

Primary Science & Technology *Bulletin*



Ideas and inspiration for teachers in Primary Schools and S1/S2

- > Walking on water - exploring surface tension
- > 'Bacteria Farm' - safety alert!



Walking on water - exploring

Have you ever looked at the surface of a pond or slow-moving stream and noticed small creatures dashing about on the surface? They really are walking on water! Common pond skaters (*Gerris lacustris* - Figure 1) make use of the phenomenon of surface tension so that they can travel across the surface of a water body. The advantage to the pond skater of staying on the surface rather than swimming beneath is that they use sensitive hairs on their legs and bodies to detect vibrations on the water surface caused by dead or dying insects that have fallen in the water and the pond skaters feed on these [1].



Figure 1 - Common pond skater on the surface of a water body (photo: Darius Baužys/flickr.com).

So how do pond skaters walk on water? In a body of water, all the water molecules are pulled equally in all directions but molecules at the surface are only pulled sideways and downwards into the main body of water, resulting in a net inward force which leads to the surface layer acting like a very thin elastic sheet [2] (Figure 2). Pond skaters use their long legs to distribute their weight over a wide area and this technique, together with surface tension, allows them to move across the surface of a still or slow-moving body of water. Larger animals and objects break the surface tension and therefore cannot remain on the surface of the water.

Observation of pond skaters in your local pond can provide a perfect lead in to discussion on the characteristics of these animals that relate to their survival and activities to explore surface tension.



Figure 3 - Equipment for coin drop activity.

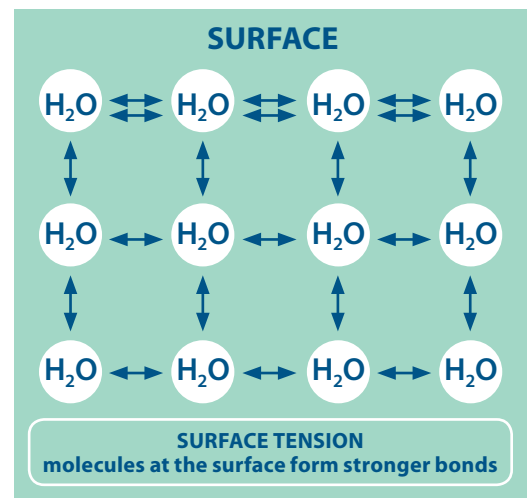


Figure 2 - Molecules at the water surface form stronger bonds, causing the surface layer to act like a thin elastic sheet (diagram: www.water.usgs.gov).

The following are a selection of activities to help you to explore surface tension in your classroom.

Coin drop

This is a simple demonstration using two coins, a dropper or pipette and some water (as in Figure 3).

We used two coins for this activity so that we could compare a coin with water drops to one without. Using the pipette, simply place one drop of water on one coin and observe. Does the water spread out over the surface of the coin or form a mini-dome? Formation of a dome is due to the surface tension in the water 'holding' the water

surface tension



Figure 4 - One drop of water on one coin.



Figure 5 - Coin showing dome of water - maximum capacity before surface tension was broken.

molecules together, resulting in minimal contact between the water molecules and the coin (Figure 4).

What happens if we add more drops of water? How many can the coin hold before the surface tension breaks and the water spills over the edge of the coin ending the dome effect? We managed 71 drops on a 2 p coin (Figure 5).

Full to the brim

Fill a cup with water then place it on a table so that the children can easily see the brim. Carefully add water to the full cup, one drop at a time. Surface tension allows you to fill the cup beyond the brim, forming a dome similar to the one seen in 'Coin Drop' (Figure 6). How many drops can you add before the surface tension is broken and the cup overflows?



Figure 6 - Cup filled beyond the brim with water held in place by surface tension.

The paper clip experiment

For this simple experiment you will need a tray, two paperclips, a small piece of tissue paper, a cotton bud and some washing up liquid (Figure 7). If you do not have a tray then a washing-up bowl or any similarly wide container will work well. Half fill the dish or tray with water. First, set up the control for this experiment by dropping a paperclip into the water. It will sink. You can then use another paperclip for the next stage or you can retrieve this paperclip and dry it so that it can be used for direct comparison.

If you have a steady hand then you will discover that it is possible to carefully place the paperclip directly on the water surface. If you do not have a steady hand then place a small piece of this tissue paper on the water surface and carefully place the paperclip on top of the paper (Figure 8).



Figure 7 - Equipment needed for paperclip experiment.



Figure 8 - Tissue paper and paperclip sitting on the surface of the water.



Figure 9 - The paperclip has separated from the tissue paper and is now sitting on the water surface.



Figure 10 - Washing up liquid was applied to the surface near the paper clip and the paperclip sank.

As the tissue paper absorbs water it will slowly start to sink, leaving the paperclip on the surface (Figure 9). This process can be helped by gently pushing down the edges of the tissue paper to separate it from the paperclip. Just be careful that you do not touch the tissue paper too near the paperclip as you will break the surface tension and both the tissue paper and the paperclip will sink – leaving you to start all over again!

If you now add some washing up liquid to the water near the paperclip the surface tension will be broken and the paperclip will sink to the bottom (Figure 10). Sometimes the paperclip might move across the surface before sinking. ▶



Figure 11 - Equipment needed to make your own compass using surface tension.

Make your own compass

For this activity you will need a tray of water, a sewing needle, a small piece of tissue paper and a compass (Figure 11).

Remember: a compass is magnetic and will therefore be affected by metal nearby. We placed our water tray and compass on the floor for this activity because the metal table legs were affecting the compass and preventing it from providing a true bearing.

Place a compass flat on the floor, next to the water tray and check which direction is north (Look closely at Figure 11 - the red needle on the compass is pointing north). Place the sewing needle on the water surface in an east-west alignment (Figure 12 - the sewing needle has been placed on a piece of tissue paper in line with east-west on the compass).

Once the tissue paper has absorbed water and fallen away from the needle, watch how the needle turns and settles on a north-south alignment (Figure 13).

Repeat this activity, placing the needle on the water surface at different compass angles. It will always swing around to align itself with north-south.



Figure 12 - Needle placed on tissue paper in an east-west alignment.



Figure 13 - Needle is held on the surface by surface tension and has aligned north-south.



Figure 14 - Equipment needed for 'Hurrying Herbs'.



Figure 15 - Herbs remain on the water surface.



Figure 16 - Once the washing up liquid is introduced to the centre of the tray, the herbs are all pulled towards the edge.

Hurrying herbs

For this activity you will need a tray of water, some dried herbs, a cotton bud and some washing up liquid (Figure 14).

Fill a tray approximately half full with water, then sprinkle dried herbs on the water [3]. Due to surface tension, the herbs will remain on the surface (Figure 15).

In the paper clip experiment we found out that adding a very small amount of washing up liquid to the water will break the surface tension, so what happens if we break the surface tension in this case? Place a drop of washing up liquid on a cotton bud, then dip the cotton bud into the centre of the tray of water. The herbs will all hurry towards the edge of the tray (Figure 16)!

As with the paperclip experiment, the addition of washing up liquid or soap breaks the surface tension. The bonds between soap molecules are not as strong as those of water molecules alone so the soap molecules are unable to stop the

stronger water bonds pulling them away from the centre and dragging the herbs out towards the edge of the tray.

We have found that herbs, sesame seeds, and powdered paint all work well in this activity. However, for the sesame seeds we added a few drops of blue food dye to the water so that the pale seeds would be more easily seen on the surface.

Milk fireworks [4]

Surface tension can also be observed in milk. You can demonstrate this by carrying out the hurry herbs activity on milk or with this colourful practical activity. You will need a plate, some milk, three different colours of food dye, a cotton bud and some washing up liquid (Figure 17).



Figure 17 - Equipment needed for milk fireworks.

Pour the milk onto the plate and place a few drops of each type of food colouring near the centre (Figure 18). We used red, blue and green colouring for this activity.

Put some washing up liquid on a cotton bud and dip the cotton bud into the centre of the plate of milk. As the food dyes are pulled across the surface and away from the centre of the plate by the washing up liquid they form a coloured circle towards the edge of the plate (Figure 19). You can enhance this effect by dipping the cotton bud into the resultant outer circle of colour to give even more dramatic colour mixes (Figure 20).

We tested this activity using a variety of milk types. We found that it works best with full fat milk,



Figure 18 - Plate of milk with 5 drops each of red, blue and green food colouring.



Figure 19 - Dyes moving away from centre of plate after application of washing up liquid.



Figure 20 - Milk fireworks.



Figure 21 - Equipment needed for surface tension boat launch.

quite well with semi-skimmed milk though the results were less dramatic and with skimmed milk the results were less dramatic again. We also tried a variety of food dyes and found that several supermarket brand food dyes dispersed through the milk very quickly but did congregate in a circle near the edge on application of washing up liquid and did produce a firework effect on further application of washing up liquid. For the photographs shown here we used Blends Food Service food colouring which we ordered from www.tts-group.co.uk.

Surface tension-powered boat

So if we can use surface tension to make herbs move across the surface of water in a tray then why not use surface tension to make a tinfoil

boat move [5] using a tray of water, a piece of tinfoil, a cotton bud and some washing up liquid (Figure 21)?

To make our boat we used a small piece of tinfoil cut into a pentagon shape, then cut a notch in the stern of the boat. We then placed the boat on the surface of the water in a tray (Figure 22).

In order to make the boat move, we put some washing up liquid on a cotton bud and then dipped the cotton bud onto the surface of the water in the notch at the stern of the boat. And the boat took off across our tray (Figure 23)! ▶



Figure 22 - Boat on water surface just before the washing up liquid is applied.



Figure 23 - After the washing up liquid is applied to the water surface near the stern, the boat moves across the tray.

Experiences and Outcomes

- I can identify and classify examples of living things, past and present, to help me appreciate their diversity. I can relate physical and behavioural characteristics to their survival or extinction - *SCN 2-01a* (cf Pond Skaters).
- I have investigated different water samples from the environment and explored methods that can be used to clean and conserve water and I am aware of the properties and uses of water - *SCN 2-18a*.

References

- [1] RSPB A to Z of a wildlife garden: <http://www.rspb.org.uk/makeahomefor/wildlife/wildlifegarden/atoz/p/pondskater.aspx> (accessed 10th August 2016).
- [2] http://encyclopedia.kids.net.au/page/su/Surface_tension (accessed 10th August 2016).
- [3] <http://thekidshouldseethis.com/post/experimental-the-soap-boat-water-experiment>, boat and oregano (accessed 10th August 2016).
- [4] <http://www.stevespanglerscience.com/lab/experiments/milk-color-explosion/> (accessed 11th August 2016).
- [5] <http://www.physics.org/marvinandmilo.asp?id=11>, foil boat (accessed 10th August 2016).

'Bacteria Farm' - safety alert!

Safety in Microbiology - A Code of Practice for Scottish Schools and Colleges.

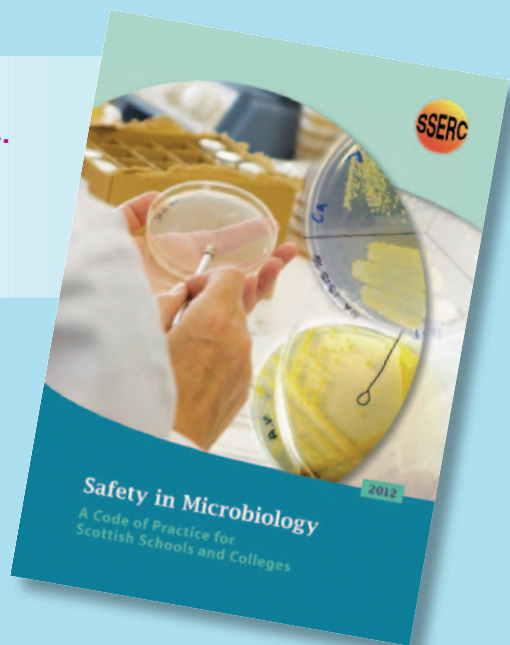
1.1 All microbiological materials, cultures, media, environmental samples etc. from whatever source should be treated as though they were a potential source of pathogens.

'Bacteria Farm' is the name of a hands-on Artec Science Series kit (Science Series 196415) which until recently was for sale to schools via the *Scientific and Chemical Science Education Resources Catalogue* (September 2016 - September 2017), catalogue number HLB010040, for around £6.00 [1]. The resource is available from other suppliers including, for example, Amazon [2].

SSERC was alerted to the existence of the kit by a school technician who, while flicking through the catalogue, saw and recognised the inherent hazards associated with the activities mentioned in the product description which reads, "Try cultivating different kinds of bacteria. You will be surprised to see how many kinds of bacteria are surrounding us in our everyday lives! Place a clean and dirty finger in different cells, use a swab to take a sample of bacteria from your toilet, shoe, dustbin, mouth or nose and see the bacteria grow!" [3].



'Bacteria Farm' - a hands-on Artec Science Series kit.



The 'study guide' that accompanies the kit, which is aimed at children 'Age 6+', outlines procedures and activities that anyone with even a passing familiarity with SSERC's *Safety in Microbiology: A Code of Practice for Scottish Schools and Colleges* [4] would find alarming. However, after brief correspondence with SSERC, Scientific and Chemical's marketing team commendably withdrew the product from their catalogue and destroyed their stock of the kits. It is reassuring to know that no kits have been purchased from *Scientific and Chemical* by Scottish schools.

It should be noted, however, that other providers, for example Amazon [2], do have the 'Bacteria Farm' kit for sale. For this reason we thought it would be worthwhile highlighting some of the potential hazards associated with 'Bacteria Farm'.

Safety in Microbiology: A Code of Practice for Scottish Schools and Colleges (SSERC, 2012) is a set of risk assessed guidelines that teachers and technicians involved in delivering microbiology in Scottish local authority schools and SSERC member colleges and schools follow. In addition, personnel (technicians or teachers) trained to 'Level 3' in microbiological safety support the delivery of this aspect of the curriculum. Therefore, appropriately trained staff prepare sterile media and ensure the safe disposal of inoculated cultures by autoclaving.

Health & Safety

In our view none of the activities associated with 'Bacteria Farm' are suitable to be carried out in schools because any media prepared using the instructions and equipment supplied in the kit would not be sterile.

Furthermore, 'Bacteria Farm' suggests that children could take samples, from toilets, bins, noses etc., using swabs to collect the samples and inoculate the (non-sterile) culture medium in the 'cultivation plate' that comes with the kit. **Alarm bells!**

The *Code of Practice, Section 2.19, page 9*, states [4]:

*Samples from carefully chosen areas of the environment may be used, but only to inoculate sterile solid media. In particular, samples **must not** be taken for culture from:*

- human or other animal body surfaces;
- body fluids and secretions;
- animal cages or aquaria;
- lavatories;
- faecal material;
- poultry, eggs or areas which have been in contact with poultry;
- meat or meat products;
- dead animals;
- milk which has not been pasteurised;
- soft, unpasteurised, cheeses;
- water sources likely to contain faecal or sewage pollution;
- soil fertilised by animal manure or fouled by animal faeces;
- mud (e.g. from a pond or field).

The problem is of course that the growth medium provides ideal growing conditions for microorganisms and by swabbing, or sampling, any of these areas and then inoculating a growth medium you may well culture human pathogens.

In secondary schools, if students were to swab suitable areas, laboratory work surfaces for example, on to sterile media in Petri dishes, the resulting cultures would be disposed of by autoclaving carried out by a suitably trained person. Nowhere in the 'Bacteria Farm' study guide does it say how one might safely dispose of the 'cultivation plate' with its farm of unknown and potentially pathogenic organisms. The 'Bacteria Farm' study guide also advocates taping along the edge of the cultivation plate to seal it. Petri dishes containing inoculated media should never be sealed all the way round with tape as this excludes oxygen and thus encourages the growth of anaerobic organisms; these are more likely to be dangerously pathogenic than aerobic organisms.

There are several other issues with 'Bacteria Farm' we could mention, but suffice to say that, given the issues we have pointed out, 'Bacteria Farm' is an activity which should not be used in Scottish secondary schools. It is even more unsuitable for primary schools, where it is unlikely that there would be appropriately trained staff or suitable equipment such as autoclaves. The idea of young children and a supervising adult carrying out these activities at home unaware of the hazards is very worrying indeed.

SSERC has shared this information with CLEAPSS [5], the organisation that performs the equivalent health and safety role for schools in England, Wales and Northern Ireland.

Thank you to the technician who brought this matter to our attention and thank you to *Scientific and Chemical's* marketing and sales staff who responded so swiftly and decisively to SSERC's advice. ◀

References

- [1] Scientific and Chemical science education resources catalogue (September 2016 - September 2017), catalogue number HLB010040. Also available at <http://education.scichem.com/Catalogue/Search>.
- [2] www.amazon.com.
- [3] Scientific and Chemical science education resources catalogue (September 2016 - September 2017), page 139.
- [4] Safety in Microbiology: A Code of Practice for Scottish Schools and Colleges, (SSERC, 2012). Also available from the SSERC website at <http://www.sserc.org.uk/index.php/biology-2/health-a-safety-home151>.
- [5] CLEAPSS, www.cleapss.org.uk.