beetles
Science and Teaching for Field Instructors

## Student Activity Guide

# Snow Crystal Exploration

Looking at snowflake structures up close can be fun and interesting! All it takes is a hand lens to see beautiful and complex snowflake crystal shapes. Although every snowflake is unique, scientists have grouped crystal shapes into broad groups based on their characteristics. These shapes are evidence of the conditions in which the snowflake formed.

In *Snow Crystal Exploration*, students use hand lenses to observe and draw real snowflake crystals. Students discuss crystals they've found, learn to use a field guide/key to identify snowflake crystal types, look for patterns in snowflake shapes and where they're found, and try to figure out the conditions in which their snowflakes formed. In an optional discussion, students look at and interpret a diagram that connects snowflake shape and size to temperature and moisture content of the atmosphere. Finally, students reflect on their learning process.

**Students will:**

- **Observe and describe snowflakes they find.**
- **Use a field guide/key to identify snow crystal shapes and think about snowflake formation.**
- **Look for patterns in where different types of snowflakes are found.**
- **Work together in pairs and small groups, discussing their ideas with peers.**
- **Optional: Interpret a diagram about snowflake formation and environmental conditions.**

**Grade Level:**
Grades 4–8. Adaptable for younger or older students.

**Timing:**
70–100 minutes

**Related Activities:**
*I Notice, I Wonder, It Reminds Me Of; Hand Lens Introduction; Thought Swap*

**Materials:**
See the Materials and Preparation section on pages 3–4 for details.

**Tips:**
To ensure a successful experience, review the teaching tips found on page 2 and throughout this guide.

**Setting:**
Anywhere with relatively freshly fallen snow that has not previously melted.

**Acknowledgment:** This activity is based on an activity shared with us from the Teton Science School in Jackson, Wyoming.

**Note:** Due to program closures related to COVID-19, this actrivity did not go through as extensive field testing as our other BEETLES student activities. Do you have a suggestion or feedback based on using the activity? Reach out to: beetles@berkeley.edu.

**Equity, Inclusion, and Cultural Relevance** (informed by Youth Outside):
This activity has been designed to demonstrate how to create an equitable, inclusive, and culturally relevant teaching and learning experience. Read more, beginning on page 16.

NEXT GENERATION SCIENCE STANDARDS
For additional information about NGSS, go to page 18 of this guide.

| FEATURED SCIENCE AND ENGINEERING PRACTICE | FEATURED CROSSCUTTING CONCEPT | DISCIPLINARY CORE IDEAS |
| --- | --- | --- |
| Obtaining, Evaluating, and Communicating Information | Patterns | Weather and Climate, Structure of Matter |

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

# Snow Crystal Exploration

## ACTIVITY OVERVIEW

| Snow Crystal Exploration | Learning Cycle Stage | Estimated Time |
|---|---|---|
| Thinking About Snowflakes | Invitation | **5 minutes** |
| Observing Snowflakes | Exploration | **20 minutes** |
| Discussing Snowflakes | Concept Invention | **10–15 minutes** |
| Identifying Crystals | Application | **20–25 minutes** |
| Discussing Snowflake Patterns | Concept Invention, Application | **10–15 minutes** |
| Optional: Looking at a Snow Phase Diagram | Concept Invention, Application | **10–15 minutes** |
| Wrapping Up and Reflecting | Reflection | **5 minutes** |
| **TOTAL:** | | **70–100 minutes** |

**TEACHING TIPS**

**Read the Instructor Support section.** Beginning on page 14, you'll find more information about pedagogy, student misconceptions, science background, equity and inclusion, and standards.

**Find fresh snow.** Students need to be able to observe the crystal structure of snowflakes for this activity to be successful. Once snow melts, it no longer shows its original crystal structure, so you need fresh and unmelted snow. Pick a time for this activity when you know it will have just snowed or in a setting where snow won't have melted and refrozen.

**Student experience with snow.** Students will have a range of experience with snow. Some students may live where it snows regularly; for others, snow may be a newer experience. If students are newer to snow, offer the group some time to just play and have fun in the snow in a more unstructured way before the activity begins. (Make sure there will still be some areas of snow where students aren't playing so they can observe freshly fallen snow.) This experience offers students more to share when you ask them about prior experiences with snow. As you are walking or moving to the location where you will do the activity, you can also invite students to focus on the sensory experience of being in snow. Ask, "What do you notice? Shapes? Smells? Patterns?"

**Activities in snow take more time.** Moving through snow, sitting down and getting back up, managing gloves and materials can take time. The timing in the Activity Overview table above accounts for this. However, depending on your group and conditions, the stages of the activity may need more time or less time.

**Field Card.** At the end of this activity write-up, you'll find a condensed, pocket-sized version to use in the field.

## MATERIALS AND PREPARATION

### MATERIALS

**For the instructor**

- portable whiteboard
- grease pencil (dry-erase markers tend not to work well in snow conditions)
- 1 copy of Comparing Snowflake Crystals (page 23)
- 1 copy of Example Snowflake Photos (pages 24–25)
- optional (if you choose to do the Optional: Looking at a Snow Phase Diagram extension activity):
  - copies of Snow Phase Diagram/Questions for Interpreting the Snow Phase Diagram (page 27)

**For each pair of students**

- 1 copy of Snowflake Crystal Field Guide (page 26)
- optional: 1 copy of Snow Phase Diagram/Questions for Interpreting the Snow Phase Diagram (page 27)
- optional: ruler

**For each student**

- 1 hand lens
- 1 laminated black index card OR 1 small piece of cardboard with black felt glued to the top (felt tends to help the snowflakes "stick" more than on laminated cards)
- a few 5" x 8" index cards
- pencil
- optional: a foam sit pad (which can make it more comfortable to sit on snow)

### PREPARATION

1. **Print Comparing Snowflake Crystals (page 23).** You will show these photos to students during the "Observing Snowflakes" activity.
2. **Print Example Snowflake Photos (pages 24–25).** You will show these photos to students during the "Identifying Crystals" activity.
3. **Make copies of Snowflake Crystal Field Guide (page 26).** Make enough copies so each pair of students can share a copy of the field guide.
4. **Think through the Optional: Looking at a Snow Phase Diagram extension activity and decide whether or not this discussion**

## TEACHING NOTES

## TEACHING NOTES

**Location for optional discussion.** In the Optional: Looking at a Snow Phase Diagram extension activity, students discuss and analyze a graph that shows how different factors affect snowflake shape and formation. Depending on the weather needs of your group, you could conduct this discussion inside during the "Observing Snowflakes" activity or later in the field experience.

## MATERIALS AND PREPARATION (continued)

**would be appropriate for your students and situation.** This discussion is most appropriate conceptually for 6th-grade students and older. If you choose to do this extension:

- **Make copies of Snow Phase Diagram/Questions for Interpreting the Snow Phase Diagram (page 27).** Make enough copies so each pair of students can share the diagram/questions.

5. **If possible, put the black laminated index cards/the black felt-covered cardboard cards in the freezer several hours before you plan to lead the activity.** Freezing these materials will slow the pace of melting as students use the cards as a surface for observing snowflakes. Alternatively, if it is actively snowing, several minutes before you conduct the activity, place the cards outside near the area where you plan to do the activity so snowflakes collect on the laminated cards/felt-covered cards.

6. **Consider how you will tend to students' physical comfort throughout the activity.** Being physically uncomfortable makes it more challenging to focus, make observations, and engage in a learning experience. Some suggestions for tending to students' physical comfort include the following:
   - Give students a clear picture of how long they will be outside, what kinds of activities they will be doing, and what kind of gear they might choose to bring to be comfortable in that setting.
   - Offer extra jackets or warm clothes that students could choose to bring and wear during the field experience.
   - Offer frequent breaks for students to move their bodies or eat a snack.
   - Check in regularly with individuals and with the group.
   - Be responsive to the group's needs, making adjustments as needed to support students' comfort and engagement.

## Thinking About Snowflakes

1. **While moving to the activity site, invite students to *Thought Swap* (formerly known as *Walk & Talk*) with a partner about their ideas about and experiences with snow.**
   - *What have you heard, learned, or noticed about snow? This could be from your own experience, things you've noticed from pictures or movies, or something you learned from a peer or adult.*
   - *Why might scientists study snow and weather data?*
   - *As we move as a group, observe the landscape and snow around us. What do you notice about the snow? What do you see, smell, or hear?*

## Observing Snowflakes

1. **Share that students will have the opportunity to explore and study snowflakes up close and to make observations to learn more about snowflakes.** Share that students will get to use hand lenses to observe snowflakes to notice differences and similarities between the snowflakes.
2. **Show the Comparing Snowflake Crystals photographs and ask students to share the similarities and differences between Snowflakes A and B. Add observations that students don't share.** This is an opportunity to model making detailed snowflake observations and to highlight the kinds of differences and patterns between snowflakes that students might observe later. Encourage students to observe differences in shape and the number of points coming out of the snowflakes. Add to the discussion, sharing differences and similarities that you observe, as well.
3. **Share: We can use hand lenses to look at the details of snowflakes up close.**
4. **Model how to use a hand lens, distribute one hand lens to each student, and invite students to practice using them by looking at their fingertips (or gloves, mittens, or clothing).** Share that students can hold the hand lens close to their eyes and move what they're looking at closer or farther from the lens to bring it into focus. Invite students to say, "Whoa!" out loud when the object comes into focus.
5. **Share and model how to use the black laminated card or the felt-covered cardboard card to scoop snow while keeping it from melting.**
6. **Distribute a black laminated card or a felt cardboard card to each student and invite students to try out the cards from where they are sitting or standing.**
   - *Use this to scoop up a few snowflakes right where you are. Scoop up as few snowflakes as possible.*
   - *Gently spread the snowflakes on the card by shaking the card a little to see the snowflakes better.*
   - *The dark background will help you see the snowflakes better.*

**TEACHING NOTES**

**Logistics of the *Thought Swap* routine (formerly known as *Walk & Talk*).** See the BEETLES *Thought Swap* activity for the logistics of this discussion routine.

**Keep it moving.** The goal is to briefly engage students in observing photographs of snowflakes, offer a couple of examples of things they might notice or look for, and then move on. Keep this section moving so students are sure to have plenty of time to explore and check out actual snowflakes.

**Hand lens introduction.** If you haven't done the activity *Hand Lens Introduction*, take the time to introduce the hand lenses as described in that activity (http://beetlesproject.org/resources/for-field-instructors/hand-lens-intro/).

**Optional: Drawing a snowflake from memory.** If you have time indoors before bringing the group outside to observe snow, you might choose to invite students to take about 3 minutes to draw a snowflake from memory, using words to label or describe it. Then, invite students to *Think-Pair-Share* about their drawing with a neighbor, compare their two drawings, and silently consider the following questions: *What do you notice about your partner's snowflake? What things do your two snowflake drawings have in common? What things are different?* (Think). Then, invite students to discuss their ideas with their partners (Pair). Finally, invite a few students to share their ideas with the whole group (Share): *Many people have said that no two snowflakes are the same, but we found lots in common when we compared our drawings. What are possible differences and similarities you think we might find in actual snowflakes if we looked at them up close?*

TEACHING NOTES

- *Try not to breathe on the snowflakes or touch them with your fingers, or they'll melt.*
- *If it's sunny, keep the snowflakes you're looking at in your shadow to avoid melting.*
- *If it's windy, you might need to protect your sample so it doesn't blow away.*

7. **Ask students to say some observations out loud so others can hear. Coach students as needed to help them be engaged and successful.** Keep this part short. The goal is for students to briefly practice observing a snowflake while you coach and support them, before sending them out to explore on their own. Ask follow-up questions to encourage detailed observations and comparison of snowflakes. Coach students through any challenges they may have with scooping and observing snow without it melting.

**Engaging directly with nature.** Centering learning on students' in-the-moment observations of a phenomenon such as snow helps create an inclusive learning experience by focusing it on a shared experience to which every student has access. This sets up a collaborative learning context in which students' ideas and observations drive the learning experience, and students recognize themselves and one another as sources of expertise. This is in contrast to science learning situations in which participation requires prior knowledge about science ideas, and students who have had more exposure to science tend to have an advantage.

8. **Share that students will have about 10 minutes to work with a partner to observe different kinds of snowflakes, looking for differences and similarities between the snowflakes.**
   - *Move around and observe different kinds of snowflakes.*
   - *Try to observe several snowflakes from different places—for example: exposed area vs. under vegetation, on a slope vs. flat, surface of the snow vs. deeper in the snow, in shade vs. sun, etc.*
   - *Make as many observations as you can and look for similarities and differences between the snowflakes you find.*
   - *These might be similarities and differences in their shapes—for example: one is long and skinny, while another is flat with lots of branches—or similarities and differences in size.*
   - *Use your hand lens to look at the snowflakes up close.*
   - *Share and discuss your observations with your partner.*

9. **Share that students will likely find snowflakes that look different from the photographs you showed earlier, including snowflake crystals that might be broken into pieces, and encourage students to observe whatever they find.** Let students know that they might find snowflake crystals with shapes that are very different from the example photographs you shared with them earlier. Share that some snowflakes might have a completely different shape, while students might also find just a piece of a snowflake or pieces combined from different snowflakes.

10. **Model recording observations of a snowflake on a whiteboard and offer the following drawing and journaling tips as you do.** Let students know that they will work in pairs and that each student will make their own drawings on an index card.
    - *After a little while, I will bring you an index card and pencil so you can use these tools to record observations of your snowflakes.*
    - *Please use words, pictures, and numbers together to describe snowflakes.*

- *Draw snowflakes larger than their actual size so it's easier to see their features.*
- *If the snowflake is symmetrical (the same on both sides), you only need to draw one side of the snowflake. Then, you can write "same on the other side."*
- *Use words to label things that are harder to draw. For example, you could write "snowflake is fuzzy all over" instead of taking the time to draw fuzz all over your snowflake.*
- *Use numbers to count and label parts of the snowflake, such as the sides of the snowflake. Draw a line or a dot to show the actual size of the snowflake and write "actual size" next to that.*
- *Use words to record where you found the snowflake and add information to describe the area where you found the snowflake, such as whether you were in the shade or sun, if it's an area exposed in the wind, etc.*
- *Include information from a few different samples of snowflakes.*

11. **Share safety expectations or considerations and boundaries.** Share the boundaries of the area where students can explore, as well as any safety considerations appropriate for your location. Note: The larger you make your boundaries, the longer it will take for students to gather and disperse during the activity as it takes time to move in the snow. Strike a balance between offering enough space so students can spread out and observe snow in a few different locations and not making the boundaries so expansive that it will take students a long time to disperse and gather.
12. **Pair students and then invite them to begin observing snowflakes.** Either assign partners you think will work well together or invite students to pair up with someone with whom they think they will work well (which is sometimes *not* their buddy).
13. **After students have observed a few snowflakes, distribute pencils and index cards and invite students to begin drawing snowflakes from their observations.**
14. **As students observe snowflakes, circulate and ask them questions about their observations and support participation and engagement.**

## Discussing Snowflakes

1. **After about 10 minutes, gather students back to discuss their observations.**
2. **Ask students to turn to someone next to them that they weren't exploring with and discuss journaling and observations by using the following questions:**

   If students *did* draw their snowflakes:

   - *Find two or more similarities and two or more differences between the snowflakes you drew.*

### TEACHING NOTES

**Support, scaffolding, and student engagement.** *Snow Crystal Exploration* includes scaffolding throughout the activity to support students' participation. When the instructor models looking up information from a field guide or uses Think-Alouds to show how students might respond to a discussion question, they are modeling learning behaviors that students can apply during the activity. These strategies also support literacy and language development, as does inviting students to unpack vocabulary or to clarify definitions. This activity write-up also offers a range of options for how students might respond to a question, including writing time, thinking time, or *Pair-Shares*; this encourages instructors to consciously choose the approaches that they think will work best for their specific group of students.

**Too cold or wet for journaling?** Journaling is a valuable tool for making and remembering observations. However, if students are physically uncomfortable, they'll be less likely to be able to focus on journaling and learning. If it is actively snowing, it can also be challenging to journal because the paper will get wet. If it doesn't make sense to journal in the moment, allow students to make observations without their journals.

**Managing tools.** It can be challenging to hold and manage a hand lens, snow collection card, paper, and a pencil all at once in the cold with gloved hands! Pay attention to your group as they begin to observe snowflakes. If they are successfully engaged in using their hand lenses and snow collection cards, move forward with distributing pencils and index cards. If it seems like adding a new set of tools will be challenging for your students to manage, don't distribute the sketching tools; instead, focus on encouraging students to make thorough observations verbally.

**TEACHING NOTES**

***Think-Pair-Share.*** In this useful discussion routine, students are given a brief time to think quietly about the topic, then discuss in pairs, and then some students share out with the whole group. This routine helps break up the common dynamic of a whole-group discussion where only a few students participate. Many learners benefit from quiet processing time before they can articulate their thoughts. Having students share in pairs gives every learner an opportunity to articulate their ideas. Learners who may be intimidated about participating in a whole-group discussion often feel more comfortable sharing with one other person. Students who are quick to participate in whole-group discussions also benefit from time to think and speak with a partner, and the ideas they share will likely be more thoughtful.

- *What did you notice about the snowflakes you drew here and other snowflakes you observed?*

If students *did not* draw their snowflakes:

- *Share with your partner: What did you notice about snowflakes?*
- *Describe to each other a few of the snowflakes you found. What were their shapes like? How were the snowflakes you found different from one another?*

3. **Invite students to turn back to the same partner; focus on one snowflake that they thought was especially cool, mysterious, or interesting; and describe it.**

4. **Get the attention of the whole group, invite a few students to share their observations, and then lead a short discussion about the group's observations and ideas by using the questions below.** Listen as students share their observations and guide the discussion to follow their interests. Encourage students to build on one another's ideas, asking follow-up questions such as, "Did anyone else notice something like that?" "Does anyone want to add to what they said?" "What else did you notice?" The goal is to build some common understanding of patterns of snowflake shapes. Pay attention to student engagement during the discussion. After a few students have had time to share their thoughts and ideas, and before the group starts to seem disengaged, move on to the next stage of the activity.
   - *What did you notice?*
   - *What were some of the similarities and differences you noticed between the snowflakes?*
   - *How would you describe some of the most interesting snowflakes?*

**Take a break.** Before moving on to sharing about crystal identification, read the energy of your group. If students are engaged and seem excited to continue thinking about snow, move forward. If it seems like students are cold or are beginning to disengage, consider taking a short break and moving around; playing a short, high-energy game; or sharing a snack.

## Identifying Crystals

1. **Share: Each snowflake is unique, but we can group them into types or categories based on what they have in common.**

2. **Share: Some scientists study snow, and they have used observations, like you just made, to describe different groups of snowflakes.**

3. **Distribute one copy of the Snowflake Crystal Field Guide to each pair of students and share that it is a tool for learning about some of the ways scientists have grouped snowflakes.** Give students a minute to look at the field guide/key with their partners.

4. **Offer guidance and scaffolding for students as they use the Snowflake Crystal Field Guide to identify snowflakes.** Invite students to use the Snowflake Crystal Field Guide, along with their knowledge and experience, to help sort the different crystal types for which you share examples. As you introduce each type of snowflake, ask a few questions about what the text says about the type of snowflake.

5. **Hold up Example Snowflake Photo #1 (Star-Shaped).**

- *Let's say you found a snowflake with a shape like this. Take a look at your Snowflake Crystal Field Guide and see which kind of snowflake you think it matches most closely. Use the photos, drawings, and words on the field guide to help you make a match.* (Pause for students to look at their field guides.)
- *This is a star-shaped kind of snowflake. We can use this Snowflake Crystal Field Guide to find out some information about this kind of crystal.*
- *About what temperature does the field guide say that a star-shaped snowflake forms high up in the sky?*
- *For comparison, what was today's coldest temperature down here on the ground?*

6. **Repeat the questions for Example Snowflake Photos #2 (Fern-Shaped), #3 (Twelve Branches), and #4 (Column), as needed.** Follow a similar process for as many other examples as seems appropriate. Encourage students communicating with each other to decide which kind of snowflake each example is. Work to clear up any confusion and ask some questions about what the text in the field guide/key says about the types of snowflakes.

7. **Invite students to try to use the Snowflake Crystal Field Guide to identify the snowflakes they drew and then label the snowflakes on their index cards.** If students didn't draw snowflakes, skip this step.

8. **Share that students will have around 10 minutes to move around and try to identify snowflake crystals, using the field guide/key. Repeat that the snowflakes students find might look a little different than the images in the field guide/key.** Share that with their partners, students should observe as many crystals as they can, taking a few moments to look closely at each crystal and share observations.
   - *Describe and discuss the snowflake's shape, features, and size and try to identify the type of snowflake.*
   - *The snowflakes you find might look a little different from the ones in your field guide/key. Use the pictures, drawings, and words to help you match the snowflakes.*
   - *Remember to be careful not to touch the flakes with your bare hands or they'll melt!*

9. **Share that students will also have the opportunity to look for patterns of snowflake crystals. Offer some examples of patterns that students might look for.** Share that students are going to use this information to try to figure out how and why different shapes of snowflakes form. Offer:
   - *You'll also look for patterns of where you find types of snowflake crystals and how many you find.*
   - *Scientists often look for patterns to learn about what's going on in nature.*
   - *As you explore and try to identify snowflakes, pay attention to the types of snowflakes you are finding and look for patterns in where you find them.*

## TEACHING NOTES

**Nonscientific descriptive names.** Science experiences can sometimes introduce a lot of vocabulary that students will rarely encounter again (unless they choose to go into that specific science discipline.) In the Snowflake Crystal Field Guide, we chose to alter a couple of names to be more intuitive and provide descriptive terms for snowflake types. If you prefer to introduce students to the scientific terms, and it makes sense for your group of students, feel free to do so. The star-shaped crystals are called stellar dendrites, and the fern-shaped crystals are called fern-shaped dendrites. For more detailed crystal types and names, see http://www.snowcrystals.com/guide/snowtypes4.jpg.

**Broad questions and science learning.** Science is often viewed or taught as a collection of facts; this is reinforced by science learning experiences that focus on memorization or recall of facts and narrow questions posed to students that invite only one correct answer. However, science is a way of knowing and a process for thinking and learning, not just a body of knowledge. Including broad questions in science learning (questions that have multiple possible responses, such as *What might cause snow crystals to have different shapes?*) engages students in scientific sense-making, encourages critical thinking, and makes space for divergent perspectives and differing ideas to be shared. Weaving broad questions throughout science lessons also sends the message that students' ideas and creative thinking are an essential part of science learning, contradicting the exclusionary idea that memorizing facts is what it means to be good at science.

TEACHING NOTES

**Digging snow pits.** When snow falls several inches thick on the ground, the snowflakes at the bottom metamorphose (change shape due to the pressure of the snow above them). You can consider asking students to dig down into the snow, observe and compare crystal shapes at the bottom to those on the top, and try to make explanations for what has caused the differences.

**Moving inside and taking a break.** It's possible to do this next part of the activity inside, if your students will be more comfortable inside and if it is possible to move inside. If you're going to continue the activity outside, consider taking a short break, moving to a new location, or offering time for students to move around or warm up before the next discussion.

- *Is there more of one snowflake type in one place than in other places? Are there certain types of snowflakes you aren't finding at all? For example: "We're mostly finding star-shaped." Or "We're only finding graupel, or rounded grains, when we dig up snow from below." Or "We haven't found any fern-shaped snowflakes."*
- *Do you think there are any trends you might see in patterns of where you find specific types of snowflakes?*

10. **Ask students to share examples of locations where they might find different kinds of snowflakes and record them on your whiteboard.** For example, students might share that different snowflakes under the eaves of a building vs. farther away from the building; different snowflakes in a place that never gets sun vs. a sunny area, etc.
11. **Ask students to keep a tally on their index cards of the types of snowflakes they find and information about where they found each type.** Invite students to write the name of each type of snowflake they find and then make a tally mark for each one they find of that kind. They can also record other information such as: "Found more column snowflakes in the open field." or "We didn't find any star-shaped snowflakes anywhere! If it's too cold or wet for writing on paper, ask students to focus on identifying snowflake types, looking for patterns, and sharing ideas with their partners.
12. **Send students out to identify snowflakes and as they work, circulate and engage them in conversation about their findings.**
13. **After about 10 minutes, ask pairs to summarize how many snowflakes of each type they found as they rejoin the group.**
14. **With the whole group back together, facilitate sharing of students' data about snowflakes in a way that makes sense for your group.** Facilitate students sharing their data with the whole group. This might be circling up and giving a short amount of time for each pair to share what they found. Or, if you have a larger number of student pairs, consider giving students a short break while you move around to each pair to ask them for their data. As students share their data, record a few notes about patterns on your whiteboard.

## Discussing Snowflake Patterns

1. **Lead a short discussion to hear some students' initial ideas about snowflake formation.** Use the questions below to facilitate the conversation. Follow students' interest and ideas, asking follow up questions and encouraging students to build on one another's thinking.
   - *What do you know about how snowflakes form?*
   - *What kinds of things need to be present for a snowflake to form?*
   - *What might cause snow crystals to have different shapes?*

2. **Share the following points, connecting them with what students brought up during the discussion:**
   - For snow crystals to form, you need temperatures below freezing (review: 0 degrees Celsius/32 degrees Fahrenheit), moisture in the air, and something such as dust for crystals to form on.
   - Snowflake crystals form as different shapes depending on how cold it is and how much moisture there is in the air.
   - Snowflakes form high in the sky above an area and then fall toward the ground. As they fall, they can keep forming and growing.
   - Colder air can hold less moisture than warmer air. *Have you ever noticed cold air feeling dry or warm air feeling humid?*
   - When there is more moisture in the air, snowflakes can be more complex and bigger.
   - When the temperature is very, very cold, snowflakes tend to be tiny.
   - On the whiteboard, write:
     - more complex and bigger = more moisture
     - tiny = very cold
     - Colder air can hold less moisture than warmer air.

3. **Lead another short large-group discussion using some of the questions below, listening to students' ideas, following student interest, and asking follow-up questions as appropriate.** Use some of the following questions to get the discussion started. Don't just ask each question one after another in short succession. Ask a question, listen to students' responses, ask students follow-up questions to draw out their thinking, and then offer another question to the group. If students are interested in one topic, keep discussing it. If they seem disinterested, move on to a new question.
   - ▶ *What patterns can you find in the types of snowflakes you found? Are they complex or simple? All snowflakes are small, but some are super tiny. Were the snowflakes you found small or super tiny?*
   - ▶ *Were there patterns of where you found different kinds of snowflakes?*
   - ▶ *How might you explain those patterns?*
   - ▶ *Judging from the snowflakes you found, what might you be able to explain about what the conditions were like as they formed up in the air?*
   - ▶ *What kinds of factors might change the snowflakes over time after they have landed? [Melting, refreezing, animals stepping on it, vehicles, etc.]*
   - ▶ *What can you explain about how the snowflakes might have changed over time after they were on the ground?*
   - ▶ *How do you think the kinds of snow crystals that fall from the sky in this area change throughout the winter season? If there was a wetter, warmer storm, what kinds of snow crystals might you expect to find? What about a drier, colder storm?*

**TEACHING NOTES**

**Delay Steps 2–3 if you choose to lead the optional Looking at a Snow Phase Diagram activity.** If you are going to lead the optional activity (on pages 12–13), skip Steps 2–3 of Discussing Snowflake Patterns. The same questions are included in the optional activity, so students will get to figure out some of these concepts at that time.

**Intersperse partner discussions within the whole-group discussion.** Discussion gives students authentic opportunities to process content, formulate and share ideas, and to make meaning. Partnered discussions give every student the chance to share and process their ideas and listen to those of their peers. Partner discussions also help create an equitable and inclusive learning space. The opportunity to think through ideas and rehearse what to share with the whole group in a low-stakes situation is particularly beneficial for emerging multilingual learners and provides increased opportunities for all students to participate successfully. Include opportunities for pair talk throughout this activity.

**TEACHING NOTES**

**Should you do the Optional: Looking at a Snow Phase Diagram activity with your students?** This optional section of the activity is most appropriate for 6th-grade groups and older. Review this section and the diagram and decide ahead of time if you think it will be appropriate for your group of students.

**Discuss the diagram indoors.** It's possible to lead this stage of the activity later, in an indoor location. Read the energy of the group, check in with your group of students, and consider facilitating this discussion indoors if you think your students are likely to engage with it.

## Optional: Looking at a Snow Phase Diagram

**Note:** This discussion is most appropriate for 6th-grade students or older. If you're not doing this optional stage of the activity, skip ahead to the "Wrapping Up and Reflecting" section (beginning page 13).

1. **Distribute one copy of the Snow Phase Diagram/Questions for Interpreting the Snow Phase Diagram to each pair of students and share that the x-axis shows temperature (getting colder toward the right), while the y-axis shows moisture (more moisture as you go up).**
2. **Ask students to look at the Snow Phase Diagram, ask questions about it, and make explanations (with their partners) about why certain snowflake crystal structures might form in certain conditions.** Let students' know that they will discuss the Questions for Interpreting the Snow Phase Diagram in a few minutes.
3. **After a few minutes, have pairs use the Questions for Interpreting the Snow Phase Diagram to help them interpret information in the diagram.**
4. **Get the group's attention and invite students to share a few of their thoughts about the diagram. Lead a short group discussion about students' ideas.** As appropriate, use some questions from Questions for Interpreting the Snow Phase Diagram to guide the discussion. Ask follow-up questions and encourage students to build on one another's ideas.
5. **Ask students to look at the Snow Phase Diagram and try to make some general statements about what the conditions were like when the snowflakes they found today formed.**
6. **Ask: "Based on the diagram and what you know about weather/seasons, how do you think snowflake shapes might vary throughout the winter season, throughout a day, or across different geographical areas?"** Invite a few students to share their ideas. Ask follow-up questions to encourage students to elaborate on their thinking.
7. **Share the following points, connecting them with what students discussed, when appropriate:**
   - There is a lot that still isn't known about snow and crystal formation, and it can be fun to keep looking at snowflakes and keep learning!
   - Snowflakes don't form here on the ground. They form high in the sky, above an area, and then fall toward the ground. As they fall, they can keep forming and growing.
   - For snow crystals to form, you need temperatures below freezing (review: 0 degrees Celsius/32 degrees Fahrenheit), moisture in the air, and particles such as dust for crystals to form on.
   - Colder air can hold less moisture than warmer air. *Have you ever noticed cold air feeling dry or warm air feeling humid?*

- When there is more moisture in the air, snowflakes can be more complex and bigger.
- When the temperature is very, very cold, snowflakes tend to be tiny.
- What patterns can we find in the types of snowflakes we found? Complex or simple? Tiny?
- On the whiteboard, write:
  - more complex and bigger = more moisture
  - tiny = very cold
  - Colder air can hold less moisture than warmer air.

8. **Ask the following questions, listen to student ideas, and ask follow-up questions as appropriate:**

   ▶ *When there is more moisture in the air, snowflakes tend to form more complex and bigger shapes. Why might that be the case? Use evidence to support your thinking.*

   ▶ *When it is very cold, it tends to lead to smaller, more compact snowflakes. Why might that be the case?*

   ▶ *Judging from the snowflakes we found, what might we be able to explain about what the conditions were like as the snowflakes formed up in the air?*

   ▶ *What kinds of factors might change the snowflakes over time, after they have landed? [Melting, refreezing, animals stepping on it, vehicles, etc.]*

## Wrapping Up and Reflecting

1. **Invite students to *Turn & Share* or *Thought Swap* (formerly known as *Walk & Talk*) about some of the following questions:**

   ▶ *How have your ideas about snowflakes changed throughout the activity?*

   ▶ *Thinking about just the daily temperatures and weather conditions in this area, how do you think the snowflakes we observed here might change over time?*

   ▶ *If we were to dig down into layers of snow to see snow that has fallen over time, what kinds of differences do you think we might find?*

   ▶ *What did you do that helped you learn about snowflakes today?*

   ▶ *What are you still curious about? What are some things you could do to learn about snowflakes and answer your questions?*

   ▶ *What are some skills you think you got better at?*

2. **If students have field journals, give students a chance now or later when indoors, to tape their index cards into their journals and to write notes about their observations and ideas about snowflakes.**

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**Optional follow-up activities.** Some optional follow-up activities are: Looking at the subnivean (under snow) zone, discussing organisms in the subnivean zone, looking for animal tracks and signs, discussing local historical patterns in climate and snowpack, and looking at layers in the snow and discussing metamorphosis of snow crystals.

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# Instructor Support

## Teaching Knowledge

**Teaching and learning in the snow.** Teaching in the snow offers unique opportunities and brings up unique physical challenges. The more physically comfortable students are, the more they will be able to focus on learning. Plan breaks for students to move around, stay warm, or eat a snack. Be responsive to students' needs throughout the activity. Consider collecting and bringing a small foam sit pad for each student that they can sit or kneel on during more stationary parts of the activity. Or, plan to do the activity somewhere with a stable surface where students can sit upright, such as a location with a set of picnic tables. It often takes longer to physically move around in the snow, to shift from a sitting position to a standing position, and to manage gloves and materials, so consider this as you plan timing for your field experience.

**Engaging students in discussion.** In order for students to be able to engage in discussion, it's important to set up a culture of discourse in your group and to give students opportunities to discuss in pairs and in small groups before participating in a whole-group discussion. To establish a culture of discourse, create and nurture an atmosphere of respect and intellectual curiosity by responding equitably to students' ideas as a facilitator and facilitating—not dominating—the discussion. When you respond to students, do so in a neutral, accepting manner and then probe their thinking with follow-up questions. Encourage agreement and disagreement that builds toward a deeper understanding. Establish that when there is disagreement about ideas, students will not be ridiculed for having the wrong answer. Emphasize that sharing ideas as a group is an important part of the learning process.

## Content Knowledge

### Snow Crystal Formation

Snow is formed in the atmosphere. Conditions needed for snow crystals to form include moisture in the air, a temperature below freezing, and particles such as dust for the crystal to form around. Snow crystals form when a tiny water droplet freezes, and they grow as water vapor freezes and adds onto the crystal. Snowflakes have repeating, uniform shapes; these shapes and the properties of the types of snow crystals are affected by variations in temperature and moisture. Generally, more moisture leads to larger snow crystals, and very cold temperatures lead to smaller snow crystals. This is because cold air holds less moisture. The Snow Phase Diagram shows more complex ways that moisture and temperature interact, generating a wide array of patterns and shapes of snow crystals. Scientists don't yet know why some of these variations occur.

Specific patterns in the air temperature and moisture conditions in which snow forms leads to predictable patterns in snow crystals. That's why examining freshly fallen snow up close can offer evidence of the conditions in which the snowflakes formed. Once snow is on the ground, it can be affected by a whole new set of conditions. If the temperature is above freezing, snow

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may partially melt and then refreeze as the temperature drops again. When snow melts, it loses the crystal structure with which it started out. Wind and foot traffic can also cause snow crystals to break. This is why it's important to focus on freshly fallen snow for the part of the activity in which students are examining crystal structure.

There can also be rich and interesting patterns to observe in snow that has been on the ground for a while. In areas where snow sticks on the ground for multiple days, weeks, or months, layers of snow can form. Over time, as more snow accumulates, the weight and pressure of the layers causes melting and refreezing of snow crystals, and temperature continues to have an effect on the snow crystal structure. Snow can also form through deposition, turning directly from a gas into a solid.

### Snow as an Eosystem: Subnivean (under snow) Activity

It may not look like there's much life in a snowy landscape, but because snow is an insulator from cold air, the space between the layers of snow and the ground is typically warmer and a more stable temperature—around 32 degrees Fahrenheit. That may seem colder, but it's much less cold than the air at the surface of the snow  which can drop much lower than freezing throughout the winter. Small mammals such as moles, mice, and voles live in this area, feeding on dead plants, seeds, and flowers. The snow layers also offer protection from predators.

It's possible to see some tunnels where these small mammals live by digging down into the snow or waiting until spring comes, and the snow melts. Burrowing animals often push dirt from digging tunnels up into snow tunnels. After the snow melts, these look like long, thin tubes of dirt. Predators such as fox, weasels, and owls sometimes prey on animals that live in the subnivean zone. It's possible to find tracks of these animals, as well as other animals that live aboveground during the snowy season. Looking for tracks and signs can be a fun and engaging learning experience in the snow.

### Avalance Formation

Avalanches are another effect of layers of snow forming during winter, especially on steep, snow-covered slopes. Avalanches also are caused when a weak layer of snow is underneath many other layers of snow. A weak layer of snow can form when snow crystals have shapes that don't bond or stick together very well. These kinds of snow crystals that form weaker layers of snow are usually rounder, leading to layers of snow that slide quickly due to reduced friction.

## Common Relevant Misconceptions

**Misconception.** The temperature in which a snowflake forms is the same as at Earth's surface.

**More accurate information.** Conditions high in the atmosphere can be much colder than at the surface. That's why snow or hail can form and fall even if the air temperature is above freezing at ground level (although it won't stick). That's why freshly fallen snow crystals are

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evidence of conditions up high where they formed, and older snow has been changed by conditions at the surface.

**Misconception.** Water can only freeze to a solid state from a liquid state.

**More accurate information.** Water vapor (gas) can turn directly into solid ice, skipping the liquid phase. This is called deposition. The reverse can also happen when solid water turns into water vapor, skipping the liquid phase. That is called sublimation. An example of sublimation is when ice cubes in a freezer sublimate and get smaller (or "disappear").

## Supporting Equitable, Inclusive, and Culturally Relevant Learning Experiences

This BEETLES student activity has been intentionally designed to create an equitable, inclusive, and culturally relevant learning experience for a community of learners. BEETLES design principles [http://beetlesproject.org/about/how-do-we-approach-teaching/] ensure that each activity is student-centered and nature-centered. This enables all learners to access, participate, and engage in the learning experience.

**When learners engage directly with nature, they all have access to learning, regardless of their prior knowledge or experiences.** Centering learning on students' in-the-moment observations of nature builds an inclusive learning experience by focusing the conversation on an experience shared by every student, as opposed to relying on students' prior knowledge or past experiences. As students engage with nature, instructors are in the role of the "guide on the side." This approach shifts power from the instructor to learners, challenges the typical learning situation in which the instructor is the only expert, encourages students to share their ideas and experiences, and makes learning a more decentralized and collaborative experience.

**When learners think like a scientist and practice academic language, they develop critical thinking skills that support them to become more independent learners—learners who have skills and thinking tools they use to learn, regardless of the level of support available from a teacher or instructor.** Giving students the opportunity to think like a scientist by making observations, asking questions, and constructing explanations supports students' growth as learners and offers them the opportunity to build critical thinking skills and learning behaviors they can apply in any context. Many students in schools that have historically been under-resourced due to racist school funding policies, redlining, income inequality, and police profiling have fewer opportunities to develop as independent learners. Specifically ensuring that students in these kinds of schools have opportunities to develop as independent learners is an issue of equity. Learning and practicing critical thinking skills in an engaging outdoor context supports students to succeed back in their classrooms, in science, and in other academic disciplines. Offering opportunities for students to discuss ideas with their peers and knowledgeable adults makes science more accessible by connecting it to students' own actions and discoveries in the moment—not just to knowledge they may not have or experiences they may not have had.

**Through discussion, learners make connections to prior knowledge, share their lived experiences, listen to different perspectives, and have time to process the material.** Productive discussions in which many voices are heard, and the group builds off one another's ideas, create an experience in which students see themselves and one another as sources of expertise. This ensures that instructors don't fall back on positioning themselves as the only source of accurate or important information. Participating in discussions also supports students to develop cognitive rigor and the ability to take on more advanced learning tasks. Discussions make student thinking and ideas visible to the instructor. When instructors value, appreciate, better understand, and connect to students' lived experiences, they create a more inclusive and culturally relevant learning space. Finally, multiple opportunities for discussion provide time and space for neurodiversity—allowing students to process information in different ways. Using discussion strategies such as *Turn & Share* or *Thought Swap* (formerly known as *Walk & Talk*) that are part of every BEETLES student activity can help ensure that students have these kinds of opportunities for discussion.

Specifically, *Snow Crystal Exploration* promotes an equitable, inclusive, and culturally relevant learning experience by:

- using broad questions to invite students to share their observations, prior knowledge, perspectives, and experiences with one another and with the instructor.
- providing space for students to come up with connections between what they are observing and prior experiences and knowledge, which supports their learning and retention.
- providing a simple field guide/key that students can use to pursue their own interests within the subject area.
- scaffolding skills of scientific observation, including accessing information from a field guide/key, supports students' visual literacy and language acquisition and supports students to be independent learners; visual literacy and language acquisition are also critical pieces of the Common Core State Standards (CCSS).
- engaging students in meaning-making discussions that prepare them to take on increasingly rigorous learning tasks in the future.
- engaging students with commonly found parts of nature such as snow, contrasting the exclusionary idea that nature only exists in pristine wilderness areas, requires a panoramic view or unique geographic feature to be engaging, or is otherwise a place students need to go to as opposed to something they are always surrounded by.
- focusing the group's learning on a common experience to which everyone has access.
- offering opportunities for students to engage in the Next Generation Science Standards (NGSS) Science and Engineering Practice of *Obtaining, Evaluating, and Communicating Information*, which is a transferable learning skill that students can continue to apply in other academic disciplines.

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**"Classroom studies document the fact that underserved English learners, poor students, and students of color routinely receive less instruction in higher-order skills development than other students."** (Allington and McGill-Franzen, 1989; Darling-Hammond, 2001; Oakes, 2005) –Zaretta Hammond, *Culturally Responsive Teaching & the Brain*

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**Resources on unconscious bias.** There are many great resources on understanding and shifting unconscious bias. Here are a few books and organizations we have looked to consistently to work on our own unconscious bias and to better understand how it can affect teaching and learning in the outdoors:

- *White Fragility : Why It's So Hard for White People to Talk About Racism* by Robin DiAngelo
- *Culturally Responsive Teaching & the Brain* by Zaretta Hammond
- Youth Outside [http://www.youthoutside.org/]
- The Avarna Group [https://theavarnagroup.com/]
- Center for Diversity & the Environment [https://www.cdeinspires.org/]

- providing a lesson structure in which the instructor acts as a "guide on the side" and builds a collaborative learning environment in which students make observations, share ideas, and see themselves and one another (not just the instructor) as sources of expertise.

Overall, these factors contribute to creating a student-centered approach in which "the ultimate goal . . . is to help students take over the reins of their learning." (Zaretta Hammond, *Culturally Responsive Teaching & the Brain*, 2014). This approach to teaching supports students in becoming independent learners who are able to succeed, regardless of any individual teacher or learning context. BEETLES has intentionally designed the sequence and structure of this activity to support learning experiences in which all students feel capable of success and have the tools to carry that success into other domains.

Using student-centered and nature-centered learning approaches is just one piece of the work we can do to create equitable, inclusive, and culturally relevant learning experiences. Instructors must also work to become more aware of their own unconscious biases and triggers around culture, identity, and race that impact their interactions with students and affect their students' sense of inclusion.

## Connections to Next Generation Science Standards (NGSS)

BEETLES student activities are designed to incorporate the three-dimensional learning that is called for in the NGSS. Three-dimensional learning weaves together Science and Engineering Practices (what scientists do), Crosscutting Concepts (thinking tools scientists use), and Disciplinary Core Ideas (what scientists know). Students should be exploring and investigating rich phenomena and figuring out how the natural world works. The abilities involved in using Science and Engineering Practices and Crosscutting Concepts—looking at nature and figuring things out, using certain lenses to guide thinking, and understanding ecosystems more deeply—are mindsets and tools students can take with them and apply anywhere to deepen their understanding of nature, and they're interesting and fun to do!

The NGSS are designed to have fewer concepts for students to learn than the standards that preceded them and for students to go into more depth with each of those concepts. That means students need to have multiple learning experiences focused on developing understanding of Disciplinary Core Ideas and many opportunities to engage in Science and Engineering Practices. *Snow Crystal Exploration* should be one of many activities in formal and informal learning environments in which students explore ideas related to weather and climate.

In *Snow Crystal Exploration*, students engage in the Science and Engineering Practice of *Obtaining, Evaluating, and Communicating Information* and have the opportunity to relate what they learn to the Crosscutting Concept of *Patterns*. Students will build understanding of Disciplinary Core Ideas related to *Weather and Climate* (ESS2.D) and *Structure of Matter* (PS1.A).

### *Featured Science and Engineering Practice*

**Engaging students in *Obtaining, Evaluating, and Communicating Information.*** According to the National Research Council's *A Framework for K–12 Science Education*, a major goal of science is to deepen human understanding of the world through making explanations about how things work. Students should develop their understanding of science concepts through obtaining, evaluating, and communicating information about natural phenomena. It's important for scientists and, according to the NGSS, for students to get scientific information from many sources, to try to interpret this information, to communicate their own ideas in written and spoken form, and to discuss their observations and explanations with their peers. Students are exposed to different sources of information during every step of *Snow Crystal Exploration*.

- Students engage with the Science and Engineering Practice of *Obtaining, Evaluating, and Communication Information* in the Invitation stage of the activity when they draw a snowflake from memory and then compare their observations to those of their peers.
- Then, the instructor models using pencil and paper to record observations of snowflake crystals and offers several strategies for note-taking. Students apply these strategies as they work in pairs to observe differences and similarities in snowflakes.
- Later, students use a field guide/key to group snow crystals into categories and learn about those types of snow crystals through text. The instructor models how to use the field guide/key and offers scaffolding.
- Students also engage with the Science and Engineering Practice of *Obtaining, Evaluating, and Communicating Information* throughout several stages of the activity as they discuss and refine ideas with their peers in pairs and in the whole group.
- At the end of the activity, students discuss what they did to learn about snow, which offers an opportunity to reflect on how students learned information through making their own observations, discussing ideas with peers, and engaging with sources such as the field guide/key and the instructor.

### *Featured Crosscutting Concept*

**Learning science through the lens of *Patterns*.** The idea that patterns can be found everywhere and that noticing them can lead to interesting questions about what has caused them is an important lens for scientific investigations. Recognizing patterns can be a step toward using classification systems to make sense of the natural world.

- Throughout *Snow Crystal Exploration*, students focus on observing and thinking about differences and similarities between shapes of snow crystals.
- Initially, students draw a snowflake from memory and compare it to their peers' drawings and then to photographs of snowflakes. Students then

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**About the Next Generation Science Standards (NGSS).** The development of the NGSS followed closely on the movement to adopt nationwide English language arts and mathematics Common Core standards. In the case of the science standards, the National Research Council (NRC) first wrote *A Framework for K–12 Science Education* that beautifully describes an updated and comprehensive vision for proficiency in science across our nation. The *Framework*—validated by science researchers, educators and cognitive scientists—was then the basis for the development of the NGSS. As our understanding of how children learn has grown dramatically since the last science standards were published, the NGSS has pushed the science education community further toward engaging students in the practices used by scientists and engineers and using the "big ideas" of science to actively learn about the natural world. Research shows that teaching science as a process of inquiry and explanation helps students to form a deeper understanding of science concepts and better recognize how science applies to everyday life. In order to emphasize these important aspects of science, the NGSS are organized into three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas (DCI's). The DCI's are divided into four disciplines: Life Science (LS); Physical Science (PS); Earth and Space Science (ESS); and Engineering, Technology, and Applied Science (ETS).

**Read more about the Next Generation Science Standards at http://www.nextgenscience.org/ and http://ngss.nsta.org/**

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look for differences and similarities in real snowflake crystals. Looking for similarities and differences is one way to begin to notice patterns.

- Students apply the idea of patterns as they discuss their observations. They begin using common characteristics to group snow crystals into categories. Students then think about the patterns in weather conditions that lead to the formation of specific types of snow crystals.
- Finally, students apply the idea of patterns further as they use a field guide/key to identify snowflake types. At this stage of the activity, the instructor explicitly refers to the concept of patterns as a thinking tool, inviting students to look for patterns in the locations where they find different types of snowflakes.

### *Featured Disciplinary Core Ideas*

**Building a foundation for understanding Disciplinary Core Ideas.** The NGSS make it clear that students need multiple learning experiences to build their understanding of Disciplinary Core Ideas. *Snow Crystal Exploration* gives students an opportunity to develop understanding of some life science core ideas related to *Weather and Climate* (ESS2.D) and *Structure of Matter* (PS1.A).

- Throughout the activity, students focus on observing differences and similarities in the shape and structure of snow crystals. By engaging with the field guide/key and discussing snow formation with their peers and the instructor, students have multiple opportunities to consider the complex interactions that determine their local weather pattern and that generate snow. (ESS2.D)
- As students discuss how heating and refreezing might connect to some of the properties they observe in snow crystals, they see an example of the concept that heating and cooling substances causes changes that are not reversible. (PS1.A)
- The optional section, Looking at a Snow Phase Diagram, offers opportunities for students to go deeper and consider how the physical properties of snow crystals are reflected in the atomic structure and are affected by variation in temperature and moisture. (PS1.A)

You can informally assess students' understanding of these concepts during different stages of the activity in individual interactions with students and by listening carefully during the group discussions. This information can help you decide which ideas to focus on in future lessons so follow-up activities or discussions can be used to further student understanding.

### *Performance Expectations to Work Toward*

**No single activity can adequately prepare students for an NGSS Performance Expectation.** Performance Expectations are designed as examples of things that students should be able to do to demonstrate their understanding of content and big ideas in science after engaging in multiple learning experiences and instruction over a long period of time. They are *not* the curriculum to be taught to students. Following are a few Performance Expectations this activity can help students work toward:

**Translating the codes for the NGSS Performance Expectations.** Each standard in the NGSS is organized as a collection of Performance Expectations (PE's) for a particular science topic. Each PE has a specific code, which is provided here so they can be easily referenced in the NGSS documents. The first number or initial refers to the grade level: K = kindergarten, 1 = first grade, 2 = second grade, MS = middle school, and HS = high school. The next letters in the code refer to the science discipline for the standard: LS, PS, ESS, ETS. The number following the discipline denotes the specific core idea within the discipline that is addressed by the PE, and the last digit identifies the number of the PE itself. So, 3-LS4-4 means the Performance Expectation is part of a third-grade standard (3) for life science (LS), addressing the fourth core idea (4), Biological Evolution: Unity and Diversity, within the life science standards, which deals with Biodiversity and Humans. It's also the fourth Performance Expectation (4) that makes up the complete LS4 standard at this grade level.

- **3-ESS2-1.** Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
- **MS-ESS2-5.** Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

## Activity Connections

*I Notice, I Wonder, It Reminds Me Of* taught before this activity helps prepare students to be curious investigators. *Hand Lens Introduction* taught before this activity helps students become comfortable with this important tool. *Thought Swap* can be used before, during, and/or after the activity to discuss questions in rotating pairs.

## Resources for Further Learning

- Snow Grains Photo Library (http://www.snowcrystals.it/index.php?Lg=en)
- Sturm, Matthew. *APUN: The Arctic Snow.* (2009) University of Alaska Press Fairbanks, Alaska.
    - This children's book includes a chapter on snow crystals that explains how they form and how "depth hoar" (the type of snow that indicates an avalanche may take place) forms.

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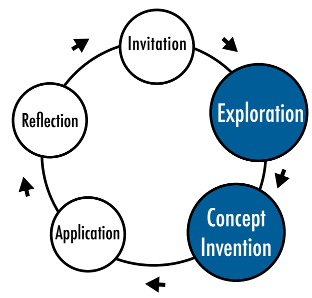
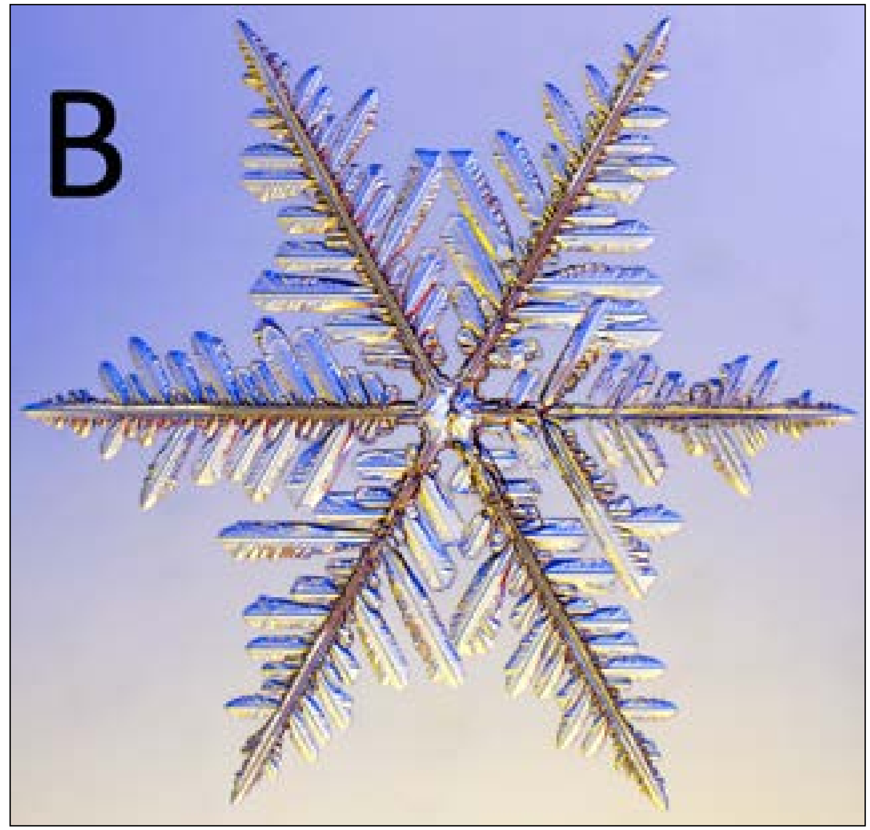



**Learning cycle.** In a series of activities focused on concepts of weather and climate, this activity could function as an Exploration or a Concept Invention.

# Comparing Snowflake Crystals


Credits: Photos were adapted with permission from SnowCrystals.com, a wonderful site featuring the photographs and work of Kenneth G. Libbrecht.

# Example Snowflake Photos

# #1

Credit: Photo was adapted with permission from SnowCrystals.com, a wonderful site featuring the photographs and work of Kenneth G. Libbrecht.

# #2

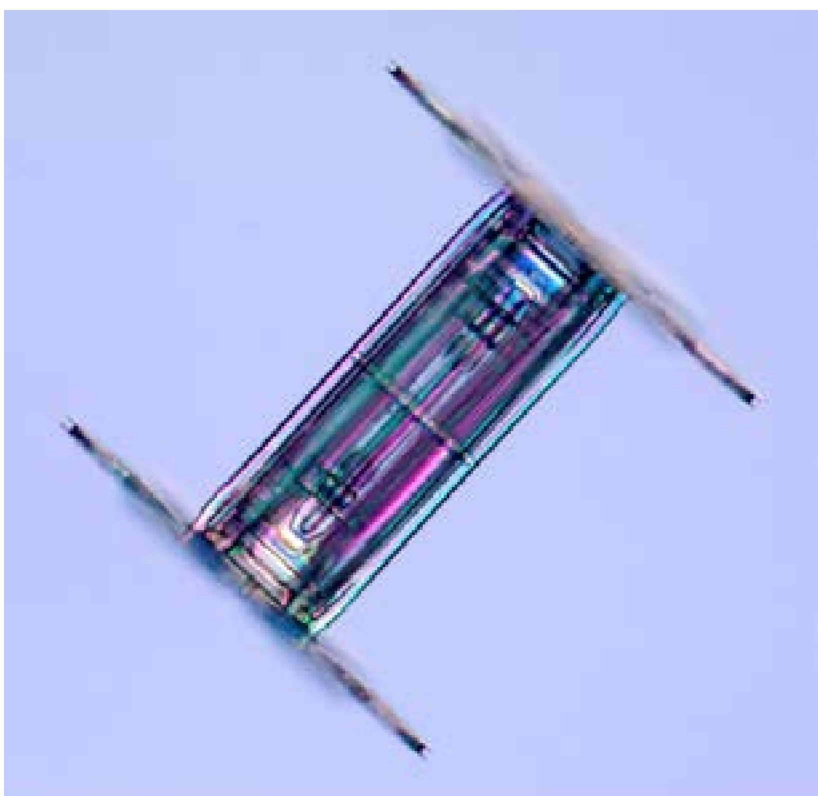
Credit: Photo was adapted with permission from SnowCrystals.com, a wonderful site featuring the photographs and work of Kenneth G. Libbrecht.

# Example Snowflake Photos (continued)

# #3

Credit: Photo was adapted with permission from SnowCrystals.com, a wonderful site featuring the photographs and work of Kenneth G. Libbrecht.

# #4



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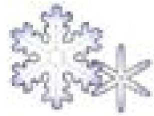
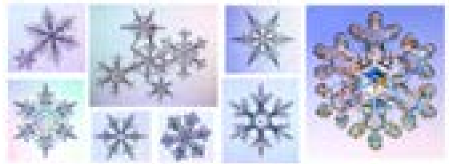
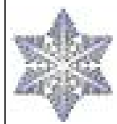
# SNOWFLAKE CRYSTAL FIELD GUIDE

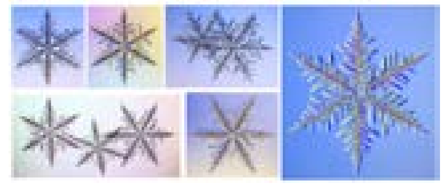


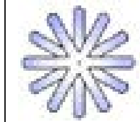
**Star-Shaped**
Large, common, and easy to see. The best usually appear when the weather is quite cold, about –15°C (5°F).



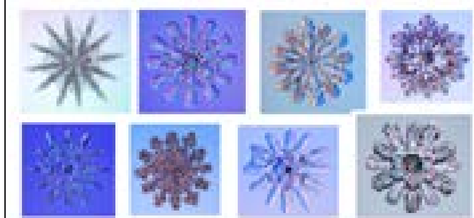


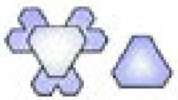
**Fern-Shaped**
Like star-shaped, but larger and leafier with many side branches that look like branches of a fern. Are the largest snow crystals; specimens up to 5 mm in diameter can be found.



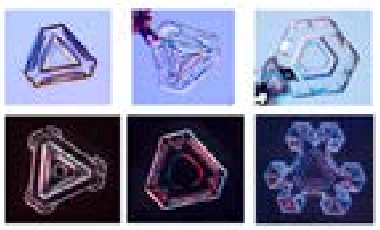


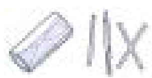
**Twelve Branches**
Form when two six-branched snow crystals crash in midair and stick together.



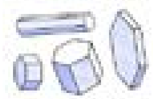


**Triangular**
These are unusual and tend to be small.

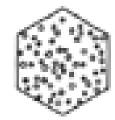




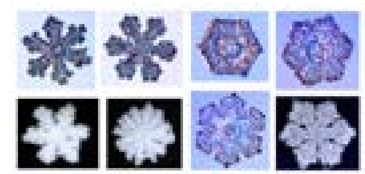
**Columns and Needles**
Form when temperature is around –6°C (21°F). Common, small, easy to miss because they look like small bits of white hair on your sleeve.



**Diamond Dust**
Tiny snow crystals. Look like sparkling dust in sunlight. The smallest snow crystals—many no larger than the diameter of a strand of human hair. Most often seen in bitter cold weather.



**Snowflakes with Frozen Water Drops (Rime)**
Form when water droplets freeze onto a snow crystal. There may be a few frozen droplets, or sometimes they are completely covered with them.



**Round Like a Ball**

**Graupel** = snow pellets. White and grainy. Form when so many water droplets freeze on snowflakes that they become blobs. May be sign of avalanche danger.

**Sleet** = ice pellets. A mixture of rain and snow. Clear enough for light to pass through.

**Hail** = irregular lumps of ice. Form in thunderclouds. Winds make them go up and down. Grow as more water freezes to them until they become so heavy that they fall out of the cloud.

**Another**

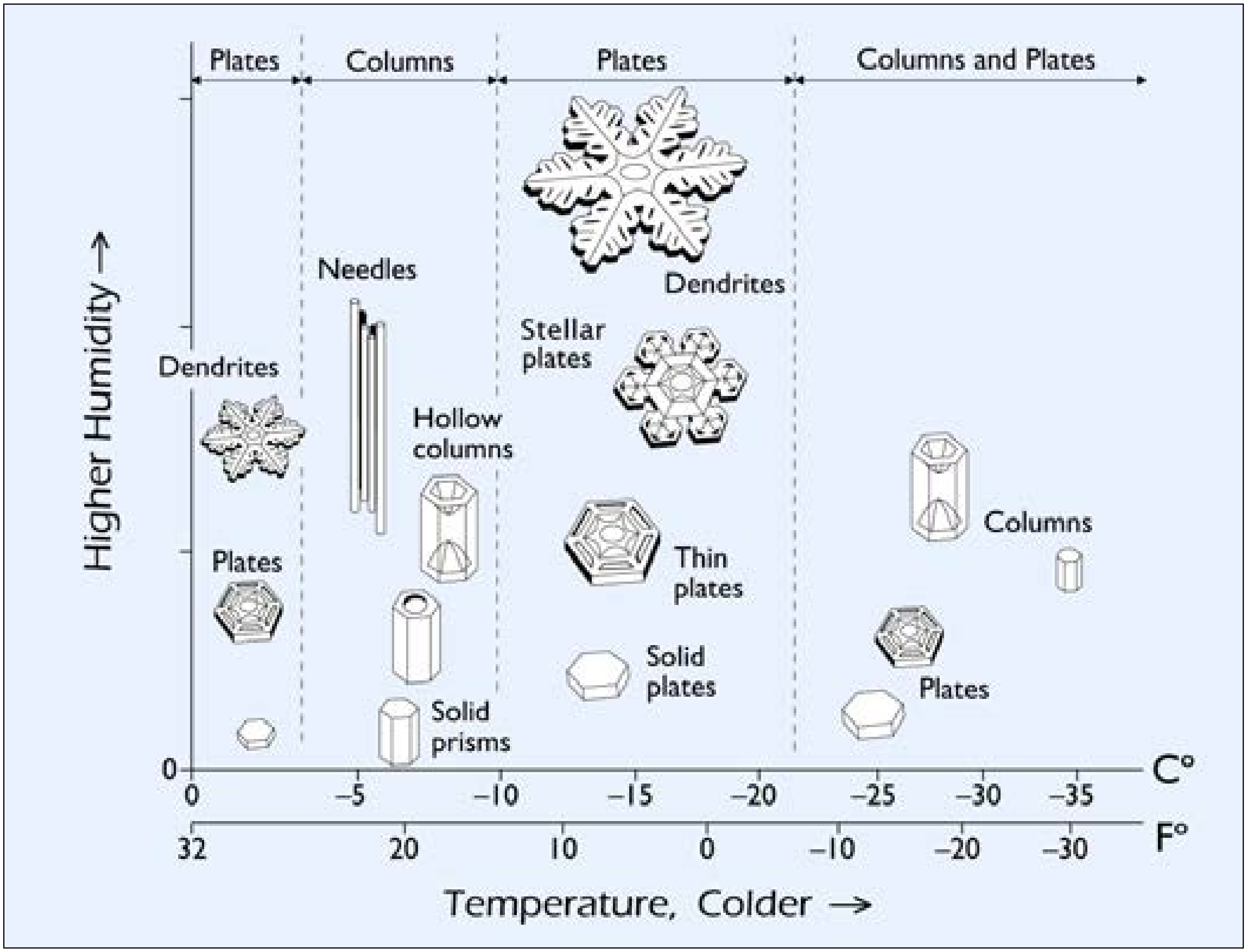
**Mixed or Irregular**
Many snowflakes are irregular shaped or more than one type combined.

**Machine-Made**
Machine-made snowflakes form so fast that they don't grow like natural snowflakes.

**Ice**
There are many types of ice that form on surfaces and are not snowflakes.

The Snowflake Crystal Field Guide was adapted with permission from SnowCrystals.com, a wonderful site featuring the photographs and work of Kenneth G. Libbrecht. All photos credited to SnowCrystals.com, except those listed below. Additional credits: Star-Shaped, Twelve Branches, Triangular, Fern-Shaped, Diamond Dust: SNOWFLAKES.COM; Graupal: (cc)GraupleLASSENNPS; Mixed or Irregular: (cc)IrregularBENJAMIN BALAZS; Sleet: (cc)Sleet MIKE EPP; Machine-Made: NASA; Ice: Kevin Beals

# Snow Phase Diagram




Credit: Adapted with permission from SnowCrystals.com, a wonderful site featuring the photographs and work of Kenneth G. Libbrecht.

# Questions for Interpreting the Snow Phase Diagram

- Look at the diagram and use it to try to understand more about snowflakes.
- In what conditions do flat snowflakes form? In what conditions do column-shaped snowflakes?
- What kinds of snowflakes form in the coldest conditions?
- Come up with your own questions about snowflake formation based on the diagram. Then, try to make some explanations about why certain kinds of crystal structures happen in certain conditions.
- Why are the biggest snowflakes at the middle-top of the diagram? What conditions make it possible for big and complicated snowflakes to grow?
- What about the upper-right corner on the diagram where there are no snowflakes forming? What might be going on there?

# FIELD CARD

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## Snow Crystal Exploration

### Thinking About Snowflakes

1. While moving to the activity site, invite students to *Thought Swap* (formerly known as *Walk & Talk*) with a partner about their ideas about and experiences with snow.
   - *What have you heard, learned, or noticed about snow? This could be from your own experience, things you've noticed from pictures or movies, or something you learned from a peer or adult.*
   - *Why might scientists study snow and weather data?*
   - *As we move as a group, observe the landscape and snow around us. What do you notice about the snow? What do you see, smell, or hear?*

### Observing Snowflakes

1. Share that students will have the opportunity to explore and study snowflakes up close and to make observations to learn more about snowflakes.
2. Show the Comparing Snowflake Crystals photographs and ask students to share the similarities and differences between Snowflakes A and B. Add observations that students don't share.
3. Share: "We can use hand lenses to look at the details of snowflakes up close."
4. Model I how to use a hand lens, distribute one hand lens to each student, and invite students to practice using them by looking at their fingertips (or gloves, mittens, or clothing).
5. Share and model how to use the black laminated card or the felt cardboard card to scoop snow while keeping it from melting.
6. Distribute a black laminated card or a felt cardboard card to each student and invite students to try it out from where they are sitting or standing.
7. Ask students to say some observations out loud so others can hear. Coach students as needed to help them be engaged and successful.
8. Share that students will have about 10 minutes to work with a partner to observe different kinds of snowflakes, looking for differences and similarities between the snowflakes.
   - *Move around and observe different kinds of snowflakes.*
   - *Try to observe several snowflakes from different places—for example: exposed area vs. under vegetation, on a slope vs. flat, surface of the snow vs. deeper in the snow, in shade vs. sun, etc.*
   - *Make as many observations as you can and look for similarities and differences between the snowflakes you find.*
   - *These might be similarities and differences in their shapes—for example: one is long and skinny, while another is flat with lots of branches—or similarities and differences in size.*
   - *Use your hand lens to look at the snowflakes up close.*
   - *Share and discuss your observations with your partner.*
9. Share that students will likely find snowflakes that look different from the photographs you showed earlier, including snowflake crystals that might be broken into pieces, and encourage students to observe whatever they find.
10. Model recording observations of a snowflake on a whiteboard and offer the following drawing and journaling tips as you do.
    - *After a little while, I will bring you an index card and pencil so you can use these tools to record observations of your snowflakes.*
    - *Please use words, pictures, and numbers together to describe snowflakes.*
    - *Draw snowflakes larger than their actual size so it's easier to see their features.*
    - *If the snowflake is symmetrical (the same on both sides), you only need to draw one side of the snowflake. Then, you can write "same on the other side."*
    - *Use words to label things that are harder to draw. For example, you could write "snowflake is fuzzy all over" instead of taking the time to draw fuzz all over your snowflake.*
    - *Use numbers to count and label parts of the snowflake, such as the sides of the snowflake. Draw a line or a dot to show the actual size of the snowflake and write "actual size" next to that.*



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- *Use words to record where you found the snowflake and add information to describe the area where you found the snowflake, such as whether you were in the shade or sun, if it's an area exposed in the wind, etc.*
- *Include information from a few different samples of snowflakes.*

11. Share safety expectations or considerations and boundaries.
12. Pair students and then invite them to begin observing snowflakes.
13. After students have observed a few snowflakes, distribute pencils and index cards and invite students to begin drawing snowflakes from their observations.
14. As students observe snowflakes, circulate and ask them questions about their observations and support participation and engagement.

**Discussing Snowflakes**

1. After about 10 minutes, gather students back to discuss their observations.
2. Ask students to turn to someone next to them that they weren't exploring with and discuss what they noticed about the snowflakes they observed and drew (e.g., shapes, differences and similarities, different kinds of snowflakes).
3. Invite students to turn back to the same partner; focus on one snowflake that they thought was especially cool, mysterious, or interesting; and describe it.
4. Get the attention of the whole group, invite a few students to share their observations, and then lead a short discussion about the group's observations and ideas by using the questions below.
   - *What did you notice?*
   - *What were some of the similarities and differences you noticed between the snowflakes?*
   - *How would you describe some of the most interesting snowflakes?*

**Identifying Crystals**

1. Share: Each snowflake is unique, but we can group them into types or categories based on what they have in common.



2. Share: Some scientists study snow, and they have used observations, like you just made, to describe different groups of snowflakes.
3. Distribute one copy of the Snowflake Crystal Field Guide to each pair of students and share that it is a tool for learning about some of the ways scientists have grouped snowflakes.
4. Offer guidance and scaffolding for students as they use the Snowflake Crystal Field Guide to identify snowflakes.
5. Hold up Example Snowflake Photo #1 (Star-Shaped).
   - *Let's say you found a snowflake with a shape like this. Take a look at your Snowflake Crystal Field Guide and see which kind of snowflake you think it matches most closely. Use the photos, drawings, and words on the field guide to help you make a match.* (Pause for students to look at their field guides.)
   - *This is a star-shaped kind of snowflake. We can use this Snowflake Crystal Field Guide to find out some information about this kind of crystal.*
   - *About what temperature does the field guide say that a star-shaped snowflake forms high up in the sky?*
   - *For comparison, what was today's coldest temperature down here on the ground?*
6. Repeat the questions for Example Snowflake Photos #2 (Fern-Shaped), #3 (Twelve Branches), and #4 (Column), as needed.
7. Invite students to try to use the Snowflake Crystal Field Guide to identify the snowflakes they drew and then label the snowflakes on their index cards. If students didn't draw snowflakes, skip this step.
8. Share that students will have around 10 minutes to move around and try to identify snowflake crystals, using the field guide/key and observing snowflake shapes, features, and sizes. Repeat that the snowflakes students find might look a little different than the images in the field guide/key.
9. Share that students will also have the opportunity to look for patterns of snowflake crystals.
   - *You'll also look for patterns of where you find types of snowflake crystals and how many you find.*

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- *Scientists often look for patterns to learn about what's going on in nature.*
- *As you explore and try to identify snowflakes, pay attention to the types of snowflakes you are finding and look for patterns in where you find them.*
- *Is there more of one snowflake type in one place than in other places? Are there certain types of snowflakes you aren't finding at all?*
- *Do you think there are any trends you might see in patterns of where you find specific types of snowflakes?*

10. Ask students to share examples of locations where they might find different kinds of snowflakes and record them on your whiteboard.
11. Ask students to keep a tally on their index cards of the types of snowflakes they find and information about where they found each type.
12. Send students out to identify snowflakes and as they work, circulate and engage them in conversation about their findings.
13. After about 10 minutes, ask pairs to summarize how many snowflakes of each type they found as they rejoin the group.
14. With the whole group back together, facilitate sharing of students' data about snowflakes in a way that makes sense for your group.

**Discussing Snowflake Patterns**

1. Lead a short discussion to hear some students' initial ideas about snowflake formation.
   - *What do you know about how snowflakes form?*
   - *What kinds of things need to be present for a snowflake to form?*
   - *What might cause snow crystals to have different shapes?*
2. Share the following points, connecting them with what students brought up during the discussion:
   - For snow crystals to form, you need temperatures below freezing (review: 0 degrees Celsius/32 degrees Fahrenheit), moisture in the air, and something such as dust for crystals to form on.
   - Snowflake crystals form as different shapes depending on how cold it is and how much moisture there is in the air.
   - Snowflakes form high in the sky above an area and then fall toward the ground. As they fall, they can keep forming and growing.
   - Colder air can hold less moisture than warmer air. *Have y ou ever noticed cold air feeling dry or warm air feeling humid?*
   - When there is more moisture in the air, snowflakes can be more complex and bigger.
   - When the temperature is very, very cold, snowflakes tend to be tiny.
   - On the whiteboard, write:
     - more complex and bigger = more moisture
     - tiny = very cold
     - Colder air can hold less moisture than warmer air.
3. Lead another short large-group discussion using some of the questions below, listening to students' ideas, following student interest, and asking follow-up questions as appropriate.
   - *What patterns can you find in the types of snowflakes you found? Are they complex or simple? All snowflakes are small, but some are super tiny. Were the snowflakes you found small or super tiny?*
   - *Were there patterns of where you found different kinds of snowflakes?*
   - *How might you explain those patterns?*
   - *Judging from the snowflakes you found, what might you be able to explain about what the conditions were like as they formed up in the air?*
   - *What kinds of factors might change the snowflakes over time after they have landed? [Melting, refreezing, animals stepping on it, vehicles, etc.]*
   - *What can you explain about how the snowflakes might have changed over time after they were on the ground?*

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- *How do you think the kinds of snow crystals that fall from the sky in this area change throughout the winter season? If there was a wetter, warmer storm, what kinds of snow crystals might you expect to find? What about a drier, colder storm?*

**Note:** The Optional: Looking at a Snow Phase Diagram activity is most appropriate for 6th-grade students or older. If you choose to do this optional phase of the activity, do so now and then return to the "Wrapping Up and Reflecting" section.

**Wrapping Up and Reflecting**

1. Invite students to *Turn & Share* or *Thought Swap* about some of the following questions:
   - *How have your ideas about snowflakes changed throughout the activity?*
   - *Thinking about just the daily temperatures and weather conditions in this area, how do you think the snowflakes we observed here might change over time?*
   - *If we were to dig down into layers of snow to see snow that has fallen over time, what kinds of differences do you think we might find?*
   - *What did you do that helped you learn about snowflakes today?*
   - *What are you still curious about? What are some things you could do to learn about snowflakes and answer your questions?*
   - *What are some skills you think you got better at?*
2. If students have field journals, give students a chance now or later when indoors, to tape their index cards into their journals and to write notes about their observations and ideas about snowflakes.

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**Optional: Looking at a Snow Phase Diagram**

1. Distribute one copy of the Snow Phase Diagram/Questions for Interpreteing the Snow Phase Diagram to each pair of students and share that the x-axis shows temperature (getting colder toward the right), while the y-axis shows moisture (more moisture as you go up).
2. Ask students to look at the Snow Phase Diagram, ask questions about it, and make explanations (with their partners) about why certain snowflake crystal structures might form in certain conditions. Let students' know that they will discuss the Questions for Interpreting the Snow Phase Diagram in a few minutes.
3. After a few minutes, invite pairs to use the Questions for Interpreting the Snow Phase Diagram to help them interpret information in the diagram.
4. Get the group's attention and invite students to share a few of their thoughts about the diagram. Lead a short group discussion about students' ideas.
5. Ask students to look at the Snow Phase Diagram and try to make some general statements about what the conditions were like when the snowflakes they found today formed.
6. Ask: "Based on the diagram and what you know about weather/seasons, how do you think snowflake shapes might vary throughout the winter season, throughout a day, or across different geographical areas?"
7. Share the following points, connecting them with what students discussed, when appropriate:
   - There is a lot that still isn't known about snow and crystal formation, and it can be fun to keep looking at snowflakes and keep learning!
   - Snowflakes don't form here on the ground. They form high in the sky, above an area, and then fall toward the ground. As they fall, they can keep forming and growing.
   - For snow crystals to form, you need temperatures below freezing (review: 0 degrees Celsius/32 degrees Fahrenheit), moisture in the air, and particles such as dust for crystals to form on.
   - Colder air can hold less moisture than warmer air. *Have you ever noticed cold air feeling dry or warm air feeling humid?*
   - When there is more moisture in the air, snowflakes can be more complex and bigger.
   - When the temperature is very, very cold, snowflakes tend to be tiny.
   - What patterns can we find in the types of snowflakes we found? Complex or simple? Tiny?
   - On the whiteboard, write:
     - more complex and bigger = more moisture
     - tiny = very cold
     - Colder air can hold less moisture than warmer air.
8. Ask the following questions, listen to student ideas, and ask follow-up questions as appropriate:
   - ▶ *When there is more moisture in the air, snowflakes tend to form more complex and bigger shapes. Why might that be the case? Use evidence to support your thinking.*
   - ▶ *When it is very cold, it tends to lead to smaller, more compact snowflakes. Why might that be the case?*
   - ▶ *Judging from the snowflakes we found, what might we be able to explain about what the conditions were like as the snowflakes formed up in the air?*
   - ▶ *What kinds of factors might change the snowflakes over time, after they have landed? [Melting, refreezing, animals stepping on it, vehicles, etc.]*

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