Arctic Alive

Look beyond its frozen, barren reputation and the Arctic is full of life. It is comprised of more than fifteen ecosystems and is home to more than 100,000 Canadians and thousands of plant and animal species. It's also a place of remarkable change, where today's fossils and minerals reveal the history of the Arctic's fire to ice evolution.

Canadian Geographic Education's (CG Education) giant floor map, Arctic Alive: Explore the natural history of Canada's Arctic, was developed in partnership with the Canadian Museum of Nature (CMN). The map and associated activities provide an in-depth look at Arctic geography and natural science through the CMN's four main disciplines: zoology, botany, palaeobiology and mineralogy. Authentic specimens from the museum's collections have been provided for students' use, along with hand-held map legends, to explore Canada's arctic ecosystems.

Ten accompanying activities impart a greater understanding of nature in the Arctic, and of the work that organizations such as the CMN do to collect, research, document, share knowledge and preserve this inspiring natural region for future generations.

CG Education and the CMN are proud to make this innovative educational resource available to educators and students across Canada. Comments on your experience with the map are welcome at info@cgeducation.ca.

The Activities

In this guide, you will find 10 curriculum-linked activities designed for all Canadian students at the elementary and secondary levels.

1. Defining the Arctic

This activity gives students the opportunity to investigate what characterizes the Arctic and how the region is defined. Students will explore the climate of the Arctic, discuss stereotypes associated with it and compare it to other geographic regions in Canada.

2. Exploring Ecozones

This activity allows students to learn about Canada's terrestrial and marine ecozones by investigating how physical geography shapes ecozone classification and the landforms, climate, wildlife, plants and human activities that occur within each.

3. Natural History on the Record

This activity helps students learn the importance of natural history collections and their role in researching, protecting, documenting and sharing natural history.

4. Adaptation: The Role of Survival

This activity helps students learn about species' ability to adapt and the difference between behavioural and biological adaptation. Students will study the Arctic's changing climate and discuss how living organisms need to adapt to survive.

5. Great Migrations

This activity explores how and why animals migrate. Students will investigate six different migratory animal species in the Arctic and use exact location to discover where they migrate.

6. In the Field

This activity explores different vocations that study natural history in the Arctic. Students will look at the Canadian Museum of Nature's scientific research and plot scientists' fieldwork itineraries on the giant floor map.

7. Areas of High Diversity

This activity teaches students about natural areas of high diversity in the Arctic. Students will examine the locations of natural areas of high diversity in the Arctic based on mineral, fossil and biodiversity trends.

8. Arctic Ice

This activity teaches students the types of ice in the Arctic and how they are formed. Students will learn about the importance of Arctic sea ice, where it is located and its effects on ecosystems.

9. Beneath the Surface

This activity provides students with the opportunity to study the geology of the Arctic. Students will learn the locations of various minerals and energy deposits.

10. The Arctic Through the Ages

This activity encourages students to use fossils to learn about the natural history of the Arctic. Students will learn how some fossils were discovered in Canada's Arctic and how these fossils improved the knowledge of the region.

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1 Defining the Arctic

Learning objectives

- Students will investigate what characterizes the Arctic and how the region is defined.
- Students will explore the climate of the Arctic and discuss stereotypes associated with it.
- Students will compare the Arctic to other geographic regions in Canada.

Time required

45 minutes

Grades

K-12

Materials

- Coloured chains (12)
- Coloured pylons (16)
- Arctic definition cards (5)
- Diatom image cards (2)

Set-up

Place matching-coloured chains and pylons on each corner of the map.

.../continued

Introduction

Allow students time to explore the map independently and distribute the hand-held legends. Encourage them to look for place names, ecozones and geographic features with which they are familiar (Rocky Mountains, Hudson Bay, Baffin Island, etc.). Ask students to determine the type of map they are looking at (physical) and what they think each colour on the map represents. Discuss and locate the five essential elements of a map (title, border, legend, scale and compass). Have students identify which of these components are highlighted on the map, which are missing and whether the students' hometown is labelled. If their hometown is labelled, place a coloured pylon on it. If not, ask students why it may not be labelled on this map. Next, have students try to locate major cities on the map such as Toronto, Ottawa and Montreal. Ask them why they think these cities are not on this map. Explain that this map does not show all of Canada. Instead, it focuses on one geographic region. Using the map's title and previous geographic knowledge, ask students if they can identify the region of focus of this map (Canadian Arctic).

Ask students how they would define the Arctic and to create a list of adjectives to describe the region. Have students work together to create a border that best outlines Canada's Arctic region according to the definition they developed. Students may use their bodies or the props found in the trunk. Discuss how your class defined the Arctic and what factors they considered when displaying their definition on the map.

Development

Explain that the Arctic is defined in many ways (e.g., treeline, political borders, temperature, geographical lines, culture). Divide students into five groups and give each an Arctic definition card. Allow time for each group to examine their card, read the information on it and use the coloured chains and pylons to highlight the Arctic's borders as outlined on their card.

Have each group present their border to the rest of the class once all have been mapped. After each presentation, ask students to consider who would likely support the definition presented. Once all groups have finished, have the class compare and contrast each viewpoint. Discuss which perspective best matches the definition that the class created at the beginning of the activity.

Conclusion

In the same groups, ask students to discuss the factors that influenced each definition. Discuss the climate of the Arctic, explaining that climate refers to the average weather of a place over many years, while weather refers to the day-to-day conditions of the region. Ask students what factors influence the climate in the Arctic (e.g., temperature, landforms). Encourage students to look further into the physical geography of the Arctic and the factors that influence its climate using the content labelled on the map and on the hand-held legends.

For example, how do ocean currents, mountain ranges, elevation and latitude play a role in the Arctic's climate? Explain that sunlight is one of the most important factors. In the winter, the sun rises for only a short period each day (in some places, not at all), leaving the region dark and cold. In the summer, the sun shines around the clock, warming the region.

Finally, have students locate and stand on any Arctic community highlighted on the map. Have them imagine they live in this community and encourage them to contemplate what it would be like to live there. Ask your students if they think life would be different there and how. If their hometown is in the Arctic, have students stand on a community in another area that is different from their own. Ask students which definition of the Arctic would most likely be used by their community.

Extend your geographic thinking

Look into the climates of the past through the study of diatoms (the most common type of phytoplankton). Explain to students that a diatom is a single-cell organism with a hard glass shell that is sometimes preserved as a fossil after it dies. Diatoms can be found in both fresh and salt water, and their remains are widely distributed in soil and sea ice, forming deposits. Diatoms can be classified in two groups: pennate and centric diatoms. Show students the diatom image cards and have them discuss the similarities and differences (one is pen-shaped and one is round). Explain that diatom shells grow differently depending on their exposure to sunlight, nutrients and the surrounding temperature. By studying diatom remains, scientists can learn what the Arctic's climate was like in the past.

Studying diatoms that currently grow in the Arctic and comparing them with fossil evidence from the past helps scientists to learn more about how the Arctic is changing today. The study of marine diatoms reveals changes that will impact the entire Arctic food chain, which relies on marine diatoms at its foundation.

As a class, locate the Beaufort Sea and place a pylon there. Tell students that at Franklin Bay (70.04°, -126.26°), scientists recently monitored diatoms at the bottom of landfast sea ice in the Beaufort Sea to learn how the seasonal development of this fundamental food source has changed in response to environmental variation and recent thinning of sea ice (given that some types of diatoms are more abundant in certain conditions).

Locate the Josephine River in the Boothia Peninsula (70.43°, -94.40°) in Nunavut and explain that this is an example of freshwater diatom research. Scientists took a core sample from the bottom of the Josephine River and discovered that it provided information about the Arctic climate as far back as 6,700 years (during the Middle Holocene period). Explain that the diatom species found at the bottom of the core sample told scientists that thousands of years ago, the Arctic had a warmer climate than it has today.

Go to the Canadian Museum of Nature website (nature.ca) and investigate other ways scientists are using diatoms to learn about the changing climate.

Links to the Canadian National Standards for Geography

Essential Element 1: The World in Spatial Terms

- Spatial graphics (e.g., air photos, satellite images, various map types and atlases)
- Map types (e.g., topographic navigational, thematic)

Essential Element 2: Places and Regions

- Physical and human characteristics of places and regions within the province and Canada
- Political and historical characteristics of regions
- Regional analysis of geographic issues and questions

Essential Element 5: Environment and Society

- Environmental issues (e.g., water supply, air quality, solid waste)
- Limits and opportunities of the physical environment for human activities
- World patterns of resource distribution and utilization

2 Exploring Ecozones

Learning objectives

- Students will learn about Canada's terrestrial and marine ecozones.
- Students will investigate how physical geography shapes ecozone classification.
- Students will examine the landforms, climate, wildlife, plants and human activities in Canada's ecozones.

Time required

60-70 minutes

Grades

4-12

Materials

- Landform map (1)
- Ecozone quiz card (1)
- Ecozone cards (30)
- Species cards (5-10 plant and animal cards)

Set-up

Select five to 10 plant and animal species from the species cards to highlight during your ecozone discussion. Review all material and ensure all cards are present.

.../continued

Introduction

Bring attention to Canada's landforms while students are exploring the map. Explain that a landform region is an area that possesses similar geologic structures, physical features, climate conditions, soils and vegetation. An example of a physiographic, or landform, region in Canada is the Canadian Shield. When viewed from space, Canada's eight physiographic regions are clearly visible. As a class, locate and label Canada's landform regions using the landform map as a guide.

Next, encourage students to count the number of ecozones highlighted on the map. Explain that, according to the Canadian Council of Ecological Areas (ccea.org), Canada has a total of 31 ecozones: 18 terrestial ecozones, 12 marine and one freshwater. Have students each locate and stand on an ecozone. Ask your students if all 31 of Canada's ecozones are labelled on this map. Determine which ecozone does not appear on the map (the Great Lakes) and have your students discuss why. Explain that this map focuses on Canada's northern region and that the Great Lakes marine ecozone is one of the most southern ecozones in Canada. Ask students what other features are not included on this map and why.

Development

Ask students to find and determine the differences between landform regions and ecozones, using the map to guide their discussion. Ask if more than one ecozone can exist in one landform region. Explain that an ecozone is often referred to as a natural region and is an area where plants, animals and micro-organisms interact with each other. Landform regions, on the other hand, are characterized by their similar physical geography and geological features.

Have students line up along the map's border and give each an ecozone card. Once they have had time to locate their ecozone and read the information on the back of their card, encourage students to examine its size and neighbouring ecozones.

Discuss the biodiversity in some of Canada's ecozones. Ask students to highlight one plant and one animal species found in their ecozone using the information on the back of their ecozone card. Have students share their answers with the class and encourage them to look for similarities and differences among the different ecozones in the Arctic. Ask students to explain the characteristics that the plants and animals in their ecozone have to help them survive.

Show students the species cards you selected at the beginning of class, and ask students to stand up if a species lives in their ecozone. If more than one student stands up, discuss some of the ways this species can survive in each ecozone.

Conclusion

Using the ecozone quiz card, read one question to the class and have them find the correct answer on the map. Each answer will highlight a different ecozone. Continue until all questions have been answered.

Extend your geographic thinking

Ask students if they can distinguish between ecozones and habitats (the environments in which animals live). Ask students to list the four essential elements of a habitat (food, water, shelter and space). Have students line up along the border of the map and distribute a species card to each. Have students pretend that they are the species on their card and locate an ecozone in which they would like to create their habitat. Next, have students determine what they would eat, where they would go for water and where they would live.

As a follow-up project after the map is gone, have students research their species' habitat and share it with the class.

Links to the Canadian National Standards for Geography

Essential Element 1: The World in Spatial Terms

- Location of continents and oceans
- Relative and absolute locations
- Physical/political maps of the province, Canada and the world
- Map, globe and atlas use
- Map projections
- Major cities of the province and Canada
- Provinces and territories of Canada

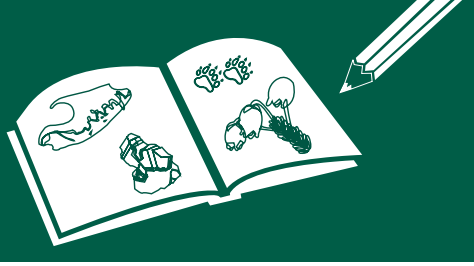
Essential Element 3: Physical Systems

- Concept of an ecosystem
- Physical processes shape patterns in the physical environments
- World climate regions
- World patterns of biodiversity

Essential Element 5: Environment and Society

- Physical environment influences human activities
- Limits and opportunities of the physical environment for human activities
- Global effects on the human environment by changes in the physical environment

3 Natural History on the Record



Learning objectives

- Students will learn the importance of natural history collections and their role in researching, protecting, documenting and sharing natural history.
- Students will examine an individual natural history specimen based on those in the Canadian Museum of Nature's collection, identify it, categorize it, determine its origins and explore how it can be used to build knowledge of the Arctic.

Time required

60 minutes

Grades

K-12

Materials

- Species cards (40)
- Step cards (20)
- Teacher answer card (1)

Set-up

Ensure all specimens, image cards and materials are present.

.../continued

Introduction

Gather students on the border of the map and ask them to define the term collection. Discuss the types of things people collect, why they collect them and how they protect their collections.

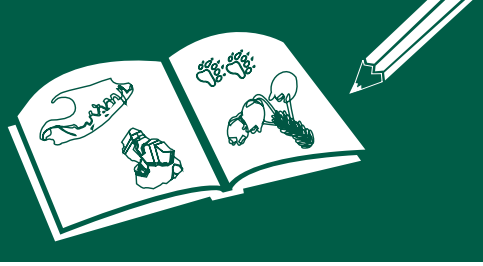
Next, ask your students why it's important for museums to have collections, and have them describe the types of collections they've seen. Explain that with more than ten million specimens gathered over 150 years, the Canadian Museum of Nature documents Canada's natural history for research, education and appreciation. Have students stand on any place on the map and brainstorm something they think they would find there that could be added to a collection at a museum. Allow time for students to share their answers with the class.

Development

Distribute one specimen to each student. Explain that each specimen is an example of something that was either collected by a Canadian Museum of Nature scientist or found in the museum's collection. Allow time for students to examine their specimen and share them with their classmates.

Next, explain to students that the collection at the Canadian Museum of Nature can be divided into four main disciplines: botany (the study of plants), palaeobiology (the study and comparison of fossils to modern animals and plants), mineralogy (the study of minerals) and zoology (the study of animals). Highlight these disciplines using the images presented around the map's title and have students determine where each specimen may be found in the Arctic.

Using the information provided with each specimen, have students group themselves into one of the four disciplines. Have each group locate where their specimens were collected and place them on the giant floor map in those locations. Allow time for each group to share their specimens and discipline with the class, addressing how they feel their specimen has helped scientists gain a better understanding of the Arctic. Have students explain what these specimens can teach us about the Arctic and why it's important to study the region through minerals, animals, plants and fossils.



Natural History on the Record

3

Conclusion

Explain that there are certain ways in which scientists find, document and transport natural history specimens. Give each group a step card, which outlines the steps that scientists from the Canadian Museum of Nature follow to collect specimens in the field. Steps are divided into three categories: preparation before venturing into the field, work in the field, and work in the lab and/or collection. Highlight the important steps scientists need to take to ensure their specimens and data are efficiently, safely and legally collected.

Distribute one step card to each student. Have students read their step and determine whether it would happen in the preparation stage, while in the field or upon returning. Have students group themselves based on one of the three stages and stand on a different corner of the map. Once all students have determined where they belong, allow each group to read their individual steps. Create a class discussion on the importance of each stage, and have each group brainstorm additional steps that may be missing.

Additionally, have students determine specific tools that are unique to their discipline. For example, identify which types of tools would be relevant to a botanist but not a zoologist. Using the map, have each group highlight where one of their specimens was found, how it was collected and how it was likely transported back to the museum. Ask students to explain their reasoning and discuss why these steps need to be taken.

Extend your geographic thinking

Explain to students that specimens of all shapes, sizes and conditions arrive at the Canadian Museum of Nature and each requires different preservation methods. The museum has specimens that date back to four billion years ago (rocks and minerals). In pairs or small groups, ask students to choose a specimen and brainstorm what factors may cause it to deteriorate over time and what the museum can do to preserve it.

To continue learning after the map leaves, visit the museum's website (nature.ca) and explore its four disciplines. Show your students the series of photos "Ten Agents of Deterioration" (http://nature.ca/en/research-collections/our-collections/collection-conservation/photos-ten-agents-deterioration) to continue the discussion on preservation.

Links to the Canadian National Standards for Geography

Essential Element 1: The World in Spatial Terms

- Latitude, longitude and the global grid
- Map types
- Map projections for specific applications

Essential Element 2: Places and Regions

- Perceptions of places and regions
- Regions defined by multiple criteria
- Factors that influence people's perceptions of places and regions
- Concepts of formal, functional and perceptual regions
- The importance of places and regions to individual and the social identity

Essential Element 4: Human Systems

- Human settlement patterns and land use
- Regional development in Canada and the world

4 Adaptation : The Role of Survival

Learning objectives

- Students will learn about species' ability to adapt.
- Students will study the Arctic's changing climate and discuss how living organisms need to adapt to survive.
- Students will learn the difference between behavioural and biological adaptation.
- Students will examine fossils of organisms found in the Arctic and discuss why and how they did not adapt to the changing environment

Time required

60 minutes

Grades

4-12

Materials

- Coloured chains (12)
- Coloured pylons (16)
- Species cards (31)
- Adaptation cards (10)

Set-up

Separate the species cards into four piles (plants, animals, fossils and minerals) and place the mineral cards back in the trunk. Ensure all cards and materials are present.

.../continued

Introduction

Ask students how animals, including humans, protect themselves from certain aspects of their environment (i.e., keep warm, keep cool, etc.). As a class, discuss how the characteristics and behaviours of some animals help them survive in their environment. Next, have students find one location on the map that they would like to visit and ask them what they would pack to visit this place in the summer and winter. Ask your students how and why their choices changed with different seasons. Discuss what different factors are important to the survival of animals, including humans, in the Arctic's harsh climate.

Explain to students that many plant and animal species in the Arctic (on land and in the water) have adapted or changed (some over millions of years) in some way to survive in this part of Canada. Have students identify one of the plants or animals highlighted around the map's title and brainstorm how it has been able to adapt to the Arctic climate. Encourage students to estimate where these specimens may exist and discuss some answers with the class.

Development

Have your class stand along the border of the map and form 10 groups. Distribute one plant or animal adaptation card to each group. Allow students time to examine the card, read the information on the back and locate an area on the giant floor map where this species can be found. Ask students to consider what kind of environment their species lives in and how it is able to survive.

Explain to students that there are two kinds of adaptation: behavioural and biological. An example of **behavioural adaptation** is when a bird lays its eggs on a steep cliff to protect them from predators; it's a behaviour that is the result of a long evolutionary process to protect the species. An example of a **biological adaptation** is a polar bear's thick fur, which protects it from frigid temperatures; it's a physical change evolved over time that helps the species survive in an environment. Ask students which type of adaptation they think relates to their species and whether it has adapted in both ways (behavioural and biological). While walking around the map, have student groups pair up with another whose species has undergone a similar adaptation (behavioural or biological) to their own (e.g., both the Arctic fox and Arctic hare use camouflage to avoid predators). Ask groups to share their species' adaptation strategies with the class and discuss any patterns and trends. Discuss whether species can adapt to their environment in more than one way, and if plants and animals have similar adaptation strategies. Have students discuss which type of adaptation relates most to humans living in the Arctic and consider how humans can inhabit virtually every corner of the Earth, except the deepest parts of the oceans.

Adaptation : The Role of Survival

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Conclusion

Divide students into small groups and have them sit around the map. Ask the class to imagine the Arctic 1,000 years in the future and discuss what it might look like. Encourage students to use coloured chains and pylons to highlight areas that have changed drastically or remained the same based on their previous knowledge of the changing climate in the Arctic. Have each group choose one animal or plant from the species cards and discuss how it has changed. Was it able to adapt to the Arctic's changing climate? If so, how? If not, what factors may cause this species to become extinct (e.g., flooding, extreme weather, competition, etc.)? Repeat this exercise with a different jump in time, such as 1,000,000 years.

Extend your geographic thinking

Ask students what happens when a species cannot adapt. How do we know when a species that no longer exists once thrived in an environment? Using small groups, give each a different fossil card from the species card pile. Using the information provided on the card, have each group determine where this fossil was discovered and brainstorm what may have caused this species to become extinct. Encourage students to discuss what the Arctic looked like millions of years ago when this species was alive and how factors such as continental drift, climate change and species competition may have led to its extinction. A great connecting activity is "The Arctic Through the Ages."

To continue learning after the map leaves, visit the Expedition Arctic website (expeditionarctic.ca) and examine fossils discovered in the Arctic.

Links to the Canadian National Standards for Geography

Essential Element 2: Places and Regions

- Perceptions of places and regions
- Regions defined by multiple criteria
- Changes in places and regions over time
- Concepts of formal, functional and perceptual regions
- Political and historical characteristics of regions

Essential Element 3: Physical Systems

- Physical processes shape Earth's features and patterns
- Climate types
- Ecozones
- Plate tectonics/continental drift

Essential Element 6: The Uses of Geography

- Physical and human characteristics of places change over time
- Interaction of physical and human systems and influence on current and future conditions
- Influence of geographical features on the evolution of significant historic events and movement

5 Great Migrations

Learning objectives

- Students will learn how and why animals migrate.
- Students will explore the paths of six different migratory animal species in the Arctic.
- Students will learn what lines of latitude and longitude are and how to find exact location.

Time required

60 minutes

Grades

4-10

Materials

- Coloured chains (12)
- Migration cards (12)
- Animal portrait cards (6)

Set-up

Place six chains off one side of the map. Ensure all migration and animal portrait cards are present.

.../continued

Introduction

Bring attention to the white lines on the map and ask students to stand anywhere along one. Explain that these lines are called lines of latitude and longitude. They are used to help find exact location on the Earth's surface. Lines of latitude, also known as parallels because they never intersect, run east to west and measure the Earth north to south. Ask all students standing on a line of latitude to walk across the map from east to the west. Have students identify the latitude of the Arctic Circle (66.33°) and the Equator (not shown on the map, 0°). Next, explain that lines of longitude run from north to south, but measure the Earth from east to west. Have all students standing on a line of longitude walk towards the North Pole. As they walk, have students explain what they observe about the distance between each line.

Explain that lines of latitude and longitude are expressed in degrees to measure exact location. The first number is the degree of latitude: positive numbers measure the location's distance north of the equator, while negative numbers measure the location's distance south of the equator. (Alternatively, latitude numbers can be followed by an "N" for north of the equator or an "S" for south.) The second number is the degree of longitude: positive numbers measure the location's distance east of the prime meridian, while negative numbers measure the location's distance west of the prime meridian. (Alternatively, longitude numbers can be followed by an "E" for east of the prime meridian or a "W" for west.)

Have students get into pairs, stand on one community labelled on the map and determine its exact location, reminding them that they will have to use partial degrees to describe it accurately.

Development

Discuss the meaning of migration with your class, and ask them how and why people and animals migrate. Have the class line up along the map's border in 12 small groups, and distribute one migration card to each. Using the latitude and longitude coordinates provided on the card, have groups place their cards on the map in the correct location. Give each group a chain and instruct them to connect the coloured dots on their cards with their chain. Once each group has connected their migration cards, allow time for groups to brainstorm whether they think their migration path belongs to an air, land or marine species and have each group explain their decision.

Conclusion

Give each group their corresponding animal portrait card, and allow time for students to read the additional information on the back. It is important to highlight here that the places students plotted on the map are not the only places these animals can be found. Most migratory species in the Arctic can be found in multiple locations and distributed widely throughout the region. For example, Arctic terns can be found flying throughout most Arctic coastal regions. The location on Ellesmere Island that was plotted by students is one of their many breeding grounds and was chosen as one location for this activity. Have each group share their information with the rest of the class, and create a discussion on which migration routes have similar characteristics. Ask students which species migrate in a similar way (i.e., fly, run/walk, swim) but have completely different routes. Finish by determining which factors influence a species' migration and why different species may have similar migration routes.

Extend your geographic thinking

Discuss the meaning of climate change and ask your students how they think the Arctic will be affected as global temperatures continue to increase. How do they think species' migration routes will change? Have students discuss these changes in their groups and alter their species' migration route to demonstrate how it may adapt to a warming climate. A great connecting activity is "Adaptation: The Role of Survival."

Links to the Canadian National Standards for Geography

Essential Element 1: The World in Spatial Terms
- Map elements
- Location and distribution of physical and human features
- Latitude, longitude and the global grid

Essential Element 2: Places and Regions
- Physical and human characteristics of places and regions
- Regions defined by multiple criteria
- Physical and human processes shape places and regions

Essential Element 3: Physical Systems
- Basic components of Earth's physical systems
- Concept of an ecosystem
- World climate patterns
- World patterns of biodiversity

Essential Element 5: Environment and Society
- Physical environment influences human activities
- Human modification of the physical environment
- Environmental issues

6 In the Field

Learning objectives

- Students will explore different vocations that study natural history in the Arctic.
- Students will look at the Canadian Museum of Nature's scientific research and plot scientists' fieldwork itineraries on the giant floor map.

Time required

60-90 minutes

Grades

6-12

Materials

- Coloured pylons (16)
- Coloured chains (12)
- Meet the experts cards (27)
- Scientist expedition route cards (4)

Set-up

Ensure all cards are present.

.../continued

Introduction

Have students choose a spot on the map, identify the ecozone and describe what they think the landscape looks like using the information provided on the hand-held legends or using their previous geographical knowledge. Ask students what would be necessary to pack if they were preparing to visit this place. If you have completed the lesson, "Adaptation: The Role of Survival," have students reflect on the process of adaptation and whether people adapt to their working environments. If you have completed the lesson "Natural History on the Record," consider how this preparation would fit into the steps involved in collecting specimens in the field.

Discuss which industrial or human development activities have a presence in the Arctic. Encourage students to consider natural resources, culture and the environment when brainstorming. Have students think about which occupations within these industries might require fieldwork to gain a greater understanding of the Arctic environment — that is, which jobs require travelling to specific sites in the North?

As a class or in small groups, have students brainstorm the types of scientists that study natural history in the Arctic. Ensure you highlight occupations like mineralogist, palaeobiolologist, botanist, and zoologist (the Canadian Museum of Nature's four disciplines), and where on the map they may work. For younger students, play a game of charades on the map and have students guess which types of occupations they are acting out.

Development

Have students line up along the map's border and give each a different "meet the experts" card. Inform students that the individuals on the cards are scientists who work for the Canadian Museum of Nature. This team of experts contributes to and maintains the museum's collection to help Canadians better understand the Arctic.

Allow time for students to read the information on their card, determine the places these individuals would work, and then stand on one location. Have students also consider the types of gear the scientists would use and the kind of team they would travel with (including number of people and their responsibilities). Explain to students that these researchers do not travel alone and that they must assemble a team based on the kind of research being conducted. Often researchers from the Canadian Museum of Nature are able to join another expedition team of scientists (usually from government, other museums or universities) as part of a larger research group. Have students think of 10 items they would need to pack if they were scientists researching in the Arctic.

Then ask students to present their expert to the class, sharing their ideas on where they think these experts travel, who would be included in their research team and the types of items they would pack.

Conclusion

Review with students that much of the work at the Canadian Museum of Nature can be divided into four areas: botany, zoology, palaeobiology and mineralogy. Have students determine the discipline in which their scientist works, and then group themselves with other students in the same field (to create four different groups).

Review latitude and longitude with your students, and give each group a scientist expedition route card that matches their discipline. Explain that each card highlights the itinerary of one Canadian Museum of Nature scientist who has travelled to the Arctic to conduct research. Each card explains the route the scientists travelled, who they travelled with, what equipment they brought and what they studied. Have each group read through their card together and highlight on the map the places mentioned on their card using the chains and pylons.

Allow time for each group to present their scientist's expedition to the class. Conclude the class by discussing patterns and trends of places where different research has occurred in the Arctic. Ask students if all the scientists had a common start or end point and what they think their biggest challenges may have been.

Extend your geographic thinking

Have students think about their own perception of the Arctic and encourage them to think of a question they may have about it. For example, questions can involve the study of the past, present or future of the Arctic's climate, environment, resources, inhabitants, communication, industry or culture. Questions can also reflect one of the four disciplines of the Canadian Museum of Nature. Have students share their questions with the class and use the map to determine where they would like to go find their answers. This can also be a good research project where students research and highlight their particular topic of interest. Remind students that there are no right or wrong answers to these questions; this is their opportunity to explore.

After the map leaves, visit the Canadian Museum of Nature's website (nature.ca) and conduct further research.

Links to the Canadian National Standards for Geography

Essential Element 1: The World in Spatial Terms

- Physical/political maps of the province, Canada and the world
- Distribution of major human and physical features at country and global scales
- Location/allocation situations

Essential Element 2: Places and Regions

- Physical and human characteristics of places and regions
- Concepts of formal, functional and perceptual regions
- Regional analysis of geographic issues and questions

Essential Element 4: Human Systems

- Human settlement patterns and land use
- Regional development in Canada and the world
- Transportation and communication networks in Canada and the world

7 Areas of High Diversity

Learning objectives

- Students will learn about natural areas of high diversity in the Arctic.
- Students will examine the locations of natural areas of high diversity in the Arctic based on mineral, fossil and biodiversity trends.

Time required

40-60 minutes

Grades

6-12

Materials

- Coloured pylons (16)
- High diversity area cards (20)

Set-up

Ensure all cards are present.

.../continued

Introduction

Review how to read latitude and longitude with your students by having them stand on a community on the map and determine its exact location (see the "Great Migration" activity to explore latitude and longitude). Once students are comfortable with these concepts, have them line up along the border of the map, and give each an area card. For larger classes, have students work in small groups. After students read the information on their card, ask them to place their card on the map using the coordinates provided. Once all groups have found their card's location, ask each to share why their place is unique. Discuss any patterns or trends that may be evident, such as areas of high diversity having similar locations for different disciplines (botany, palaeobiology, zoology and mineralogy).

Development

Explain to students that the places they highlighted on the map are areas of high diversity. Ask students what they think this means based on the information they read on their card. Explain to students that these areas can be defined differently based on the species or specimens. A geological area of high diversity refers to an area where there is an abundance and/or diversity of mineral deposits. An area of high biodiversity is a natural environment that contains a significant number of different kinds of organisms. A palaeobiology (fossil) area of high diveristy is a large deposit of fossils (whether they have been discovered yet or not). Have students examine their card and determine what type of area of high diversity they may have. Have students gather into groups based on their discipline and discuss what their areas teach us about the Arctic. What can we learn from these locations and how are scientists studying them?

Explain that some areas of high diversity in the world are threatened because of insufficient conservation efforts, or natural land erosion. Ask students what would happen if areas of high diversity did not exist. Discuss some of the factors that threaten areas of high diveristy in Canada's Arctic and what this might mean to the future of the region. Divide your students into three groups, each representing minerals, fossils and biodiversity (plants and animals). Have each group brainstorm ways to conserve areas of high diveristy related to their discipline and share their ideas with the class. Ask students how humans can benefit from the areas of high diveristy shown on this map and how we use these areas.

Conclusion

Explain that more than three million years ago, the Arctic was once covered in boreal forest and rich in biodiversity. It then cooled and became the ice-covered region we know today. With global temperatures quickly rising, scientists have observed that the Arctic is warming and ice is melting. Ask students to imagine what the Arctic would look like if the ice melted and the region became part of the boreal forest again. Have students brainstorm and use the coloured pylons to highlight new areas of high diveristy that may develop. Discuss how students think current areas of high diversity would change. Ask them how the land would change near mineral areas and if biodiversity areas would get larger or smaller. Ask students how this would affect fossils that have yet to be discovered in the Arctic. Have students brainstorm in their groups and then share their ideas with the class.

Extend your geographic thinking

Explain to students that Canada is not the only country that has many areas of high diversity. Have students research various areas of high diversity that exist throughout the world and compare them to the ones in Canada. Have students create a Venn diagram comparing the similarities and differences between different areas of high diversity around the world. Use a world map to highlight global areas relating to biodiversity, minerals and fossils and look for any patterns or trends. Ask students what they can do to help protect these areas.

Links to the Canadian National Standards for Geography

Essential Element 1: The World in Spatial Terms

- Latitude, longitude and the global grid
- Map types
- Location/allocation situations

Essential Element 2: Places and Regions

- Physical and human characteristics of places and regions within the province and Canada
- Factors that influence people's perceptions of places and regions
- Regional analysis of geographic issues and questions

Essential Element 5: Environment and Society

- Human modification of the physical environment
- Limits and opportunities of the physical environment for human activities
- Use and sustainability of resources

8 Arctic Ice

Learning objectives

- Students will examine the types of ice in the Arctic and how they are formed.
- Students will learn about the importance of Arctic sea ice, where it is located and its effects on ecosystems.
- Students will learn about the geographic and magnetic North Poles.
- Students will map changes in Arctic sea ice from 1979 to the present.

Time required

40-60 minutes

Grades

4-12

Materials

- Coloured pylons (16)
- Coloured chains (12)
- Ice cards (9)
- Species cards (13 animal cards)
- NASA sea ice images (2)
- Compass (optional) (1)

Set-up

Organize activity cards in piles to access throughout the lesson.

.../continued

Introduction

Have students examine the map and locate the North Pole. Ask them to explain how its location was decided. Explain that there are two North (and South) poles; the geographic North Pole, otherwise known as true north, and the magnetic North Pole. The geographic North Pole is where all the lines of longitude intersect. Place a pylon on this location. The magnetic North Pole is not a fixed point, but one that moves as the magnetic core of the Earth naturally shifts. When you use a compass, it points to the magnetic North Pole.

Review latitude and longitude with your students. Use coloured pylons to label the changes in the magnetic North Pole in the years 2000 and 2010. In 2000, the magnetic North Pole was located at **81°**, **-109°**. In 2010 it was at **85°**, **-132°**. Ask students if these poles are on land or in the Arctic Ocean, and how the movement of the poles might affect people navigating the Arctic.

Development

Bring attention to the ice shown on the map. Explain that there are many types of ice in the Arctic and that ice is characterized by how it is formed. Researchers study different types of ice to monitor how the climate is changing. By investigating the location and speed at which ice forms, researchers are better able to understand the Arctic's climate and its impact on global temperatures. Also, the cold water at the northern and southern poles plays a huge role in global temperatures and is a major driving force of the ocean's currents. These currents transfer heat around the world and, in doing so, cool or warm our climate.

Divide students into pairs or small groups and distribute one ice card and a coloured pylon to each. Have students read the information on the back of their card and use the coloured pylons to show the location of their ice type in the Arctic. For example, ice shelves can be found attached to Ellesmere Island and north of 82°. After all the ice has been labelled on the map, allow each group time to describe their type of ice to their classmates, highlighting where it is found. Discuss the patterns and trends that arise between many types of ice. Have students estimate which type of ice they think is oldest (glaciers) and explain why.

Conclusion

Ask students how humans use ice. Have students get into pairs or small groups and stand on an Arctic community that is labelled on the map. Allow time for students to examine the kinds of ice around their Arctic community and determine how it affects the everyday lives of people there. Ensure students consider that ice is used for transportation, hunting and protection.

Next, distribute the animal species cards to each group. Have students read the information on the back of their card and determine where this animal lives and how it uses ice (e.g. protection, hunting, habitat building, birthing, food, transportation, etc.). Ask students to identify patterns and trends between these animals' habitats and Arctic communities. Have students share their conclusions about how different types of ice are important to both animals and humans.

Extend your geographic thinking

Have students clear the coloured pylons and cards off the map and line up along the border. Using the red chains from the trunk, outline the Arctic sea ice labelled on the map. Explain that the ice labelled on this map came from data taken in July 2013. Ask students how the ice may look in the winter, fall or spring. Divide your class in half, and give one group the NASA image from 1979 and the other group the 2003 image. Have each group use a different coloured chain to label the extent of the sea ice on the map.

When both groups have finished, discuss what they notice between the summer sea ice extent in 1979, 2003 and the ice labelled on the map (2013). Explain that global temperatures have been rising because of an increase in human activities that release more CO2 into the atmosphere. These gasses block heat from escaping from the atmosphere, causing the Earth's climate to get warmer. The Arctic is one of the places where these effects are most prominent and can observed through the melting of multi-year sea ice. Highlight the snow on the NASA images and explain that the white ice and snow reflect heat back into the atmosphere while the blue (from oceans) and green (from forests) reflect less. Therefore, less white means less heat reflection and more heat absorption. Consequently, the effects of greenhouse gases are magnified in the Arctic: as the sea ice melts, even more heat is absorbed, in turn melting more ice.

Ask students to contemplate how the sea ice will change in the next 10 years, and use the final coloured chain to map out where students think the Arctic sea ice will be in 2050. Ask your students what would happen if all CO2 emissions stopped tomorrow. Explain to students that even if CO2 emissions stopped, it does not mean that the sea ice would immediately come back. After the map leaves, have your students go to the Intergovernmental Panel on Climate Change website (ipcc.ch) and learn about a group of scientists who are developing different scenarios of climate change based on how much and when we change our emissions.

Links to the Canadian National Standards for Geography

Essential Element 2: Places and Regions

- Perceptions of places and regions
- Changes in places and regions over time
- Physical and human processes that shape places and regions
- The importance of places and regions to individuals and social identity

Essential Element 3: Physical Systems

- Concept of an ecosystem at different scales
- Climate types
- Components of Earth's physical systems
- Inter-annual climate variation

Essential Element 4: Human Systems

- Human settlement patterns and land use
- Processes of cultural diffusion
- Patterns of culture in Canada and the world
- Convergence and divergence of cultures

9 Beneath the Surface

Learning objectives

- Students will study the geology of the Arctic.
- Students will learn the locations of various minerals, and energy deposits.

Time required

60-75 minutes

Grades

8-12

Materials

- Coloured chains (12)
- Coloured pylons (16)
- Geology region cards (5)
- Teacher Information Card (1)
- Mine cards (12)
- *Canadian Geographic's* "Canada's Energy Resources and Reserves" poster maps (4)
- Species cards (40)

Set-up

Review the information on the back of the cards and ensure all image cards, chains and pylons are present.

.../continued

Introduction

Explain to students that between one billion and two billion years ago, Canada was part of one supercontinent, called Laurentia. Geology, the study of rocks and the Earth's physical structure, is important because it helps us understand our planet's history and the processes that changed, and continue to change, the Earth. It is through studying rocks that we've learned that the Earth is over 4.6 billion years old and its plate tectonics have shaped the current physical form of the planet supporting the development of life.

Explain that Canada can be divided based on its geological history. Divide students into five groups and give each a geology region card. Have students read the information on the back and use the coloured chains to outline their geological region. Have each group present their region to the class and discuss how Canada's geology and landscape differs across the country. Ask students to predict how the Earth looked millions of years ago and what it may look like millions of years into the future.

Development

Review the three types of rocks: igneous (formed directly by the cooling of magma), metamorphic (changed over time by heat, pressure or chemical action) and sedimentary (compacted sediment). Ask students if they know the difference between a rock and a mineral. Explain that minerals, such as gold and quartz, are made up of a pure inorganic substance and have a definite chemical composition. Rocks, such as granite and marble, are made up of more than one mineral and do not have a defined chemical composition. Highlight some of the minerals depicted along the title of the giant floor map and the mineral examples provided in the trunk, explaining that crystallized minerals can be characterized by their hardness, cleavage and colour, while rocks can be any size or shape. Humans use rocks and minerals for many different purposes. Rocks are mainly used as building materials, while minerals are used for things like steel or wire, electronics, jewelry, pencils, toothpaste and even the salt in food. There are more than 4,700 different kinds of mineral species on the planet.

Review how to read latitude and longitude with your students and give each group a different mine card. Have students read the information on the back of their card, find it on the map and place a coloured pylon on the correct location. Explain to students that the location they plotted is (or was) a mine for a specific mineral. Ask students to identify which geological region their mine is located in. Using the information on the back of the mine card, ask students to identify how they think humans use the minerals from this mine. Have students consider how close these mines are to other communities. Ask students what impact these mines have on local communities. Have students share their information with the rest of the class.

Beneath the Surface

9

Conclusion

Clear everything off the map. Explain that there is much more than rocks and minerals beneath Canada's surface. Canada has a wealth of reserves used for energy production, and a large number of these resources are found in the Arctic. Explain that while metallic resources, like gold and copper, can be formed throughout any geological time period, it takes millions of years to form energy resources, such as oil and natural gas.

Divide students into four groups and, using Canada's Energy Resources and Reserves poster map and the pylons, have each group highlight one of the four energy resources located in northern Canada: oil, natural gas, uranium and coal. Allow time for each group to share their energy resource and discuss any patterns they observe, such as these reserves in relation to each other or to communities. As some of the Earth's resources are depleted, discuss the issues that may arise particularly in the Arctic. Ask students what the benefits and drawbacks are to extracting these resources in the Arctic.

Extend your geographic thinking

Have students get into pairs and stand on a point on the map. Explain to students that they just got back from a vacation at this location. While they were exploring, they stumbled upon a new kind of mineral or type of rock unique to Canada. Have students explore the possibility of developing their own mine. Students are encouraged to determine the type of ore, how it will be extracted, how the surrounding environment will be affected and how humans may use the rock or mineral. Encourage students to name it. Once the map leaves, have students present their ideas to the class.

Links to the Canadian National Standards for Geography

Essential Element 1: The World in Spatial Terms

- Latitude, longitude, and the global grid
- Map types
- Map projections for specific applications

Essential Element 2: Places and Regions

- Changes in places and regions over time
- Perceptions of places and regions
- Physical and human characteristics of places and regions in Canada and the world
- Critical issues and problems of places and regions
- Regional analysis of geographic issues and questions

Essential Element 3: Physical Systems

- Physical processes shape Earth's features and patterns
- Plate tectonics/continental drift
- World climate patterns

10 The Arctic Through the Ages

Learning objectives

- Students will use fossils to learn about the natural history of the Arctic.
- Students will learn how some fossils were discovered in Canada's Arctic and how these fossils improved our knowledge of the region.

Time required

30 minutes

Grades

6-12

Materials

- Species cards (6 palaeobiology cards)
- Fossil image cards (10)
- Teacher information card (1)
- *Puijila* card (1)
- Ecozone cards (optional; from activity 2: "Exploring Ecozones") (29)

Set-up

Review the information on the cards and ensure all materials are present. Review Earth's geologic time periods to understand that the Arctic did not always look like it does today and that the fossils discovered in this region come from different time periods.

.../continued

Introduction

As a class, locate Devon Island's Haughton Crater on the map (75.38°, -89.66°). Explain that the Haughton Crater is 16 kilometres wide and in Canada's High Arctic. The crater was formed when a meteorite hit the Earth about 21 million years ago. The impact created a depression, and over time a series of lakes developed. It is within these lake deposits that plant and animal fossils have been discovered. Explain that fossils are the remains of an animal or plant that have been preserved.

During the Miocene era, about 21 million years ago, a variety of animals and plants lived in and around the Haughton Crater lakes. When these animals and plants died, some of their remains sank to the bottom of the lake and were eventually buried. Through a process called diagenesis, these animals and plants became the fossils that we see today. The Arctic is a special environment for fossil preservation because of its relatively recent glacial periods; these cold conditions have helped preserve fossils, like those found in the Haughton Crater, remarkably well.

Explain to your students that a fossil can also preserve a footprint, a track or even a burrow. These are known as ichnofossils, or trace fossils, and often help researchers understand the behaviour of animals. Fossils can also be an internal cast, giving insight to otherwise unseen structures in an animal, or even an external impression of soft tissue structures, such as skin or feathers.

Show students the *Puijila* card (pronounced poo-ee-yi-la). Read the story of *Puijila's* discovery at the Haughton Crater and have a class discussion about why this was important to Canada and to understanding the Arctic's past.

Development

Explain to students that, similar to rocks, fossils provide valuable information about the Earth's history. Divide students into 10 small groups and distribute one fossil image card to each group. Tell students that these images are fragments of species that once lived in the Arctic millions of years ago. Have students examine their image and contemplate what species they think they are looking at. Use the teacher information card to help students determine their species. Turn it into a scavenger hunt game by giving clues like "I am the jaw bone of a giant beaver" or "I am the shin bone of a camel."

What information can students gather just by looking at the image? Where was this fossil discovered? Inform students that each species does not necessarily come from the same geologic time period. Ask students to locate the time era their specimen lived in. What do we learn about the Earth's history just by looking at the species that existed in different time periods?

Conclusion

Now that students know the specimens that match their fossils, have them examine the ecozones where these fossils were found (use the ecozone cards from "Exploring Ecozones" for additional information). Ask each group to consider what their ancient animal may have needed to survive (i.e., the type of climate it preferred, what it ate, etc.) and compare it with what the ecozone looks like today.

Have each group brainstorm reasons why their species could or could not survive in the Arctic now and share their ideas with the class. Conclude by discussing how fossils help us understand the history and future of the Arctic.

Extend your geographic thinking

Have students stand on the Prairies and ask them to think of one adjective that defines this landscape. Now go back in time 100 million years. Ask students what they think the Prairies looked like then. Explain that 100 million years ago, the Prairies were under a vast inland sea called the Western Interior Seaway. After the map leaves, explore the Canadian Museum of Nature's fossil collection online (nature.ca), specifically the webpage Marine Creatures from the Age of Dinosaurs, to learn where other fossils have been discovered in Canada.

Links to the Canadian National Standards for Geography

Essential Element 1: The World in Spatial Terms

- Location of major human and physical features on Earth
- Physical/political maps of the province, Canada and the world
- Latitude, longitude and the global grid

Essential Element 2: Places and Regions

- Changes in places and regions over time
- Factors that influence people's perception of places and regions
- Political and historical characteristics of regions

Essential Element 3: Physical Systems

- Physical processes shape Earth's features and pattern
- Plate tectonics/continental drift