Polar Literacy Principle #1
The Arctic and Antarctic Regions are unique because of their location on Earth.

The Arctic and Antarctic are both cold environments but geographically different.

- The Arctic is a large ice-covered ocean surrounded by land.
- Antarctica is an ice-covered continent (land) surrounded by the Southern Ocean.
- Sea ice on Arctic Ocean is ~2 meters thick; ice on Antarctica is ~2 kilometers thick

Earth's tilted axis affects polar seasons – summer and winter. In summer the sun does not set, and in winter the sun does not rise.

Polar microclimates create different living conditions. For example, vegetation in the Arctic tundra consists of lichens, perennials, and dwarf shrubs. Antarctic vegetation is limited to mosses, liverworts, lichens and fungi that can survive extreme environments.

The physical characteristics of the environment (weather, climate, topography, geology) are significantly different.

- The air temperature in Antarctica is much colder than in the Arctic.
- Temperature at the Poles is moderated by predominance of ocean versus land as well as elevation: the Arctic is at sea level while Antarctica is about 2.5 kilometers on average.

Polar Literacy Principle #2
Ice is the dominant feature of the Polar Regions.

Ice comes in many shapes and sizes—big, small, floating in water or sitting on land, thin or thick, solid or porous. soft.

- Glaciers and ice caps are made from compacted snow (freshwater).
- Glaciers can break off into chunks, which can fall into the ocean to make icebergs.
- Icebergs are made of freshwater but float in saltwater and move with winds and ocean currents.
- Sea ice forms when sea water freezes. It is also mostly fresh because the salt is removed by the freezing process.

Ice shapes the Polar landscape.

- An ice field is an area of flat ice on land or floating on the ocean covering an area greater then 10 Km.
- Tundra is a treeless area with permanently frozen soil (permafrost) and low growing vegetation.
- The Antarctic ice sheets are the largest on Earth, containing 90% of the world's ice, while the Greenland ice sheet contains 10%.

Sea ice naturally shrinks and expands with the seasons. However, this natural cycle is affected by increasing air and water temperatures occurring at the Poles due to climate change.

Polar Literacy Principle #3
Polar Regions play a central role in regulating Earth's weather and climate.

Polar oceans play a key role in global circulation of ocean water and air masses that keep the Earth temperate.

- Global wind circulation involves three types of cells: Hadley, Ferrel, and Polar cells. Air rises in the hot tropics and sinks at the cold poles. Winds bring warm air toward the poles and carry cold air to lower latitudes.
- Global ocean circulation is driven by the formation of different water masses in the ocean. Arctic and Antarctic water masses are two important components of global circulation patterns.

Climate is affected by changes in the amount of light from the sun that bounces off the Earth's ice/snow covered areas back into space. Ice and snow (white surfaces) reflect sunlight back into space. Ocean and land (dark surfaces) absorb more solar energy. As snow and ice disappear, more heat is absorbed which accelerates melting of ice and snow. Scientists use the term albedo to describe the measurement of the reflectivity of the Earth's surface.

- Ice and snow have a high albedo while rock and ocean surfaces have a low albedo. Melting ice and snow produce a positive feedback loop.
- Feedback loops occur when an initial change is intensified (positive feedback) or weakened (negative feedback) by other factors.
- Snow and ice in polar regions are involved in mainly positive feedbacks, which is why the Arctic is warming faster than the rest of the planet.

Humans rely on the Polar Regions to maintain a temperate planet.

- Changes in the Poles will not only affect local people and ecosystems but also the rest of the world.

Polar Literacy Principle #4
The Polar Regions have productive food webs.

Productivity (generation of life) is tied to the Polar summer and winter.

Sea ice cover and temperature change with the seasons.

- Phytoplankton, tiny plants at the base of the food web, grows abundantly during the long days of polar summer. Krill, small shrimp like crustaceans, feed on plankton.
- Each winter, as the sun disappears and temperatures plunge, sea ice grows to cover large areas of ocean. Young krill need ice to sustain their populations during the winter (add more about why?).
- Krill feed the higher levels in the Polar food webs.

The Antarctic Food Web is simple and dependent on ice.

- Although Antarctica has no terrestrial mammals (*no polar bears*), marine mammals (whales and seals) and sea birds inhabit the region.

Polar regions have a unique and complex ecosystem.

- The Arctic has many terrestrial mammals including musk ox, reindeer, caribou, fox, hare, lemmings, bears, and more. *Penguins do not live in the Arctic.*

- Marine and terrestrial predators are predictors (indicators) of change in food webs.

Polar Literacy Principle #5
Humans are a part of the Polar system. The Arctic has a rich cultural history and diversity of Indigenous Peoples.

Polar systems affect humans in a variety of ways.
- Weather - large dips in the jet stream can sweep cold air into low latitudes where billions of people live.
- Climate- Changes at the Poles affect local people and global ecosystems.
- Food webs- loss of sea ice is allowing sub-Arctic species of to migrate northward and disrupt Arctic fisheries.

Arctic residents (about 4 million), including 40 different indigenous groups (about 10% of Arctic residents), are affected by changing climate, environments and food webs, from available food to sustainable buildings.
- Receding sea ice is affecting animals that depend on ice cover (fish, polar bears, seals).
  Species are migrating and/or declining, affecting the people who depend on those species for food, clothing, and other uses.
- Thawing permafrost is damaging homes, roads, pipelines, and buildings.

Arctic indigenous people have a traditional connections to the land that they have inhabited, including reindeer herding, fishing and hunting.
- Industrialization, social change, and climate change present threats to the continuity of these livelihoods and culture.

Arctic indigenous people are important partners to the science community in understanding and observing the Arctic.
- Native knowledge of Polar Regions contributes to the understanding of natural ecological cycles and the impacts of climate change on the system.

Polar Literacy Principle #6
The Poles are experiencing the effects of climate change at an accelerating rate.

Arctic sea ice is declining at a rapid rate.
- Scientists predict the Arctic will be sea ice-free during summer within 30 years.
- The receding ice cover affects Arctic food webs and the global ocean circulation. Scientists are not sure exactly how the receding ice will affect ocean circulation.

Antarctica is experiencing less sea ice loss than in the Arctic – for now.
- Antarctic and Southern Ocean air temperatures are predicted to rise in the future.
- The Western Antarctic Peninsula (WAP) is the fastest winter-warming region in the world (about 10 times faster than global average).
- The warming Southern Ocean flows close to the WAP and melts the glaciers from underneath. This accelerates the WAP glacier melt and collapse.
- Increased glacial melt affects the WAP food web.

Warmer Polar Regions have a moister atmosphere, which leads to more snowfall.

- Increased snow can affect Polar animals, such as Adelie penguins in Antarctica whose breeding can be disrupted by a heavy snowcover.

Effects of climate change at the Poles ripple across the Earth.

- The amount of ice tied up in Greenland and Antarctica ice helps define our current sea level.
- Sea-level rise is caused by melting ice sheets and glaciers combined with the thermal expansion of seawater as the oceans warm.
- Global coastlines are home to 80% of the world's population, which are being threatened by sea-level rise.
- Many Polar species will face adaption or death in a changing climate.

Polar Literacy Principle #7
New technologies, sensors and tools -- as well as new applications of existing technologies -- are expanding scientists' abilities to study the land, ice, ocean, atmosphere and living creatures of the Polar Regions.

Historically Polar explorers took photographs and collected observational data (primarily atmospheric and meteorological observations) at various intervals during explorations to the Poles.

Today scientists use satellites, drifting buoys, tethered buoys, subsea observatories, unmanned submersibles, and automated weather stations to constantly and remotely study the Poles.

- This baseline information is coupled with regular scientific explorations to the Poles to collect samples and measurements, including photographic evidence.

Piecing together historical data (recorded by early explorers) with ice cores and sediment cores gives scientists an understanding of natural history.

- Combining current data with historical data, scientists can construct models to understand connections in the past and improve predictions of future environmental conditions at the Poles.

- **Antarctica's high elevation and dry atmosphere allow measurements of cosmic microwave background (fossil light from the early universe).**

Scientists look at how much the ice and snow is shrinking over many decades to observe climate change in the Arctic landscape.

Scientists are gathering genetic information across the whole range of Polar species, from DNA to the broad ecosystem.

- Genomic sequencing of polar species provides insights into complex biological processes and biotechnological exploitation (development of new drugs, bioremediation, food systems, etc.).