Inclusive experimentation units for Experimento | 10+

“Health”

Collection of digital materials

Created by the State Institute for School Quality and Teacher Training in Saxony-Anhalt
in collaboration with Siemens Stiftung.

C1 and C2 Inclusion: We burn sugar and Carbohydrates as providers of energy for metabolism – Starch and sugar

1 Main question

These experiments will give students insight into the metabolism of carbohydrates in the human body. It will be shown that many of our foods contain carbohydrates in the form of starch, sucrose, and glucose (sugar). The experiments also deal with the enzymatic cleavage and subsequent degradation processes of polysaccharides.
Students will become acquainted with the characteristic detection reactions for carbohydrates and the principle of catalyzed reactions.

2 Integrating the experiment into the teaching context

2.1 Basic principles

Students are often already familiar with metabolism in humans from elementary school. They have prior knowledge of what we should eat in order to be active. Food provides the energy for life. Students have already learned about the main constituents of food – fats, carbohydrates, and proteins – and can combine them to prepare a balanced and healthy meal, for example, for breakfast. In building on this knowledge, relationships will be established between the subject areas of nutrition, substance transport, respiration, and energy conversion. The topic of catalysis is covered via enzymes (C1 We burn sugar – Catalyst).

2.2 Relevance to the curriculum

Areas of expertise in selected curricula from Saxony-Anhalt

Biology in grade 7/8
Explaining system and system levels based on the example of humans, taking their environment into account

- Presenting metabolic processes in consideration of the interaction of the corresponding organ systems and explaining the significance for performance
- Conducting and logging experiments to detect nutrients
- Recognizing the correlation between an unhealthy lifestyle (for example, poor nutrition, alcohol and nicotine abuse, lack of physical activity, vaccine fatigue) and possible diseases as well as a decrease in quality of life, and deriving conclusions for one’s own behavior

Chemistry in grade 9/10
Describing chemical processes for producing vital substances
- Describing the controllability of chemical reactions through the use of catalysts

Home economics
5/6 Leading a healthy lifestyle and maintaining wellbeing in a household

7/8 Selecting foods and evaluating their health benefits

9/10 Examining and evaluating nutritional behavior

The students will …
- know the constituents of food in a wide variety of foods.
- know the path taken by food in the human body.
- be able to carry out detection reactions for carbohydrates and explain the observed phenomena.
- be able to summarize the basic principles of energy conversion through catabolism.
- be able to apply the principle of sugar combustion to the metabolic processes.

2.3 Experimental variations

The experiments for detection and hydrolysis of starch (C2 “Verification of starch and sugar in unchewed and chewed bread”) do not require much material or time, and they can be integrated into lessons as student experiments that can be conducted individually or in pairs. Because of the complexity of the overall topic of nutrition, digestion, and cell metabolism, teaching methods are available to spur students to action. These methods provide additional material for background information in addition to the experimental approach.

The “Sugar can be burned” experiment (C1 “Catalyst”) demonstrates that sugar can be burned and that a catalyst is necessary for this. Students will first try to light a sugar cube. Then they will light a sugar cube sprinkled with ash in a tea light holder. To verify water, they will hold a cold test tube over the flame for a few seconds. This leads to the conclusion that a catalyst is required to burn sugar. This provides a good starting point for discussion of the enzymatic processes in human metabolism. Catalysis and catalysts can also be addressed.

Typical examples of such approaches could be learning at workstations or group puzzles. These methods are also well suited to the different learning paces and progress rates of individual students. The hints allow students to work at different levels. Visualization of how to conduct the experiments provides support in the sense of inclusive lessons.

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 Siemens Stiftung: https://medienportal.siemens-stiftung.org.
(See the teacher instructions from Experimento | 10+: C1 We burn sugar and C2 Carbohydrates as providers of energy.)

C1 Inclusion: We burn sugar

The historical development of the term “catalyst”

People have known for thousands of years that beer and wine are produced through fermentation processes. They could also produce acetic acid. Without understanding the principle and the progression of these reactions, people realized that catalysis was a phenomenon that occurred all the time. Catalysis first stirred up scientific interest about two hundred years ago. The first people to carry out studies in this field were Antoine Parmentier (1781), who discovered the catalytic decomposition of starch into sugar (through experiments), and Joseph Priestley (1783), who succeeded in synthesizing ethylene from ethanol in the presence of clay (aluminum oxide). Other inventions based on the principle of catalysis were the night lamp of Humphry Davy (1816) and the lighter of Johann Wolfgang Döbereiner (1832). The night lamp burns ethanol on a platinum, copper, or constantan wire. Döbereiner’s lighter produced hydrogen initially from an acid and zinc, and the hydrogen then spontaneously ignited on a platinum sponge.

Swedish researcher Jöns Jakob Berzelius (1779-1848) was the first to study these reactions and found out that the reaction mixture always contained a substance that was present in its original form both before and after the reaction. He called this type of reaction “catalysis.” He believed that these substances were solely responsible for adding energy (“catalytic force”) and did not participate in the reaction.

- “The catalytic force seems essentially to consist of the property that bodies, by their mere presence and not by their own affinity, are able to awaken affinities that are dormant at this temperature (...)” (1836)

Alwin Mittasch (1939) was the first person to describe the catalytic force named after Berzelius more comprehensively. In his opinion, a catalyst is a

- “substance that, although it seemingly does not participate in the reaction, induces or accelerates this reaction or guides it in certain pathways.”

In 1875, Marcellin Berthelot (1827-1917) first hypothesized the presence of intermediate bonds during catalytic reactions. In 1894 and 1901, German chemist Wilhelm Ostwald (1853-1932) introduced the catalyst definition that is nearly unchanged to this day:

- “Catalysis is the acceleration of a chemical reaction, which proceeds slowly, by the presence of a foreign substance” (1894).

- “A catalyst is any substance that changes the speed of a chemical reaction without appearing in the end product of the reaction” (1901).

In 1909, Ostwald received the Nobel Prize for Chemistry for his work in the field of catalysis.

Definition: Catalyst

A catalyst is a substance that increases the speed of a chemical reaction without being consumed in the reaction and without altering the final condition of thermodynamic equilibrium of this reaction.

Tasks:

1. Indicate the reaction equations for the catalytic reactions mentioned in the text.

2. Conduct the experiments on the decomposition of starch into sugar. (Experimento | 10+: C1 We burn sugar)
3. Complete the following table.

Name	Year	Proposed definitions
Berzelius		
	1939	
		Catalysis is the acceleration of a chemical reaction, which proceeds slowly, by the presence of a foreign substance
Ostwald		

4. Name at least two necessary properties of a substance for it to be suitable as a catalyst.

C1 Inclusion: We burn sugar

All organisms need energy to live. Our energy requirement depends on the work we perform. At complete rest, your body needs between 6,000 and 7,000 kJ per day.
For light physical work, during class for example, you need 9,000 to 11,000 kJ per day.
If you play sports, you need even more energy,
which is produced by the breaking down of nutrients in the mitochondria in your body. For this purpose, the carbohydrates taken into the body with food are converted to sugar and "burned" in the cells. The reaction equation is:

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O \quad \text{(exothermic)}$$

Research task

Complete the following tasks on "cellular respiration in an experiment." If you need help, choose the corresponding hint card.

1. Burn sugar and verify the reaction products, which are also contained in the air we exhale. Draw a sketch of each experiment.

2. Summarize your observations.

3. Transfer the results to the process of cellular respiration.

4. Do research and list three high-carbohydrate foods with their energy content per 100 g.

Additional tasks

Biology in grade 8

Determine the quantity and types of food you must eat to cover the basic energy need for an hour of playing soccer or dancing.
Think about how to manage your own nutrition.

Chemistry in grade 10

- Name catalysts in technology.
- Name a catalyst in a car.
- Explain the term catalyst.
  See, for example, the worksheet Historical development of the term "catalyst."

Apparatus and materials

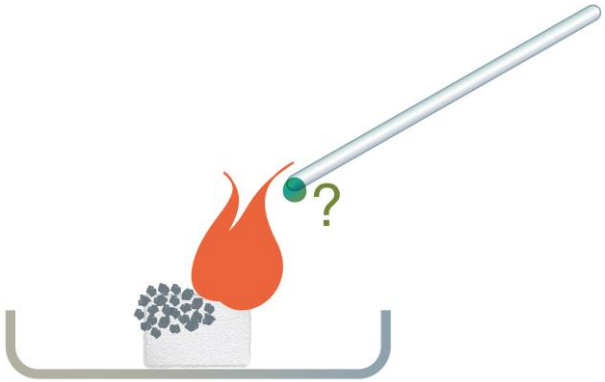
- Fireproof surface; for example, an aluminum bowl
- Lighter
- Test tube
- Test tube clamp
- Glass rod
- Sugar cubes
- Lime water
- Cigarette ashes
- Alcohol

Safety aspects

- This activity can result in burns or fires.
- You must use a fireproof surface.
- The substances are not suitable for consumption.
- Lime water is caustic; wear protective clothing.
- Dispose of residues properly as instructed by your teacher.

C1 Inclusion: We burn sugar

Hint	Answer
Hint 1 – Understanding of the task Explain the task to each other again in your own words. State what you understood the task to be and what is still unclear to you.	**Answer 1:** We're supposed to burn sugar and think about what products will be formed in the process. Hint: We exhale the same products. We're supposed to verify the products. We'll draw sketches of the experiments. We'll write down our observations. We'll apply the results to cellular respiration and explain this phenomenon. We'll search in media for three high-carbohydrate foods and indicate how much energy 100 g contains in each case.
Hint 2 – What do I need? Formulate the word equation for the reaction taking place and think about what is needed for burning.	**Answer 2:** Sugar and oxygen react to form carbon dioxide and water. A catalyst is needed.
Hint 3 – What is suitable as a catalyst? Look on the tray. Which substances could work as a catalyst?	**Answer 3:** 1. Alcohol 2. Cigarette ashes Correct answer: 2. Cigarette ashes Catalysts are not consumed.
Hint 4 – Verification of water In the reaction equation, you see that water is produced. Hold a cold test tube in the flame. How can you tell that water is forming?	**Answer 4:** The side of the test tube steams up. That indicates condensing water vapor.

Hint	Answer
Hint 5 – Verification of carbon dioxide Experiment setup The second reaction product is carbon dioxide, a gas. Develop an experiment setup using the provided devices.	**Answer 5:** 
Hint 6 – Means of verifying carbon dioxide You need a substance (on the glass rod) that reacts with carbon dioxide as a means to verify the gas. Observe.	**Answer 6:** Carbon dioxide can be verified with lime water $Ca(OH)_2$. Dip the glass rod into the lime water and hold it over the burning sugar. The drop of water on the glass rod becomes white and cloudy.
Hint 7 – observations You now have all information you need. Formulate your observations. 1. Burning sugar 2. Verifying water 3. Verifying carbon dioxide	**Answer 7:** 1. Sugar alone → flame does not form Sugar + cigarette ashes → flame forms Heat develops 2. Side of test tube steams up 3. Lime water turns white and cloudy

Hint	Answer
Hint 8 – Transferring statements to cellular respiration Think about what your observations reveal about cellular respiration.	**Answer 8:** In the body, carbohydrates are broken down with the help of catalysts/enzymes. This produces CO_2 and H_2O. We exhale these substances. In addition, energy is produced for our body.
Hint 9 – Examples of high-carbohydrate foods and their energy content Use the provided books or search online. Look for: ▪ Food for people ▪ High-carbohydrate foods ▪ Energy content of foods	**Answer 9:** For example: ▪ 100 g mixed wheat and rye bread→1,000 kJ ▪ 100 g marmalade→960 kJ ▪ 100 g potatoes→360 kJ ▪ 100 g lentils→1,480 kJ ▪ 100 g apple→210 kJ ▪ 100 g bread roll→1,060 kJ ▪ 100 g carrots→120 kJ

C2 Inclusion: Carbohydrates as providers of energy for metabolism – Starch and detection of sugar

Apparatus and chemicals

- 2 test tubes in the test tube holder
- 3 watch glasses
- Gas burner
- Test tube clamp
- Lighter
- Pipette with iodine/potassium iodide solution
- Pipette with Fehling's solution A
- Pipette with Fehling's solution B
- Spray bottle with distilled water
- Spatula

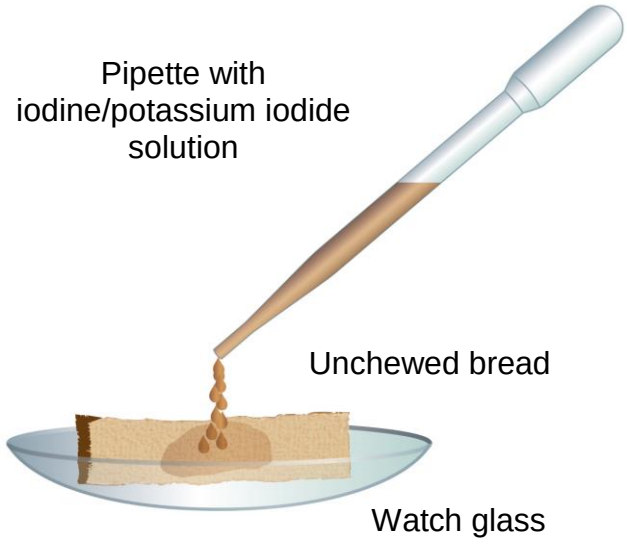
Safety information

- The bread is not suitable for consumption.
- This activity can result in burns or fires.
- If iodine/potassium iodide solution, Fehling's solution A, or Fehling's solution B splashes on your skin, wash it off immediately with clear water!
- Wear protective clothing.
- Dispose of residues properly as instructed by your teacher.

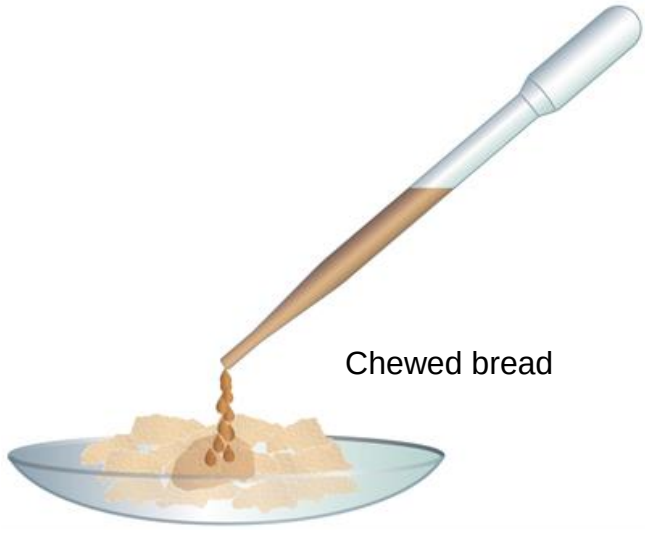
Level 1

1 Verifying starch

1.1

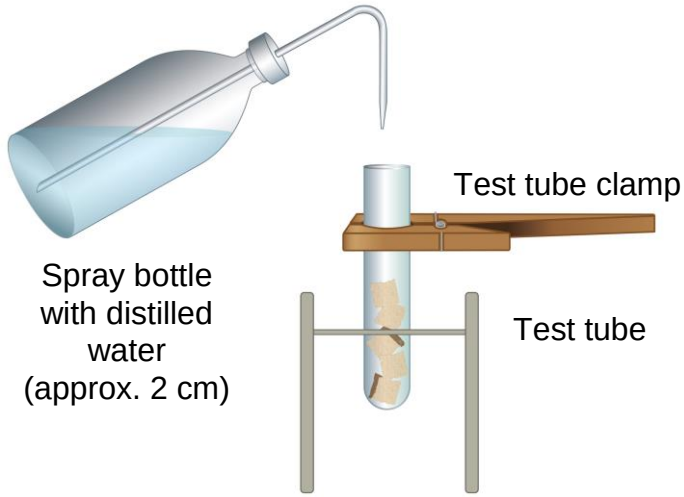


1.2

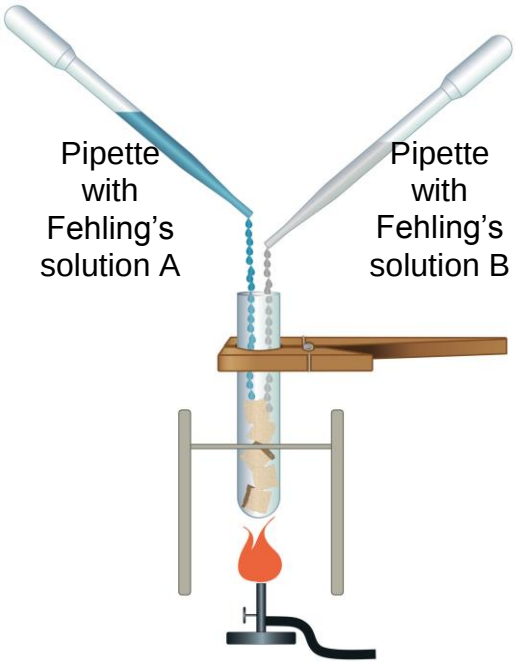


2 Verifying glucose

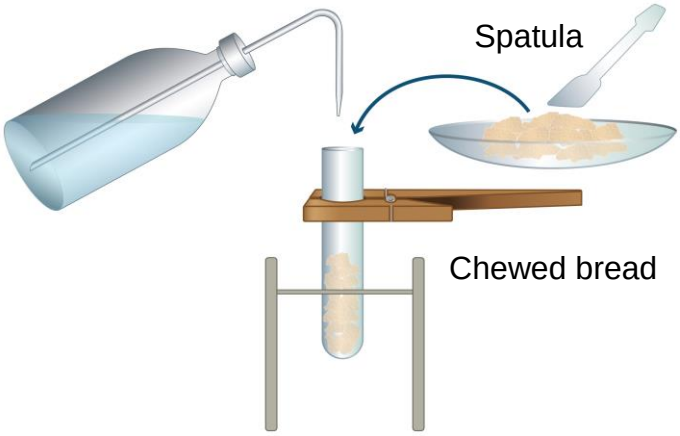
2.1.1



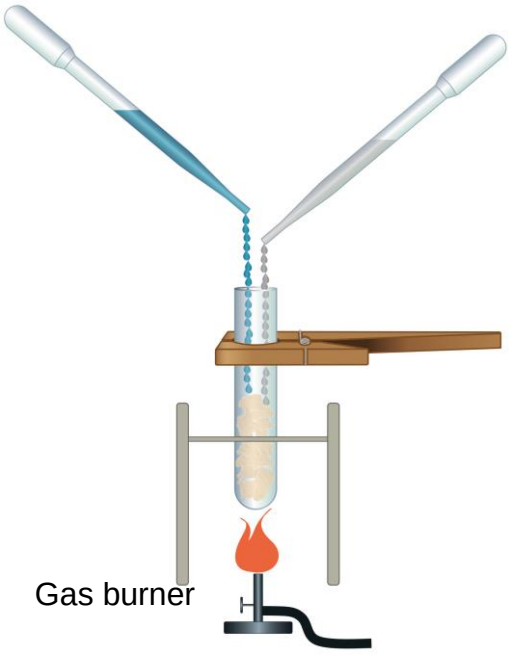
2.1.2



2.2.1



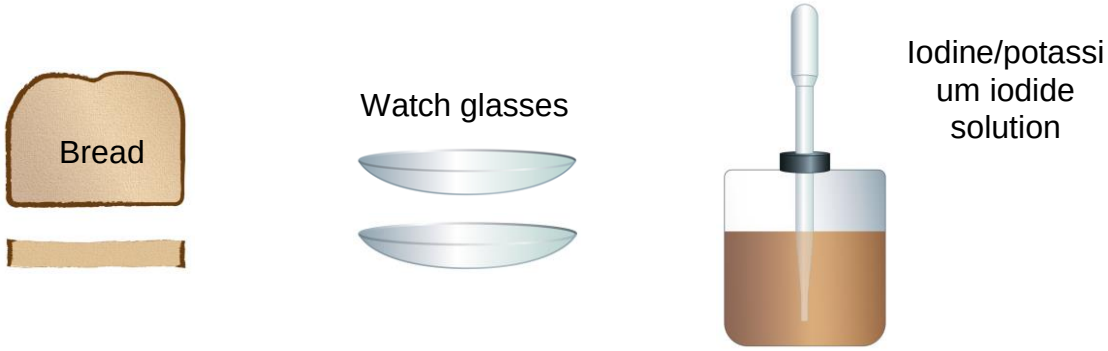
2.2.2



Level 2

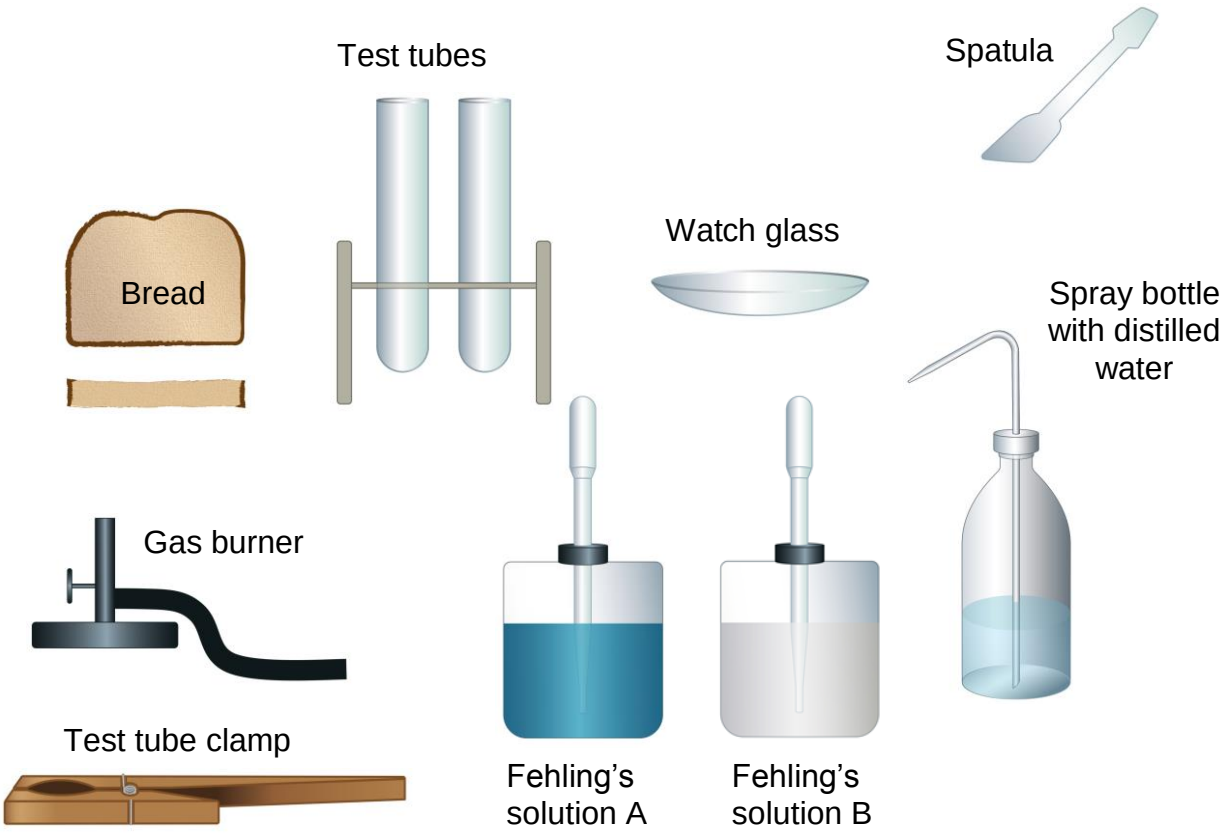
1 Verifying starch

Using the following “symbols,” plan the verification of starch with unchewed and chewed bread. Make sketches of the experiments.



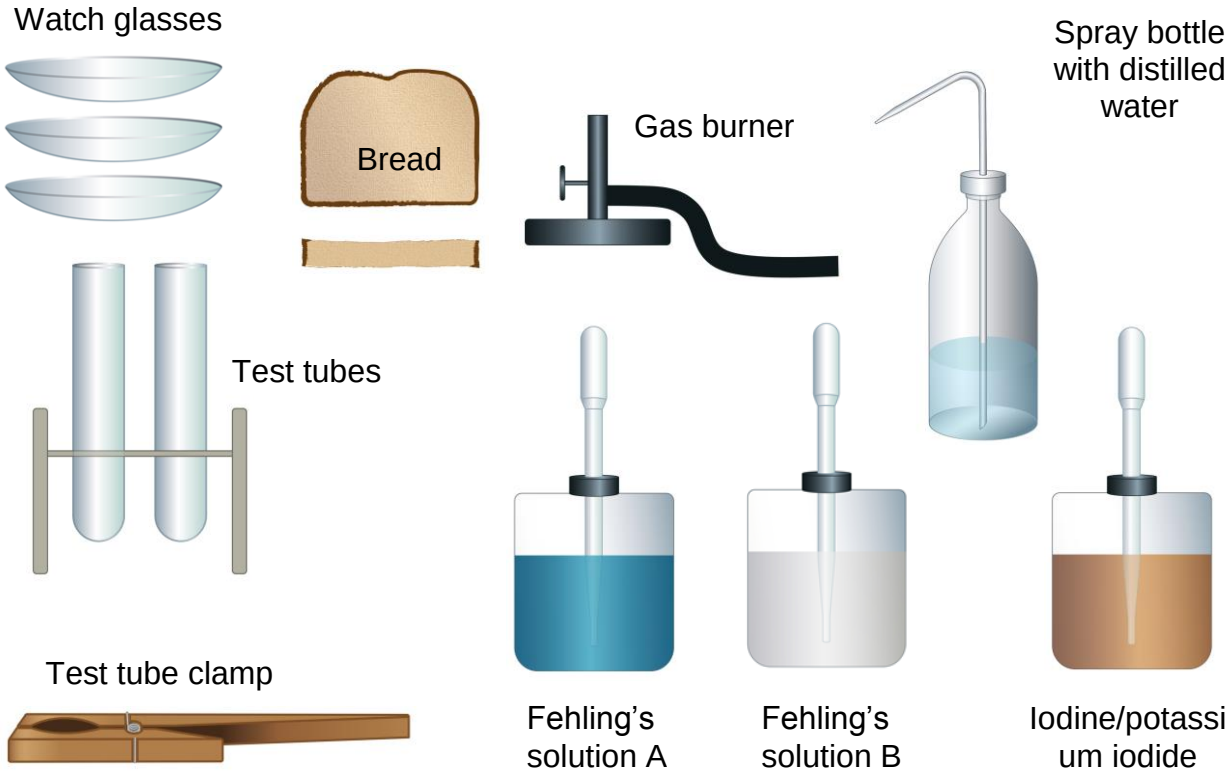
2 Verifying glucose

Using the following “symbols,” plan the verification of glucose with unchewed and chewed bread. Make sketches of the experiments.



Level 3

Using the following “symbols,” plan the verification of starch and glucose with unchewed and chewed bread. Make sketches of the experiments. Present your sketches to your teacher before you start experimenting.



C2 Inclusion: Carbohydrates as providers of energy for metabolism – Starch and detection of sugar

In biology class, Max learned that he shouldn't eat quickly. Instead, he should chew thoroughly because that promotes digestion. He doesn't believe this information and therefore wants to test it. Max chews a piece of bread for about one minute and notices that the taste has changed. It tastes sweet. Max knows that bread contains starch, but that doesn't taste sweet. What happened to the starch during chewing? Has sugar formed? If yes, how?

Preparation for the subexperiments

We want to test unchewed and chewed bread for starch and glucose.

Work according to the instructions using the apparatus and chemicals. You can use the textbook and provided references.

Conduct the experiments according to your instructions.

Write down your observations.

Analysis

Compare the starch and glucose content in the unchewed and chewed bread.

What role does saliva play in the conversion of starch to glucose?

C2 Inclusion: Carbohydrates as providers of energy for metabolism – Starch and sugar

Level 1

Fill in the missing words using the following terms:
intense, a lot of, a lot of, green, brick-red, little, saliva, starch, glucose, enzyme

Based on the deep black coloration of the unchewed bread during verification of starch,

_____ starch is present in it. With chewed bread, the coloration is not as

_____; less starch is present.

Unchewed bread tested for glucose with Fehling's solutions A and B reveals

_____ coloration. That is verification for _____ glucose. Thus, the

chewing and mixing with _____ has started the digestion of _____ to

_____.

This reaction was triggered by amylase, an _____ in saliva. It works as a catalyst.

Level 2

Fill in the missing words.

Based on the deep black coloration of the unchewed bread during verification of starch,

_____ starch is present in it. With chewed bread, the coloration is not as

_____; less starch is present.

Unchewed bread tested for glucose with Fehling's solutions A and B reveals

_____ coloration. That is verification for _____ glucose. Thus, the

chewing and mixing with _____ has started the digestion of _____ to

_____.

This reaction was triggered by amylase, an _____ in saliva. It works as a catalyst.

Level 3

Summarize your results in a table.

Unchewed bread	Chewed bread
_____ starch, recognized by the _____ coloration.	_____ starch, …
_____ glucose, recognized by …	_____ …
No conversion from _____ to _____	_____ from _____ to _____ has been triggered by amylase, an _____ in _____. _____ are biocatalysts that _____, _____, and accelerate chemical reactions.

C6 Inclusion: Skin and hygiene – “Don’t forget to wash your hands before eating!”

1 Introduction

Research question: Why is washing your hands necessary?

2 Integrating the experiment into the teaching context

2.1 Basic principles

People’s hands are important vehicles for transmitting pathogens. For example, if people touch their face or the warm damp mucous membranes of the mouth, nose, or eyes with their hands, pathogens multiply. For this reason, washing hands is critically important (for example, to reduce the number of pathogens clinging to hands after going to the toilet, sneezing, or blowing one’s nose). If students don’t wash their hands before leaving the bathroom, they run the risk of passing on fecal germs, bacteria, and viruses to their surroundings.

2.2 Relevance to the curriculum

Areas of expertise in selected curricula from Saxony-Anhalt

Biology in grade 9
Structure and function of selected sense organs and the nervous system as well as keeping people healthy

- **Apply knowledge:** Compare the structure, function, and performance of various sense organs. Structure and function of the skin as a sense organ (sense of touch and sense of temperature).

- **Gain knowledge:** Describe and compare the structure, function, and interaction of the sense organs. Plan, conduct, and analyze hypothesis-based experiments on the functions of sense organs. (Connection between the skin’s structure and function; plan and conduct simple investigations.)

- **Communicate:** Derive and present findings about the functions. Plan, develop, and give lessons. Analyze investigations according to specified criteria; read and analyze scientific texts; make and analyze comparisons.

- **Evaluate:** Assess different measures and behaviors for maintaining one’s health. Measures for keeping skin healthy.

Chemistry in grade 8
Classifying, examining, and comparing acids, bases, and salts in everyday life

- **Apply knowledge:** Assign the skin (protective acid mantle) to the substance class of acids, assign cleanser (soap) to the substance class of bases, and give reasons; technical knowledge about pH value, the term indicator.
- **Gain knowledge:** Examine acid, base, and neutral solutions in experiments.
- Determine pH value; research pH balance in specified materials; use the experimental method; plan, conduct, analyze, and log the experiment.
- **Communicate:** Be able to derive and determine findings about pH value; analyze investigations according to specified criteria; read and analyze scientific texts; present findings.
- **Evaluate:** Assess different measures and behaviors (use of soap, cleanser, pH balance) for maintaining one's own health; derive measures for one's own behavior toward keeping skin healthy.

2.3 Experimental variations

The goal of these experiments 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 made of sweat, sebum, and corneocytes, it protects the skin from drying out and from pathogens. Pathogens have a difficult time multiplying in this environment. The skin is protected by its slightly acidic pH value.
When you wash with a soap solution, the "protective mantle," the pH value, is raised from 5.5 to 9 for 30 to 80 minutes. During this time, the natural defense function is impaired. The skin becomes susceptible to drying out, as well as to pathogens and irritants.
Hints have been added to this experiment to support the process of gaining knowledge.
The teacher has all students wash their hands with soap (base).
Question: What happens when you wash your hands? Write down your observations and analyses. How can you protect your skin?

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 Siemens Stiftung: https://medienportal.siemens-stiftung.org.
(See Experimento | 10+: C6 Skin and hygiene (teacher instructions).)

C6 Inclusion: Skin and hygiene – “Don’t forget to wash your hands before eating!”

Task

1. The skin can transmit diseases. List ways to protect yourself.
2. Explain how skin can protect itself against infections.

Preparation for the subexperiments

Apparatus and materials

- Soap
- Water

Safety information

The materials may be used only as instructed by your teacher or as described in the experimentation instructions.
Remove all water-sensitive materials from your workspace.

Conducting the experiment

Wash your hands very thoroughly with soap.

Observation

Write down a summary of your observations.

Questions

1. What did you observe about your skin after you washed your hands?
2. How can you protect your skin?
3. Why is washing your hands with water (for example, after going to the toilet) not sufficient for eliminating the bacteria on the skin?
4. Why does the pH value on the inside of the elbow generally vary from the pH value 7?

C6 Inclusion: Skin and hygiene – “Don’t forget to wash your hands before eating!”

Hint 1: Explain the task to each other again in your own words. State what you understood the tasks to be and what is still unclear to you.	**Answer 1:** We’re supposed to find out what happens to our skin when we wash with soap. Is it possible to simulate the changes on our skin in an experiment?
Hint 2: Write down the changes that occurred on your skin after washing.	**Answer 2:** My skin feels dry and taut.
Hint 3: Investigate the layers of skin and their means of protection.	**Answer 3:** The skin consists of three layers: Together with acid substances made of sweat, sebum, and corneocytes, a water-grease film protects the skin from drying out and from pathogens.
Hint 4: In addition, skin has a pH value of 5.5. How does this value help?	**Answer 4:** The slightly acidic pH value plays a particularly important role. It has allowed the skin to develop a good defense mechanism against pathogens.
Hint 5: As a result of washing skin with soap, the pH value can move into the base range. Do you know what can happen then?	**Answer 5:** Incorrect skin care (with soap) raises the skin’s pH value to approximately pH 9 for roughly 30 to 180 minutes. 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.
Hint 6: Now conduct the “The pH value of skin” experiment. Compare the pH values resulting from the washed and unwashed elbows.	**Answer 6:** The pH value of the unwashed elbow is approximately 5.5; the pH value of the washed elbow is approximately 9. Conclusion: The skin’s protective function has been impaired. Soap damages the skin’s protective acid mantle. Skin damage may occur through excessive use of soap. (Risk when soap is overused)

Hint 1:	**Answer 1:**
Hint 2:	**Answer 2:**
Hint 3:	**Answer 3:**

Hint 4:	**Answer 4:**
Hint 5:	**Answer 5:**
Hint 6:	**Answer 6:**