C2 Hygiene

Subexperiment C2.1 Hand washing
Subexperiment C2.2 Cooling without electricity
Subexperiment C2.3 Acid on the teeth

1 Main question

The following questions underlie the subexperiments and guide the activities:

- What purpose do hand, food, and oral hygiene fulfill?
- What role do bacteria play in hygiene?
- How does cleaning with soap work?
- How can I cool foods and thus prevent bacteria from multiplying?
- How does tooth decay form and what role do acids play in the process?
- What effect does brushing teeth have?

2 Background

2.1 Relevance to the curriculum

The topic of hygiene is excellent for developing an understanding of health among the students. According to the curriculum, the students will recognize that they can boost their own well-being with simple hygiene habits, such as by washing up after physical education class or by brushing their teeth regularly: They will learn how personal behavior and health are interrelated. In addition, the research provides the opportunity for the students to broaden their knowledge of natural substances and their scientific-technical way of thinking.

Topics and terms

Bacteria, fat, hygiene, tooth decay, cooling, fungi, acids, soap, enamel

2.2 Skills

The students will ...

- be able to better estimate the hygiene of their bodies and of foods.
- expand their level of knowledge about organisms that they cannot necessarily see, such as bacteria.
- become more confident in following scientific-technical processes, such as measuring and reading temperatures and observing and writing down results.
- be able to recognize relationships between developments in technology, personal behavior, and health.

3 Additional information on the experiment

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

4 Conducting the experiments

Notes:

- The required apparatus and materials that are not supplied as well as those that are supplied in the kit are designed for experimentation by **one** group of a maximum of **five** students. In total, the material is sufficient for **ten** groups of students.
- Each of the three subexperiments has a waiting time, so another experiment can be started during these waiting times. Based on the facilities and materials, the available time, and the students' abilities, decide which experiments you would like to combine and what sequence you want to follow.

4.1 Subexperiment C2.1 Hand washing

4.1.1 Apparatus and materials

Required materials that are not supplied

Materials	Quantity
oil (for example, light, inexpensive cooking oil such as corn oil)	several drops
water	100 ml

Supplied

Materials	Quantity	Box no.
container with lid, 100 ml	1	18
dish detergent	1 drop	10
pipette	2	12
wooden skewer	1	18

Note: If the dish detergent in the kit has been used up and you need to provide a new bottle, please make sure it is conventional dish detergent and not a creamy or sensitive-skin dish detergent.

4.1.2 Organizational aspects

Facilities	At a simple table in the classroom or outdoors
Time required	Approx. 45 minutes (together with C2.2)
Safety information	See the “Safety information on the topic of health” guide book binder.

4.1.3 Explaining the subexperiment in the teaching context

The students will learn the necessity of soap when washing their hands.

Technical background

When we wash our hands with soap, we remove dirt from them, including dirt that cannot be seen or felt. Dirt gets on our skin as we constantly touch a wide variety of objects. Germs are everywhere, for example, on banisters, doorknobs, and money. Residues of skin flakes, sebum, and sweat (grease) create a breeding ground for pathogens such as bacteria and fungi, which multiply and can cause diseases. Grease is difficult to remove from our hands using only water, because grease is not water-soluble.

Hand washing with soap:
Soap consists of specific molecules called tenside molecules. Each tenside molecule has two different ends. One end is attracted to water and not to fat (hydrophilic and lipophobic), and the other end is attracted to fats and not to water (lipophilic and hydrophobic). If you combine oil and soap, each oil droplet will be completely surrounded by tenside molecules, with the lipophilic ends pointing inward and the hydrophilic ends pointing outward to the water. The oil is now enclosed in many small tenside bubbles (micelles) within the water and can be washed off with fresh water.
In this way, the greasy breeding ground for potential pathogens is bound and rinsed away. You

should always wash your hands with soap after going to the toilet and before meals. In addition, it is recommended that you wash your hands after direct contact with animals and when you come home. Washing your hands thoroughly also includes the spaces between the fingers and under the fingernails. A nail brush helps with stubborn dirt under the nails. Drying hands with a clean towel completes the washing process. Otherwise, the germs washed out of the skin would remain on the skin's surface. Demonstrate thorough cleaning to the class as a role model. Not all students know that they should also wash between the fingers (it's quite similar to the inner tooth surfaces; many children are not aware of brushing there until they are a bit older). However, in addition to the "dirty greases", soap also destroys the skin's natural protective mantle. For this reason, you should not use soap unnecessarily frequently.

4.1.4 Ask about the students' prior knowledge and ideas

The students should already have heard and possibly experienced that soap and dish detergent remove grease from items such as our hands or dishpans. Perhaps the students have tried at some point to wash dirty dishes with water. Ask them what can be cleaned well with water, for example, granola crumbs in a cereal bowl or leftover tea or juice in a cup. Ask them what dirt cannot be handled with plain water. From their own experience or from advertisements, the students know that greasy pans can be a problem. They can make small connections in their minds when you ask what the difference between shampoo, soap, and dish detergent is and whether people could also wash their hair with dish detergent. (Dish detergent is unnecessarily highly concentrated for hair and does not contain any care substances, so the hair could dry out. However, the hair would be clean.)

4.1.5 The research cycle

Important aspects and information regarding the individual process steps of the research cycle during the student experiment:

The research question	The following alternatives to the research question stated in the student instructions are possible: ▪ Find out why greasy hands cannot get clean without soap. ▪ What happens with the grease when you wash your hands with soap?
Collecting ideas and guesses	Some possible guesses: **Related to the research question:** ▪ "The soap makes the grease foamy." ▪ "The soap makes the grease go away." **Related to the experiment:** ▪ "The dish detergent surrounds the big oil drops." ▪ "The dish detergent destroys the oil." Segue from the guesses to the experiment.

Experimenting	**Experiment setup:** Be sure that conventional dish detergent is used, if possible; do not use special dish detergent for rough hands because they are creamier and do not work well enough for this experiment. The experiment works very well with inexpensive, light oils, such as sunflower or corn oil. Combinations such as organic olive oil with organic sensitive dish detergent do not yield the desired result. **Conducting the experiment:** The students should make sure that they slowly place one large drop of oil in the water rather than several small droplets. If there are no results even after an extended period of observation, the oil-water-dish detergent mixture can be lightly stirred at targeted locations using the wooden skewer.
Observing and documenting	**The most important observations:** ▪ The students will observe that the drop of oil does not become dispersed in the water; instead, it floats on the water's surface. ▪ However, if they add a bit of dish detergent on the oil drop, the floating oil drop begins to spread out and become flatter on the water's surface. Then it mixes with the water.
Analyzing and reflecting	**Results to be expected:** 1. The students can conclude from their observations that dish detergent or soap is able to dissolve the oil in water. It does so by breaking up and dispersing the oil drop. If children wash their greasy hands with water only, the grease will continue to stick to their hands. Fat and water cannot bind together. In contrast, if they add soap, the grease is bound by the soap so that it dissolves and can be rinsed off with the water. 2. In the student instructions, the students are encouraged to draw their observations. Do not expect correct results. The main objective here is to have the students closely observe, think through what they have understood, and possibly find a way to present it. In the best case, they will draw little balls of oil floating in the water and the soap is a shell surrounding the oil. If you have the feeling that your students are overwhelmed beyond their drawing skills, assist them and ask what they would draw if they could. **Reference to the story to get the students thinking about the topic:** The experiment showed Mia why she needs soap to wash the grease off her hands after lunch. From now on, she will always use soap to wash her hands.

4.1.6 Other information

In the student instructions

Doing further research	There are other ways to remove dirt besides cleaning with soap. The students should find out which cleaning methods they can use to get rid of different types of dirt residue. Depending on the available equipment, you can provide the students with various dirty objects and different cleaning methods for them to test. Some examples: ▪ Clay residue, glue residue, such as from adhesive strips: rubbing, peeling, for example, with sand or coarse salt (mechanical cleaning) ▪ Blood: cold water (no denaturation of the proteins in the blood due to too warm water) ▪ Paint residue: nail polish remover (dissolves paints by binding with them) ▪ Felt-tipped pen marks: solvents, or better, heavy-duty hand cleaner (binds well with grease-dissolving substances) ▪ Oil stains, for example, from repairing a bicycle: also heavy-duty hand cleaner

Miscellaneous notes

Together with the students, do some investigating in history books. Soap has been around for a very long time. The Sumerians, Greeks, and Egyptians made soap from plant ashes and various oils. In those times, soap was often used as a remedy for injuries. In the Middle Ages, soap was a real luxury item. However, the people needed only a small amount of soap, because they didn’t like to wash themselves with water. This was because they thought that water could transmit diseases like the plague. Even among the wealthy and the nobility, it was customary to “clean” with powder and perfume instead of with soap and water. In this way, they covered the unpleasant smell of their own unwashed bodies.

4.1.7 Reference to values

What is your opinion?	In the discussion about values for this experiment, the teacher can provide a prompt or tell a story in which a problem is posed. Both actions lead to a discussion based on reflections. What’s important is that the reference to values can be established in the experiment. The discussion can focus either on values related to the learning process (for example, working reliably in groups) or on object-related values (for example, handling paper as a resource). The student instructions for **C2.1 Hand washing** address object-related values. **Object-related dilemma:** An object-related dilemma for the value “acceptance of responsibility” can be integrated at the end of the student instructions. The students should express their opinions about it.

Dilemma related to hand washing:

Your friend has come to your house for lunch after school. Your mother calls you to the table. You both go into the bathroom. Your friend says, "I don't need soap. My hands will get clean with water."

Think about it: What would you do?

Possible examples of students' statements for and against washing hands with soap:

Reasons for washing hands with soap	Reasons against washing hands with soap
▪ The grease comes off my hands. ▪ The breeding ground for germs is washed away.	▪ The water is adequate for getting my hands clean. ▪ You can't see any dirt.

Objective: The students should reflect on how they can handle their health responsibly. The value of acceptance of responsibility will be addressed in the process.

Alternatives: Statements or questions related to the story told in the student instructions are also suitable as prompts for encouraging discussion. The value of acceptance of responsibility remains unchanged.

- **For discussion:** You are eating at a restaurant with your parents. When you go to the restroom to use the toilet, you see that the person next to you washes his or her hands with just water and without soap.
- **Question for discussion:** Why is it important to always wash your hands thoroughly with soap?

Notes: The students should reflect on values and express their opinions. It may turn out that several values are addressed.

4.2 Subexperiment C2.2 Cooling without electricity

4.2.1 Apparatus and materials

Required materials that are not supplied

Materials	Quantity
clay pot (for example, clean, unpainted flower pot)	1
cotton cloth	2
pail	1
cold water	a few liters

Supplied

Materials	Quantity	Box no.
container with lid, 100 ml	3	18
thermometer	1	17

4.2.2 Organizational aspects

Facilities	In the classroom or outdoors; direct sunlight is necessary
Time required	Approx. 45 minutes (in the 30-minute waiting time, experiment C2.1 or C2.3 can be conducted, for example)
Experimental variations	Another liquid can be used instead of water. You can also assign a different liquid to each group and then compare the results with the various liquids.
Safety information	See the “Safety information on the topic of health” guide book binder.

4.2.3 Explaining the subexperiment in the teaching context

The students will learn that people can cool a liquid or food using simple materials even when the outside temperature is high. In addition, they will gather information on why refrigerating some foods is important for health.

Technical background

In general, biological processes and chemical reactions run more slowly at low temperatures. Many cell division processes take place when bacteria and mold fungi multiply, which is why multiplication progresses all the faster at higher temperatures. After a certain temperature, though, the microorganisms are killed. Eating spoiled foods is unhealthy and can even be dangerous. Therefore, it is absolutely necessary to foster awareness for the hygienic handling of food. We frequently read about scandals in the food industry, for instance, when the temperature-controlled supply chain for ice cream was interrupted on its way to the consumer.
What can individuals themselves do so that foods, especially meat, milk, and vegetables, are kept cool? A clay pot is well suited for refrigerating foods. This is due to the material’s low thermal conductivity. The temperature inside the pot can thus be held constant for a relatively long time as compared with a changing temperature outside the pot. The cooling effect in the experiment is achieved mainly through the evaporation of the water in the clay: The evaporation of a liquid requires energy, which is drawn from the environment. This leads to a cooling off of the wet clay pot.

4.2.4 Ask about the students' prior knowledge and ideas

Ideally, the students should already have experience with or made observations about how foods can be chilled. For example, foods can be stored in cool basements, holes in the ground, refrigerators, or coolers. Foods can also be packed in waterproof packaging and placed in cold water.
The phenomenon that energy is drawn from the surroundings during evaporation and the surroundings are cooled off as a result is not an intuitive concept. You can help the students understand by making a reference to wet skin: Even when skin is moistened with warm water, a person gets the impression of cooling off. That is also the reason why people have numerous sweat glands or why they quickly become cold when they climb out of a swimming pool and do not dry off right away.

4.2.5 The research cycle

Important aspects and information regarding the individual process steps of the research cycle during the student experiment:

The research question	The following alternatives to the research question stated in the student instructions are possible: ▪ Find out how you can cool foods.
Collecting ideas and guesses	Some possible guesses: **Related to the research question:** ▪ "I will use ice." ▪ "I will use salt." ▪ "I will build a box and put the food and ice inside." **Related to the experiment:** ▪ "The clay pot emits cold." ▪ "The heat doesn't get to the container due to the cloth/clay pot." Segue from the guesses to the experiment.
Experimenting	**Experiment setup:** It is recommended that the experiment be conducted outdoors due to handling of fragile objects and water. Make sure that the students use cold water. **Conducting the experiment:** A total of six measurements are to be made, such that each student in the group can practice using a thermometer. If necessary, provide assistance and help the students correctly read the temperature.
Observing and documenting	At the beginning, the temperature in all three arrangements is the same. The students will observe that the temperature of the liquid that was placed under the clay pot in the first arrangement decreases, while the temperature of the liquid in the third arrangement that is exposed directly to the sun increases.

Analyzing and reflecting	**Results to be expected:** 1. After 30 minutes the temperatures will be different depending on the experimental conditions at the location, which is why no absolute values are listed here. Arrangement 1: The temperature will have decreased. Arrangement 2: The temperature will have remained about the same or dropped a little. Arrangement 3: The temperature will have increased. 2. The first arrangement shows that the wet clay pot with the wet cotton cloth is best suited for cooling water and foods since the temperature drops despite exposure to the sun. 3. In the first arrangement, the water evaporates from the clay and the cloth fibers. However, energy in the form of heat is required for the water to evaporate. This energy is drawn from the surroundings and thus also drawn from the water in the container. As a result, the water cools down. In the third arrangement, energy is absorbed from the surroundings and the water evaporates, causing it to be converted to water vapor in the air.

4.2.6 Other information

In the student instructions

Doing further research	The experiment can be changed to see how that change affects the temperature of the liquid in the mini refrigerator. For example, the container can be replaced with a glass or a metal container. The students could also soak the cotton cloth in hot water. Have the students conduct the experiments and compare the results.

Miscellaneous notes

- You can discuss with the students further possibilities for cooling or preserving foods.
- In addition, you can focus on technical aspects: Compare the different designs. Which cooling model is most effective and which materials were used for it?
- The students can compare their homemade cooling apparatus with their family's refrigerator at home. How many degrees does the temperature of water decrease in 30 minutes in the refrigerator? Depending on the students' level of curiosity, they can create a table and fill it in themselves with the date, time, specific food, and measured temperature in a purposeful and scientific manner. You can also specify a table. Depending on your students' interest, provide prompts, such as whether the freezer compartment and its cooling power could also be investigated. Do butter and cucumbers refrigerate equally well? Remind the students that the thermometer must be clean or else they might transfer germs to the foods.
- What technical cooling devices are the students familiar with from their everyday lives? For example, how does the radiator in a car work and why does a car even need a radiator? What risks does winter weather pose for the radiator? (See also chapter 4.2.7)

4.2.7 Reference to technology

Freezers and refrigerators are found in practically every household and supermarket, so the students are familiar with them. However, do they know how they work?

In the student instructions

Tracking down technology	Two photos are shown in the student instructions: ▪ As a reference to everyday life: **Interior and back of a refrigerator** ▪ As another idea: **Air-conditioning system on a commuter train** The students should discuss the refrigerator's purpose and function. Questions and tips are offered to help them. The work assignment serves to solidify the learning results and document the students' progress. The photo of the air-conditioning system on the commuter train serves as an example of a research project for further study.

The exact functioning of a refrigerator is complicated. However, the teacher should absolutely make sure that the students can make the transfer from this experiment to the technical application. To support the students in forming the analogy and transferring the knowledge, you can ask them the following question:

1. How do we produce a cold temperature in the experiment, or how do we draw heat from the surroundings?
   Answer: through evaporation.
2. How do we produce a cold temperature in the refrigerator? Answer: through evaporation of the coolant.
3. What is the difference between our experiment and the refrigerator?
   Answer: In our experiment, the "coolant" escapes into the surroundings, and in the refrigerator, the coolant is circulated. The circulated coolant cools the interior of the refrigerator and heats the exterior surroundings at the back of the refrigerator.

An air conditioner is simply a variation of a refrigerator; the teacher's only task is to make sure that the students recognize this fact.

Other prompts via research projects for the students

1. When is a cold temperature produced through evaporation in everyday life?
   - Clay buildings in hot desert regions (humidity adsorbed at night; the water evaporates during the day)
   - Shade trees (evaporation of the water from the leaves causes lower temperatures)
   - After swimming, people quickly become chilled if they do not dry off.
   - Earthenware beverage chillers (water adsorbed by the earthenware evaporates)
2. What other possible applications are there in everyday life for cooling and freezing systems?
   - Refrigerated warehouses in the food sector
   - Refrigerated trucks for food transport
   - Cooling equipment for medicines and laboratory samples in medicine and pharmacy
   - Air conditioning in cars and buildings
   - Cooling system in ice stadiums or for bobsled and luge runs

You will find the answers to the questions asked in the student instructions on the answer sheet in the guide book binder. In the “Experimento | 8+: Tracking down technology” media package, which is available on the media portal, you will find additional technical information compiled in an information sheet and a link list. This media package also includes the work assignment as a prepared worksheet as well as the individual photos.

4.3 Subexperiment C2.3 Acid on the teeth

4.3.1 Apparatus and materials

Required materials that are not supplied

Materials	Quantity
disposable glove, size S	5
egg	1
spoon, large (tablespoon)	1
vinegar, clear, 5 percent acidity	approx. 200 ml
Additional experiment	
egg	1
toothpaste with high fluoride content (approx. 2,000 mg)	approx. 1 teaspoonful

Supplied

Materials	Quantity	Box no.
magnifying glass	1	11
plastic cup, 500 ml	1	loose in the kit
spoon, small, metal	1	14
Additional experiment		
cup with lid, 100 ml	1	18
plastic wrap, approx. 25 x 25 cm	1	loose in the kit

4.3.2 Organizational aspects

Facilities	In the classroom or outdoors
Time required	Daylong or weeklong experiment (the longer the egg sits in the vinegar, the clearer the results will be)
Safety information	See the “Safety information on the topic of health” guide book binder.
Cleanup	Generally, the treated eggs can be disposed of in the regular trash. If the eggs have been sitting for some time, or if the trash is not emptied promptly, the treated eggs should be put into a tightly tied bag with a dash of alcohol. The vinegar solution can be poured down the sink. Wash the used equipment first with cold water, then with hot water and dish detergent, and then dry it.

4.3.3 Explaining the subexperiment in the teaching context

In this experiment, the students can develop a better understanding of the destructive process known as tooth decay. As a result, they will better understand the importance of brushing their teeth and eating a healthy diet.

Technical background

In this experiment, the students learn will about the destructive process known as tooth decay when teeth are exposed to acid. Although tooth enamel is the hardest material in the human body, it is powerless against acids. Why is that? Tooth enamel consists mainly of apatite, a salt made of calcium, phosphate, and hydroxide ions. Eggshell also consists of a calcium compound, calcium carbonate. These calcium compounds have something in common: they are sensitive to acids. If an acid is added to these calcium compounds, a chemical reaction takes place. The calcium salt is dissolved and carbon dioxide is formed. The formerly hard substance is now present in the water, dissolved in its ionic form. The carbon dioxide is gaseous, and the beginning of the reaction can be recognized by the formation of gas bubbles.
How do acids find their way to our teeth? First, many foods are acidic, such as vinegar, citrus fruits, and sodas. Also, our teeth harbor bacteria that feed on sugar as an energy source and produce lactic acid when they process the sugar. This acid attacks the tooth enamel, resulting in tooth decay. That's why dental hygiene is very important.
Toothpaste with fluoride can be used to counteract the erosion of the tooth enamel. The fluoride can then help remineralize the tooth enamel. Our saliva can also provide valuable protection. However, for this to occur, it's particularly important to adhere to breaks between meals and to avoid sugary drinks throughout the day.

4.3.4 Ask about the students' prior knowledge and ideas

Many elementary school children know which foods they should enjoy only in moderation for the sake of their teeth: sweets. Some may know that sour food can also damage teeth. In addition, they should know what tooth decay is and that brushing their teeth can protect them from tooth decay. Use this opportunity to review with the students the structure of teeth and the correct way to brush teeth, for example, following the acronym COI: chewing surface – outside – inside.

4.3.5 The research cycle

Important aspects and information regarding the individual process steps of the research cycle during the student experiment:

The research question	The following alternatives to the research question stated in the student instructions are possible: ▪ Using an egg, find out how acid damages teeth.
Collecting ideas and guesses	Some possible guesses: **Related to the research question:** ▪ "The acid makes holes in the teeth." ▪ "The acid dissolves the tooth." **Related to the experiment:** ▪ "The vinegar eats the shell." ▪ "The eggshell gets holes." Segue from the guesses to the experiment.

Experimenting	**Experiment setup:** Allow the students to handle the raw eggs. This trains their motor skills. Have extra eggs and paper towels on hand. **Conducting the experiment:** ▪ Make sure that the students practice good hygiene when they handle the eggs. Point out that the students should not touch their faces during the experiment, and make sure that they wash their hands after they place the eggs in the vinegar. ▪ Good hygiene must also be practiced when the students remove the eggs from the vinegar later to examine them. In principle, the vinegar has already destroyed potential microorganisms, but the students should wear gloves when they touch the eggs. ▪ There won't be much to observe at the beginning of the experiment. After some time, the first gas bubbles form on the egg's surface. ▪ The more time that has passed, the more of the egg surface is dissolved, but in many cases it must still be scraped off. Unpleasant red or white streaks and froth frequently appear. They constitute proteins that are denatured (destroyed) by the vinegar and are completely harmless. If too many streaks and too much froth form, they can be removed from the container and disposed of in the regular trash, sink, or toilet. ▪ The students will probably want to hold and burst an egg that has been completely "peeled" by the acid. Demonstrate this in a bowl and point out that the experiment can be conducted at home with parental supervision. ▪ The typical observation period for the experiment is one day. It can be extended if the result isn't clear after one day. Explain that in such "long-term experiments", it is particularly important to record results in writing since otherwise after a long time, the observations can no longer be remembered.
Observing and documenting	Asking the students to draw their observation trains them to look closely. The students could draw the formation of gas bubbles and froth, possibly also the egg when the shell has been completely removed. **Most important observations:** ▪ The students will observe that the eggshell separates from the inner membranes of the egg over time. The acid "peels" the egg. The white egg under the shell appears. By handling the egg while wearing gloves, the students will discover that it is rather wobbly, but is still elastic and firm. ▪ At first, the students will be able to observe only the formation of gas bubbles. The longer they wait, the more clearly the caustic effect of the acid appears. The result will be determined by the length of the observation period. Basically, at some point the students will observe that the egg is being held together only by the egg membranes. The table provides space for an extended observation period.

Analyzing and reflecting	**Results to be expected:** 1. Vinegar will dissolve the eggshell. 2. The students will infer that acids also attack tooth enamel since it has a structure quite similar to that of an eggshell. It will become clear to the students that the tooth enamel will erode and, as a result, the tooth itself will be irreversibly damaged.

4.3.6 Other information

In the student instructions

Doing further research	To observe the effect of fluoride toothpaste, the students can repeat the experiment. This time they will treat the eggshell with toothpaste beforehand; it's best to do so at least four days in advance. Allow the students to handle the raw egg and apply the toothpaste with their fingers. Four days later, they will place the egg in the vinegar as described above. When they remove the egg from the acid, they can test the shell for hardness using a sharpened pencil. While an untreated egg becomes soft, the treated egg remains hard.

Miscellaneous notes

Calcium compounds are abundant in nature. Snail shells, freshwater pearls, mussel shells, and the lime deposits in an electric kettle all consist of calcium compounds and therefore react just as sensitively to acid. The students can also examine the decomposition of these substances in another experiment.