C1 Nutrients

Subexperiment C1.1 Potatoes make us strong
Subexperiment C1.2 Protein shake
Subexperiment C1.3 Fat detectives

1 Main question

The following questions underlie the subexperiments and guide the activities:

- Which nutrients are vital for humans?
  (ingredients of foods)
- What do your own eating habits look like? (self-awareness)
- How can you keep your body healthy and fit through nutrition?
  (care/prevention)

2 Background

2.1 Relevance to the curriculum

The topic of nutrients is very useful for establishing links to the wider topic of nutrition. This gives the students the power to make their own decisions regarding their health. Moreover, their own research into nutrients expands their knowledge of natural substances and their scientific-technical mind-set.

Topics and terms

Carbohydrates, fat, fatty acids, nutrition, nutrients, nutritional value, protein, starch

2.2 Skills

The students will ...

- expand their knowledge about nutrients and the methods used to detect their presence.
- develop an awareness of healthy nutrition and its importance for their lives.
- become more confident in following the process of independent research.

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 Conducting the experiment

Note: The listed materials are designed to allow **one** group of maximum **five** students to conduct the experiment.

4.1 Subexperiment C1.1 Potatoes make us strong

4.1.1 Required materials

Material	Quantity
Dishtowel	1
Grater	1
Knife (or alternatively, a potato peeler)	1
Measuring cup, 100 ml	1
Raw potato (medium)	1
Small spoon	1
Tray	2
Water (cold)	50 ml

Material for the additional experiment	Quantity
Matches	1
Pipette	1
Tea light	1
Tea warmer	1
Test tube	1
Test tube brush (for cleaning)	1
Test tube clamp	1

4.1.2 Organizational aspects

Facilities	At a simple table in the classroom or outdoors
Time required	Approx. 15 min
Experimental variations	Additional experiment: making starch paste
Safety instructions	See the “Safety instructions on the topic of health” in the guidebook. Pay attention to the students’ use/handling of the knife and sharp grater. There is a risk of injury.
Cleanup	All materials must be cleaned (grater, test tube, etc.) before they are put away.

4.1.3 Explaining the subexperiment in the teaching context

The students will become familiar with the nutrient starch as well as a method they can use to extract starch from a potato and then detect it.

Technical background

Glucose is a monosaccharide and the main provider of energy for human cells. The brain depends on a supply of glucose since it cannot access fats as an energy source. Glucose molecules are the smallest components of various polysaccharides such as malt sugar (maltose), starch (amylose), cellulose, or animal starch (glycogen). The form of glucose storage depends on the number of glucose molecules linked together and the structure of the resulting molecule. If we take in starch with our food, this polysaccharide is broken down again into the monosaccharide glucose, for example, through enzymes in our saliva, and then our blood can transport the glucose to our cells. If too much glucose is in the blood of animal organisms, another polysaccharide, glycogen, is formed and stored in muscles and the liver.
The principle is always that the glucose chain is broken down into the single component glucose through digestion, glucose is supplied to the cells, and excess glucose is used to form glycogen.

Starch is produced exclusively by plants, which is why cereal products and potatoes, for example, are such important high-starch foods. If we eat too few carbohydrates, the body first uses the stored glycogen and then the fat reserves or proteins (for example, in muscles) to obtain energy.

Starch cannot be dissolved in cold water, but it swells up in water that is around 50°C or hotter. Starch can be detected with an iodine solution (elemental iodine and potassium iodide, also known as Lugol's solution) and appears blue.

4.1.4 Ask about the students' prior knowledge and ideas

Starch occurs as a reserve substance in seeds (wheat grains, corn, rice) and storage organs, such as tubers (potatoes) and roots (turnips), of higher plants and is by far the most important staple of humans (and many mammals). Accordingly, the foods made from these plant parts, such as pasta, bread, and tortillas, also contain a lot of starch.

4.1.5 The research cycle

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

Recognizing the problem/phenomenon 	In this experiment, the students will learn how they can detect starch in foods.
The research question 	The following alternatives to the research question stated in the student instructions are possible: ▪ What foods contain starch? ▪ What are the properties of starch? ▪ How is starch extracted from potatoes?
Collecting ideas and guesses 	Some possible guesses: **Related to the research question:** ▪ "You could dry the potato in the sun, in which case the starch remains." ▪ "You can boil out the starch that remains in the water after the potatoes are cooked." **Related to the experiment:** ▪ "The substance that remains looks like wet flour." ▪ "The starch is difficult to separate from the potato." Segue from the guesses to the experiment.

Experimenting 	**Experiment setup:** Since the experiment setup is not very challenging, the students should exercise independence and try to manage with only limited assistance. As the teacher, however, make sure they handle the knife and grater safely. **Conducting the experiment:** The second tray is intended as a resting surface for used materials, but it can also be used to collect the potato water.
Observing and documenting 	The students will observe that a whitish substance settles to the bottom of the pan. This is the starch. You can also have the students check other properties of starch. For example, you can have the students rub the whitish liquid (“potato juice”) between their fingertips. It feels grainy or sandy.
Analyzing and reflecting 	The students will learn that starch is white (in contrast to the yellowish potato). In addition, they may already know from home that starch is used to thicken foods. This is because starch swells up and dissolves when heated in water. This solution becomes sticky (“paste”). Another important understanding is the fact that not only potatoes contain starch, but also rice and corn, for example. Rice starch is used to starch laundry, for instance. **Results to be expected:** Products at home that contain starch: pudding powder, pasta and potato water, edible paper and edible dishes, laundry starch. **Reference to the story to get the students thinking about the topic:** You have found out that potatoes contain starch. This potato starch is also processed into flour, potato flour, or starch. This flour makes a cake fluffier.

4.1.6 Further information

In the student instructions

Doing further research 	In this additional experiment, the students will become familiar with the making of starch paste. They need additional materials for this purpose (see section 4.1.1 under “Additional experiment”). The water-starch mixture is heated in a test tube over a tea warmer. In this case, the students should use the test tube clamps in order to avoid burning their fingers or hands. Because of the heat, the water will evaporate, and the starch will remain in the test tube. It is worthwhile to have the students immediately test the adhesive properties of the resulting starch paste. If the students do not come up with any ideas of what to do with the sticky mixture, get them on track with targeted questions such as “The result is rather sticky. Do you have an idea of what this sticky mixture could be used for?” Make sure that the test tube clamp is not too loose or too tight: If it is too loose, the test tube will slip through and if it is too tight, the test tube will break.

4.2 Subexperiment C1.2 Protein shake

4.2.1 Required materials

Material	Quantity
Container	1
Cooking oil	Half a test tube
Drinking glass – based on the number of foods to be tested	3 – 6
Egg	1
Funnel, small	1
Milk	Half a test tube
Other foods at room temperature (for example, cream, soy milk, water, fruit juice)	Half a test tube each
Plant clip – based on the number of test tubes	3 – 6
Pipette – based on the number of foods	4 – 7*
Test tube – based on the number of foods	3 – 6
Test tube stopper – based on the number of test tubes	3 – 6
Tray	1
Vinegar – per food to be tested	15 – 20 drops

Material for the additional experiment	Quantity
Matches	1 package
Tea light	1
Tea warmer	1
Test tube clamp	1

* When selecting the number of pipettes, please keep in mind that an additional pipette is needed for the vinegar.

4.2.2 Organizational aspects

Facilities	At a simple table in the classroom or outdoors
Time required	20 minutes (conducting and analysis), or possibly longer depending on the number of foods used
Experimental variations	Citric acid (instead of vinegar)

Safety instructions	See the “Safety instructions on the topic of health” in the guidebook. Make sure that the test tubes do not shatter from being held too tightly with the plant clip or that they do not slip out from being held too loosely (see photo). Both cases pose a risk of injury.  Test tube with plant clip as a test tube stand.
Cleanup	All materials must be cleaned before they are put away. It’s best to use a test tube brush to clean the test tubes. The foods in the test tubes can be disposed of in the regular trash (do not pour down the sink).

4.2.3 Explaining the subexperiment in the teaching context

The students will learn a method for detecting whether protein is present in foods. They will learn that proteins are important nutrients that they should eat regularly.

Technical background

Proteins are biological macromolecules consisting of amino acids. They are present in all cells of organisms and perform a variety of tasks and functions: Our connective tissue consists of proteins, which enable many metabolic processes, are responsible for transporting substances, and recognize cell signaling substances. Proteins are constantly being rebuilt. Proteins taken in with food are broken down into their individual components, the amino acids, which are used to build new proteins for the body. Therefore, proteins (plant or animal proteins) must continuously be taken in with food for growth and regeneration. According to recommendations, adults should eat about 0.8 grams of protein every day per kilogram of body weight. For children and adolescents, the need is 12.5 percent higher, at 0.9 grams per kilogram of body weight. Plant-based proteins occur, for example, in legumes and vegetables, and animal-based proteins are contained in foods such as meat, milk, and eggs. In principle, it is more difficult for a vegetarian to eat a high-protein diet. Proteins can be detected using acids (for example, acetic or citric acid), which change the structure of the protein molecules. This process is called denaturation, which can often result in a loss of biological activity and a decrease in solubility of the protein molecules. The latter is visible in the form of flaking or curdling.

4.2.4 Ask about the students’ prior knowledge and ideas

The students are familiar with protein, for example, as a gelatinous mass from an egg cooked for breakfast. If they have helped with cooking and baking, the students have gained experience with the consistency of an egg white, for example, how it changes after being beaten with a mixer. The students may have experienced the “clumping” of milk, such as sour milk in hot drinks or curdled milk.

4.2.5 The research cycle

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

Recognizing the problem/phenomenon 	In this experiment, the students will learn how they can detect protein in foods.
The research question 	The following alternatives to the research question stated in the student instructions are possible: ▪ How can we make protein in foods visible? ▪ What foods contain proteins?
Collecting ideas and guesses 	Some possible guesses: **Related to the research question:** ▪ “Protein is in egg white, which is why we sometimes separate the egg white from the yolk when baking a cake.” ▪ “Milk is white because it has protein.” **Related to the experiment:** ▪ “The protein is made visible using the vinegar.” ▪ “Protein is present only in a few foods.” Segue from the guesses to the experiment.
Experimenting 	**Experiment setup:** ▪ The egg yolk and egg white must be separated cleanly. Any trace of egg yolk in the egg white will discolor the egg white when it is shaken with the vinegar, and the curdled egg white will no longer be recognizable. If necessary, the teacher should separate the egg. ▪ During the experiment, clarify to the students that the foods are to be used exclusively for research purposes and are not to be eaten. ▪ The egg white of one egg is sufficient to fill 3 – 4 test tubes halfway, depending on the size of the egg. ▪ So that the individual foods can be drawn up more easily with the pipette, they should be poured into drinking glasses beforehand. ▪ Ask the students to carefully clamp the test tubes in the plant clips. **Conducting the experiment:** ▪ Pipettes or small funnels can be used for filling the test tubes more easily. Even the egg white from the chicken egg can be transferred easily using the pipette. ▪ In the first round, acid will be added to test the curdling of the protein in the egg white: The results of the experiment are obvious and the appearance can be clearly described.

Observing and documenting 	The acid causes the protein to precipitate out: White streaks quickly form in the glass with the egg white. The students may describe this as white foam that forms on the surface. The egg white also changes when it comes into contact with vinegar. **Most important observation:** ▪ The cooking oil remains unchanged. Instead, the mixture separates into two layers (oil on top, vinegar on the bottom). ▪ Egg white and milk curdle (animal protein). Soy milk also curdles (plant protein).
Analyzing and reflecting 	Soluble proteins normally have a globularspatial structure. The addition of acid changes this spatial structure, which affects the solubility of the protein. The protein flakes out. This is called denaturation. On the basis of this observation, the students can conclude that milk and egg white contain protein, while cooking oil does not. Accordingly, the acid helps them verify the presence of protein in foods. **Results to be expected:** ▪ These foods contain protein: egg, milk, soy milk, … ▪ These foods do not contain protein: cooking oil, fruit juice, … **Reference to the story to get the students thinking about the topic:** Now you know that your cocktail looks so unappetizing because the protein in the milk becomes denatured by the addition of orange juice – white flakes form.

4.2.6 Further information

In the student instructions

Doing further research 	This additional experiment shows that egg white also flakes/curdles when it is heated. The students need additional materials for this purpose (see section 4.1.1 under “Additional experiment”). The leftover egg white is heated in a test tube over a tea warmer. The students should use the wooden test tube clamp to hold the test tube over the flame to avoid burning their fingers or hands. Learning objectives: The students will learn another method for curdling egg white: through heating (previously, they had curdled the egg white by adding acid). The teacher should have the students compare the material properties of the egg white before and after heating, that is, transparent/white, liquid/solid, etc. In addition, the teacher should point out the importance of temperature-dependent changes in material properties in everyday life, for example, when eggs are cooked, cakes are baked, etc. Another way to change the structure of the egg white is to beat it with a whisk.

4.3 Subexperiment C1.3 Fat detectives

4.3.1 Required materials

Material	Quantity
Blotting paper, standard letter size	1
Cutting board	1
Foods at room temperature (cereals, nuts, potato, chocolate, cheese, onion, potato chips, etc.)	1 small piece each
Measuring cup, 100 ml	1
Scissors	1
Small knife	1
Small spoon	1
Spreadable fat (such as butter or margarine)	1 pea-sized amount
Stone, for crushing the nuts, etc. (optional)	1
Tray	1
Watch	1
Water (cold)	20 ml

4.3.2 Organizational aspects

Facilities	At a simple table in the classroom or outdoors
Time required	Approx. 30 minutes or longer for conducting and analyzing, depending on the number of foods used
Experimental variations	Instead of spreadable fat, oil can also be used (approx. 5 drops).
Safety instructions	See the “Safety instructions on the topic of health” in the guidebook.
Cleanup	All materials must be cleaned before they are put away.

4.3.3 Explaining the subexperiment in the teaching context

The students will learn a method for detecting whether fats are present in foods. They will learn that fats are one of the basic nutrients of humans, but also that too much fat is unhealthy.

Technical background

Fats are an important energy store for the human body and an important component of cells. In addition to storage fat, there is structural fat, which is indispensable to the body. For example, fatty tissue is found in the eye socket. An inadequate supply of fat leads to weight loss, weakness, and vitamin deficiency (vitamins, such as vitamin A, are stored in fat cells). However, too much fat can cause obesity (adiposity), cardiac diseases, and a vitamin E deficiency. The body can absorb both vegetable and animal fats in food. Plant fats are present in such things as nuts and seeds. Nutritionally, eating polyunsaturated fatty acids, such as those in salmon and canola oil, is especially beneficial. Nutrition experts designate fats that contain many of these unsaturated fatty acids “good fats.” In contrast, saturated fatty acids, such as those in most animal fats or hydrogenated plant fats like margarine, result in adipose tissue and can cause deposits in blood vessels (arteriosclerosis) due to the high cholesterol content. For this reason, nutrition experts designate such fats “unhealthy fats.” A balanced diet is based on the right proportion of both types of fat.

Blotting paper absorbs water and fat. However, when the paper dries, the traces of water disappear but the traces of fat do not. The reason is that water evaporates at room temperature, but fat doesn't.

4.3.4 Ask about the students' prior knowledge and ideas

In highly industrialized countries, obesity is rapidly increasing, especially among children and adolescents, and fast food has become part of the daily diet. Students in these countries are more likely to be familiar with "fat" in everyday life as something negative. They have perhaps heard comment in everyday language such as "that's greasy" or insulting phrases like "you look fat." And when asked "what does fat look like?" the students may most likely imagine a thick gut. Have a class discussion about which high-fat foods the students are familiar with and whether they know how to find out how much fat is present in a particular food (nutrition table on the packaging; see also "Doing further research").

4.3.5 The research cycle

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

Recognizing the problem/phenomenon 	In this experiment, the students will learn how they can detect fat in foods.
The research question 	The following alternatives to the research question stated in the student instructions are possible: ▪ How can we make fat visible? ▪ What foods contain fat?
Collecting ideas and guesses 	Some possible guesses: **Related to the research question:** ▪ "Fat is in the things that my parents don't want me to eat a lot of, such as potato chips and chocolate." ▪ "Fat is in fried foods." **Related to the experiment:** ▪ "Fat is only in foods that you can see it in, such as in butter. There is no such thing as 'invisible' fat." ▪ "Traces remain on the blotting paper when you place different foods on it." Segue from the guesses to the experiment.

Experimenting

Experiment setup:

- The foods should be at room temperature and always be prepared and cut up for the students' needs.
- The dimensions for the pieces of blotting paper are only an approximate value so that one sheet of blotting paper is enough for all foods to be tested by a group.

Conducting the experiment:

- To be able to read results in a timely manner during the experiment, the students should not spread the pure fat (butter, margarine, oil) too thickly on the blotting paper.
- They may need assistance when checking their results again after 15 minutes.
- A watch can be provided to the students for precise checking of the results.
- Excess foods should be removed from the blotting paper. The knife can be used for this purpose. If a paper towel is close at hand, it can also be used. A cotton cloth is less suitable because it must be thoroughly cleaned after the experiment.

Observing and documenting

The students will attempt to describe the types of traces on the blotting paper and the transparency of the blotting paper.

Most important observations:

Food	Immediately	After 15 minutes
Water	Transparent, becomes soft	No longer transparent
Butter	Transparent	Transparent
Chocolate	Somewhat transparent	Transparent
Potato	See water	No longer transparent
Nuts	See butter	Transparent

Analyzing and reflecting

After a while, the students can recognize that the traces of some foods disappear when they dry. As already mentioned, this is because water evaporates at room temperature, but fat doesn't. Therefore, the traces of fat remain visible on the blotting paper for a long time. The more translucent the paper, the more fat the tested food contains. Foods that contain water will also leave behind traces on the blotting paper when they are crushed. However, these traces disappear when they dry, that is, when the water has evaporated.

Results to be expected:

- Foods that do not contain fat include water and potatoes.
- Butter, oil, nuts, cheese, chocolate, etc., contain fat.

Reference to the story to get the students thinking about the topic:

Through the experiment, you understand why your mother doesn't want you to eat chips while watching TV. Namely, they leave greasy spots wherever they fall.

4.3.6 Further information

In the student instructions

Doing further research 	The students should examine their own eating habits and daily fat consumption. For children, the daily required amount is approx. 30 g to 40 g. Adult women require about 40 g to 70 g, and men require about 50 g to 100 g. Some growing adolescents may have an even greater need for fat than adults. Note: These data regarding the amount of fat are purely to cover energy needs. In terms of the fat needed as a building block for body cells, hormones, etc, the quality of the fats is more important than the actual amount. When the students are analyzing the results, reflect with them on whether the amount of fat present in the respective food is a lot or a little in relation to the daily fat requirement. An important contribution to the students' maturity is reading and understanding nutritional value information.

Miscellaneous

- For further study, the students can create a food guide pyramid and enter their findings from this subexperiment and the previous one.
- Discuss why fat is important for the body, but also the risks of too much fat. Write down the results, observations, and students' statements. For example, you can record the results of the discussion on a poster.
- Why does blotting paper become transparent when you spread fat or water on it? Explanation: Light that falls on paper is diffracted in all possible directions by the paper fibers. For this reason, it barely goes through the paper, and certainly not in its original direction. If fat or water permeates the fibers, the droplets act like optical fibers (similar to fiberglass); the physical phenomenon that can be observed is "total internal reflection."

4.3.7 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 learning-process-related values (for example, working reliably in groups) or on object-related values (for example, handling paper as a resource). The student instructions for **C1.3 Fat detectives cells** address object-related values.

Object-related dilemma:

An object-related dilemma can be integrated in the discussion of the value "acceptance of responsibility" (being responsible for one's own health) at the end of the student instructions. The students should express their opinions.

Dilemma related to chips: In the afternoon you go to the supermarket with your friend to buy something with your allowance. Your friend picks up a bag of chips from the shelf and tries to convince you that you should pool your money to buy the chips. He/she doesn't have enough money to buy the chips because they are too expensive. Your friend is very important to you and you would like to help.

Think about it: How would you behave?

Possible statements by the students:

Do not listen to my friend	Listen to my friend
▪ Fat can be unhealthy ▪ I would rather buy something else	▪ Chips taste good ▪ Help my friend ▪ It's my own money

Objective:

The students should learn to pay attention to their own bodies. This dilemma deals with the value of acceptance of responsibility (being responsible for one's own health).

Alternatives:

Statements and questions related to the story told in the student instructions are also suitable as prompts for encouraging discussion. The value of acceptance of responsibility (being responsible for one's own health) remains unchanged.

	▪ **Image for discussion:**  ▪ **Question for discussion:** Why is it important that you do not eat a bag of chips every day? **Note:** The students should reflect on values and express their opinions. It may turn out that several values are addressed, such as initiative.