

**Teacher’s Guide**

**When Winter is Too Cold**

***December 2019***

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Activate students’ prior knowledge and engage them before they read the article.

[Reading Comprehension Questions](#_Student_Reading_Comprehension) 3

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[Graphic Organizer 5](#_Graphic_Organizer)

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[Answers 6](#_Answers__to)

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[Additional Resources 9](#_Additional_Resources)

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

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# Anticipation Guide

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. A polar vortex is a large mass of high-pressure cold air swirling above both the North and South poles. |
|  |  | 1. Air speeds in a polar vortex are as fast as a category-5 hurricane. |
|  |  | 1. The air in the jet stream travels more slowly than the polar vortex air. |
|  |  | 1. Oceans warm more quickly than land. |
|  |  | 1. There are two types of polar vortices. |
|  |  | 1. Rome, Italy, experiences several days of snow every year. |
|  |  | 1. The Arctic is warming more slowly than anywhere else in the world. |
|  |  | 1. Scientists hypothesize that when temperature differences are smaller, the jet stream is weaker and breaks, allowing a polar vortex to move into more temperate latitudes. |
|  |  | 1. Scientists have been collecting variations in polar outbreaks for 100 years. |
|  |  | 1. Weather news reporters may oversimplify polar outbreak explanations to make the phenomena easier to understand. |

# Student Reading Comprehension Questions

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: Use the article to answer the questions below.

1. What is a circumpolar vortex?
2. What are Rossby waves and how do changes in their location impact a jet stream?
3. List events that may cause Rossby waves to move to higher sections of the troposphere.
4. Which atmospheric layer contains the ozone layer?
5. What happens to air masses when a jet stream weakens?
6. What happened to the stratospheric polar vortex as a result of its warming in February of 2018?
7. Describe the subtropical jet stream and how it relates to the tropospheric polar vortex.
8. Compare and contrast the tropospheric polar vortex with the stratospheric polar vortex.
9. Explain the roles of conduction and density in the movement of air masses.
10. What is the primary cause of the strong polar jet stream?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Examine the graph of average monthly arctic sea ice extent. What patterns do you notice? How might those patterns be explained?
2. Explain how the melting of sea ice may contribute to an increase in the surface temperature of water in the Arctic.
3. Review the graph of CO2 during ice ages and warm periods. In parts per million, what is the difference in the level of carbon dioxide for 2018 and the highest previous concentration? Perform research to determine at least three activities that may contribute to high levels of carbon dioxide and how those causes could be mitigated.
4. While an occasional snow day may be cause for celebration, a polar vortex event is not. Research the impacts of a polar vortex on people, plants, and/or animals. Design a public service announcement (PSA) to inform others of these impacts and how they can be avoided.

# Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to compare the two types of polar vortices and how they may move to more temperate areas of the Earth.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Tropospheric Polar Vortex** | | **Stratospheric Polar Vortex** |
| **Location** |  |  | |
| **Effect on weather in a normal year** |  |  | |
| **How a polar outbreak can occur** |  |  | |
| **Rossby waves** |  |  | |
| **Severity of polar outbreak** |  |  | |
| **Hypothesis for polar outbreak** |  |  | |

**Summary:** On the back of this paper, write a one-sentence summary (18 words or less) explaining how unusually cold weather may be caused by Arctic warming.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **What is a circumpolar vortex?**

*A circumpolar vortex is a large mass of low-pressure, cold air that swirls above the North and South poles.*

1. **What are Rossby waves and how do changes in their location impact a jet stream?**

*Rossby waves are large, slow-moving flows of air that are created at Earth’s surface but can move higher up into the troposphere when they are excited. The waves can disrupt the flow of the subtropical jet stream, causing extreme cold weather.*

1. **List events that may cause Rossby waves to move to higher sections of the troposphere.**

*Uneven heating in Earth’s surface may cause Rossby waves to rise into the atmosphere. Air particles of a Rossby wave that encounter a mountain can also be propelled into the atmosphere.*

1. **Which atmospheric layer contains the ozone layer?**

*The ozone layer is located in the stratosphere.*

1. **What happens to air masses when a jet stream weakens?**

*When a jet stream weakens, cold air masses move down into lower latitudes and warm air masses move into higher latitudes.*

1. **What happened to the stratospheric polar vortex as a result of its warming in February of 2018?**

The stratospheric vortex warmed causing wind flow to reverse and split the vortex in two.

1. **Describe the subtropical jet stream and how it relates to the tropospheric polar vortex.**

The subtropical jet stream is a wind stream that moves at speeds around 200 miles per hour. It serves as a barrier between the cold air of the polar vortex and the warmer air in the midlatitudes.

1. **Compare and contrast the tropospheric polar vortex with the stratospheric polar vortex.**

Both are surrounded by a fast-moving jet stream. The tropospheric polar vortex extends from the surface of Earth to six miles above it while the stratospheric polar vortex is found 30 miles above Earth’s surface. The tropospheric polar vortex is present year-round while the stratospheric polar vortex develops when temperatures cool in the fall and disappears when temperatures get warmer in the spring.

1. **Explain the roles of conduction and density in the movement of air masses.**

When land heats up, the heat from it transfers to the atmosphere through the process of conduction. Warm air expands and its pressure changes. This change in temperature and density causes the mass of air to move.

1. **What is the primary cause of the strong polar jet stream?**

The large temperature difference between the Arctic and the midlatitudes is the primary driver of the wind in the jet stream.

**Questions for Further Learning**

1. **Examine the graph of average monthly arctic sea ice extent. What patterns do you notice? How might those patterns be explained?**

*The graph shows cycles of an increase and decrease in extent over the years. The general trend is a loss of extent. The overall downward trend in extent may be caused by climate change.*

1. **Explain how the melting of sea ice may contribute to an increase in the surface temperature of water in the Arctic.**

*The ocean is darker than the bright sea ice, so it absorbs heat while the ice reflects it. As the ocean absorbs heat, the temperature of the water becomes warmer which causes the ice in the ocean melts.*

1. **Review the graph of CO2 during ice ages and warm periods. In parts per million, what is the difference in the level of carbon dioxide for 2018 and the highest previous concentration? Perform research to determine at least three activities that may contribute to high levels of carbon dioxide and how those causes could be mitigated.**

*The difference in parts per million is 107.4. Greenhouse gases are emitted through the burning of fossil fuels for transportation, heat, etc. (EPA -* [*https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions*](https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions)*). Clearing land can also contribute to greenhouse gases because of the removal of natural carbon sinks.*

1. **While an occasional snow day may be cause for celebration, a polar vortex event is not. Research the impacts of a polar vortex on people, plants, and/or animals. Design a public service announcement (PSA) to inform others of these impacts and how they can be avoided.**

*Answers will vary.*

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

# 

# Additional Resources

**Labs and demos**

When Air Masses Collide – This quick demo can be used to help students understand how warm and cold air masses interact when they meet. <https://www.education.com/science-fair/article/when-air-masses-collide/>

**Simulations**

Climate Time Machine – Students can use this interactive to visualize recent historical data about the change in levels of sea ice, sea level, carbon dioxide, and global temperature. <https://climate.nasa.gov/interactives/climate-time-machine>

Giving Rise to the Jet Stream – This NOVA simulation explains the science behind the jet stream. <https://www.pbs.org/wgbh/nova/education/earth/giving-rise-jet-stream.html>

**Lessons and lesson plans**

Climate Change – A Human Health Perspective: In this set of lesson plans students explore how extreme changes in temperature impact human health. <https://www.niehs.nih.gov/health/assets/docs_a_e/climate_change_and_human_health_lesson_plan_a_508.pdf>

Air Masses – This lesson introduces information about the types of air masses found in the United States. <http://sciencenetlinks.com/lessons/air-masses/>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Chemistry Basics
  + Physical properties
* States of Matter
  + Gases

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-ESS-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth’s systems.

**Disciplinary Core Ideas**:

* ESS2.D: Weather and Climate

**Crosscutting Concepts:**

* Patterns
* Cause and Effect: Mechanism and explanation
* Systems and system models

**Science and Engineering Practices:**

* Analyzing and interpreting data
* Constructing explanations (for science) and designing solutions (for engineering)
* Engaging in argument from evidence

**Nature of Science:**

* Scientific knowledge is based on empirical evidence.
* Scientific knowledge assumes an order and consistency in natural systems

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html) at www.acs.org/chemmatters.

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* Alternative to the Anticipation Guide: Before reading, ask students if they have heard of a polar vortex and how they think it might affect the weather.
* Ask students what they found most interesting from reading article.