

Science and Technology for Secondary School

The Blue Planet

The Water Cycle in the Earth Systems

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Curricula


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This publication was made possible by the support and participation of UNESCO, Organization of the United Nations Educational, Scientific and Cultural Organization.

Please note: The English edition of The Blue Planet was written for the United States, but can be used for any English-speaking country in the world. We encourage you to adapt the materials for your local region and environment to increase the relevance of the topic to the students in your country.

In addition, the targeted grade level for this curriculum is flexible, and could be used with students at a wide range of levels. We suggest looking over the materials and deciding if it is appropriate for your students.

THE BLUE PLANET can be found at this website:

<http://stwww.weizmann.ac.il/g-earth/geogroup/main.asp?pagekind=4&ID=20>

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Publisher: Weizmann Institute of Science
English Edition 2012

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Preface

All signs point to our environment moving in a frightening direction: The water will be a serious problem in the 21st century. Obviously, it is expected that this is an extremely critical change, and it could be the cause of a series of crises in different parts of the world. There are compelling data that we all know, for example, that 1.2 billion people lack access to safe drinking water, 2.4 billion people lack access to adequate sewage systems, from 5 to 8 million people die annually from diseases and disasters related to water, including 6,000 children per day. The expected impact as a result of global changes (such as the continued global population growth, changes in land use, migration from rural areas to cities, the excessive growth of large cities and the changes climate, to name just some of the global trends) have likely caused dramatic changes in the hydrological cycle. Although the total amount of water will remain constant, its distribution in time and space on Earth's surface is likely to change considerably, causing extreme hydrological events such as floods and droughts. It is reasonable to assume that there will be changes in water recharge.

Therefore, in the near future we will face a great challenge related to severe water crises, and we find it necessary to consider appropriate adaptation strategies, including appropriate institutional responses. The appropriate response will require, of course, a deeper study of the water cycle. This can only be achieved by launching new educational programs suitable for all individuals, including for community leaders, politicians, citizens, and for future generations.

With this in mind the meeting related to World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa, the United Nations launched the Decade of Education for Sustainable Development (UN DESD). The Decade, under UNESCO management, covers the period 2005-2015. As part of the UN DESD, the UNESCO International Hydrological Programme is implementing a comprehensive program of education, whose main objective is to raise awareness and knowledge about water issues at all educational levels, from kindergarten through programs for Ph.D. study.

It is therefore with great pleasure, that UNESCO presents all the countries of English-speaking world this book, "The Blue Planet - The Water Cycle in the Earth System", which contains a novel program for the study of topics related to water, with the level of primary-secondary education. This program encourages different learning abilities of students and promotes the ability of teachers to teach based on scientific reasoning and focusing on the

developing of higher order thinking skills and reflection regarding environmental issues.

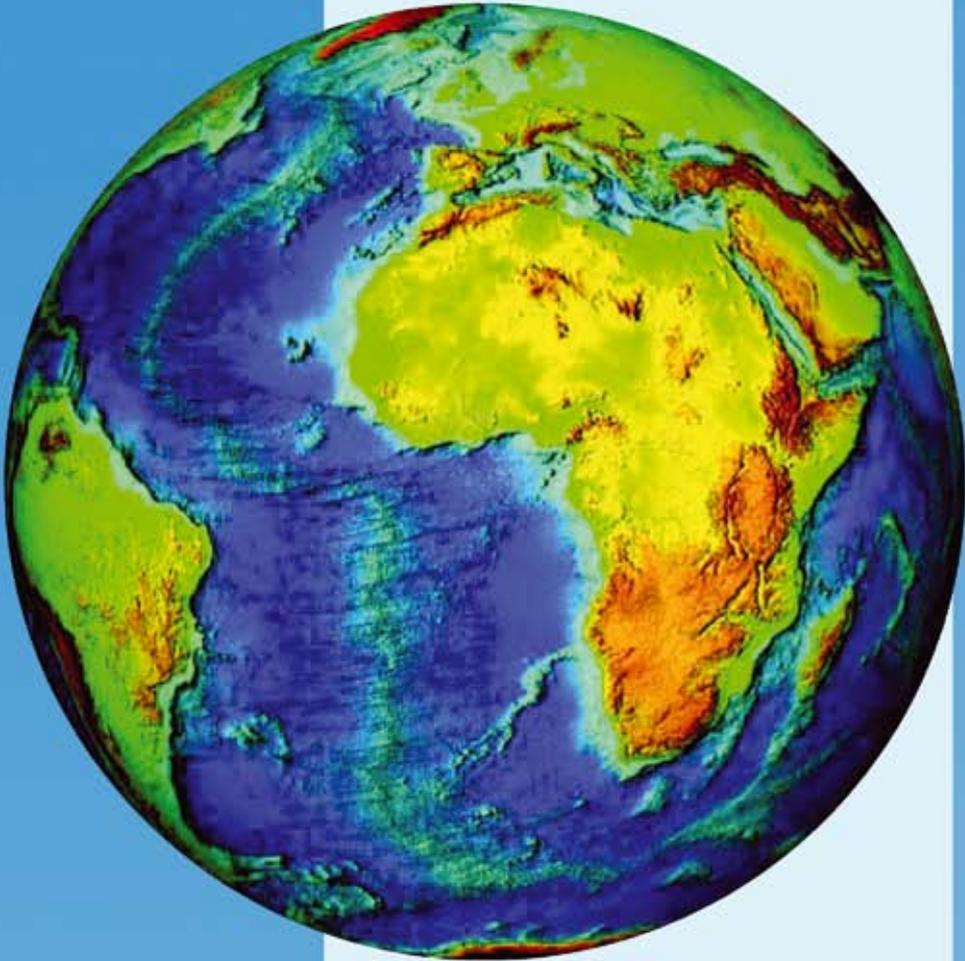
The program was developed, translated, and adapted by the Weizmann Institute of Science in Israel. The program has been generously donated by the Israeli National Commission for the International Hydrological Programme and the Israeli National Commission for UNESCO. We appreciate this generous donation and wish to express our sincere appreciation to all those involved in this noble process.

I have the conviction that “The Blue Planet” will provide the opportunity to immerse young people all over the world in exciting and interesting topics related to water. This will enhance our identification with one of the treasures that have made life possible on our planet. We also hope that this contribution will help improve our knowledge and awareness about the importance of water and our planet as vital and necessary for humankind. We also hope that this generous donation will help avoid misunderstandings and build bridges between people by showing that our needs are similar and that only together can we work to safeguard this vital resource for our common future and a better world. The water binds, and does not divide.

Prof. Andras Szollosi-Nagy
Deputy Assistant Director-General
Secretary of the International Hydrological Programme
UNESCO

Chapter 1:

WHY WATER?



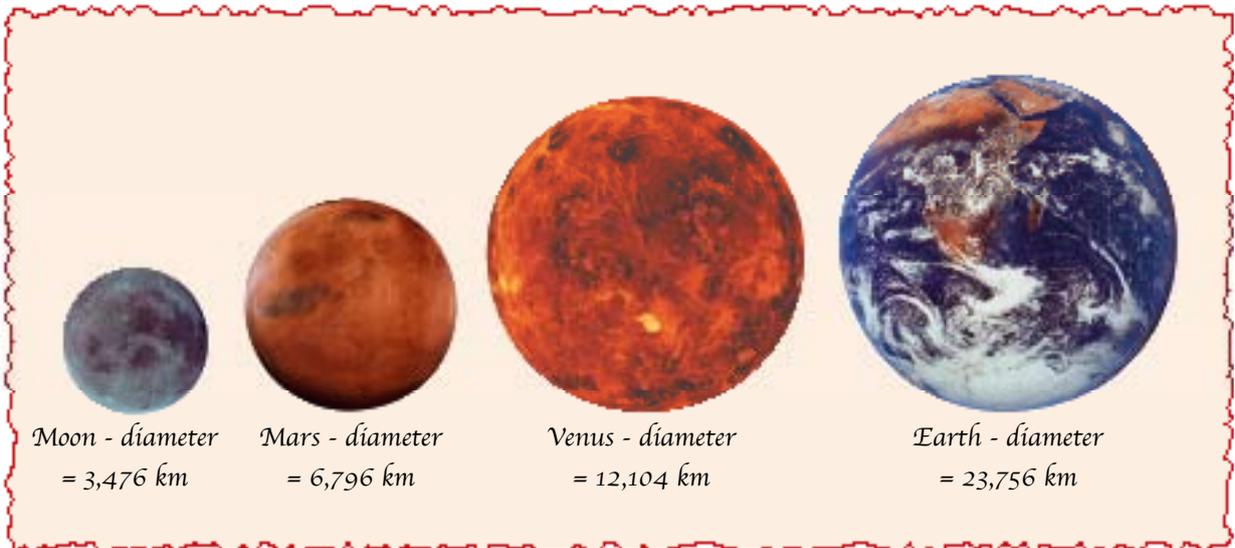


PLANET EARTH - A VIEW FROM SPACE

Activity 1:

Which is the most blue?

Below are images of the planets Earth, Venus, and Mars, and a picture of the Moon. Use the pictures to answer the following questions:



1. What are some similarities and differences between Earth, Venus, Mars, and the Moon?

Similarities:

Differences:

2. What are the characteristics of the Earth when compared to Venus, Mars, and the Moon?
How is this shown in the images?

3. Why is the Earth called “The Blue Planet”?

4. If the Earth’s surface was covered by oceans, what would be the color of the Earth from space?



*Surfing the
Internet*

<http://www.windows2universe.org/>

Visit the website “Windows to the Universe” at the above address. Click on “Solar System.” Choose a planet to study.

Mission: Access the websites that provide information about the planets in the Solar System. Prepare identification cards for these planets: Jupiter, Mars, Venus, Mercury, and Earth. Remember to include the following data for each planet: distance from the Sun, surface temperature, presence of liquid water, and the composition of the atmosphere.

What does your gathered data suggest about the possibility of finding life on each of these planets?

Activity 2:

The closer object is green

In the previous activity, we learned that the Earth is called “The Blue Planet” because the oceans, whose color is blue, cover $\frac{2}{3}$ of the surface. In this activity, we will explore this fact further.

1. Look at the picture below. Which is the Earth, and which is the Moon? Explain.
2. Imagine that you are on a space journey to the Earth from the moon. The photograph shows how the Earth would look at the beginning of the trip. What other details about the surface can you gather as the spacecraft reaches the height at which airplanes normally fly?



3. Can you see these surface details when we go to other planets? Explain.
4. Explain the connection between the two statements below:
 - a. The planet Earth is apparently the only planet in the Solar System that has liquid water.
 - b. The planet Earth is apparently the only planet in the Solar system in which there are living beings.



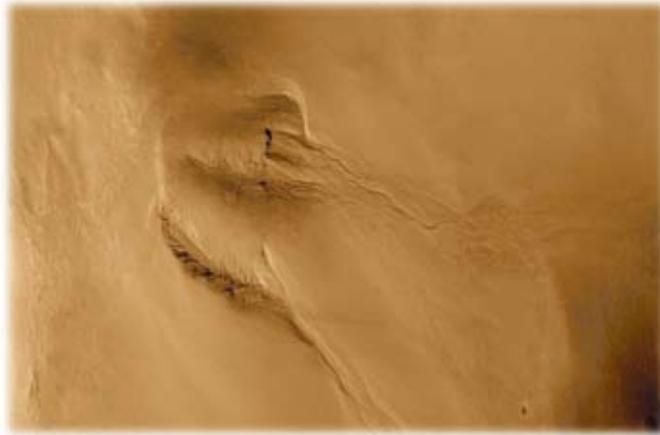
*Surfing the
Internet*

<http://www.windows2universe.org/>

Visit the website “Windows to the Universe” at the above address. Click on “Solar System.” Choose Mars.

Mission: Exploration of Mars

1. One of the objectives of Mars exploration is to investigate whether there is life on the surface of this planet. Find and explore websites with photographs and information about Mars.
2. What evidence is shown in the pictures that suggests the presence of liquid water in Mars’ geologic past?
3. According to the information you read, what evidence suggests that liquid water was present on Mars in the geologic past?
4. A geological analysis of photographs taken by the spacecraft Pathfinder, which landed on the surface of Mars in 1998 clearly shows that there were rivers that flowed on the surface of Mars in the geologic past. Do you think that this discovery necessarily proves that there was life on the surface of Mars at one time? Explain.



View of Mars

Activity 3:

What type of environment sustains life on Earth?

In this activity, you will try to understand where the water on Earth originated.

Two important features of the “Blue Planet” are the large amount of liquid water present, and the existence of living beings.

The investigation of **planets** like Mercury, Venus, Mars, and Jupiter shows that these planets do not have **liquid water** and there is no evidence of the existence of **living beings**.

The planets **Mercury** and **Venus** are relatively close to the sun, therefore the temperature on these planets are relatively high (over 100° Celsius). This is why they have no water.

The planets **Mars** and **Jupiter** are relatively far from the Sun, therefore the temperatures are relatively low (below 0° Celsius). It is reasonable to assume that if there were water on these planets, it would be frozen water.

The distance between Earth and the Sun is such that the temperature range on Earth allows for the existence of liquid water and living beings.





Surfing the Internet

Use Google to search for the phrase “origin of water on Earth.” Read about the theories on the origin of water on Earth. As you’re reading, write down the various factors that likely contributed to the water on Earth, and answer the questions below.



Questions

Read through the information again and answer the following questions:

1. What are the various accepted theories about the origin of water on the Earth’s surface?
2. According to researchers, what evidence suggests that Earth’s water came from comet impacts?
3. What interesting scientific ideas did you learn from the reading?
4. Draw a diagram that represents a chain of events that lead to the existence of living beings on Earth.



Surfing the Internet

Next, do a Google search for the phrase “formation of the oceans.” Read and explore this topic.

Based on the new information, do you agree with the previous conclusions you made regarding the conditions that lead to life on Earth?



B:

NO LIFE WITHOUT WATER



In the previous chapter, we looked at the link between the presence of liquid water and the presence of living beings on Earth. This chapter examines the relationship between life and water, and will help you understand why all living things need water.

To examine this question, first investigate whether water is actually an important component of living things.

Activity 1:

How much water is in living things?

How much water is contained in the human body?

How much water is contained in a tomato?

What is the relationship between the questions above and the question below:

How much water is needed for the activities of living things?



The table below describes the ratio of the amount of water relative to body weight in various organisms.

Organism	Amount of water in the body, as a percentage of body weight
Human	66
Bacteria	70
Chicken	75
Frog	78
Worm	80
Jellyfish	98
Sunflower Seed	9
Pineapple	84
Tomato	88



Questions

Look at the data in the table above and answer the following questions:

1. Write three conclusions you can make from the data table above.
2. Organize the organisms according to their amount of water, from highest to lowest.
3. Which organism has the most water? Which organism is the driest?
4. A sunflower seed contains 9% water. What is needed for a sunflower seed to germinate (begin growing)?
5. What are the most important ideas you have learned, and what can you conclude from the analysis of these data?
6. In the previous activity, we learned that living things contain water. Describe where water is found in living things, including humans.

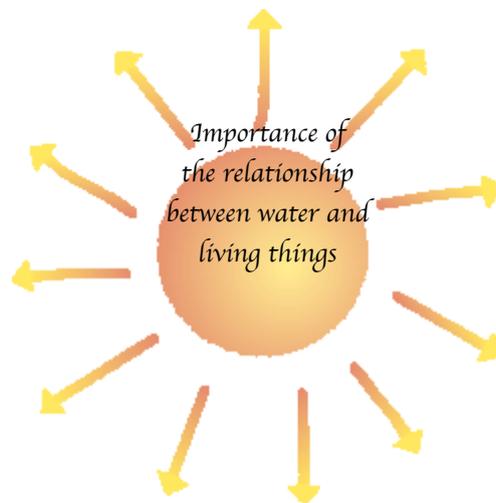
Activity 2:

What have I learned so far about the relationship between water and living things?

In the previous activity, we learned that most living things contain a lot of water. Now, we

can analyze the relationship between water and the characteristics of life.

1. For each arrow, record an idea that describes the relationship between water and life.



2. In the table on the next page, there are two columns: “living things” and “non-living things”:
 - a. Classify each of the elements found in the left column under “living” or “non-living” as appropriate.
 - b. Write an explanation of each choice in the comments column.
 - c. If you could not classify any of the items, describe and explain in the comments column.



	Living	Non-Living	Comments
Domestic cat		
Flowing river		
Large truck		
Dry leaf		
Human-shaped robot (<i>humanoid</i>)		
Goldfish		
Limestone (<i>calcareous rock</i>)		
Chicken egg		
Wild mushrooms		
Romaine lettuce		
Sheep's wool		
Cypress tree		

3. Below is a list of “characteristics of living things” and a list of “definitions.” Connect the dots so that the characteristics match up with the appropriate definition.

Characteristics of living things		Definition	
1. Metabolism	●	●	a. Living things are sensitive to stimuli such as light, sound, humidity, and temperature, and react to them.
2. Cell structure	●	●	b. Process of respiration and nutrition that maintains life and generates energy, by using substances taken from the environment.
3. Reaction to stimulus	●	●	c. Living things grow by cell division, differentiation, and shape change.
4. Reproduction and heredity	●	●	d. Living things can reproduce and have offspring that resemble them in their characteristics.
5. Growth and development	●	●	e. All living things are made of a cell or several cells. Every living cell (in unicellular or multicellular organisms) has all the characteristics of living things.

4. In your opinion, how can one or more of the five characteristics of living things above, occur in an environment without water?
Explain your idea.



Creatures living in an aquatic environment

Activity 3:

The relationship between metabolism and water



One of the characteristics of life is metabolism which is a process that takes place in living organisms. During the process of breathing, oxygen (O_2) is captured, and carbon dioxide (CO_2) is released. To check whether the process of respiration occurs in seeds, use bromothymol blue, a compound that is used to detect the presence of carbon dioxide.

The following experiment illustrates one of the changes that occur in a living thing - the seed of a bean plant - as it absorbs water.

Laboratory Materials: 3 graduated test tubes with stoppers, seeds of a bean plant, bromothymol blue solution, straws (like those used to sip liquids).



Experiment

Part One: What substance do we exhale?

1. In front of you are two test tubes with a bromothymol blue solution, diluted in water (2 cm high). What color is the solution?



Additional Information

Bromothymol blue is a compound used to detect carbon dioxide. In other words, the presence of carbon dioxide will cause the solution to change color. It is a pH indicator.

2. Using the straw, blow slowly into the test tube. What was the color change?
3. How do you explain the change that occurred in the color of the solution as a result of the blowing?



Part Two: How does water influence seeds?

You have two graduated test tubes in front of you. In the first tube, there are 20 dry bean seeds. In the second, there are 20 bean seeds that have been soaked in water for 24 hours.

1. What are the differences between the seeds of the two test tubes?
2. In your opinion, what is the reason for the observed differences?
3. Add a third test tube and keep it empty. Add 10 mL of bromothymol blue to each of the three test tubes. Close each test tube with a stopper, and wait 20 minutes.
4. What do you think will happen in each of the test tubes? Explain.
5. Observe the test tubes after about 20 minutes. Summarize the results in the following table:

Treatment	Color of the solution in the test tube at the beginning of the experiment	Color of the solution in the test tube at the end of the experiment
Seedless		
Dry seeds		
Wet seeds soaked in water		

6. Which seeds breathed faster: dried or those that were soaked in water? What is the basis of your conclusion?
7. What is the importance of water in this metabolic activity of breathing?
8. Which test tube is the control? Explain.
9. The snail is enclosed in its shell during the summer, hibernating. When the rainy season arrives, the snail comes out of hibernation. In your opinion, how does the metabolism of the snail change with the onset of the rainy season?
10. Which characteristic of living things have we studied with this activity?
11. What is the importance of water for activities related to this characteristic of living things?





Synthesis

1. How would you explain to your classmates, as clearly as possible, what you have learned?
2. In the tombs of Egyptian pharaohs, 3,000 year old wheat seeds were found. Investigators proposed a quantitative experiment to examine whether the seeds were dead, or in a state of hibernation.



Thinking Scientifically

Scientific research often seeks to answer new questions posed by research studies.

1. What is the research question posed in this case?

A scientific experiment examines how a system reacts to changes. It examines how a variable (factor) affects another variable.

For example, in the experiment you just completed, the variable that influences (independent) is the water content in the seed, as a result of soaking. The variable that is influenced (dependent) is seed respiration. Because the variable “**seed respiration**” depends on the variable “**water content in the seed**”, that is called the dependent variable. Therefore, the research question is: How is seed respiration (a characteristic of living things) influenced by water content?

2. To answer this research question, what changed in this experiment with bean seeds?

In any scientific experiment, you want to verify that the conclusions made are related to the changes, and not to other factors. The part of the experiment that performs this function is known as a **control**.

3. In the first part of the experiment, which of the test tubes is the control?

4. In the second part of the experiment, which of the test tubes is the control?

In any scientific experiment, you want to ensure that the observations made are accurate, and that you can draw appropriate conclusions.

The factors influencing the authenticity of the observations are:

- a. Measurement error: In this experiment, for example, 10 mL of bromothymol blue were added to the test tube. If you add a little more, the color of the solution in response to the respiration of the bean seeds can vary.
 - b. Changes in the properties of the objects being measured: A large bean seed can produce more carbon dioxide (CO₂) than a small seed.
5. To verify that the results obtained are accurate, it is standard procedure to conduct the experiment at least three times, and to take the average of all observations.
6. In your opinion, was the experiment conducted in a scientifically reliable way?

Generally, in a classroom, each group of students carried out the experiment, so that across the entire group, there are 5-6 similar trials (repetitions of the same experiment). In this case, given the trials of all the groups, we can reach scientific conclusions based on these observations.

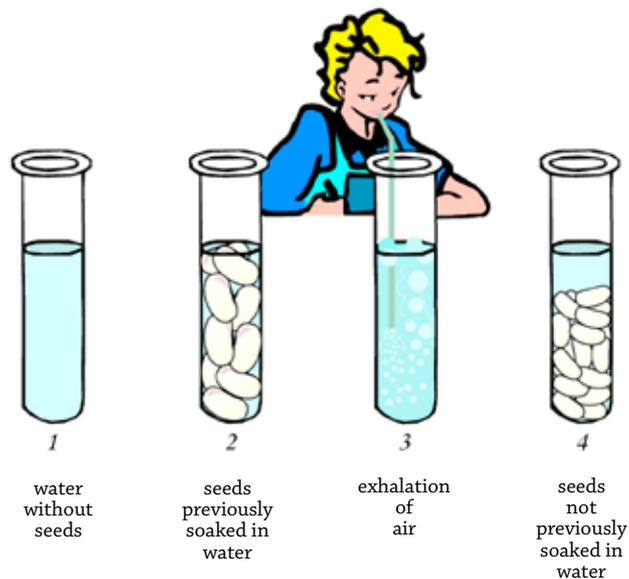


Classification

What role does each of the test tubes play in the experiment?

Below, draw lines that show the relationship between the components of the experiment (in the test tubes) and the function of each test tube (factors being explored).

Components of the experiment		What is the function?
1. Plain water	● ●	a. Examine whether the presence of water in the seed gives rise to respiration.
2. Seeds previously soaked in water	● ●	b. Examine whether the absence of water in the seed releases CO_2 , and if so, what the rate of respiration is compared with the seeds soaked in water.
3. Exhaled air	● ●	c. Verify that the factor causing the color change in the bromothymol blue solution is, in fact, carbon dioxide (CO_2).
4. Seeds not previously soaked in water	● ●	d. Verify that the CO_2 comes from seeds, and not water.



Activity 4:

What is the importance of water for living?

In the next few pages, you will find five different activities that deal with learning a single theme - the importance of water for living. Although all activities deal with the same subject, each has been addressed based on learning in a different way. The premise of this style of learning is that different students achieve understanding in different ways. There are those who understand better when they read written material. Some students find it easier to understand the way you use facts and figures that provide different arguments. There are those who understand best through activities that involve listening, rhythm, music, etc.

Choose your preferred way of learning by following these instructions:

Choosing the style you prefer: Place an X next to the statements that you agree with. The learning method that has the most Xs is likely the method that best suits you.



Learning Method 1

- I ask lots of questions about how things work.
- I solve arithmetic problems quickly.
- I like math.
- I like to play chess, checkers, or other games of strategy.
- I like to solve logic puzzles and 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 formed by homonyms, etc.
- I pay attention well by listening (listening to stories, programs, talk radio, audio books, etc.)

Total Score ____



Learning Method 3

- I have the ability to identify songs, musical 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 choral group.
- I hum a lot.
- I am sensitive to environmental sounds (e.g., drops of rain falling on the roof).
- I have a positive reaction when I hear music.

Total Score ____



Learning Method 4

- I understand maps and graphics much more easily than text.
- I like activities that have an artistic aspect.
- I like drawing in complex ways.
- I like puzzles, mazes, and other similar activities.
- I like building relatively interesting 3D structures (e.g., using Legos®).
- I enjoy images more than text.

Total Score ____



Learning Method 5

- I excel at one or more sports.
- I move often, and have difficulty when I must sit in one place for a long time.
- I like taking things apart and then putting them back together.
- I like to play with everything I see.
- I like running, jumping, wrestling, or similar activities.
- I like working with clay /experimenting with other materials (e.g., painting landscapes).

Total Score ____

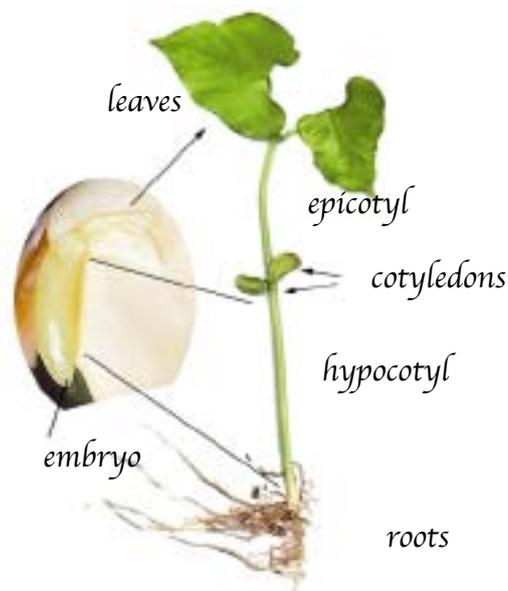


Learning Method 1

The relationship between water and growth and development

In front of you is a seed tray and a pot with some bean seedlings.

Gently pull out some seedlings from the soil and try to identify the structural components.



Bean seedling

- In the bean seedling root, identify the part that crosses the seed coat and penetrates down into the soil. This physically holds the seedling root in the Earth. Try to determine whether the root has any additional function.
- Identify the cotyledons (first leaves). Do these reach for the sun, or remain underground?
- Identify the stem (hypocotyl and epicotyl) and leaves.
- Try to design an experiment that describes the relationship between growth and development and water.
 - What is the research question in this experiment?
 - In the experiment you're designing, what is the variable that influences (independent) and what is the variable that is influenced (dependent)?

3. Is it important to have a control in this experiment? Why? If your answer is yes, what is the control in the experiment you're planning?
4. How would you determine if the observation you made was accurate and whether reliable inferences can be made from it?
5. How can you avoid measurement errors, and errors due to changes in the characteristics of the objects being measured?



Synthesis

How can you communicate to your peers the most important issues you have learned?

Prepare a flow chart on a sheet of paper that describes the germination of a seed, as a result of absorption of water.



Learning Method 2

The relationship between reproduction and water (1)



Additional Information

Read the following paragraph, and then answer the questions:

Multicellular organisms reach adulthood when their reproductive systems mature and are ready for reproduction. The process of reproduction involves the union of the **sperm** (male sex cell) with the **egg** (female sex cell) to produce a fertilized **egg cell** or **zygote**. The zygote contains genetic material from the father and mother, and it is an **embryo** whose development results in an **offspring**. The process of union of sperm and egg can only occur in a moist environment. In nature, there are at least two ways to ensure that this process occurs in a **moist environment**.

Among animals that live in water, such as fish and amphibians, **fertilization** (of the **fertilized egg**) is **external**. Females lay their eggs in the water, and males deposit their sperm into the liquid water. The sperm move around in the water, and when they find an egg, they are united and fertilization occurs (union of the genetic components).

Among land animals, such as mammals, birds, insects, and reptiles, **fertilization** is **internal**. In this type of fertilization, the egg is inside the moist environment of the female body. During courtship, the male and female send signals about their intentions in preparation for mating. During mating, sperm are moving (in a fluid medium) directly from the male to the female, entering the reproductive system of the body. Within the moist reproductive environment of the female, the sperm finds the egg in the fallopian tubes or oviducts. When the sperm meets the egg, fertilization occurs. In some terrestrial animals, there are organs that help the transfer of sperm from the male body to the female body. These organs are known as coupling bodies, and their purpose is to prevent sperm from being exposed to dry conditions, thereby increasing the chances of fertilization. In **human beings**, considered terrestrial animals, fertilization is internal. Sperm are transferred

through the male reproductive organ (penis) to the woman's body (vagina). The sperm then move toward the uterus. Fertilization occurs in the moist environment of the fallopian tubes, which connect the ovaries to the uterus.

Also in **plants**, fertilization is internal, and is protected within the flower. A plant that is flowering is mature, and able to reproduce. The **gynoecium**, or **pistil** is the female reproductive organ of the flower, and eggs are produced there. The pistil has a flared base called the ovary. In the ovaries, eggs* are produced along with several other cells, one of which is the female sex cell. The eggs are protected in a moist environment by several layers. The flower also has **stamens**, which are the male reproductive system of the flower that produce male sex cells known as **pollen grains**. Pollen travels in various ways from the stamen to the female reproductive organ of the same flower or another flower, and there, the egg is fertilized in the moist environment.

After fertilization, the fertilized egg develops into an embryo inside the seed, and the ovary becomes the fruit.



Questions

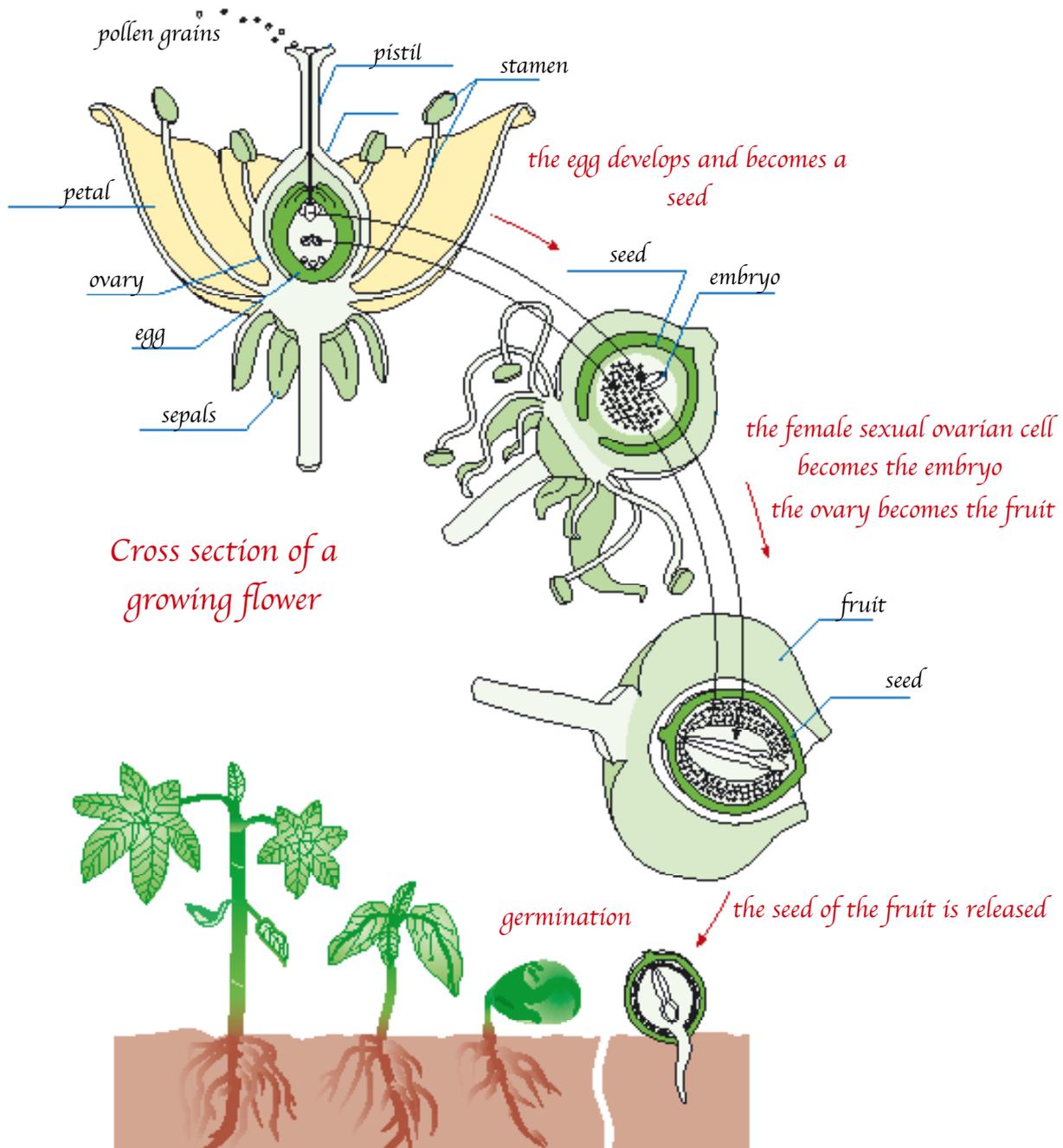
1. Provide examples of creatures that live in the water. Try to infer how fertilization occurs for each creature.
2. Provide examples of creatures that live on dry land. Try to infer how fertilization occurs for each creature.
3. How do creatures that live on dry land ensure a moist environment for fertilization?
4. What are the advantages of internal fertilization for creatures that live on Earth?



African lynx (caracal) - Animal that lives in a desert environment (picture courtesy of the Hadvarim Teva Newspaper)

* When dealing with processes that are carried out in animals, we can use the concept of the egg to describe the female sex cell. However with plants, we must make a distinction between the two concepts because the female sex cell develops into the egg, along with other cells in the ovaries, as explained above.

5. The illustration below describes the life cycle of a plant, from the pollen grains to the growth and development of an entire plant.
 - a. Record two new facts you learned from this illustration.
 - b. Record two questions you have regarding the process shown in the illustration.
6. What characteristic of life is described in this activity?



The life cycle of the plant from the grain of pollen to adult plant



Synthesis

1. Write a summary of the importance of water in activities related to reproduction.
2. How can you best convey this summary and what you've learned to your classmates?
3. Choose an option from the list below, and describe the way in which the sperm reaches the egg in an aqueous environment.
 - a. Concept map or flow chart.
 - b. Short story.
 - c. Power Point® presentation.



Learning Method 3

The relationship between reproduction and water (2)



Movie

1. Watch the first two minutes of the movie “Look Who’s Talking.” (search youtube.com for “Look Who’s Talking opening credits”). Pay attention closely.
 - a. Identify the steps involved in the fertilization process, and write down what you see.
 - b. Read the following passage, and note the processes that occur in both the passage and the movie.

In **humans**, fertilization is internal. During copulation, or sexual union, the sperm moves in liquid directly from the male sexual reproduction system to the female sexual reproductive system. In humans, who live on dry land, our bodies help the sperm move from the male body to the female body. These organs are called sexual organs, and their purpose is to prevent the sperm from being exposed to dry conditions. In the female reproductive system, sperm are transferred to the egg through the fallopian tubes. When the sperm meets the egg, fertilization occurs, and it is carried out in the moist environment of the fallopian tubes, which connect the ovaries to the uterus.

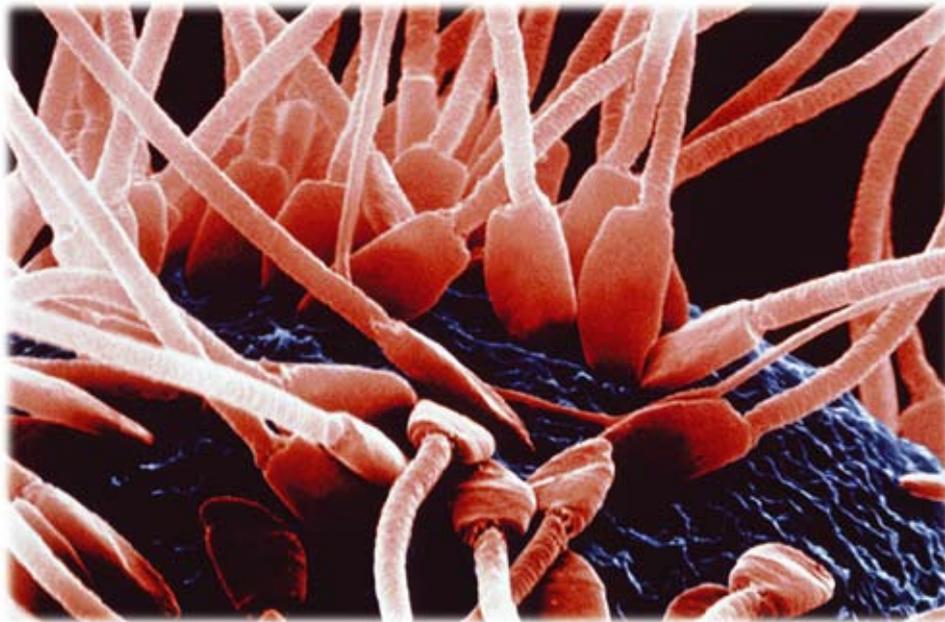


2. In your opinion, does liquid water serve another function at this stage of pregnancy?
3. Which characteristic of living things are shown in this portion of the movie?
4. How does the music that accompanies this portion of the film contribute to your understanding of the topic?



Synthesis

1. How can you convey the major points you've learned to your classmates? Prepare a synthesis.
2. Prepare a short story that describes the path of the sperm to the egg within an aqueous (wet) environment.
3. Compose a song whose lyrics can be used as an accompaniment to the soundtrack of this movie. In the song, you should include a comprehensive explanation about the phenomenon you've studied.



The sperm in the process of trying to penetrate the egg. Taken with a scanning electron microscope (magnification 4,000X).



Learning Method 4

The link between cellular structure and water

Part One: Observation of the plant “impatiens” (*Impatiens wallerana*)

1. Below are two photographs of the plant “impatiens.” Describe how the two plants are similar and different:

Similarities:

Differences:

2. In your opinion, what caused the difference between the two plants?
3. The first photo below was taken one day, and the second photo was taken after six days of not being watered. Try to infer the relationship between the physical appearance of the plant and the action of not watering the plant.



Impatiens wallerana

Part Two: Building a model

In this activity, you must build a model that is similar to the two plants you’ve observed. The materials available include: a bowl of water, two plastic bags, and tape.

1. In your opinion, to what extent does this model represent the plants you observed in the photos in Part One?

2. What difficulties did you encounter during the process of building the model?
3. Try to relate the components of the model with the natural phenomenon you are simulating. Copy the following table in your notebook, and match the items in the two columns.

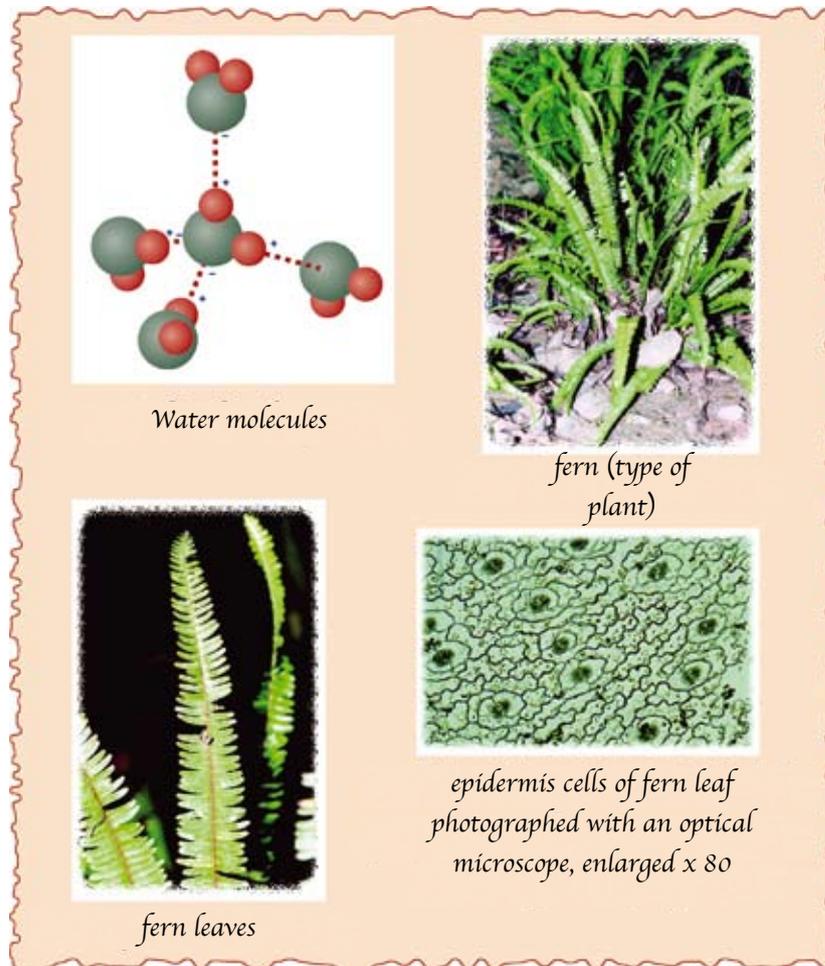
Components of the Simulation		Components of the Natural Phenomenon
1. Water container (bowl)	● ●	a. Plant tissue
2. Bag	● ●	b. Plant cells
3. Spaces in the bag	● ●	c. Water in living organisms
4. The plastic that makes up the bag	● ●	d. Does not exist in nature
5. Tape	● ●	e. The plant
6. Does not exist in the simulation	● ●	f. The cell wall

4. Again, note the two plants. One photo shows the plant wilting, while the other looks healthy. Where is the water in the plants located?

It is important to understand where water is found inside the plant.

Part Three: Where is the water in living organisms?

1. Following are four images that describe a plant and its components on four different scales of magnitude. Rank the images according to the actual size of the objects that appear in the photographs. Record the names of the objects from largest to smallest.



Water molecules

fern (type of plant)

fern leaves

epidermis cells of fern leaf photographed with an optical microscope, enlarged x 80

Components of a plant at different scales



Additional Information

Water maintains the shape of a body

In this activity, you learned that water plays an important role in maintaining the shape of a body in living things. You noticed that when a cell loses some of its water, it loses part of its volume or turgor, and looks more **wilted**. Also, when the whole plant lacks water, it withers and becomes flaccid. The reason lies in the role that water plays in maintaining the volume and cell turgor, and firmness of the body as a whole. As you know, all living things are composed of cells that contain a certain amount of water. A cell filled with water is swollen like a bag full of water. A cell that lacks water is flaccid and wrinkled. This phenomenon applies to all living things. Further, in living organisms, like the worm and the jellyfish, which lack a solid skeleton, water

fills the internal volume and gives strength to the entire body.

How will you explain what you've learned in this activity to your classmates as clearly as possible?

Prepare your explanation for the class.



Learning Method 5

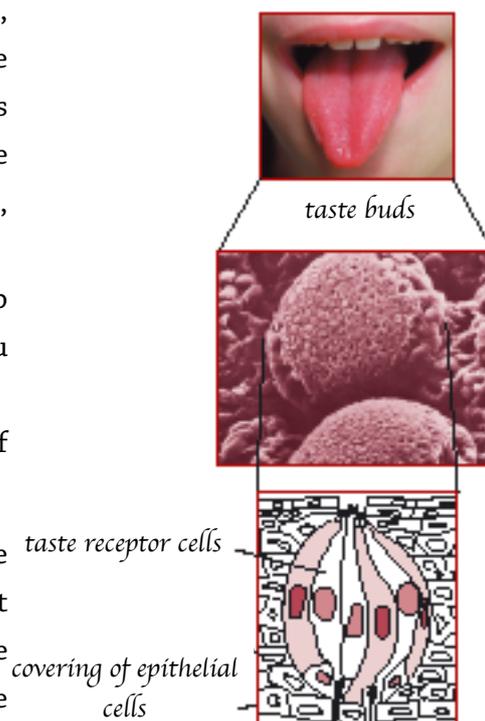
The relationship between water and response to a stimulus

Part One: The link between taste and water on the tongue

The sense of taste allows us to identify different substances. Our tongues can easily discriminate between different types of food. In fact, we only perceive four tastes or flavors: sweet, sour, salty, and bitter. The tongue has different areas that are sensitive to these different tastes. The taste sensation you get happens when different substances come into contact with sensors, or special receptors found within your taste buds. Most taste buds are concentrated at the tip, in the back, and along the perimeter of the tongue.

Due to the contact of flavor compounds with receptors found on the surface of the cells responsible for taste, the sense of taste (stimulus) is transmitted to the brain. The connection between the flavor compounds and the receptors on the tongue, and then the transmission of the sensation of taste to the brain, can only occur in an aqueous environment.

1. Dry your tongue very well with a tissue. On the tip of your tongue, place a few grains of sugar. Do you taste the sugar?
2. What is the importance of water in the sense of taste?
3. Some people associate the sense of smell with the sense of taste. When we do not feel well, we do not taste well. Is water also an important factor for the sense of smell? Try to infer how our noses enable us to taste flavors.



Schematic illustration of the tongue

Part Two: The link between eyesight and the presence of water in the eye

1. Look closely at a classmate's eye. Notice that the eye looks "wet." The eye is filled with liquid known as vitreous humor (like glass), which is composed mostly of water.



2. Where is the water in the eye?
3. The fluid in the eye is very important for the sense of sight, and for focusing light rays. Try to come up with at least two questions about the link between the sense of sight and the presence of water in the eye.



Synthesis

1. What characteristic of living organisms did we work with in this activity?
2. Summarize for yourself the importance of water for life activities related to this characteristic.
3. How will you explain what you learned in this activity to your classmates? Prepare an explanation for the class.



Knowledge Organization

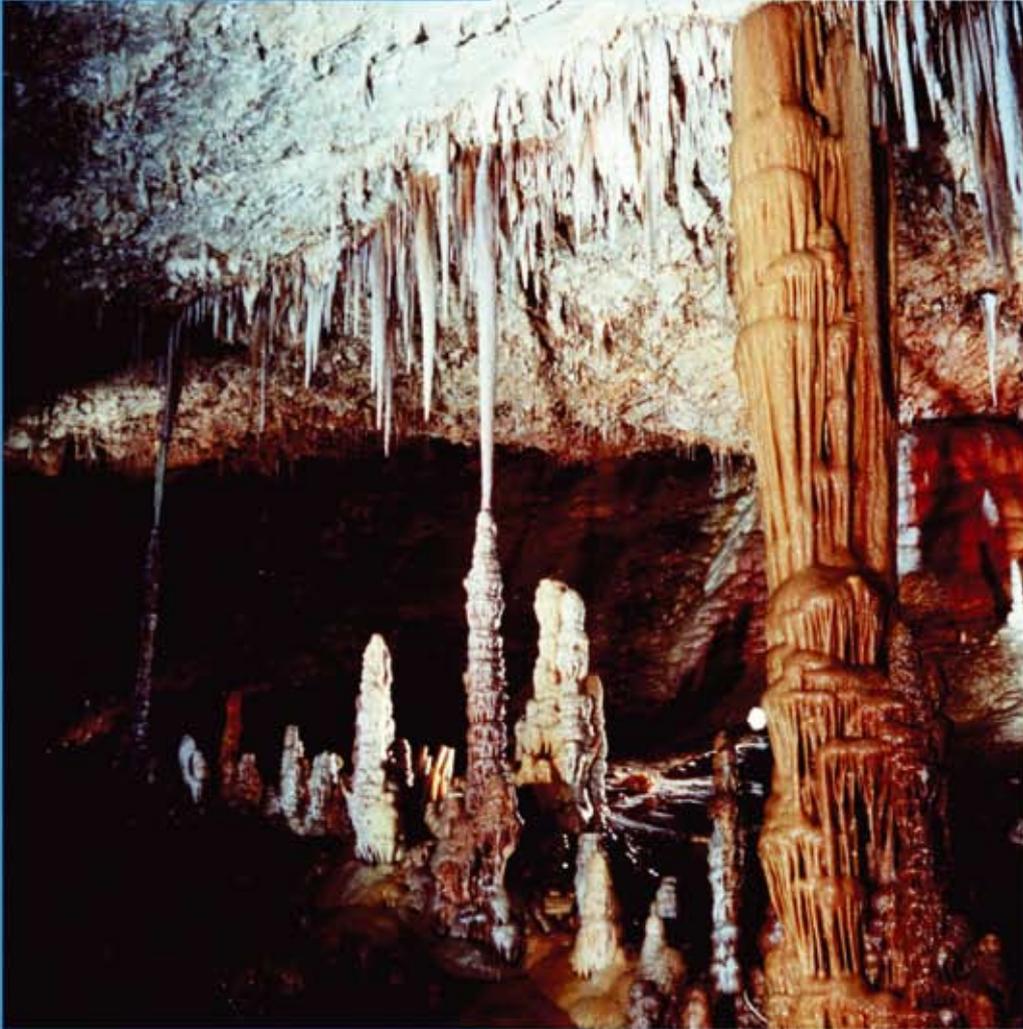
What is the importance of water to the function of living beings?

1. Ask your teacher for a copy of the table on the next page.
2. Each group should use the table to record the feature of living organisms that you studied, which depended on the presence of water.
3. Each group should record on their table how their observations led to each of the findings and conclusions.

Characteristics of Living Organisms	Observations and Conclusions
Group that dealt with Growth and Development	Observations Conclusions
Group that dealt with Reproduction (1)	Observations Conclusions
Group that dealt with Reproduction (2)	Observations Conclusions
Group that dealt with Cell Structure	Observations Conclusions
Group that dealt with Reaction to Stimuli	Observations Conclusions

CHAPTER 2:

THE GROUNDWATER SYSTEM





THE WATER CYCLE ON PLANET EARTH



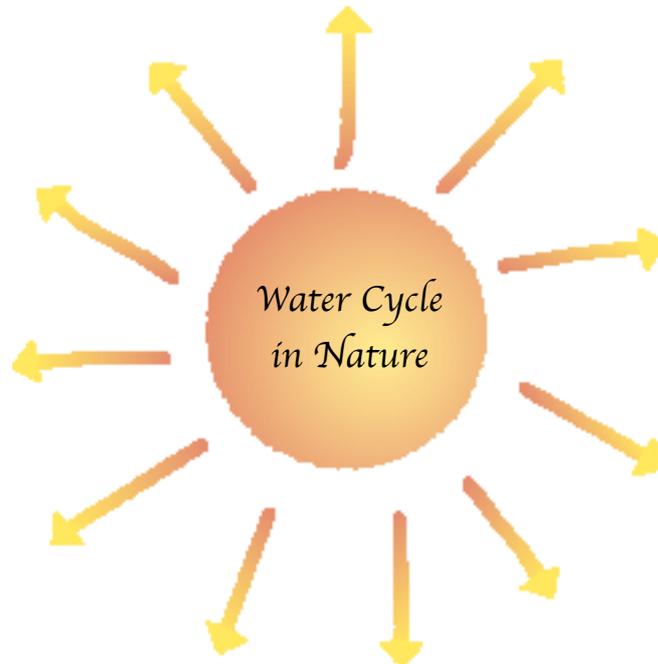
In the previous chapter, we characterized the planet Earth as a place where there were direct links between water and life. This chapter will focus on the question, “Where is water found on Earth?”

Activity 1:

What do we know about the water cycle in nature?

In this activity, try to determine what processes, and locations are important in the water cycle, and what you do not know yet.

1. For each arrow, write down a concept that is related to the water cycle in nature.





Classification

2. Sort the ideas you just recorded, into two categories:
 - a. Concepts that describe locations or places where water is found in the cycle, for example, an ocean or a cloud.
 - b. Concepts that describe processes that occur in the water cycle, for example, evaporation, or precipitation.

Locations	Processes through which water passes from place to place



In this activity, you defined two categories:

“Locations” - Places where water is found on planet Earth. For example, oceans, groundwater plants, clouds.

“Processes” - Physical or chemical changes that occur in water and that allows passage from one location to another. For example, evaporation is a process in which a substance changes from liquid to gas. The vapor is a gaseous substance, which was previously a liquid or a solid.





Drawing

Activity 2:

Drawing the water cycle in nature

1. Individually, try drawing a diagram on a sheet of paper, that describes the movement of water on Earth.
2. On your drawing, indicate the locations and processes that make up the water cycle on Earth.

Reminder:

Locations - places where there is water on Earth, such as oceans or plants.

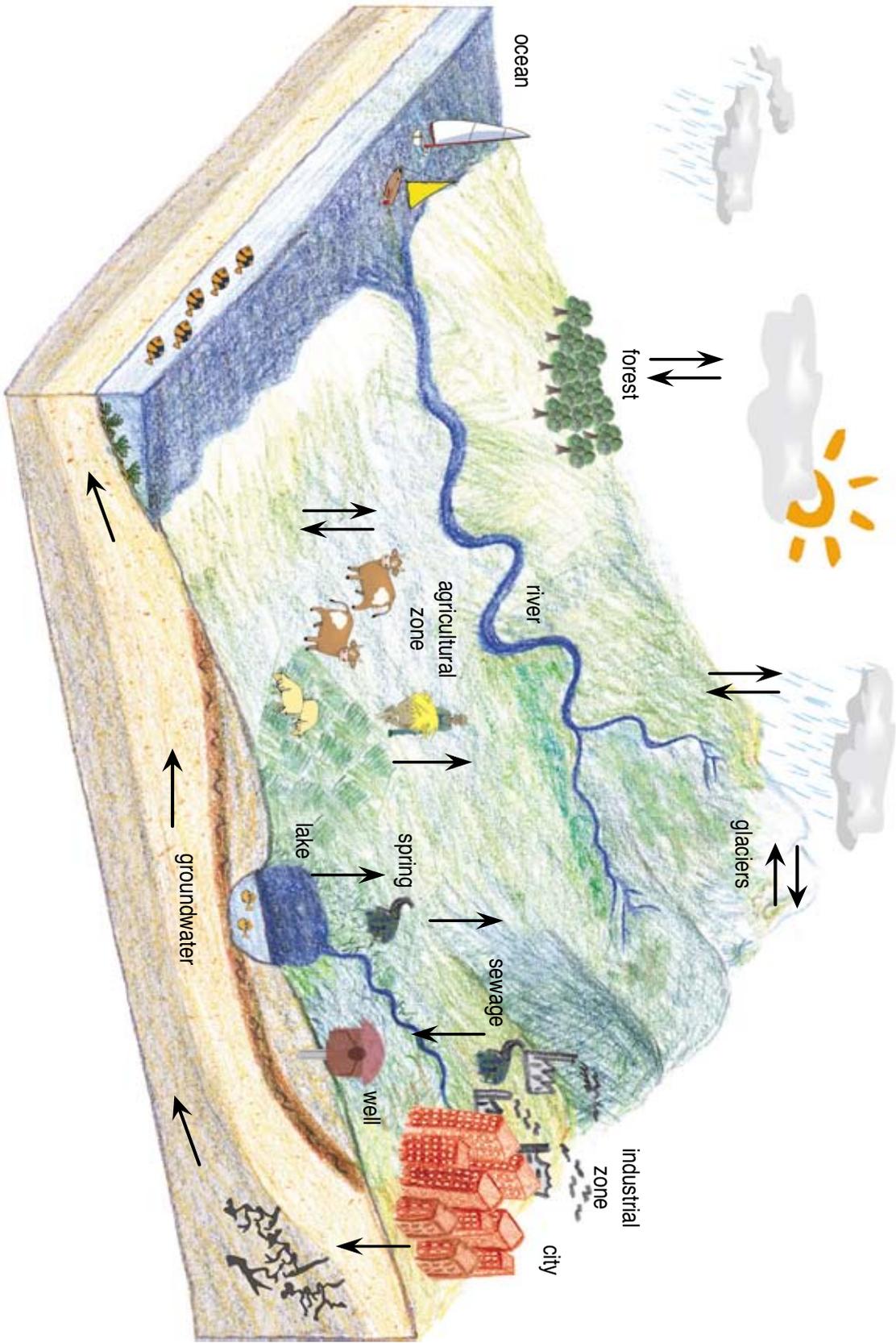
Processes - physical or chemical changes that occur in water, during its movement from one location to another, through the water cycle.

Activity 3:

The water cycle and Earth systems

1. Look at the diagram on the next page, which shows the processes occurring on Earth. Try to identify the different Earth systems: rock system (Geosphere), the system of living things (Biosphere), the air and weather system that surrounds the Earth (Atmosphere), and the water system (Hydrosphere). **[Note: not all locations and processes are labeled.]**
2. In the table below, write at least two components that make up each of the Earth systems described above:

Rock system (Geosphere)	System of living things (Biosphere)	Air and weather system (Atmosphere)	Water system (Hydrosphere)



3. Look at the diagram on the previous page, and in the table below, record how the different components of the water cycle influence each other.

Factor that has an influence	Factor that is influenced	Type of influence
Example: Snow	Rivers	The melting snow adds to the water supply of the river.



Activity 4:

Transfer of substances in the water cycle in nature

In the previous activity, you observed a diagram that showed the different Earth systems. Many of the processes occurring on Earth correspond to processes in which substances are transferred from one system to another.

For example: When we breathe, we inhale oxygen (O_2) and exhale (release) carbon dioxide (CO_2).

Therefore, breathing includes two processes:

- a. Oxygen (O_2) passes from air (atmosphere) to our bodies (biosphere).
- b. Carbon dioxide (CO_2) passes from the body (biosphere) to air (atmosphere).

1. Carefully read each of the statements in the table below. Complete each example to explain the transfer of substances between two systems (see the example).

Processes of transfer of substances	Substance from which system...	...into which system
Example: Humans breathe and inhale oxygen (O_2)	Atmosphere	Biosphere
1. Evaporation of water from the surface of plant leaves		
2. Groundwater absorption by plant roots		
3. Dissolution of rocks by water		
4. Evaporation of ocean water		
5. Drying soil in a garden		
6. Rainfall on the Earth's surface		
7. A tiger drinking water from a spring		



Photographing the Environment

2. Take one or two photos in the area where you live, showing the interrelationships between Earth's systems.
 - a. Mark the Earth systems shown on the photograph.
 - b. Record the transfer of substances between Earth systems occurring in the photo. Draw an arrow and record which substances are being transferred.





THE WATER AND ROCK SYSTEMS ON EARTH

In the previous activity, we learned that water moves from one system to another. The Earth systems include the hydrosphere, biosphere, atmosphere, and geosphere. It is especially important to understand the geosphere because it is related to the groundwater system, and the quality of drinking water.

For example, in Israel, the groundwater system provides its inhabitants with more than 65% of the annual amount of water they need (1.6 - 1.8 million cubic meters). The rest of the water reaches the Sea of Galilee and reservoirs from the process of runoff.

In this chapter, we try to understand how the groundwater system affects water availability per person, and the quality of drinking water. The origin of groundwater is rain that seeps into rocks, where it is stored. Water is stored in the pores and cracks found in rocks. To understand the water quality in groundwater systems, we must understand the interrelationships between rock and water.

Note: If you have not completed the unit “The Cycling of Earth Materials”, conduct the activity at the end of the book, Appendix 1 “How to characterize and identify rocks.”

Activity 1:

How rocks react to water

Laboratory Equipment and Materials: samples of limestone, dolomite, sandstone, calcareous sandstone, soft limestone, and clay stone; ID cards for the samples of rocks and soils; a water dropper; a flask with 6% hydrochloric acid (HCl); a nail.



Activity Procedure:

1. Identify the samples of rocks in front of you, using the identification cards. Write their names in the table.



Observation

What is an observation? An observation is any information that we acquire through our senses. For example, if we saw that a rock cannot be scratched with a nail, it means that we use the sense of sight. Therefore, the statement “the rock is not marked with a nail” is the result of our observation. Observations are made directly, as in the example above, or through the use of instruments.

For example, if we examine the mass of a rock using a balance, the statement, “The mass of the rock is 100 grams” is considered an observation. For this, we used a tool, and not an estimate based on direct observation of the rock.

- Place the rocks in a dish. Place 10 drops of water on each rock, and record your observations in the table below.
- Examine the malleability of each rock after they have been soaked with water, and record your findings in the table below.

Name of the Rock	What happened when water touched the stone?	What happened to the stone when it became wet?
	infiltrated: a lot /a little /not at all / other:	it is malleable / it is not malleable
	infiltrated: a lot /a little /not at all / other:	it is malleable / it is not malleable
	infiltrated: a lot /a little /not at all / other:	it is malleable / it is not malleable
	infiltrated: a lot /a little /not at all / other:	it is malleable / it is not malleable
	infiltrated: a lot /a little /not at all / other:	it is malleable / it is not malleable
	infiltrated: a lot /a little /not at all / other:	it is malleable / it is not malleable



Conclusion

1. Based on your observations, write two conclusions about how rocks react with water on the planet Earth.

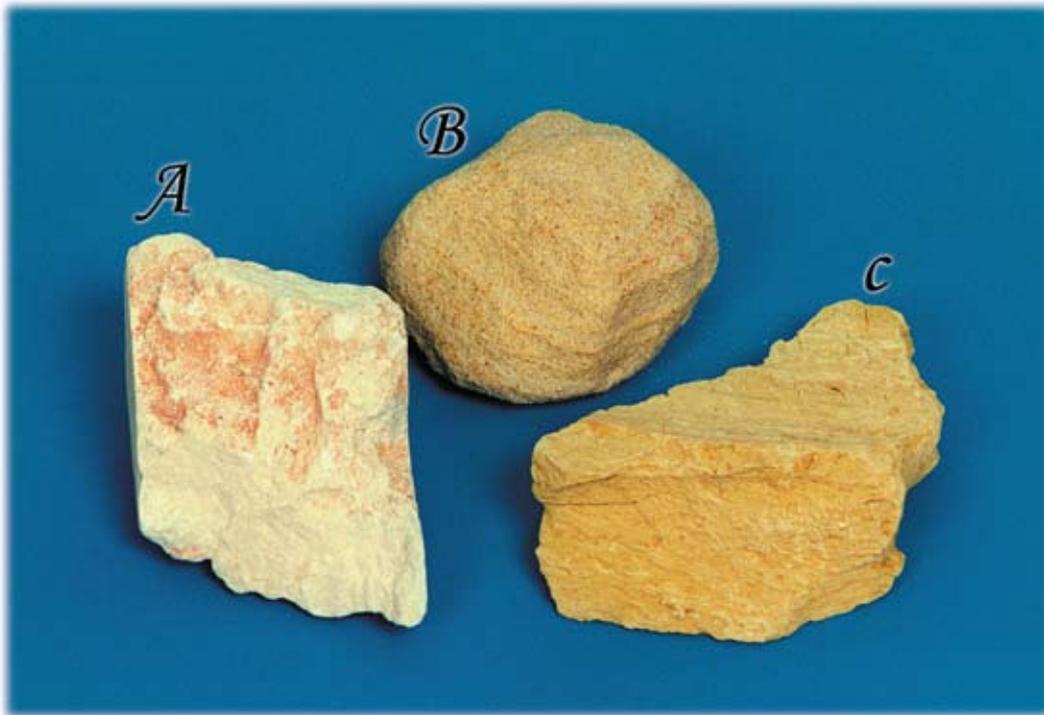
What is a conclusion?

A **conclusion** is what results from your observations. In the earlier example, if we observed that a rock is not scratched with a nail, the sentence “the stone is hard” is a conclusion that we reached as a result of our observation that “the rock was not marked with a nail.” No one can see that the stone is hard! You can only see that the rock is not marked by a nail.

2. Use the table below to sort the rocks on the tray into three groups according to their response to the addition of water:

	Group 1	Group 2	Group 3
Includes the following rocks:			
The similarities of the rocks in this group:			
Hypotheses regarding the reaction to water of the rocks in this group:			

3. List two general statements that describe the connection between water and rocks on Earth.



(A) Limestone, (B) sandstone, and (C) clay stone with varying amounts of calcium carbonate.

Activity 2:

The link between rock structure and water infiltration.



In the previous activity, we observed that water reacts different to different rocks. Now, you will examine how the structure of the rock influences water infiltration.

Laboratory Equipment and Materials: a magnifying glass; polished limestone; granite; sandstone; hammer; two small glass beakers with tap water; dropper; paper towels.



Experiment

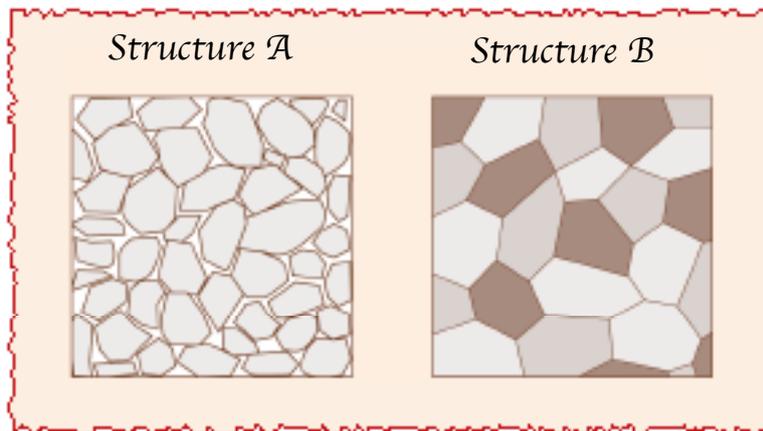
A. Infiltration of water into sandstone

Activity procedure:

1. Rub two samples of sandstone against each other, and describe what happens.
2. Observe the sandstone sample with a magnifying glass. Which of the two illustrations below best represent the structure of the rock, Structure "A" or Structure "B"?
3. How would you describe the structure of sandstone?



Sandstone



4. Try to infer how the grain structure of the sandstone contributes to the infiltration of water in this type of rock.
5. Observe the granite sample with a magnifying glass. Which of the two illustrations above best represent the structure of the rock, Structure "A" or Structure "B"?
6. How would you describe the structure of granite?
7. Try to infer how the crystal structure of the granite influences the infiltration of water in this type of rock.
8. Fill two beaker with water, and place the sandstone into one, and granite into the other. Watch what happens, and describe your observations.
9. Does the experiment you just conducted support the hypothesis you made above? Explain.



The sandstone has a granular structure. Between the sand particles are pore spaces. In a rock with granular structure, the water penetrates into the spaces between the particles, and seeps inward. The air inside these spaces is ejected outward in the form of bubbles.

The rocks in which water seeps through their pores are known as rocks with porous structure.

B. Infiltration of water in limestone and dolomite

Observe the polished limestone sample through a microscope. Can you identify pores?



Additional Information

Any observations found or conclusions made by other people, or documented in books, movies, CDs, newspapers, or photographs is additional information. Many times, we cannot draw conclusions based on our observations if we do not have the help of additional information. For example, when the rocks were identified based on direct observations, there was additional information in the cards so that they could be identified by name.

1. The lower illustration shows a very thin piece of dolomite, as seen through a microscope. How would you describe this structure: dense crystals or granular?

The rocks do not contain pores that allow water to infiltrate. These are known as rocks that have a dense structure.

2. In the previous activity, we observed that water does not infiltrate into limestone. Also, we know that in the mountains, there are often springs that flow beneath layers of limestone.

How does water infiltrate, then, beneath the limestone?

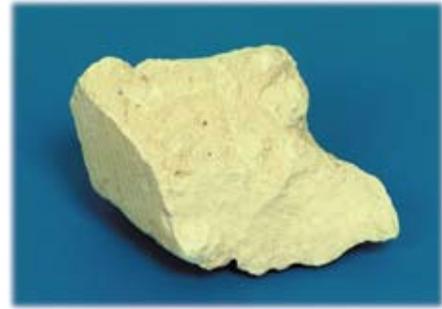
Dolomite Stone



Interior structure of the dolomite stone, as seen through a microscope



Experiment



Limestone

Activity 3:

Infiltration of water into a dense rock - Simulation Experiment

1. Place the polished limestone on a paper towel, and put a few drops of water on the center.
 - Did the water infiltrate to the paper towel?
2. With the hammer, break through the center of the polished limestone so you have two pieces. Place the two pieces on the paper towel so they are in contact with each other. Put a few drops of water in the crack.
 - This time, did water infiltrate to the paper towel?
3. What can you infer from this experiment with respect to the question: How does water infiltrate through a dense rock structure?
4. Below, you have a list of the components of the simulation, and a list of natural phenomena simulated in the experiment. Draw a line connecting the component of the experiment with the natural phenomenon it represented in the simulation.

Components of the simulation experiment			Natural phenomena
1. Polished limestone	●	●	a. Internal forces acting within the Earth
2. The water dripping on the stone	●	●	b. Time: millions of years
3. The blow from the hammer	●	●	c. The limestone on Earth
4. Does not exist in the simulation	●	●	d. The rain that falls on Earth



Polished Limestone



Additional Information

The crystal structure of limestone (or granite) is very dense. There are almost no air spaces (pores) and therefore water cannot infiltrate through it. However the internal forces acting on the Earth's crust create cracks and fissures in the rocks. These cracks allow water to move through the rocks that have dense structure.



Knowledge Organization

1. Fill in the missing words in the following text:

In this activity, we examined two rocks: _____ and _____.

In the experiment we conducted on the _____ rock, we found that water infiltrates easily. We infer that the _____ structure of this rock allows water _____ through. To examine our hypothesis, we conducted an experiment in which a sandstone rock was submerged in water, and we saw that the rock produced _____. We _____ that the rock has _____ particles, and that there are air spaces between them that allow _____ of water.

In the second experiment that we conducted, we found that water cannot _____ through a limestone rock that is not cracked. We hypothesized that this is due to the _____ structure of the limestone.

When we cracked the limestone, we observed that water had infiltrated through the _____ that were created in the rock. Given this phenomenon, we hypothesized that in nature, water seeps into the rock or limestone through _____ generated as a result of pressure exerted on the rock layers.

This phenomenon can explain the existence of numerous _____ under the layers of limestone rocks that exist in mountains.

2. Synthesize the scientific thinking processes described in the completed text above, and fill out the following table. Use the terms observation, conclusion, and hypothesis.

Observation 1:	
Conclusion:	
Hypothesis:	
Observation 2:	
Conclusion:	
Hypothesis:	

Activity 4:

Infiltration of water into Earth's geosphere system

In the previous activity, we learned that some of the rain that reaches the Earth's surface seeps through the rocks. This activity will identify the factors that influence water infiltration into the porous structure of the geosphere system: We will examine the ability of water to move through materials of differently sized particles.

Laboratory Equipment and Materials: magnifying glass; 6 beakers (50 mL); graduated cylinder (25 mL); syringe (25 mL); 3 funnels lined with filter paper; Earth materials (3 different sized particles).



Experiment

Experimental Setup:

Place the Earth materials of different sizes into the funnels, and place the funnels into the test tubes:

Test tube 1: contains clay composed of tiny particles of about 0.065 mm (65 microns diameter).⁽¹⁾

Test tube 2: contains sand composed of fine particles between 0.25 and 0.5 mm diameter.⁽²⁾

Test tube 3: contains sand composed of coarse particles larger than 1 mm diameter.

⁽¹⁾ The naked eye cannot distinguish particles smaller than 200 microns in diameter.

⁽²⁾ Can be distinguished with the naked eye.

1. Use the graduated cylinder to measure 25 mL of water, and pour 25 mL into each of the three beakers.
2. Use the syringe to slowly pour the 25 mL of water into the funnel containing the soil to allow infiltration of the water.
3. Pour the water that accumulates in the beaker back into the graduated cylinder. Measure the amount of water that passed through each of the different types of Earth materials, and record your data in the table.

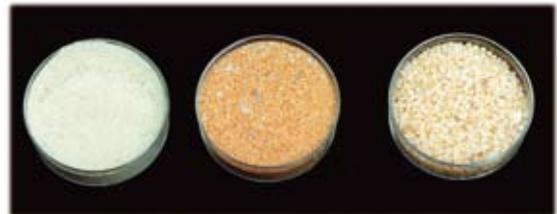
Also record in the table the difference between the initial volume of water (25 mL) and the amount of water that infiltrated into the soil.

Type of Earth Material	Amount of water (mL) before infiltration (X)	Amount of water (mL) after infiltration (Y)	Amount of water (mL) that was trapped in the soil (X-Y)
a) Gravel	25		
b) Fine sand	25		
c) Clay	25		



Observation

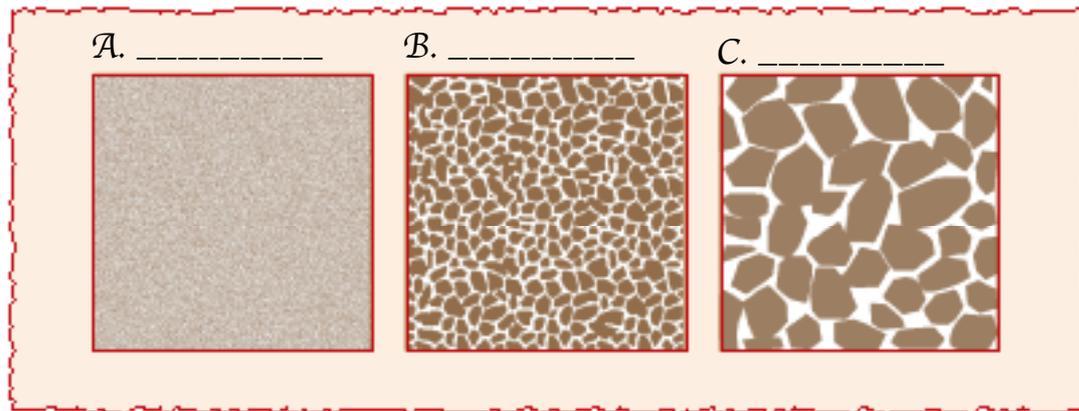
1. Which Earth material infiltrated the largest amount of water?
2. Which Earth material infiltrated the smallest amount of water?



Conclusion

1. What can you conclude from the experiment about the factors that influence the rate of water infiltration in a granular rock or loose Earth material?

- The diagrams below show the structure of Earth materials used in the experiment.
Match the structures below to the illustrations on the previous page by writing the appropriate name next to each picture.
- Use the color blue to identify where the water lies between the grains in each illustration.



- Which figure could you color most easily?
- How do the pictures illustrate the differences in water infiltration for different types of loose Earth materials?



In the previous chapter, we described what makes a scientific experiment reliable:

- Scientific research often seeks to answer a research question.
- A scientific experiment examines how a system reacts to changes. It examines how a variable (factor) affects another.
For example, in the experiment we conducted in the activity “The link between metabolism and water”, the variable that influences (independent) is the water content in the seed, as a result of soaking them. The variable that was influenced (dependent) is the seed respiration.
- In any scientific experiment, you want to check that the observation made was caused solely by the change in the variable you analyzed, and not due to other factors. The component of the experiment whose role is to help determine this is known as a control.
- In any scientific experiment, you want to check that the observations were accurate, and

that your conclusions are appropriate.

Draw a line to match the statements that describe components of an experiment, with their role in the experiment.

Components of the experiment	What is the function?
1. Control.	a. Measurement accuracy - in this experient, you were asked to add 25 mL of water to each beaker.
2. Research question.	b. Because you cannot carry out the experiment without loose Earth material, each funnel serves as a control for the other two funnels.
3. Variable that influences (independent).	c. Rate of water movement in the Earth material.
4. Factors influencing the accuracy of the experiment.	d. Each group carried out the experiment, so each classroom has five to six repetitions. In this case, the average of the groups provides a reliable result.
5. Variable that is influenced (dependent).	e. Particle size of the Earth material.
6. Number of observations (repetitions of each experiment).	f. How the particle size of the Earth material influenced the movement of water.

Activity 5:

Influence of inadequate urban planning on water infiltration

1. Observation of photographs

These photographs were taken after several rain storms.

1. Examine the pictures, and record three questions you have.
2. Write a caption for the photograph to the right.



Flooded town, where the nearby agricultural crops also suffered significant damage.

2. Where you live, is it possible for rainwater to percolate down into the groundwater system?



Water runoff in streets is a well-known phenomenon during the rainy season. As a result, roads are damaged, and the wastewater system breaks down, flooding homes and causing problems for pedestrians and motorists. All of these are consequences of the urbanization process (the process of population growth in cities), especially if it is not properly planned.

These problems only appear in the media for short periods of time. However with this phenomenon, we can ask many questions: What happens to water that collects in the streets after it rains? Is this water “lost” and no longer usable? Is it possible to avoid wasting and squandering fresh water runoff?



Surfing the Internet

To explore some of these questions, and others that you have, visit Internet sites, such as:

- Water Resources at United States Geological Survey (USGS)
<http://www.usgs.gov/water/>
- Water Science for Schools (USGS)
<http://ga.water.usgs.gov/edu/>



Photographing the Environment

1. Explore your neighborhood, and photograph sites that will allow infiltration of water during the rainy season, and sites that will not allow infiltration.
Next to each photograph, write your own explanation about the possibility of water infiltration.
2. If you were contacted by a water engineer in your city, who requested your opinion on what you’ve found, how would you respond?
Prepare a report with feedback and improvements that you propose for each site.

Activity 6:

Where is the water cycle found in our environment?



In the previous activity, you encountered various components of the water cycle in nature. In this activity, we will go on a journey to investigate the following sites: a cave, a spring, and a sewage treatment facility for the city.



Field Trip

Instruction sheet for the trip:

General information: (your teacher will share the missing details).

The trip will take place on (day) _____ (date) _____.

We will leave from school at (time) _____. We will return to school in the afternoon at approximately _____.

We will eat lunch during the trip (be sure to bring food with you).

The transportation from one site to another will occur by bus (the trip does not require excessive physical effort).

The drive to the spring _____ (first stop) takes about _____ hours and the activity at the spring will last about ____ hours. The journey from the spring to the sewage treatment facility of the city will take about ____ minutes and the activity there will last ____ minutes. The trip from the facility to the cave is _____, and will last _____ minutes.

The activity at each location will involve two stages:

Stage 1 - Individual and team work.

Stage 2 – Group discussion on the findings and conclusions.

Items you must bring:

- Hat
- Small backpack
- Bags for collecting garbage
- Closed toed shoes for walking
- Water (at least 2 liters per student)
- Sandwiches for breakfast and lunch during the day
- On a rainy day, a coat/jacket/umbrella

Equipment and materials for the trip:

- Notebook - each student should have their own
- Pens and pencils
- A clipboard to support your writing
- Flashlight – with batteries



Synthesis

Tasks to summarize the trip

To summarize the trip, you will create a poster that represents the linkages and interrelationships among the different systems of planet Earth and how they were expressed during the trip.

The poster can be organized as a concept map, or a drawing that integrates the trip stations within the systems of planet Earth.

In order to prepare the poster well, you must first perform tasks 1, 2, and 3.

Note: Tasks 1, 2, and 3 will involve the preparation of separate posters.

Task 1:

Choose three observations made in the field, and discuss the conclusions reached as a result of these observations.

Submit your comments in text form, and accompany with photographs and sketches, as possible.

In the analysis of the observations and conclusions, differentiate between conclusions resulting directly from field observations on the trip, and findings related to laboratory observations, and geological observations made in other places and by other people.

After completing the task, write down what you consider important concepts and integrate them into the poster you will prepare.

Task 2:

Part A: Processes of dissolution and sedimentation in the cave



Surfing the Internet

<http://www.nps.gov/cave/naturescience/geologicformations.htm>

Visit websites about caves, stalactites and stalagmites. Read the websites carefully.

Learn how stalactites and stalagmites form. Read the explanations carefully.

Next, complete these activities:

- a. Write the differences between caves, caverns, stalactites, and stalagmites.
- b. Highlight the most important statements.
- c. Highlight with a different color, the concepts that you know and understand from prior knowledge. Copy the information into your notebook.
- d. Highlight with a different color the concepts you do not know or understand. Copy the information into your notebook.





Questions

1. What kind of rocks are common in a cave with stalactites and stalagmites?
2. How do you differentiate between the rocks limestone and dolomite?
3. Why is the concentration of carbon dioxide (CO_2) in the soil 100 times greater than its concentration in the atmosphere?
4. What is the relationship between the formation of carbonic acid (H_2CO_3) in the soil, and the formation of a cave?
5. Represent the information in the websites, using an illustration describing the chain of events that led to the creation of a cave with stalactites and stalagmites. Present the final illustration on an overhead transparency or piece of paper.

Part B: The process of dissolution and sedimentation in a laboratory

From reading the articles, we learned that these formations are the result of dissolution and sedimentation processes that take place in the cave. The dissolution process begins with the respiration of plant roots, bacteria, and fungi, which enriches the soil with carbon dioxide (CO_2). Therefore, the soil is the source of carbon dioxide (CO_2). When rainwater enters the ground, it dissolves carbon dioxide and through a chemical process, converts it to an acid called carbonic acid (H_2CO_3) which reacts with the rocks in chemical processes. This process can be represented by chemical formulas as follows:



Experiment

In this activity, we will conduct an experiment that simulates the influence of living things on the characteristics of the rock.

Laboratory equipment and materials: bromothymol blue solution⁽³⁾ diluted (0.01%); three test tubes; a marker; fragments of limestone, straws

⁽³⁾ The bromothymol blue is a substance that reveals the presence of carbon dioxide.

Experiment:

1. You have 2 test tubes containing water with dissolved bromothymol blue (to a height of 4 cm). What color is the solution?
2. Blow slowly, using the straw, into the test tube. How did the color change?
3. How can we explain the change that occurred in the color of the solution as a result of the exhalation? (hint: $\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3$)
4. Pour half the liquid from the test tube that you did not blow into, into the empty test tube. You now have two test tubes with a solution to a height of 2 cm. Write on one tube “experiment” and the second “control”.

Into the experimental test tube, introduce a few pieces of limestone. Agitate the test tube. Wait 10 minutes.



Observation

Record the results obtained in the following table:

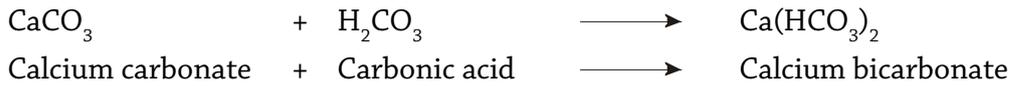
		Test tube (which you blew into)	Experimental test tube (with limestone)	Control test tube (without limestone)
Color	Start of the experiment			
	End of the experiment			



Conclusion

1. In your opinion, what evidence is there that the color change occurred after adding limestone fragments?
2. Try to describe the chemical reaction that took place in the experimental test tube.
Hint 1: The limestone is composed of the mineral calcium carbonate, whose chemical formula is CaCO_3 .

Hint 2: The reaction that took place in the experimental test tube can be described by a chemical formula:



3. Try to describe the chemical reaction that took place in the test tube in which you blew air.



Classification

Describe in a few sentences the phenomenon that takes place in a cave with stalactites and stalagmites, and the relationships between the different Earth systems.



Cave stalactites and stalagmites

Task 3:

a. Examine the observations and conclusions you recorded in your notebook from the trip, and try to identify components that represent the different Earth systems (write at least two components for each system)

Rock system (Geosphere)	Living system (Biosphere)	Air system (Atmosphere)	Water system (Hydrosphere)

- b. Which pieces of evidence from the trip provide evidence of human intervention in the natural environment? Which would you like to include in your poster?
- c. In the table below, put 10 examples that describe the relationships between components of Earth's systems from the trip:

Factor that influences	Factor being influenced	Type of influence
Example: rain	plants	causes germination and growth

- d. On the trip, there were numerous processes representing the water cycle in nature. These are processes of material transfer from one system to another on Earth. Describe at least three examples of transfer of materials or substances (e.g., molecules of water, pollutants, fragments of rock/minerals) that are transferred in the water cycle in nature, as you saw on the trip:

The material	passes from system...	...to another system	through the following process
-->	-->	-->	
-->	-->	-->	
-->	-->	-->	

- e. Write the concepts that are important to include in your poster.

Task 4:

1. As a result of tasks 1, 2, and 3, write the concepts that are important to include in your poster.
2. Prepare a poster that represents the linkages and interrelationships between the different Earth systems, as you observed on the trip.

Earth system: Rock system (Geosphere), system of living things including humans (Biosphere), air system surrounding Earth (Atmosphere), and the water system (Hydrosphere).



Drawing

Prepare a draft of the poster and show it to your teacher.

Remember: It is important to prepare the final poster only after your teacher has commented on your draft.



GROUNDWATER SYSTEM IN A COASTAL PLAIN

In the previous activity, we saw that some of the water that falls as precipitation on Earth infiltrates into the rocks beneath the layer of soil.

In the next activity, we will try to show what happens in those rocks.



Activity 1:

What happens down there? – Simulation Experiment



Drawing

1. Try to draw what you think the groundwater system looks like. With one color, draw the soil and rocks through which water seeps, and with a different color, draw the water.



Observation



outlet holes

clay

coarse sand

2. In front of you is a model that represents three layers of the crust: a layer of sand, a layer of clay, and another layer of sand. Pour in a little water with food coloring into the container, and keep pace with the fluid flowing out of the outlets.

Synthesize your findings in the following table. Mark the correct column with an X.

Rock type	Rate of flow		
	No flow	Slow flow	Fast flow
Sand (top layer)			
Clay			
Sand (bottom layer)			

3. Explain the results of the experiment. Use the elements of scientific thinking: observation, hypothesis, additional information, and conclusion.

Note: After the water was poured into the container, try to identify the line that divides the area in which all the pores of the rock are saturated (full) of water (**saturated zone**), and the area in which many of the pores are filled with air (**unsaturated zone, or zone of aeration**).

The line between the saturated zone and the unsaturated zone is called the “**water table**” or “**groundwater level**”.

In the simulation, pay attention to the real water level which is a few inches below the line where the color change occurred. This is because of a phenomenon known as “wicking”, which occurs when water rises through the pores of rock due to adhesion of water molecules (bipolar) to the walls of the capillaries. Dig a little below the line where the color change occurred, and find free groundwater that saturates the pores of the rock. Explore this phenomenon further.



4. Try to infer what generates the differences in the ability of water to move in different layers. Relate this ability to the rock properties in each layer.



Drawing

5. Draw the simulation container. In the drawing, show the layer of sand, clay, and another layer of sand with a single color. Add the water to the drawing with another color. Mark the water table, saturated zone, and unsaturated zone in the drawing.



Synthesis

Conceptualization and Generalization



Rock layer that carries water – The term “porosity” refers to all the spaces and cracks between the rock crystals or particles. The pores of a rock can carry water if they are connected to each other, so water has continuous flow paths, and can flow into the rock. In Latin, this layer is called the **aquifer** (*aqua* = water, *ferre* = carry).

1. What layer of rock in the experiment simulates the layer of rock that holds water (aquifer)?
The upper sand layer / layer of clay / bottom sand layer



Rock layer that stops the water – In this case, the pores of the rock are disconnected from each other and that is why water cannot flow between them, and is retained by capillary forces. In Latin, this layer is called the **aquiclude** (*aqua* = water, *cludere* = closed, locked).

2. Which layer of rock in the experiment simulates the rock layer that stops water (aquiclude)?
The upper sand layer / layer of clay / bottom sand layer



Groundwater level – This is the area that divides the saturated zone (where most of the pores are filled with water) from the unsaturated zone (where most of the pores are filled with air).



Classification

Summarize the process that took place in the simulation container, according to the elements of scientific thought: observations, conclusion, additional information, or hypothesis.

Below are a list of statements. For each one, record if it is describing an observation, a conclusion, additional information, or a hypothesis.

1. We saw that water came through the upper hole found in the sand layer composed of large particles.

Observation/ conclusion/ additional information/ hypothesis.

2. No water came through the holes in the clay layer or bottom layer of sand.

Observation/ conclusion/ additional information/ hypothesis

3. The clay is a layer that allows slow water movement.

Observation/ conclusion/ additional information/ hypothesis

4. The movement of water in the clay layer is very minimal, and therefore acts as a layer that will slow the infiltration of water into the container.

Observation/ conclusion/ additional information/ hypothesis.

5. The sand has a characteristic that permits water to flow easily between the particles - the sand is a layer that carries water.

Observation/ conclusion/ additional information/ hypothesis.

6. Clay rock is composed of tiny particles with a diameter of 0.065 mm (65 microns). On the other hand, the layer of gravel is composed of particles larger than 1 mm.

Observation/ conclusion/ additional information/ hypothesis.

7. There may be a relationship between grain size and ability of water to move through rocks.

Observation/ conclusion/ additional information/ hypothesis.

8. The water did not reach the bottom layer of sand, and the clay layer stopped the water and prevented it from moving down.

Observation/ conclusion/ additional information/ hypothesis.

9. Because there are spaces (pores) between the sand particles, the sand is a layer that permits water to move.

Observation/ conclusion/ additional information/ hypothesis.

10. On the beach (which consists of sand), water infiltrates quickly through the sand particles.

Observation/ conclusion/ additional information/ hypothesis.

11. The rock is made of clay minerals and has a unique structure.

Observation/ conclusion/ additional information/ hypothesis.

Activity 2:

How do you drill a well?

In the previous activity, we concluded that the water seeps through the rocks that have a porous structure, and can be stored in the pores as well. We know that throughout human history, people have relied on the availability of water from groundwater systems.

In the next activity, we will try to understand the way in which water in the pores of rocks (which is unavailable to humans) can be made available for human use.

The Need: You're touring the desert when suddenly, the car breaks down. The nearest town is far away and would require a few days of walking. It is likely that you will become dehydrated before you reach the town. The water supply you brought is minimal. You have no way to contact anyone for help, and you have no form of communication.

The Mission: Drill a hole in the simulation container to extract water for the members of the group.

Laboratory Equipment: In one of the vehicles, you found a hose, a drill, a syringe, and a plastic container. Use them to help in your mission.

A. Preparation Phase:

1. Write down the different steps you should undertake in order to drill the well and draw water by suction.
2. Record the technical difficulties you encountered during the preparation of the operation.

B. Execution Phase:

Now, carry out the drilling and extraction of water, then answer the following questions:

1. What happens when you try to draw water with the help of the syringe only?
2. What happens when you try to draw water with the help of the hose only?
3. What characteristics should the walls of the hose have in order to allow extraction of water with good quality?



Classification

On a sheet of paper, draw the movement of water from the groundwater system until it reaches the well.



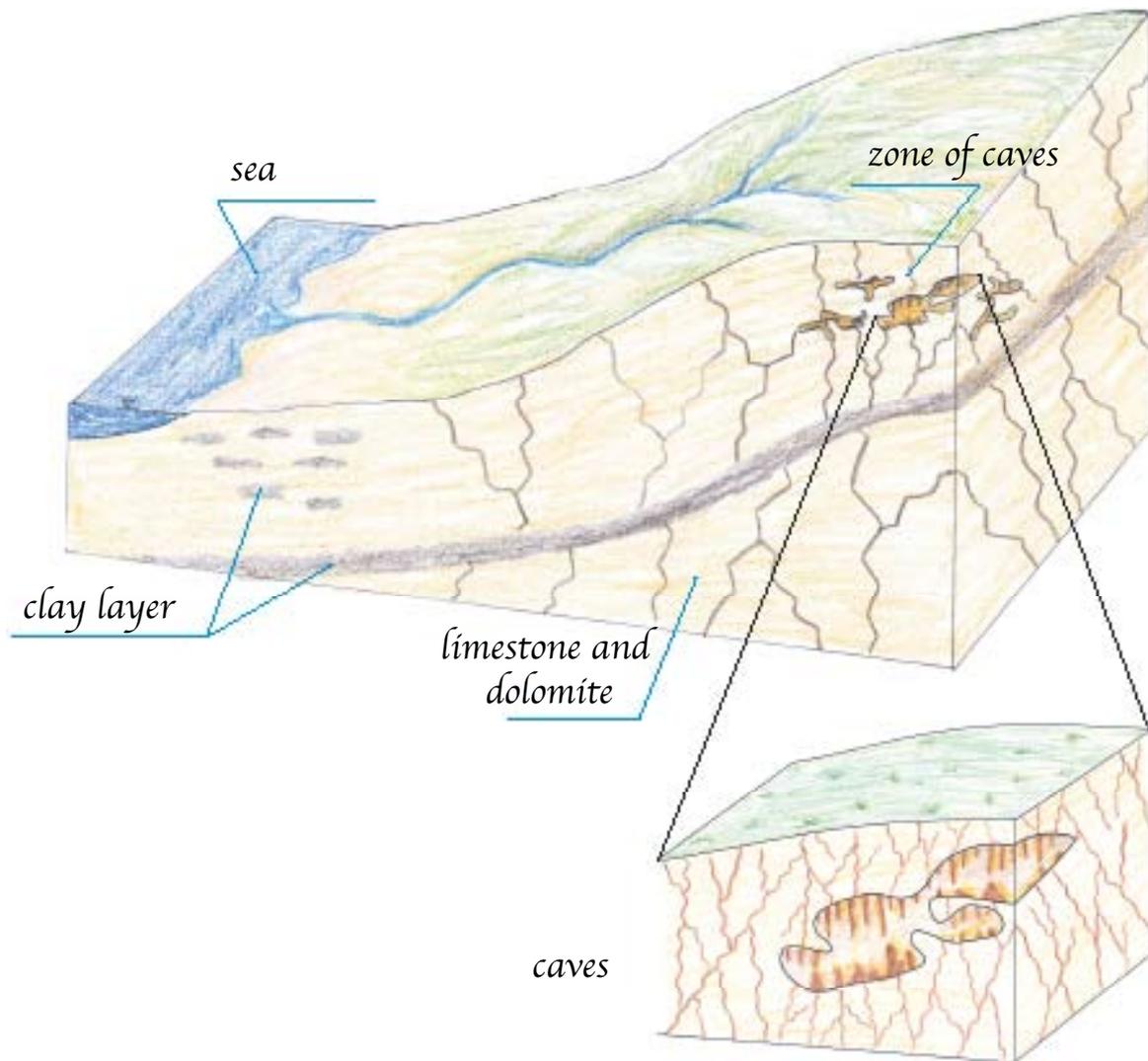
Synthesis

In this activity, you drilled a hole through which you could draw water in the desert. For example, suppose that most drinking water wells in coastal towns are supplied from a groundwater system that extends throughout a sandy coastal strip. A cross-section of rocks found in a sandy area shows that it consists of layers of porous rock (e.g., sand), as well as layers of clay and calcareous sandstone.



Drawing

On the next page is a diagram representing a cross-section from the sea to the mountains. If you had to dig a well in the illustration, where would you dig in order to reach the groundwater system? Draw the location on the picture.



Cross-section of the groundwater system of a coastal plain.



Experiment

Activity 3:

How do you build a spring in the side of a hill? - Simulation Experiment

Fill the container to the top with water, and watch the flow of water through the holes in the simulation model.

1. What is most similar to the opening from where spring water flows? Explain.
2. The illustration shows a section of rocks exposed in the hillside. Where do springs appear on the hillside when rain falls on the mountain?. Mark the route of the water droplets on the illustration.



porous rock

clay rock

3. In the simulation, the spring flowed through the porous rock. Are there situations in nature where a hillside spring emerges through a rock that is not porous? (Hint: The activity on page 60.) Explain.

4. A group of hikers were in the mountains of a semi-arid region when they ran out of water. An old man told them that nearby, there was a place that might have a spring. One of the hikers said that if they found a layer of a specific type of rock, and walked along the contact line between it and the rock above it, there was a chance they would find it. What specific types of rock is the hiker referring to? Explain.
5. In the tour of the spring, you saw an area where water comes from rocks of limestone and dolomite. What are the special features of these rocks that allows water to move through them?

Activity 4:

The journey of groundwater into the sea - Simulation Experiment

In the previous activity, we learned that the supply of water to the groundwater system are the rains that infiltrate into the soil and rocks, until they reach a layer with a slow rate of infiltration. Water is stored in the pores and crevices of the rocks.

The amount of rainwater that infiltrates into the groundwater reservoir each year is called “recharge.”

In this activity, try to understand how water moves below the soil surface and how its movements affects the groundwater system and humans.

Laboratory Equipment and Materials: A simulation container showing the movement of water from the groundwater system to the sea; a 200 mL beaker; water; food coloring.

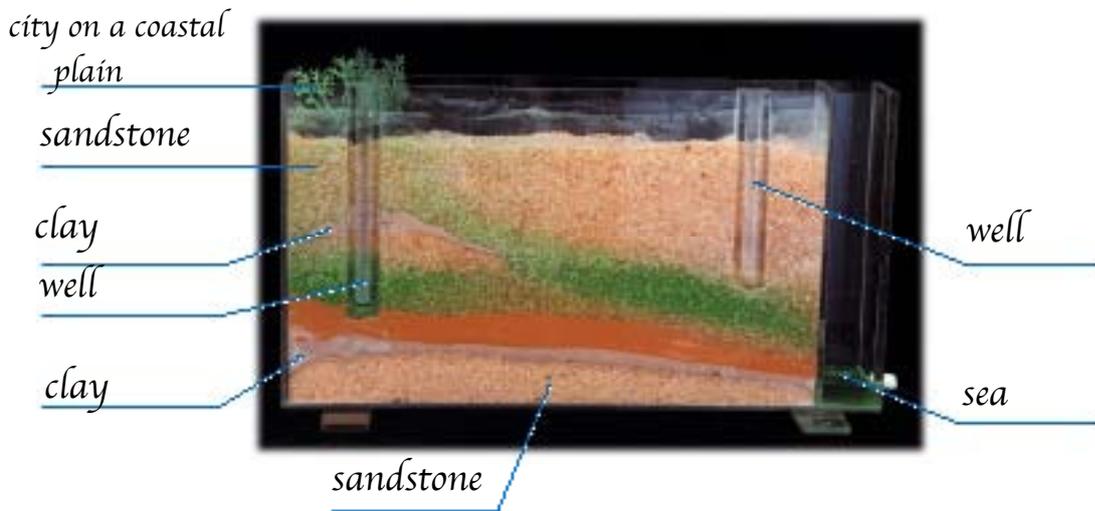
A. Journey of groundwater into the sea



Questions

Activity:

1. Identify the following components of the groundwater system in the simulator, and label them with an erasable marker: sandstone rock (rock layer that transports water), clay (layer of rock that has a slow rate of water infiltration), a well, the sea, a coastal city.



2. Pour a little water containing blue food coloring onto the surface of the simulator, far from the sea, so that it can infiltrate down. Describe what is happening.
3. Write three conclusions that result from the observation.
4. Why is the rain that falls on the sand resulting in practically no runoff (flow of water over the surface), but all the water moves immediately into the sand?
5. In one class, students claimed that in a desert area, the amount of rainfall is so small that there should be no aquifers. What is your opinion? Explain.

B. What happens to the pollutants from industry?



Hypothesis

In the center of the container is an industry that produces chemicals (pesticides). In the two wells in the simulator, hazardous pollutants were found, whose origin could have been the chemicals.

1. Is there a relationship between industry and the pollution of the wells? Explain.



Conclusion

Pour a little water with food coloring (a different color than above) in the center of the container.

Draw water from one well and see what happens.

2. Does your observation support the hypothesis from Question 1?
3. If the pesticide manufacturing industry was located on clay, would the wells have been contaminated? Explain.
4. Pour a little water with food coloring over the area where the clay layer is located, and describe what happens.
5. If this industry had been placed on layers of limestone rock, would the rate of contamination of the wells be influenced? Explain.

C. Are we able to extract all that is needed from the groundwater system?

In recent years, many freshwater wells have been closed along the coastal plain, due to increased salinity by the inflow of sea water. Because this phenomenon is worth understanding in more depth, we will make the following observation.



Observation

Close the valve on the bottom of the simulator, and pour some water with food coloring into the sea. Make at least five withdrawals from the well near the sea.

Observe closely and describe what happens.



Conclusion

1. Write down two conclusions resulting from the observation.
2. Describe what happens in a coastal plain as a result of excessive extraction of fresh water from wells near the sea.



Additional Information

In the coastal area near the sea, groundwater is located near the surface and is easily pumped. Fresh water is less dense and therefore, in coastal areas, fresh groundwater sits above the salt water (more dense). Uncontrolled extraction of water alters the balance between salt water and fresh groundwater. Excessive extraction causes a decrease in the level of groundwater. The result is that the salty sea water rises and enters the wells, making them salty.

The saline well water is unsafe, both for drinking and for irrigation. Damage can last for many years and may never be corrected. Groundwater is not a closed and disconnected system, but rather the water flows slowly through the pores of the rocks toward the sea.

In addition, each year, water is removed from the groundwater system. To keep the level of water constant, and to avoid salinization of wells near the sea, it is important to match the rate of extraction of groundwater, and recharge the system through infiltration of rainfall.

Concluding Activity:

Journey of groundwater into the sea

1. After the simulation experiment, draw in your notebook the path of the water that falls as precipitation, and its movement in groundwater until it reaches the sea and returns to the atmosphere. Show the different locations where water passes, and which processes affect the properties of water as it passes from place to place.

Comment: Remember to integrate into your drawing the path of water from the polluting industry, and the wells from which water is extracted.

2. Compare the current drawing and the drawing of the water cycle that you made at the beginning of the chapter (see page 49).

Similarities	
Differences	

3. In the table, record at least three changes in the properties of water that occur when it passes from place to place. Use the list of sites and processes that you prepared in the first activity of Chapter 2.

The water changes from site...	... to site	Through the process of	The change in water properties due to the passage from one place to another is...
Example: River	Ocean	Runoff	The water is enriched with minerals and soil sediments

Activity 5:

The groundwater system and environmental quality

In an earlier activity, we saw that for rock that has a granular structure, groundwater is present within the small pores. In this activity, find out where wells are located, and where you can find a layer of rock that contains water (an aquifer).

To summarize, describe how human beings affect the groundwater system.

Divide into groups of two, three, or four students. Each student must read the information found on various websites about these topics:

- contamination of groundwater
- groundwater
- artesian wells
- aquifers



Synthesis

Ask the teacher for a copy of the relevant information, or visit websites appropriate to your chosen topic. Carry out the following activities:

- Use a highlighter to mark the concepts you know and understand due to prior knowledge.
- Use a different color highlighter to mark the concepts that are unknown or that you do not understand.
- Use a different color highlighter to mark the most important concepts.



Questions

Use the information acquired from reading the articles or websites to answer the following questions:

- What evidence is there of the interaction between man and the groundwater system?
- How should this evidence influence the planning of the water system in your state?
- Try to write at least three suggestions for the preservation of the groundwater system.



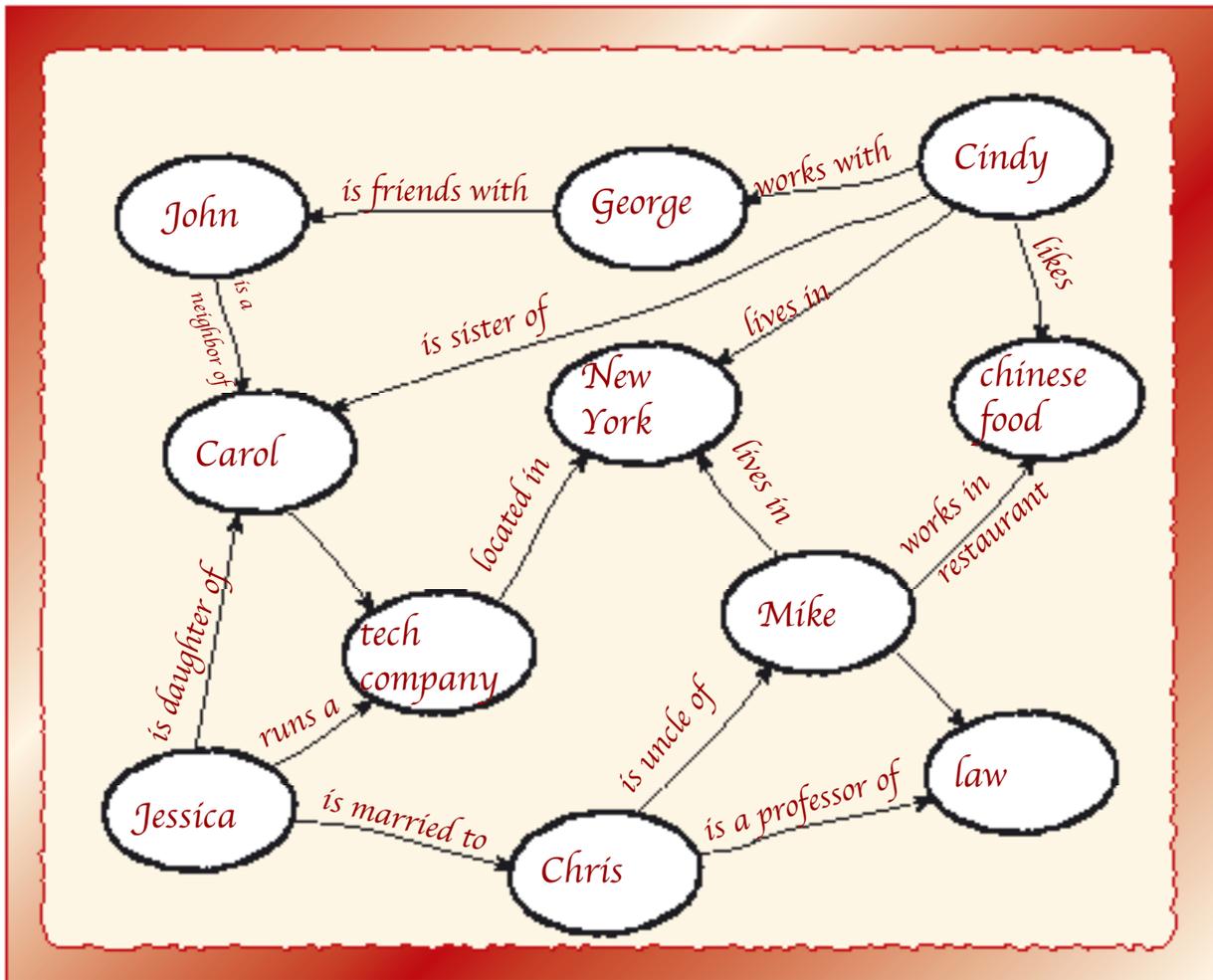
Classification

Activity 6:

Organization of knowledge into a concept map

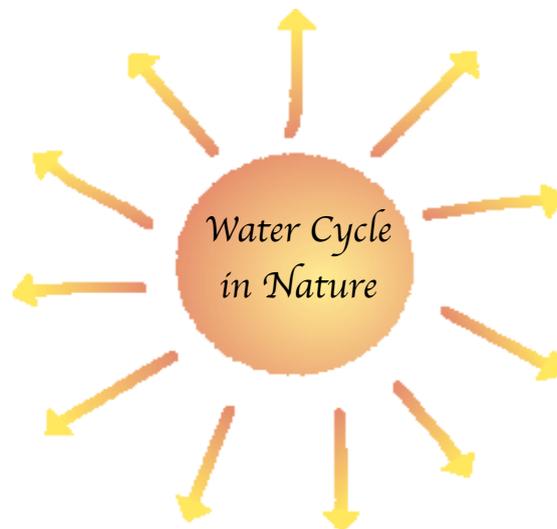
How to construct a concept map-

A concept map is a learning tool for organizing your knowledge about a particular subject. In the first phase, you will recall all the concepts related to a specific topic. Try to remember all the ideas related to your favorite TV show or a novel that you have read. Copy it into the circles. Now draw a line between the concepts that are linked in the TV show you chose, so that two ideas are connected by a relationship, and form a sentence or phrase. When creating links between different concepts related to a topic, the map you generate is an image of your knowledge about a topic (see example).



Now, try to organize your knowledge regarding the water cycle in nature.

1. At the end of each arrow, list the concepts that you think are linked to the water cycle in nature.



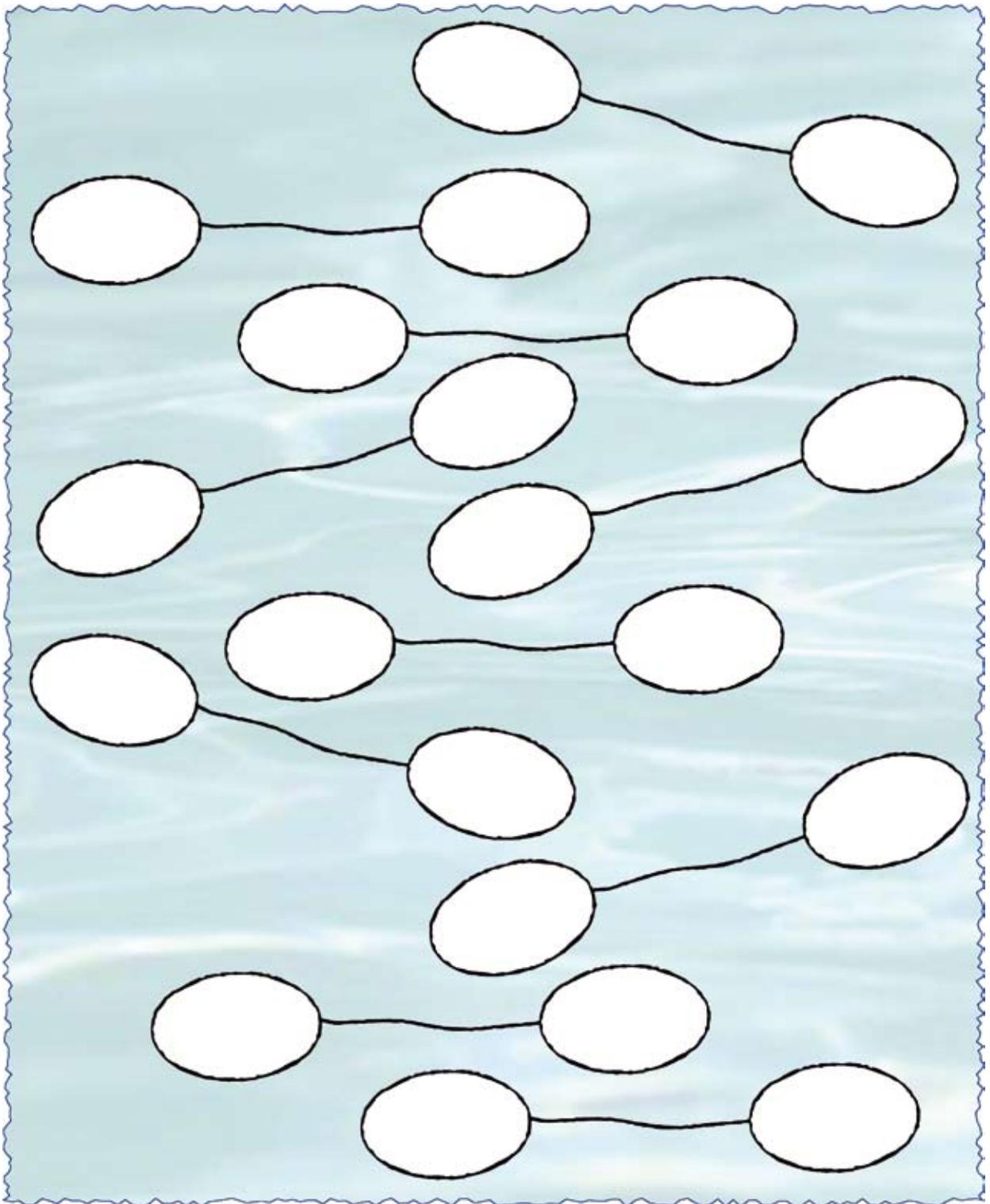
2. Try to generate sentences or phrases that describe the relationship between two concepts in the sun diagram. Write them down on the picture that appears on the next page: write in the two circles the concepts you want to link, and place words on the line to make a sentence (see example).



3. Try to generate a concept map that describes the different relationships between the concepts relating to the water cycle in nature.

Remember that a concept map does not have a specific order and can be started with any concept you choose. It is important to generate the greatest number of links or connections between concepts. Building a concept map is a task that has no correct or incorrect answer. You can create different concept maps with different links between concepts.

4. Was the creation of the map a pleasant or unpleasant experience for you? Explain.



CHAPTER 3:

WHAT IS WATER?





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.

* 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

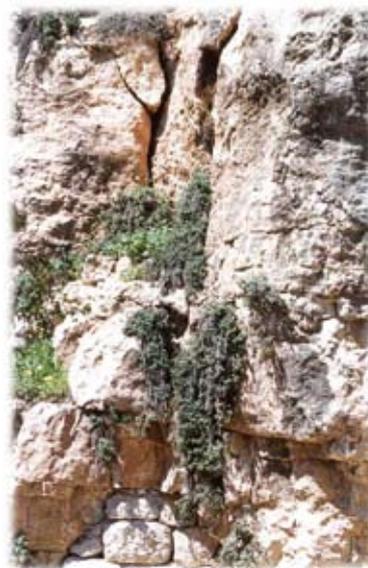
CALCIUM ION CONCENTRATION AS A VARIABLE FOR MEASURING THE “HARDNESS” OF WATER

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_2O_2 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_2O , 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.

Sample Number	Chemical analysis – ion concentration in mg/L		Physical analysis – milliamps	Origin of water Circle the correct origin
	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	
1				<ul style="list-style-type: none"> ● rain water ● spring water ● treated wastewater from contaminated river
2				<ul style="list-style-type: none"> ● rain water ● spring water ● treated wastewater from contaminated river
3				<ul style="list-style-type: none"> ● 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 H₂O**.

A clear liquid containing H₂O 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 (**H₂O**) and a **solute** that is a dissolved substance 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 the solvent (H_2O) and dissolved substances (solutes) would look through the “magic glasses.”



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?

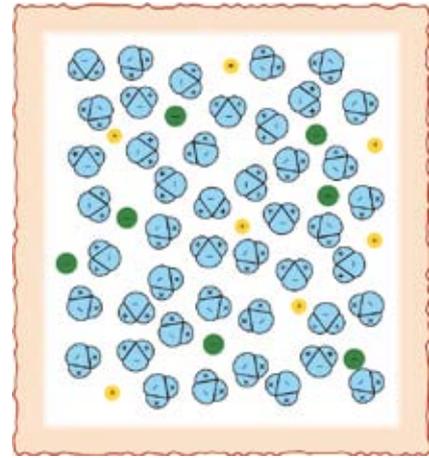


Conclusion

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

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.



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



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 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 · 2H ₂ O		
		Dolomite	Calcium and magnesium 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.			

- Write at least two characteristics of a solution.
- 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

- 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 H₂O).



Observations

1. Pour exactly 40 mL of distilled water (almost pure H₂O) 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).

- 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
- 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
- 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
- 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
- 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 attractive 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
<p>1. Types of particles: as we saw, not all particles are dissolved with each other. Properties of substances influence their solubility.</p>	<p>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+}).</p> <p>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.</p> <p>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.</p>
<p>2. Arrangement of particles in the solution: the solvent molecules surround the solute molecules.</p>	<p>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).</p>



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 ____



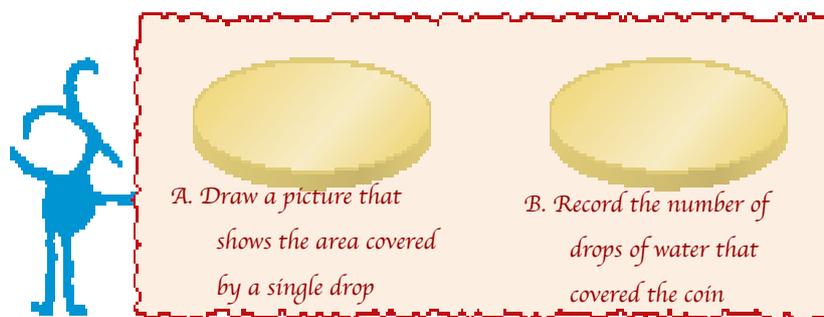
Learning Method 1: A Penny

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

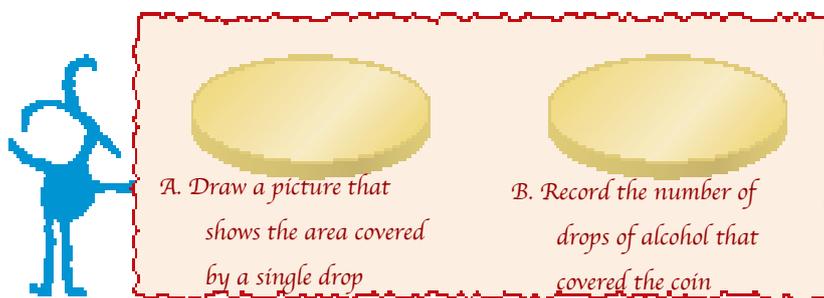
Compare the result with the average forecast. If the result is far from the average forecast, try to find the cause.

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

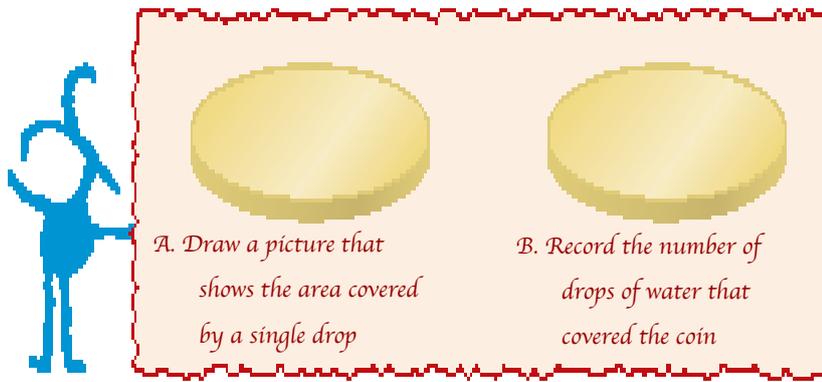
Compare the result with the average forecast. If the result is far from the average forecast, try to find the cause.

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.



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.



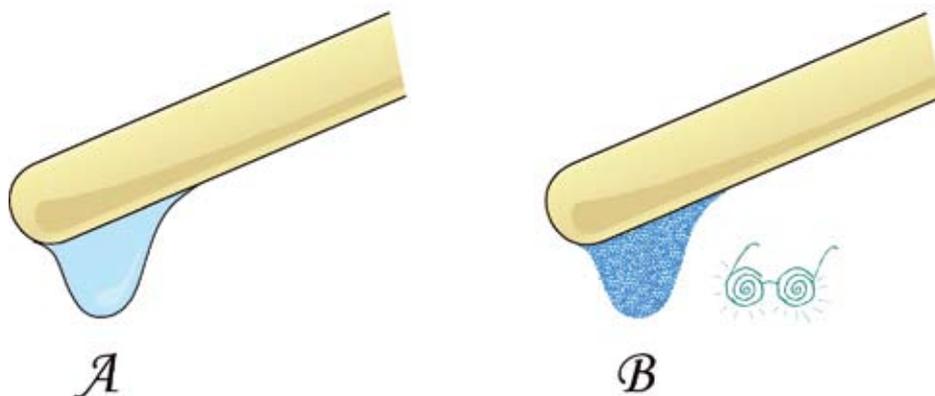


Learning Method 2:

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 make up 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 a 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.

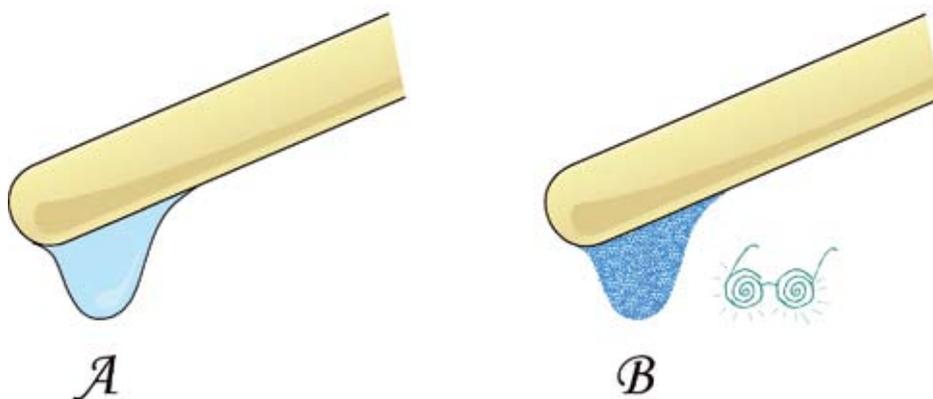




Learning Method 5:

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 make up 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.

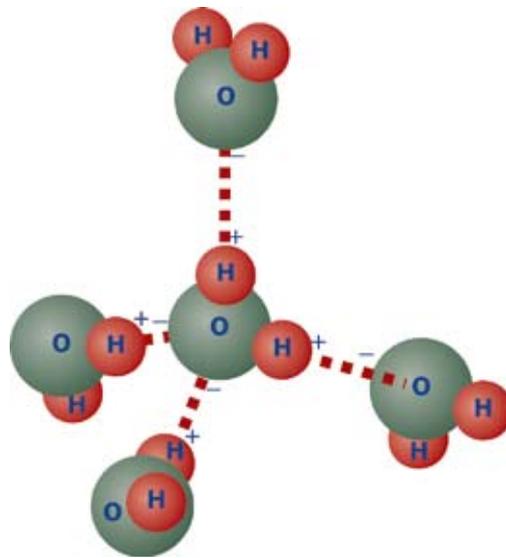
Synthesize your findings from this activity, according to the parts of scientific thinking: observation, hypothesis, additional information, and conclusion.



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 molecules 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. Place 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>

CHAPTER 4:



IS THERE ENOUGH WATER FOR EVERYONE?



AVAILABILITY OF WATER ON EARTH

Activity 1:

Distribution of water on Earth

Points to consider...



In the first chapter, we learned that most of the Earth's surface is covered by water. In your notebook, complete the following sentence:

“If two-thirds of the Earth's surface are covered by water, then...”

Next, write at least three questions related to this statement.



To answer these questions, we will study the distribution of water on Earth.



Hypothesis

Development of the Activity

1. Formulating a hypothesis.

- a. Look at the photographs on the cover of this chapter. The pictures represent different forms of water in nature. Match each form of water in nature with a hypothesis about the proportion (percentage) of the total water on Earth.
- b. In your notebook, synthesize your hypotheses in the center column of the table. After the classroom discussion, complete the right column of the table.

Use the percentages from Figures 1 and 2 to organize your ideas in the table below.



Water Bodies in Nature	My hypothesis of proportion (in percent)	Scientific knowledge of proportion (in percent)
Oceans		
Glaciers		
Groundwater		
Precipitation (Atmospheric)		
Lakes		
Rivers		
Living things (Humans, Animals, Plants)		



Graph Analysis

On the next page, you will find two charts showing the distribution of water on Earth. Figure #1 shows the distribution of all water (“fresh” and “salt”). Figure #2 only shows the distribution of fresh water.

- a. Try to make three conclusions (at least) from your exploration of the figures.
- b. Mark whether each statement below is correct or incorrect.
 1. 97.2% of the water on Earth is salt water, and only 2.8% is fresh water.
 correct **incorrect**
 2. The amount of water in the atmosphere (such as rain, snow, hail, and water vapor) is less than that found in all rivers on Earth.
 correct **incorrect**
 3. The smallest percentage of fresh water on planet Earth is locked up in glaciers.
 correct **incorrect**
 4. Most of the water on planet Earth is in the oceans, and is salt water.
 correct **incorrect**
- c. On the previous page, fill in the right column of the table with the data about the water distribution, based on scientific knowledge. Do the data from the graph agree with the hypotheses you made in the table?
- d. In your opinion, why is there a need to provide two different graphs to show the distribution of water on planet Earth?
- e. In your opinion, why is the data about living things not shown on Figure 2?

f. Try to determine the relative proportion of each place water is found in nature. Record these forms below the number that represents the proportion of these forms relative to the total amount of water in nature.

1	2	3	4	5	6	7

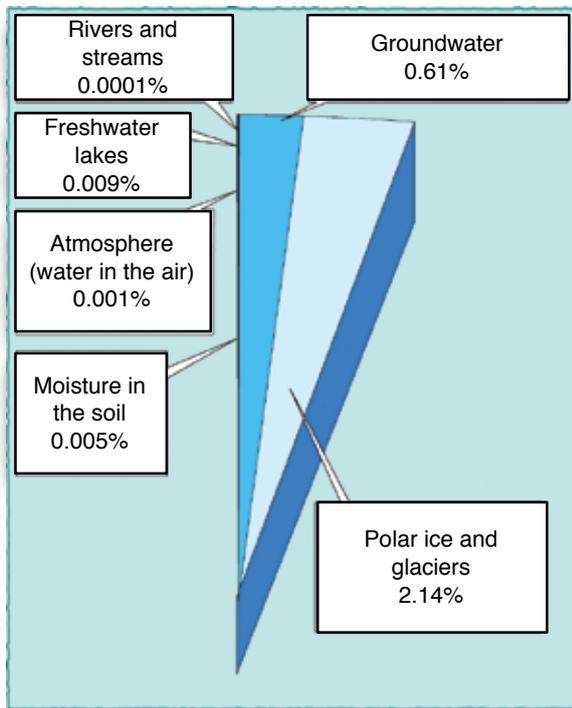


Figure 2: Distribution of fresh water on Earth*

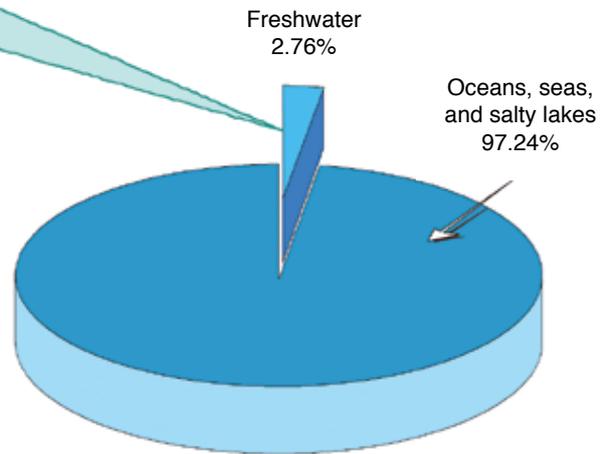


Figure 1: Distribution of all water on Earth*

* Data from the American Geosciences Institute

Activity 2:



What water is available?

We consider the existence of water in our life as stable, and generally, we do not reflect on its importance. Looking at the history of planet Earth and humanity, we notice that water has played an important role in the development of life on Earth. In the following section, we will examine the percentage of the total water on Earth, and also for the United States, and how much of that water is available

for use by humans.

1. Next to each body of water in the table below, record a reason why you can use the water source, and a reason why you cannot use this water source.

Source	Yes: Reason that the water is available for use No: Reason that the water is <u>not</u> available for use
Polar ice and glaciers	Yes: No:
Groundwater	Yes: No:
Streams and rivers	Yes: No:
Fresh water lakes	Yes: No:
Atmosphere (water in the air)	Yes: No:
Soil moisture	Yes: No:
Oceans, seas, and salty lakes	Yes: No:

2. After this activity, answer the question: What sources of water are available for human

use?

3. Below is a table that describes the amount of water found in each of the bodies of water (and the different forms in which water is present) on Earth.

Mark whether each source of water on Earth is fresh or salt water, and whether it is or is not available for humans (see the example).

Source	Percentage (%) of total	“Fresh water”	“Salt water”	Water is available to humans	Water is not available to humans
Atmosphere (water in the air)	0.001	✓			✓
Polar ice and glaciers	2.140				
Groundwater	0.610				
Streams and rivers	0.0001				
Fresh water lakes	0.009				
Soil moisture	0.005				
Seas and salty lakes	0.008				
Oceans	97.240				



Summary of the distribution of water on Earth	Percentage (%)
a. Add up the “salt water”	
b. Add up the “fresh water”	
c. Add up the amount of water available for human beings	



Conclusion

List at least three conclusions that can be derived from the data in the table.



Additional Information



The phrase “water availability for humans” refers to the ability to use fresh water that is safe, without using extremely expensive technology and great effort. It is no coincidence that this definition may sound ambiguous - as water that is available for drinking in India may not be considered available for drinking in Spain. Many tourists are meticulous, and only drink bottled water when visiting some countries. **The availability of water is a social issue, which has technological, economic, and environmental meanings.**

Mission: Choose a source of water and explore whether this water is available or not, for humans.

Each group will receive a transparency and will write down their chosen water source, and then present the economic, technological, and environmental aspects of using this water source. The presentation can also be made in Power Point® or on a poster.

For example: The water from glaciers is not available to humans due to the high cost of transporting the water over long distances. The exploitation of this source of water brings up environmental concerns, as the transportation of this source requires a large amount of gasoline. The use of gas as an energy source generates air pollution, and involves the exploitation of nonrenewable resources on Earth. Therefore, the use of this source of water is damaging to the environment in two different ways.

Technological Aspects

Environmental Aspects

Economic Aspects

Technological Aspects

Source of water

Economic Aspects

Environmental Aspects

Presentation: Availability of water on Earth



Surfing the Internet

Visit the following websites:

<http://ga.water.usgs.gov/edu/followadrip.html>

Explore this website and read the section about “**Following a Drop Through the Water Cycle.**” Pay special attention to the movement of drops of water through different parts of the water cycle.

What happens if no one interferes with the water cycle?

http://en.wikipedia.org/wiki/Water_cycle

Read through the section of this website about “**Residence times,**” which specifically refers to estimates of the amount of time a water molecule spends in each part of the water cycle.

Where do water molecules spend significant amounts of time? Where do they spend the least amount of time?

http://news.bbc.co.uk/1/hi/english/static/in_depth/world/2000/world_water_crisis/default.stm

Read an overview of the “**World Water Crisis**” (at the bottom of the page), and then explore some areas of the world in which people do not have access to safe drinking water.

<http://www.scientificamerican.com/article.cfm?id=freshwater-crisis-current-situation>

Read the article “**Freshwater Crisis: Current Situation.**” Examine the map at the bottom of the article that shows where water supplies are abundant or scarce around the world.

What does it mean when a country faces a scarcity of fresh water?

Which regions of the world are facing the most significant water scarcity?

What is the difference between physical and economic water scarcity?

<http://www.worldwater.org/data.html>

This website catalogs large amounts of data about the world’s fresh water supply, and the availability of fresh water to people in different countries of the world. Use the data from this site, and in particular, **Table 3: Access to Safe Drinking Water, by Country, 1970 to 2004**) to answer the questions that follow.



Excel Activities

1. Explore the data about countries and their respective water availability.
2. Rank the countries according to the availability of fresh water.
3. Make a chart that shows the ranking of countries with respect to the availability of fresh water.
4. How does the United States' water availability compare with other countries in the region?
5. Assuming that the trend of water availability continues to be the same, forecast the water availability of several countries of interest, by 2025.

Activity 3:

Who is taking care of our fresh water sources?



Analysis of Information

Earth's rivers play a significant role in water runoff. In a large number of countries, including Kazakhstan, the rivers carry water to remote areas, for use in irrigation and drinking. In this activity, you will study the history of the Aral Sea, which is a tragic example of the exploitation of water resources.



Surfing the Internet

<http://www.nationalgeographic.com/familyx/14/aral.html>

http://en.wikipedia.org/wiki/Aral_sea

<http://geography.usgs.gov/feature/description.php?id=173>



Visit the websites from the previous page, and read the articles about the Aral Sea and the Ecological Catastrophe in that region. Be sure you look at the photos and satellite images on those sites to see how the Aral Sea has changed.



Questions

Questions about the Aral Sea articles.

- Which article was most useful?
- What is the main issue presented in the articles?
- What is the central message of the articles?
- What influenced the availability of fresh water in Kazakhstan, and how?
- How did this article influence your understanding of human's influence on the availability of fresh water? Explain.



Satellite view of the Aral Sea

The story of the Aral Sea shows how countries that are rich in water resources, such as Kazakhstan may lose their water sources if they are not used properly.



Surfing the Internet

Now, visit the following website, and click on the links to learn more about water quality:

<http://ga.water.usgs.gov/edu/waterquality.html>

- Highlight the most relevant parts of this article.
- What is the central message of the article?
- What impact does human activity have in the degradation of water quality in lakes?
- What ideas could you propose to restore the degraded environment?
- Does this article make you more interested in studying how human activity affects the pollution of our water? If so, how?



HUMAN ACTIVITIES AFFECTING THE QUALITY OF FRESH WATER	DAMAGE TO THE QUALITY OF FRESH WATER DUE TO THESE ACTIVITIES



Synthesis

Activity 4:

Activity to synthesize the theme of water availability in the United States

This work will be done in groups of 3-4 students. Consider the following tasks:



Surfing the Internet

Task 1: Population growth and water availability in the United States.

1. Search the Internet for data about how the population of the U.S. has grown since 1900. Sketch or record your findings in your notebook (Note: if you prefer to focus on the data for a specific state, try to find the requested information in these tasks for that location).
2. Next, search for data about the way freshwater resources are used in the U.S. or in the state you have chosen. Ex: agriculture, recreation, industrial, domestic, etc. Record your data in your notebook.
3. Search for data about the breakdown of the population of the state you've chosen to study. What percentage of people live in urban, suburban, and rural areas?

Living situation of the population in _____ (state)	Percentage of people
Urban	
Suburban	
Rural	

4. Merge with another group of students in your class who studied a different state and compare your findings.



Analysis of Data

1. Write down three new facts that emerged from the data and information you gathered, which you did not previously know.
2. As a result of your analysis of the information, write down at least four conclusions regarding the availability of water in the United States, a specific state, and/or the world.

Task 2: Water problems in the United States



Synthesis

In this activity, discuss with your classmates which places in the U.S. have water problems. Search the Internet for information on these places. Be sure to include the sources of your information in your notebook. Use the following questions to guide your search:

- a) How much water is available for human use?
 - b) What is the source of water in this location?
 - c) What are the reasons for the water problems in this location?
 - d) What actions are being taken to solve these problems?
-
1. Worldwide, industrial development and the rising living standards enhance the consumption of water, resulting in an increase in the exploitation of water sources.
 2. Summarize in a few statements how the people of the United States (or your chosen location) might affect water availability.
 3. How should the findings from your research influence the planning of the water system in the future?
 4. How will developing industries increase the quality of life, and water availability for humans?



The use of water for agriculture.

Task 3: Humans and water.



*Surfing the
Internet*

Find an article about human's influence on water in the United States, or in the location you've been studying. Use your list from Task 1, Question 2 to get you started.

1. Highlight the most relevant parts of this article.
2. What is the central message of the article?
3. Does this article make you more interested in studying how human activity affects the pollution of our water? If so, how?



Analysis of Information

Task 4: Summary of Information

Water in the United States – analysis of information sources.

1. Try to locate in the daily newspapers, fragments of information or articles related to water availability problems in the United States.
2. Synthesize the information found in these sources by referring to the following points:
 - a. What are the factors that influence the availability of water in the United States in the 21st century?
 - b. In your opinion, what could endanger the water resources available to the US population in the 21st century? Refer to the findings and emphasize the points you need more information about or better information in order to answer this question more convincingly.
 - c. If the authors proposed possible solutions to prevent the decline of water resources in the United States, describe them in the table below.
 - d. Explain the views of the authors on the proposed solutions. Are they feasible? Suggest additional solutions.

FACTORS AFFECTING THE AVAILABILITY OF WATER	POSSIBLE SOLUTIONS TO THE DIMINISHING AVAILABILITY OF WATER

CHAPTER 5:

TRANSPORT OF SUBSTANCES IN THE WATER CYCLE





DO YOU THINK THE AMOUNT OF WATER ON EARTH IS FIXED?



The previous chapters analyzed parts of the complex path of water cycling on Earth. In this chapter, we will integrate the entire picture, which includes the passage of water through Earth’s systems: the hydrosphere, geosphere, biosphere, and atmosphere.

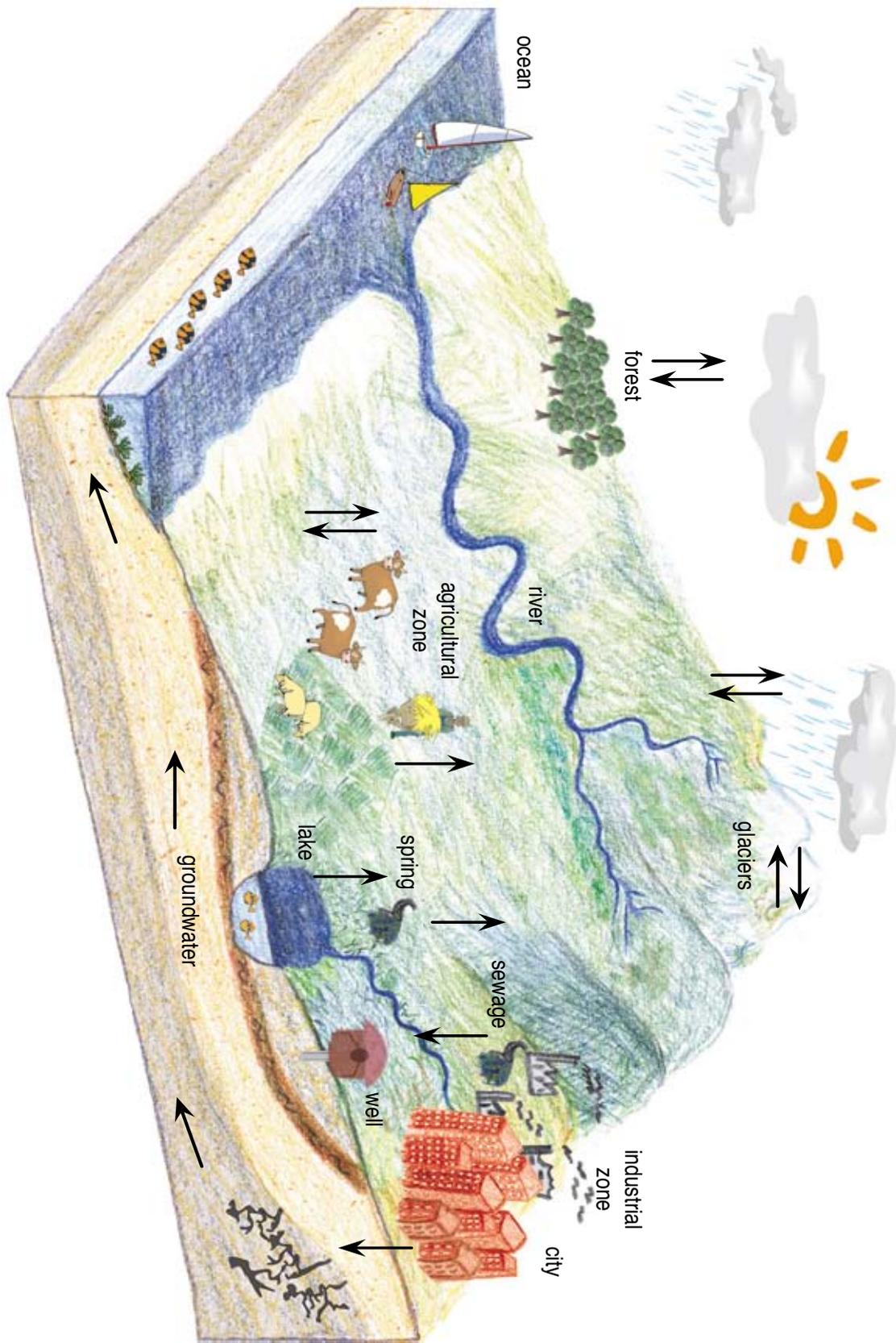
Activity 1:

Another look at the water cycle in nature

- On the next page, you’ll find an illustration that represents the water cycle in nature. Arrows show the direction of flow* from site to site. Next to each arrow, write down the name of the process that links these two sites.
- Use this list of processes to get started:
 - Dissolution
 - Evaporation
 - Melting
 - Condensation
 - Infiltration
 - Groundwater flow
 - Precipitation (rainfall)
 - Surface water runoff
 - Freezing
- Write at least three movements that take place during the journey of water from one location to another on Earth.

Name of substance	From Site “A”...	...To Site “B”	Through the process
Ex: the mineral calcite (CaCO ₃)	Limestone rock	Groundwater	Dissolution

* Flow: The amount of matter per unit area and time, for example: g/m² day.



Activity 2:

Balance in the water cycle in nature

Here, we present a graph showing the amount of water that evaporates, and the amount of water that precipitates as rainfall over a year.

Look at the graph and answer the following questions.

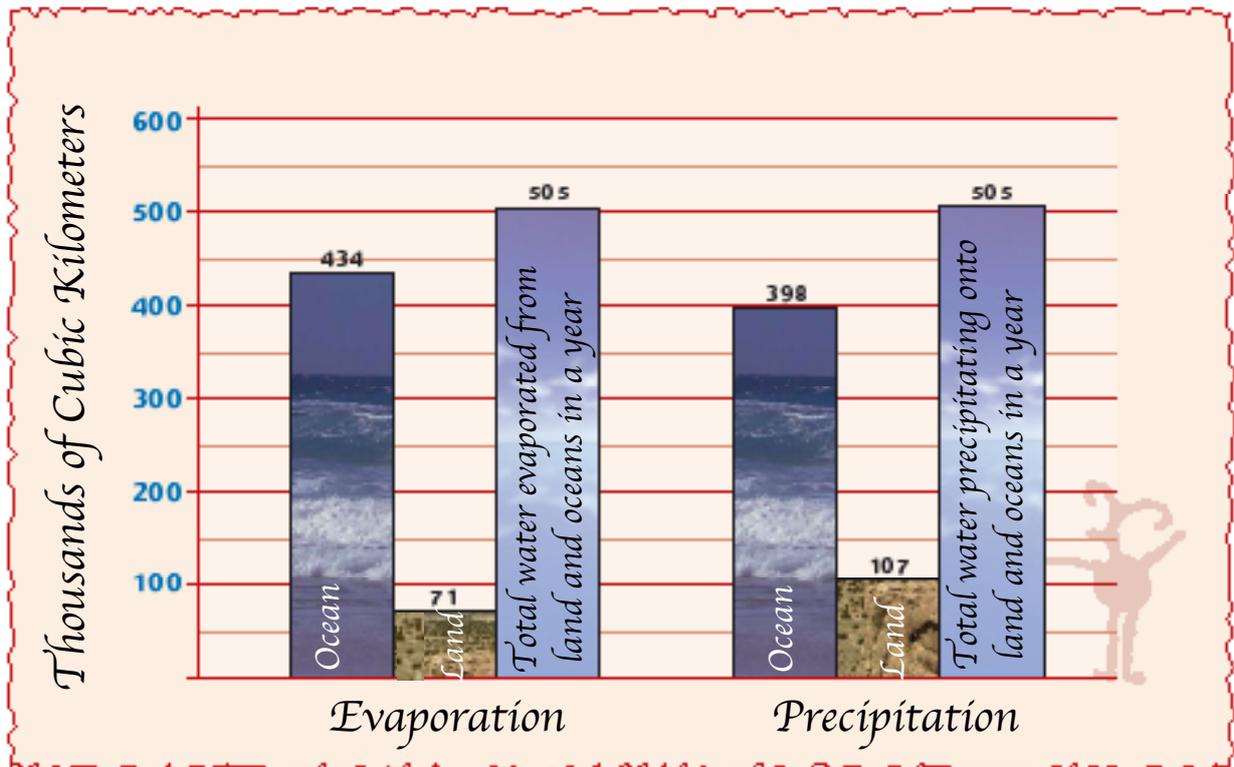


Figure: Equilibrium in the Water Cycle in Nature

Chart data taken from Press, F. and Siever, R. (2000). *Understanding Earth*. W.H. Freeman and Company. New York - ISBN 0716735040.



Graph Analysis

1. Write three conclusions you can deduce from the graph.
2. Circle the correct answer:
 - a. The amount of water in the water cycle in nature is not fixed. right/wrong
 - b. The amount of water that evaporates from the oceans is greater than the amount the oceans receive as rainfall. right/wrong
 - c. The amount of water that falls as precipitation on the surface is always equal to the amount of water that evaporates from it. right/wrong
 - d. In the water cycle, the total amount of water that evaporates in a year is equal to the amount of water that falls as precipitation each year. right/wrong
3. The amount of water in the entire water cycle is fixed. However, oceans evaporate about 40,000 cubic kilometers **more** water than the amount they receive as a direct result of rainfall. How can you explain this?

[Hint: look back at the information on cloud formation \(pages 142-143\).](#)

Points to consider:

1. In your opinion, is the amount of water in the oceans growing from one year to the next, as a result of the entry of water into the ocean from groundwater and rivers? Explain.
2. The amount of water in the oceans is 1.32×10^9 cubic kilometers. In your opinion, can humans influence the amount of water in the oceans? Explain.
3. In recent years, a large number of scientists have argued that the Earth's atmosphere is getting warmer. We know that radiation from the sun causes evaporation of water from the surface of the Earth and oceans. In your opinion, can the quantity of water on Earth decrease as a result of global warming? Explain.

Activity 3:

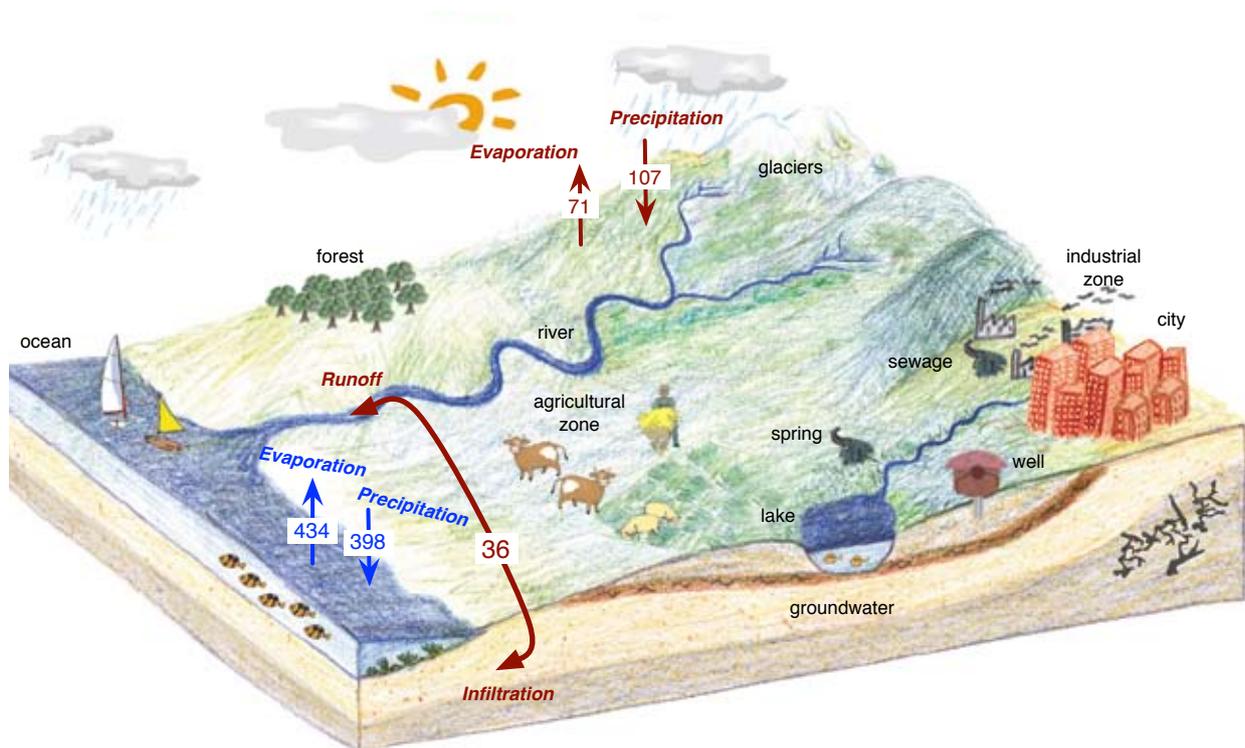
What happens to water in the water cycle in nature?



In the previous activity, we concluded that the amount of water on the surface of the Earth is fixed. We also found that the amount of water that falls on the Earth's surface as precipitation is always greater than the amount of water that evaporates from it.

Below is a picture that shows the water balance in the water cycle in nature.

The numbers represent the amount of water moving in nature from one place to another through various processes of the water cycle.



* Data taken from Press, F. and Siever, R. (2000). *Understanding Earth*. W.H. Freeman and Company. New York- ISBN 0716735040.

A. The water balance on the Earth's surface (crust)

1. In the table, write down how much water reaches the Earth's surface and how much comes out of it.



Process by which water moves from one site to another	Quantity of water flowing in the process (in 1,000 km ³)
Precipitation	
Evaporation from the surface	
Amount that remains	

2. What happens to water that evaporates from the surface into the atmosphere?
3. Describe two phenomena that provide evidence of the transportation of water in the crust (where the water does not reach the atmosphere).

B. The balance of water in the oceans

1. In the table, write down how much water reaches the oceans and how much comes out of it.



Process by which water moves from one site to another	Quantity of water flowing in the process (in 1,000 km ³)
Precipitation	
Evaporation from the surface	
Amount that remains	

2. What happens to water that does not return to the ocean as precipitation?

B:

MOVEMENT OF WATER FROM THE OCEAN INTO THE ATMOSPHERE

Activity 1:

How does water evaporate in nature?



In this activity, we will conduct a simulation experiment to examine the mechanism of evaporation of ocean water (salty) and condensation of water vapor in clouds (freshwater). Also, we will examine how this simulation is similar to, and different from processes in nature.

Materials: A Styrofoam cup that can hold 30 mL of water, one teaspoon of salt, a stand that holds a light bulb (or lamp) of at least 100 Watts, 2 watch glasses of about 7-8 cm in diameter, a 100 mL graduated cylinder.



Experiment

- Place a watch glass in the refrigerator, preferably in the freezer.
- Pour 30 mL of water into a Styrofoam cup, and add a teaspoon of salt to the water. Stir well and taste the water.
- Cover the cup with the second watch glass.
- Use the bulb (or lamp) to illuminate the glass for at least 25 minutes.
- After 25 minutes, turn the light off, and place the cold watch glass (which was in the freezer) on the cup (instead of the hot watch glass). Be careful! Put your fingers into the water vapor that condensed on the cold glass, and taste it.



Classification

1. Summarize the processes you observed by completing the following statements.
 - The warming of salt water in the glass caused the _____ of water moving at a faster rate.
 - The water molecules left the surface of the liquid as a _____.
 - Salts dissolved in the water solution are not _____ and therefore remained in the cup.
 - The cold glass with which we covered the cup caused the _____ of water vapor present in the ambient air.
 - Water _____ and water droplets became _____.
2. What is left in the cup after the water evaporated?
3. Draw a line linking the components of the experiment with the natural phenomenon it simulates (write the letter and number it corresponds to in your notebook).

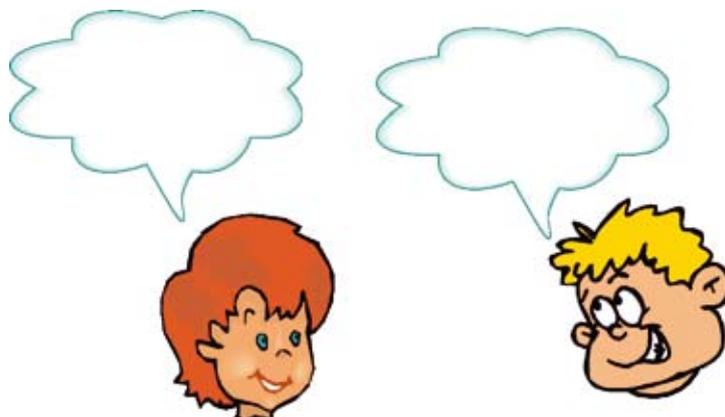
Components of the experiment			Natural phenomena
1. Salt water solution in the cup	●	●	a. Sunlight
2. Fresh water	●	●	b. Ascent of water vapor to a layer of cold air
3. Does not exist in the simulation	●	●	c. Condensation nuclei for water vapor
4. Heating the container	●	●	d. Ocean
5. Cold watch glass	●	●	e. Water from a cloud

In this activity, we learned how water evaporates from the ocean into the atmosphere of planet Earth.

In one school, students claimed that a cloud formed over Lake Titicaca (whose water comes

from melting glaciers in the Andes) is different in composition and taste, compared with a cloud created over the Dead Sea (which has a salt concentration of 230 g/L - seven times higher than the average ocean).

1. What is your opinion on this issue?
2. Discuss your argument with the members of your group and write down the conclusions you arrive at regarding this issue.



Activity 2:

Does water evaporate as well in the cold?



In the previous activity, we conducted a simulation of the evaporation of ocean water. The rate of evaporation from the ocean has a great influence on the formation of clouds and the climate of Earth. This activity will examine the rate of evaporation from the oceans and seas surrounding countries where winter temperatures are very low.

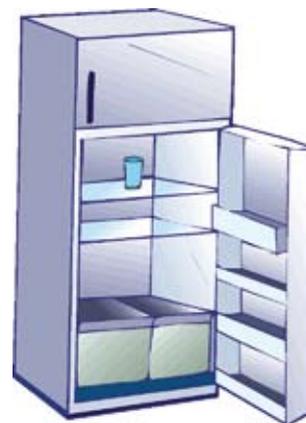
Materials: A refrigerator, 2- 100 mL beakers; labels; pencil; tap water; **patience**.



Experiment

Development of the Experiment:

1. Fill each beaker with 100 mL of water from the tap.
2. Stick a label on each beaker so that it extends from the bottom to the top.
3. Use a pencil to mark the initial level of water in the beakers.
4. Place one cup in the refrigerator of your home, and one outside the refrigerator for a period of two weeks.
5. Do you think the rate of evaporation will be different in the two glasses?
6. Be careful to note the level of water reduction due to evaporation on the label every two days.
7. Record how much the amount the water level decreased in each vessel, in mm.



		Day 2	Day 4	Day 6	Day 8	Day 10	Day 12	Day 14
Evaporation rate (mm)	In the refrigerator							
	Outside the refrigerator							



Activities in Excel

- A. Prepare a chart that describes the rate of evaporation of water inside and outside the refrigerator, and its relationship (dependence) with temperature, using Excel® or another spreadsheet software on the computer.
- B. Try to describe the process that took place in the experiment using the elements of scientific thinking: observation, hypothesis, additional information, and conclusion. Refer to concepts such as particle movement, surface, gas, liquid, temperature, and air.

C. Read “Thinking Scientifically” which appears on page 24, and answer the following questions:

1. What is the research question in this experiment?
2. In your opinion, what is the variable that influences (independent) in this experiment? And what is the variable that is influenced (dependent)?
3. What is the change that took place in this experiment in the beakers of water that helps you answer the research question?
4. Which of the two beakers is the control?
5. Why should you not include graphical data obtained from the experiments of different groups?

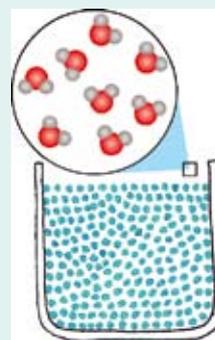
Hint: This experiment was conducted in each of your homes.



Knowledge Organization

Those of you who studied “The Structure of Matter - Vacuum and Particles” used magic glasses to help you imagine the change in the physical state of water. If you had access to magic glasses through which you could see the physical changes in water, how would you describe what happens during evaporation?

The evaporation of a liquid involves the dispersal of molecules of matter. This is a state in which they are bonded together in a higher density (liquid) to a state in which they are scattered with a large distance between them (gas) and therefore they are characterized by a lower density. Because the scattering is only possible if there is movement, evaporation begins the moment molecules begin moving in liquid form. Heating the liquid can increase the speed of movement of the molecules as they begin moving faster and faster. As a result of this movement, some of the molecules detach from the liquid surface, and move away - that is, they evaporate. Although, at low temperatures, the molecules move, the movement is relatively slow.



Activity 3:

The forces of attraction between particles of water

1. What physical condition of water molecules will attract each other with the greater force: when water is in a liquid or a gaseous state? Explain.

30 water molecules in liquid state	30 water molecules in gaseous state
	

2. Try to draw 30 water molecules as they would look in a liquid state, and in a gaseous state.
3. In your opinion, why is it only the water that is on the surface of the liquid that evaporates (the area is in contact with air)?



Additional Information

In the gaseous state, the attractive force between water molecules is very weak. In liquids, and especially in solids, the force of attraction is higher. Water molecules found in the bottom of the liquid cannot leave, because in any direction they move, they collide with other water molecules. In contrast, for the water molecules found at the surface of the liquid, i.e. in the area in contact with the air, it is easier to disconnect from the rest of the liquid particles because there are fewer water molecules around. If a molecule of water leaves the liquid, it moves between the spaces of the air molecules, and becomes part of the mixture of gases in the air. These water molecules, driven now by the collisions between the molecules found outside the surface of the liquid, are known as **water vapor**. The humidity level in the air increases.

Relative Humidity: percentage of water molecules in a gaseous state, with respect to the maximum capacity of the atmosphere (at the same conditions of temperature and pressure) that contain this type of molecule.



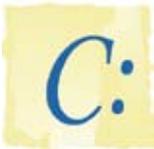
*Surfing the
Internet*

Activity 4:

A movie to study what makes up clouds

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

In the last activity, we found that most of the water on Earth evaporates from the ocean, and returns to the ocean as precipitation, and that this is related to the fact that two-thirds of the Earth's surface is covered by oceans. We will try to find out how the process of evaporation from the ocean to the atmosphere influences the properties of water in the water cycle in nature. In this activity, we will discuss from what clouds are made.



MOVEMENT OF WATER FROM PLANTS TO THE ATMOSPHERE



In the previous chapters, we explored the transport of water from the groundwater system (geosphere) to the oceans (hydrosphere), as well as the transport of ocean water into the air (atmosphere). In this chapter, we focus on the connection between water and the biosphere. Try to understand the mechanism that enables the movement of water from the roots of the trees to the top of them, and what this movement says about the rest of the Earth System.

Activity 1:

Do plants lose water?



Experiment

Materials:

3 50 mL graduated cylinders numbered 1, 2, 3, and marked with a horizontal line at a height of 2 cm below the top edge, a stopper with a hole, a stopper with no hole, a stem with leaves, clay, a waterproof marker, an analytical scale.



Development of the experiment:

- Fill three cylinders with tap water to the marked line.
- On cylinder #1, place the stopper with no hole.
- Cover cylinder #2 with the stopper with a hole. Insert the stem of the plant, and seal the edges with clay between the stem and the hole.
- Leave cylinder #3 uncapped.
- Weigh each of the systems (plant + cylinder) at the beginning of the experiment, and after six days. Record your findings in the table.
- Measure the height of the water in the three samples every two days (every other day) **for six days**, at a fixed time. Summarize your findings in the table on the next page.



Observations

1. Describe what happened in each of the cylinders.
2. In your opinion, what is the research question in this experiment?
3. Which of the cylinders is the control?
4. What is the role of the control cylinder?

Time	Cylinder 1 Covered with stopper with no hole, and no plant	Cylinder 2 Covered with stopper with hole, and plant	Cylinder 3 No stopper, and no plant
Weight at the beginning of the experiment (g)			
Decreased level of water after 2 days (mL)			
Decreased level of water after 4 days (mL)			
Decreased level of water after 6 days (mL)			
Weight at the end of the experiment (g)			



Conclusion

1. What are your conclusions as a result of the experiment?
2. Why did the level of the water in the test tube with the cap remain unchanged?
3. In the cylinder with the cap and plant, where did the water go?

4. In the cylinder without the cap or plant, where did the water go?
5. Transpiration is a process through which the water on the surface of a leaf evaporates into the atmosphere. How does this process relate to the results you obtained in this experiment?



Thinking Scientifically

Draw arrows to connect the statements that describe the components of the experiment with the factor being studied in each trial.

Components of the experiment		What are you studying?
1. Control 1.	● ●	A. Movement of water from plants into the atmosphere
2. Research question.	● ●	B. In this experiment, we were asked to confirm that the sample with the cap and plant were completely sealed.
3. Variable that influences (independent).	● ●	C. We performed this experiment only once, so the credibility is in doubt.
4. Factors affecting the credibility of the observation.	● ●	D. The cylinder with the stopper and no plant is for examining whether water can also disappear from the system if there is no plant present.
5. Variable that is influenced (dependent).	● ●	E. The water level in the cylinder serves as an indicator to determine if there was water moving through the cylinder into the atmosphere.
6. Control 3.	● ●	F. The cylinder with no cap and no plant allows us to explore the movement of water through the process of evaporation into the atmosphere.
7. Number of observations (repetitions) of each experiment.	● ●	G. The presence of a plant in the cylinder.



Surfing the Internet

Visit the websites below, or search for “water cycle” videos on youtube.com. Watch several animations or videos, and then answer the following questions.

http://www.youtube.com/watch?v=rUqIWRW6_Pc&NR=1

<http://www.youtube.com/watch?v=RpYFpQHMFsc>

1. What are the physical processes represented in the animation and video which occur in the water cycle in nature?
2. Which processes take place in more than one location?
3. Describe the stages of the transportation of matter (water) that occurs in the water cycle in nature, and which appear in the animations or videos.

Activity 2:

Where do plants lose water to?

In the process of transpiration, plants release water vapor into the atmosphere through openings in their leaves known as stomata. Stomata are tiny pores or openings usually found in the outer layer of leaves (epidermis) and through which water vapor leaves the plant. The pores open and close, in most cases, according to the balance of water in the plant. In this activity, you will try to locate the stomata.

Materials: Leaves of *Tradescantia pallida*; clear nail polish; tongs; dropper; microscope slide and cover slip; microscope.



Experiment

Part One:

In this activity, you will use nail polish to make a mold of the stomata in a leaf:

1. On the **bottom of the leaf** spread a uniform layer of nail polish, and let it dry for about 5 minutes.
2. Use the tweezers to carefully pull the nail polish layer off the leaf, and once removed, place it on a drop of water on a glass slide. Cover the slide with a coverslip and observe the slide under a microscope under low, medium, and high magnification.
3. Look at the tiny openings on the prepared slide. On both sides of the openings are **guard cells**. These cells surround the stomatal pore that is open when there is abundant water in the plant, and closed when water is scarce.



Note: Sometimes, when you prepare a slide, an air bubble gets trapped in the pore of the stoma, and a black spot appears. This spot is unrelated to the stomata.

4. **Observation**
 - a. Draw the stomata as it appeared with the highest magnification on the microscope.
 - b. Record the magnification next to each drawing.
 - c. Write a caption for the stomata drawing as it was seen under the microscope.

Part Two:

1. Drop a little water onto the leaf of the *Tradescantia pallida* plant. Describe what happens using the terms observation and conclusion.

Additional information: The leaf tissue is covered by a cuticle and waxes, which are fatty materials that repel water (hydrophobic).

2. **Hypothesis:** In your opinion, is there a link between the observation that you've just made, and the presence of stomata in the leaf tissue? Explain.



Activity 3:

Where do plants absorb water?

So far, we know only part of the mechanism that allows the passage of water from the roots of plants to the tips. We learned that the stomata play an important role, because through these pores, the release of water vapor through the process of transpiration is regulated. In this activity, we will examine where the plant captures the water required to meet the demand generated in the leaves.

Materials: young shoots of wheat germinated on a clay pot; Petri dish; black paper; binoculars; microscope; marker; methylene blue; a glass slide; a glass coverslip; a bowl of water; a dropper; paper towels; a knife.

Development of the activity:

a. Observation through binoculars.

Put the bud on a dark background, and illuminate the bud from the top with a light, and observe through binoculars. Draw the bud and label its parts (be sure to record the magnification of the binoculars and how the bud was prepared). Pay attention to the small filaments found at the ends of the roots. These are called root hairs. The hairs are tubular extensions of young epidermal root cells. They can reach up to 1.5 mm in length.

1. What characterizes the structure of hairs?
2. Try to estimate the number of hairs at the end of a root. Are there tens, hundreds, or thousands?

b. Observation of the bud through a microscope.

1. On a clean glass slide, place a drop of methylene blue. Cut the end of a bud that has many hairs (only 1-2 mm), and place it on the solution on the glass slide, and cover with a coverslip. Clean the excess liquid off the slide with a paper towel. You now have prepared a slide that shows the roots of a wheat bud.
2. Observe the prepared slide through the optical microscope. Begin at a low magnification and gradually increase, drawing what you see. Be sure you draw a large and detailed drawing. Record the method of preparation and level of magnification for the picture you drew.
3. Can you distinguish cell nuclei in the prepared slide?
4. In your opinion, how many cells make up a single hair?
5. Try to infer: how do the hairs absorb water for the root structure?
6. The hairs play an important role in the growth process of the root. In your opinion, how does growth in the root change the top of the plant?



Additional Information

The hairs are very thin and delicate. Their large number enables them to effectively absorb water because there is a great deal of contact with the ground. The hairs are inserted between the soil particles and grow towards the water found in the soil. Water enters the root hairs through their membranes and through the cell wall, which is especially thin and covers the protoplasm of the hairs. Through the hairs, minerals (salts) dissolved in the ground water are also absorbed.

The hairs are **singular** and only located near the ends of the root, and not along the entire root. Water also enters through the other parts of the root, but in a smaller amount, since the root is covered with a thick layer of cells that do not have hairs. To grow and develop, the root lengthens and branches. The ends lengthen, expand, and penetrate deeper into the ground, and new hairs are produced continuously near the ends of the new roots. Along with the creation of new hairs near the ends that are elongating, the mature root hairs die in areas of the root that are more developed.

Activity 4:

How does the water move from the roots to the leaves?

In the previous activity, we learned that the root hairs are located in an area where they can increase the absorption of water for the plant. Earlier, we learned that through the stomata, mostly found on the underside of leaves, water is released through the process of transpiration. This activity will examine the mechanism in the plant that allows the rise of water from the root to the stem, and even higher into the leaves, for example, in trees.

Materials: a white carnation or chrysanthemum with a long stem (15 cm); two 100 mL graduated cylinders; filter paper; a rubber band; red or blue food coloring.



Experiment

Development of the experiment:

1. Into each tube, pour 15 mL of water colored with red food coloring.
2. Place the stem of the white carnation into one of the tubes.
3. Cut the filter paper into a rectangle, about 15 cm by 10 cm. Fold it out so that it resembles the petals of a flower, like the photo to the right.
4. Place the filter paper into the second tube.



Place the two samples in the sun for half an hour.

1. Explain the results of the experiment using the components of scientific thinking: observation, hypothesis, additional information, and conclusion.
2. Cut the stem of the carnation along its length (cut a slit) and width (cross-section). What is the direction that matter is guided in the stem - along its length, or along its width?
3. In your opinion, what caused the water to ascend (rise)?
4. In a living plant, will water only rise?
5. What can you learn from this observation about the mechanism of water ascent in plants?

Activity 5:

How does water rise up the stem of a plant? Simulation experiment

In the activity, we saw that water rises along the plant from the roots to the leaves, which are found in the treetops. In this activity, try to understand what allows the continual movement of water in the system, which can reach tens of meters long for the water transportation system of tall trees. Try to understand this, based on the information we have accumulated in the previous activities.

Materials: 50 g of plaster; a narrow glass tube (diameter of about 5 mm); a beaker; food coloring; a support stand; pliers; wooden clips (clothespins); 2 small plastic cups; a 75 W lamp.



Experiment

Experimental process:

- a. Pour the plaster into the plastic cup. Gradually add water and stir well until the mixture is smooth and thick.
- b. Pour the plaster slurry into another small plastic cup until it is half full.
- c. Fill the glass tube with water. Be careful that no air bubbles enter the tube, and that it is filled with water to the ends.

- d. Insert the glass tube into the plaster so that it sinks in at least 1 cm. Be careful that the water in the pipe does not leak out. Hold the tube firmly in an upright position into the plaster for about 40 mins until the plaster hardens.
- e. After the plaster has hardened, break the plastic cup, and remove the plaster and glass tube filled with water. Use a free finger to keep the end of the tube plugged, and insert the end into the beaker that contains the colored water.
- f. Release your finger from the end of the tube once it is immersed in the colored water. Hold the plaster with the wooden clips as shown in the illustration.
- g. Place the lamp close to the setup, and shine the light onto the plaster.



Observations

Observe the model and describe what is happening.



Conclusion

1. What is your **conclusion** based on the results of this experiment?
2. Determine the factors that may have influenced the rise of water in the tube.
3. If you had magic glasses through which you could see the water particles and glass particles, how do you think the process that took place in the tube would look? Try to describe the phenomenon with a drawing.



Additional Information

The force of attraction between particles is the reason for the adhesion and bonding of the water particles to each other. These **attractive forces** are responsible for the adhesion of water droplets to the walls of the vessels of the plant. The rise of a liquid into an empty tube, or within a narrow space is known as **capillary action**.



But listen up! Water on the ground does not rise to the tops of the trees by capillary forces. What determines the rise of water are the differences in the chemical potential, or energy level of the water along the columns of the plant. These differences manifest themselves as suction, generated by the loss of water through the leaves during the process of transpiration.

Connect the components of the experiment with the natural phenomenon it represents. Match each number to a letter.

Components of the experiment			Natural Phenomena
1. Glass tube	●	●	a. Water
2. Plaster block	●	●	b. The cells that make up the vessels in the stem of the plant
3. The micropores in the plaster	●	●	c. The leaf
4. Artificial lighting	●	●	d. Sunlight
5. Not in the simulation	●	●	e. Stomata
6. Water	●	●	f. Vessels on the stem of the plant

Activity 6:

Capillary action in the soil

In the previous activity, we were introduced to a property - the presence of attractive forces between water particles - that allows water to play an important role in life. These attractive forces are responsible for the physical phenomenon known as capillary action, and are manifested in two ways:

1. The forces of attraction between water particles themselves.
2. The forces of attraction between the particles of water and solid surfaces, which enable the rise of the particles along the walls of thin tubes.

The result is the formation of a water column that rises against the force of gravity.

In this activity, you will study the phenomenon of capillary action and its importance in the soil.



Additional Information

The capillary action phenomenon is manifested in the ability of water to generate a continuous column of water that rises in slender pipes and through cracks and small spaces, against the force of gravity. This phenomenon, which is associated with properties of water, is one that allows for the transportation of water in the **biosphere** (the world of living things on planet Earth). However, the capillary action phenomenon also occurs in the **geosphere** (the rocky/inert world), as discussed in the next activity.

Try to infer: How can plants absorb water from the soil, even well after the last rainfall?



Experiment

In this activity, you will try to partially answer the question: How do plants absorb water from the soil, even weeks or months after a rain?

Materials: a Petri dish; white paper towel; sandy soil; water.



Development of the experiment

- Place the paper towel in the dish.
- Get the paper towel very wet.
- Fill the dish with dry sandy soil and wait 10 minutes, and then make another observation after another 30 minutes.



Observations

- What change occurred in the level of soil moisture after 10 minutes?
- What change occurred in the level of soil moisture after 30 minutes?



Conclusion

What conclusions do you arrive at after making the observations?



Hypothesis

In your opinion, how is the paper towel similar to water on Earth?



Direction of water movement in soil due to the process of capillary action



Additional Information



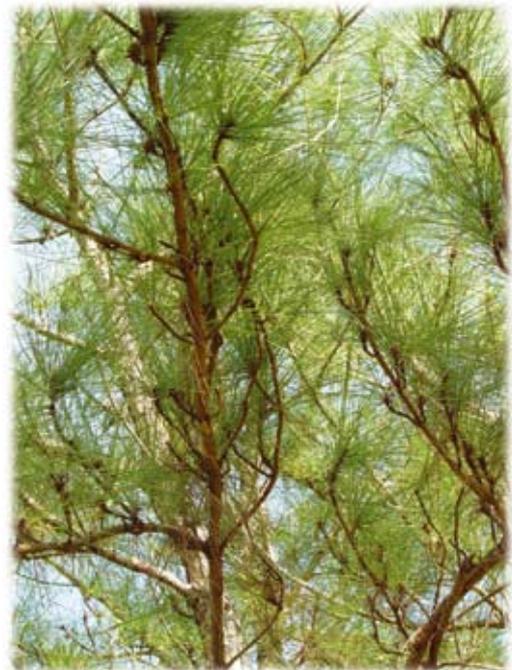
Capillary action also occurs on the ground. This phenomenon is largely responsible for the drying of the soil due to the rise of water to the surface of the soil and the subsequent evaporation from the soil into the atmosphere. Capillarity is the mechanism in which water has an adhesion force with the soil particles. The liquid water climbs and ascends along the micropores of the soil, similar to microcapillaries (very thin tubes).

Activity 7:

What role does transpiration of plants have on the groundwater system?

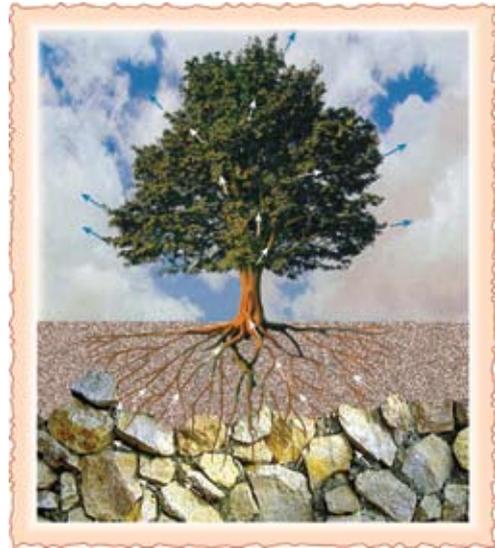
1. During a sunny summer, a subtropical pine forest can transpire 7 to 8 m³ per hectare (1m³ = 1,000 liters). What is the volume of this water? Assuming that the daily requirements of an urban family (4 members) is about 800 to 1,000 liters (excluding a swimming pool): The consumption of how many families is equivalent to the flow of forest transpiration during the warmer months?

Note: 2/3 of domestic consumption is related to the bathroom.



Pine forest in California

- On the illustration to the right, label the parts of the following systems that represent the Earth: biosphere (living things), geosphere (soil and rocks), atmosphere (air), hydrosphere (water).
- What influence does evaporation of water from the trees have on the different systems? (biosphere, geosphere, atmosphere, hydrosphere)

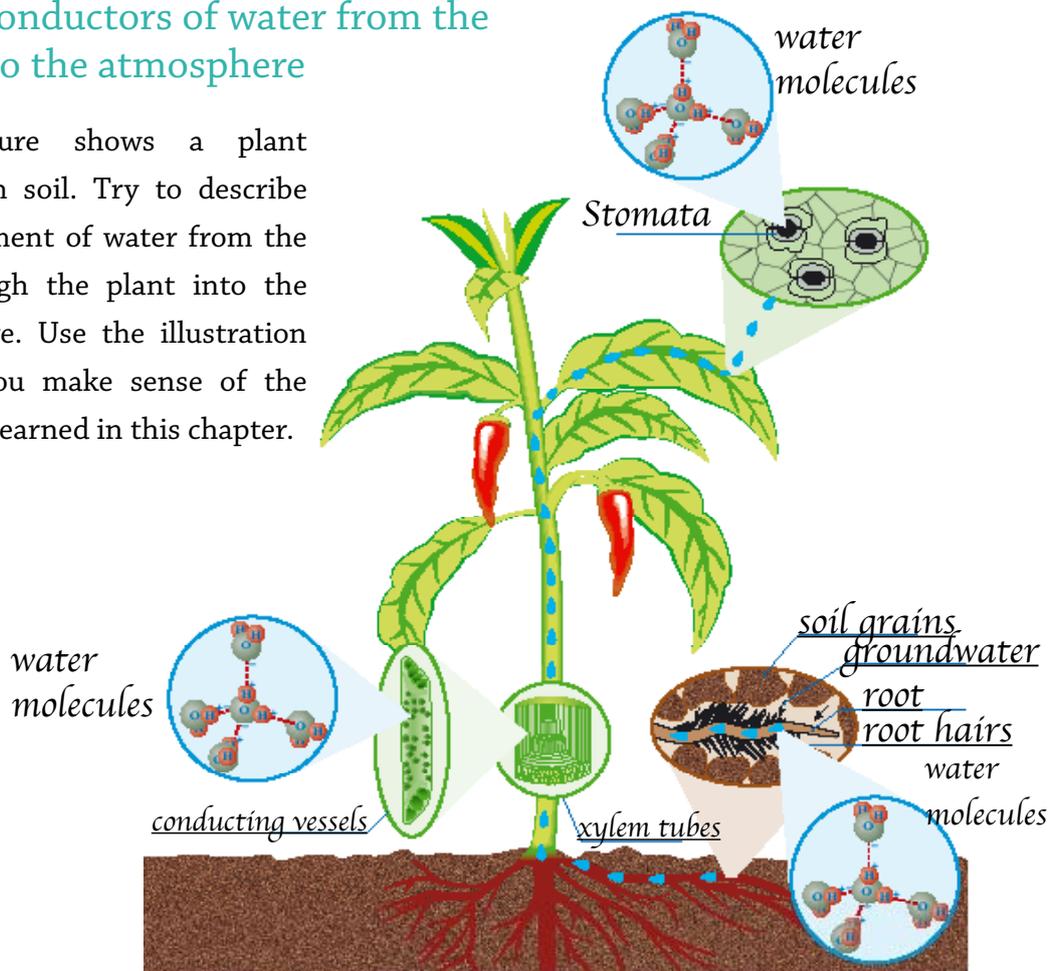


Activity 8:

Synthesis Activity - Plants and the movement of water into the atmosphere

Part One: Organization of knowledge - plants as conductors of water from the ground into the atmosphere

- This picture shows a plant growing in soil. Try to describe the movement of water from the soil through the plant into the atmosphere. Use the illustration to help you make sense of the processes learned in this chapter.



2. What are your main conclusions regarding the statement: “plants are conductors of water from the ground into the atmosphere,” as a result of the last seven activities conducted?
3. Organize your knowledge in the following way: at the top of the table are the concepts learned in this chapter (the names of the experiments are in the left column). Next to each experiment, indicate with a check (✓) below each concept learned in this experiment.

Concepts	Transpiration	Capillary action	Stomata	Water absorption	Tubes of conduction	Suction	Evaporation
Experiment							
Do plants lose water?							
Where do plants lose water to?							
Where do plants absorb water?							
How does the water move from the roots to the leaves?							
How does water rise up the stem of a plant?							
Capillary action in the soil							
What role does transpiration of plants have on the groundwater system?							

Part Two: Observe a photograph

Look at the cover photo of this chapter, and try to calculate the height of the trees in this forest.

Use the photo to describe, in a few sentences, the mechanism that enables the rise of water in the trees of the forest from the roots to the tops of trees that are tens of meters high.

Important: Use the information you've accumulated in the activities in this chapter in your description.

Part Three: Analysis of additional information

Read the additional information found on the following pages, and under each, write down the observation, and the conclusion we reached with the experiments conducted in this chapter. See the following example.

Do plants lose water?

Everything that is exposed to air loses water: a wet floor, wet clothes, a pool, a freshly watered lawn, living things, plants, etc. This loss of water takes place due to the process of evaporation of water when exposed to air, and its transformation to water vapor (a gas). The loss of water into the air as water vapor is known as **evaporation**, and when this occurs from a plant, it is called **transpiration**. The rate of water loss depends on many factors, among which is the surface area to volume ratio of the body exposed to air. You probably know that laundry extended over a large area dries faster than when it is crumpled.

The evaporation process takes large amounts of water from plants and moves it into the atmosphere. Forest researchers have studied the amount of water that evaporates daily from the surface of the leaves and needles of pine trees, and moves into the atmosphere.



Additional Information

Forest researchers showed that during the summer, each hectare of pine trees (10,000 m²) evaporated about 7,000 liters of water to the atmosphere daily.

Observation: In the activity “Do plants lose water?” we saw that the weight of the graduated cylinder + plant after six days was lower compared to its weight on the first day of the experiment.

Conclusion: plants are carrying out a process of losing water to the atmosphere.



How do plants lose water?

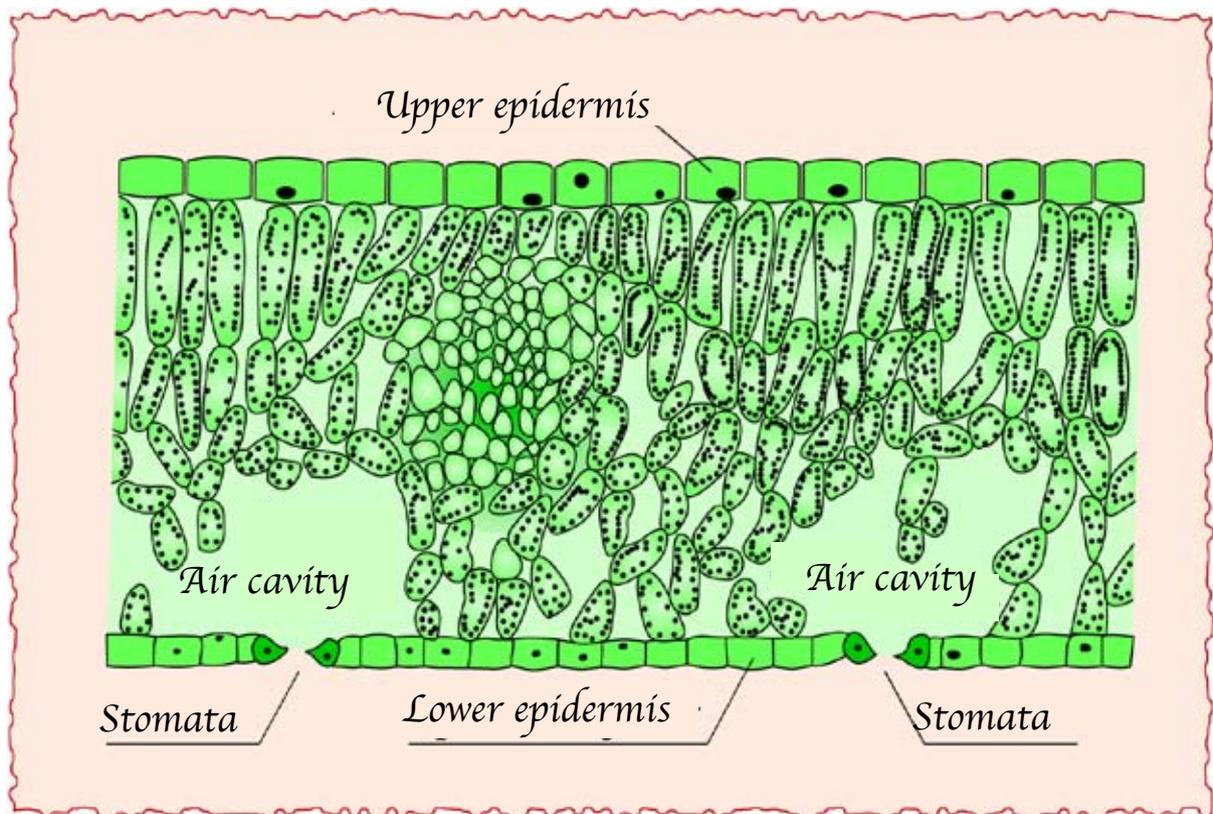
Plants, like all living multicellular organisms, are surrounded by an outer layer (epidermis) that consists of cells. When we look through the microscope, the stoma of leaves or stems can be identified because of relatively large cells that form structures whose shape looks like a mouth. This is why the structures are called stomata. “Stoma” is Greek for mouth.

The stomata lead to a large air cavity that takes up much of the internal volume of the leaf. Therefore, the interface between the leaf tissue and air is much larger than the outer surface of the leaf.

Stomata consist of two large cells known as **guard cells** and they serve as the “lips” of the stomata. When the plant is engorged, guard cells are enlarged (they have greater turgidity) and take the form of two bananas between which there is an opening (pore). The stoma is completely open. In times of higher temperature and radiative energy, the plant may lose too much water. Therefore, guard cells partially lose their turgidity, and the edges of the pore come together, and the pore closes, closing the stomata almost completely.

Observation:

Conclusion:

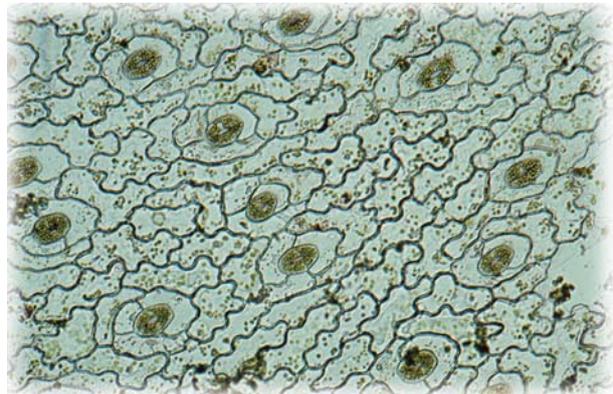


Cross-section of a leaf

Why do plants need tiny pores in their epidermis?

The plant tissue is exposed directly to light, and is covered by a cuticle made up of cutin and waxes. These are fatty substances that repel water (hydrophobic). Therefore, over 95% of the water lost during the day leaves the plant through the stomata. Only 5% of the water evaporates directly through the cuticle of the leaf. It is through the stomata that gases are exchanged between the plant and its surrounding environment.

During the day, the plant absorbs air, mainly carbon dioxide, through the stomata. The plant releases water vapor and oxygen through the stomata as well. During the night, the stomata



*Stomata in the epidermis of a fern.
Photographed with an optical microscope
(X160 magnification)*

are nearly closed, and it absorbs very small amounts of oxygen and releases very small amounts of carbon dioxide. The pores of the stomata lead to cavities of air found in the tissue of the leaf or stem, and in them, gas exchange is carried out. Under certain environmental conditions, stomata are nearly closed, and gas exchange is greatly reduced. Therefore, the plant can regulate gas exchanges with the environment through the stomata.

Observation:

Conclusion:

Can the opening of the stomata harm the plant?

Plants lose large amounts of water through the stomata. Excessive water loss can cause an imbalance in the plant, and a great loss of water can lead to the collapse of the water transportation systems in the plant. Evolutionary processes select for plants that can adapt and adjust their mechanisms to conserve water in unfavorable conditions. The pore size of the stomata changes over the course of a day. In most plants, the stomata are open when it's light, and close almost completely when it's dark. Meanwhile there are plants whose stomata are never closed, or only open at night (family: Cactaceae). In the morning and afternoon, the guard cells absorb water from the neighboring cells of the epidermis. They increase their volume, and the stomata open. Similarly, when the guard cells lose water around noon for example, their volume is reduced, and the stomata can partially close.

In a large number of plants, such as corn, apples, and tomatoes, the number of stomata on the top of the leaf (exposed to direct sunlight) is much smaller than the number of stomata found on the bottom of the leaf. This arrangement allows the stomata to open without generating a significant loss of water.

Observation:

Conclusion:

From where does water for the plant come from?

The main role of the root is the absorption of water and salts dissolved in it, but the root is also associated with plant growth.

In a large number of plants, the root system has branches, therefore a large number of lateral roots significantly increases the overall length of the root, and its surface area. This huge surface area of the root system makes contact with the soil particles, and the water solution in the pores of the soil.

The roots absorb water, especially in the zone of the hairs. These long, and very thin hairs grow between the soil particles and absorb water found in the surrounding environment and the salts dissolved in it.

This solution passes through the cells, their cell walls, membranes, and through the intercellular spaces found in the xylem tubes in the root, which then lead up to the other parts of the plant. It is worth noting the volume of water flowing through the plant, compared with other processes. On a summer day, a corn plant loses one liter of water, but only requires 40 mL for the growth of new leaves, and only 4 mL for the biochemical process of photosynthesis.

Observation:

Conclusion:

What transports the water into the plant?

The drivers of the plant system are composed of two subsystems that have different, but important functions:

- a. **Phloem** – System that transports food substances (mainly organic) in the plant. Green leaves produce soluble sugars (mainly glucose) through the process of photosynthesis. Glucose is generated in the leaves, and passes through the phloem in the stem to the organs responsible for consumption and reserves, such as fruit, roots, and shoots. There are plants whose roots have specialized reserves for storing substances, such as carrots, potatoes, sweet potatoes, and radishes. The process of photosynthesis and the transport of food substances in the plant will be examined in more depth in future studies.
- b. **Xylem** – System that transports mainly water and minerals through the plant. Xylem transports water and salts from the root to all other parts of the plant. The transport of water takes place in a system of dead cells (vessels) in which the cell walls are thickened. Where the cell has died, a space is opened and facilitates the movement of water. These cells are generally larger in diameter, and longer, and contain many holes that allow water to pass between neighboring cells.

Observation:

Conclusion:

Why water rises in the plant?

Two factors determine the upward movement of water:

1. **Transpiration** – In the air cavities found in the leaves, water turns to vapor (evaporates) and is released into the environment through the process of transpiration. As a result, especially during the day, the leaves generate a lower chemical potential or energy level of water with respect to the roots. You can imagine water traveling up through the ground, like a long train in which each of the cars is a molecule of water. When water molecules evaporate from the leaves, the suction generated by the transpiration pulls the “train.” The water in the vessel is sucked up through the transportation system and for each molecule that leaves through the top, another molecule comes in from below. In this way, new water molecules are absorbed through their roots.

If it were not for the process of transpiration, it would not be possible to move water from the roots to the treetops, because the process of capillary action only helps to explain the water column rises to a few tens of centimeters high. The rate of water transport in plants varies according to the species. In eucalyptus trees, which have a height of 50 meters, the rate of water transport has been measured to be 20-45 meters per hour.

2. **The cohesive forces between water molecules** – The continuity of the water column within the plant is due to the cohesive forces between water molecules. The water is mostly absorbed by the plant through root hairs found at the ends of the root. They move onto the the transportation system, which generates a continuous flow of water through the plant (like columns of water) until it reaches the leaves found at the top. There are cohesive forces between the water molecules and between the water and the walls of the tubes. This is important in order to avoid rupture of the water column and the penetration of air into the system. Air moving into the system would cause the collapse of the water column (a phenomenon called cavitation) and would prevent the arrival of water to the rest of the plant.

Observation:

Conclusion:



CHAPTER 6:

THE WATER WE DRINK





WHAT HAPPENS TO WATER AFTER YOU USE IT?

Activity 1:

What happens to water?

Water is an essential component. Without it, we could not exist.

Humans get the water they need by drinking and eating. In cases where a human lacks water, he is called “dehydrated” and can become seriously ill, and even die.

The following website (<http://www.scientificamerican.com/article.cfm?id=noaa-makes-2011-most-extreme-weather-year>) will help you appreciate the consequences of climate variations associated with global warming on Earth, and how this may alter the water cycle and ultimately impact human beings.

Water has many uses in addition to drinking. We use water and depend on it for many everyday activities. In this activity, try to determine how humans influence the properties of water.

Part One:

1. In the table below, record the different ways you use water **in your home**. Try to determine how much water you use for each of these purposes, and place an X in the appropriate box in the table.

Type of Use	1% of water	5% of water	10% of water	20% of water	30% of water	40% of water	50% of water

- Look at the table to the right: "Water use in my home." Use Excel to prepare a graph that represents the percentage of water used for each of the individual purposes shown in the table.
- Explore the graph to try to make at least two conclusions regarding the use of water in your home

in %	Use
14 %	laundry 
32 %	shower/ tub 
6 %	dish- washing 
5 %	drinking and cooking 
3 %	bathroom sink 
40 %	toilet water 



Activities in Excel

Part Two:

Visit the website: <http://www.answers.com/topic/water-balance-1> "Oxford Companion to the Body: Water Balance." Pay particular attention to the pattern of intake and output of water in the human body.

Answer the following questions:

- What is the balance of water?
- What are the activities through which the body brings in water?

3. What are the activities through which the human body puts out water?
4. Can you influence the water balance of your body?
5. Can the flow of water from your home to the drain influence the water balance of your body? Explain.

Food for Thought

1. What happens to the water from your house after you're finished using it?
2. Can this water be reused? Explain.
3. The water we use flows to a sanitation plant. Where does wastewater (sewage) flow?



Additional Information

The liquid flowing into the drain from household sewage is composed mostly of water (approximately 99%) and a small part (about 1%) is composed of other compounds, such as remains of human excretions, cleaning materials, medicines, paints, salt, food waste, and pesticides. In many countries, the law specifies that every city should have a system of pipes that collects wastewater (sewage) and moves it to a treatment plant. The purpose of this plant is to separate water from contaminating particles. However, not all harmful particles can be separated from water through this purification process. For example, metal particles (ions of different metals) are not separated. Many of the substances found in wastewater, such as metal ions, can affect human health, even in very small amounts. That is why even after purification, wastewater cannot be used as drinking water. However, this water may be suitable for irrigation. The price of a water purification system for a city is extremely high, and that is why some towns and cities prefer to send their wastewater to collection tanks or rivers. In the next activity, you will see what happens in a polluted river, in an area where you live.





Wastewater treatment plant



Surfing the Internet

Go online and locate one or two websites that describe what happens to the water you use at home after it's been used (wastewater flow). For example, these sites may have useful information:

<http://ga.water.usgs.gov/edu/wuww.html>

<http://ga.water.usgs.gov/edu/wwvisit.html>

Pay special attention to the treatment of “domestic wastewater,” also known as “greywater” in some countries.

Prepare a poster or sheet that explains “Where does wastewater flow?” after you’ve collected information on the Internet.

Activity 2:

The water cycle in my local environment

For this activity, we will travel to a river in the neighborhood and look at what might happen to the water we use.



Study Trip

Part One: Visit several websites to find articles about pollution of rivers.

For example:

- <http://www.grinningplanet.com/2005/07-26/water-pollution-facts-article.htm>
“Water Pollution Facts for the United States”
- <http://www.grinningplanet.com/2005/09-06/water-pollution-causes-article.htm>
“Water Pollution - Point and Nonpoint Sources”

Part Two: Visit the website for the Environmental Protection Agency. (www.epa.gov)

Prepare an outline that describes the health and environmental quality of rivers in the United States.



Additional Information

Here are some facts about the development of the field trip to a river in your neighborhood, the learning style, and the equipment needed for this activity. Your teacher will provide the missing details on the following page:

General Information:

1. The study tour will take place on _____ on the date _____.
2. We will leave the school at _____.
3. We will return to school at _____, approximately.
4. Lunch will/will not be eaten during the course of the trip.
5. The itinerary will include visits to the following sites: _____, _____, _____.
6. Moving from one place to another will be done by bus or walking to the locations where you will carry out the activities. This educational event will not require significant physical effort.
7. We will be at each site for approximately _____ minutes.

Equipment Necessary for the Field Study:

1. Notebook (one per student).
2. A pen or pencil.
3. A clipboard for writing (one per student).
4. One **camera** per group (students' responsibility).
5. A large bottle of water, not to be used for drinking, but for collecting water samples.

Equipment Necessary for being Outdoors:

1. Hat.
2. Drinking water (at least 2 liters per student).
3. Sandwiches and other food.
4. Sunscreen.
5. A small backpack.
6. Bags to collect trash.





Synthesis

Summarize the field trip using photographs, words, and pictures.

1. Record your feelings and ideas as a result of visiting the river and its surroundings.
2. Categorize the photographs taken according to the divisions of the Earth System:

Parts of planet Earth (Geosphere) in the water environment.

Living things (Biosphere) in the water environment.

Evidence of the existence of water (Hydrosphere) in the environment.

Evidence of human activity in the water environment.

3. Glue the pictures you took into your report of the field trip as follows:

Biosphere
in a water environment



Here is an image that presents the biosphere in a water environment



Here is an image that presents the biosphere in a water environment



Here is an image that presents the biosphere in a water environment

The factors that appear in the image are linked to the biosphere include:

The image shows an example of mutual influence between _____ and _____

What is the nature of the influence? _____

4. Write a story that makes connections between the photographs you took.



HOW DO WE KNOW IF THE WATER IS SUITABLE FOR DRINKING?

Activity 1:

Science and Technology: Water purification by activated carbon

In recent years, as a result of publications about the presence of different contaminants in drinking water sources, a portion of the population has lost confidence in tap water. In many houses, people have installed water purification equipment that contains activated charcoal. This activity will examine whether the movement of contaminated water through activated carbon improves its quality.

Equipment and Laboratory Materials:

A spoonful of potting soil

Two Erlenmeyer flasks

Concentrated raspberry juice

Two funnels

A teaspoon of salt

Filter paper

Two teaspoons of powdered charcoal (activated carbon)

One teaspoon

Ammeter



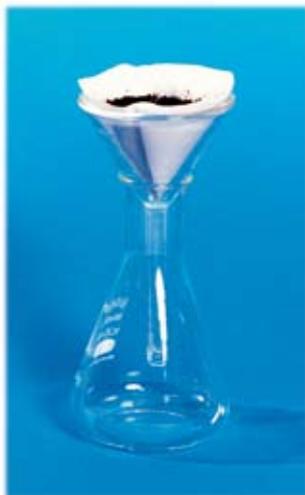
Experiment

Part One: Water Purification with Activated Carbon

Development of the experiment:

- a. Prepare a flask with mixture of potting soil in water, and a teaspoon of salt.
 1. Describe the properties of the solution: What color is it? Does it look cloudy?
 2. Examine the electrical conductivity as a measure of salinity (use a milli-ammeter).
 3. Examine the concentration of nitrate ions (NO_3^-) in solution (as in Chapter 3).

- b. Prepare a funnel with filter paper and the powdered activated carbon. Pour the prepared solution into the funnel. Describe the properties of the solution. After it's been filtered: What color is it? Is it cloudy?
1. Examine the electrical conductivity as a measure of salinity (using a milli-ammeter).
 2. Examine the concentration of nitrate ions (NO_3^-) in solution.
 3. Briefly describe the process of the experiment and its results. Use the terms observation,



conclusion, and inference.



Synthesis

Synthesis of the experiment: Copy the following statements into your notebook, and complete the statements using the **word bank**: *attractive forces, adsorbs, not adsorbed into, large particles, dissolved, water, attracted*.

The water solution contains water molecules and molecules of another substance which is _____ in the water.

Activated carbon _____ molecules dissolved in water.

It is possible that molecules of water and salt are less _____ by activated carbon.

You may not have generated _____ between the molecules of water and salt with molecules of activated carbon, and therefore, it is not adsorbed into it.

The molecules of the mixture of potting soil are _____ and therefore _____ the activated carbon.

A clear water solution contains a large number of molecules of _____ and few

molecules of other substances that are dissolved in the water.



Observations

Part Two: What is the mechanism behind activated carbon?

Development of the experiment:

- a. Pour the raspberry concentrated solution into the second funnel, and describe what happens.

What is the observation of this experiment?

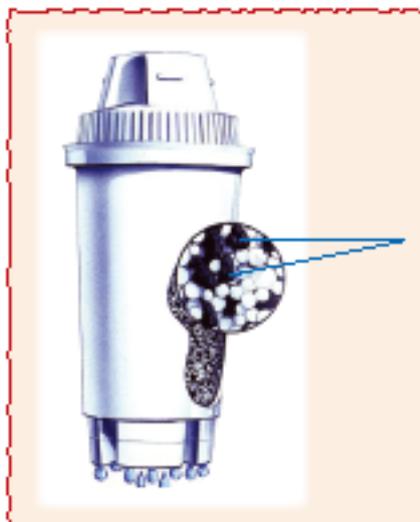
What is the hypothesis of this experiment?

What is the conclusion of this experiment?

- b. Activated carbon is made up of tiny particles, or granules. Importantly, as the pellet size gets smaller, the ratio of its outer surface area to its volume increases. What is the relationship between this and the disappearance of the color of the raspberry juice concentrate? Explain.

- c. The smaller the granule of a substance, the greater its capacity for adsorption. Can you come up with other situations in which this phenomenon occurs?

- d. In the previous activity, you learned that although water appears transparent, it may still contain substances that are harmful to your health. In this activity, the process of water filtration made the particles of raspberry vanish. Do you think that the clear water is suitable



*activated
carbon
granules*

Activity 2:

Quality of the drinking water at home



for drinking, after being filtered? Why?
It is known that good quality drinking water is vital to maintaining our health. Frequently, the public is warned by the media about possible contamination of drinking water. Some people believe that manufacturers of water purification systems, or bottled water (mineral water) contribute to the conflicting views on water. However, we can't ignore the news about the contamination of water sources in different regions of the world, which appear almost weekly on the news and in the media. Likewise, in the last few decades, various serious events related to microbiological and chemical contamination of water have occurred, such as polio epidemics, cholera, and other diseases in people and livestock

due to the ingestion of contaminated water from rivers.



Surfing the Internet

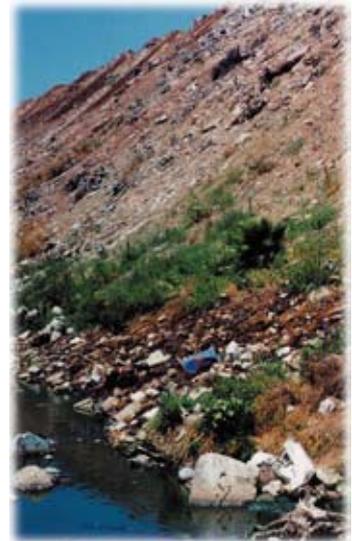
Part One: Search the Internet for one or two articles published in local or national newspapers about water quality and drinking water in the United States.

Answer the following questions:



Questions

1. Why was the article published in the newspaper?
2. Based on the articles you read, come up with three questions you have about drinking water quality.
3. Is there a real problem with the quality of water we drink, or do the articles discuss accidents and damage to the water supply as isolated cases that don't allow us to make generalizations?



Part Two: Locate an additional article on the Internet with scientific data about the quality of drinking water that you consume. Describe specifically, the quality of drinking water in the United States.

- a. Carefully read the article, and then complete the activities below:
 1. Write down the author of the article.
 2. Note whether the author is an expert on the subject.
 3. Use a highlighter to mark the concepts that you do not know or understand in the article. Copy these concepts to your notebook.
 4. Use a different color highlighter to mark the concepts that you already know. Copy these to your notebook.
 5. Use a different color highlighter to mark the most important statements in the article.
- b. Record three scientific facts that emerged from the article, and for which you had no prior knowledge.
- c. Record the factors that influence the quality of drinking water in the United States.

The influential factor	How it influences the quality of drinking water

- d. Record the agencies that are responsible for ensuring that citizens get suitable water for drinking.

Organizations	Its role in ensuring the quality of drinking water



Synthesis

Gather each article you read for the earlier tasks, and record ten key statements the authors make in the table below.

Statement	Author

Activity 3:

What do people know about the water quality in the United States?

In this activity, try to find out if friends and family (who live nearby) are aware of the issue of drinking water quality, and their opinion on this question: Is the water in the United States

suitable for drinking? To do this, you should know about the health standards in the United States with respect to drinking water.

The concept of a **“standard”** refers to the maximum concentration of substances and microorganisms that are allowed in the water for it to still be considered potable (safe for drinking). This includes certain physical characteristics, such as being tasteless, odorless, and colorless.

We will conduct the survey according to the following steps:



Step One: What is the scientific knowledge we need to conduct this survey?

1. Why is it important to know the answer to this question? Explain.
2. Make a list of questions whose answers may provide information that will help answer the question. It may help you accomplish this task by considering question words: what, why, how, how much.
3. Among the questions you recorded, mark those that you can answer, based on what you've learned so far.
4. Use a different color to mark the questions which you cannot yet answer, based on what you've learned so far.



Conclusion

5. Fill in the center column of the following table, which corresponds to the standard that defines the maximum concentration of substances allowed in drinking water in the United States, using data found here: <http://water.epa.gov/action/advisories/drinking/upload/dwstandards2011.pdf>
6. Compare the standard of the United States, with the equivalent standard in Mexico (<http://www.salud.gob.mx/unidades/cdi/nom/127ssa14.html>)*.
7. Examine the table, and answer the following questions:
 - a. What three conclusions (at least) can be drawn from an analysis of the table?
 - b. Write down three new questions (at least) about the issue of the quality of your drinking water, which emerged from the analysis of the table.
8. Do the data contained in the table influence the type of survey regarding water that you will carry out? Explain.

* You may also consider the guidelines of the World Health Organization (<http://water.epa.gov/action/advisories/drinking/upload/dwstandards2009.pdf>)

Component	Maximum Level (Standard) in the United States	Maximum Level (Standard) in Mexico
Total solids		500 mg/L
Detergents (active compounds)		0.5 mg/L
Turbidity		< 5 units
pH		6.5 – 8.5
Chloride (Cl ⁻)		250 mg/L
Nitrate (NO ₃ ⁻)		45 mg/L
Mercury ions (Hg ²⁺)		0.002 mg/L
Cadmium ions (Cd ²⁺)		0.005 mg/L
Lead ions (Pb ²⁺)		0.015 mg/L
Bacteria		Zero presence of fecal coliform bacteria
Atrazine		0.003 mg/L
Glyphosate		0.7 mg/L

Units: There are different units for the various measurements to establish the concentration of substances in water. The best known is milligrams per liter (mg/L) i.e., the amount of substances found in milligrams, in a liter of water.

Step Two: Results of the scientific information collected.

1. In order to reach reliable conclusions from the survey conducted, it is important to think carefully about the following:
 - a. What are the objectives of the survey?
 - b. What are you trying to learn from the survey?
 - c. Write at least three questions you would like answered as a result of the survey.
2. What is the population to be surveyed?
Who will participate in the survey? Residents of the building or house where you live, the entire neighborhood, people chosen at random in the street, school students, visitors of all ages in a shopping center, school teachers, family, etc.
3. What are the criteria to determine the population to be surveyed?
4. How many people will participate in the survey? Who will determine the sample size (number of people participating in the survey)?

Step Three: Deciding how to conduct the survey.

1. What type of survey did you choose? Placing a kiosk in a public area, making phone calls, sending letters by mail, survey through a website, etc.
2. How can you adapt the type of survey you chose based on the type of population you want to survey?

Step Four: Drafting the survey questionnaire.

1. Write ten questions on the topic you chose to focus on in your survey.
2. Respond to all questions, and review each one based on the answers given:
 - a. Are the questions on the survey meeting your objectives/goals?
 - b. How appropriate is the degree of difficulty of the questions for the people who will complete the survey?
 - c. Will the information you receive as responses contribute to the process of drawing conclusions?
 - d. What is the degree of difficulty for each question? Do I need extensive knowledge to answer questions?
 - e. Choose five questions, and print them out.

Step Five: Conducting the survey.

Important

1. Give your teacher the first draft, before distributing the survey.
2. To investigate whether the selected questions are clear and appropriate for the goals you've set, we recommend first conducting a survey of only five people, and only after should you address your chosen survey population (the sample).
3. Present to each subject the topic and purpose of the survey.
4. After the interview, remember to thank the respondent for their cooperation and the time they spent.

Step Six: Analysis of survey results.

1. After conducting the survey, it is important to carry out the following activities:
 - a. Summarize the answers you received, and compare them with the answers written in the drafting stage of the survey questionnaire.
 - b. Think about the criteria you will use to classify the answers of your respondents: e.g., age, scientific knowledge, awareness of the issue, level of interest.
 - c. For each answer, write down the conclusions reached by considering the responses from all respondents.
 - d. Next to each answer, write down how the information you received is aligned to the objectives of the survey.
2. How can we use the results of the survey as a basis for preparing a targeted outreach program that addresses the public about the importance of conserving the quality of drinking water?
3. To summarize, it is important to publish the results of the survey in the daily newspapers, or in the school newspaper.

Activity 4:

Who influences the quality of water we drink?

Research Laboratory of Dr. Hydrology



In the previous activities, you learned that the level of turbidity of the water solution is not necessarily an indicator of water quality. The clear water can contain compounds that are harmful to your health, but are not seen with the naked eye. Not all compounds that produce turbidity in the water are dangerous to our health.

Objective of the Activity

For this activity, we will visit the laboratory of Dr. Hydrology, and learn how to analyze the quality of water solutions, and to adjust the quality if needed, for drinking.



Laboratory investigation of water quality

Collect a sample of tap water and characterize it as you did in Chapter 3, on page 104.

Sample Number	Chemical analysis – ion concentration in mg/L		Physical analysis – milliamps
	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
1			
2			
3			



*Knowledge
Organization*

Activity 5:

Is industrial pollution inevitable? An exercise in asking questions

Following is a story that describes an initiative to create a company. Read it carefully.

In a certain city, there was an initiative to create an industry for the production of dyes. It is known that in the process of the preparation of dyes, the industry uses water-soluble substances whose residues are left behind at the end of the process.



Production zone in an industry

Near the area where they plan to build this industry is a tributary of a river on the banks of which a park has been built, and where the locals tend to go for a walk. The construction industry is rushing, as hundreds of jobs will be provided to people living in the city, who are currently unemployed.

Recently, you were appointed as director of the committee representing the inhabitants of the city. The function of this committee is to prepare a document to determine what impact this industry will have on the environment, and particularly, on the water system. The commission that you lead will ultimately decide whether to go through with the building of this industry.

“At Your Service” is a team of experts who specialize in the preparation of environmental impact surveys (a survey that determines how a project impacts the environment).

The team includes specialists in different areas, such as: environmental quality, geology (study of rocks), ecology (study of living things), hydrology (study of water), economics (money management), chemistry (study of substances), architecture (home design and landscape design).





Questions

What do you see as the important questions to ask the team of experts which you are heading, in order to collect the greatest amount of information? Remember, their responses will help you make an informed decision regarding the construction of the new industry.

Photocopy the table below on an overhead transparency, and write down at least two questions that you will use to address each of the experts. Present the table to your classmates.

Type of Expert	Questions
Environmental quality 	1. _____ 2. _____ 3. _____
Geology (research on rocks) 	1. _____ 2. _____ 3. _____
Ecology (interrelationships between living things) 	1. _____ 2. _____ 3. _____
Hydrology (research on water) 	1. _____ 2. _____ 3. _____
Economy (money management) 	1. _____ 2. _____ 3. _____
Chemistry (research on substances) 	1. _____ 2. _____ 3. _____
Architecture (houses and landscape planning) 	1. _____ 2. _____ 3. _____

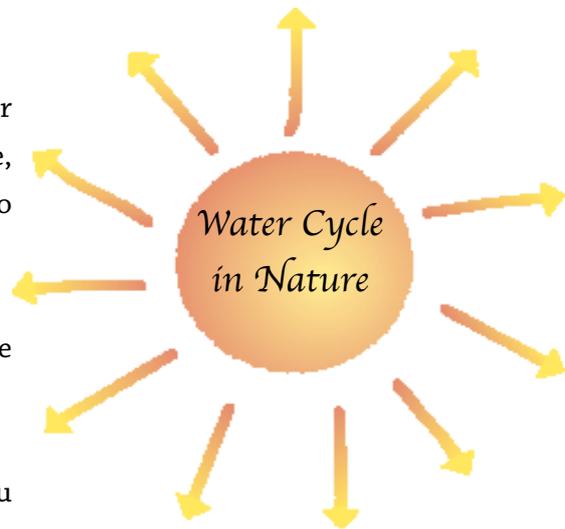


Activity 6: Knowledge organization using a concept map

How do you build a concept map?

A concept map is a learning tool for organizing your knowledge about a given topic. In the first phase, you will try to remember all the concepts related to the main topic.

Now, we will try to organize our knowledge on the subject of the water cycle in nature.

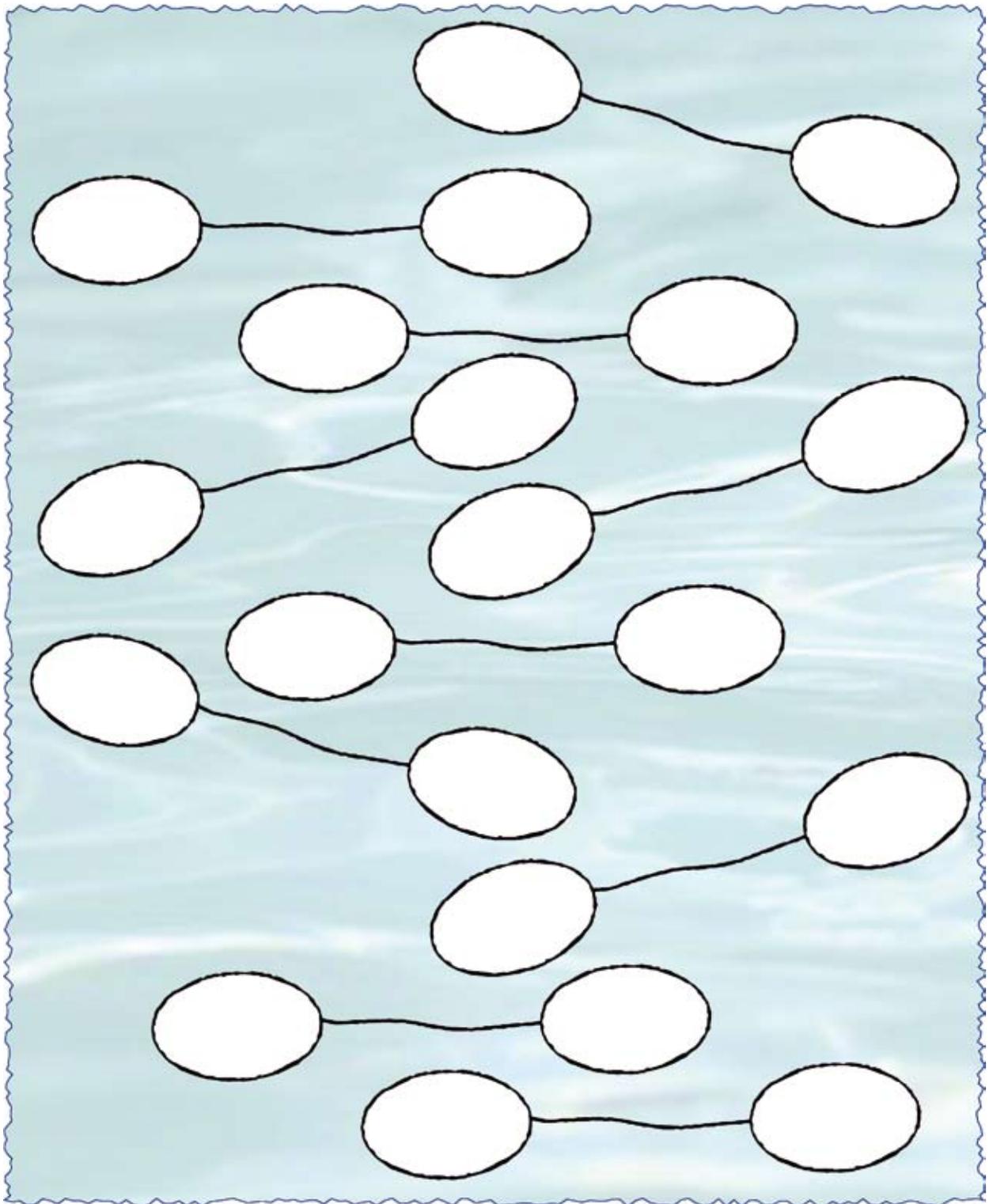


1. For each arrow, write down the concepts that you believe are related to the water cycle in nature.
2. Try to create statements that describe the relationship between two concepts that are included in your concept bank. Use the illustration on the next page. In each circle, write down the concepts, and on the line, write down a phrase or sentence to connect the two concepts. Use the following as an example:



3. Try to create a concept map that describes the various links between the concepts related to the water cycle in nature.

Remember that in a concept map, there is no particular order, and you can begin with any concept you choose. It is important to try to generate the maximum number of connections between different concepts. Creating a concept map is a task in which there is no “correct” or “incorrect” answer. Instead you can create different maps with different conceptual links between the concepts.



4. Was the development of the concept map enjoyable or difficult for you? Explain.



Synthesis

Activity 7: Synthesis of “The Blue Planet” unit

Workshop for the Resolution of the Water Problems in the United States

A workshop will be organized to analyze the Water System of our country.

For this activity, divide the class into 6 groups, representing six different groups that influence water resources and water quality in the country. These might include:

1. **Health Commission** - Responsible for analyzing the standards for drinking water quality and monitoring its quality and care.
2. **Finance Committee** - Responsible for establishing the distribution of the national budget and the allocation of financial resources for water conservation.
3. **Water Commission** – Responsible for tracking and maintaining the balance of natural water reserves in the country, and for the distribution of water to citizens. It monitors water quality in aquifers, lakes, and rivers. This body warns of future issues associated with water resources, and offers solutions such as desalination, water conservation, and importing water from abroad.
4. **Manufacturer’s Association** – Represents the industries that both consume and pollute water. The Association offers advanced technological treatments which can be applied in industry to prevent the contamination of water sources. It also organizes conferences for the development of environmental awareness.
5. **Green Organizations** – Represents the citizens of the country that warn people about the lack of attention to water problems, and discovers how this lack of attention impacts different organisms. They are also responsible for providing legal advice, and the promotion of laws for environmental conservation, and education for the conservation of natural resources.
6. **Environmental Commission** – Tracks compliance with standards to prevent pollution of water sources.

Task

You must choose one of the groups mentioned previously and collect testimony from the press and websites that represent their position. For the next class, bring in at least one testimony - a fragment of a newspaper article or a website. You will also meet with other students who chose to represent the same group as you, and you will prepare a portfolio of evidence and documents that support your position.

To summarize the activity, each group will present their position and together, will write a proposal with practical solutions to the water problems in your region.

Appendix 1

Cycling Materials of Planet Earth

For the investigation of soils, rocks, and minerals

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Published under the initiative and supervision

Israeli Center for Science Education under Amos De-Shalit; Ministry of Education, Culture, and Sport of Israel; Hebrew University of Jerusalem; the Weizmann Institute of Science in Rehovot; and Tel Aviv University.

1

HOW CAN WE CHARACTERIZE ROCKS?



The Earth's crust is composed of matter known as rocks.

In this activity, we identify and characterize rocks based on their properties.

A:

Characterization of rocks

1. To gain experience with the characterization of rocks, practice by playing the following “game”: In front of you are ten different types of rocks. Take a few minutes to look over the rocks, and pick one rock without letting your team members know which one you chose.

Take turns, describing a characteristic of your

chosen rock to your classmates. The winner is the one who uses the largest number of characteristics to describe the chosen rock.

(Hint: Start the description with properties that represent the largest number of rocks, rather than the most prominent property of the chosen rock).



2. In the left column of the following table (ignore the right column for now), write down the properties you used that helped you describe the rocks. (For example, if your description is a statement like: “I chose the rock that is the smallest of the rocks,” then the property would be “size”).

Properties that were helpful	Type of Property (permanent / not permanent)
a.	
b.	
c.	
d.	
e.	
f.	

Permanent and non-permanent properties used to characterize rocks

There are some properties which can be used to describe a rock in any situation. These properties are related to the internal characteristics of the rock, and are therefore also valid when the shape or size of the rock changes as a result of weathering or erosion. For example, the property of hardness is a permanent property. If we break a rock, each of its fragments have the same hardness as the original, and therefore may be used to identify it based on this property.

In contrast with permanent properties, there are some non-permanent properties that are not related to the internal characteristics of the rock. If the rock undergoes external changes, these properties change. For example, the property "size" is not permanent. If we break the rock, each fragment will have different sizes, compared to the original, however the properties of all the fragments will remain the same, because they are all still the same material! Therefore, the property "size" is not a helpful property with which to characterize rocks.

- Now, fill in the second column in the table above ("Type of Property"). Decide whether each property you listed is permanent or not.

Permanent properties are used to identify rocks in geology¹.

When we want to identify rocks, we use only the permanent properties, which deal with the internal characteristics of the rock, and do not change regardless of the sample used. Therefore, the list of properties that a geologist uses to identify rocks in the field include:

- ★ **Color**
- ★ **Malleability**
- ★ **Friability**
- ★ **Hardness**
- ★ **Reaction to dilute hydrochloric acid**

The following sections will help you classify the rocks according to the properties mentioned above.



1. The field of Earth Sciences that deals with the world of rocks is known as Geology (Geo – Earth, -logy – study of) and the researchers in this field are known as geologists.



Classification of rocks according to their properties

How can we examine the color property of rocks?

The colors of an exposed surface of rock can vary due to contact with air and water. Therefore, it is important to examine the properties of color in a piece of rock that shows a recently cut "fresh" surface.



1. Classify the rocks in front of you according to the color property. Detail the type of test, the category according to which each rock was classified, and the number of rocks that were in each group. Record your observations in the table.

Property	Type of Test	Classification Group (Categories)	Number of Rocks in the Group
		1. White 2. Yellowish 3. Greenish 4. Red 5. Brown 6. Black 7. Other:_____	_____ _____ _____ _____ _____ _____

How can we examine the property of malleability in rocks?

To examine whether a rock is malleable, you need to put a drop of water on it, and rub the wet area with a finger. If you can mold a piece of the rock between your fingers, like kneading clay, it is a sign that the material that makes up the rock reacts with the water, and becomes malleable.



2. Classify the rocks in front of you according to the property of malleability. Detail the type of test, the category according to which each rock was classified, and the number of rocks that were in each group. Record your observations in the table.

Property	Type of Test	Classification Group (Categories)	Number of Rocks in the Group
Malleability	We placed a drop of water on the rock and examined whether it was possible to mold a piece of the rock between our fingers.	1. Not malleable 2. Slightly malleable 3. Very malleable	<hr/> <hr/> <hr/>

How to examine the property of friability of rocks?

The friable rocks are those that can be broken up using your finger, into sand-sized grains.

Pay attention! A rock that disintegrates into a fine powder should also be classified as a friable rock!



- Classify the rocks in front of you according to the property of friability. Detail the type of test, the category according to which each rock was classified, and the number of rocks that were in each group. Record your observations in the table.

For the next task, you will need the rocks that were categorized as friable. Place those separately on a tray.

Property	Type of Test	Classification Group (Categories)	Number of Rocks in the Group
Friability		1. _____ 2. _____	_____ _____

How do we examine the property of hardness of rocks?

The test for hardness of a friable rock will be different from those that are not friable (as explained below). Start with the hardness tests of rocks that are **not friable**.



Hardness test in rocks that are not friable:

In non-friable rocks, you can examine the property of hardness by scraping rocks with easily accessible instruments that have different degrees of hardness.

To examine the hardness of a non-friable rock, you can try to scratch the rock with a metal tool, such as a nail or hammer. If the metal tool leaves a mark or scratch, we can infer that the hardness of the rock is high.

It is important to note that sometimes the rock shows a scratch-like mark, but in fact, this is not due to an actual scratch. This line can be "erased" easily, by cleaning the area with a little water. This is evidence of the **high degree of hardness** of the rock.

If the rock is scratched by a metal instrument, try to scratch it with your fingernail. If the rock is scratched with a metal instrument, but cannot be scratched by your fingernail, we conclude that the rock has a **medium degree of hardness**.

If the rock is scratched by a metal tool, and your fingernail, we can conclude that the rock has a **low degree of hardness**.

4. Select the rocks belonging to the group “non-friable” according to the classification carried out in the previous activity, and determine their hardness using the scratch test. Record your observations in the table.

Property	Type of Test	Classification Group (Categories)	Number of Rocks in the Group
Scratch test to determine hardness		1. Is scratched with a fingernail	_____
		2. Not scratched with fingernail, but scratched by metal.	_____
		3. Not scratched by metal.	_____



Hypothesis

5. Why can't you examine the hardness of friable rocks by scratching them?
Can you think of an alternative method for determining the hardness of brittle rocks?

Examination of the hardness of friable/brittle rocks:

When we try to scratch crumbly rocks, the rock breaks apart into particles or grains. Because the small grains that make up the crumbly rock cannot be scratched with a nail, geologists examine the property of hardness of friable rock particles by grinding them in their teeth.

How to examine the hardness of a friable rock by grinding?

Break apart the rock into small pieces, place several pieces between your front teeth, and try to crush them..

If the granules are ground between the teeth, we can conclude that they have a low degree of hardness.

If the granules are not ground between the teeth, we can conclude that they have a high degree of hardness.

(Remember the last time you ate a sandwich on the beach. Certainly, you've experienced the sound and feeling when granules are not crushed...)

6. Select the rocks that were classified as “friable” in your previous classification, and determine their hardness by grinding.

Property	Type of Test	Classification Group (Categories)	Number of Rocks in the Group
Hardness determined by grinding (only in friable rock) Note: Only for sandstone and gravel.		1. _____	_____
		2. _____	_____

How can we examine the property in which rocks react with dilute hydrochloric acid?

To examine the reaction of rocks with dilute hydrochloric acid, you will place a drop of acid on the rock to clean it, and then squeeze another drop on the clean area. If gas bubbles are released in response to the acid contacting the rock, then this means that the rock is composed of a material that reacts with dilute hydrochloric acid. The reaction is known as effervescence.



7. Classify the rocks in front of you according to whether they react with dilute hydrochloric acid. Record the details of the test, and the category to which you classify each of the rocks. Record your observations in the table.

Property	Type of Test	Classification Group (Categories)	Number of Rocks in the Group
Reaction to dilute hydrochloric acid		1. _____ 2. _____ 3. _____	_____ _____ _____

Where do we go from here?

In this activity, we learned that rocks can be classified in different ways, based on various properties. In the next activity, we will see how the rocks can be identified based on a specific set of properties that you've determined in advance.



2

HOW CAN WE IDENTIFY THE ROCKS?



In front of you are ten rocks that you classified in the previous activity, along with ten identification cards that go along with these rocks. Try to classify the rocks according to the ID cards.

How can we identify a rock described by an ID card?

To identify a rock, you will need to classify the rock several times, each time according to another property described on the card. In each separate classification round, only the rocks that match the chosen card will be selected, which will reduce the number of initial rocks. In other words, at each stage, you will classify only those rocks that correspond to the card in the previous stages.

Detailed instructions for identifying the rocks are below.

Instructions for the identification of rocks by ID cards:

- a. Pick a card and read the first property described.
Note: The cards include terms that you may not know yet, and so you will not be familiar with the properties.
- b. Sort all the rocks according to the first property listed on the card, and form two piles: one pile of rocks that match, and another pile of rocks that do not match this property. (For example: if the first property on the card is “white, yellow, or red”, then all the rocks should be classified according to color. Therefore, you will form a pile of the white, yellow, and red rocks, and another pile with the rest of the rocks).

- c. Next, classify the rocks that correspond just to the first property, according to the second property indicated on the card. In this way, you can determine which rocks correspond to both the first and second properties. (For example, if the second property on the card is “high malleability”, sort from the pile of white, yellow, and red rocks only those that are also highly malleable).
- d. Continue sorting in this way until you have found the rock that has all the properties listed on the card. The name of the rock is listed at the bottom of the card!
- e. Place each rock next to the appropriate ID card so your teacher can be sure they’ve been identified correctly.

Pay attention!

When considering the hardness of a rock, remember the two methods from the previous activity:

If the rock is friable, examine the hardness by grinding the grains between your teeth (in this case, you cannot examine the hardness by scratching), and if the rock is not friable, examine the hardness by scratching (in this case, you cannot examine the hardness by grinding).

Table of properties of the examined rocks:

Name of Rock	Prominent properties to help identify the rock in the future
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

3

THE LINK BETWEEN THE PROPERTIES OF ROCK AND ITS COMPOSITION



In the previous activity, you identified rocks based on a group of properties that characterize them. The question is: Where did the properties of each rock originate?

In the next two activities, you will try to answer this question.

A:

Property of Taste

1. In the previous activity you worked with ten rocks and three minerals.

What are minerals?

At this stage, we will refer to the mineral as the building block of rocks: minerals are the materials that make up rocks. There are rocks that are composed of a single mineral, and there are rocks that are composed of several minerals. In the following activity, we will try to determine what minerals and rocks are, based on their chemistry.



Observations

Examine the taste property in the three minerals in front of you. Which of the minerals is the saltiest?

How do I examine the taste property?

Find the mineral that has the saltier taste.

It is possible that the mineral has a salty dust due to friction with other minerals in the box, and therefore, the minerals will all taste a bit salty. Therefore, as a first step, wash the minerals with a little water.



Conclusion

Name of mineral (use the ID cards to help you): _____

Complete the table below, which will help you identify this mineral in the future.

Name of mineral	Relevant properties that will help me identify the mineral in the future



Hypothesis

2. There is a rock that is composed entirely of the newly identified mineral.
Which property do you think will characterize this rock? _____



Conclusion

3. Examine the rocks found on the tray. Which rock is composed of the mineral you just identified?



Additional Information

To answer this question, assume that the mineral is the only one identified that tastes salty in the collection of soils, rocks, and minerals. This assumption is based on the fact that the other minerals rarely taste salty, and the possibility of finding one is slim.



Use the ID cards to find the **name of the rock**: _____.



Property of Malleability



Observations

1. Examine the minerals on the tray with respect to the property of malleability. Which mineral becomes highly malleable when it comes in contact with water?

Name of mineral (Use the ID cards to help you): _____.

Complete the table below, which will help you identify this mineral in the future.

Name of mineral	Relevant properties that will help me identify the mineral in the future



Hypothesis

2. There is a rock that is composed entirely of the newly identified mineral.

Which property do you think will characterize this rock? _____



Conclusion

3. Examine the rocks found on the tray. Which rock is composed of the mineral you just identified?



Additional Information

To answer this question, assume that only the rocks that contain this mineral are malleable when the rock comes in contact with water.



Use the ID cards to find the **names of the rocks**:

_____ , _____ .



Hypothesis

4. Both rocks contain the mineral found to be malleable when it comes in contact with water, but the two rocks are different from each other. What is the reason for this difference?
Try to make a hypothesis:



The effervescence property due to contact with dilute hydrochloric acid



Observations

1. Examine the minerals on the tray with respect to the property of effervescence with dilute acid. Which mineral reacts when it comes in contact with dilute hydrochloric acid?

Name of mineral (Use the ID cards to help you): _____.

Complete the table below, which will help you identify this mineral in the future.

Name of mineral	Relevant properties that will help me identify the mineral in the future



Hypothesis

2. There is a rock that is composed entirely of the newly identified mineral.

Which property do you think will characterize this rock? _____



Conclusion

3. Examine the rocks found on the tray. Which rock is composed of the mineral you just identified?



Additional Information

To answer this question, assume that the mineral is the only one identified that effervesces when it comes in contact with dilute hydrochloric acid. This assumption is based on the fact that other minerals rarely react with dilute acid, and the possibility of finding one is slim.



Use the ID cards to find the **name of the rock**: _____.



Combination of properties in rocks



Observations

1. Which rock has these two properties: malleability and reaction with dilute hydrochloric acid?

Name of the rock (use the ID cards to help you): _____.



Conclusion

2. What can you determine about the mineral composition of this rock? (In other words, which minerals make up this rock?) _____ and _____.



Conclusion

3. Is this rock made up of one mineral or several minerals? _____.



Conclusion

4. We have now made enough observations to try to answer the question from the beginning of the activities: Where did the properties of each rock originate?
_____.



Observations

5. Look at the rock with your naked eye, and with the help of a magnifying glass. Can you distinguish between the particles of the minerals that are malleable and those that react with acid? If the answer is no, explain the reason.

In the previous sections, you examined a rock that was made up of tiny particles of different minerals. We could not distinguish between the malleable minerals and the minerals that react to dilute hydrochloric acid. In the following section, we will examine a rock with larger particles of different minerals, which can be distinguished quickly.





Examination of the components of granite

Instructions for the activity

Work with your peers to identify the granite rock using the identification cards.

Now, go back to the rest of the rocks and minerals, and select the three minerals that make up the granite rock.



Observations

1. In contrast to the limestone, which has very small particles, the particles that make up granite are large, and you can see the minerals that make up the granite with your naked eye (each mineral has a different color).

How many minerals can you distinguish in the granite? _____.



Conclusion

2. Is the granite rock made of one mineral or several minerals? _____.



Conclusion

3. There are three main minerals in granite rock, which you can distinguish with the help of the color property. Write down the colors of the different minerals, and use the ID cards to record their names:

Instructions for identifying minerals:

The mineral biotite is fragile, and comes apart easily into very thin pieces. In the sample, the biotite crystals are attached to a crystal of the mineral orthoclase, and are not separated.

	Color of the mineral	Name of the mineral
Mineral 1		
Mineral 2		
Mineral 3		

CARDS FOR THE IDENTIFICATION OF ROCKS AND SOILS

Color:  green or gray or red or yellowish-red

Malleability:  very malleable

Hardness:  is scratched with a fingernail

Reaction to dilute HCl acid:  no effervescence

Name of the rock: clay stone

Color:  gray or yellow or brown

Malleability:  not malleable

Crumbly:  crumbles

Reaction to dilute HCl acid:  effervescence

Name of the rock: calcareous sandstone

Color:  white or gray or yellowish

Malleability:  not malleable

Hardness:  not scratched with a fingernail, scratched with nail

Reaction to dilute HCl acid:  effervescence

Name of the rock: limestone

Color:  there are 3 options:
-gray or white
-black
-red or pink

Malleability:  not malleable

Hardness:  not scratched with a nail

Reaction to dilute HCl acid:  no effervescence

Name of the rock: granite

Color:  white or gray or clear

Malleability:  not malleable

Hardness:  not scratched with a fingernail, scratched with nail

Reaction to dilute HCl acid:  no effervescence

Taste: salty

Name of the rock: salt (halite)

Color:  gray or brown or white or black

Malleability:  not malleable

Hardness:  not scratched with a nail

Reaction to dilute HCl acid:  no effervescence

Name of the rock: chert

Color:  gray or yellow or red
or reddish or purple

Malleability:  not malleable

Hardness:  crumbles

Reaction to dilute HCl acid:  no effervescence

Name of the rock: quartz sandstone

Color:  brown - red

Malleability:  malleable

Reaction to dilute HCl acid:  no effervescence

Attention: there are sometimes small fragments in limestone that effervesce strongly with acid

Name of the soil: red soil

Color:  red

Malleability:  not malleable, slightly malleable

Reaction to dilute HCl acid:  no effervescence

Name of the soil: silty soil

Color:  yellow or light brown

Malleability:  not malleable

Reaction to dilute HCl acid:  no effervescence

Name of the soil: sandy soil

