Snowflake Formation

A Series of Lesson Plans for 4th through 6th Grade

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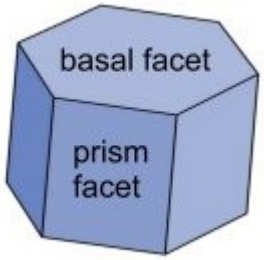
Lesson Plan 1: Snow Crystals

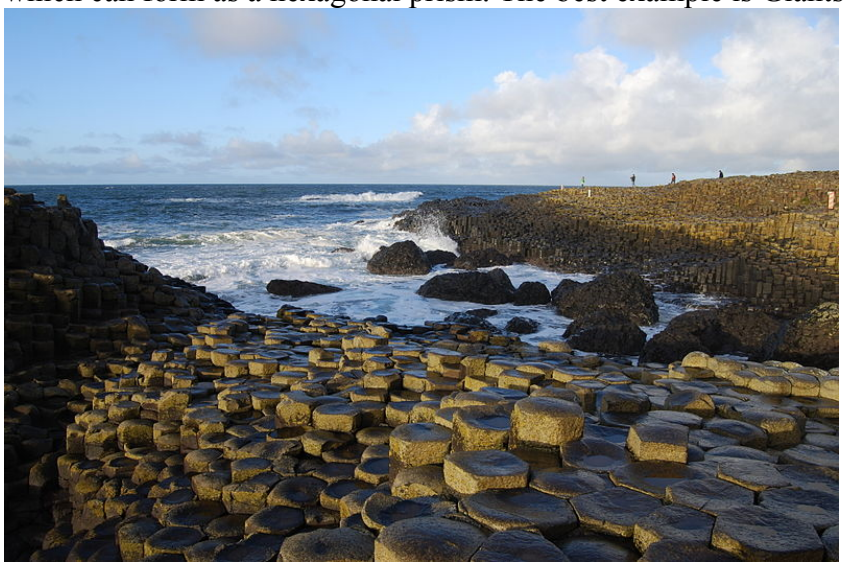
Learning Objectives: Students will be able to describe that snow crystals are made of ice, and they have a six-sided symmetry. They will be able to create realistic looking examples cut out of paper.

Materials: Tape, Scissors, Paper
Preparation: One photocopy of page 2 for each student. 3 pieces of square paper per student, cut from Letter sized paper.

Science background: Snow flakes that fall from the sky are made out of crystals. There are many kinds of crystals. Table salt is made of little cubes: each "facet" of the cube is a square. This is the natural shape of the salt crystal we eat. Ice crystals have a different natural shape that is a hexagonal prism.

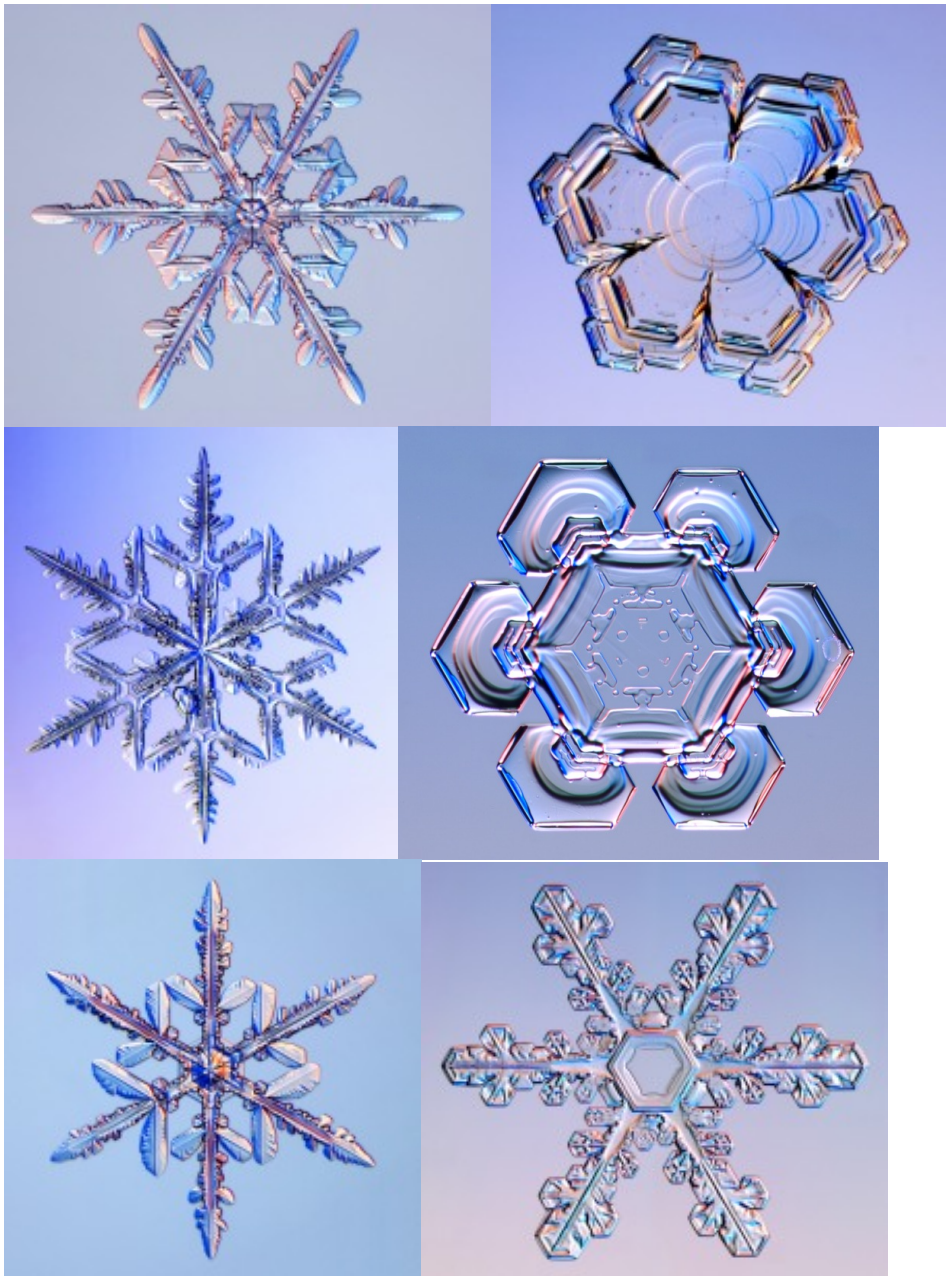


Rocks can be crystals with facets too! Diamonds are one example. Another is basalt, which can form as a hexagonal prism. The best example is Giants' Causeway in Ireland

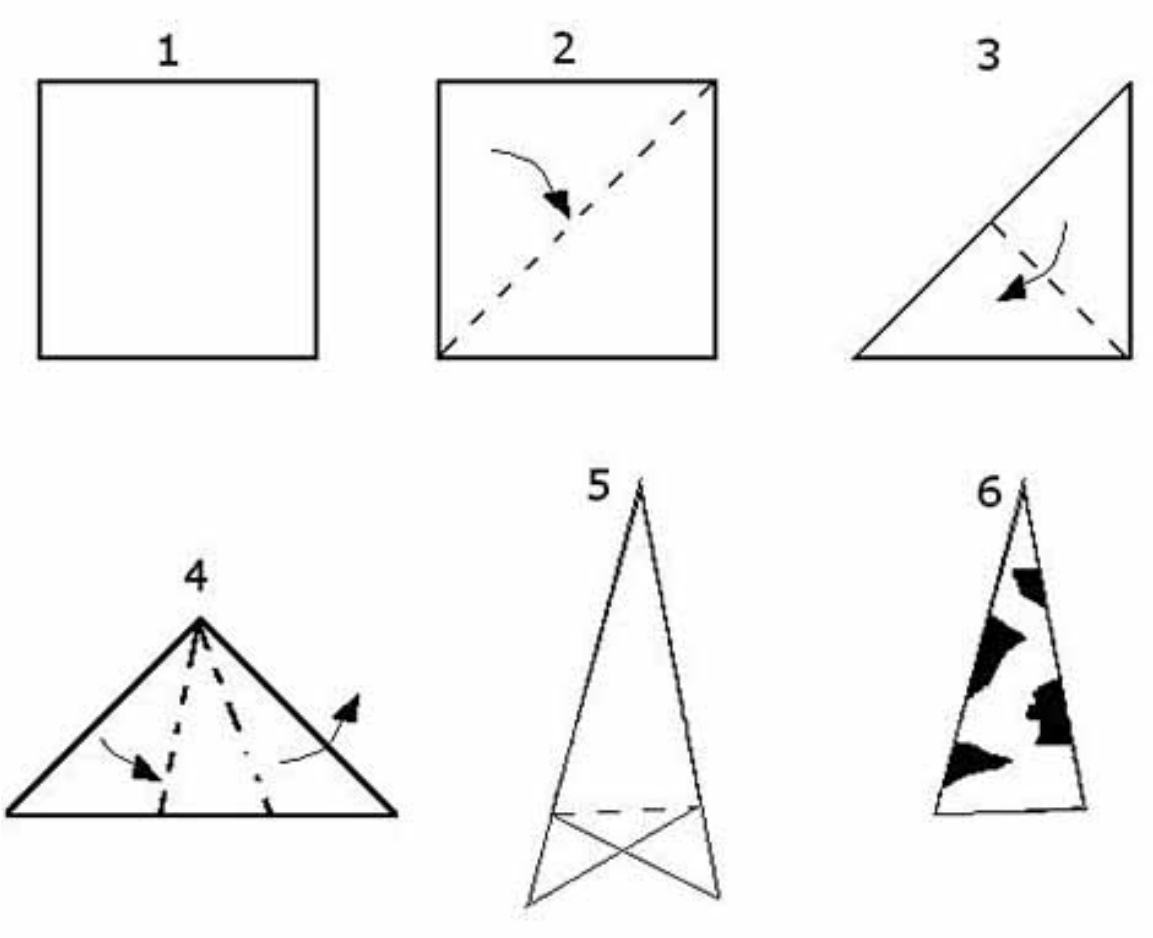


Activity: With paper and tape, make a hexagonal prism. To do this, the students can use the final page as a template.
Science Background: Real snow crystals can look much more complicated, especially if they grow very quickly. Snow crystals form in clouds. They start their life as droplets

which freeze. When a droplet freezes is grows because water vapor “condenses” onto it. This can happen very quickly, and lead to beautiful shapes. The photos below of real snow crystals were taken by Kenneth Libbrecht using a camera, a microscope, and some colored lighting. Note that these snow crystals are very complicated but they still have six sides! Even complicated snow crystals are still based upon the shape of simple hexagonal prisms.

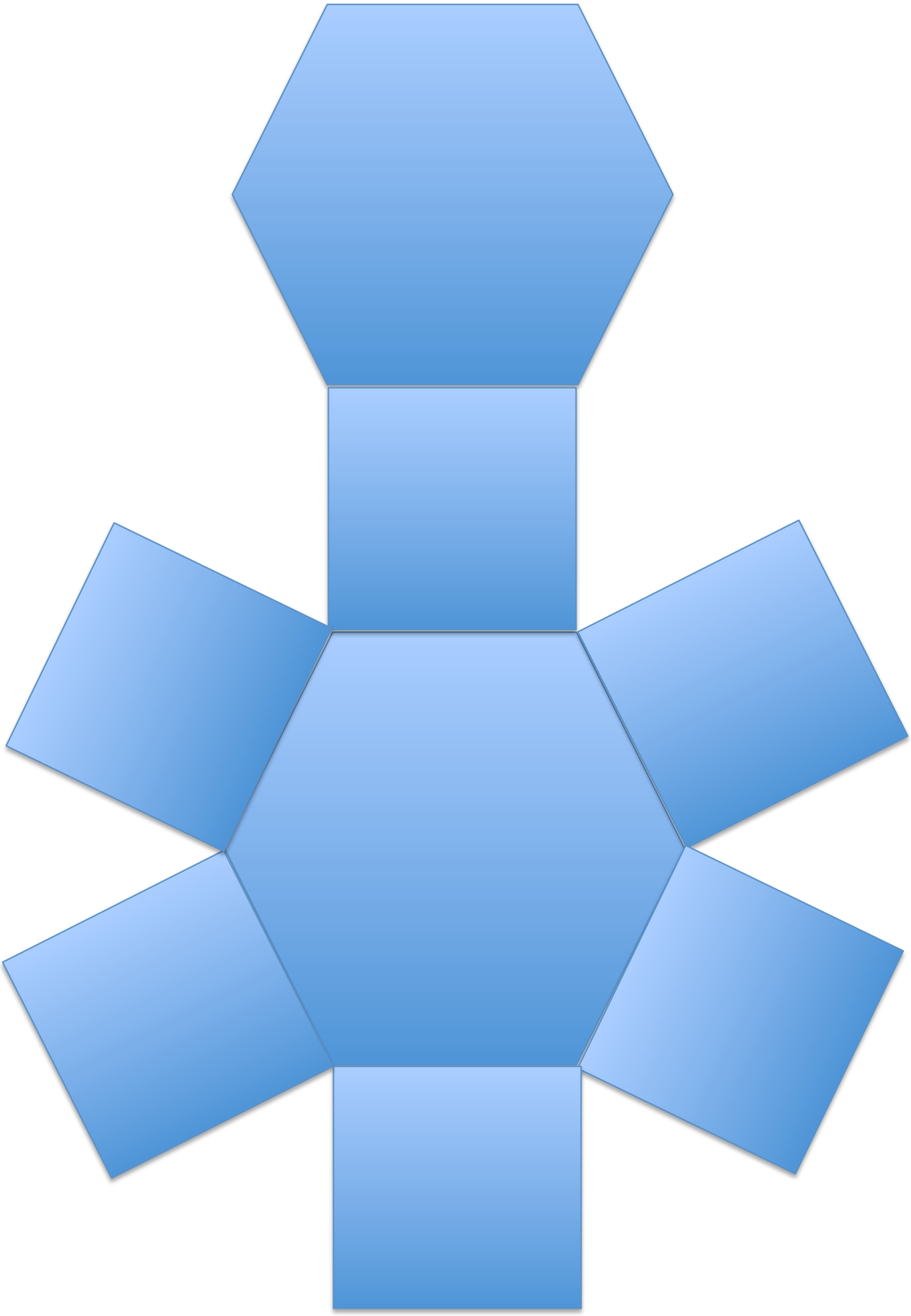


Activity: Have the students try to make snowflakes from paper. A template for doing this is below.



Step 1: Take a square piece of paper
Step 2: Fold in half along the diagonal
Step 3: Fold in half
Step 4: Fold in *thirds* as shown
Step 5: Cut off the bottom
Step 6: Cut out sections. Realism is best attained by trying to maintain the character of a hexagon in the cuts.

Carefully unfold and lay flat. Ideally, each student should make at least three. These can be flattened with a book or iron. They will be kept for a future lesson plan.



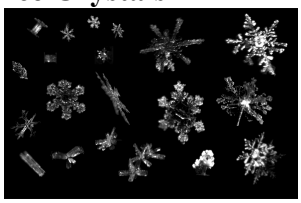
Lesson Plan 2: Snow Flakes

Learning Objectives: Students will be able to describe that snowflakes are made from collections of snowflakes to form "aggregates" or lots of little droplets to form "graupel" in a process called "riming". They will be able to create realistic looking examples cut out of paper.

Materials: Tape, Elmer's Glue, Paper, Coarse-balled Styrofoam.
Preparation: The students will use the snowflakes and hexagonal cubes they created in the previous class. The Styrofoam can be broken up into many little balls ahead of time. A few hundred balls would be ideal.

Science background: True snowflakes are only rarely very simple crystals like hexagonal prisms, or even the more complex shapes that were made out of paper in the previous class. These simple snowflakes are small, like those below

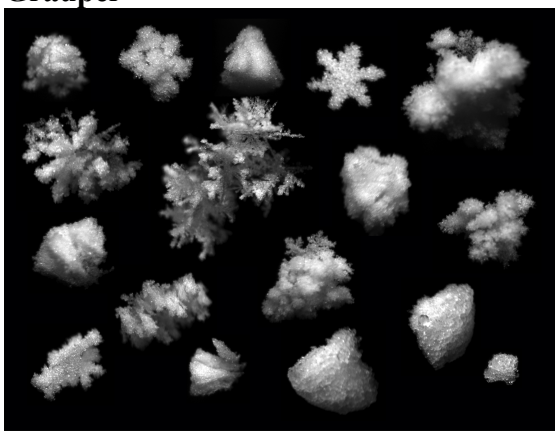
Ice Crystals



Normally, snowflakes are larger because they form through collisions. These include two main types of snowflakes.

One type of snowflake is called "graupel" which forms when a simple crystal falls through a cloud of tiny liquid droplets.

Graupel



When the droplets hit the crystal, they instantly freeze in a process known as "riming". After many, many, collisions, an ice pellet forms. This process is shown below. Simple crystals (top) collect droplets (middle). Eventually they collect so many droplets that they become round graupel (bottom).

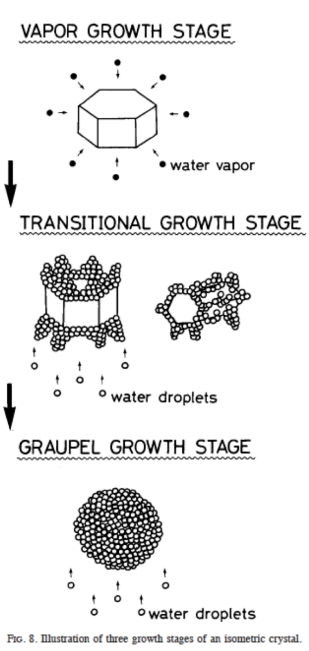
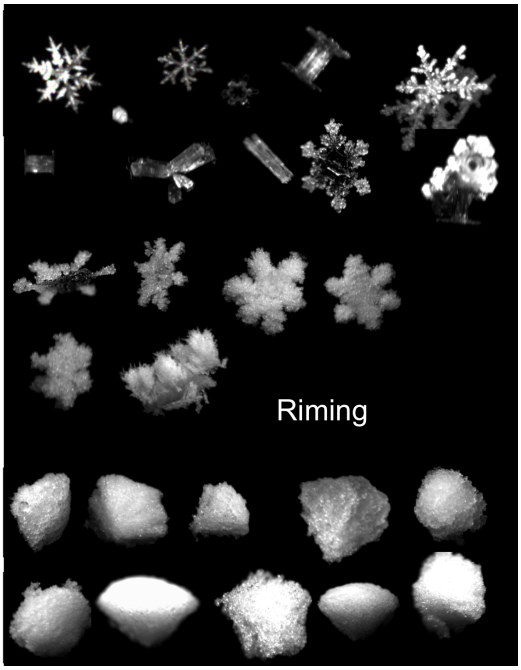
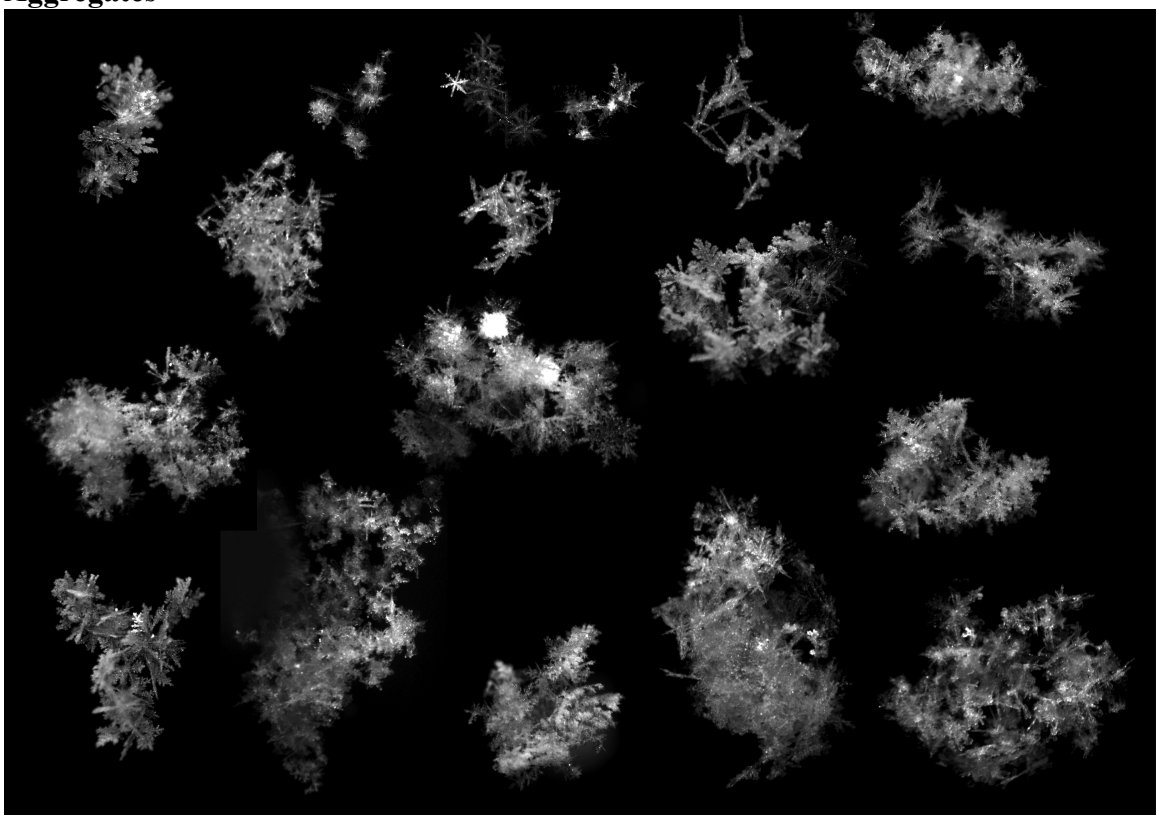


FIG. 8. Illustration of three growth stages of an isometric crystal.



Another type of of snowflake is called an “aggregate”, which is what forms when many snowflakes collide to form a much larger and fluffier snowflake.

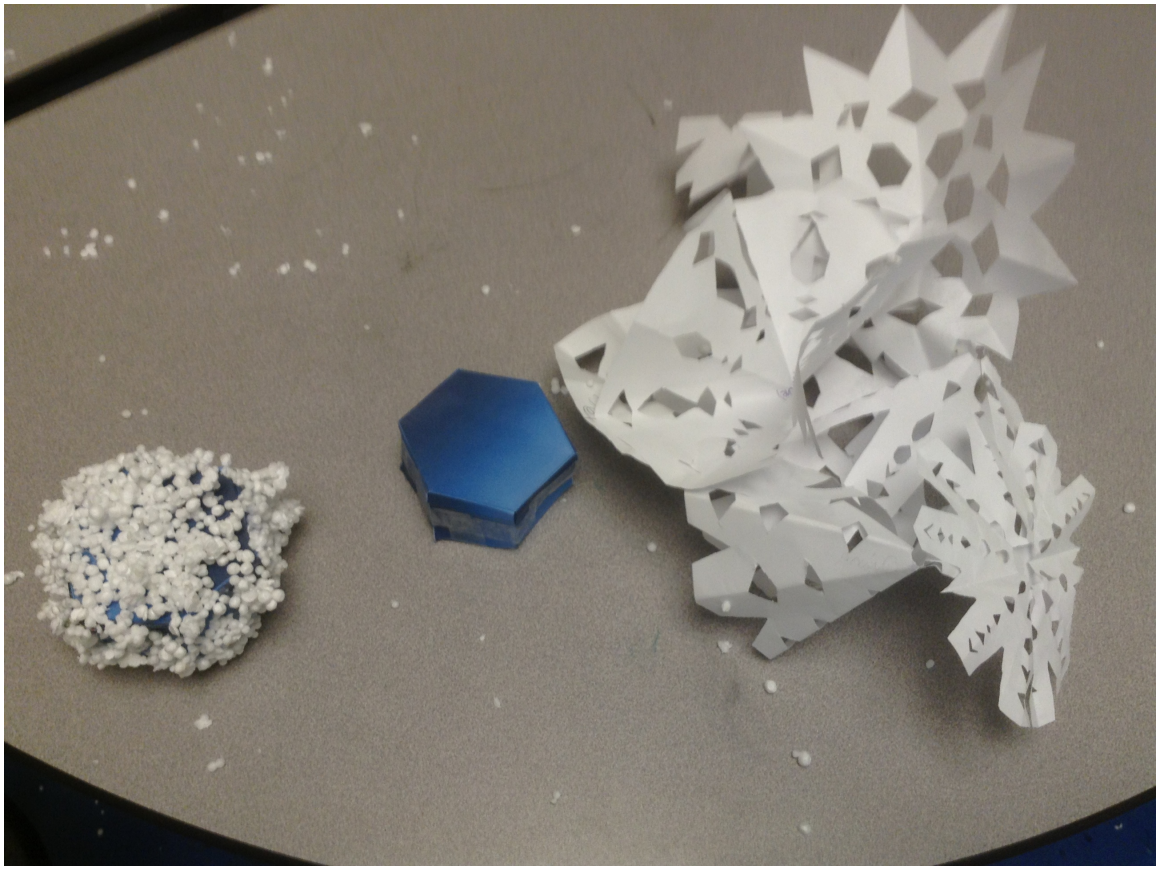
Aggregates



Activities: The students will create “graupel” by coating with glue the base of one end of the hexagonal prisms they created previously and dropping Styrofoam balls onto it. As one end is drying they will flip the prism and do the same to the other end, repeating until they have something that looks like a graupel particle as shown above, or at least the one shown in the “transitional growth stage”.

They will then do the same process, either with tape or glue, but dropping one cut out snowflake onto another cut out snowflake that lays on the table. This will create a much larger snowflake. The goal is not to have the snowflakes fall perfectly on one another, but rather that the combined snowflakes create a larger “raft” of aggregated snowflakes.

The graupel and aggregate snowflakes will be saved for the next class.



Lesson Plan 3: Snowflake Fall Speed

Learning Objectives: Students will be able to show that even though that "aggregate" snowflakes are much larger, they fall more slowly than more compact "graupel" formed by "riming".

Materials: Aggregate snowflakes and graupel made in the previous class. Stopwatch. Preparation: None beyond what was done previously.

Science background: In the previous class, two different types of snowflakes were made. Graupel is formed by riming during a fall, through the collection of up to millions of tiny droplets on the surface of a crystal, which then freeze to make a very small pellet of ice. Aggregates are formed by collecting snow crystals during a fall, to make a single very large snowflake.

Snowflakes are almost always much bigger across then graupel particles. But which falls faster? As might be expected, the denser and more compact graupel particles are the fastest falling even though they are smaller.

For meteorologists who try to predict the weather, predicting whether graupel or aggregates form in a snowstorm is a very difficult, but very important problem. Because graupel falls faster it doesn't get carried as far downwind before it falls as snow. Predicting snowfall accurately means meteorologists must predict the right kind of snow, something they are not yet able to do.

Activities:

The first activity is to take a piece of paper and drop it, watching it fall to the ground. Then drop the same piece of paper crumpled up. Which falls faster? Obviously, the crumpled piece of paper.

Prod the students for ideas about why this might be the case, highlighting the seeming paradox that we normally expect larger things to fall faster. Students should be able to come up with suggestions relating to the aerodynamics of flow around objects. This need not be terribly scientific, but they could talk about race cars, the stance of downhill skiers, parachutes, etc..

The second activity is for the students to take the graupel and aggregate snowflakes they made in the previous lesson and time their fall using a stop watch. They will need to figure out themselves a way to do this consistently. A suggestion is that they take the measurement five times for each snowflake type, record the fallspeed each time, and take the median (middle) value for each type as the point of comparison. They should notice two things. First, the graupel falls faster, and second, the graupel fallspeed is more consistent between measurements.

Start a discussion about the results, encouraging ideas for why the students see the observed differences. Also encourage discussion about which type of snow you would expect to fall first from a storm, hoping that they arrive at the conclusion that graupel will fall first because it falls fastest.

	Aggregate	Graupel
Measurement 1		
Measurement 2		
Measurement 3		
Measurement 4		
Measurement 5		
Median measurement		

Lesson Plan 4: Snowflake Photography

Learning Objectives: Students will be able to photograph snowflakes

Materials: Black felt or paper, camera, snowy day, a sheltered awning outside.

Science background: Snowflakes come in a tremendous variety of forms. Truly no two are alike. They can have tremendously different shapes. On some days the variety is extraordinary. On others, perhaps when graupel is falling, the snowflakes look remarkably similar. But then from one moment to the next they can change dramatically. But good observations of snowflakes are rare! And many of the most modern techniques used by real scientists remain those done using the methods that students will do for this class.

Activities:

When it is snowing outside, find a sheltered awning. Allow a couple of minutes for the felt or paper to cool down to the outdoor temperature. When the paper is cold, stick it out of the shelter of the awning for a long enough period that it is partly covered with snowflakes, certainly not so many that they begin to overlap. Bring the paper under the awning, lay it on a flat surface or the ground, and without delay photograph the snowflakes as close as possible while maintaining focus. Several photos may need to be taken. The students should also not if the snowflakes appear to be falling slowly or very quickly. If possible download the photos on to a computer where they can be viewed on a larger screen. The students will then proceed to identify the snowflake types and imagine what sort of life they had before the hit the ground. This can be done either through group discussion or through a brief written report.

An alternative option is to look at snowflakes photographed in freefall in a live feed from Alta Ski Area in Utah, made using a modern scientific camera system called the Multi-Angle Snowflake Camera

http://www.alta.com/pages/snowflakeshowcase.php