Antarctic Ecology II
Penguins and Seals

Lesson Objectives: Students will be able to do the following:
- Indicate the location of Antarctic endemic and circumglobal species on a map
- Identify three categories of adaptations
- Compare and contrast penguin and seal adaptations

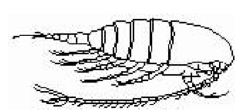
Key concepts: endemic species, circumglobal species, behavioral adaptations, morphological adaptations, physiological adaptations, community, niche

Classification of Adaptations

Organisms of the Antarctic can be divided into the **endemic** and **circumglobal** species. These categories describe the geographic range of organisms. The Antarctic, endemic animals are those that are found exclusively in the Southern Ocean. They will only be found south of 60° south latitude, because they are confined to the Antarctic ecosystem. The circumglobal species are found at all longitudes in waters between 40° south latitude and 40° north latitude. They may be found in a variety of habitats.

Both groups of organisms have **adapted** to this harsh environment by finding diverse solutions to some common problems. They use a combination of **behavioral**, **morphological**, and **physiological adaptations** to meet their needs. Behavioral adaptations describe how the animal lives. For instance in what season will penguins lay their eggs, how many will be laid, and who will take care of them. Morphological adaptations describe the appearance of an organism. This includes their size and shape. It is the reason a penguin looks like a penguin. Physiological adaptations describe body processes. For instance, seals provide adequate oxygen to their bodies during long dives by shutting down oxygen flow to their extremities.

If we look at a typical Antarctic **food chain**, we can see how organisms have adapted to their situation. For instance, we find a combination of circumglobal and endemic species at the lower levels of the Antarctic food chain that are **ectothermic** or “cold blooded”. The body temperature of these organisms depends on the surrounding water. These include the copepods, krill, and fish.



The microscopic **phytoplankton,** consisting mainly of **diatoms**, drift along with the currents **photosynthesizing** while the sun’s energy is optimum. **Copepods,** comprising the major portion of the **zooplankton,** use their oil reserves to float in the water. As the winter days grow shorter copepods become **dormant** to conserve energy while their main food source of phytoplankton are in short supply. **Krill** become opportunistic, scouring the bottom of the sea ice looking for **plankton**. If plankton are in short supply, they live off their fat reserves. As the winter grows longer, the krill slow their living processes as they rise and fall through the water column. They pass through several larval stages of development until they reach maturity over a two-year period. The krill all the while are excreting **ammonia** into the water, which is used by the phytoplankton to restore their nitrogen reserves. The krill swarm together in masses and in turn are eaten by a variety of organisms at the higher **trophic** levels. These include the ice fish, an endemic species that contains no **hemoglobin** in its blood so it appears white in color. The lantern fish, with its big eyes and **luminescent** organs contains antifreeze to keep its blood from freezing.

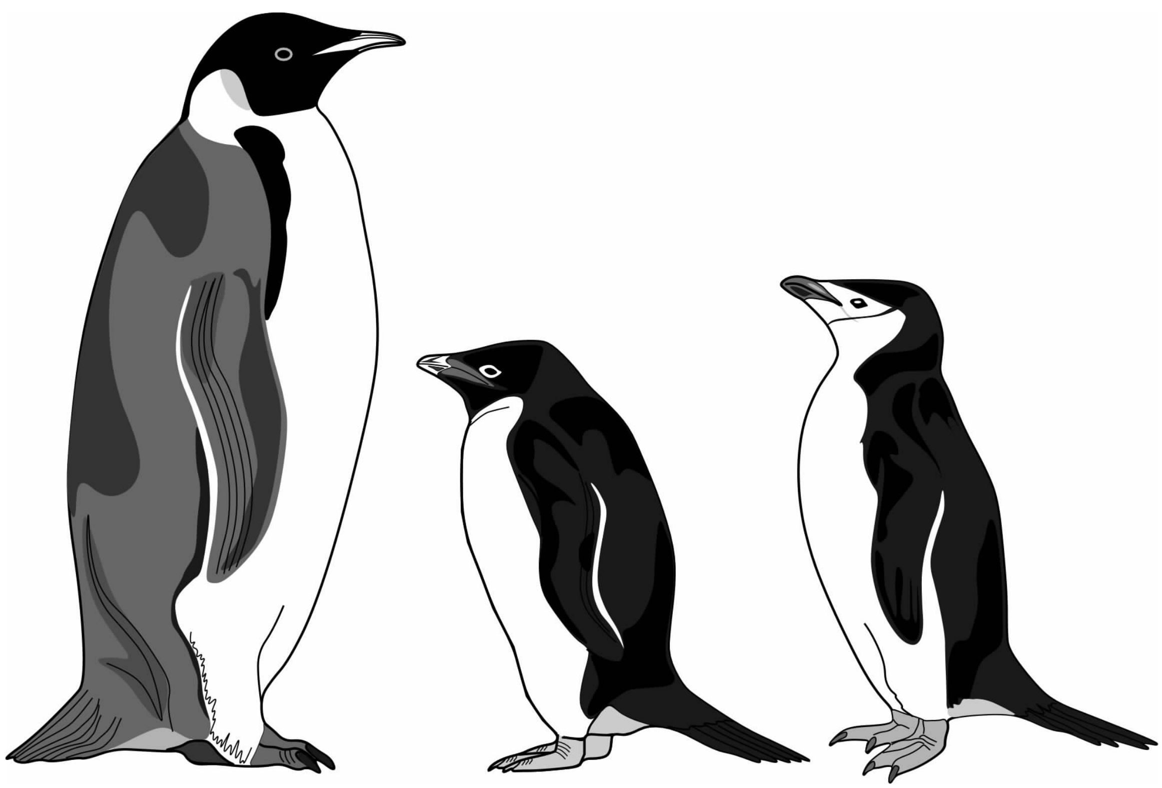
At the upper levels of the food chain, we find the endothermic or "warm-blooded" animals that include humans, whales, and seals. These organisms can maintain body temperatures significantly different from their environment. A closer look at three species of penguins and six species of seals will give insight into how these animals meet their needs.

Penguin Adaptations

Morphological adaptations among penguins are the most noticeable. All penguins are well adapted to the cold and for them this may be an advantage. They have a thick layer of blubber that acts as an insulator and a food reserve. They are also well adapted to the water environment in which they spend much of their time. Waterproof feathers keep them dry after long swims in the ocean. Good underwater vision and streamlined bodies allow for swift movement through the water. Since their wings are used for swimming and not for flying, they are shaped like flippers. Their webbed feet act as paddles. Unlike flying birds, they have solid bones that add extra weight to help them when they dive. Their coloration is also designed to protect them in the water environment, with dark feathers on their backs and light feathers on their chests. This is called **counter shading** and **camouflages** the penguin while it is in the water. When seen from above, they blend with the water. When viewed from the depths they blend with the ice or sunlight.

Behavioral adaptations describe how penguins relate to each other within their group as well as how the whole group relates within its **community**. Behavioral adaptations also help to define the **niche** or job each species occupies. This in turn contributes to their abundance and range. For instance, the emperor penguins do not build nests for their chicks, but the male holds the egg on his feet and warms it with a brood pouch, staying with it for up to nine weeks. The Adelie penguin, however, produces two eggs about a month apart and the adults share the care taking duties. Other behavioral differences include the habitat region occupied by each group, their diet preferences, and the space requirements among individuals in the group.

Physiological adaptations are difficult to see since they occur at the molecular level, but their results are fairly obvious. For example, penguins eat foods that have a high salt content and **regurgitate** it for their young. The bodies of their young are already adapted to this diet, with kidneys that help to excrete excess salt. Scientists are still studying the exact mechanism of these and other physiological adaptations.



Emperor Penguin **Adelie Penguin** **Chinstrap Penguin**

Seal Adaptations

Little is known about the life cycle of seals because they live on the thick pack ice and over-winter in the icy Antarctic waters. Morphologically, seals can be identified by their size, coat color, and the absence or presence of external ears. They are generally found separately or in small groups, except during the breeding seasons. Scientists are very interested in their behavioral adaptations related to their range. Their **migrations** are followed by satellite, and recorded with **transmitters.**

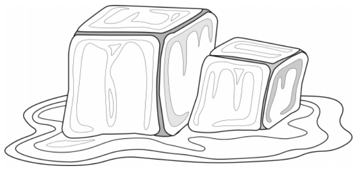
Seals also have adapted morphologically to their environment. Their bodies, though not designed for fast movement on land, allow them to move gracefully in the water. Their large eyes are designed for keen underwater vision, and their fur color helps them to blend well with the snow on the ice floes that they call home. Size also plays a part in their survival. Killer whales feed upon the smallest and most rare Ross seal. Tooth shape and size plays an important part in the seal life cycle. The Ross seal has needle like teeth for spearing fish and squid that are the main components of their diet. The Crabeater seals have lobed teeth that help them to strain krill from the water. They actually get their name from the red colored **scat** that they produce. The Leopard seal, the main **predator** of young penguins, has long sharp teeth for tearing. The Weddell seal uses its teeth to chew holes through the ice in order to live underwater in the wintertime.

Behaviorally, seals are an interesting group. Studies have been limited due to the isolated life styles of some species. For instance, the Crabeater seal occupies the outer edges of the ice pack. One mother and pup occupy an ice floe so the mother identifies her pup spatially because no other pups are within her territory. The males stand guard and actually prevent the mother from leaving the ice floe during certain stages of chick development.

The diving response of seals represents a physiological adaptation. Seals shut down the circulation to their extremities and concentrate oxygen in the heart and lungs where it is most needed. During this process they must also be concerned with the build up of carbon dioxide and nitrogen within their bodies.

Each species has a unique role and spatial distribution within the ecosystem that allows each to coexist and maximize resources.

Activity: Antarctic Insulators



Animals living in a particular habitat are suited to that environment. Various animals have chosen different ways to meet their needs. Penguins live in cold regions where they spend much of their time in the water. They have developed effective insulation to help regulate their body temperature in and out of the water.

Objectives: Students will be able to do the following:
1. Prepare experiments to simulate penguin insulators and waterproofing.
2. Compare and contrast the results of their experiments.
3. Determine the most efficient design.
4. Support their conclusions with data.

Materials:
- Containers with leak proof lids
- Water
- Thermometers
- Insulating materials such as newspaper, starch noodles, plastic bubble wrap, fake fur, air filled plastic bags, etc. (Make duplicates available.)
- Masking tape or duct tape
- Paper
- Pencil

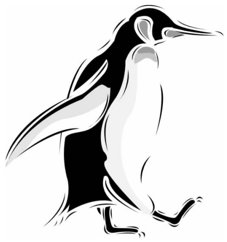
Procedure:
1. Give each student (or group of students) a container filled with water, a leak proof lid, and masking tape. (Water temperature is up to the discretion of the teacher.)
2. Have students measure and record the temperature of the water in the container.
3. Have students fasten the lid tightly onto the container.
4. Have students choose an insulating material.
5. Have students wrap the container with the insulating material and secure it with tape. (Be sure the lid can still be easily removed.)
6. Have all students place their containers in the same area for a specified amount of time. (Containers could remain at room temperature or they could be put into a refrigerator or freezer.)
7. After the time has elapsed, have students measure the temperature and record the results.
8. Have students determine the amount of temperature change and record.
9. Use the results from the duplicate insulators (all jars wrapped in paper, etc.) to determine an average temperature change.
10. Use the following as topics for discussion:

Which insulator appears to work the best?
What affected the results?
Why are the data from duplicate insulators different?
What were the variables involved?
Compare and contrast this experiment to one that scientists would do.
(Discuss replications and statistically valid numbers, etc.)
Compare and contrast to real penguin adaptations.

Possible Extensions:

1. Repeat using a different core material such as ice.
2. Use different thicknesses of the various materials.
3. Use a combination of materials.

Activity: Antarctic Waterproofing



Penguins as flightless birds spend much of their time associated with the ice and water in the Antarctic region. In addition to insulating their bodies against the cold temperatures, they must also find ways to keep themselves dry while conserving energy. They have adapted efficient waterproofing techniques using their feathers and the oils associated with them.

Objectives: Students will be able to do the following:
1. Identify waterproofing materials.
2. Compare and contrast the effectiveness of various waterproofing materials.

Materials:
- Transparent container (a 5 gallon aquarium is ideal)
- Water (enough to fill the container)
- Feathers
- Cooking oil
- Solid shortening
- Plate or shallow pan
- Plastic bags

Procedure:
1. Fill the transparent container with water.
2. Have a student coat a feather with oil.
3. Have the student put the feather into the water
4. Observe and record the results.
5. Repeat the experiment.
6. Have a student coat a feather with the solid shortening using a plastic bag as a glove.
7. Have the student put the feather in the water.
8. Observe and record the results.
9. Repeat the experiment.
10. Have students try the experiment varying the thickness of the shortening.
11. Have students use various measured amounts of oil on the feather.
12. Have students compare and contrast the results for each type of waterproofing.
13. Use the following as topics for discussion:
    What are the advantages and disadvantages for each type of waterproofing?
    How does efficiency increase or decrease with more waterproofing material?
    How do the results of this experiment relate to actual penguin adaptations?

Possible Extensions:

1. Use a variety of oils and solid fats. Compare and contrast their suitability. Have students infer that the oil penguins produce most effectively meets their needs.
2. Design an insulated item that is also waterproof. Set up some additional criteria such as weight and size restrictions.
3. Give students the same criteria and materials to design the best penguin.
4. Have students work in groups to design a penguin with additional adaptive needs such as diving requirements.

Student Information: Antarctic Adaptations

Adaptations allow animals to survive in a particular environment. We can separate adaptations: physical characteristics, types of behaviors, or body processes. Animals use a combination of these adaptations to become best suited to their environment. Scientists are particularly interested in studying the **native** species in the Antarctic including the penguins and seals to uncover some mysteries regarding their abundance and distribution.

Scientists today are focusing their studies on the health, nutrition, genetics, and **migrations** of these two groups. To study seals, researchers must come in contact with these animals. They must be well trained, because they will be approaching animals that can weigh several hundred pounds. When researchers find an animal, they place a bag over its head. This calms the animal so the researcher can take measurements and other needed data. They measure the animal's length and **girth** (waist), and weigh it on a spring scale. They also check its teeth and take a blood sample. Skin and hair samples are also collected. Next they measure the thickness of the blubber using an **ultrasound.** Blood samples that are taken let researchers know if the animal has been exposed to any particular diseases. Also it can be used in genetic studies to determine how closely some of the **species** are related. Before the animal is released, a **transmitter** is fastened to its fur. Scientists can then follow the animal as it travels.

By studying penguins and seals, researchers hope to find out some clues to their successful inhabitation of the Antarctic. Perhaps these studies will unlock keys to their abilities to adapt to this harsh environment that will, in turn, lead to new technologies or insight into disease control.

Antarctic Vocabulary

Abiotic-nonliving parts of the environment (for example light and temperature)

Adapt-to become suited to an environment over millions of years

Adaptations-characteristics that allow an organism to live in its environment

Ammonia-a colorless, pungent gas composed of nitrogen and hydrogen from animal waste (NH3=ammonia gas; NH4=ammonium ion)

Antarctic Circumpolar Current-surface ocean current that surrounds Antarctica and flows from west to east

Antarctic Convergence-An irregular ocean ring that surrounds Antarctica. In this zone, the cold waters from the southern ocean converge (meet) with warmer waters from oceans to the north.

Behavioral-pertaining to the actions of an organism

Biomass-the total mass of living matter within a given environmental area

Biotic-the living things in the environment, such as plants and animals

Brine-water saturated with salt

Camouflage-blending in with the environment

Circumglobal-found throughout waters between 40° south and 40° north latitude

Community-a group of plants and animals living and interacting with one another in a specific region

Consumer-an organism (usually an animal) that feeds on plants or other animals

Continental shelf-the area adjacent (next to) a continent or around an island, usually extending from the low-water line to the depth at which the bottom depth increases steeply

Counter shading-coloration that is dark on parts of the body surface that are usually exposed to the sun and light on parts usually in shade

Copepod-microscopic, aquatic crustacean having an elongated body and a forked tail

Diatom-microscopic, one celled plant having cell walls made of silica

Dormant-existing in a resting stage

Ecosystem-a community of living organisms

Ectothermic-an organism that regulates its body temperature by exchanging heat with its environment; cold-blooded

Endemic-an organism that naturally occurs in the environment where it is found

Food chain-the order of transfer of matter and energy from one organism to another in the form of food

Food Pyramid- a graphic representation of the food chain with producers on the bottom level and consumers on the subsequent levels

Food web-a series of overlapping food chains

Girth-the distance around something; circumference

Habitat-an area or environment in which an organism normally lives or occurs

Hemoglobin-the iron containing pigment in red blood cells

Ice Algae-aquatic, photosynthetic organisms associated with the Antarctic ice pack

Krill-any of the small, pelagic, shrimp-like crustaceans of the family Euphausiidae

Luminescent-producing light using chemical energy

Migration-the act of moving from one environment to another

Morphological-pertaining to the form and structure of organisms

Native-a life-long inhabitant of an area

Niche-the particular area and function occupied by an organism within a habitat

Omnivore-an organism that feeds on both plants and animals

Pancake Ice-pancake-shaped ice formed from seawater

Pack ice-used interchangeably with sea ice and ice pack; this is the final stage of sea ice formation; continued thickening and growth of ice results in large, thin sheets of ice floating at the ocean surface.

Plankton-small or microscopic plants and animals that float and drift in water

Phytoplankton-minute, free-floating aquatic plants

Photosynthesize-plants making their own food through a chemical process; the process uses carbon dioxide, water, nutrients, and sunlight

Physiological-pertaining to the functions, activities, and processes of living organisms

Population-a group of organisms of the same kind occupying an area

Predator-an animal that hunts for food

Producer-an organism that is able to make its own food from inorganic substances; a plant - photoautotroph, or some bacteria - chemoautotrophs

Regurgitate-vomit

Scat-animal feces

Sea Ice- ice made from seawater

Southern Ocean-the southern extensions of the Atlantic, Pacific, and Indian oceans that surround Antarctica

Species-a group of closely related organisms that can interbreed

Topography-surface features of a place or region

Transmitter-an electronic device that gives out signals that can be followed

Trophic level-a group of organisms that occupy the same position in a food chain

Ultrasound-taking a picture using sound waves

Zooplankton-very small or microscopic aquatic animals

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