Everyday Earth and Space Science Mysteries

Stories for Inquiry-Based Science Teaching

Richard Konicek-Moran

NSTApress
National Science Teachers Association

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The Stories and Background Materials for Teachers

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I would like to dedicate these stories and materials to the dedicated and talented teachers in the Springfield Public Schools in Springfield, Massachusetts. They have been my inspiration to produce materials that work with city as well as rural children.

I would like to thank the following teachers, educators, and administrators who have helped me by field-testing the stories and ideas contained in this book over many years. These dedicated educators have helped me with their encouragement and constructive criticism:

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Third-grade team at Burgess Elementary in Sturbridge, Massachusetts

Second-grade team Burgess Elementary in Sturbridge, Massachusetts

Fifth-grade team at Burgess Elementary in Sturbridge, Massachusetts

Teachers at Millbury, Massachusetts Elementary Schools

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Finally I would like to dedicate these words to all of the children out there who love the world they live in and to the teachers and parents who help them to make sense of that world through the study of science.

Preface

Earth and Space Sciences (ESS) range from the entire Earth into all of space—the universe and its galaxies. I have often thought that ESS should be the culminating science course in high schools and colleges since it has roots in all of the other branches of science. One cannot study the history of the Earth without incorporating the life sciences that laid down fossils. One cannot study the planets without physics and biology. As the Mars rover lays fresh tracks across the red planet, it looks for evidence of water and other signs that might signify the existence at one time or another of life, or at least its prerequisites. Consider this quote from the *Frameworks* document (NRC 2012):

> As a result, the majority of research in ESS is interdisciplinary in nature and falls under the categories of astrophysics, geophysics, geochemistry, and geobiology. However, the underlying traditional discipline of geology, involving the identification, analysis, and mapping of rocks, remains a cornerstone of ESS. (p. 169)

In these everyday stories you will find climatology, weather, decomposition, and astronomy. You get to go along on a geology trip with students up Bare Mountain. You will study the concepts of time, evaporation, air and air pressure, and probability. All of these stories correspond with the *scientific principles*, the *crosscutting concepts*, and the *core ideas* suggested and explained in the National Research Council's *A Framework for K–12 Science Education* (2012).

These stories are packaged in separate subject matter volumes so that those teachers who teach only one of the three areas covered in these books can use them more economically. However, it bears repeating that the crosscutting concepts meld together the various principles of science across all disciplines. It is difficult, if not impossible, to teach about any scientific concept in isolation. Science is an equal opportunity field of endeavor, incorporating not only the frameworks and theories of its various specialties, but also its own structure and history.

We hope that you will find these stories without endings a stimulating and provocative opening into the use of inquiry in your classrooms. Be sure to become acquainted with the stories in the other disciplinary volumes and endeavor to integrate all the scientific practices, crosscutting concepts, and core ideas that inquiry demands.

Introduction

Case Studies on How to Use the Stories in the Classroom

I would like to introduce you to one of the stories from the first volume of *Everyday Science Mysteries* (Konicek-Moran 2008) and then show how the story was used by two teachers, Teresa, a second-grade teacher, and Lore, a fifth-grade teacher. Then in the following chapters I will explain the philosophy and organization of the book before going to the stories and background material. Here is the story, "Where Are the Acorns?"

Where Are the Acorns?

Cheeks looked out from her nest of leaves, high in the oak tree above the Anderson family's backyard. It was early morning and the fog lay like a cotton quilt on the valley. Cheeks stretched her beautiful gray, furry body and looked about the nest. She felt the warm August morning air, fluffed up her big gray bushy tail and shook it. Cheeks was named by the Andersons since she always seemed to have her cheeks full of acorns as she wandered and scurried about the yard.

"I have work to do today!" she thought and imagined the fat acorns to be gathered and stored for the coming of the cold times.

Now the tough part for Cheeks was not gathering the fruits of the oak trees. There were plenty of trees and more than enough acorns for all of the gray squirrels who lived in the yard. No, the problem was finding them later on when the air was cold and the white stuff might be covering the lawn. Cheeks had a very good smeller and could sometimes smell the acorns she had buried earlier. But not always. She needed a way to remember where she had dug the holes and buried the acorns. Cheeks also had a very small memory and the yard was very big. Remembering all of these holes she had dug was too much for her little brain.

The Sun had by now risen in the east and Cheeks scurried down the tree to begin gathering and eating. She also had to make herself fat so that she would be warm and not hungry on long cold days and nights when there might be little to eat.

"What to do ... what to do?" she thought as she wiggled and waved her tail. Then she saw it! A dark patch on the lawn. It was where the Sun did not shine. It had a shape and two ends. One end started where the tree trunk met the ground. The other end was lying on the ground a little ways from the trunk. "I know," she thought. "I'll bury my acorn out here in the yard, at the end of the dark shape and in the cold times, I'll just come back here and dig it up! Brilliant Cheeks," she thought to herself and began to gather and dig.

On the next day she tried another dark shape and did the same thing. Then she ran about for weeks and gathered acorns to put in the ground. She was set for the cold times for sure!

Months passed and the white stuff covered the ground and trees. Cheeks spent more time curled up in her home in the tree. Then one bright crisp morning, just as the Sun was lighting the sky, she looked down and saw the dark spots, brightly dark against the white ground. Suddenly she had a great appetite for a nice juicy acorn. "Oh yes," she thought. "It is time to get some of those acorns I buried at the tip of the dark shapes."

She scampered down the tree and raced across the yard to the tip of the dark shape. As she ran, she tossed little clumps of white stuff into the air, and they floated back onto the ground. "I'm so smart," she thought to herself. "I know just where the acorns are." She did seem to feel that she was a bit closer to the edge of the woods than she remembered, but her memory was small and she ignored the feelings. Then she reached the end of the dark shape and began to dig and dig and dig!

And she dug and she dug and she dug! Nothing! "Maybe I buried them a bit deeper," she thought, a bit out of breath. So she dug deeper and deeper and still, nothing. She tried digging at the tip of another of the dark shapes and again found nothing. "But I know I put them here," she cried. "Where could they be?" She was angry and confused. Did other squirrels dig them up? That was not fair. Did they just disappear? What about the dark shapes?

How Two Teachers Used "Where Are the Acorns?"

Teresa, a veteran second-grade teacher

Teresa usually begins the school year with a unit on fall and change. This year she looked at the National Science Education Standards (NSES) and decided that a unit on the sky and cyclic changes would be in order. Since shadows were something that the children often noticed and included in playground games (shadow tag), Teresa thought using the story of "Cheeks" the squirrel would be appropriate.

To begin, she felt that it was extremely important to know what the children already knew about the Sun and the shadows cast from objects. She wanted to know what kind of knowledge they shared with Cheeks and what kind of knowledge they had that the story's hero did not have. She arranged the children in a circle so that they could see one another and hear one another's comments. Teresa read the story to them, stopping along the way to see that they knew that Cheeks had made the decision on where to bury the acorns during the late summer and that the squirrel was looking for her buried food during the winter. She asked them to tell her what they thought they knew about the shadows that Cheeks had seen. She labeled a piece of chart paper, "Our best ideas so far." As they told her what they "knew," she recorded their statements in their own words:

"Shadows change every day."
"Shadows are longer in winter."
"Shadows are shorter in winter."
"Shadows get longer every day."
"Shadows get shorter every day."
"Shadows don't change at all."
"Shadows aren't out every day."
"Shadows move when you move."

She asked the students if it was okay to add a word or two to each of their statements so they could test them out. She turned their statements into questions and the list then looked like this:

"Do shadows change every day?"
"Are shadows longer in winter?"
"Are shadows shorter in winter?"
"Do shadows get longer every day?"
"Do shadows get shorter every day?"
"Do shadows change at all?"
"Are shadows out every day?"
"Do shadows move when you move?

Teresa focused the class on the questions that could help solve Cheeks's dilemma. The children picked "Are shadows longer or shorter in the winter?" and "Do shadows change at all?" The children were asked to make predictions based on their experiences. Some said that the shadows would get longer as we moved toward winter and some predicted the opposite. Even though there was a question as to whether they would change at all, they agreed unanimously that there would probably be some change over time. If they could get data to support that there was change, that question would be removed from the chart.

Now the class had to find a way to answer their questions and test predictions. Teresa helped them talk about fair tests and asked them how they might go about answering the questions. They agreed almost at once that they should measure the shadow of a tree each day and write it down and should use the same tree and measure the shadow every day at the same time. They weren't sure why time was important except that they said they wanted to make sure everything was fair. Even though data about all of the questions would be useful, Teresa thought that at this stage, looking for more than one type of data might be overwhelming for her children.

Teresa checked the terrain outside and realized that the shadows of most trees might get so long during the winter months that they would touch one of the buildings and become difficult to measure. That could be a learning experience but at the same time it would frustrate the children to have their investigation ruined after months of work. She decided to try to convince the children to use an artificial "tree" that was small enough to avoid our concern. To her surprise, there was no objection to substituting an artificial tree since, "If we measured that same tree every day, it would still be fair." She made a tree out of a dowel that was about 15 cm tall and the children insisted that they glue a triangle on the top to make it look more like a tree.

The class went outside as a group and chose a spot where the Sun shone without obstruction and took a measurement. Teresa was concerned that her students were not yet adept at using rulers and tape measures, so she had the children measure the length of the shadow from the base of the tree to its tip with a piece of yarn and then glued that yarn onto a wall chart above the date when the measurement was taken. The children were delighted with this.

For the first week, teams of three went out and took daily measurements. By the end of the week, Teresa noted that the day-to-day differences were so small that perhaps they should consider taking a measurement once a week. This worked much better, as the chart was less "busy" but still showed any important changes that might happen.

As the weeks progressed, it became evident that the shadow was indeed getting longer each week. Teresa talked with the students about what would make a shadow get longer and armed with flashlights, the children were able to make longer shadows of pencils by lowering the flashlight. The Sun must be getting lower too if this was the case, and this observation was added to the chart of questions. Later, Teresa wished that she had asked the children to keep individual science notebooks so that she could have been more aware of how each individual child was viewing the experiment.

The yarn chart showed the data clearly and the only question seemed to be, "How long will the shadow get?" Teresa revisited the Cheeks story and the children were able to point out that Cheeks's acorns were probably much closer to the tree than the winter shadows indicated. Teresa went on with another unit on fall changes and each week added another piece of yarn to the chart. She was relieved that she could carry on two science units at once and still capture the children's interest about the investigation each week after the measurement. After winter break, there was great excitement when the shadow began getting shorter. The shortening actually began at winter solstice around December 21 but the children were on break until after New Years Day. Now, the questions became "Will it keep getting shorter? For how long?" Winter passed and spring came and finally the end of the school year was approaching. Each week, the measurements were taken and each week a discussion was held on the meaning of the data. The chart was full of yarn strips and the pattern was obvious. The fall of last year had produced longer and longer shadow measurements until the New Year and then the shadows had begun to get shorter. "How short will they get?" and "Will they get down to nothing?" questions were added to the chart. During the last week of school, they talked about their conclusions and the children were convinced that the Sun was lower and cast longer shadows during the fall to winter time and that after the new year, the Sun got higher in the sky and made the shadows shorter. They were also aware that the seasons were changing and that the higher Sun seemed to mean warmer weather and trees producing leaves. The students were ready to think about seasonal changes in the sky and relating them to seasonal cycles. At least Teresa thought they were.

On the final meeting day in June, she asked her students what they thought the shadows would look like next September. After a great deal of thinking, they agreed that since the shadows were getting so short, that by next September, they would be gone or so short that they would be hard to measure. Oh my! The idea of a cycle had escaped them, and no wonder, since it hadn't really been discussed. The obvious extrapolation of the chart would indicate that the trend of shorter shadows would continue. Teresa knew that she would not have a chance to continue the investigation next September but she might talk to the third-grade team and see if they would at least carry it on for a few weeks so that the children could see the repeat of the previous September data. Then the students might be ready to think more about seasonal changes and certainly their experience would be useful in the upper grades where seasons and the reasons for seasons would become a curricular issue. Despite these shortcomings, it was a marvelous experience and the children were given a great opportunity to design an investigation and collect data to answer their questions about the squirrel story at a level appropriate to their development. Teresa felt that the children had an opportunity to carry out a long-term investigation, gather data, and come up with conclusions along the way about Cheek's dilemma. She felt also that the standard had been partially met or at least was in progress. She would talk with the third-grade team about that.

Lore (pronounced Laurie), a veteran fifth-grade teacher

In September while working in the school, I had gone to Lore's fifth-grade class for advice. I read students the Cheeks story and asked them at which grade they thought it would be most appropriate. They agreed that it would most likely fly best at second grade. It seemed, with their advice, that Teresa's decision to use it there was a good one.

However, about a week after Teresa began to use the story, I received a note from Lore, telling me that her students were asking her all sorts of questions about shadows, the Sun, and the seasons and asking if I could help. Despite their insistence that the story belonged in the second grade, the fifth graders were intrigued enough by the story to begin asking questions about shadows. We now had two classes interested in Cheeks's dilemma but at two different developmental levels. The fifth graders were asking questions about daily shadows, direction of shadows, and seasonal shadows, and they were asking, "Why is this happening?" Lore wanted to use an inquiry approach to help them find answers to their questions but needed help. Even though the Cheeks story had opened the door to their curiosity, we agreed that perhaps a story about a pirate burying treasure in the same way Cheeks had buried acorns might be better suited to the fifth-grade interests in the future.

Lore looked at the NSES for her grade level and saw that they called for observing and describing the Sun's location and movements and studying natural objects in the sky and their patterns of movement. But the students' questions, we felt, should lead the investigations. Lore was intrigued by the 5E approach to inquiry (*engage, elaborate, explore, explain, and evaluate*) and because the students were already "engaged," she added the "elaborate" phase to find out what her students already knew. (The five Es will be defined in context as this vignette evolves.) So, Lore started her next class asking the students what they "knew" about the shadows that Cheeks used and what caused them. The students stated:

"Shadows are long in the morning, short at midday, and longer again in the afternoon."

"There is no shadow at noon because the Sun is directly overhead."

"Shadows are in the same place every day so we can tell time by them."

"Shadows are shorter in the summer than in the winter."

"You can put a stick in the ground and tell time by its shadow."

Just as Teresa had done, Lore changed these statements to questions, and they entered the "exploration" phase of the 5E inquiry method.

Luckily, Lore's room opened out onto a grassy area that was always open to the Sun. The students made boards that were 30 cm^2 and drilled holes in the middle and put a toothpick in the hole. They attached paper to the boards and drew shadow lines every half hour on the paper. They brought them in each afternoon and discussed their results. There were many discussions about whether or not it made a difference where they placed their boards from day to day.

They were gathering so much data that it was becoming cumbersome. One student suggested that they use overhead transparencies to record shadow data and then overlay them to see what kind of changes occurred. Everyone agreed that it was a great idea.

Lore introduced the class to the *Old Farmer's Almanac* and the tables of sunsets, sunrises, and lengths of days. This led to an exciting activity one day that involved math. Lore asked them to look at the sunrise time and sunset time on one given day and to calculate the length of the daytime Sun hours. Calculations went on for a good 10 minutes and Lore asked each group to demonstrate how they had calculated the time to the class. There must have been at least six different methods used and most of them came up with a common answer. The students were amazed that so many different methods could produce the same answer. They also agreed that several of the methods were more efficient than others and finally agreed that using a 24-hour clock method was the easiest. Lore was ecstatic that they had created so many methods and was convinced that their understanding of time was enhanced by this revelation.

This also showed that children are capable of metacognition—thinking about their thinking. Research (Metz 1995) tells us that elementary students are not astute at thinking about the way they reason but that they can learn to do so through practice and encouragement. Metacognition is important if students are to engage in inquiry. They need to understand how they process information and how they learn. In this particular instance, Lore had the children explain how they came to their solution for the length-of-day problem so that they could be more aware of how they went about solving the challenge. Students can also learn about their thinking processes from peers who are more likely to be at the same developmental level. Discussions in small groups or as an entire class can provide opportunities for the teacher to probe for more depth in student explanations. The teacher can ask the students who explain their technique to be more specific about how they used their thought processes: dead ends as well as successes. Students can also learn more about their metacognitive processes by writing in their notebooks about how they thought through their problem and found a solution. Talking about their thinking or explaining their methods of problem solving in writing can lead to a better understanding of how they can use reasoning skills better in future situations.

I should mention here that Lore went on to teach other units in science while the students continued to gather their data. She would come back to the unit periodically for a day or two so the children could process their findings. After a few months, the students were ready to get some help in finding a model that explained their data. Lore gave them globes and clay so that they could place their observers at their latitude on the globe. They used flashlights to replicate their findings. Since all globes are automatically tilted at a 23.5-degree angle, it raised the question as to why globes were made that way. It was time for the "explanation" part of the lesson and Lore helped them to see how the tilt of the Earth could help them make sense of their experiences with the shadows and the Sun's apparent motion in the sky.

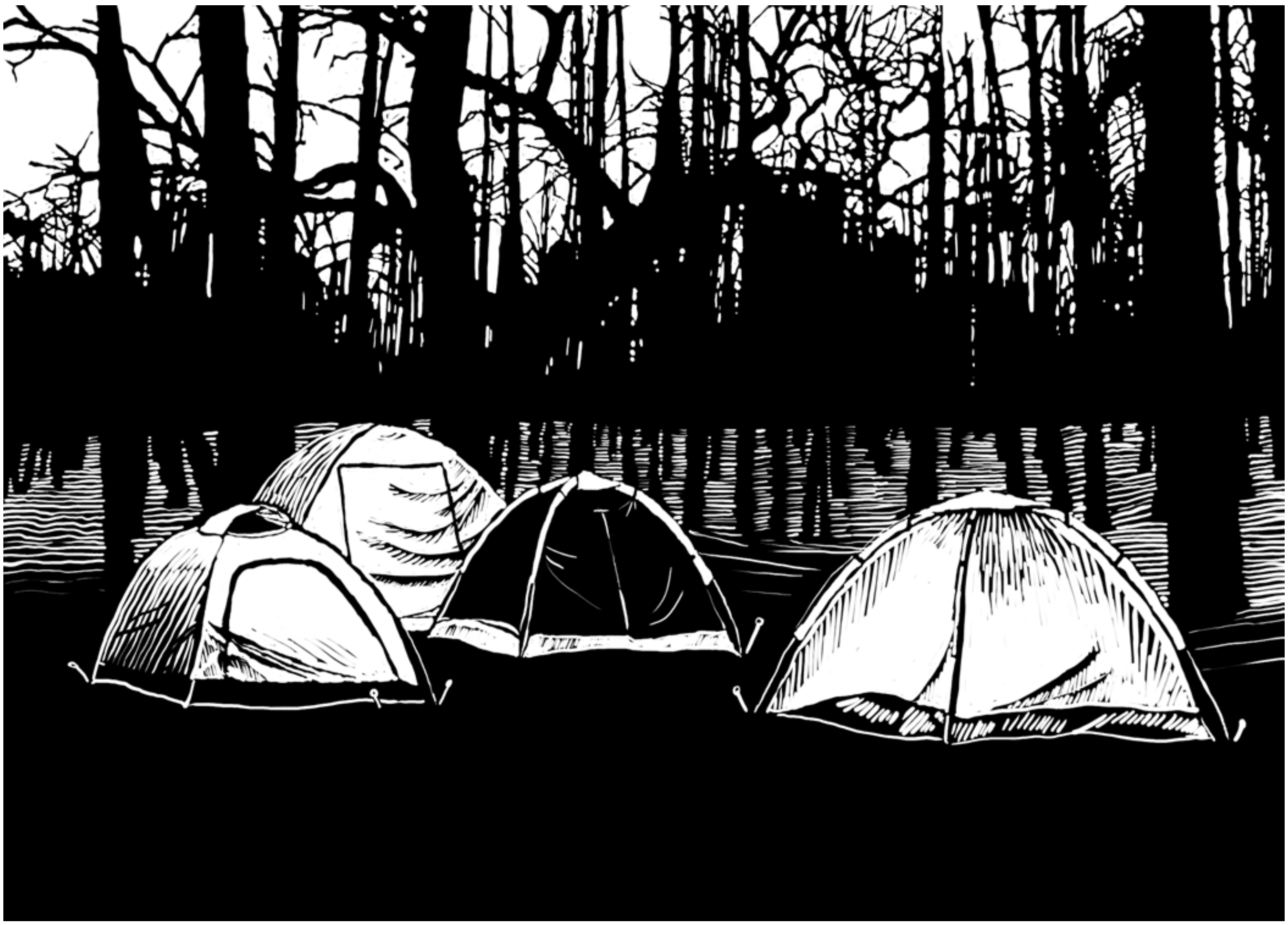
The students made posters explaining how the seasons could be explained by the tilt of the Earth and the Earth's revolution around the Sun each year. They had "evaluated" their understanding and "extended" it beyond their experience. It was, Lore agreed, a very successful "6E" experience. It had included the engage, elaborate, explore, explain, and evaluate phases, and the added extend phase.

references

Konicek-Moran, R. 2008. *Everyday science mysteries*. Arlington, VA: NSTA Press.

Chapter 14

The Little Tent That Cried



Splash! Right in the left eye.

Rani looked up into the darkness inside the tent that was her camping home for the night. Splash!! Right smack in the right eye this time.

"Okay, who's the wise guy?"

Splash!! Right in the middle of the forehead.

"Okay, that's it! Somebody is in trouble and their squirt gun is toast!"

Rani turned on her flashlight only to find the tent tightly zipped up and her tent partner, Annie sleeping soundly. At least, she was pretending to sleep.

"Annie, wake up!" yelled Rani as she shook her friend.

"Wha-, wha-, what's going on?… Why are you waking me up, Rani?" said a sleepy Annie.

"You know what's going on, Annie," said Rani angrily.

"Why is water dripping down your face, Rani? You look like you were in a shower."

"Exactly," spat Rani, "and I feel like I was in a shower too!"

Splat! Right on the pillow behind her.

And now Rani felt a little sheepish. She was looking right at Annie and yet the water was still hitting her bed. She shone the flashlight up on the tent top and there it was, a drop of water waiting to fall on her bed again.

"What do I have to do, sleep under an umbrella?"

"What are you raving about, Rani? It's the middle of the night!" And then Annie looked up at the tent top illuminated by Rani's flashlight beam.

"Oh, no! We have a leaky tent and it must be raining. But at least it's only on one side of the tent. Goodnight, Rani,"

"Oh no you don't, Annie. We share this tent, and if I get wet, you get wet."

"No way! I'm too tired to argue but if you want to slide over to my side, go ahead."

Rani opened the flap on the tent and looked out. The moon and stars were bright, it was cool—but there certainly was no rain.

"There goes that theory," said Rani and snuggled over as far as she could get toward the other side of the tent.

About an hour later: splat! Right in her right ear. This time she was too tired to care and slept the rest of the night.

The next morning, the campers awoke to another hot and muggy day. It had been in the 90s for a week now and it felt like they were swimming in hot air. Rani's pillow was soaking wet and there was plenty of moisture on Annie's pillow as well. Rani had to find out what was going on. It happened that everybody had damp spots in their tents as well. All of their tents couldn't have been leaking and anyway there had been no rain all night. The grass was wet and the leaves on the trees were wet and the inside of all of their tents were beaded with water droplets.

Penny, their counselor, was getting the morning fire started when the girls approached her and told her the story of their wet night.

"That's very interesting," said Penny. "I'll bet you are wondering where the water came from. Do you have any ideas? There has been a lot of humidity lately—you know, a lot of moisture in the air. Maybe it came from there."

Rani and Annie looked at each other. "I certainly didn't feel any water in the air and I've been walking around in it for most of the week," said Rani.

"I really think our tents are leaky," said Annie.

"Everybody's?" asked Penny.

"Well, that is strange, but where else could the water come from and get inside our tents if there wasn't a hole in the tent?"

"Maybe it came from our breath. You know, like when you breathe on a window, it gets cloudy," said Tom, who was standing nearby.

"Yeah, well maybe so, but why did it collect on the tent ceiling and rain on us?" said Annie, unconvinced.

"That sounds like a lot of magic!" muttered Rani. "Invisible water from the air or our breath suddenly turning to rain inside our tents. I think it's time for a morning swim. At least I can see that water without using my wand!"

Purpose

Rani and Annie experienced the water cycle firsthand or perhaps, "first face" would describe it better! This actually happened to me during a camping trip in Everglades National Park years ago. The humidity was fierce but the air cooled down overnight and I awoke to a wet face and wet pillow. I was not sure whether it was the high humidity of the subtropics, or my breath, or both, but I knew one thing for sure: My pillow and I were wet! This story is designed to help the students see the water cycle in a natural situation rather than in the usual highly stylized manner. The water in their breath or in the air inside their tent in vapor form condensing on the cooler tent surface and returning to liquid form "raining" down upon their bodies is something to which the students might be able to relate directly.

Related Concepts

- Evaporation
- Temperature
- Relative humidity
- Conservation of matter
- Condensation
- Humidity
- Cycle and energy

Don't Be Surprised

Your students will provide you with many interesting opinions about where the water in the tent came from. Very few children in elementary and middle schools believe that there is actually enough water in the atmosphere to cause this phenomenon. Most of the teachers with whom I have discussed this will tell stories of how difficult it is to get the children to believe that the water that collects on the outside of a cold drink comes from the air around it, but would rather believe that the water penetrated the glass from the inside. In the story, Rani is obviously unconvinced that there is water in the air surrounding her and therefore would be resistant to the idea that it could be responsible for the "rain" in her tent. Rani is typical of most children and some adults in this respect. The moisture in breath is easier to believe since we see evidence of this each time we breathe on a mirror or a glass in the fog that is created. Yet, we know that in such instances as the "sweaty" glass of cold drink, the water must come from the air and that it is indeed present. Convincing children is a different matter.

One factor that has added to the confusion in understanding the water cycle has been the traditional representation of the land, water, clouds, and rain in diagrams in many texts that show water going from ponds and lakes, directly up to the clouds and then raining down upon the source again. This oversimplification can cause children and adults alike to believe that the water cycle is a consistent, never-ending transportation from land to cloud to land again. Given the fact that most of our planet's fresh water is tied up in underground reservoirs, ice and in oceans, lakes, and streams, water that evaporates spends most of its time in one of these places or else remains in the atmosphere in our general vicinity as atmospheric moisture. Water in the oceans has been locked in place for centuries and the same is true for the glaciers and polar caps. The important concepts here are evaporation, condensation, and the conservation of matter despite the physical change in the state of the water in question. A common misconception is that water no longer exists when it evaporates.

However, we must not ignore the part of the water cycle that brings us clouds, precipitation, and the replenishing of the water on our planet, which we need so badly.

Content Background

You may have already experienced a situation like this by finding droplets of water on your ceiling or walls during a particularly humid weather episode. Or you may have noticed fogging windows during a cold spell when you were boiling something on the stove. Another example would be the fogging of the inside of your auto windows on cold days. Contrary to pictorial views of the water cycle in texts, it happens in everyday situations without rain clouds and lakes. You see a form of the water cycle when you, as Tom said in the story, breathe on a cold window and form a fine mist of water on the window. How many of us remember doing that on car trips when we were children and then writing our names (or other words) on the windows, much to our parents' chagrin? Our warm breath containing water vapor loses energy to the cold window and the gas changes into liquid. The gas, warmed by the energy from our bodies, was transformed when it touched the colder window, thus causing what scientists call a phase change. In this case it is called condensation.

Water seems to be a magical substance that falls from the sky, runs from our faucets, and seemingly disappears from wet clothes and puddles. In order to understand the water cycle, one must understand that water molecules can exist suspended in the air, that they get there through the process of evaporation or the escape of these molecules from the surface of water and that the escaped molecules (vapor) can change back into liquid water again (condensation). All of these changes require the give and take of energy. It takes energy transferred to the water molecules in a pair of jeans hanging on the line to change the water molecules to vapor. It requires a release of energy by these molecules in vapor form to become water molecules again. Both the water molecules and the energy involved are conserved; in other words, neither the mass of the water molecules or the amount of energy in the transfer changed.

First of all, water is a liquid, which means that its molecules are in motion and more loosely held, so that they can roll over each other and therefore fill a container or spill out of that container when the liquid is poured. Sometimes the energy in the motion of a molecule is great enough that it can escape the rest of its neighbors (evaporate) and suspend itself in the air. Here it joins other molecules of water in the air, which bounce off each other and thereby are able to move up into the atmosphere. As it leaves its fellow molecules to evaporate, a bit of energy was required to break it loose from its surroundings so that the liquid it has just left, which supplied the energy, is a tiny, tiny bit cooler than it was before the escape. You may have noticed this when water evaporates off of your skin when you are wet and you feel cooler since the heat from your body has supplied the energy that allows the water to evaporate. This explains the chill and the "goose bumps" on your skin when you get out of the pool.

Second, these molecules of water can change back again into liquid if they lose the energy to another source. On cool ground, high in the sky, on your cool car window, or in cool air, the vapor molecule loses its extra heat energy and returns to a liquid form. If the vapor touches the cooler surface of a tent, it reverts to water, and as the tiny droplets adhere to each other the droplets become large enough that they eventually fall on your face or pillow.

I do not intend to downplay the water cycle that involves large areas of the globe. These are the cycles depicted in most textbooks showing water evaporating from lakes or oceans, rising up to the sky, forming clouds, and raining the original water back down to earth. The basic phenomenon of the water cycle is absolutely essential to the planet. But as depicted, it gives most students an oversimplified view of the ways in which water is recycled. Students may believe from these drawings that water from puddles in Chicago evaporate around noon, go immediately into the sky, form clouds, and rain the same water later that afternoon in Detroit, from which it evaporates again during the afternoon from Lake Erie. Actually that could happen, but in reality water may spend centuries or longer in oceans and we know that some of the ice in the glaciers might be 10,000 years old. When glacial ice melts, the meltwater, which is full of glacial debris, often goes directly to the bottom of the ocean to remain there for eons before it can rise to the surface and have an opportunity to evaporate. In some cases, the glacial meltwater will mix with surface water but still remains in a huge reservoir of water.

I am particularly fond of a simulation game called "The Incredible Journey," found in the teacher's edition of Project WET (1995). It is a game in which the students act out the journey of water droplets in the cycle, moving from place to place, but often ending up in seemingly endless lines at the ocean or ice cap locations, showing that the cycle is not the idealistic cyclical occurrence that text drawings tend to suggest. You can find this activity on their website at *www.projectwet.org/activities.htm.* Click on "The Incredible Journey." The water cycle is dependent upon numerous conditions, which are the basis for the story and I hope the discussions and investigations that follow.

Related Ideas From the National Science Education Standards (NRC 1996)

K–4: Properties of Objects and Materials

- Materials can exist in different states: solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling.

5–8: Structure of the Earth System

- Water, which covers the majority of the Earth's surface, circulates through the crust, oceans, and the atmosphere in what is known as the "water cycle." Water evaporates from the Earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground.

Related Ideas From Benchmarks for Science Literacy (AAAS 1993)

K–2: The Earth

- Water left in an open container disappears, but water in a closed container does not disappear.

3–5: The Earth

- When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.

6–8: The Earth

- The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the earth, rises and cools, condenses into rain or snow, and falls again to the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it flows back into the oceans.

Using the Story With Grades K–4

If you can obtain a copy, you might want to begin with using the probe "Wet Jeans" from *Uncovering Student Ideas in Science, Volume 1* (Keeley, Eberle, and Farrin 2005). This could also be used as a pre- and postassessment.

This chapter's story is geared toward students who are at least eight or nine years old. Five- and six-year-old children may enjoy the story and provide you with interesting responses but will very likely be too young to respond to the intent of the story. In fact the Standards and Benchmarks both expect that at the K–2 age level, students should be focusing on the observations of water "disappearing" (evaporating) from puddles and dishes, and so on. I have a problem with the word *disappearing*, because it often means, "no longer existing" to children. Another definition states that disappearing means, no longer in view, which is more accurate in this case. However it might be best to use an analogy such as: A ball rolling under a chair seems to disappear but it is still there although hidden from view. For the third and fourth graders the Standards and Benchmarks both agree that the concept of water changing to vapor and back again is not too difficult. For the younger students, activities inquiring into the conditions that accelerate or hinder the evaporation of water are useful. You might ask them what things help or hinder the water from escaping from a dish of water. A good question to begin this inquiry might be, "How many ways can we think of to make water evaporate faster?"

You will have to help them identify variables such as the surface area of the dish (shallow water in large dish) or depth of water, (deeper water in a small dish or glass), and keeping the amount of water constant in all tests, placing the dishes or glasses in the same spot, and so on. If they look at the process as a race, they can predict from their own experiences and concentrate on making the race "fair." They will find that shallow water and large surface area cause the most rapid evaporation and the idea of a large, shallow surface causing faster evaporation should not be lost on them.

When using this story with third or fourth graders, you can find suggestions below in the section on using the story with grades 5–8 and modifying them accordingly.

Using the Story With Grades 5–8

As with all stories, after the reading you should ask the students what they know about the problems posed in the story. Write their comments on a large sheet of paper labeled "Our Best Thinking So Far." When these statements are turned into questions, the students may begin to pose hypotheses to test. All of these steps should be recorded in their science notebooks. If you are comfortable with having several experiments going on at the same time, small groups of students can choose a hypothesis to test and then go about designing the investigation. It usually makes a lot of sense to have these design groups report to the class and ask for suggestions. That way the entire class is involved to some degree in each investigation. Usually students seem to want to reproduce the situation featured in the story. Small tents can be constructed from coat hangers and fabric such as oil cloth, canvas, or rip-stop nylon. It will be necessary to cool off the tent surface; this can be done with a plastic bag of ice cubes hung on the tent surface. Students may want to breathe into the tent to simulate the breathing by the sleeping girls.

Some children like to place a saucer of warm water in the tent and let it evaporate. Soon, under the area that has been cooled, water droplets will form, reproducing the situation in the story. In the discussion that follows, you can introduce students to the terms *evaporation* and *condensation*, which will now have a real-world connection.

From the chart you created at the beginning of the story follow-up you will probably have children who will tell you about drink glasses that were coated with water or other experiences with condensation or evaporation. These statements need to be tested experimentally and shared with the class by summaries from their science notebooks. After playing the game "The Incredible Journey" from the *Project Wet* guide, the topic of global water cycles can be visited and at this point, the diagrams of the water cycle can be discussed with experience and knowledge about the concepts involved, evaporation and condensation. Bringing in the points about energy gain and loss can be done with students who have the maturity to discuss such things. At this point however, it is enough that they have had the firsthand experience with the water cycle system and with its component parts.

Related Books and NSTA Journal Articles

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