C6 Skin and hygiene – Why do we wash our hands?

This is a typical introductory experiment to the topic of hygiene, as well as to the topics of solutions and emulsions. The experiment itself can deal only superficially with the topic in question. The teacher will have to provide more detailed information depending on the age group of the students. The materials supplied allow eight groups of students to conduct the experiments simultaneously.

1 Main question

There are in fact two main questions relating to the topic of the skin and hygiene.

- To what extent are diseases transmitted by the skin and what can be done to prevent this?
- How does the skin protect itself against infections?

The experiments on the topic of skin and hygiene illustrate the benefits and risks of using soap as a hygienic way to clean the hands.
Subexperiment 1 highlights the fact that tensides can alter the contact between foreign bodies and the skin in such a way that the foreign bodies can be washed off. This process cannot take place to the same extent if the hands are washed with water alone without using soap. A technical understanding of the function of soap can be regarded as essential to the insight that it is important, for example, to wash your hands with soap after going to the toilet and not just with water.
Subexperiment 2 shows the flip side of this approach. The protective acid mantle of the skin ensures that pathogenic microorganisms on the skin are held in check. The pH value of the skin plays the key role in this. In this subexperiment, students will recognize by measuring pH values that the pH value of the skin can change through using soap to such an extent that the protective function of the protective acid mantle is destroyed.

2 Integrating the experiment into the teaching context

2.1 Basic principles

Humans' hands are one of the most important vehicles for transmitting pathogens. Humans touch their face with their hands about 20 times an hour, usually coming into contact with the mucous membranes of the mouth, nose, or eyes. Pathogens can multiply there in a warm damp environment and trigger symptoms of illness. Cleaning the hands with the goal of reducing the number of pathogens clinging to them is therefore a matter of crucial importance. In surveys, almost everyone polled claims to wash their hands as standard practice after going to the toilet. The reality is different. A fair number of people don't wash their hands before leaving the bathroom and so pass on fecal germs or viruses to the environment.
The goal of these two subexperiments is to make students aware of the importance of intact skin and of effective means of cleansing and caring for the skin.
The water-grease film on the surface of the skin has an important function. Together with acid substances from sweat, sebum, and corneocytes, it prevents the skin from drying out and protects it from pathogens, which are barely able to multiply in this environment. The natural, slightly acidic pH value of the skin of about 5.5 is of particular importance. pH is the abbreviation for potentia hydrogenii (power of hydrogen) and indicates the concentration of protons in an aqueous solution. The more protons there are in a solution, the lower the pH value is. Acids therefore have a pH value of 0 – 7 and bases a value in the range from 7 – 14. As a result of incorrect skin care, the pH value can move into the base range. Thorough cleansing of the skin with normal soap raises the

pH value to approximately pH 9 for roughly 30 to 180 minutes. During this time, the natural defense function of the skin is impaired. The skin becomes more susceptible to drying out, as well as to pathogens and irritants. It takes hours for healthy skin to restore the pH value to its initial level through its self-regulating capability.
Liquids and substances that mix well with water are termed hydrophilic. At the same time, they are lipophobic, since they repel fats and oils. Oils and fats in turn are lipophilic liquids in which water does not dissolve. They are therefore described as hydrophobic. Oil is not soluble in water, so if you want to disperse it finely in water, in other words produce an emulsion, you need substances that make it possible to mix the two liquids together thoroughly. Tensides are substances of this kind and are also known as emulsifiers. They can reduce the tension at the boundary surface between oil and water so that the two substances mix.
The effects of classic soap are caused by the ingredients it contains. Apart from fragrances, colorants, preservatives, thickening agents, and additives, the key role is played by tensides. Tensides are detergent substances that lower the surface tension of water. They have a water-repellent (hydrophobic or lipophilic) and a water-receptive (hydrophilic or lipophobic) molecule end. Dirt particles (especially those containing fat or oil) are literally encircled by the tensides during washing with soap. They then no longer stick to the skin, but are rinsed off with the water (Fig. 1). In addition, when tensides attach to microorganisms, they often inactivate them.

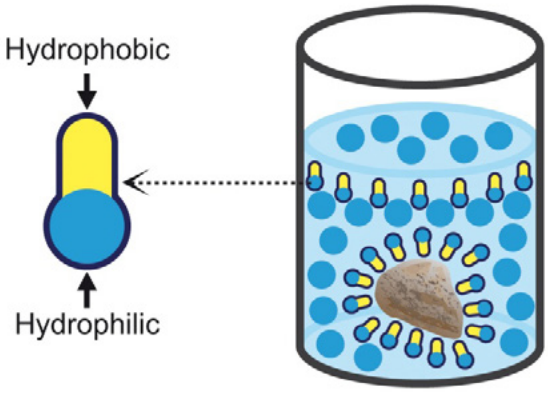

Fig. 1: Tenside molecules and their interaction with dirt particles.

2.2 Relevance to the curriculum

The phenomena shown in the subexperiments are comprehensible to students in the age group 12+.
However, students in the age group from 15 upwards will be more suitably qualified if the function of hydrophilic/lipophobic and hydrophobic/lipophilic molecule ends of tensides is to be dealt with, and if familiarity with the pH value is desired.
Students should be able to draw on their basic knowledge of chemistry for describing the phenomena observable in the subexperiments.

Topics and terms: emulsifier, emulsion, fats and oils, hand washing, hydrophilic, hydrophobic, hygiene, lipophilic, lipophobic, pathogens, pH value, protective acid mantle of the skin, proton concentration, soap, surface tension, tenside

2.3 Skills

The students will …

- observe visible changes in liquids in the test tube.
- explain how the observed changes come about.
- describe the function of soap in hand washing on the basis of their observations.
- measure the pH value on their skin with pH test strips.
- compare differences in pH value and know what causes them.
- know the significance of the protective acid mantle of the skin.
- derive possible risks of excessive use of soap from these observations.

2.4 Explaining the experiment in the teaching context

2.4.1 Subexperiment 1: What happens when you wash your hands?

In this subexperiment, students will observe that an oil-water mixture behaves differently depending on whether or not a tenside is added to it before it is shaken. A large number of oil droplets occur in the oil-water mixture when it is shaken and these combine back into large drops. Finally, two layers are visible again in the test tube: the top layer of oil droplets, and the lower layer of water. The lower layer appears clear and transparent.
After addition of the dishwashing detergent, an emulsion is formed by subsequent shaking. This has an opaque milky appearance. Minute oil droplets remain dispersed in the water. This is an oil-in-water emulsion (such as in milk or body lotion, for example). Water-in-oil emulsions on the other hand occur in skin crèmes or butter.
The phenomena described are important for understanding the function of classic soap within the context of personal hygiene. Microorganisms (for example, bacteria) stick to the skin. The tenside molecules of the soap encircle the microorganisms so that they can then be washed away with water.

2.4.2 Subexperiment 2: The pH value of skin

Subexperiment 2 illustrates the significance of the pH value of the skin. The protective acid mantle of the skin provides an acidic environment in which bacterial pathogens or yeast-like fungi cannot thrive. In this way the skin protects the body from pathogenic microorganisms. Students will understand the effects of (excessive) hygiene measures through the different pH values of the skin, depending on whether or not it was cleaned beforehand with normal soap. Such measures have precisely the opposite effect of what was presumably intended. If you use soap, the pH value of the skin is raised to a value of about 9 for several hours, thereby impairing its protective function. When not washed with soap, the skin has a pH value of about 5.5 in most regions of the body. Skin damage can be caused by (excessive) use of soap, in other words by raising the pH value. As a result, the skin can swell up due to water in combination with alkaline tensides. Moreover, alkaline tensides like normal soap result in damage to the protective acid mantle.

2.5 Experimental variations

Both subexperiments are suitable for students to conduct individually or in pairs. The results can be analyzed in small groups after the two subexperiments or also discussed with the whole class. If further study of the subject areas of emulsions, solutions, creams, etc. is desired, interested student groups can be given the opportunity to prepare simple cosmetics (see below in “Additional information on the experiment”).

3 Additional information on the experiment

You will find additional media for preparing or for further study of this experiment on the Siemens Stiftung Media Portal:
https://medienportal.siemens-stiftung.org

4 Notes on conducting the subexperiments

4.1 Facilities

No special facilities are necessary.

4.2 Time required

	Execution and analysis
Subexperiment 1	approx. 20 min.
Subexperiment 2	approx. 15 min.

4.3 Safety aspects

The students may conduct the experiments only in the presence and under the supervision of the teacher.
The teacher is to point out to the students that the provided materials may be used only according to the respective instructions.
For these experiments, watch out for the following potential dangers and make your students aware of them:

- None of the foods provided for the experiments are suitable for consumption.
- Make sure that no damage can occur to water-sensitive materials and apparatus.

4.4 Apparatus and materials

Required materials that are not supplied:

- A piece of normal soap
- Water, ideally distilled water;
  Tap water is suitable if necessary, provided it has a pH value of fairly exactly 7.0.

Supplied:
The apparatus and materials supplied are sufficient to allow **eight** groups of students to conduct the experiments simultaneously.
The following materials included in the kit are needed for **one** group of students:

Material	Quantity
Cooking oil (“vegetable oil”), bottle	1x for entire class
Dishwashing detergent, bottle	1x for entire class
pH test strip, package	1x for entire class
Plant clip (as test tube holder)	1x
Test tube, glass, 13 cm	1x
Test tube stopper	1x

Fig. 2: Apparatus and materials supplied for one group of students.
Dishwashing detergent, cooking oil, and pH test strips for the entire class.

4.5 Cleanup, disposal and recycling

All apparatus and nearly all materials from the kit can be reused. Therefore, after the students have completed the respective experiment, they should put the apparatus and materials back in the appropriate boxes and return them to the kit. This practice will ensure that you and your colleagues will find everything again quickly the next time the kit is used.
Apparatus that become dirty during the experiment, such as cups, bowls, spoons, and test tubes, should be cleaned before being returned to the kit. We recommend that you have the students do this immediately after they have completed the experiment.
Also make sure that the apparatus are in working order for the next time. For example, recharge used accumulators immediately. (It makes sense to charge the accumulators even if they will not be used for an extended period.)
Materials that cannot be reused, such as used pH test strips and filter paper, should be disposed of properly.
The waste that accumulates during this experiment can be disposed of in the regular trash or poured down the sink.