EDUCATORS' GUIDE

GRADES K-8

A WORD FROM THE FILMMAKERS

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Born in Haute-Savoie in the French Alps, Cyril spent much of his childhood in the snow. He works as both a director and a director of photography and has shot and directed many documentary films. Cyril is a technical ace, and designed and built bespoke 3D filming equipment for both *Hurricane* and *The Search for Snow*. He also built the first radio-controlled airship filming platform, "Soulcam".

FILM SYNOPSIS: THE SEARCH FOR SNOW

A passion for skiers, a child's dearest wish, a village's deepest desire — snow is cause for joy. And while snow represents the magic of Christmas, it is also a necessity for world water resources and for others, a sole source of revenue.

In an ever-changing world climate, a meteorologist follows the patterns of weather systems creating snow and helps us understand different types of snow, where it falls, and why — as well as its crucial impact on vegetation, wildlife, and people.

From the producers of ***Hurricane 3D***, immerse yourself in the magic of snow!

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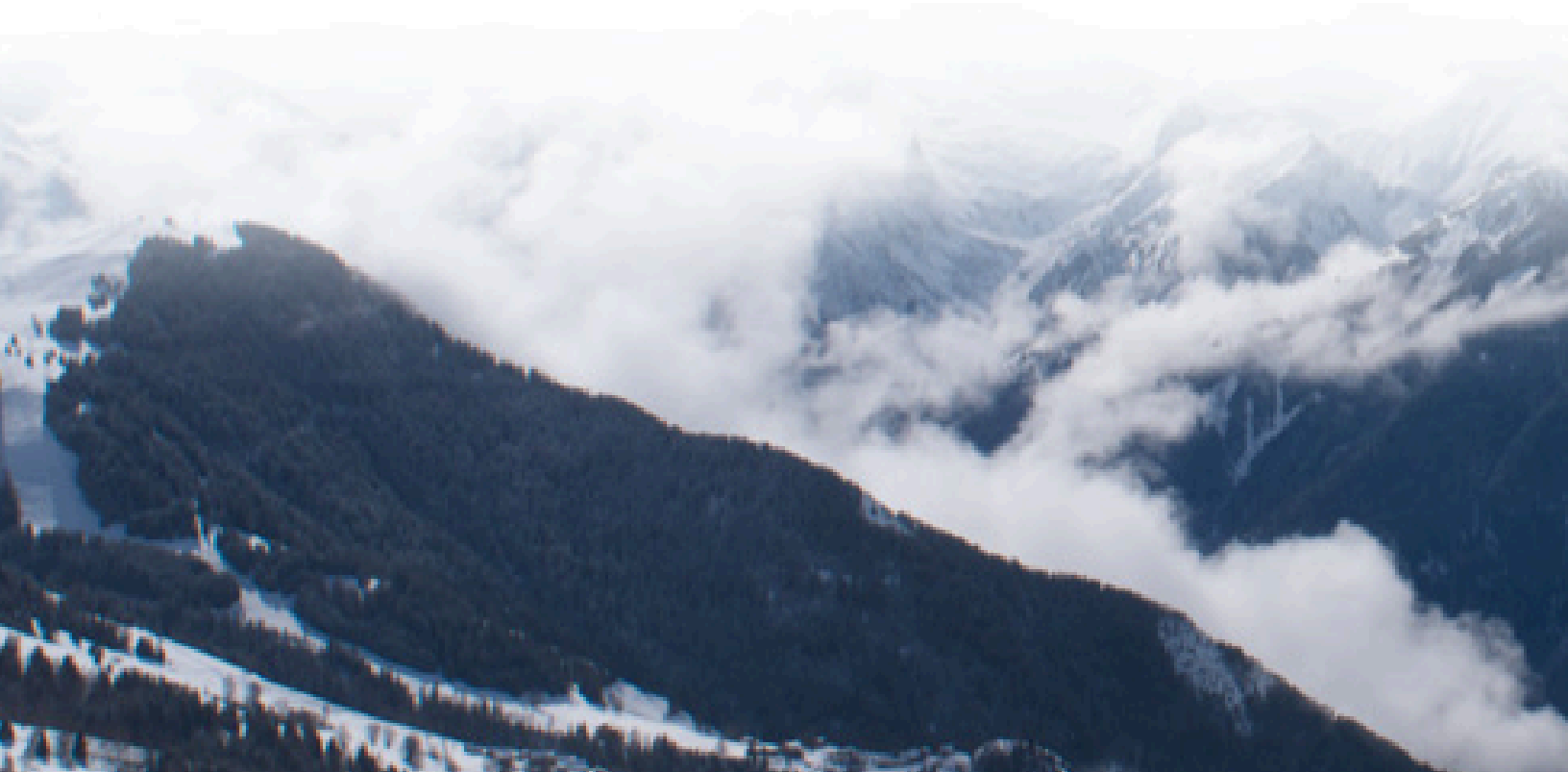


EDUCATORS' INTRODUCTION

This Educators' Resource Guide is designed for use with students who view the new nWave Pictures Distribution release, ***The Search for Snow***. The guide includes STEAM-based classroom activities for students in grades K-2, 3-5, and 6-8 designed to engage students before and after viewing either the full (40 min.) or abbreviated (20 min.) version of the film.

The last page of this guide includes website and online article resources that will help provide background and offer opportunities for further studies into climate science. It is by no means exhaustive but will provide a solid start for students to conduct research or learn more.

EDUCATIONAL OBJECTIVES

- To introduce students to the film ***The Search for Snow***.
- To tap into viewers' sense of wonder about snow and highlight the remarkable role it plays in our world.
- To educate students about the importance of snow to our water systems, life cycles, and economies.
- To demonstrate how regions across the globe are connected through water and precipitation.
- To inspire students to think critically about problems facing society and to find sustainable ways to support the environment.

PRE-VIEWING TOPICS

Create a KWL graphic organizer on the chalkboard/ whiteboard, with columns labeled "What I KNOW Already," "What I WANT to Find Out," and "What I LEARNED." Fill in the first column by asking students what they already know about snow.

- Does it snow a lot where they live?
- When do they expect snow to fall? Where?
- What do snowflakes look like? Feel like?
- How do they think animals and plants manage to survive in snowy winters?
- How do people where they live relate to snow? Do they consider the effects of snow a benefit or a drawback?

Then fill in the second column of the organizer by asking students what they want to find out about snow and snowstorms. Prompt discussion with such questions as:

- What is snow? How does it form?
- What causes snow on some days and rain on others?
- Where do storms come from?
- Why do we typically see snow on the tops of mountains, even in warm regions?
- How is snow related to glaciers?
- Why is snow important? Would it matter if there was no more snow?

Conclude by having students copy the organizer so they can fill in the final column after they have seen the film.

POST-VIEWING TOPICS

Return to the KWL graphic organizer on the chalkboard/ whiteboard to fill in the "What I LEARNED" column. Have students contribute facts and insights from their own notes on the film.

- Use the film to clarify students' understanding of the relationship between snow and climate change.
- What was the most surprising part of the film?
- What lessons can they apply to their own daily lives?
- What part of the film made them want to learn even more?
- Did they answer their six questions?
- What more do they want to know?

NEXT GENERATION SCIENCE STANDARDS*

Grades K-2		Activity			
		1	2		
K-LS1-1 From Molecules to Organisms: Structures and Processes	Use observations to describe patterns of what plants and animals (including humans) need to survive.		X		
K-ESS2-1 Earth's Systems	Use and share observations of local weather conditions to describe patterns over time.	X			
K-ESS3-1 Earth & Human Activity	Use a model to represent the relationship between the needs of different plants and animals and the places they live.		X		
2-PS1-1 Matter & Its Interactions	Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.	X			
2-LS4-1 Biological Evolution: Unity & Diversity	Make observations of plants and animals to compare the diversity of life in different habitats.		X		

Grades 3-5		Activity			
		1	2	3	
3-LS3-2 Heredity: Inheritance & Variation of Traits	Use evidence to support the explanation that traits can be influenced by the environment.		X		
3-LS4-3 Biological Evolution: Unity & Diversity	Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.		X		
3-ESS2-1 Earth's Systems	Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.			X	
3-ESS2-2 Earth's Systems	Obtain and combine information to describe climates in different regions of the world.	X		X	
4-ESS2-2 Earth's Systems	Analyze and interpret data from maps to describe patterns of Earth's features.			X	
5-ESS3-1 Earth & Human Activity	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.	X			

Grades 6-8		Activity			
		1	2	3	4
MS-ESS3-3 Earth & Human Activity	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.				X
MS-ESS3-5 Earth & Human Activity	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.				X
MS-LS2-4 Ecosystems: Interactions, Energy & Dynamics	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.	X			
MS-LS2-5 Ecosystems: Interactions, Energy & Dynamics	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.				X
MS-ESS2-4 Earth's Systems	Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	X	X		
MS-ESS2-5 Weather & Climate	Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.		X	X	
MS-ESS2-6 Weather & Climate	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.		X		

COMMON CORE STATE STANDARDS – MATH**

Grades K-2		Activity			
		1	2		
Grade K, Geometry CCSS.MATH. CONTENT.K.G.B.4	Analyze and compare two- and three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and vertices/"corners") and other attributes (e.g., having sides of equal length).	X			
Grade 1, Geometry CCSS.MATH. CONTENT.1.G.A.1	Distinguish between defining attributes (e.g., triangles are closed and three-sided) versus non-defining attributes (e.g., color, orientation, overall size); build and draw shapes to possess defining attributes.	X			
Grade 2, Geometry CCSS.MATH. CONTENT.2.G.A.1	Recognize and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces. Identify triangles, quadrilaterals, pentagons, hexagons, and cubes.	X			

Grades 6-8		Activity			
		1	2	3	4
Grade 6, Statistics & Probability CCSS.MATH. CONTENT.6.SP.B.5.C	Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.			X	

COMMON CORE STATE STANDARDS – ENGLISH LANGUAGE ARTS**

Grades K-2		Activity			
		1	2		
Grade K, Reading: Informational Text CCSS.ELA-LITERACY.RI.K.3	With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text.	X	X		
Grade K, Reading: Informational Text CCSS.ELA-LITERACY.RI.K.7	With prompting and support, describe the relationship between illustrations and the text in which they appear (e.g., what person, place, thing, or idea in the text an illustration depicts).		X		
Grade 1, Reading: Informational Text CCSS.ELA-LITERACY.RI.1.1	Ask and answer questions about key details in a text.	X	X		
Grade 1, Reading: Informational Text CCSS.ELA-LITERACY.RI.1.4	Ask and answer questions to help determine or clarify the meaning of words and phrases in a text.	X	X		
Grade 2, Reading: Foundational Skills CCSS.ELA-LITERACY.RF.2.4	Read with sufficient accuracy and fluency to support comprehension.	X	X		
Grade 2, Reading: Informational Text CCSS.ELA-LITERACY.RI.2.5	Know and use various text features (e.g., captions, bold print, subheadings, glossaries, indexes, electronic menus, icons) to locate key facts or information in a text efficiently.		X		

Grades 3-5		Activity			
		1	2	3	
Grade 3, Reading: Informational Text CCSS.ELA-LITERACY.RI.3.5	Use text features and search tools (e.g., key words, sidebars, hyperlinks) to locate information relevant to a given topic efficiently.		X		
Grade 3, Reading: Foundational Skills CCSS.ELA-LITERACY. RF.3.4.C	Use context to confirm or self-correct word recognition and understanding, rereading as necessary.		X		
Grade 4, Reading: Informational Text CCSS.ELA-LITERACY.RI.4.7	Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.	X		X	
Grade 5, Reading: Foundational Skills CCSS.ELA-LITERACY.RF.5.4	Read with sufficient accuracy and fluency to support comprehension.		X		
Grade 5, Reading: Informational Text CCSS.ELA-LITERACY.RI.5.3	Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.		X		

Grades 6-8		Activity			
		1	2	3	4
Grade 6-8, History/ Social Studies, Science & Technical Subjects CCSS.ELA-LITERACY. WHST.6-8.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.				X
Grade 6-8, Science & Technical Subjects CCSS.ELA-LITERACY. RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	X	X	X	
Grade 6, Writing CCSS.ELA-LITERACY.W.6.1	Write arguments to support claims with clear reasons and relevant evidence.				X
Grade 7 Reading: Informational Text CCSS.ELA-LITERACY.RI.7.4	Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of a specific word choice on meaning and tone.		X		
Grade 7, Writing CCSS.ELA-LITERACY.W.7.1	Write arguments to support claims with clear reasons and relevant evidence.				X
Grade 8, Writing CCSS.ELA-LITERACY.W.8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.				X
Grade 8, Writing CCSS.ELA-LITERACY.W.8.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.				X

* NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

TEACHING NOTES FOR GRADES K-2

ACTIVITY 1

THE SHAPE OF SNOW

Part 1: Begin by asking your class to imagine they are in a snowy field. Have them describe the experience from the perspective of all five senses. Then have them write three words that describe the experience in the spaces provided. (For kindergarten classes, write their words on the board and have students copy them onto the activity sheet.) Next, have students complete the snow facts sentences individually or in small groups. (For kindergarteners, complete the sentences as a class by reading them and the word choices aloud.) ***Answers:*** 1. atmosphere, 2. vapor, 3. crystal, 4. hexagons, 5. changing.

Part 2: Build observational skills by completing this part of the activity as a class. Have students point out similarities and differences between the three snowflakes. Then have them work individually to answer the questions. Conclude by having students create their own snowflakes on the back of the worksheet. ***Answers:*** Students should note that all snowflakes have six sides; for differences, they should note that some snowflakes have branches while others are much simpler in form. Some snowflakes may also collide and combine to form clusters of snowflakes.

FOLLOW-UP

- After you review the snow facts in Part 1, have students write the definition of each term.
- For older grades, review the basics of solids, liquids, and gases. Demonstrate how a substance like water changes from one form to another, for example, by melting an ice cube, boiling water, or showing how clouds can form when you leave a freezer open. Then, explain that snowflakes crystallize because they change directly from water vapor — a gas — to a solid, without ever becoming a liquid. When water vapor becomes a raindrop first and then the raindrop freezes, it is called sleet.
- For any precipitation to form as rain or snow, condensation nuclei first must be present from sources that include dust and fine particles from volcanoes, wind erosion, forest fires, the burning of fossil fuels, and pollution from manufacturing.
- The different snowflake shapes are caused by the temperature and humidity in the air as they fall. For example, at -2°C, they are usually shaped like plates, and at -40°C, like needles (see diagram on page 4 of the Activities Guide, Grades 3-5, Activity 1, Spotlight on Snow). The lacy patterns form when the flakes have more water vapor. Have students draw their own snowflakes to represent the different shapes at the varying temperatures.

ACTIVITY 2

LIFE IN SNOW

Begin this lesson by talking about the wildlife that lives near your community. What kinds of plants and animals do your students see outside? Does it change depending on the season?

Part 1: Read the introduction aloud with students and review the definitions of migrate, hibernate, and adaptive features. Then have students complete the activity individually or in small groups. (Take kindergarteners through the activity by reading the chart aloud.) ***Answers:*** A. 4, B. 5, C. 1, D. 2, E. 3.

Part 2: Talk with students about how plants react to winter (leaves fall, flower stalks shrivel, etc.). Then have students read about four plants that adapt to winter and match each one to its adaptive feature. (Again, take kindergarteners through the activity by reading the descriptions aloud.) ***Answers:*** 1. B, 2. A, 3. D, 4. C.

FOLLOW-UP

- People adapt to changing weather conditions, too. Have students talk about how their families adjust to snow or prepare for winter. Ask: What kinds of clothes do you wear? Do you eat different types of food? How do your behaviors change? Then, ask them to consider historic and modern cultures that live in very snowy regions, such as Inuit communities in the Arctic and villages high in the Alps. You can provide or ask them to search for photos of the clothing and equipment used in such settings.
- Snow can be dangerous, but it also provides water that plants and animals need to live. For example, when snow melts from the tops of mountains, it seeps into the ground below and melts into waterways. As a class, make a list of all the ways wildlife and people use water.
- Explain to students that as the climate changes, so do the habitats for plants and animals. Ask them to consider the effect this might have on animals who are adapted for historically snowy climates. For example, snow hares, Arctic foxes, and ptarmigans turn white when days become shorter. Will they still benefit from this "camouflage" if there is no snow? Do students think animals can continue to adapt? For the Alpine ibex, which moves further up the mountain as the weather warms, will there be enough food? How will the migratory patterns of birds need to change?
- Insects are also important in this discussion. Winter usually helps to control their population, but warmer winters result in less "kill-off", creating more problems for plants and people. (Example: The Mountain Pine Beetle attacks various types of pine trees, turning needles rust-colored before they fall off. See https://csfs.colostate.edu/forest-management/common-forest-insects-diseases/mountain-pine-beetle/.)

TEACHING NOTES FOR GRADES 3-5

ACTIVITY 1

SPOTLIGHT ON SNOW

Begin by asking students how they feel about snow. Would they miss it if it never snowed again? Then ask if they ever heard the expression "no two snowflakes are alike." Have students hypothesize whether they think that may or may not be true, and connect it to their experiences.

Part 1: Provide time for students to fill in the blanks in the paragraph. Then review the various shapes of snowflakes. Talk about which look soft or hard and what they might feel like if they landed on your skin. Explain that as snowflakes fall from sky to ground, they encounter changing air conditions. More crystal clusters build up during the journey by colliding with super-cooled droplets, so the snowflakes are constantly growing and evolving. Since no two snowflakes take the exact same route, it's unlikely that any will look identical. ***Answers:*** crystals, vapor, precipitation, atmospheric, temperature, humidity, plates, columns, dendrites.

Part 2: Ask the class about activities they might enjoy playing in snow, like snowball fights or skiing. Have they ever noticed that sometimes it's easy to form shapes with snow but other times it just crumbles? Have them consider why. Explain that the structure of snow determines how well it packs together. This is also true as snow piles up on the ground. Small grains of snow pack close together to form firm, dense layers. Large, fluffy snowflakes form loose, soft layers ideal for skiing. Over time, the snowpack can also be impacted by weather conditions like wind, temperature, sunlight, and humidity.

Now divide the class into groups to have students create model snowpacks and demonstrate or test avalanche conditions. Gather materials to represent different types of snow, such as round toothpicks (columns and needles), sticky notes (plates), pieces of paper (dendrites), and table salt (graupel, which is snow with a layer of ice around it forming icy snow pellets, can create a loose, unstable layer of snow). Demonstrate the activity first (see at right), and then provide time for students to complete the exercise on their own.

1. Stack two books of different thicknesses on a floor or table. The bottom book represents a densely packed base layer of snow on the ground.
2. Slowly lift one end of the bottom book to simulate an avalanche. How long does it take for the top book to slide off? Does this change when you swap out thinner and thicker books? [A thick top layer will slide off more quickly than a thin top layer. Also take note of the effect of different angles at which the book is positioned.]
3. Next, sprinkle some salt between the two books to represent a loose layer of snow. Repeat tilting the bottom book. Does the top book slide off faster or more slowly? [Faster: The layer of loose snow makes the denser top layer less stable.]

Answers: Stable snowflakes in a snowpack are plates and dendrites, which interlock with one another. Unstable forms are columns and needles, which slide over one another. Layering denser materials on top can increase instability.

FOLLOW-UP

- Continue the experiment by adding a third book or some action figures to represent people and place them on top of the stack. What happens to the people during the avalanche? What happens if the people cause a lot of movement and weight-shifting on top of the stack?
- Set up the stacks on a small stool or table, and then shake it to represent an earthquake, snowmobile, or a stampede of large animals. Discuss what happens as a result.

TEACHING NOTES FOR GRADES 3-5

ACTIVITY 2

SNOW AS A HABITAT

Part 1: The film introduces some of the unique wildlife that flourishes in snowy climates like Iceland and the Alps. Begin by asking students to recall how often they see animals and plants in their region during the winter. Have they seen animals that hibernate, birds that migrate, or a flower that heralds the spring? After the initial discussion, have students complete the quiz individually, then review their answers in a class discussion. ***Answers:*** 1. H, 2. A, 3. A, 4. A, 5. M, 6. A, 7. H, 8. H, 9. A, 10. A, 11. M, 12. A, 13. H, 14. H, 15. M.

Part 2: This part of the activity asks students to consider how a plant or animal, including insects, in your region would survive in a snowy habitat. Introduce this topic by having students talk about how their pets would adapt, then have them complete the activity individually or in small groups. ***Answers:*** Answers will vary.

FOLLOW-UP

- Snow hares have wide, flat feet that don't sink in the snow. Humans used their feet as a model for creating snowshoes. Can your students think of other tools or tricks humans use to make it easier to live in snowy seasons? Ask them to write about or illustrate some ideas, or even illustrate new ideas of their own.
- Explain to students that snow plays a complex role in the water cycle, which makes it critical for all plants and animals. Have students read and summarize an article like this one on snowmelt runoff and the water cycle: www.usgs.gov/special-topic/water-science-school/science/snowmelt-runoff-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects
- Complete the Water Cycle and Water Volume experiments found on page 10 of this guide.
- Climate change affects the water cycle at every step. Think about what would happen if the snow at the top of a mountain melted too fast. What if there was a lot less snow each winter? What if there was too much?

ACTIVITY 3

SNOW AS A SYSTEM

Weather systems are complex. Begin this lesson with a primer on storm fronts, air pressure, and how to read a weather map. (This article is a great start: https://scijinks.gov/weather-map/.)

Part 1: Lake-effect snow generated by winds from the Arctic can cause intense blizzards with 2-4 inches of snow per hour and high winds in the affected area, which is usually shaped like an arc, called a snow belt. Review the lake-effect snow diagram on the activity sheet as a class. Explain that lake-effect snow requires water to be warmer than the air. Once the water freezes, the moisture needed to feed lake-effect snow is "locked" into the lake. Have students complete the activity individually and review answers in class. ***Answers:*** 1. cold air, 2. warm water, 3. large surface

Part 2: To begin this part of the activity, point to the Great Lakes on a map and explain that they are the largest system of fresh-water lakes in the world. Review their size and shape and note that there is a lot of surface area to pick up moisture. It takes a long time for that much water to freeze, so the lakes stay warm well after the air temperatures are cold enough to produce snow. Have students describe what they see in the two lake-effect weather maps, then have them complete the activity individually. ***Answers:*** For Storm 1, the winds blew in from the southwest across the whole length of the lake, depositing heavy snow over a relatively small area at one end of the lake. For Storm 2, the winds blew in from the northwest across the width of the lake, picking up less moisture and depositing a lighter snow across a broader area along one side of the lake.

FOLLOW-UP

- Ask students to discuss whether cities on opposite sides of a lake-effect snow belt have the same climate if one gets many times more snow than the other. Also ask them to compare that to their own regional climate and weather patterns. What similarities and differences do they note?
- Warming weather patterns as part of climate change will have a complex effect on lake-effect snow. In the short term, warming will keep lakes from freezing until later in the winter, which can increase lake-effect snowfall. Over time, however, as the Arctic winds become warmer, the chance of snow will be reduced, with more rainfall instead. As an extension assignment, have students explore the historical data at https://www.ncdc.noaa.gov/cdo-web/search for cities near the Great Lakes. You will need to enter an email address in order to access reports.

TEACHING NOTES FOR GRADES 6-8

The lessons in this program are designed to serve as a launching pad for grade-level Earth science topics and offer students a more specific, nuanced look at climate change and the complexity of its impact. Before you begin the program, review what the class already knows about relevant topics such as climate, weather patterns, and the water cycle. An understanding of the molecular density of different forms of water and gases in the atmosphere may also be helpful, as well as the relationship between atmospheric pressure and weather systems. The resources on page 11 will help you get started.

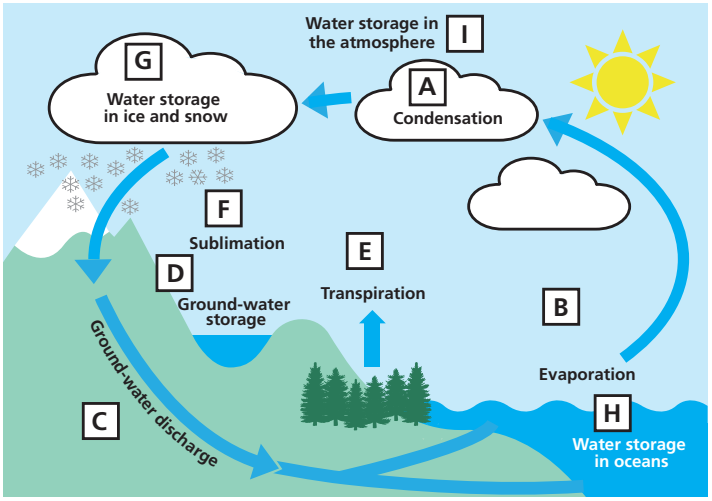
ACTIVITY 1
ESSENTIAL SNOW

Part 1: ***The Search for Snow*** illuminates the impact of snow and why it is so important to so many species, including humans. Explain to students that language is one way we can learn what is important to a particular culture. For example, in the Eskimo-Aleut family of languages, it is said that there are more than 50 different lexemes for snow. "Muruaneq," for example, is soft, deep snow, while "kanevvluk" is fine snow. In English, we have fewer specific phrases, but we can describe the nature of snow through literature. Ask students to share their personal experience of snow through a **haiku,** which is a type of poem that originated in Japan and was often used to describe nature. It contains three lines, with alternating numbers of syllables in the following pattern: 5/7/5. After students complete their haiku, share them in class.

Part 2: Snow plays a critical, often overlooked role in the water cycle. Review the diagram with your students, then provide time for them to fill in the missing labels and define these terms on the diagram:

- **Condensation:** water that collects as droplets when humid air comes in contact with a cold surface
- **Evaporation:** the process by which water changes from a liquid to a gas or vapor
- **Sublimation:** the process by which water changes from a vapor directly to a solid, such as the way snow forms
- **Transpiration:** the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems, and flowers

Answers:



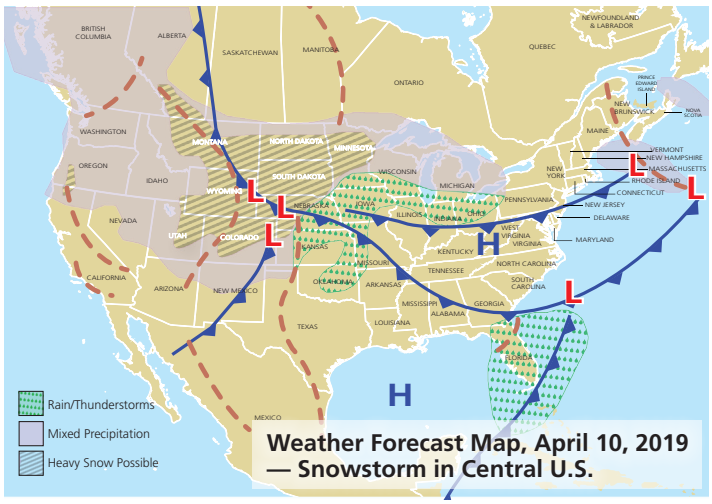
FOLLOW-UP

- Ask students to research how glacial melt causes a trickle-down effect on the water cycle. For example, as mountain snowpack thins, the mountains absorb more sunlight, warming further. As ocean levels and temperatures both rise, more water is evaporated and returns in the form of rain, which could cause flooding where it had not occurred previously.
- Lead students in an in-depth study of snow crystals and snowpack. Check out the activity ideas on page 10 titled Making Snow and Avalanche Experiment.

ACTIVITY 2
SNOWY CLIMATES

Part 1: This lesson offers a simplified look at the very complex nature of storm systems, starting with how air masses circle the Earth. Provide time for students to read the paragraph and fill in the blanks. Then review the map. Explain that these air masses affect climate and local weather events. They are connected to the water cycle as well, because they help move water from the oceans across the land masses. ***Answers:*** rotates, Equator, Tropical, Arctic, Polar, maritime, moisture, condensation, continental, precipitation, water cycle

Part 2: After students have read the information, download the weather map at ymiclassroom.com/snow (see page 9 of the Activities Guide) and review it together as a class. For reference, share the image of snowflake shapes from page 4, grades 3-5, Activity 1 with students. Ask students to identify topographical features, like oceans and mountain ranges. ***Answers:***
1. Snow is expected in the Northwest, and in higher elevations southeast of the Rocky Mountains; lower elevations will have rain. 2. Students should note that snow requires cold temperatures in the atmosphere, which is more likely in higher elevations and high latitudes. 3. Low-pressure zones are all near the storms and high-pressure zones are in areas where there is no precipitation. 4. Some areas are marked as mixed precipitation because air temperatures are always changing.



TEACHING NOTES FOR GRADES 6-8

Once students have completed the activity, provide them with the world map on page 9 of the Activities Guide and discuss the following as a class. Have students note as similarities that the Great Lakes, Iceland, and the Alps are all in the Northern Hemisphere. The Alps and Great Lakes are at similar latitudes, while Iceland is further north. Iceland is an island, unlike the other two locations. The Alps' mountain peaks are higher than those of Iceland, and both locations have glaciers that are critical to their ecosystems. Each of these three locations is subject to unique wind factors, so their weather patterns would vary from one another. Generally speaking, students should expect the Alps to have a more or less regular snow pattern, because it is mountainous. Iceland is the coldest of the three locations. In the next activity, they'll learn more about the Great Lakes, which is affected by lake-effect snow events. Because the jet stream travels from west to east, weather events in the continental U.S. can carry across the ocean to the Alps.

FOLLOW-UP

Ask students to look at the maps from Parts 1 and 2 of this lesson together. Considering the way air masses travel and their effect on local weather events, how do they think weather patterns would be affected worldwide by rising air temperatures in the Arctic? (Higher air temperatures in the Arctic would reduce precipitation, which requires contact between warm and cold air.) You can also connect this lesson to Activity 1 and discuss how the moving air masses impact the water cycle in different locations. Ocean currents also play an important role by moving warm and cold surfaces around, modifying air masses, and protecting coastal regions from both the number of snowstorms and heavy snowfall.

ACTIVITY 3
THE LAKE EFFECT

Part 1: Lake-effect snow is a unique type of storm system that happens in the Great Lakes and other similar locations where there are cold winters and relatively warm, large bodies of water. Begin by pointing out the Great Lakes on a map and explain that they are the largest system of fresh-water lakes in the world. Review their size and shape and note that there is a lot of surface area to pick up moisture. It takes a long time for that much water to freeze, so the lakes stay warm well after the air temperatures drop to where it's cold enough for snow. (Even Lake Erie, the shallowest of the Great Lakes, does not usually freeze over until the end of January.) Complete the first part of this activity as a class. ***Answers:*** Cold winds travel from west to east (left to right); water vapor rises; central impact of the blizzard lands in the east (right side of the diagram).

Part 2: Using the map of Lake Erie, ask students to trace a belt around its eastern/southeastern edge where they think snow might be the heaviest. Buffalo is right in the heart of Lake Erie's snow belt, on its eastern point. Cleveland is in the secondary belt for storms that come from the west, but vulnerable to storm winds from the north. Toledo, on the other hand, sits to the west of Lake Erie. Ask students if they think Toledo will get more or less snow than Buffalo and Cleveland. Then provide time for them to complete the chart and answer the questions.

Answers: 1. Average annual snowfall totals for October through January: Buffalo = 54.4 inches; Cleveland = 27.5 inches; Toledo = 18.5 inches. 2. November and December. 3. In November, Buffalo gets about 288% more snow than Toledo. In December, Buffalo gets about 233% more snow than Toledo. 4. On average from October through January, Buffalo gets 194% more snow than Toledo. 5. Buffalo is at the very end of the lake so the added distance enables snow to pick up additional moisture. 6. West to east. 7. It stops when the lakes freeze because water is no longer evaporating from them.

FOLLOW-UP

- The ability to create graphs is an important skill, both for helping to represent and review data visually, as well as for communication of information to a broad range of audiences. Have students create a line graph to show the differences in snowfall between each city.
- Evidence is showing that the Great Lakes are freezing later in the season. In some cases, large sections of the lakes aren't freezing at all. But as glaciers melt and global temperatures rise, Arctic winds are also warming. How do students think this will impact lake-effect snow events? Ask your class if they think these storms will happen more or less frequently and with more or less intensity. What does that mean for the people in the communities who live there? Have students conduct some research and then write a short paragraph explaining their answers. Refer to the Resources on page 11 to get them started.

ACTIVITY 4
FUTURE STRATEGIES

Part 1: Climate change is a complex mechanism. In this activity, students will apply and develop research and critical-thinking skills to tackle the issue. First, review the materials covered in the first three activities. Ask students to think about how climate change would affect all these various systems. Then provide time for students to think about and research a sub-topic that interests them from the list suggested on the sheet or others of their own interest that you approve.

Part 2: Bring the class together again to discuss students' findings from Part 1. Then have them brainstorm some solutions together and make a list of ideas. As they will learn from the example of artificial snow in the Alps, few solutions are perfect. Other strategies, like the SMART altitude project described at www.alpine-space.eu/projects/smart-altitude/en/home, are more beneficial but may be difficult or costly to implement. Provide time for students to continue their research and write a short presentation about one idea they think will help reduce or mitigate the effects of climate change on snow.

FOLLOW-UP ACTIVITIES FOR ALL AGE GROUPS

Making Snow: Making snow is fun for students of all ages. Here are two recipes. Set up a classroom STEAM lab by giving students an opportunity to try several different recipes and record their observations:

- Fake Snow STEM Lesson, https://energydayfestival.org/2017/12/05/make-fake-snow/
- Fake Snow You Can Make Yourself, https://littlebinsforlittlehands.com/make-fake-snow-winter-sensory-play/

If temperatures are below freezing where you live, you can also observe snow crystals grow inside bubbles. Here are two videos to show your class or to help them get started:

- https://www.youtube.com/watch?v=qw19MqCY2to
- https://www.youtube.com/watch?v=Kil3Pqvs8-U

Snow Observations: Weather permitting, classes can get outside and perform a number of scientific observations and experiments with snow, such as:

- Catch snowflakes on chilled black paper and examine them under a microscope.
- Make observations about the texture of the snow in different air temperatures.
- If you live in a place with a deep snowpack that builds over time, measure the depth of snowpack and try to examine the layers.

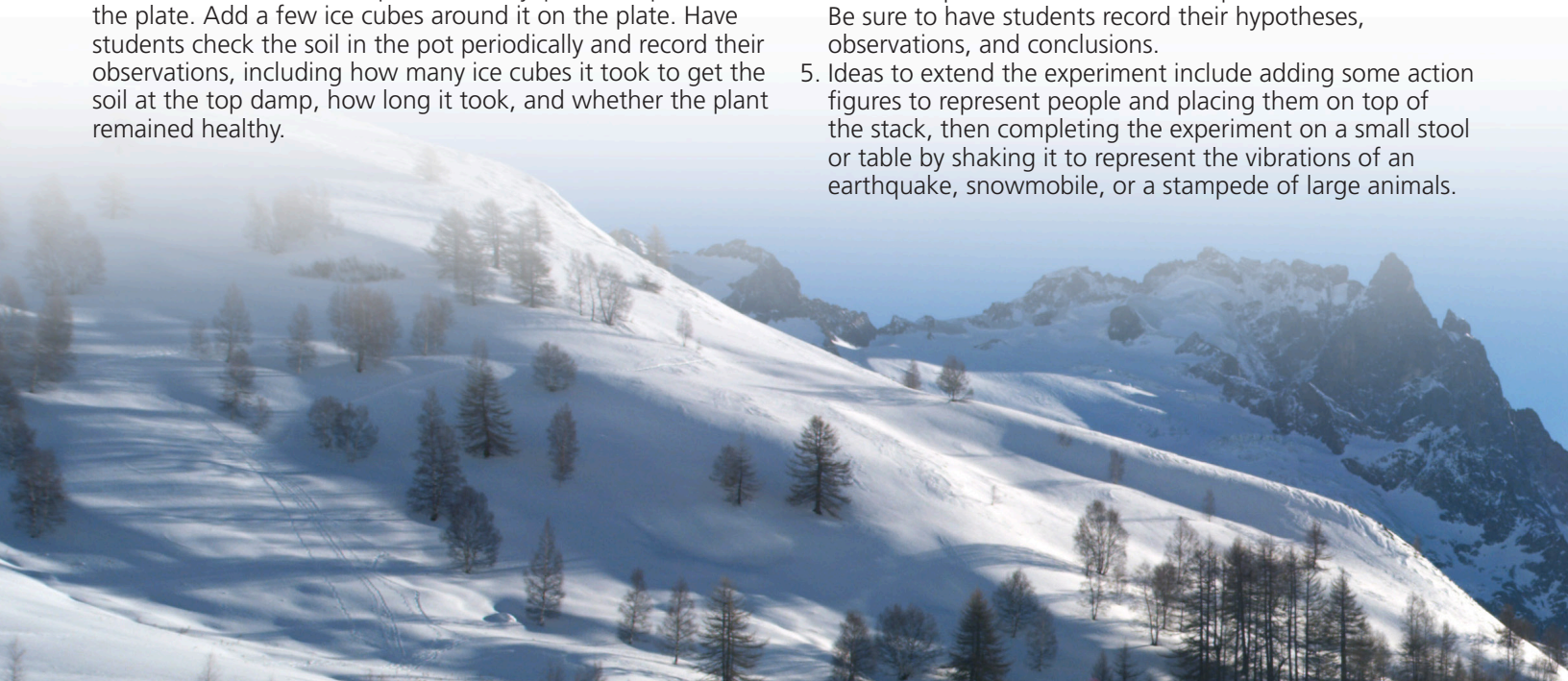
Water Volume Experiment: Weather permitting, collect a bucket of snow and measure its volume. Then let it melt and measure the volume of the remaining water. What happens? Ask students to observe, then explain that snow is less dense than water. If possible, collect different textures of snow and compare results. You can also repeat the experiment and compare between different snowstorms and different sizes and shapes of snowflakes.

Water Cycle Experiment: Demonstrate how melting ice and snow feed the groundwater by using a cup of ice, a small houseplant (African violets work well; make sure the pot has holes in the bottom for drainage), and a large flat plate. When the soil around the plant feels dry, place the pot on the plate. Add a few ice cubes around it on the plate. Have students check the soil in the pot periodically and record their observations, including how many ice cubes it took to get the soil at the top damp, how long it took, and whether the plant remained healthy.

Although the following is already Part 2 of Activity 1 for grades 3-5, it could work for other grades.

Avalanche Experiment: Gather a series of classroom materials to represent different types of snowflakes. Suggestions include round toothpicks (needles), sticky notes (plates), salt (icy snow pellets), and small pieces of paper (dendrites). Remind students that snow also continues to evolve after it hits the ground. Sometimes snow forms a layer of ice around it, turning it into icy snow pellets that easily roll and shift. This snow is called graupel and can easily create a loose, unstable layer of snow. When layers of snow pile on the top, it can cause avalanches.

1. First, stack two books on a floor or table. The bottom layer represents densely packed snow.
2. Slowly lift one end of the bottom book. How long does it take for the top book to fall? Does this change when you swap out thinner and thicker books?
3. Next, sprinkle some salt between the two books to represent graupel, simulating a loose layer of snow. Repeat the tilting of the bottom book. Does the top book fall faster or more slowly?
4. Have students complete the experiment by replacing the salt and top book with some of the provided materials. Be sure to have students record their hypotheses, observations, and conclusions.
5. Ideas to extend the experiment include adding some action figures to represent people and placing them on top of the stack, then completing the experiment on a small stool or table by shaking it to represent the vibrations of an earthquake, snowmobile, or a stampede of large animals.



AVALANCHE EXPERIMENT MATERIALS

SEE PAGE 6 FOR INSTRUCTIONS.

- round toothpicks
- sticky notes
- paper
- table salt
- 2 or more books of different thicknesses

To extend activity:

- small action figures
- small stool or table

RESOURCES

WEATHER

- **How to Read a Weather Map:** https://scijinks.gov/weather-map/
- **Snowstorms:** https://weatherstreet.com/weatherquestions/What_causes_snow_storms.htm
- **Low Pressure:** https://weatherstreet.com/weatherquestions/What_causes_low_pressure.htm
- **About Winter Storms:** https://scied.ucar.edu/learning-zone/storms/winter-storms

TYPES OF SNOW

- **Guide to Snowflakes:** http://www.snowcrystals.com
- **Types of Snow:** https://nsidc.org/cryosphere/snow/science/types.html

WATER CYCLE

- **Snowmelt Runoff and the Water Cycle:** https://www.usgs.gov/special-topic/water-science-school/science/snowmelt-runoff-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects
- **Mountain Snowpack and the Water Supply:** https://www.wcc.nrcs.usda.gov/factpub/sect_2.html

THE ALPS

- **Les Orres Snow History:** https://www.snow-forecast.com/resorts/Les-Orres/history
- **Wildlife in the Alps:** https://www.alpenwild.com/Alpshiking/alps-wildlife-coping-with-winter/

GLACIERS

- **10 Interesting Things About Glaciers:** https://climatekids.nasa.gov/10-things-glaciers/
- **Glaciers and Climate Change:** https://www.vatnajokulsthjodgardur.is/en/areas/melting-glaciers/glaciers-and-climate-change/response-of-glaciers-to-climate-change
- **Glacial Retreat and Water Impacts Around the World:** https://glacierhub.org/2018/02/15/glacial-retreat-water-impacts/

GREAT LAKES AND LAKE-EFFECT SNOW

- **What Is Lake-effect Snow?:** https://www.weather.gov/safety/winter-lake-effect-snow
- **Great Lakes Ecoregion:** https://www.noaa.gov/education/resource-collections/freshwater-education-resources/great-lakes-ecoregion
- **Lake-effect Snow Season:** https://medialibrary.climatecentral.org/resources/lake-effect-snow-season
- **Effect of Warming on Great Lakes:** https://www.nationalgeographic.com/science/2020/03/great-lakes-depend-on-winter-ice-low-cover/
- **Global Warming and Lake-effect Snow:** https://www.climate.gov/news-features/event-tracker/lake-effect-snow-paradox

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A passion for skiers, a child's dearest wish, a village's deepest desire — snow is cause for joy. It is also a necessity for world water resources and for some, a sole source of revenue.

In an ever-changing world climate, *The Search for Snow* follows the patterns of weather systems to help us understand different types of snow, where it falls, and why — as well as its crucial impact on vegetation, wildlife, and people.

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For additional educational resources and online activities, please visit https://thesearchforsnow.com/

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