I BET YOU DIDN'T KNOW...

The science of hand-washing

Dr. Rebecca Ellis, PSTT Fellow, links **cutting edge research** with the **principles of primary science**

rebecca.ellis@pstt.org.uk

Recently, we have been told again and again of the importance of washing our hands to prevent the spread of COVID- 19 (the 2019-2020 Corona virus). If you think that hand-washing is old news, you are correct and in a slight change from the usual 'I bet you didn't know...' articles, we will explain the older science of hand-washing before looking at current, cutting-edge research in the field.

For centuries, hand-washing has been part of good personal hygiene. Then about 200 years ago, following observations from doctors and nurses (including Dr. Ignaz Semmelweis and Florence Nightingale), medics dramatically reduced the death rates of their patients by improving their own hygiene routines. Being clean became vital and was the cornerstone of modern medicine long before anyone knew about the microbes that caused disease.

Click here to watch the BBC Teach class clip and find out more about the life of Florence Nightingale.

PSTT has also recently released an excellent video about Florence Nightingale in its new 'Science At Work' series to support learning from home.
Click below to find out more about Florence's life as she answers primary school children's questions about her life and work.

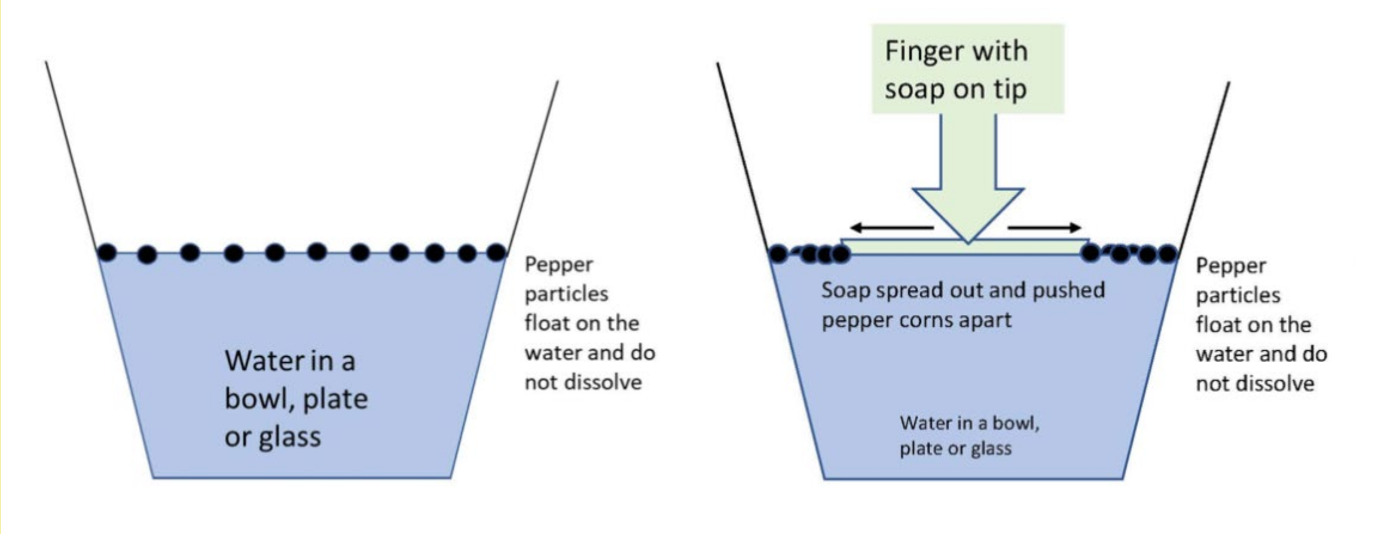
Surprisingly, there are still scientists today investigating hand hygiene and they think refining and improving how and when we wash our hands could be an important way of reducing infection rates. These scientists point out that we appreciate complicated, clever, new solutions more than the older wisdom of hand hygiene and as a result have sometimes failed to optimise the benefits of hand-washing thoroughly and consistently. If we want to persuade everybody, not just doctors and nurses, to maintain good hand hygiene, it is important that people understand the chemistry of cleaning a little more deeply...

Let's begin by thinking about why soap is so important.

Try this simple investigation. Pour water into a glass dish and sprinkle pepper over the surface. The pepper does not dissolve in the water. (Can you think of substances that would dissolve in the water? Can you remember what happens to substances when they dissolve?). Tiny pepper particles do not dissolve, and due to the surface tension of the water and the fact that they are so light, they float on the surface of the water. Cover the end of your finger in some liquid soap and dip it into the surface of the water. Observe closely.

The rapid movement of the pepper particles away from the finger to the edges of the dish is caused by the soap; but how? Well, the molecules of soap are hydrophobic which means that they hate water! To minimise how much they touch the water, they form a layer across the surface of the water and as they do this the pepper particles move to the edges (figure 1).

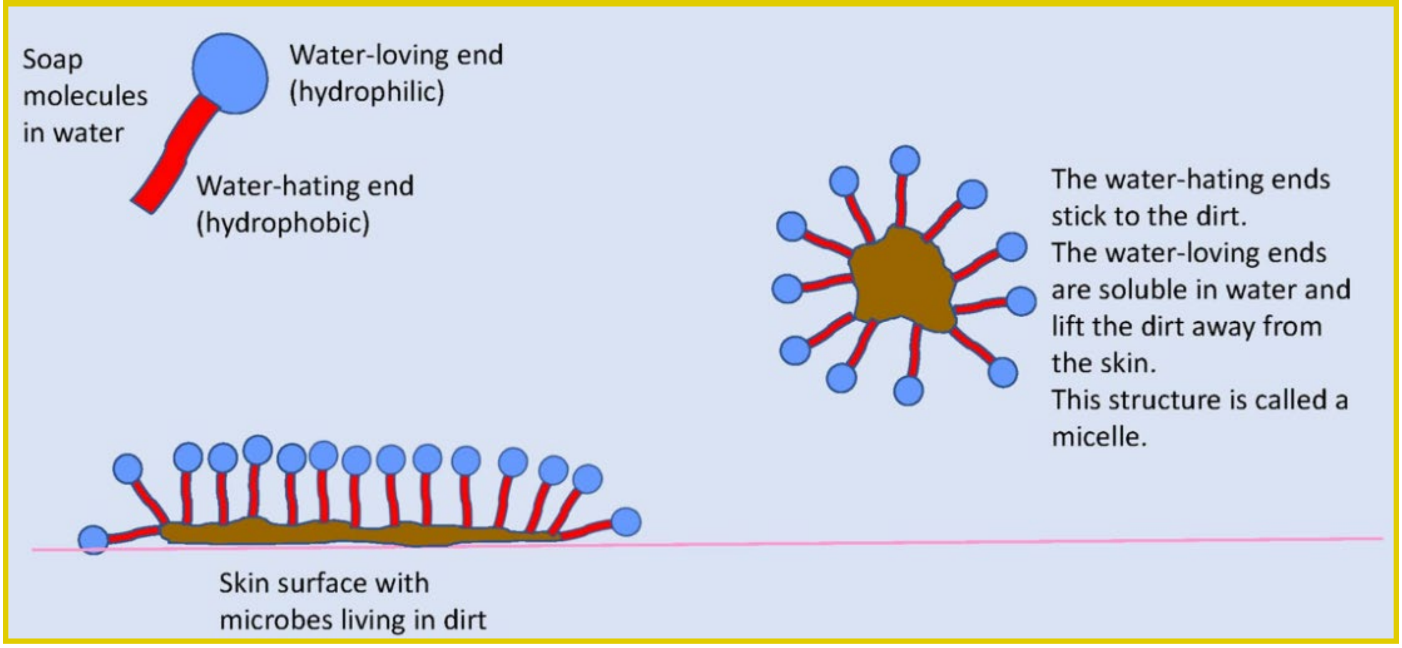
Figure 1. Demonstration to show that soap molecules spread across the surface of water because they are water-hating (hydrophobic).



Repeat your investigation with another hydrophobic substance like cooking oil. Does the same thing happen? Make a prediction and then observe similarities and differences. Try slowly pouring some of the oil into the centre of the container. Can you see the layer of oil spreading out and pushing the pepper particles away?

After this experiment, you might ask yourself why we don't use oils to clean if they work in a similar way to soaps? In fact, the Romans did use olive oil to clean themselves, but they found that they needed scrapers (strigils) to scrape it off their skin, since it doesn't rinse away with water. However, luckily for us, other cultures, as far back as 2800 BC, found that boiling oils with ashes produced a product that cleaned **and** rinsed away. The science behind this is very interesting because as well as being hydrophobic (water hating), soap molecules are also hydrophilic (water loving). To understand fully, you need to look closely at the molecules of soap and what happens when we use it to wash our skin (Figure 2).

Figure 2. Schematic diagram to show how soap molecules lift dirt away from the skin.



Our skin produces natural oils to keep it healthy. Dirt tends to mix with these oils as we touch surfaces and go about our daily life. Scientists have found that the tiny droplets of sputum (containing bacteria and viruses) which are coughed, sneezed or even breathed into the air, often settle on surfaces, so even when our hands don't look dirty, they may be!

The hydrophobic parts of the soap molecules arrange themselves next to the patches of oil, dirt and microbes on the skin. Meanwhile the hydrophilic parts, which are attracted to the water, lift the dirt to form structures called micelles. These are like tiny floating balls of dirt coated in soap and they easily disappear down the plug hole where they won't bother you.

Can you use household recycling to make a collage of a micelle? Use it to explain how soap works to someone else.

What about hand sanitizers? Surely, they are more effective than soap because the alcohol they contain can actually kill the virus rather than just wash it away? In a recent study of the influenza virus, scientists in a hospital compared antiseptic hand-washing with rubbing on ethanol-based hand disinfectants. They found that when they tested the virus in droplets of saline (salty water), the rubbing of hand sanitizer worked well – the virus was completely inactivated after 30 seconds. However, it took 8 times longer than this when they tested the virus in sputum (which is a thicker, stickier substance). In contrast, the hand-washing method worked in 30 seconds whether the virus was presented in saline or sputum. Most scientists now recommend to the public to wash their hands for about 20 seconds with warm water and soap frequently during the day and always before eating or touching their faces. Hand sanitizers remain useful when you can't wash your hands.

Click here to watch the NHS video guidance about how and when to wash your hands.

Glossary

Hydrophobic: *something that tends to repel or fail to mix with water.*

Hydrophilic: *something that tends to mix with, dissolve in, or be wetted by water.*

Micelle: *a roughly spherically shaped grouping of molecules contained in a liquid.*

Saline: *a solution of salt in water.*

Sputum: *a mixture of saliva and mucus coughed up from the respiratory tract, typically as a result of infection or other disease.*

The research paper that generated this work was:

Situations Leading to Reduced Effectiveness of Current Hand Hygiene against Infectious Mucus from Influenza Virus-Infected Patients

Ryohei Hirose[1,2], Takaaki Nakaya,[2] Yuji Naito[1], Tomo Daidoji[2], Risa Bandou[2,3], Ken Inoue[1], Osamu Dohi[1], Naohisa Yoshida[1], Hideyuki Konishi[1], Yoshito Itoh[1]. (2019)

mSphere Sep 2019, 4 (5) e00474-19 https://msphere.asm.org/content/4/5/e00474-19 last accessed 18.05.20

[1]Department of Molecular Gastroenterology and Hepatology, Graduate School of Medical Science, Kyoto Prefectural University of Medicine, Kyoto, Japan
[2]Department of Infectious Diseases, Graduate School of Medical Science, Kyoto Prefectural University of Medicine, Kyoto, Japan
[3]Department of Forensics Medicine, Graduate School of Medical Science, Kyoto Prefectural University of Medicine, Kyoto, Japan