Sweet sustainable science

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Abstract The Chilled Food Association has teamed up with a leading science teacher and author to develop hands-on activities to bridge between traditional science teaching and food science. Each activity is linked to the science National Curriculum in England, as well as the GCSE specifications in science and food science. The suite of activities explores sustainability in packaging, while using food to model science concepts as well as completing low-cost, low-risk alternatives to more traditional science experiments.

With the new Food Preparation and Nutrition GCSE in England, a lot of traditional science is finding its way into the design and technology areas. This has allowed continuing professional development to develop between departments where science specialists have shared their skills of food testing and fermentation, while the food science teachers share low-cost, safer alternatives to science practical activities. Content will be useful for classroom teachers at primary level, science teachers and food science teachers for ages 11–16, biology teachers at post-16, science technicians and food science technicians.

The introduction of sustainability, life-cycle assessment and food security into both science and food and nutrition specifications at GCSE brings in new concepts that are mirrored in each other's specification, allowing multidisciplinary collaboration and planning.

Cooking is science and there is no point in 'reinventing the wheel' when we can learn and borrow ideas and practical methods from other subjects. Teachers are always time-poor, and it is worth building good relationships with other specialists in different departments to reduce the planning workload and share skills and ideas.

Not only can food be used to model items such as DNA, but it can also be the vehicle to teach about heat transfer, chemical reactions, making and separating mixtures and how the body responds to stimuli. Many of these practical methods are very cheap, use equipment that is readily available from supermarkets, and often capture students' interest as they involve familiar materials – food.

Science can sometimes be alienating: the subject is full of jargon and can appear to use a different language to describe the world around us; scientists use special equipment that you only find in laboratories; and often you must imagine and model to understand abstract ideas. These barriers to learning can put off some students from engaging in the subject as they feel it is too difficult and hard to understand.

Every schoolchild is familiar with food, and this familiarity can be harnessed to help them engage in science. Many learners find it less off-putting than using scientific equipment and chemicals, as well as being safer and often cheaper. So, by using food we can teach traditional science concepts in a more accessible way.

Sustainability

Sustainability is a concept that is found in many exam specifications, not just science. In many science textbooks, the life-cycle assessment (LCA) is completed for shopping bags, but there is a big focus on students being able to apply their knowledge to unfamiliar situations.

Collect a selection of yogurt pots – glass, plastic, wax-coated cardboard and plastic tubes. Look at the sample yogurt pots and consider the environmental costs of sourcing the raw materials, manufacturing, use and then disposal of the packaging. One way to assess which packaging material to use is to perform a life-cycle assessment. This helps industry make decisions on sustainability.

Particle model

Gas pressure can be modelled by using a plastic straw spinner with a dot on one end. Cut a plastic straw (or suitable alternative material) to about 5 cm length. Push a drawing pin through the centre and mark one end with a pen. The dot is to represent a gas particle. Put the spinner on a plain piece of paper on a desk, with the point upwards. Spin the straw and mark a dot on the paper to show where the dot stops. Then move the drawing pin to where the dot was. Repeat this process at least 30 times. This models Brownian motion by showing how a gas particle moves randomly in all directions (Figure 1). If the spinner pointed to the edge of the paper, this is akin to a gas particle hitting the side of the container and bouncing off, causing pressure.

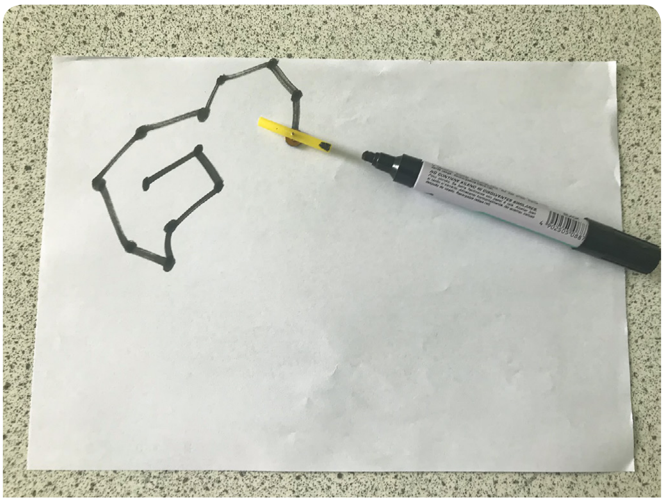

Figure 1 Modelling Brownian motion with a straw spinner

Use a mirror to indicate the position of the reflection of the dot to indicate the bounce, or, making the assumption that the gas is in an open container, this can illustrate how easily gas molecules can escape.

But what happens when the pressure is reduced? This is often illustrated using a marshmallow or shaving foam in a bell jar. With foam trapped in a bell jar, the air can be removed by using a vacuum pump. The bubbles of gas in the foam then expand and the foam increases in size. If the air is then returned to the bell jar, the foam will reduce in size. As pressure is increased, the foam gets smaller as the trapped gas has less volume.

A similar observation can be achieved on a microscale using a syringe and a mini marshmallow. Put the marshmallow in the syringe. Block the end of the syringe with a finger, draw back the plunger and observe (Figure 2). By blocking the entrance and pulling the plunger back, the pressure inside the syringe is reduced. This causes the bubbles of gas in the marshmallow to expand and so the marshmallow also expands. For physics teachers, *recently* boiled water at about 80 °C can be put in the syringe (with great care). By blocking the end and drawing up the syringe, as the pressure drops the water will boil.

Figure 2 The pressure change in the syringe can cause a foam such as a marshmallow to expand or contract

DNA modelling

The topic of the structure of DNA is now introduced in key stage 3 science in England (age 11–13) and then revisited at GCSE (ages 14–16) and A-level (ages 16–18). Many schools have a model of DNA, but students can make a low-cost version themselves from sweets (jelly babies). Sort the sweets into four colours. Decide which colour will model which base pair (e.g. red = A, green = T, yellow = G and black = C). Use cocktail sticks to match the A with T and G with C (students should be warned about the risk of spiking hands). Then link the jelly babies on either side to liquorice laces (Figure 3). As DNA is a macromolecule made from two polymer chains held in a double helix by base pairs, using sweets can be a good way to model the structure of this molecule. The DNA model can be extended for A-level students by adding sticks to represent the hydrogen bonds between the different bases (Figure 4), or, instead of using liquorice, using small marshmallows to show the monomers in the polymer backbone.

Figure 3 A model of a section of DNA double helix made from jelly babies and liquorice

Changes

In primary school, students are encouraged to consider changes as reversible and irreversible. In secondary school we build on this idea with chemical and physical change: in a chemical change a new substance is made, as in combustion, while in a physical change no new substance is made, as in melting.

Chemical change can be illustrated by giving each student a flying saucer sweet to eat as they enter the classroom. Flying saucers have sherbet in them, which contains the active ingredients of an acid such as citric acid and a base such as sodium bicarbonate. The two powders do not react, but in your mouth the moisture causes the powders to dissolve and chemically react. They evolve carbon dioxide and fizz. This chemical change is an example of a neutralisation reaction and

Figure 4 Adding cocktail sticks to the DNA model to represent the hydrogen bonds between the different bases

Figure 5 Syringes with caps can be used to demonstrate immiscible liquids and then the effect of adding an emulsifier

takes in heat, so your mouth will feel cooler as the endothermic reaction happens.

Physical changes such as creating and separating mixtures are visited from key stage 2 (age 7) upwards in schools. Using the familiar immiscible liquids of oil and water, students can investigate emulsions such as mayonnaise. A sample of oil and water can be put in a test tube and students add either a few drops of detergent or egg yolk, and then cover and shake. Notice how the liquids remain mixed in an emulsion. The detergent or the lecithin in the egg yolk act as emulsifiers. The head of the active molecules is hydrophilic and dissolves in the water, while the tail of the molecule is hydrophobic and dissolves in the fat. This makes the fat form globules that can disperse through the liquid, creating a colloid known as an emulsion (Figure 5).

Summary

These are just a few ideas to illustrate how food can be used to help teach science. There are many cross-over points between other subjects such as food and nutrition. One way to work smarter and not harder is to make connections within your own school to see how much time could be saved by sharing ideas and resources across departments.

Safety and other concerns

- Be aware of allergies: egg yolk.
- Cocktail sticks could pierce the skin if incorrectly used.
- Some people will have religious views or moral beliefs that may preclude them from using certain foods that are of animal origin or contain animal-derived ingredients such as gelatine.

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Sam and Kaarin will be presenting their workshops again at the ASE Annual Conference in January 2020.