Precipitation Matters

Hands-on and virtual activities enable students to examine precipitation.

By Thomas McDuffie

Although weather, including its role in the water cycle, is included in most elementary science programs, any further examination of raindrops and snowflakes is rare. Together rain and snow make up most of the precipitation that replenishes Earth's life-sustaining fresh water supply. When viewed individually, raindrops and snowflakes are quite varied either in size or shape and provide surprising hints about the atmospheric conditions in which they formed.

The activities described in this article invite children in grades three through six to study the sizes of raindrops and the shapes of snowflakes as an extension of a weather or water unit. In the process, myths about the tear shape of raindrops and the standard shape of snowflakes should be dispelled. Most assuredly, students will learn that snowflakes and raindrops are more complex than greeting cards suggest.

A major consideration was to develop activities that can be taught independent of local weather or time of the school year. To accomplish this, students observe "virtual" snowflakes using web-based resources. Raindrops are "captured" in flour and then examined to approximate the height from which they fell.

Background

Rain and snow, the planet's principal sources of fresh water, can be traced through the hydrologic or water cycle—evaporation, condensation, and precipitation. The cycle's processes occur simultaneously and continuously (see McDuffie and Palmer 2000 for a fuller explanation).

During condensation, water vapor (a gas) becomes a liquid or solid. For this transition to occur, water vapor must saturate the air, i.e., the relative humidity must be at least 100%. Tiny particles of dust, smoke, or salt that attract water molecules provide a physical center or seed for the condensation process. Outside the tropics, condensation generally occurs high in the atmosphere where below-freezing temperatures produce ice crystals that fall, melt, and join together to form droplets. When water droplets become large and numerous enough, they form clouds.

Precipitation in any form—rain, sleet, hail, or snow—involves the formation of droplets or particles that grow through a continuous process of collisions and re-evaporations within clouds; large drops collide with and absorb smaller ones. When ice crystals or raindrops have floated, bounced, and combined long enough and grown massive enough to overcome the upward movement of air, gravity pulls them to Earth. This means that drizzle or gentle rains on calm days consist of small drops formed relatively near the ground. On windy days when cumulus clouds fill the sky, drops can bounce around much farther from the ground. This means that the size of raindrops increases as the height where they formed increases. Consequently, the huge drops formed in summer thunderstorms began high in the atmosphere as ice crystals that grew for many minutes—even hours—before melting on the way down. Conversely, the very large snowflakes that float down like fall leaves result from collisions when temperatures are close to 0°C.

Collecting Raindrops

Our procedures for capturing raindrops are borrowed from naturalist Wilson A. Bentley, better known for his photographic record of snowflakes. Learning about Bentley's life through websites or the book *Snowflake Bentley* (Martin 1998) adds a human dimension to the pursuit of science. Bentley also studied raindrops, using an ingeniously simple method to capture raindrops in order to compare the sizes and shapes in different storms.

He allowed raindrops to fall upon finely ground flour to form dough balls. The "drops" can be separated from the loose flour using a mesh strainer. After drying for a couple of minutes, the dough balls can be used immediately or stored in a freezer in dated plastic bags. If at all possible, children should collect drops from at least one rain event in a location away from buildings or trees. Rather than hope a rain dance works, however, teachers should collect and refrigerate some "floured raindrops" from three or four rains before introducing the unit. (I admit to first testing the procedure under the shower!)

Activity 1: Investigating Raindrops

Purpose:

To observe the size and shape of raindrops and to estimate how far they fell

Background:

When rain falls onto flour, it makes dough balls the same size as the drop itself. This approach was used by Wilson Bentley almost 100 years ago to study rainstorms. He found out that the size of drops varied depending upon the type of rainstorm. Gentle rains had small drops, while thunderstorms were made up of very large drops. Scientists now know that large drops fall from greater heights than small ones. As the diameter of drops increases, the volume of water they contain grows even faster. If one drop has twice the diameter of another, it contains eight times as much water.

Materials:

- For the class: 1 lb bag powdered flour, sealable plastic bags, and a fine mesh strainer. (Plus teacher-collected samples from prior rain events.)
- For each group of three or four students: one 6 to 8" aluminum pie pan and a piece of cardboard to cover it, ruler, graph paper, dark construction paper, and a sharpened pencil.

Procedure:

1. Sift 1–1.5 cm of flour directly into each group's pie pan using the strainer. (Doing this over a wastebasket or cardboard box reduces mess.)

2. Practice uncovering and covering the flour with the cardboard before going outside; proceed to the collecting site, collect raindrops for 8–10 seconds, and then return to the class. (I pair up children to share umbrellas if anyone lacks rain gear.)
3. Separate the dough balls over a wastebasket or box using a sieve.
4. Dump the "raindrops" onto colored construction paper and allow them to dry for about two minutes.
5. Teams of two or three should observe, then line up 10 dough balls and measure the length of each one. Next, they should determine the average diameter and record this result.
6. Sketch the drops and compare the shapes of small, medium, and large drops. Arrange the drops from smallest to largest. (It's easiest to sort along the edge of a ruler, moving the dough balls carefully with a pencil.)
7. Using drops from several rain events, compare drop sizes between storms.

Questions:

- Describe the shape(s) of the drops. *(Round or slightly egg shaped)*
- Are the sizes of the drops the same or different? *(Storms usually include one to three groups of drops with the same size)*
- Are there more large, medium, or small drops? *(Depends upon the storm)*
- Draw a bar graph relating the size of drops to their number.
- Do you think most of the water in your rainstorm comes from the large or the small drips? Why? *(Predictions are based upon the number and volume of larger versus smaller drops. No exact answer is expected.)*
- Do all storms have the same drop sizes? *(No, there is a range of drop sizes.)*
- Did all drops in a rainstorm fall from the same height? *(If they are the same size, yes. If sizes differ, they fell from different heights.)*
- What happens to rain that falls on your schoolyard? *(Some goes into the ground and some runs off.)*
- How is this related to the water cycle? *(It becomes part of the groundwater or goes into a stream.)*

Follow-Up Discussion:

Children should learn several things as a result of the activity: raindrops have different sizes but the same shape; their size indicates how far they fell; and large drops contain more water than small ones. The surprise evident in children's reaction to the formation of dough balls and their varied sizes is a good starting point for a discussion. Invariably someone asks, "What causes the balls to form?" Classmates can than share ideas—the water is trapped in the flour, the flour absorbs the water, and it's like cement. The size and shape of the dough balls is related to the raindrops that formed them. After the relationship between the size of raindrops and height and altitude has been shared by the teacher, youngsters can predict which drops were formed at higher altitudes. Visually comparing the space taken up by 10 marbles and 10 golf balls is a good analogy for the volume of rain associated with large versus small drops. No follow-up is complete until raindrops, rain, and precipitation are related to the water cycle. That is, students realize that most of the Earth's fresh water falls as rain, which can be traced through this cycle. Younger children can trace the flow of water through a watershed to a lake or the ocean. More sophisticated learners can extend this to such topics as evaporation from the land and transpiration from plants, movement of groundwater, and water being trapped in glaciers.

Examining Snowflakes

If your class is lucky enough to experience a snow event when studying precipitation, it's magical for a child to capture a few flakes on a mitten and to examine them with a magnifying glass. What did they see? Did anyone find a perfect six-sided snowflake? It's not easy! They occur less than 25% of the time and less often still when the temperature is near 0°C. Ice crystals usually break when they bump into each other or when they melt and refreeze. Few crystals survive the collisions with the perfect-six sided symmetry found on holiday greeting cards.

While the firsthand experience is a magical way to study snowflakes, timing and location make it basically impossible. So I searched for alternative ways of preserving the flakes. Supposedly clear lacquer or hair spray can be used to "freeze" the shape of snow crystals on cold glass or plastic, but my many attempts over several years involving a wide range of sprays, varnishes, and finishes have been dismal failures. As a result, I turned to images on the internet for a predictable, valuable, and easily managed alternative (see Internet Resources).

Activity 2: Paper Snowflakes

Purpose:

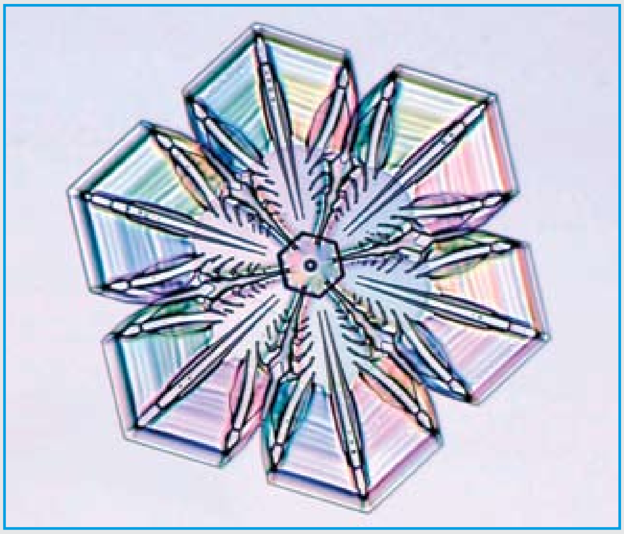
To show the basic patterns and range of shapes found in snowflakes and to provide a basis for comparison with virtual snow crystals

Background:

Making paper snowflakes is a change of pace and the results make wonderful classroom decorations. Numerous patterns are available, but to be scientifically

Figure 1.

Virtual snowflake samples.



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accurate they must be six-sided. Children find it easiest to begin with a circle of white copy paper that can be folded in half, and then the halves folded in thirds.

Materials:

Copy paper, scissors (dark construction paper and glue optional)

Procedure:

1. Each student should cut a circle out of the copy paper.
2. Paper should be folded in half, then the half into thirds.
3. Cut the folded paper to form the desired pattern.

Questions:

- Write a list of words that describe your flake. *(Pretty, pointy, same number of points/arms, some have more straight sides, some have holes)*
- Compare your flake with others in your group. List similarities and differences. *(More/less pointy, more/fewer holes, more/fewer sides, larger/smaller)*
- Why are the flakes different? Are any in the class exactly the same? *(They were cut differently; some scissors cut better; they made different patterns. They look almost the same; are very similar.)*

So far, we have looked at paper flakes. If the same basic folds were used, each of the six sections is similar and they are flat. Real snowflakes are made up of tiny particles, which must come together in three dimensions. The results can be observed using photographs that magnify actual snowflakes.

Activity 3: Virtual Snowflakes

Purpose:

To show the structure and variety in snowflakes and to classify them by shape

Background:

A website dedicated to Bentley's work is a good place to begin. This can be followed by visits to *SnowCrystals.com* and the Buffalo Museum of Science website (see Internet Resources). *SnowCrystals.com* includes a range of information for teachers and older children. Both sites provide galleries of images that can be used for developing a classification scheme for grouping differently shaped crystals. (Note: If internet access is unavailable, images can be printed and copied.)

Procedure:

1. Open the Snowflake Bentley website *(http://snowflakebentley.com)*, navigate to the sample snowflakes, and observe the different shapes.
2. Access the images in one of the galleries in the SnowCrystals.com site (Figure 1). *(www.its.caltech.edu/~atomic/snowcrystals)*.
3. Test your classification scheme by applying it to a sample of Bentley's original photos. *(http://bentley.sciencebuff.org/collection.htm)*.

Questions:

Based upon the Bentley's website

- Where did Bentley live? *(Vermont)* What was his nickname? *("Snowflake")* How did the family make its living? *(Dairy farming)*

- How do the images he photographed compare with the paper flakes your group created? *(More shapes and less exact than the paper flakes. Paper flakes look more alike. Paper flakes are pointier. Some snowflakes look prettier. Snow has different shapes.)*

Based upon the photos found on *SnowCrystals.com*, sort the images by shape.

- How many groups did you develop? *(Usually 3 or 4, depending upon the grade level)*
- What are the outstanding characteristics of each category? *("Look like" stars, cylinders, blobs, etc.)*
- Create a name for each category. *(Stars, pretty, cylinders, tubes, blobs, flowers)*
- Using the groups you identified in the second question, classify the Bentley images found at *http://bentley.sciencebuff.org/collection.htm*.
- Do all the flakes fit? *(Kids usually force them to, but some belong to a couple of categories.)*
- How would you modify the scheme to include more flakes? *(Add other categories)*
- If snow that fell on your schoolyard, what would happen to the water that melted? *(Some goes into the ground and some runs off)*
- How would it flow through the water cycle? *(It becomes part of the groundwater or goes into a stream.)*

Follow-Up Discussion:

Students readily grasp the idea of different shapes in the paper flakes. The variety in real flakes creates a challenge. At the most basic level, photos of snowflakes are grouped based upon visual appeal—"pretty" versus "ugly." The idea of common shapes needs to be teased out "What does it remind you of?" elicits responses that can be used to establish basic categories—stars, pretty, cylinders, tubes, blobs, flowers.

Inevitably two questions will be asked: "How do snowflakes form?" and "What causes the shapes?" A developmentally appropriate explanation is that tiny ice crystals form then join together like pieces of a puzzle. When flakes are forming, they often crash into each other and break, so the pattern is changed. Also, air temperature causes partial melting so flakes stick together. As with rain, teachers should relate snow to the water cycle. For example, they might ask, "What happens to snow that falls in the schoolyard?" Just like the rain, it becomes part of the water supply—and evaporates, condenses, and so on.

Showers of Learning

Although no single approach is best for all classes or grades, learning can be assessed authentically through teacher observations and student reports, or it can be limited to the various questions accompanying each activity. Relating precipitation to the larger water cycle helps extend student understanding of the effects of weather.

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Standard D: Earth and Space Science

- Changes in Earth and sky (K–4)
- Structure of the Earth system (K–4)
- Properties of Earth materials (5–8)

Teachers have been impressed by the interest these activities generate in a rarely studied aspect of the water cycle. The idea that raindrops can be captured and vary in size is novel. Similarly, the idea that rain falls from different heights escapes most. Yet, it is the large drops falling from summer thunderstorms that produce crop-damaging and life-threatening flash floods.

The beauty of snowflakes captivates interest. The range of shapes is striking, so the process of classification is a challenge best overcome through discussion and scaffolding. With guidance, students can develop and extend usable classification schemes for snowflakes.

While raindrops and snowflakes are fascinating to study, their role in the water cycle is central. What happens to rain and snow that fall on the school's area? Where does the moisture go? When children begin to explore these questions, their understanding of the interrelationships between runoff, streams, and the journey of water can begin. And, precipitation can be considered the starting point of the cycle. ■

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Resources

Martin, J.B. 1998. *Snowflake Bentley*. Boston, MA: Houghton Mifflin.

McDuffie, T.E., Jr., and A. Palmer. 2000. How big are raindrops? *The Science Teacher* 67(2): 46–50.

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.

Internet

Bentley's Snow Crystal Collection
http://bentley.sciencebuff.org/collection.htm

SnowCrystals.com
http://www.its.caltech.edu/~atomic/snowcrystals

The Snowflake Man
http://snowflakebentley.com/mullet.htm

Wilson A. Bentley: Photographer of Snow Crystals
http://www.snowflakebentley.com