Cosmetics Teaching Unit

Information for teachers

These materials are based on a one-week vacation course for third or fourth grade elementary school students, which is part of the Forscherwelt or Researchers' World education initiative. They supplement the students' worksheets and provide additional information about the materials required.

The teaching concept and program were developed under the guidance of Prof. Dr. Katrin Sommer, Chair of Chemistry Didactics at Ruhr University Bochum, Germany, with the support of Henkel.

Cosmetics Teaching Unit

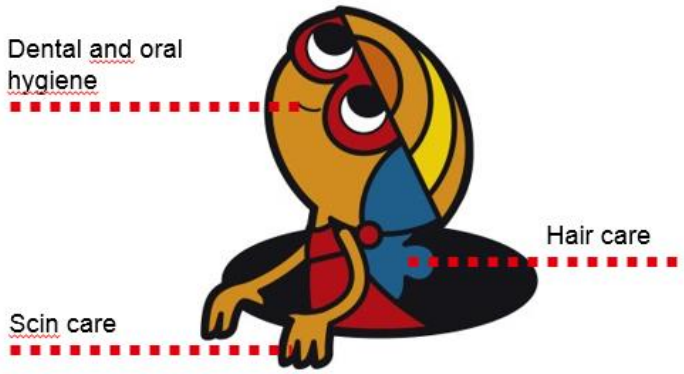
Suitable for approx. 9 double periods

In the Forscherwelt or Research World education initiative, elementary school students can become mini-researchers and conduct scientific experiments. In the process, they learn basic scientific methods that they can use to solve research assignments.

Body care products such as shampoo and toothpaste are an integral part of children's everyday life. But what is actually in these products? Why are they important, what effect do they have and how are they made? These are just a few of the questions that will be investigated during this teaching unit.

The focus of the teaching unit is on basic scientific methods. These include a systematic approach, precise observation, documentation of the results and finally evaluation of the results in conjunction with the question: "What do the things we have found out and observed tell us – did the experiment help us to answer our initial research question?"

The Cosmetics topic is divided into three areas:



Teaching unit modules

Lesson 1	Dental and oral hygiene – detecting the presence of acids
Lesson 2	Dental and oral hygiene – effect of acid
Lesson 3	Dental and oral hygiene – protecting our teeth with toothpaste
Lesson 4	Skin care – structure of the skin and the effect of cream
Lesson 5	Skin care – investigating the properties of water and oil
Lesson 6	Skin care – making your own cream
Lesson 7	Hair care – degreasing effect of shampoo
Lesson 8	Hair care – viscosity of shampoo
Lesson 9	Hair care – stability of hair

Dental and oral hygiene

Cleaning our teeth is part of our everyday routine and we should do so at least twice a day. In the first part of this lesson, the students will learn why we should clean our teeth regularly and thoroughly and how toothpaste helps us to keep our teeth healthy. The key questions below will guide us through the lessons:

- How do cavities (holes) form in our teeth?
- Why do we need to clean our teeth?
- Why do we use toothpaste to do so?
- Which ingredients in toothpaste help to both clean our teeth and to protect them from decay?

Lesson 1: Detecting the presence of acids

Class discussion to introduce the topic

The lesson can be started by taking the students on a journey back through time to ancient Egypt. A picture of a stern-looking pharaoh can be shown and the students can then be asked why he is not smiling. A classroom discussion can lead them to conclude that dental hygiene in the past was not as good as it is today. For this reason, the pharaohs – like many other people back then – probably had bad teeth.

However, dental care did exist in the past. Like many of today's products, toothpaste wasn't invented on a single day but over a long period of time. In ancient Egypt, "tooth powder" was used to clean teeth. Depending on where they lived, the Egyptians used crushed seashells, corals from the sea or eggshells. This plays a part in the third lesson on this topic.

After introducing the topic, we look at the cause of caries. The students often have a misconception about this: they think that sugar is directly responsible for caries. However, this is not the case: bacteria in the mouth excrete acid as a metabolic product, which subsequently damages the tooth enamel. This can then lead to caries (tooth decay). It is explained to the students that bacteria "eat," process the sugar and a new substance is produced: an acid. This is called "metabolism." Humans are similar: they eat food, digest it and excrete the unusable leftovers.

► Good dental hygiene protects our health because bad teeth may cause other diseases. ► What's more: healthy teeth are attractive ☺ ► Dental hygiene protects your health – and gives you a dazzling smile!

Detecting the presence of acids (Worksheet 1)

How can we see whether a liquid is acidic?

The first few experiments focus at a phenomenological level on what an acid is. The students are introduced to indicator paper/strips that they can use to test whether or not a liquid is acidic. The concept of acids and bases is deliberately not addressed at this point.

The assignment is to use the indicator to investigate liquids with different acidities: tap water, household vinegar, lemon juice, lemonade and lactic acid, which is also present in the mouth. For this experiment, each group needs five test tubes and simple indicator paper. The results are subsequently compiled on the chalkboard and discussed. Lactic acid and lemon juice are the most acidic.

When they evaluate the measurement results, the students are required to transfer their learning: 1. They see a change in color on the indicator paper. 2. Using a color scale on the indicator packaging, they assign a figure to the color. 3. In the final step, they put the liquids in order of acidity using the information that the lower the figure, the more acidic the liquid.

Lesson 2: Effect of acid

In the previous lesson, the students learned how to detect the presence of acids. The next step is to examine more closely the effect of acids on substances that contain calcium, since the teeth also contain acid-soluble calcium compounds.

One acid-soluble calcium compound, for example, is lime (calcium carbonate). Lime is also a component of eggshells. Eggshells are therefore used in the experiments below as a model substance for teeth.

The term “model substance” should be explained in the introductory discussion: model substances are substances or materials used as a substitute in investigations if experiments on the actual object under investigation are not possible. To relate this to the current situation: in the following experiment, you cannot remove your own teeth and examine them in a test tube.

What effect does acid have on the eggshell? (Worksheet 2)

Materials needed for each group of two

- Piece of eggshell
- Approx. 50 ml (2 fl. oz.) household vinegar
- Small beaker

We also need scales that are as accurate as possible (to 0.00 g).

Instructions

1. Weigh your eggshell and make a note of its weight.
2. Put a piece of eggshell into a small beaker and add enough household vinegar to cover the eggshell completely. Wait for 15 minutes.
3. Carefully dry off the eggshell before drying it with a hairdryer and then weigh it again.
4. Calculate the difference between the first and second times that you weighed the eggshell. TIP: To find the difference, you need to subtract one number from another.
5. Write down what the acid does to the eggshell.

We also use a simple digital microscope connected to a computer by USB cable. This is used to produce a highly magnified image of an eggshell before and after it was placed in vinegar.

Lesson 3: Protecting our teeth with toothpaste

The students have seen that acid attacks the calcium-containing eggshells. In a classroom discussion, the results of the model experiment should now be linked to the effect of acids on calcium-containing teeth. The model experiment suggests that acids attack teeth and cause cavities (caries).

The students know that caries can be prevented by regularly cleaning your teeth with toothpaste. But how exactly does toothpaste work?

Toothpaste contains two important components that are responsible for protecting our teeth: firstly fluoride, which protects tooth enamel, and secondly abrasive particles that help the toothbrush to remove food and plaque from the teeth.

How can you show that toothpaste protects your teeth from acid? (Worksheet 3)

Before the instructions for the experiment are handed out, the students should suggest how the question could be answered. The experiment can be conducted as an open assignment in which it is left up to the students to decide whether they want to develop their own procedure or follow the model solution. The approach depends on the amount of time available.

Materials needed for each group of two

- 1 eggshell
- Toothpaste
- Beaker/container for the egg
- Household vinegar

Model solution

1. Divide your eggshell into two halves by drawing a line in the center.
2. Rub toothpaste into one side and wait for three minutes.
3. Carefully remove the toothpaste with a piece of paper towel.
4. Put the egg carefully into the beaker and add enough vinegar to completely cover the eggshell.

Which substances in toothpaste help to remove food and plaque from your teeth? (Worksheet 4)

To answer the question, test whether a coin can be cleaned using toothpaste, tooth salt (or table salt), lime or detergent.

Materials needed for each group of four

- 4 dirty coins
- Thin cleaning cloths
- Toothpaste
- Detergent
- Salt
- Lime (calcium carbonate)

Experiment instructions

Work in a group of four. Each student receives a different “cleaning agent.”

1. Put a small amount of your cleaning agent onto a damp cloth and rub it onto the coin for 10 minutes.
2. Compare your coin with the coins cleaned by the others in your group.
3. What cleaned the coins best and what wasn’t as good?
4. Make a note of the order.

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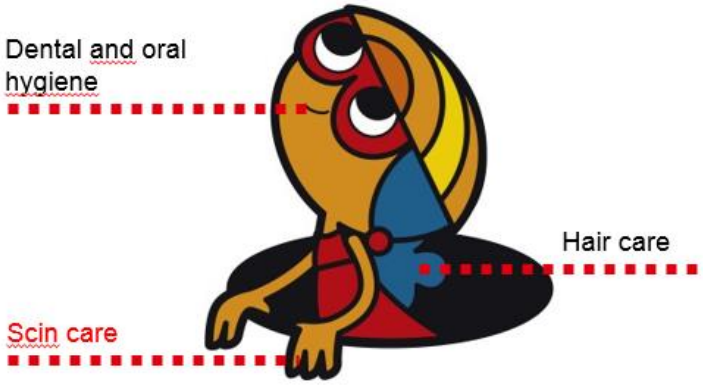
Skin care



Our skin covers our entire body and is the organ that weighs the most. In its thickest places, it can be up to 8 mm (⅓ inch) thick; in other places it is as thin as paper.

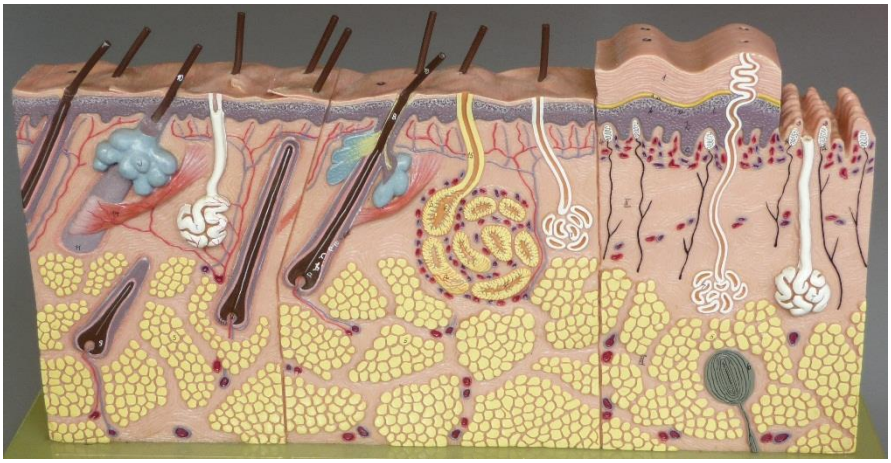
Children don't always like to have cream applied to protect their skin. Many resist when their parents apply sunscreen to their skin in summer or cream to prevent moisture loss in winter. The second part of this lesson can help illustrate the benefits of skin cream to the students. The key questions below guide us through the lessons:

- What is the structure of our skin?
- What effect does cream have on our skin?
- What is cream made from?

Lesson 4: Structure of the skin and the effect of cream

In the introduction, we look at the important role that our skin plays by asking the students what they already know and making a note of everything on the board.

We can only see the surface of the skin with our eyes. In reality, however, it is an organ made up of several layers. The components of the skin fulfill a variety of functions. To illustrate this, we look at a model:



- **Dermis:** The dermis is located between the epidermis and hypodermis. It contains a large number of nerves, blood vessels and other components such as sweat glands.
- **Hypodermis:** The hypodermis forms the lowest layer of the skin. It consists mainly of fat tissue.
- **Hair:** Hair begins in the dermis and extends up to the surface of the skin. It is moved by small muscles and protects us from the sun's rays and heat loss.
- **Sebaceous glands:** The sebaceous glands are mainly located in the upper part of the dermis and are attached to hair follicles. They form fat that protects our skin and hair.
- **Epidermis:** The epidermis is the outer layer of our skin and so provides a protective barrier from the external environment.
- **Nerves:** The nerves are located in the hypodermis and dermis. They allow us to feel touch and pain. Some of them have an oval end.
- **Blood vessels:** Blood vessels supply the skin with nutrients and oxygen.
- **Sweat glands**: The twisted tubes of the sweat glands are located deep in the skin, from where they wind their way up to the surface. Their function is to form sweat.

One can provide a large illustration of the skin and laminated cards showing the individual components of the skin. On the board, the students should match the components to the illustration.

To next give the students an idea of the size of the skin, they will conduct an experiment.

How large is the surface of the skin? (Worksheet 5)

Materials needed for each group

- 1-2 rolls of toilet paper
- 1 roll of masking tape

Experiment instructions

To determine the surface area of our skin, a test subject is wrapped in toilet paper.

1. The test subject first puts their left foot on the start of the toilet paper. Carefully wrap the toilet paper around their left leg up to their hips and then back down their right leg. Tear off the toilet paper and put the end under their right foot.
2. Fasten the new start of the toilet paper to the test subject's pants using masking tape and wrap the toilet paper up to their chest. At one shoulder, wrap the toilet paper down their arm until you reach the hand. Then tear off the toilet paper again. The test subject holds the end of the toilet paper with their hand.
3. Put the new start of the toilet paper in the test subject's other hand. Wrap it up their other arm and around their shoulders and neck until you reach their head. Be very careful when wrapping the shoulders and head as the toilet paper tears easily here.
4. Now carefully remove the toilet paper.
5. Carefully tear off the individual sheets and lay them out on the prepared squares.

A 1 m x 1 m (3 ft. x 3 ft.) square is provided on the floor as the measurement unit (piece of cardboard or marked with masking tape).

What effect does cream have on your skin? (Worksheet 6)

The next experiment shows the students one of the effects of skin creams: they protect the skin from loss of moisture.

Materials needed for each group of two

- 2 freezer bags
- Petroleum jelly (e.g. Vaseline)
- 2 hair bands

Experiment instructions

1. The test subject washes both hands thoroughly with soap.
2. Pull a hair band over the test subject's right and left wrists (one on each wrist).
3. Apply some Vaseline to the test subject's right hand. Do not apply anything to their left hand.
4. Put both hands into freezer bags and seal the bags with the hair bands so that no air can get in.
5. Observe the test subject's hands for 5 minutes.

Observation: After 5 minutes, significantly fewer drops of water have accumulated on the inside of the freezer bag containing the hand to which Vaseline has been applied than on the inside of the other freezer bag.

Conclusion: The skin can lose water via its surface. Dry patches of skin do not contain enough moisture. Cream protects the skin from water loss and improves its moisture and fat content.

Optional

In the Forscherwelt or Research World education initiative, a simple digital microscope is available that can be used to produce greatly enlarged images of the skin and show them on a computer screen. By way of example, we produce an image of the inner and outer surfaces of the hand:

The skin on the back of the hand (hairy skin) is very different from the skin on the palm of the hand (hairless skin). Hairless skin is found on the fingers, palms of the hand and soles of the feet and forms a pattern made up of lines that is different in every person. Hairy skin is found on the rest of the body. It forms diamond-shaped areas of differing sizes.

Hairless skin

Hairy skin

Lesson 5: Investigating the properties of water and oil

Having looked at the skin itself and the effect of creams in the previous lesson, the students will now investigate two important ingredients of creams: oil and water. Creams are emulsions in which either microscopically fine droplets of oil are dispersed in a water phase or, conversely, tiny droplets of water are dispersed in an oil phase. Because water and oil cannot in principle be mixed, emulsifiers are needed as additives.

In the first experiment, the students must investigate whether various oils and water can be mixed together. They are familiar with some oils, such as sunflower oil, from everyday life. In addition to cooking oils, there are also other oils such as isopropyl myristate, which is abbreviated to IPM. This is a colorless and odorless thin oil that is also used in creams. IPM helps the cream to be better absorbed and reduces oily shine. It is important to briefly introduce this oil as a cream component before the experiment is started as the students will not have come across it in everyday life.

Which liquids can be mixed together? (Worksheet 7)

Materials needed for each group of two

- Approx. 20 ml (1 fl. oz.) sunflower oil
- Approx. 20 ml (1 fl. oz.) olive oil
- Approx. 20 ml (1 fl. oz.) IPM
- 6 test tubes
- Pipettes
- Water

Experiment instructions

1. Label 6 test tubes with the numbers 1 through 6.
2. Conduct experiment 1 as in the table below:
    a. Pour about 1 cm (½ inch) of liquid 1 into the test tube.
    b. Add exactly the same amount of liquid 2 and carefully seal the test tube with a stopper.
    c. Shake the liquids well and wait for about 3 minutes.
    d. Check the boxes in the table to show whether or not the liquids can be mixed together.
3. Conduct experiments 2 through 6 in exactly the same way.

The students record their results in a table in the worksheet.

Which of the liquids to be investigated can conduct electricity? (Worksheet 8)

Some liquids can conduct electricity. Using block batteries that are connected to a small LED light, the students can see whether or not a liquid conducts electricity.

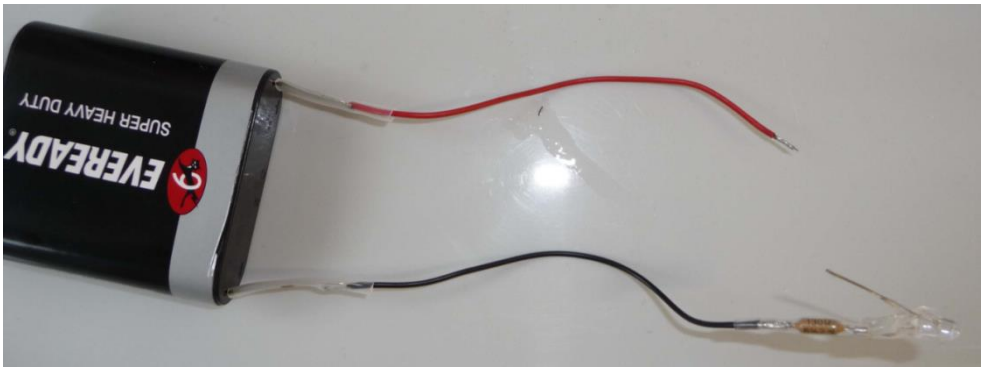
Materials needed for each group of two

- 1 block battery (9 V) with two wires and connected LED light
- 3 watch glasses
- Pipettes

- Approx. 5 ml (1 teaspoon) sunflower oil
- Approx. 5 ml (1 teaspoon) IPM
- Water

Experiment instructions

1. You are provided with a battery with an LED. Check whether the LED lights up red when you briefly hold the two ends of the battery wires together.
2. Use a pipette to add 2 ml (½ teaspoon) of water to a watch glass.
3. Hold the ends of the battery wires in the water. The ends of the wires must not touch each other. If the small light illuminates, the liquid conducts electricity. Make a note of the result in the table.
4. Wipe the ends of the wires well with a tissue or paper towel after they have been used.
5. Repeat steps 2 through 4 with sunflower oil, olive oil and IPM.



The students are now in a position to answer the following questions:

- Can water be mixed with oil?
- What floats on top, water or oil?
- Can the different oils be mixed together?
- Does water conduct electricity?
- Does oil conduct electricity?

➔ If a substance has “water properties,” it cannot be mixed with oils but does conduct electric current.

➔ If a substance has “oil properties,” it can be mixed with other oils but not with water. Oil does not conduct electricity.

Option: If a variety of creams are available, the students can investigate their conductivity. Depending on whether the cream is an oil-in-water (o/w) or water-in-oil (w/o) emulsion, it conducts or does not conduct electricity. This measurement can be used as the introduction to the next lesson.

Lesson 6: Making your own cream

To conclude the lessons on skin care, the students are given the opportunity to make their own cream. This introduces them to an additional component, the emulsifier. An emulsifier is an additive that enables fine droplets of oil to be dispersed in an aqueous phase or, conversely, fine droplets of water to be dispersed in an oil phase without the water and oil re-separating. In other words, an emulsifier can be used to produce emulsions, e.g. skin creams.

Materials needed for each group of two

- 2 metal balls (approx. 5 mm or ¼ inch in diameter)
- Plastic container with a screw top
- Approx. 5 ml (1 teaspoon) emulsifier (e.g. macrogol stearate 8, available from pharmacies)
- Approx. 5 ml (1 teaspoon) paraffin oil

Experiment instructions (Worksheet 9)

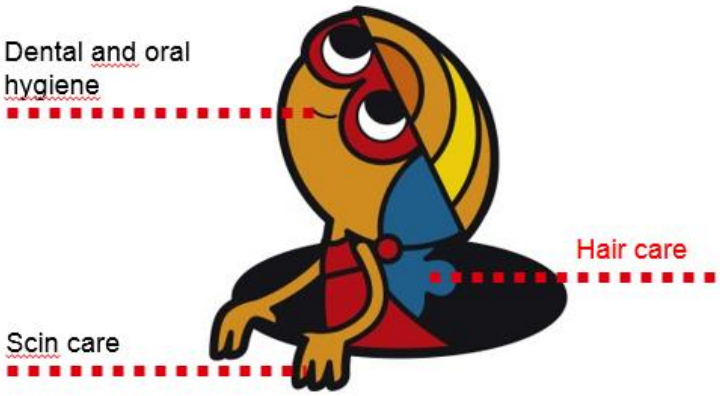
1. Put 2 metal balls into a plastic container with a screw top.
2. Put into the plastic container:
   a) 4 ml (1 teaspoon) paraffin oil
   b) 3 ml (¾ teaspoon) IPM
   c) 1 ml (¼ teaspoon) emulsifier
3. Screw the top onto the container and shake vigorously.
4. Add 2 ml (½ teaspoon), screw the top back onto the container and shake for approx. 30 seconds.
5. Repeat step 4) another six times until you have added 14 ml (3½ teaspoons) of water to your cream.

To help the students keep track when adding the water, they should check off a box in the table below each time they do so:

1	2	3	4	5	6

In the previous lesson, the students learned how to investigate the properties of oil and water. On the basis of this knowledge, they should now test the conductivity of the cream they made.

Hair care



Our hair also requires special care to make sure it stays healthy. In the previous lessons, we learned that skin produces sebum (fat). This makes our hair greasy after a while and means that we need to wash it. But why do we use shampoo to do so? The key questions below will guide us through the topic of hair care:

- What happens when we wash our hair with shampoo?
- How viscous is shampoo?
- How stable is a single hair?

Lesson 7: Degreasing effect of shampoo

To introduce the topic, it is important to mention why we need to wash our hair at all. The students are reminded of the structure of the skin, which has already been discussed: the skin contains sebaceous and sweat glands. They produce fat and sweat on the head too, which means that our hair becomes greasy after a few days. This is why we need to wash our hair regularly. To do so, we use shampoos which contain surfactants. They are able to wash the fat out of our hair.

Surfactants are active cleansing agents used in detergents and cleaning products as well as in body care products such as shower gel, shampoo and toothpaste. Surfactants have a part that attracts water and a part that repels water. As a result, they can be found at the interface between the aqueous and the oily phase in water/oil mixtures. When we wash our hair, they surround the fat in the hair and lift it away.

In addition to the surfactants that degrease and clean our hair, shampoos also contain other ingredients that have different effects depending on their composition. Examples include shine, ease of combing, moisturizing effects, greater degreasing or reduced formation of dandruff. The students should now experience at a phenomenological level how shampoo works in order to understand why we use it to wash our hair.

Why do we use shampoo to wash our hair? (Worksheet 10)

Materials needed for each group of two

- 6 filter papers (at least 7 cm or 3 inches in diameter; round coffee filters are also suitable)
- 4 strands of hair (buffalo hair or synthetic hair from a hairdressing supplier)
- Approx. 30 ml (2 tablespoons) sunflower oil
- 4 cable ties in different colors
- 4 watch glasses
- Hairdryer
- Pipettes
- Scales
- Shampoo
- Soapsuds

Preliminary test – the grease spot test

1. Use a pencil to draw two circles on a sheet of filter paper and label them “water” and “oil.”
2. Add a drop of water to one circle and a drop of sunflower oil to the other circle.
3. Dry the filter papers using a hairdryer.

Observation: A stain remains on the filter paper onto which oil has been drizzled after it has been dried; the water stain disappears completely after drying.

Work with your partner. Check off the steps as you do them.

☐ 1. Three strands of hair need to be washed with different cleaning agents (water, soapsuds and shampoo). You need a fourth strand of hair for comparison. The four strands of hair must be marked so that you can tell the difference between them. To do so, use cable ties and the following color code:

Hair strand	Cleaning agent	Color of cable tie
1	Water	Blue
2	Soapsuds	Yellow
3	Shampoo	Red
4	No cleaning agent	White

☐ 2. Rub sunflower oil into the four strands of hair: put each strand of hair onto a watch glass. Add 5 ml (1 teaspoon) of sunflower oil to each strand and massage it into the hair.
☐ 3. Carefully dab excess sunflower oil from the strands of hair.
☐ 4. Rinse hair strand 1 (blue) under running water for one minute.
☐ 5. Dry the strand of hair with the hairdryer.
☐ 6. Use the disposable pipette to put 5 ml (1 teaspoon) of soapsuds onto a watch glass and rub it into hair strand 2 (yellow) for 1 minute.
☐ 7. Rinse the hair strand under running water for one minute and dry it with the hairdryer.
☐ 8. Put 5 ml (1 teaspoon) of shampoo onto a watch glass and treat hair strand 3 (red) like hair strand 2.
☐ 9. Do the grease spot test on all the strands of hair.

Which cleaning agent worked best and leaves the least amount of grease on the filter paper? Make a note of the order.

Lesson 8: Viscosity of shampoo

In this lesson we will look at another important property of shampoo: its viscosity.

Shampoo must be dispensed and distributed throughout the hair. This means it is essential that it has the right viscosity. If a shampoo is too liquid, it would run off the fingers before it could be applied to the hair. If it is too thick, it would not be properly distributed throughout the hair. But how viscous is shampoo in comparison with other liquids? This is something we will test using a measurement device (falling ball viscometer) that we build ourselves.

How viscous are water, honey, syrup and shampoo? (Worksheet 11)

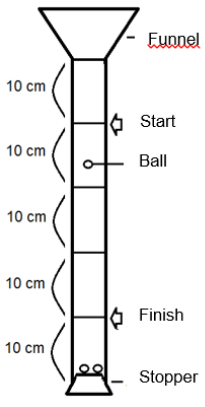
Materials needed for each group

- 1 transparent plastic tube (50 cm or 20 inches long, diameter of approx. 1 cm or ½ inch)
- Funnel
- Rubber stopper
- 4 metal balls (diameter approx. 6 mm or ¼ inch)
- Shampoo
- Liquids of different viscosities, e.g. syrup, liquid honey, shampoo, water
- Support rod + base
- 2 stand clamps + bossheads

First divide the class between four tables so that the students on each table can set up their measuring apparatus. Each table is assigned a liquid (water, honey, syrup or shampoo).

Measuring apparatus setup

1. Label the tube with lines 10 cm (4 inches) apart and clearly mark the start and finish. The distance between the start and finish should be 30 cm (12 inches).
2. Fix the tube to a support rod so that it hangs vertically.
3. Seal the bottom end of the tube with a stopper.



Procedure

1. Fill the tube with the liquid assigned to your table (water, honey, syrup or shampoo).
2. Put a ball into the tube and measure the time it takes the ball to travel the distance between the start and finish. Record the time in the table below (fall time 1).

3. Repeat the measurement three times and also record the figures in the table (fall times 2-4).
4. Now go to the next table and carry out the measurements there with the liquid that the students on that table put into their tube.
5. After you have been to all 4 stations, you will be back at “your” table. Calculate the average (mean value) of the four fall time measurements for “your” sample.

The students are given instructions in their worksheet on how to find the average and so will be able to fill out this table at the end of the experiment. The results of all the groups are compiled on the board and discussed.

Sample	Water	Honey	Syrup	Shampoo
Fall time 1 (in seconds)				
Fall time 2 (in seconds)				
Fall time 3 (in seconds)				
Fall time 4 (in seconds)				
Average (in seconds)				

The results of the experiment clearly illustrate the different viscosities of the liquids. The viscosity of honey would be too high for a shampoo, whereas the viscosity of water and syrup would be too low.

Lesson 9: Stability of hair

In the last lesson, we investigate how stable hair is. To do so, the students develop their own measurement method using the resources available to them. They work in groups of four.

Develop a method to test the stability of a single hair (Worksheet 12)

Materials

- Strands of hair
- Metal balls
- Scales
- Plastic cup
- Stand
- Adhesive tape
- Plastic tub
- Wire
- Freezer bags
- Cord

After the students have thought of a test method, they should draw a sketch of the measuring apparatus in which they label the different materials used.

As soon as the apparatus has been set up, the students should take several measurements to test how much weight a hair can bear.

Conclusion: It's surprising how elastic a single hair is and how much weight it can thus withstand. The maximum weight a single healthy hair fiber can bear is around 100 g (3½ oz.).