CHAPTER 3:

WHAT IS WATER?

A: WHAT IS THE MAKEUP OF THE WATER IN MY ENVIRONMENT?

In the previous chapter, we found that water is located in various places at different stages of the water cycle.

In this chapter, we try to understand how to change the properties of water as it passes through the various stages of the water cycle.

Activity 1:
Hydrological Research - How can you identify water?

During the field trip, you collected water samples at different locations: rain water, spring water and treated wastewater from a polluted river (effluent).

... unfortunately, on the way back to school, the labels that identified the bottles fell off, and now we have no idea what the source of the water is for each of them...

Experiment

...so what do we do?

We communicate with the lab, and talk with Professor Hydrology in person. He did not even flinch, and told us there was no problem. He believes that we can identify the source of water for each bottle. He sent us a kit with a few laboratory items which we can use to help us identify the source of water. He also sent some written materials that will help us understand how to carry out the tests.

... and now, to work!

Work Plan

Professor Hydrology sent laboratory materials and information that allow us to perform the following tests and analyses to assess the water quality.

1. Measuring the electrical conductivity as a variable to measure the salinity or salt concentration of water.
2. Measuring the concentration of ions (electrically charged particles) of calcium as a variable that reflects the "hardness" of water.
3. Measuring the concentration of nitrate ions in the water as a variable that indicates the level of pollution in the water.

Each group will perform a single analysis that you choose... but before that, you probably wonder, "What is the purpose of this analysis?" and "What can I learn from them?"
Of course you are absolutely correct. It makes no sense to work without a plan. First you must understand "Why?", and then "How?"
Therefore, after choosing the type of analysis you will perform based on advice from your teacher, read the following articles that explain **why** you should carry out the analysis, and then how to perform them.

Additional Information

Electrical conductivity as a variable to measure the concentration of salts in the water

Why is it important to examine water salinity?

Drinking salt water is not recommended, not only because of the salty taste, but also because it affects the health of humans. Also, ornamental plants, lawns, and many agricultural crops such as corn and tomatoes are sensitive to a high salt concentration in irrigation water.

What causes salinity?

The main source of salt in the water are compounds containing ions (electrically charged particles) of the element chlorine (i.e., chlorides, Cl-). The increased salinity of groundwater is caused by four main factors:

1. Infiltration of water through rocks containing chloride salts. For example, edible

rock salt is composed of the mineral halite, whose composition is sodium chloride (NaCl). Halite and other minerals containing chlorine are easily dissolved in rainwater that seeps into the rocks, enriching the solution of water with chloride ions.

2. **Excessive extraction of groundwater found in a coastal plain near the sea.** If you draw from the aquifers that are fed by infiltrating rain water, the groundwater level gets lower. The result is that the salt water penetrates into the non-saline (fresh) groundwater (remember the simulation experiment).
3. **Industrial waste water infiltration into groundwater.** Industrial drainage, for example from the food industry, is often rich in edible salt. In many cases, the sewage moves through the ground surface, infiltrating through the rocks and eventually reaching the groundwater.
4. **Irrigation with treated waste water.** In several places, many agricultural crops are irrigated with treated waste water effluents. This water contains a high concentration of chloride ions and its infiltration increases the salinity of the groundwater.

How do we measure the salinity of water?

It is common to measure the concentration of chloride ions in water in order to find out the salinity. In this activity, we will indirectly measure the concentration of chloride ions, with the help of a device that measures the electrical current, known as an ammeter. This will give a reading in units of amps*. We use the device to measure the electrical conductivity of an aqueous solution. The conductivity is higher (higher electric current) with increasing concentration of salts in a water solution. In other words, we will obtain higher values of electrical conductivity on the device.

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* The unit of current in the International System of Units is the **ampere**.

Hypothesis

In which of the three samples of water (spring, treated waste water from the polluted river, or rain) do you hope to find a high concentration of chloride ions, and in which do you hope to find a small concentration?

Observations

Description of Activity

Determine the electrical conductivity of different samples of water with the help of an ammeter (a device that measures this variable). Remember to order water as follows: sample 1, 2, and 3. It is important to dry the ammeter between measurements using a cloth.

Results:

Record the electrical conductivity of water samples from the readings on the ammeter.

Sample 1	Sample 2	Sample 3 Treated Wastewater
		50 – 70 milliamperes*

* For health and safety reasons, we cannot carry out the examination of Sample 3 in a school laboratory. The measurements were carried out in a laboratory that was able to provide results, which have been entered into the table.

Synthesis

Synthesize the findings of this activity using the components of scientific thinking: observation, hypothesis, additional information, and conclusion.

Additional Information

CALCIUM ION CONCENTRATION AS A VARIABLE FOR MEASURING THE "HARDNESS" OF WATER

Why is it important to examine the calcium ion concentration in water?

The "hardness" of water is a property that is caused by the presence of calcium compounds in water. This property is important for determining if the water is suitable for use in homes and industry. The presence of calcium compounds in the water affects the effectiveness of cleaning appliances like washing machines and dishwashers. Calcium ions tend to bind with molecules of soap and create a new compound that neutralizes the cleaning action of soap. Water "hardness" also causes scale buildup in pipes that carry water in industries and at home. However, calcium ions in water can contribute significantly to maintaining the health and strength of bones and teeth.

What causes the "hardness" of water?

The origin of the water withdrawn from aquifers is rain water that infiltrated through the rocks, such as limestone. As we learned in relation to "karst" (formations due to chemical weathering of rock), the limestone rock is made up of the mineral calcium carbonate ($CaCO_3$). Therefore, the infiltration of slightly acidic water through a rock causes the dissolution of calcium carbonate in the water, and as a result, the groundwater becomes enriched by ions (electrically charged particles) of calcium (Ca^{2+}).

Hypothesis

Which of the three samples of water (spring, treated waste water from the polluted river, or rain) do you hope to find a high concentration of calcium ions, and in which do you hope to find a small concentration?

Observations

Description of analysis:

Using the laboratory materials, find the concentration of calcium carbonate ($CaCO_3$) in the water samples by following these steps:

1. Rinse the glass and fill it to the black line with the water sample you want to inspect.
2. Add two drops of $H_{20}F$ and gently agitate the glass until the solution turns red. If the sample changes to a green color, it means that it contains calcium carbonate.
3. Place the yellow plastic tip on the syringe, and collect the solution in the bottle marked TL H_{20}, so that the plunger is at the black line marked on the syringe.
4. Drip the solution slowly from the syringe into the beaker containing the sample. Gently shake the beaker after adding each drop, until it turns green. Remember to wait about 10 seconds before adding each drop.
5. On the graduated syringe, determine which drop made the solution change color by examining the number of "d" (divisions) - the number appears on the blue syringe. Multiply by 17.8 to obtain the concentration of calcium carbonate ($CaCO_3$) in milligrams per liter (mg/L). (1 "d" = division = 17.8 mg/L).

Results:

Record the concentration of calcium carbonate ($CaCO_3$) in milligrams per liter of water sample.

Sample 1	Sample 2	Sample 3 Treated wastewater
		550 mg/L*

* For health and safety reasons, we cannot carry out the examination of Sample 3 in a school laboratory. The measurements were carried out in a laboratory that was able to provide results, which have been entered into the table.

Synthesis

Synthesize the findings of this activity in line with scientific thinking: observation, hypothesis, additional information, and conclusion.

Additional Information

PRESENCE OF NITROGEN COMPOUNDS IN WATER SOLUTION

Why is it important to examine the concentration of nitrogen compounds in the water?

Nitrogen is a vital element for life. Living things need nitrogen compounds to carry out processes such as growth and development. However, a high level of nitrogen compounds in drinking water, or the mere presence of a nitrogen compound called nitrate (NO_3^-), may cause methemoglobinemia in infants (blue babies) until the age of six months. The disease occurs because nitrates prevent blood from carrying enough oxygen from the lungs to different body parts, including the brain.

How do the nitrogen compounds get into the water?

There are two main sources of nitrogen compounds that can contaminate drinking water:

1. **Agricultural fertilizers:** In modern agriculture, it is customary to use nitrogen compounds such as fertilizers for plants. Unfortunately, only 50% of nitrogen fertilizer added to a field is used by plants, while the rest infiltrates with rainwater into the groundwater system.
2. **Wastewater:** Untreated drainage, especially domestic and agricultural drainage contains nitrogen compounds. When wastewater flows into rivers, some of these compounds seep into groundwater.

Hypothesis

Which of the three samples of water (spring, treated wastewater from the polluted river, or rain) do you hope to find a high level of nitrogen compounds, and in which do you hope to find a low level?

Observations

Description of analysis:

With the materials in front of you, determine the concentration of nitrogen compounds in the water samples. Follow these steps:

1. Take out a strip of test paper from the tube. Be sure to not touch the end of the paper (close the tube after removing the strip).
2. Immerse the marked end of the test paper strip in the water sample for a second. Remove the strip and wait a minute.
3. Compare the color obtained in the test area with the colors on the tube that holds the test strips (see photo). The concentration of nitrogen compounds, known as nitrate ions (NO_3^-), is based on what the tube shows that matches the test strip.

Results:

In the table below, record the concentration of nitrate ions in the water sample, in milligrams per liter.

Compound	Sample 1	Sample 2	Sample 3 Treated wastewater
Nitrate (NO_3^-)			100 mg/L*

* For health and safety reasons, we cannot carry out the examination of Sample 3 in a school laboratory. The measurements were carried out in a laboratory that was able to provide results, which have been entered into the table.

Synthesis

Synthesize the findings of this activity in line with scientific thinking: observation, hypothesis, additional information, and conclusion.

Classification

Activity Summary: Summary of observations and conclusions.

1. In the following table, summarize the results of the tests and come to conclusions regarding the origin of the water samples. Use the information provided in the previous pages to help you reach conclusions.

	Chemical analysis – ion concentration in mg/L		**Physical analysis – milliamps**	
Sample Number	**Concentration of nitrate ions (NO_3^-)** **Variable to measure water pollution by toxic salts**	**Concentration of calcium ions (Ca^{2+})** **Variable to measure the "hardness" of water**	**Electrical conductivity** **Variable to measure water salinity**	**Origin of water** **Circle the correct origin**
1				• rain water • spring water • treated wastewater from contaminated river
2				• rain water • spring water • treated wastewater from contaminated river
3				• rain water • spring water • treated wastewater from contaminated river

2. Write a few statements describing the properties of rain water, spring water, and treated waste water from the polluted river. List two factors that influence the properties of water at each site.

Activity 2:

What makes up the water we drink?

In the previous activity, we learned that the properties of water change from place to place as water cycles in nature. These properties have an influence on humans because as living beings, we depend on water in all life activities. **In this activity, we will identify and characterize the water we drink.**

1. Explain what “fresh water” is.
2. Explain what “salt water” is.

Activity:

You have four numbered glasses containing different water solutions: distilled water, tap water, bottled water, and salt water solution (3.5%).

Pure water is a compound whose chemical formula is H_2O. This means that all water molecules are composed of two atoms of hydrogen (H) and one oxygen atom (O). The ammeter is a device that measures the intensity of the electrical current of a solution (in amperes), thus it indirectly measures the conductivity of the solution which is a function of the concentration of salts in the water. That is, in pure water, where there is no salt, the ammeter reads "0".

Observations

1. Taste the water in each container, and summarize your findings of this test in the following table.
2. Measure the electrical conductivity of the solutions. Record the result of your measurement for the different types of water.

No. of glass	Water source	Taste of water in the glass	Electrical conductivity (milliamps)
1	Deionized water		
2	Tap water		
3	Bottled water		
4	Sea water		

Conclusion

1. Is there a relationship between the taste of water from each glass, and the electrical conductivity?
2. Are you surprised by the results obtained with the device for the different water sources? Explain.
3. As a result of the activity, try to redefine the terms "salt water" and "fresh water."
4. Is there a problem with the term "fresh water"? Explain.
5. In nature, can we find pure water in liquid form? Indicate how the observations you made support or validate your hypothesis.

It is **extremely unusual** to find **pure water on Earth** in liquid form, i.e., water that does not contain any other substances, only the **compound H_2O**.

A clear liquid containing H_2O plus other compounds (even in trace amounts) is not chemically defined as pure water, but is rather an **aqueous solution**.

Activity 3:

What is a solution?

In the previous activity, we indicated that the **water** found in nature and everyday life is a **solution**. A solution is a liquid in which another substance is dissolved. This means that a **solution** consists of a **solvent** and **solute.**
The aqueous solution is made of a **solvent** that is water **(H_2O)** and a **solute** that is a dissolved substances in water. The solute can only be detected by chemical or physical tests.
In this activity, try to find out which substances are dissolved in the water we drink.

What are the substances dissolved in bottled water?

In front of you are three labels from bottled water from different companies.

Observations

1. Note the different labels and record in the table the four main substances that are dissolved in each of the three bottles of water.

Solute in bottled water "a"	Solute in bottled water "b"	Solute in bottled water "c"

2. Where did the substances dissolved in the water come from?
   Hint: What is the process you learned about in the stalactite cave?

3. Use the information cards about the rocks and soils found in the Appendix of the book. In the table below, indicate the name of the mineral* or rock from which dissolved ions are found in different bottles of water:

The ion dissolved in water	Name of mineral from which the substance was dissolved	Chemical formula of mineral	Name of rock containing the mineral
Calcium ion (Ca^{2+})	calcite	$CaCO_3$	limestone
Carbonate ion (CO_3^{2-})			
Sodium ion (Na^+)			
Chloride ion (Cl^-)			
Magnesium ion (Mg^{2+})			

* A **mineral** is an inorganic substance, usually with a definite chemical composition, physical properties and characteristics. All salts are minerals and are composed of particles in solution with electrical charge (ions). An example is the compound and mineral sodium chloride (salt) whose chemical formula is NaCl and in aqueous solution dissociates into chloride ions (Cl^-) and sodium ions (Na^+).

Conclusion

1. How do you explain the difference in the concentration of calcium ions in different brands of bottled water?
2. Explain the origin of the name "bottled mineral water".

Hypothesis

A water solution is transparent and you cannot see the components of the solution: the compound or substance that acts as a solvent and the compounds or substances that are dissolved in it (solutes). Imagine you have "magic glasses" through which you can see the components of the solution. Draw each of the following three aqueous solutions to show how the particles of solvent (H_2O) and dissolved substances (solutes) would look through the "magic glasses."

Seawater	Bottled water	Deionized water
		

Particles of the solution as seen through "magic glasses"

Classification

Differences between deionized water, bottled water, sea water, and tap water.

Read the following passages and write two questions regarding each type of water.

Deionized water - is water used in industrial laboratories and research laboratories. Deionized water can be obtained from the common water solution through a laboratory process in which there is a separation between the particles of water and most of the particles dissolved in solution. The composition of deionized water is close to that of pure water.

Bottled (or mineral) water - the concept of bottled mineral water is quite complicated. The name comes from bottling spring water from springs in Europe, which is distinguished by the

high content of dissolved ions as a result of the dissolution of the minerals that make up rocks through which rainwater infiltrated into groundwater. These waters were considered (and still are) to possess curative powers. Typically, mineral water refers to a water solution that has a lower concentration of dissolved minerals as compared to tap water. In addition, it has a bacteriological purity that is within international standards.

Tap water - is a solution of water that can reach houses from two main sources:

1. Water sources found on the surface, such as water from lakes and rivers.
2. Underground water sources such as aquifers that supply water by extraction from pumps placed in wells of varying depth. Aquifers are the result of infiltration of rainwater through the rocks. Later in the chapter, we will learn that tap water is extracted from wells in the coastal plain, and is often relatively rich in salts due to the type of rock through which it infiltrates.

Sea water - is a solution of water in which the concentration of dissolved salts is very high.

Activity 4:

How does water get salty?

In the previous activity, we learned that drinking water is not pure water, but rather a solution that contains mostly water particles and other particles of different substances. This activity will characterize the special properties of the sea (ocean) as a solution.

Part A: How do dissolved minerals (salts) get into the ocean?

Laboratory instruments and materials:

2 beakers containing 100 mL of water, a container with mineral dust from halite (salt) known as sodium chloride (NaCl), a container with mineral calcium sulfate ($CaSO_4$), 2 teaspoons.

Experiment

Description of experiment:

1. Taste the water before adding sodium chloride. How would you describe the taste?

2. Add a teaspoon of sodium chloride to the glass of water, stir gently, wait a few seconds, and see if sediments appear at the bottom of the glass. Repeat the process until sediments appear at the bottom of the glass. Summarize your findings in the table below.
3. In the other cup, add a teaspoon of gypsum minerals and stir gently, wait a few seconds, and see if sediments appear at the bottom of the glass. Repeat the process until sediments appear at the bottom of the glass. Summarize your findings in the table below.

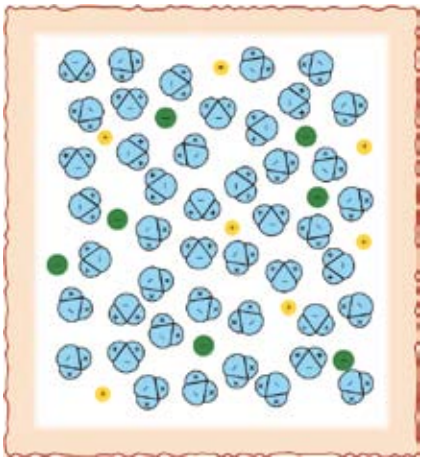
Number of teaspoons	Did sediments of sodium chloride (salt) appear in the bottom of the glass?	Did sediments of calcium sulfate appear in the bottom of the glass?
1 teaspoon	yes / no	yes / no
2 teaspoons	yes / no	yes / no
3 teaspoons	yes / no	yes / no
4 teaspoons	yes / no	yes / no
5 teaspoons	yes / no	yes / no
6 teaspoons	yes / no	yes / no

Observations

1. How many teaspoons of sodium chloride were dissolved in the water before solids formed?
2. How many teaspoons of calcium sulfate were dissolved in the water before solids formed?
3. What would happen, in your opinion, if you were to add more teaspoons of sodium chloride to the water?

Conclusion

Which of the minerals, halite or gypsum, dissolved better in water? Explain.



Aqueous solution (water molecules + ions) as seen through magic glasses

How to determine the concentration of a solution:

You can define the concentration of the solution as the amount of substance (g) that was dissolved in a defined volume of solution (liter). For example, the concentration of sodium chloride in a saturated solution at a temperature of 20°C, is 357 grams per liter (g/L). Comparatively, the concentration of calcium sulfate in a saturated solution at the same temperature (20°C) is only 2 g/L. That is, in each liter of solution, only 2 grams of calcium sulfate can be dissolved.

Questions

1. What will happen if you add 500 grams of sodium chloride to one liter of water?
2. Which sample do you expect to have a low concentration of sodium chloride, and which do you think will have a high concentration?

Research Exercise

Part B: An exercise of geo-hydrological detective research, or How did sea water become salty?

As we all know, sea water has a salty taste. However, at the time when the oceans were formed on Earth, water on the face of the Earth had no salt, or was, as we call it "fresh water."

1 liter of water

500 grams sodium chloride

In this activity, try to understand how the oceans became salty. We will join the laboratory of Professor Hydrology and try to examine how to characterize sea water.

Description of the activity:

On trays before you, you will find **5 types of rocks:** limestone, dolomite, chalk, salt, and gypsum. Remember that the Appendix of the book includes cards to identify rocks and soils. The trays have labels that indicate which ions are contributed by each of the five kinds of rocks, to the solution of ocean water. Professor Hydrology sent us a chart that shows the concentration of ions that have been found to be dissolved in sea water. According to him, and with the help of the table, cards, and some detective skills, determine which minerals are contributing ions to the solution of sea water.

...I am sorry to tell you, but again, on the way to school, the samples were dropped and the labels were separated. We have no idea which rocks are a source of minerals found in sea water. We called the lab and talked with Professor Hydrology and he said we have the ability to match the labels to the rocks. He sent a table containing the concentration of ions in the sea water. Again, he says that with the help of the table, cards, and a little skill, that we can solve the mystery.

So let's get to work...

Ions found in the Mediterranean sea water	Chemical Symbol	Concentration (grams per liter)
Sodium ion	Na^+	10.70
Magneisum ion	Mg^{2+}	1.27
Calcium ion	Ca^{2+}	0.40
Potassium ion	K^+	0.40
Chloride ion	Cl^-	19.40
Sulfate ion	SO_4^{2-}	1.42
Bromide ion	Br-	0.07
Carbonate ion	CO_3^{2-}	0.0142

The mission: Use the cards (in the Appendix) to identify rocks and soils, along with the previous table. Try to to match each mineral to the rock that contributes that ion to the sea water solution. Record your findings in the table below:

Ions found in sea water		Minerals composed of ions		Rock composed of the mineral	
Ion A	**Ion B**	**Mineral**	**Mineral compound**	**Rock A**	**Rock B**
Na^+	Cl^-	Halite	Sodium chloride NaCl		
		Calcite	Calcium carbonate $CaCO_3$		
		Gypsum	Calcium sulfate dihydrate $CaSO_4 \cdot 2H_2O$		
		Dolomite	Calcium and magneisum carbonate $CaMg(CO_3)_2$		

Additional Information

The water on Earth is generated as a result of volcanic eruptions, which threw a lot of water vapor into the atmosphere. This water vapor cooled, condensed, and fell as rain, which accumulated on the face of the Earth. In other words, in principle, all water on Earth was fresh water in the beginning. Scientists assume that at a later stage, more water came to planet Earth when a comet containing ice, crashed into the Earth, and large amounts of water were added. Since then, water runoff has flowed into the oceans, and into the groundwater system. This water contains ions, whose source is the dissolution of the minerals that make up rocks. This increases the concentration of salts in water. From this, we conclude that the composition of seawater and the concentration of salts in it are the result of the interaction between the **geosphere** and **hydrosphere.**

Activity 5:

Are there solutions in my home?

What is a solution? – Generalization:

There are substances that when mixed, create a solution. However there are many liquids that do not dissolve in each other (they do not create bonds between their ions) and if we try to mix them, we get two separate layers (e.g., oil and water).

1. At home, prepare solutions that are familiar from everyday life, and record their properties in the table, based on the examples. If you did not generate a solution (a homogeneous mixture), indicate this in the table.

Solution	Solvent	Solute	Solution properties
1. Water and oil mixture	Water	Oil	Did not create a solution. Two separate layers of water and oil.
2. Bleach (for cleaning and disinfecting)	Water	Sodium hypochlorite	Yellowish-green color. Characteristic strong smell of chlorine.
3. Paracetamol® liquid (pain reliever and fever reducer)	Water	Paracetamol® (acetoaminofen)	Maroon-colored, viscous solution, characteristic odor.
4.			
5.			

2. Write at least two characteristics of a solution.
3. In the previous activity, we defined the term "concentration." Explain in two sentences what the concentration of a solution is.

Product Name	Product Function	Concentration	Units of concentration
Example: "Bubbles"	Dishwashing detergent	18% of active substance	Grams of active substance in a liter of detergent

4. In your opinion, why is it important to know the concentration of a solution?

Hint: In everyday life, we use many substances that are in fact solutions. For example: medicines, cleaning materials, concentrates of various foods, and even pesticides.

Activity 6:

What affects solubility?

In this activity, we will find the special properties of aqueous solutions and try to understand why water is the most common liquid on Earth.

Experiment

Part A: Development of the experiment

On the table are five 100-mL graduated cylinders, a closed container containing 90% alcohol, and a closed container containing distilled water (almost pure H_2O).

Observations

1. Pour exactly 40 mL of distilled water (almost pure H_2O) into graduated cylinder #1.
2. Pour exactly 40 mL of alcohol into graduated cylinder #2.

Inference: What will the final volume of liquid in a graduated cylinder (for example, #3) be if you pour the entire contents of the first two samples (water and alcohol) into the empty cylinder? (circle one response).

80 mL a little more than 80 mL a little less than 80 mL

3. Now pour the contents of the first two samples (water and alcohol) into graduated cylinder #3. Write down the volume of liquid in mL in each of the boxes in the table below.

Average the results of the volume of liquid in the third cylinder across the groups in your class.

Group 1	Group 2	Group 3	Group 4	Group 5	Average:

Conclusion

The experiment **strengthened or refuted the inference?**

Part B – Development of the experiment

1. Pour exactly 40 mL of alcohol into graduated cylinder #4.
   Does the level of the sample decrease in half a minute?
   Pour exactly 40 mL of distilled water into graduated cylinder #5.
   Does the level of the sample decrease in half a minute?
2. How does this observation help to explain the outcome of the experiment?
3. If you had magic glasses through which you could see the water particles and alcohol particles, how would you imagine the process that occurred in this experiment would look? Try to draw it.

Specimen No. 1 Distilled water	Specimen No. 2 Alcohol	Specimen No. 3 Water and alcohol

Knowledge Organization

Try to summarize what happened in graduated cylinder #3.

Indicate whether each statement describes an observation, a conclusion, additional information or a hypothesis (circle one response).

1. At first, the volume of liquid from graduated cylinder #1 was 40 mL and the volume of liquid from graduated cylinder #2 was also 40 mL. After the liquids were emptied into graduated cylinder #3, we found that the volume of liquid in cylinder #3 was less than 80 mL.
   Observation / conclusion / additional information / hypothesis
2. When we poured 40 mL of alcohol into graduated cylinder #4, we noted that the alcohol level in the specimen did not go down in half a minute.
   Observation / conclusion / additional information / hypothesis
3. When we poured 40 mL of water into graduated cylinder #5, we noted that the water level in the specimen did not go down during a minute.
   Observation / conclusion / additional information / hypothesis
4. The volume obtained in graduated cylinder #3 is less than 80 mL and this is not the result of evaporation of particles of alcohol and/or water.
   Observation / conclusion / additional information / hypothesis
5. The density of the particles of water and alcohol, when mixed, is greater than the density of the particles of alcohol and the particles of water when separate.
   Observation / conclusion / additional information / hypothesis

6. An attractive force is generated at bonds between the particles of water and alcohol. This force of attraction brings the particles closer together, and reorganizes them, resulting in a higher density* compared to when they were separated.
   Observation / conclusion / additional information / hypothesis
7. Between the water particles and alcohol particles, there is a gap.
   Observation / conclusion / additional information / hypothesis

* **Density** refers to the amount of mass per unit volume. For example, g/L.

Although this experiment doesn't allow you to reach conclusions regarding the existence of bonds, but only to make conjecture, this hypothesis was verified scientifically, and therefore we can assert that other bonds are formed between the particles of water and alcohol. The liquid obtained in graduated cylinder #3 is known as a **solution** and the process we saw in this experiment is called **dissolution**. In the process of **dissolving**, alcohol particles were scattered amongst the water particles to create a water and alcohol solution.

Thinking Scientifically

1. Scientific research often seeks to answer the questions posed by research.
   What is the research question in this experiment?

2. In a scientific experiment, we can examine how a system reacts to changes.
   What change occurred in this experiment with alcohol and water samples that we can use to answer the research question?
   In a scientific experiment, we examine how one variable affects another variable. For example, in the experiment we just completed, the variable that influences (independent) is the mixture of alcohol and water. The variable that is influenced (dependent) is the density of alcohol and water.

3. In any scientific experiment, you want to check whether the observation made is caused solely by the change in the variable analyzed, and not by other factors. The research component, whose role is to help in this is called a **control**.

For example: In the experiment carried out, some of the students assumed that the decrease in water level was caused by the evaporation of alcohol or water from the sample during the experiment, and not by attractice forces between the two compounds.
Which of the five graduated cylinders is the control?

4. In any scientific experiment, you want to check that the observations are accurate, and therefore you can reach a reliable conclusion.
   Factors that influence the reliability of observations are:
   Measurement Error - for example, in the experiment, there was a need to carefully measure volume. 40 mL of alcohol, and 40 mL of water were added to a graduated cylinder. If you accidentally added more mL of each sample, you would not have obtained the same results, and therefore, you would not have reached the same conclusions.
   Number of Observations (repetitions) - to verify that the experimental results are accurate, you should carry out at least three observations per experiment. The results present the average of all observations. Explain why.

5. Is the experiment conducted in class reliable in terms of scientific experiments?
   Often in class, each group carries out an experiment, so as a group, 5-6 repetitions of the experiment were performed. In this case, based on an average group size, you can reach reliable conclusions.

Knowledge Organization

What affected the solubility?

In the previous activity, we determined that certain particles can dissolve together.
In the column on the left are variables that influence the solubility of substances in nature and everyday life. In the right column, you will find observations conducted and the conclusions you have arrived at so far.

Match the variable that influences the solubility, with the observation or conclusion affected by this variable. It is possible that each variable accounts for more than one observation or conclusion. In your notebook match the numbers with the letters.

Variable that influences	Observation or conclusion influenced by variable
1. Types of particles: as we saw, not all particles are dissolved with each other. Properties of substances influence their solubility.	A. In the solution of seawater, there are a large number of ions surrounded by water molecules, for example, sodium ions (Na^+), magnesium ions (Mg^{2+}), and calcium ions (Ca^{2+}). B. The density of the particles of water and alcohol, when mixed, is greater than the density of water particles, and the density of alcohol particles, when they are separate. C. The concentration of sodium chloride in a saturated solution at a temperature of 20°C, is 357 g/L. The concentration of calcium sulfate in a saturated solution at a temperature of 20°C, is 2 g/L.
2. Arrangement of particles in the solution: the solvent molecules surround the solute molecules.	D. There are liquid mixtures that form a solution. However, there are many other liquids that do not tend to mix with one another (they don't create bonds between particles) and when we try to mix them, we get two separate layers (e.g., oil and water).

SPECIAL PROPERTIES OF WATER

Activity 1:

Demonstrating the properties of water by the learning method most appropriate to me

In previous activities, you characterized water as a solvent. In this activity, try to understand the special properties of water molecules, which allow you to interact with a large number of solutions in nature and in everyday life.

In the following pages, you will find five different activities dealing with this subject: the properties of water. All learning activities deal with the same subject, however each is based on a different method of learning.

Choose the preferred learning method for you, according to the following guidelines

How to choose: Put an "X" by each statement with which you agree. The learning method that has the most "X's" is the method that best suits you.

Learning Method 1

- I have many questions about how things work. ☐
- I solve arithmetic problems quickly. ☐
- I like math. ☐
- I like to play chess, checkers, or other strategy games. ☐
- I like to solve logic puzzles or other riddles. ☐
- I like putting things into categories or hierarchies. ☐

Total Score ___

Learning Method 2

- I write better than the average person. ☐
- I love creating stories and telling jokes and stories. ☐
- I enjoy verbal games. ☐
- I enjoy reading. ☐
- I like rhymes, puns, expressions with homonyms, etc. ☐
- I like to listen to broadcasts (stories, radio talk shows, audio books, etc.) ☐

Total Score ___

Learning Method 3

- I have the ability to detect dissonance or an instrument out of tune. ☐
- I remember the melodies of songs. ☐
- I play a musical instrument or sing in a choir or other vocal group. ☐
- Humming is unconscious. ☐
- I am sensitive to environmental sounds (e.g., the patter of rain on the roof). ☐
- I have a positive reaction when I hear music. ☐

Total Score ___

Learning Method 4

- I read maps and graphics much more easily than text. ☐
- I like activities that have an artistic nature. ☐
- I draw in complex ways for my age. ☐
- I like puzzles, mazes, and other similar activities. ☐
- I build relatively interesting three-dimensional structures (e.g., with Legos®, etc.). ☐
- I most enjoy the images while reading text. ☐

Total Score ___

Learning Method 5

- I excelled in one or more sports activities. ☐
- I move, drum my fingers, or feel restless when I sit in one place long. ☐
- I like taking things apart and then putting them back together. ☐
- I like to play with the things I see. ☐
- I like running, jumping, wrestling, or similar activities. ☐

Total Score ___

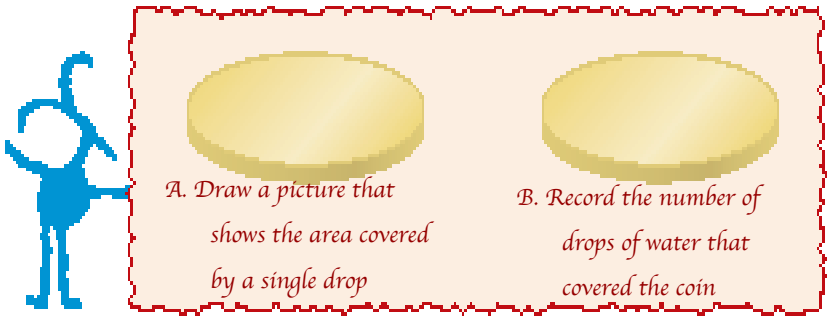
Learning Method 1: A Penny

Experiment 1: How many drops of water can cover a penny?

For this experiment, you will need the following **materials**: a dropper, 3 coins (pennies), a container with distilled water.

Development of the Experiment:

1. Predict how many drops of water will cover a penny. Prepare a table of "forecasts" from each student in your group, and calculate the average. Number of members of the group: _____, the group average forecast: _____ drops.
2. Use the dropper to drip water on the coin and record the results in the illustration below.



Conclusion

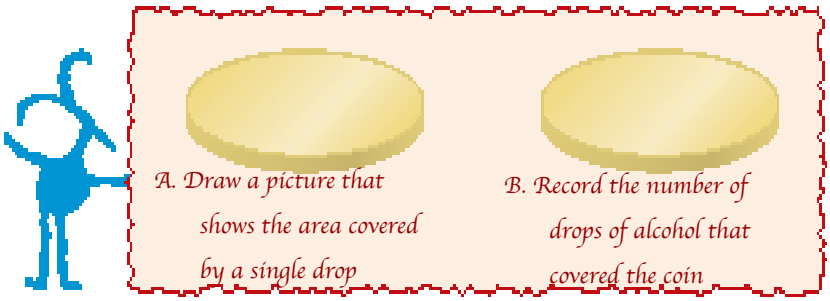
Compare the result with the average forecast. If the result is far from the average forecast, try to find the cause.

Experiment 2: How many drops of alcohol cover a penny?

For this experiment, you will need the following **materials**: a dropper, 3 coins (pennies), a container with 90% alcohol.

Development of the Experiment:

1. Predict how many drops of alcohol will cover a penny. Prepare a table of "forecasts" from each student in your group, and calculate the average. Number of members of the group: _____, the group average forecast: _____ drops.
2. Use the dropper to drip alcohol on the coin and record the results in the illustration below.



Conclusion

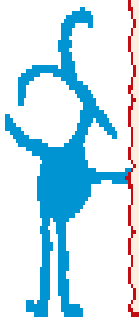
Compare the result with the average forecast. If the result is far from the average forecast, try to find the cause.

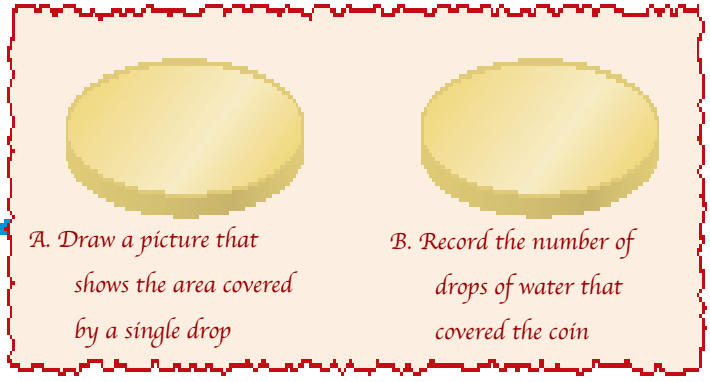
Experiment 3: Influence of soap

For this experiment, you will need the following materials: a penny, a dropper, a container of distilled water, a small plate of dishwashing soap or detergent.

Development of the Experiment:

1. With your finger, apply a small amount of dishwashing soap or detergent to the surface of a dry penny.
2. Predict how many drops of water will cover a penny. Prepare a table of "forecasts" from each student in your group, and calculate the average. Number of members of the group: _____, the group average forecast: _____ drops.
3. Use the dropper to drip water on the coin and record the results in the illustration.





A. Draw a picture that shows the area covered by a single drop

B. Record the number of drops of water that covered the coin

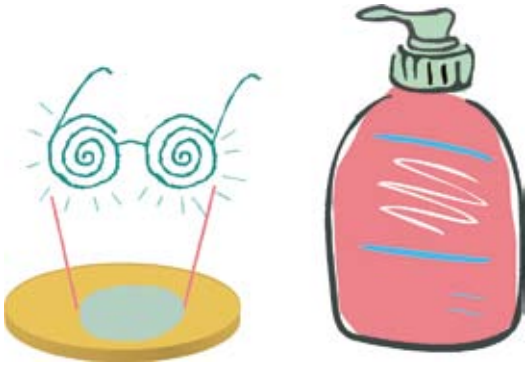
Conclusion

What is the impact of the soap on the water? Try wearing the magic glasses and describe what happened.

Now move to the of "magic" experiment found on page 135.

Synthesis

1. After carrying out all the experiments and reading the information about the properties of water, how do you explain the special properties of water?
2. Don't forget to read the explanations on pages 136 - 138 and try to find an explanation for the special properties of water discovered in this activity.

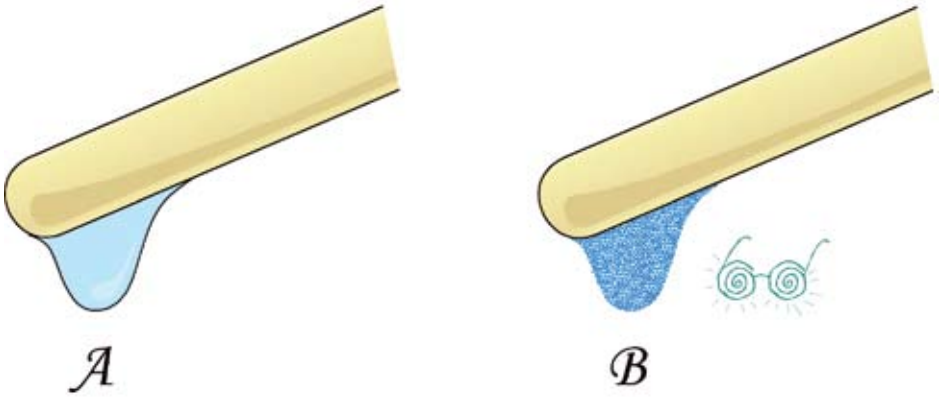


Learning Method 2:

Experiment 1 - Why does water not fall?

The phenomenon: In illustration "A" we see a glass test tube with a small drop of water hanging on. Illustration "B" shows an imaginary drawing of particles that together make up the drop of water, as seen through "magic glasses."

According to all the ideas and assumptions presented so far, **a drop of water is a liquid that consists of a huge number of particles**. Each tiny particle of water is a body with a mass. Although this mass is tiny, the physical laws under which each body is attracted by another body do not change. Because the tiny drop is attracted by a large body - the planet Earth - it is expected that every particle of water is attracted to, and will fall on the surface of the Earth.



Development of the Experiment:

Carry out the observation described in the illustration using a test tube and water.

Hypothesis

Why do all the water particles, which together makeup the drop, remain clustered together? What holds them together despite the attraction of planet Earth?

Observations

Experiment 2 – Water "Magic"

The illustration shows a hand holding a bunch of pieces of magnets. You will use magnets in the next experiment.

1. Try to separate the magnet pieces. What keeps them together in clusters?

Hypothesis

2. Why do the magnets not separate from each other? Why do they not fall apart anywhere on planet Earth? Why do they attract each other?
3. Use the example of the "bunch of magnets" to help you respond to the question about the water particles, which together make up a drop. Why do they remain linked together?

Now move to the "magic" experiment found on page 135.

Observations

Experiment 3: Does water have the force of attraction?!

For this experiment, you will need the following **materials:** pieces of paper, a plastic ruler.

Development of the Experiment:

1. **Place a small piece of paper on the table. If you touch the paper with a dry finger, do you think the paper will stick to your finger?**
2. Wet the paper with a drop of water and touch the paper with the top of your finger. Did the paper stick to your finger this time?

3. How can you explain this phenomenon? (you will build on this experiment during the "magic" experiment).
4. Don't forget to read the explanations on pages 136 - 138 and try to find an explanation for the special properties of water discovered in this activity.

Synthesis

Mission - In your own words, explain the phenomenon of a "particle" of water in a hanging drop. Illustrate the special properties of water you have learned about in the experiments you conducted, and the information you read.

Learning Method 3:

Experiment 1 – A musical finger

For this experiment, you will need the following **materials**: 2 crystal wine glasses with thin edges, tap water, oil.

Development of the Experiment:

1. Dip the tip of your finger into the water. Now pass your finger over the top of the crystal glass, with slight pressure. Make several quick laps around the rim and describe the effect of this action.

Hypothesis

2. What caused the phenomenon you generated?
3. Now wet the tip of your finger with oil and repeat the experiment. This time, did you manage to produce sound?

Now move to the "magic" experiment found on page 135.

Synthesis

1. Prepare a brief musical presentation with the cup of water.
2. Put on the magic glasses and imagine what happens between the finger, the particles of water, and the glass. Write down what happened in s musical way (a rap).
3. Don't forget to read the explanations on pages 136 - 138 and try to find an explanation for the special properties of water discovered in this activity.

Prepare a full explanation for your peers about the unique properties of water based on the experiments you conducted.

Learning Method 4:

Experiment 1 – The painter's brush

For this experiment you will need the following **materials:** a soft hair paint brush, paper, a glass, tap water, watercolors, pencil.

Synthesis

Development of the Experiment:

Dip the brush in clear water, and keep it submerged.
Observation "A": Describe the hairs of the brush.
Hypothesis "A": Please explain this phenomenon.

Continuation of the Experiment:

Take the brush out of the water.

Observation "B": Describe the hairs of the brush now.

Hypothesis "B": How could this be true?

Continuation of the Experiment:

Dip the brush into a little color and paint with it. Now try to paint with the medium dry brush, and then the dry brush.

A. Why does water make the hairs of the brush "stick" together?
B. The gills of fish are spread out in the water, and when they are pulled out of water, the gills stick to each other. What is the significance of this phenomenon for the life of the fish?

Observation C: What influence does the amount of water have on the texture of the painting? How would you take advantage of these properties in the painting?

Continue painting and drawing to show what you've learned.

Now move to the "magic" experiment found on page 135.

Synthesis

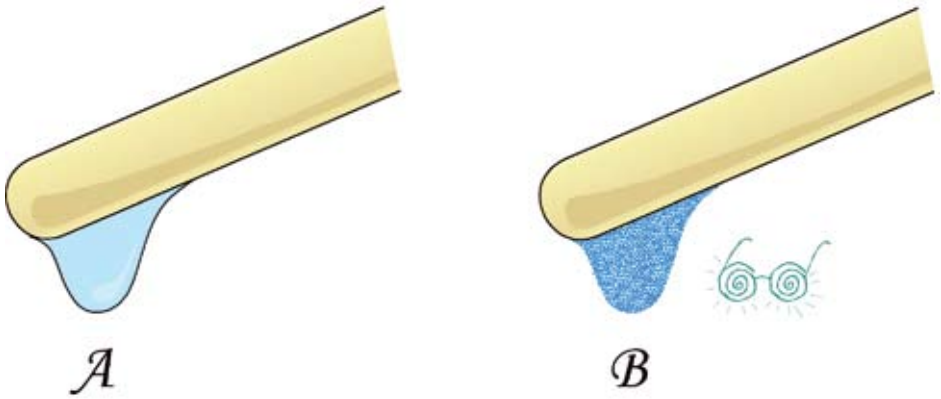
Mission:

1. Continue painting with different amounts of water.
2. Put on the magic glasses and imagine what happens with the hairs of the brush. Use clay and sticks to build a **three-dimensional model** that illustrates the phenomenon.
3. Don't forget to read the explanations on pages 136 - 138 and try to find an explanation for the special properties of water discovered in this activity.
4. Prepare a full explanation for your peers about the unique properties of water based on the experiments you conducted.

Learning Method 5:

The phenomenon: In illustration "A" we see a glass test tube, with a small drop of water hanging on. Illustration "B" shows an imaginary drawing of particles that together make up the drop of water, as seen through magic glasses.

According to all the ideas and assumptions presented so far, **a drop of water is a liquid that consists of a huge number particles**. Each tiny particle of water is a body with a mass. Although this mass is tiny, the physical laws under which each body is attracted by another body do not change. Because the tiny drop is attracted by a large body - the planet Earth - it is expected that every particle of water is attracted to, and will fall on the surface of the Earth.



Hypothesis

Why do all the water particles, which together makeup the drop, remain linked together? What keeps them together against the attraction of planet Earth?

This photo shows some dewdrops. Many living creatures, such as insects, drink the morning dew. Why do you think the dew drops are spherical?

Now move to the "magic" experiment found on page 135.

Hypothesis

Mission A:

Use clay and sticks to build a three-dimensional model of the particles of water in a suspended drop.

Mission B:

Create a performance to show what happens to the raindrop.

Mission C:

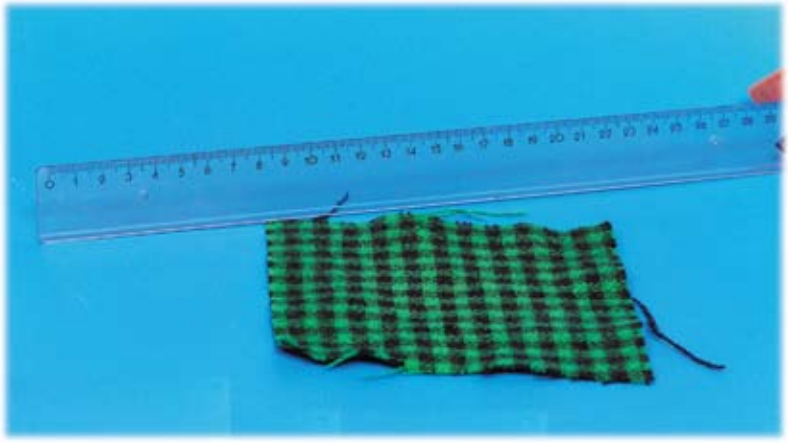
Don't forget to read the explanations on pages 136 - 138 and try to find an explanation for the special properties of water discovered in this activity.

Prepare a full explanation for your peers about the unique properties of water based on the experiments you conducted.

Experiment

The "Magic Ruler"

Surely in the past, you have done an experiment in which you rubbed a plastic ruler with a wool cloth. As a result of the friction, bits of paper can then stick to the ruler. (If this experiment is unfamiliar, you are invited to try it). The explanation for this phenomenon is that the friction on the ruler charges it with "static electricity." Let's see how this electricity affects the flow of water.



Development of the Experiment:

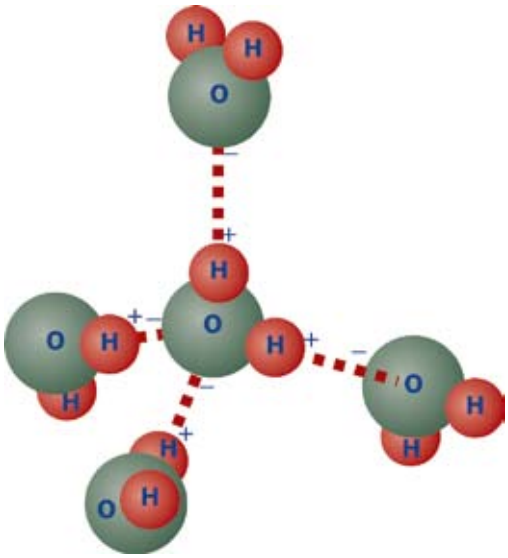
1. Allow water to trickle from the water faucet at a very slow rate.
2. Charge the ruler with static electricity by rubbing it vigorously with a piece of wool cloth.
3. Hold the ruler near the stream of water, but don't get it wet.

Synthesize your findings from this activity, according to the parts of scientific thinking: observation, hypothesis, additional information, and conclusion.

Additional Information

If we use the magic glasses to look at a drop of water, we notice that the water is composed of tiny particles. These tiny particles are called molecules. Each water molecule consists of two hydrogen atoms and one oxygen atom. In the language of chemical formulas, water is H_2O. A drop of water contains millions and millions of water molecules.

The formula of water (H_2O) represents a structure that is schematically shown in the following illustration:



As can be seen in the illustration, the water molecule is polar. That is, electrons in the molecule are more concentrated around the oxygen atom compared to the hydrogen atoms. This results in a negative pole next to the oxygen atom, and a positive pole next to the hydrogen atoms. The illustration above shows what happens when a number of water molecules are located together. In this situation, the electrical charges cause an interaction (mutual forces - attraction or repulsion) between the molecules. These adjust so that the positive pole of a molecule of water is facing the negative pole of another molecule. As a result of the mutual attraction between the positively charged hydrogen atom in a molecule, and the negatively charged oxygen atom in another molecule, bonds are created between the water moelcules known as “hydrogen bonds” (represented by dashed lines above). The hydrogen bonds that are created between the polarized molecules of water are responsible for the “sticky” properties of water.

Synthesis

Summary of Activities:

Below are explanations of the experiments carried out to understand the special properties of water. Beside each explanation, jot down which parts you already know, and any questions you have.

Explanation "1":

The finger does not move evenly over the surface of the glass. The forces of attraction between the water particles and the glass generate a continuous jumping on the edges of the glass. This jump continuously generates a vibration, and therefore a sound. This is similar to a violin. The violinist applies a resin to the hairs of a violin bow. This creates a "stickiness" between the bow and strings of the violin. The motion of the bow generates a vibration, and this makes sound.

Explanation "2":

The forces of attraction between water particles are apparent between the finger and water, and between water and paper. Water serves as an adhesive medium between the paper and finger. The "sticky" properties are rooted in the structure of water particles. What "sticks" the water particles to each other, are the attractive forces generated between them. Water is a "sticky" material because the water particles are strongly attracted to each other and also strongly attracted to particles of the compounds to which it "sticks."

Explanation "3":

There are attractive forces between the particles of water. If we introduce a brush into water, the attractive forces between the water particles create water particles that penetrate the brush bristles and separate them from one another. If we take the brush out of the water, the water flows down as a result of the Earth's attractive forces. The small amount of water remaining between the bristles of the brush creates an attraction between the water and the bristles so that the water works like an "adhesive."

Explanation "4":

If we drop water on a coin, it is spherical (with a height and volume) due to the force of attraction between the particles. It does not "spread" out on the surface of the coin. Other liquids, like oil,

do not have large attractive forces between the particles, so they immediately spread out on the surface of the coin, and do not form into a spherical drop.

Explanation "5":

The forces of attraction between the particles of water are what allows dew drops to have a spherical shape. As a result of this structure, many insects are able to drink the dew drops and can even survive in desert conditions.

Activity 2:

Frozen Water

In previous activities, we learned about the special properties of water as a solvent. However, water has other special properties which have a significant influence on planet Earth in general, and on the biosphere in particular. In the next activity, you will learn about the unique properties of water as a solid.

The image above shows a lake in the advanced stages of becoming frozen. This lake is located in a climate where temperatures drop to 10°C below zero (14°F) during the winter.

1. What will happen to creatures who live in the lake during the winter? Will they survive at such low temperatures? Explain.
2. From this picture, it seems that despite the low temperatures, the lake did not freeze completely, but only at the top. Try to give a possible explanation for this phenomenon.

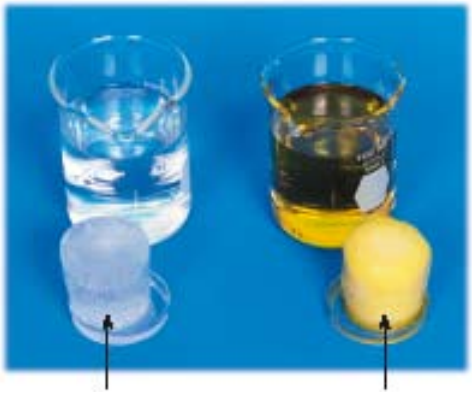
Experiment

Experiment 1: Can a solid float in its own liquid?

For this experiment, you will need the following **materials**: an ice cube, a cube of frozen olive oil, a beaker with 100 mL of water, a beaker with 100 mL of olive oil.

Development of the Experiment:

1. Plate the ice cube in the container with liquid water.
2. Place the frozen olive oil cube in the container of liquid olive oil.



Ice cube

Cube of frozen olive oil

Observations

1. What happened to the ice cube in the liquid water?
2. What happened to the cube of frozen olive oil in the liquid oil?

Conclusion

1. What is your conclusion from the experiment?
2. Try to explain the phenomenon you discovered in this experiment.

Most substances in nature and in everyday life behave similar to the olive oil. This means that the substance, when found in solid form, will usually sink into the same substance when it's in its liquid state. Water is an unusual substance because solid state water will float on liquid water. This phenomenon and abnormal behavior of water is known as an anomaly.

Experiment

Experiment 2: What happens to the volume of water when it freezes?

For this experiment, you will need the following **materials**; small plastic bottle with cap, water, freezer, sewing thread, ruler.

Development of the Experiment:

1. Fill the bottle completely with water and place the cap on it.
2. Measure the perimeter of the center of the bottle using sewing thread and a ruler. Record the perimeter of the bottle (in centimeters) in your notebook.
3. Place the bottle of water in the freezer for a day.
4. Measure the perimeter again, in the same place you measured before, and record the perimeter of the bottle of frozen water. What do you think will happen if you perform the same experiment with a glass bottle?

Conclusion

Conclusions and hypotheses:

1. What is your conclusion from the experiment?
2. Try to explain the phenomenon discovered in this experiment.

Synthesis

As a result of this activity, try to respond again to the two questions related to the photograph that appears on page 138.

a. What will happen to the creatures that live in the frozen lake?
b. What will happen to the water in a frozen lake?

You may be interested to know: How can there be life in frozen lakes and seas?

In this activity, you learned that water in a solid state occupies a larger volume, compared with the same amount of liquid water. The result is that solid water tends to float in liquid water.

It is difficult to explain the phenomenon because it is complex, and is influenced by the properties of water. During the freezing process, bonds are formed between water molecules that give rise to an ordered structure. In this structure, water molecules are farther apart, and therefore, occupy a larger volume compared to when the molecules are in liquid form. This anomalous property of water is of great important in nature, specifically in cold areas found on Earth. In winter, water at the freezing point is less dense (the molecules are further apart) and therefore it is lighter than its surroundings and floats upwards. The top layer of water is the first to freeze, and because the solid ice is lighter and less dense than water, it remains floating on the water, and creates an insulating layer that prevents the deeper liquid water from freezing. The result is that aquatic creatures can live beneath the ice.

If water were like other substances, its solid state density would be higher than its liquid state density. Whenever the top layer of water would freeze, it would sink to the bottom of the sea or lake. This process would result in the freezing of all the water in a sea or lake, and therefore the possible death of aquatic creatures living in that environment.

Knowledge Organization

1. Choose one of the following four methods to organize the knowledge acquired with respect to the special properties of water, and the natural phenomena and everyday life in which water plays a central role:

a. Story.
b. Drawing.
c. "Power Point"® Presentation.
d. Concept/idea map.

Additional Information

Cloud Formation

The process of cloud formation is an important stage in the water cycle. For clouds to form in the atmosphere requires the presence of:

1. water
2. dust particles that act as condensation nuclei
3. changes in temperature or pressure

How is a cloud formed?

The following processes must occur:

1. Evaporation - When the sun heats a wet surface, water evaporates (changes from a liquid to a gas).
2. Rising water - The water vapor is driven by thermal air currents and rises into the atmosphere (ascends).
3. Condensation - The water vapor condenses (changes from a vapor to a liquid or a solid) at various altitudes, depending on changes in temperature and pressure that occur (descends), giving rise to different types of clouds.

The video at the website below will help you better understand this process:

http://www.youtube.com/watch?v=uoHCMGBgIFQ