is to wind a small quantity of wool around the centre of a pencil and allow the wool to drop down into the solution whilst the pencil rests across the top of the cup. Crystals will form on the wool.

Crystals are not forming

Collect the solution back in and warm it up. Then add some more sugar and stir till it is dissolved as before. Repeat until no more will dissolve and undissolved sugar is present at the bottom. This is now a SUPERSATURATED SOLUTION. Filter as before and place in the tubes/cups with cocktail stick/wool. Crystals should form in a day or two.

Activity 2 – Surface tension

You will need:

- One penny pieces
- Plastic pipettes or droppers
- Plastic cups of water
- Paper towels

What to do:

1. Each child to have a penny, a pipette and a cup of water.
2. Carefully drop a water droplet onto the surface of the penny.
3. Keep adding drops until the water layer bulges.
4. How many drops will it take before the water layer bursts and runs off the penny on to the table? See illustration below

Water drops on a penny

What is happening?
Water molecules prefer to stick to each other rather than anything else and so it forms a 'skin' on its surface. This is **surface tension** and means that small objects such as a needle or a paperclip will float on the surface of water. It is true of some insects too e.g. the pondskater.

Water travels through porous stone by **capillary action**. Like surface tension this revolves around the idea that molecules of water 'stick' together. If you put a very fine tube into a beaker of water you will see that some of the water travels a short way up the tube; this is called capillary action and is caused by the water clinging to the sides of the tube and to other molecules of water, pulling them up the tube with it. Eventually the weight of the water being pulled is too great to be supported and the water stops moving, having reached an equilibrium. This same principle allows plants to draw water up from the ground; as water molecules travel up the stem more water molecules stick to them and more stick to those and so on until a column of water is being transported in the xylem.
https://nrich.maths.org/7273
This can be demonstrated by putting a stick of celery or a white flower such as a carnation into a glass of food colouring in water. In a few days the celery can be cut to shown the colour has risen through the channels of the celery. Or the white carnation is now tinged with the colour of the food colouring.

Water can travel through porous stone by capillary action.

Activity 3 - Building Walls

See **Stone.ppt**

You will need:
- White sugar cubes
- Brown sugar cubes
- Mini marshmallows
- Tubes of icing
- Shallow dishes e.g. plastic or foil food containers
- Water sprays

What to do:
1. Children to work in pairs.
2. Each pair to be given a known number of sugar cubes and minimarshmallows e.g. 10 of each.
3. Aim is to build a wall using these materials and use icing as cement and mortar.
4. Children to construct a small wall in the shallow dish for testing.
5. When the walls are complete they should be put somewhere they will not be disturbed for 3 or 4 days.

6. The walls can now be tested by spraying them to simulate rainfall and/or adding a small amount of water to the base of the dish to simulate flooding. How well do the wall designs stand up to water damage?

Note: The sugar cubes used in these model walls will dissolve in water, however real stone does not dissolve in water. The salts within the stone will dissolve though and they will move through the stone and cause problems.

Extension Ideas . . . Cross Curricular Links

Stone (Science)

- What type of stone is used in Holy Trinity Church?
- Find examples of stone damage on the outside of the church. Is there any damage inside?
- Map where water may collect, does this match where you see stone damage?

Where in the world? (Geography)

- Where did the stone come from to build Holy Trinity Church?

Science at your fingertips

What does salt have to do with stone?

A salt is a chemical compound not just what we know as table salt. However this salt does exist in sedimentary stone because this stone is originates in sea water. Salt is very

soluble in water and also it can change into other salts on exposure to e.g. polluted air or water etc. These salts when dissolved in water can move through the stone by capillary action or by evaporation processes and then crystallise back out in different locations. Hence the salting effects on the surface of stone.

Why use sugar in these investigations?
Sugar is a safe substance to use as it dissolves easily in water and crystallises well. Sugar cubes are a good shape to use when building model walls

Web links

Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00001798/mixing-and-dissolving-materials?cmpid=CMP00005341
Teacher notes to assist with dissolving substances to make a saturated solution.

Royal Society of Chemistry
http://www.rsc.org/learn-chemistry/resource/res00000486/limestone-weathering?cmpid=CMP00000556
How stones are weathered by acid rain. Aimed at KS3 but may have useful information.

heritage lottery fund
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