Teaching unit: The water cycle

1 The topic in a nutshell

“There’s no life without water!” Everyone has likely heard this statement or something similar. We use a huge amount of water every day. But do we give any thought to it? An animation on the water cycle in the teaching unit illustrates that water is not lost; rather, it is constantly undergoing change. Experiments on the water cycle and evaporation give the students practical insights and contribute to a better understanding. Questions such as the following are resolved:

- What is water?
- How can water change physically and chemically?
- How can you clean or store drinking water?
- What happens when drinking water becomes scarce?

The teaching unit is suitable for grades 5–7. The water cycle is partly a review from elementary school. Some materials in this teaching unit, especially the animation and interactive graphic, are also suitable for elementary school.
The topic is split into teaching sequences, giving the teacher the opportunity to adapt the contents based on the class level.

2 Main objectives of the teaching unit

The students will come to know the resource water as a precious element vital for people. They will learn that water is distributed very unevenly and in various states of aggregation on Earth. The students will recognize that sustainable use of the resource water will become increasingly important. By evaluating information sheets, diagrams, and images, the students will learn the significance of water for people and the resulting changes for our natural environment.
The project allows the students to develop the topic extensively and to present the results of their work as an exhibit. This will motivate and enable them to work with “new media” and evaluate information sheets. They will develop solutions to improve the drinking water supply and draw conclusions regarding their own water use habits.
The main objective is to motivate the students to learn more about this topic, both to spark their interest in the environment and to further develop their ability to accurately perceive with all senses. They should be encouraged to question processes and actions and to recognize and grasp correlations.

3 Content of the teaching sequences

The content of each topic is introduced below, and the chapter that follows outlines the individual teaching sequences in tables. Notes on the various media (such as images, Flash files, and PDF files) from the media package are explicitly provided.
The division into three teaching sequences was chosen deliberately in order to not have to specify an exact number of hours since the sequences may vary widely depending on the grade level, classes, and the amount of time available to the teacher.

However, the following guidelines are estimated:

- Teaching sequence 1: 2 hours
- Teaching sequence 2: 2 hours
- Teaching sequence 3: 3 hours

3.1 Teaching sequence 1

3.1.1 What is water?

Water is the source of all life. Without water, life on Earth would not be possible. That's why it is also referred to as the "elixir of life."
Water is the basis of all plant and animal life, and it is essential for the production of all foods that humans consume.
Water makes up approximately 60 percent of the human body. It is used to perform vital tasks. Water works as a solvent and means of transport, helps in the excretion of metabolites and salts via the kidneys, and regulates body temperature.
Viewed scientifically, water is a tasteless, odorless, clear, and colorless liquid. It is composed of two hydrogen atoms and one oxygen atom. The chemical formula is H_2O.
Water occurs in various forms and is distinguished based on its contents. For instance, we speak of mineral water, salt water, and fresh water.

3.1.2 Water cycle

All of Earth's water resources circulate in a closed system. The water moves between oceans and land, changes its state of aggregation several times, and passes through the various spheres of Earth without losing any volume.
Due to the effects of the sun and wind, great quantities of water droplets evaporate from oceans, but also from surface waters, streets, buildings, and other surfaces on land. Since water vapor is lighter than air, it rises, cools off in the upper layers of air, and condenses into clouds. If the clouds are saturated with moisture, they will rain on the mountains. In lower layers of air, the air moisture can also precipitate as fog, dew, hoarfrost, or hail as the temperature drops.
A portion of the precipitation evaporates even as it is falling. On the way to Earth, the water droplets absorb numerous substances found in the air. They clean the air in this way, but they can also absorb dust and exhaust gases such as sulfur dioxide and react to form acid. This is how acid rain develops. If the precipitation falls directly into bodies of water, the cycle is completed and can start again from the beginning.
When a droplet seeps into the ground, substances absorbed from the air and the condition of the soil will determine how clean the droplet is when it reaches the groundwater. Microorganisms clean the water in the upper layers of soil where biological activities occur. The water is also filtered mechanically. The finer the pores of the subsoil and the longer the water flows in the soil, the more thoroughly it is cleaned.

3.2 Teaching sequence 2

3.2.1 Actions in connection with water and its states of aggregation

An important action in the water cycle is evaporation, which will be looked at more closely in this sequence with water's various states of aggregation (solid, liquid, gas).
Water is the only chemical compound on Earth that occurs in all states of aggregation in nature. Evaporation is the reverse process of precipitation. In this action, water passes from the liquid state to the gaseous state (water vapor) below the boiling point and enters the atmosphere. Evapo-

ration from the soil or from open water surfaces is referred to as evaporation, and the release of water from living beings is referred to as transpiration. Because the two actions are difficult to distinguish, we speak of evapotranspiration.
Condensation occurs when the saturation level of water vapor in the atmosphere is exceeded. In this action, water passes from the gaseous state to the liquid state. Depending on the temperature, water can also fall to Earth in a solid state as snow or hail.
As an illustration of the evaporation process, the media package includes complete experimentation instructions on evaporation from plants. Conclusions can be drawn about the evaporation process in Earth's water cycle based on the findings.

3.2.2 Energy storage and release based on water

Each of the described actions is associated with an energy conversion. The simulation shows particle models of the phase change of water in the solid, liquid, and gaseous states of aggregation. It illustrates that substances with a lower temperature also have less kinetic energy. The type of movement is completely different in the three models. In the gaseous state, the particles move in straight lines (like billiard balls, for example) until they collide with another particle or with the wall of the container. In the liquid state, the particles must squeeze through the gaps between the adjacent particles. In ice, the particles move very little from their position of rest.

3.3 Teaching sequence 3

3.3.1 Water balance in the natural water cycle

The water balance compares the "intake" of water with the "release" of water within a limited region and a defined period of time.
The intake side primarily includes precipitation and the flow from glacier melt.
The release side is made up of evaporation from plants, Earth's surface, surface waters, oceans, industrial facilities, and people, as well as the draining of surface water into oceans and groundwater.
The calculation of the water balance shows the proportion of water that is available to a region.
The two sides can be observed independently in the animation.

3.3.2 Water distribution on Earth

If students look at the world map and the "Distribution of land and water on Earth" and "Size of oceans and landmasses on Earth" charts, they can easily recognize that the majority of Earth's surface is covered with water. The total volume of water on Earth is estimated to be approximately 1.4 billion km^3.
Images of Earth from space make it clear why our planet is also referred to as the "Blue Planet." Indeed, approximately two-thirds (approximately 70 percent) of Earth's surface is covered by water; in contrast, land accounts for only about one-third (approximately 30 percent).

3.3.3 Water shortages

The question arises as to why we speak of water shortages on Earth when the water resources are so vast. To answer the question, it is necessary to take a closer look at water distribution on Earth. Oceans and seas contain 97 percent of the total volume of water. However, seawater cannot be used as drinking water.
Only 2.5 percent of the world's volume of water is fresh water. And even of this very small amount, only about 1 percent can be used by people.

The essential problem of the global water supply is that the low volume of usable fresh water on Earth is distributed very unevenly due to climatic reasons. There are areas of excess water and areas of water shortage (humid climate vs. arid climate).
A mind map on the natural and human causes of water shortages provides a complete picture, either as an interactive graphic to be developed gradually or as an image. The “Measures and technologies to address water shortages” information sheet and the “Overcoming water shortages” information module offer solutions. In addition, the media package includes a detailed project idea on the topic of “overcoming water shortages.”

3.4 Flow of the teaching unit

Lesson step	Explanations and notes
Teaching sequence 1: The students will review and supplement their existing knowledge on the topic of water and the water cycle.	
Introduction	What is water? Thoughts and ideas are compiled as a mind map.
Working through the topic	Linking with physics and chemistry to convey the scientific context. → Graphic “The water molecule”
Review/ continuation	Review of the natural water cycle with the aid of the → Animation “Water balance in the natural water cycle” Students will give a presentation on the animation to explain the processes. Additional information is conveyed: → Interactive graphic “The natural water cycle”
Experiment	Experiment 1 is conducted according to the instructions. → Experimentation instructions “Experiencing and observing the natural water cycle” Understanding is fostered and the result is reinforced as the students answer the questions on the test. → Multiple-choice test “Experiment on the water cycle” Evaluation and conclusions
Summary	Students may select different types of presentations (for example, posters, PowerPoint presentations) in partner work or group work to introduce their classmates to the topic of “water and the water cycle.”

Teaching sequence 2: An important component of the water cycle is evaporation with the various states of aggregation that are visualized by the students in an understandable way as experiments, particle models, and information sheets.	
Review	Review of the states of aggregation of water
Application/ working through the topic	Incorporate knowledge on the states of aggregation in the evaporation process. Illustrate the flow of the evaporation process to the students using the → Simulation “The principle of evaporation” Follow this with a test of their knowledge. → Worksheet “The principle of evaporation”
Experiment	Experiment 2 can be conducted to underscore the knowledge gained. → Experimentation instructions “Evaporation from plants” Linking with physics and chemistry based on the example of the particle models of ice, liquid, and gas: → Simulation “Energy storage and release using water as an example”
Summary	Performance level query

Teaching sequence 3: The students will identify a global distribution of water on Earth and receive general information on overcoming/combating water shortages.	
Introduction	View of Earth or 3D animation of Earth (for example, from the web) that shows the proportions of water and land. Building on this: → Chart “Distribution of land and water on Earth” and → Interactive graphic “Size of oceans and landmasses on Earth” A water balance compares “intakes” and “releases” of water and shows that water cannot be lost. → Animation “Water balance in the natural water cycle” Collect information sheets on the topic of water shortage (causes and measures). Compare and contrast the results on the following mind map: → Interactive mind map “Water shortage interactive mind map” or mind map “Mind map for water shortages”
Project introduction	Development of solutions based on the information module and the information sheet. → Information module “Overcoming water shortages” → Information sheet “Measures and technologies to address water shortages”
Carrying out the project	Instructions on how to carry out the project are described in detail in the project idea of the media package. → Project idea “Overcoming water shortages” Step 1: Atlas task Step 2: Determining causes Step 3: Finding the solution
Analysis	Step 4: Visualizing the results