Groundwater Movement

How does water move through Earth's layers?

Overview

Students explore how porosity and permeability of different sediments affect the way water flows through Earth's layers. Students use interactive computational models to explore the underground flow and deposition of water and determine the best places to access the water in a sustainable manner.

For the complete activity with media resources, visit:
http://education.nationalgeographic.org/activity/groundwater-movement/

Directions

1. Spark student discussion about how water moves.

Show the **Model 2: Sediment Columns.** Run the model, and let students observe how the water molecules move through the different sediments. Ask:

- *Why do you think water pools at the top of the black column while it flows through the pink column?* (Students might respond that the material of the black column has fewer holes through which the water can flow. The material in the pink column might be more loosely packed than the material in the black column. The spaces allow the water to flow down. If there are no spaces, then the water can't flow down as easily (or at all).)
- *What would happen if the water level reached the top of the black basin?* (If the water level reached the top of the black basin, it would spill over into the next column.)

Tell students that they will be investigating the characteristics of different rocks and sediments that let water flow through at different rates.

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the "right" answers when they start to investigate a question. We can see examples of scientists' uncertainty in the forecasting of precipitation amounts. Have students go to **NOAA National Weather Service**. Ask them to input their zip codes, hit "Go", scroll down to the bottom of the page, and click on the "Hourly Weather Graph". This page shows the hourly weather forecast for your area. The first box shows the predicted temperature and dew point (along with wind chill or heat index, when applicable). The second box shows the predicted wind speed and direction. The third box shows the predicted sky cover (i.e. cloud cover), relative humidity, and chance for precipitation. The boxes below that line show whether the precipitation is likely to be rain, snow, freezing rain, or sleet. Point out the line for precipitation potential (the brown line). Ask:

- *Why is the precipitation shown as a "%"?* (Precipitation is dependent on other factors, such as relative humidity and temperature. It is more likely to precipitate when the temperature is the same as or lower than the dew point.)
- *If there is a likelihood of precipitation, why is the amount of rain/snow shown as ranges?* (The amount of precipitation that will fall is dependent on the amount of moisture in the atmosphere. The atmosphere is continually changing, so the amounts are guidelines for what could happen rather than perfect predictions.)

  **If there is no or low likelihood of precipitation in your area, you may want to find a different location (in the United States) that has a higher likelihood of precipitation. You can look at a current weather map (radar) to find where in the United States precipitation is happening currently. Your students will then be able to see scientists' forecasts of precipitation amounts represented as a range overlaid on the bar graphs.*

Tell students they will be asked questions about the certainty of their predictions and that they should think about what scientific data are available as they assess their certainty about their answer. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of systems in Earth's water resources.

Tell students that forecasting what will happen to Earth's fresh water supplies is a complicated process because there are many different interacting parts. Tell students that scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a system, as described in the scenario below.

On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits. Ask:

- *When there are a lot of rabbits, what will happen to the fox population?* (It will increase because there is an ample food supply.)
- *What happens to the fox population when they've eaten most of the rabbits?* (The foxes will die of starvation as their food supply decreases.)
- *What happens to the amount of grass when the fox population is high?* (The amount of grass will increase because there are fewer rabbits to eat the grass.)
- *If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?* (The rabbit population will decrease because they have a lesser food supply. The fox population should also decrease as their food supply decreases.)

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply. Ask: *What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?* (The foxes will decrease because they are sharing their food supply, the rabbits will decrease because they have more predators, and the grass will do well because of the lowered impact of the smaller rabbit population.)

Tell students that simple cause-effect relationships can expand into more complex system relationships. Let students know that they will be exploring the relationship between how sediments and rock types affects groundwater movement. Encourage students to think about how human actions play a role in changes in the flow of water and in freshwater availability.

4. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. The weather forecast provides a good example of how model input is used to predict future conditions. Go to **NOAA Weather Forecast Model**. Tell students that scientists used current information about the energy and moisture in the atmosphere as an input to the model, and that what they see on the weather map is the output of the model's calculations.

5. Have students launch the Groundwater Movement interactive

Provide students with the link to the Exploring Groundwater Movement interactive. Divide students into groups of two or three, with two being the ideal grouping for sharing computer work stations. Inform students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Let students know that this is Activity 3 of the **Will There Be Enough Fresh Water? lesson.**

6. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *How can water move through rocks that look solid?* (Water moves through very small spaces.

The rock can look solid even when it has many tiny spaces through which water can move.)

- *How does the shape and size of pore spaces affect the permeability of different sediments?* (More porous sediments have larger particles with large spaces between them. Sediments with smaller particles are less permeable because the particles pack closer together, leaving less space for water to move through.)
- *If a rock/sediment is porous, does that mean it is also permeable?* (A rock/sediment can be porous without being permeable. If the spaces do not connect to each other, water cannot move through the rock/sediment.)
- *What kind of rocks/sediments make a good aquifer?* (Rocks/Sediments that are very permeable make a good aquifer. This is because they allow quick flow of water, which means that you can get a good flow from the well as well as quick recharge from precipitation, assuming that the aquifer is unconfined.

Tip
To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip
This activity is part of a sequence of activities in the lesson Will There Be Enough Fresh Water?. The activities work best if used **in sequence**.

Modification
This activity may be used individually or in groups of two or three students, or as a whole class activity. If using as a whole class activity, use an LCD projector or interactive whiteboard to project the activity.

Informal Assessment
1. Check students' comprehension by asking the following questions:

- How can water move through rocks that look solid?
- Why does sand have such a high flow rate compared to clay?
- If a rock is porous, does that mean it is also permeable?
- Is it better to use a confined aquifer or an unconfined aquifer for a water supply?

2. Use the answer key to check students' answers on embedded questions.

Objectives
Subjects & Disciplines
Science

- Earth science
- General science

Learning Objectives
Students will:

- explain the difference between porosity and permeability within the context of water movement
- explain how the permeability of a sediment affects water movement
- predict where water will accumulate based on topography and permeability
- predict the location of aquifers based on a given topography
- predict what types of rocks/sediments will form aquifers

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Environmental Literacy
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

National Science Education Standards

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard D-1:**
Structure of the earth system
• **(5-8) Standard E-2:**

Understandings about science and technology
• **(5-8) Standard G-2:**
Nature of science
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard B-2:**
Structure and properties of matter
• **(9-12) Standard B-6:**
Interactions of energy and matter
• **(9-12) Standard D-1:**
Energy in the earth system
• **(9-12) Standard E-2:**
Understandings about science and technology
• **(9-12) Standard G-1:**
Science as a human endeavor
• **(9-12) Standard G-2:**
Nature of scientific knowledge

Common Core State Standards for English Language Arts & Literacy

• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3

ISTE Standards for Students (ISTE Standards*S)

• **Standard 3:**
Research and Information Fluency
• **Standard 4:**
Critical Thinking, Problem Solving, and Decision Making

Next Generation Science Standards

• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 4:**
Systems and system models
• **Crosscutting Concept 5:**
Energy and matter: Flows, cycles, and conservation
• **Crosscutting Concept 6:**
Structure and function
• **Crosscutting Concept 7:**
Stability and change
• **Science and Engineering Practice 1:**
Asking questions and defining problems
• **Science and Engineering Practice 2:**
Developing and using models
• **Science and Engineering Practice 3:**
Planning and carrying out investigations
• **Science and Engineering Practice 4:**
Analyzing and interpreting data
• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
• **Science and Engineering Practice 7:**
Engaging in argument from evidence
• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

What You'll Need

Required Technology

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per pair, Interactive whiteboard, Projector

Physical Space

- Classroom
- Computer lab
- Media Center/Library

Grouping

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

Resources Provided: Websites

- NOAA National Weather Service
- NOAA Weather Forecast Model

Resources Provided: Handouts & Worksheets

- Answer Key - Groundwater Movement

Resources Provided: Interactives

- Model 2: Sediment Columns
- Groundwater Movement Interactive

Background & Vocabulary

Background Information

Water moves through Earth's geological layers. Its movement is controlled by the topography and the permeability of the layers. Sediments have different porosities and permeabilities. Porosity is a measure of how much space there is between sediment particles. Permeability is a measure of how connected the holes are. A sediment can be porous without being permeable if the pores do not connect to each other and to the outside.

Aquifers are layers of rock/sediment below Earth's surface that hold groundwater, preventing it from seeping further underground. When humans drill wells into the ground to extract water, they drill into aquifers. The flow of water out of an aquifer is dependent on the permeability of the rocks/sediments around it.

Aquifers come in two varieties: confined and unconfined. Confined aquifers are covered by an impermeable layer, preventing precipitation from refilling the aquifers. Unconfined aquifers are covered by permeable layers, allowing precipitation to refill them.

Prior Knowledge

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Recommended Prior Activities

- Availability of Fresh Water
- Using Fresh Water

Vocabulary

Term	Part of Speech	Definition
aquifer	*noun*	an underground layer of rock or earth which holds groundwater.
bedrock	*noun*	solid rock beneath the Earth's soil and sand.

Term	Part of Speech	Definition
clay	*noun*	type of sedimentary rock that is able to be shaped when wet.
confined aquifer	*noun*	layer of water-bearing rock between two layers of less permeable rock.
conservation	*noun*	management of a natural resource to prevent exploitation, destruction, or neglect.
freshwater	*noun*	water that is not salty.
gravel	*noun*	small stones or pebbles.
groundwater	*noun*	water found in an aquifer.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
permeable	*adjective*	allowing liquid and gases to pass through.
pore	*noun*	tiny opening.
porosity	*noun*	the ratio of the volume of all the pores, or holes, in an object and the object's total mass.
porous	*adjective*	full of tiny holes, or able to be permeated by water.
pumice	*noun*	type of igneous rock with many pores.
recharge	*verb*	to renew or restore to a previous condition.
runoff	*noun*	overflow of fluid from a farm or industrial factory.
sand	*noun*	small, loose grains of disintegrated rocks.
silt	*noun*	small sediment particles.
sustainability	*noun*	use of resources in such a manner that they will never be exhausted.
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.
topography	*noun*	the shape of the surface features of an area.
unconfined aquifer	*noun*	layer of water-bearing rock covered by permeable rock.

Term	Part of Speech	Definition
water cycle	*noun*	movement of water between atmosphere, land, and ocean.

For Further Exploration

Reference

- National Geographic: Encyclopedic Entry: aquifer
- National Geographic: Encyclopedic Entry: watershed
- National Geographic: Encyclopedic Entry: basin
- National Geographic: Encyclopedic Entry: wetland
- National Geographic: Encyclopedic Entry: reservoir
- National Geographic: Encyclopedic Entry: river
- National Geographic: Encyclopedic Entry: lake
- National Geographic: Encyclopedic Entry: water table

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