LIVING PLANET
UNIT ONE

SUMMARY OF UNIT ONE MATERIAL

The videotapes to watch for this unit are:

Video Episode 1 - The Building of the Earth
Video Episode 2 - The Frozen World

For each video episode in this unit:

read the **CONCEPTS** section in the study guide
answer the **Concepts Study Questions**
watch the Video Episode
answer the **Video Study Questions**

OVERVIEW OF UNIT 1 LEARNING OBJECTIVES

Video Episode 1 - The Building of the Earth

To become acquainted with:

1. symbiosis
2. the characteristics of life
3. ecology of mountains: location, climate, characteristics, zonation, life forms and adaptations
4. volcanic activity
5. colonization process that occurs after volcanic eruptions
6. succession
7. ecology of deep sea vents: locations, characteristics, life forms and adaptations
8. ecology of hot springs: locations, characteristics, life forms and adaptations

Video Episode 2 - The Frozen World

To become acquainted with:

1. where the cold regions of the earth are located
2. the problems of living in cold climates
3. adaptations of life forms that live in cold climates
4. typical life forms that live in cold climates
5. relationship between body shape, size and cold
6. ecology of Antarctica: location, climate, characteristics, life forms and adaptations
7. ecology of the Arctic: location, climate, characteristics, life forms and adaptations
8. differences between Antarctica and the Arctic
9. tundra ecology: location, climate, characteristics, life forms and adaptations

CONCEPTS FOR EPISODE 1: THE BUILDING OF THE EARTH

MOUNTAINS AND ZONATION

One noticeable characteristic of mountains is the presence of distinct life zones. As you start at the bottom of a mountain and go towards the top, you move through different layers, each with its own particular group of plants and animals.

What causes zonation? The principal factor is temperature. As you increase **altitude,** the temperature becomes colder. Plants that live on the top of tall mountains must be able to withstand more cold than plants that live at the bottom. As the plant community changes, the animal community changes as well, since animals rely upon plants for their food. As the temperature drops, the amount of snow and ice increases.

Latitude also has an effect on zonation. If you compare a mountain in the tropics to a mountain in Colorado, you will have to go to higher altitudes in the tropics to reach the same conditions of cold. As a result, the comparable life zones are found at different altitudes. The following tables show the influence of latitude on life zones.

TABLE 1: UPPER LIMIT OF TIMBERLINE. This shows the <u>average</u> altitude (in meters) at which trees CANNOT grow.

Mountain	Location	Upper Limit of Timberline
Mt. Kilimanjaro	equatorial Africa	3,000 meters
Mt. Etna	Italy	2,200 meters
Ural Mountains	Russia	1,100 meters

(Reference: Ricciuti, E. R. 1979. *Wildlife of the Mountains*. Harry N. Abrams, Inc., NY.)

TABLE 2: ALPINE ZONE FOR DIFFERENT MOUNTAINS.
This shows the average altitudes (in meters) at which the alpine zone is found.

Mountain Name	Altitudes for Alpine Zone
Western Alps, Europe	2000 to 2800 meters
Central Rockies, North America	2600 to 3100 meters
Eastern Himalayas, Asia	4400 to 5500 meters
Mount Kenya, Africa	3300 to 4200 meters

(Reference: Ricciuti, E. R. 1979. *Wildlife of the Mountains*. Harry N. Abrams, Inc., NY.)

Other physical factors affect zonation. **Wind** can have a major impact upon plant life. Generally, winds are stronger at higher altitudes. Plants that live on high mountain peaks are buffeted by strong winds, especially when they are not insulated by snow. These plants generally are small and hug the ground, which exposes less of the plant body to the wind.

In the northern hemisphere, **southern-facing slopes** are generally sunnier, warmer and drier than **northern-facing slopes.** Other factors **- loose soil, volcanic rubble, avalanches** - can also affect vegetation.

Zonation in the Himalayas

In the tape, Attenborough begins in the deep valley and climbs upward towards the mountain peaks. He describes five distinct life zones, which are further explained below. The altitudes given are average altitudes.

(1) lower reaches of the deep valley. The climate is warm, humid and tropical. There is lush vegetation of many species, including bamboo and many rhododendron trees. Animals are numerous, including tigers, rhinoceros and many birds. Watch the tape for descriptions of the animals found here: langur monkeys, ring-necked parakeets and pheasants.

(2) 1000 meters - rhododendron trees dominate. The air is still moist but the temperature is cooler, with many warm days and cold nights. Night frosts are common. Watch the tape for descriptions of the organisms found in the cooler forests: orchids, moss, close-packed flowering plants, Himalayan panda, musk deer.

(3) 2500 to 3300 meters - coniferous forests of Himalayan fir and Bhutan pines. Animals on the tape include yellow-throated marten, Himalayan bear, ants, insects and rodents.

(4) 3300 to 4400 meters - shrubs, grasses and small cushioned flowering plants. Watch the tape for the animals who live here - bearded vultures, snowcocks, tahrs and choughs.

(5) 4400 to 5400 meters - lichens.

Above this altitude (5400 meters), there is no vegetation. The ground is covered with snow and ice.

LICHENS AND SYMBIOSIS

The meaning of **symbiosis** may be somewhat vague but it is still useful. Commonly, symbiosis refers to a very close relationship between two different organisms. In fact, the word "symbiosis" translates into "living together." Most ecologists use symbiosis to represent a relationship which (1) is required by at least one partner in order to survive or reproduce and (2) benefits at least one partner.

Symbiosis is a broad ecological term (often abused and misused) that refers to organisms living in close association with one another. There are different kinds of symbiosis: **mutualism, commensalism** and **parasitism.** In **mutualism,** both partners benefit from the relationship. In **commensalism,** one partner benefits and the other gets no apparent benefit nor is harmed. In **parasitism,** one partner (the parasite) benefits from the relationship while the other (the host) is harmed.

So what is the problem with clearly defining symbiosis? Symbiotic relationships are not always simple and straightforward. Some appear obvious. The termite cannot digest the cellulose in wood. The termite must have living one-celled organisms called flagellates in its gut to digest cellulose. The termite provides the flagellates with wood; the flagellates provide the termites with food. Seems like a clear-cut relationship, doesn't it? Further study has shown that the flagellates contain bacteria inside their bodies; it is the bacteria inside the flagellate that actually digest the cellulose. So, this is a mutualistic relationship between three species: termites, flagellates and bacteria. Everybody wins.

Not all relationships fit the definition of only one category of symbiosis. Understand that these categories are **our** attempt to make sense of what we observe in the natural world. Nature does not necessarily fit into our categories. A case in point is the symbiotic relationship found in lichens. For many years, lichens were the "classic" example of mutualism.

A lichen is formed by an association between one kind of algae and one fungus. Traditionally, it was felt that both organisms benefited from the relationship. The algae provide food by photosynthesis; the fungus provides nutrients, through decomposition, which the algae need for growth. Lichens are usually considered to be an example of mutualism. However, this is not always so clear-cut. Under some situations, the fungus eats the algae. When this occurs, the relationship then becomes parasitic.

There are other factors to consider. The algae can live without the fungus; the fungus cannot live without the algae. However, the combination of the fungus plus the algae forms a totally different "organism" (the lichen) with characteristics that are different from either partner. Many species of algae and fungi form these relationships and they are so specific that particular lichens are considered to be lichen species, each with its own specific shape, color and preference of substrate (type of rock, wood, etc.)

So, what is a lichen? Is it mutualistic or parasitic? Well, a lichen can be mutualistic at one time and parasitic at another time. Complex relationships found in nature can be very difficult to categorize.

Lichens are very important organisms in many ecosystems. Since the fungus can break down bare surfaces, such as rock or wood, the lichen is able to colonize surfaces that other organisms cannot. The algae provide the food while the lichen breaks down the substrate. As a result, the surface is changed, often providing opportunities for plants to move into the area.

In very harsh environments, such as mountain peaks, polar regions and bare rock surfaces, lichens become very important sources of food. Reindeer moss (which is a type of lichen) is even able to grow on the soils of tundra and northern coniferous forests. As you watch tapes 1 and 2, pay attention to the animals that eat lichens.

Lichens are able to absorb nutrients which are dissolved in rain and dew. Because of this, lichens are very sensitive to air pollution, especially heavy metals and acid rain. Lichens can thus be used as an indirect measure of some types of air quality. Look around Austin. Do you see lichens? What does that tell you about air quality in Austin? If lichens begin to disappear, what will that indicate?

HYDROTHERMAL VENTS

Hydrothermal vents were first discovered in 1977 by scientists examining the volcanic ridges of the Pacific Ocean floor, near the Galapagos Islands. These hydrothermal vents are deep-sea springs that release water that has been heated to very high temperatures by underwater volcanoes. In the process, the heated water picks up large amounts of sulfides. When it comes out of the hydrothermal vent, the sulfides are released into the cold deep-sea waters.

Living near the hydrothermal vents is an entire community of organisms that take advantage of the sulfide-rich waters. The sulfides are used by chemosynthetic bacteria that use the energy from sulfides to produce their own food. Giant tube worms contain bacteria in their tissues, apparently living in a symbiotic relationship. The tube worm receives food from the bacteria living in its body. In exchange, the tube worm concentrates sulfides in its blood, which are then delivered to the bacteria for processing. Other organisms - mussels, giant clams and polychaete worms - filter bacteria from the water. For a while, it was thought that this was the only system on earth that did not rely upon sunlight for energy. Recently, other enclosed ecosystems (caves) have been discovered that are also based on chemosynthetic bacteria.

Website for hydrothermal vents:
http://www.pmel.noaa.gov/vents/nemo/explorer/concepts/hydrothermal.html

Reference for hydrothermal vents:
Smith, Robert Leo. 1992. *Elements of Ecology,* 3rd edition. HarperCollins, NY.

There are numerous journal articles written about hydrothermal vents. These are two references available from the ACC Libraries:

Grassle, J. F. 1985. Hydrothermal vent animals: Distribution and biology. *Science* 229: 713-717.

Grassle, J. F. 1991. Deep-sea benthic diversity. *Bioscience* 41: 464-469.

Reference for cave ecosystem:
Discover, January 1997.

CONCEPTS STUDY QUESTIONS FOR EPISODE 1:

1. Describe the factors that affect zonation in mountains

2. Define symbiosis and state the two criteria used by ecologists to determine whether or not a relationship is symbiotic.

3. Define and compare the three different kinds of symbiotic relationship described in the CONCEPTS.

4. Describe the relationship between termites, flagellates and bacteria, including the benefit to each species in the relationship.

5. Describe the organisms that form lichens and the relationship between them.

6. Explain why it is difficult to decide whether lichens represent mutualism or parasitism.

7. Describe why lichens are sensitive to air pollution.

8. Describe a hydrothermal vent.

9. The energy that supports the organisms living near a hydrothermal vent comes from _____.

10. What kind of bacteria can use the energy in sulfides to produce their own food?

11. Describe the relationship between chemosynthetic bacteria and giant tube worms.

12. Describe the relationship between chemosynthetic bacteria and mussels, giant clams and polychaete worms.

13. Where, besides hydrothermal vents, have chemosynthetic bacteria been found?

VIDEO STUDY QUESTIONS FOR EPISODE 1:

1. In what way is the Earth unique?

2. What are the two essential requirements for life? Where is life most abundant on Earth?

3. How much of the Earth's surface is covered with water? Where did life begin?

Locator: Himalayas

4. Describe the location of the deep valley through which the Kali Gandaki River flows.

5. Describe the vegetation that is found in the deep valley. What is the climate? Why do the rhododendrons produce blossoms?

6. Describe the animal life found in the deep valleys:

    a. langur monkeys

    b. ring-necked parakeet

    c. blood pheasant

    d. tragopan pheasant (the male pheasant is called the cock and the female is called the hen)

    e. impeyanus pheasant

7. Be able to describe the changes that occur in the climate, vegetation and animal life as one moves from the valley to the highest peaks. (Be able to identify the 5 life zones.)

Locator: "As you walk higher..." [Note - about 1000 meters altitude]

8. What changes take place in the rhododendron forest? What other plant life is found here? What adaptation is seen in the flowering plants?

9. Describe the animals that are found in the cooler rhododendron forests. What adaptations are seen in these animals? What is their diet?

   a. Himalayan panda

   b. Musk deer

   c. griffon vultures

10. How does the physical environment affect the animals and plants that live in that environment? How does the vegetation influence the animal life?

Locator: Fir Forests [Note - about 2500 meters]

11. What type of trees are found in this forest? What physical factor is responsible for the lack of rhododendrons?

12. Describe the following animals and their adaptations to life in the fir forests. What is their diet?

    a. yellow throated marten

    b. Himalayan bear

Locator: 10,000 feet [about 3000 meters]

13. What is happening to the fir forest? What is different about the climate?

14. What is unusual about the Kali Gandaki River?

Locator: Village

15. Describe the following animals that are found at high altitudes. What do they eat? [Note - altitude is about 3500 meters]

    a. lammergeier or bearded vulture

    b. snow cock

    c. tahr

    d. red-billed chough

    e. yellow-billed chough

Locator: "Higher still...." [Note: about 4500 meters]

16. What type of organism can grow at very high altitudes? How long is the growing season?

17. As the altitude increases, what happens to the vegetation?

18. What other mammal (besides man) can live at very high altitudes? What adaptations are seen in animals and humans who live at very high altitudes?

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ADDITIONAL INFO: In his book, Attenborough also explains that chests and lungs are larger in highland people. Even with these changes, humans have not fully adapted to very high altitudes. Above 6000 meters, women cannot have children, according to Attenborough. The problem is providing sufficient oxygen to the developing young. (p. 18)

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19. How old are the Himalayas? When were they formed? What evidence shows that they were once at the bottom of the sea?

Locator: Iceland

20. What is basalt? How is it formed?

21. How are basalt columns, such as those found in the Hebrides, formed?

Locator: Africa

22. How are lava lakes formed?

Locator: Icelandic Volcano

23. How are volcanic islands formed?

24. Describe the ridge found on the Atlantic floor. [Note: this is called the Mid-Atlantic Ridge.]

25. Explain how the continents of Africa and South America were separated.

26. Describe the events happening to the plate that forms the eastern part of the Pacific ocean floor. Describe the trench formed at the western edge of North America. What is different about volcanic activity as a result of the trench?

Locator: Mount St. Helens

27. What was the impact of the volcanic eruption that occurred on May 18, 1980 at Mount St Helens?

Locator: "On the opposite side of the Pacific"

28. Describe the volcanic eruptions that occurred when a volcano erupted on Krakatau on August 27, 1883.

29. What was the impact of this eruption upon the climatic conditions of the earth?

30. Describe the changes that have occurred since the initial eruption, including the formation of Anak.

31. What are volcanic fumes composed of?

Locator: Underwater Volcanoes [deep sea springs or hydrothermal vents]

32. What happens to sulphurous fumes when volcanoes erupt on the ocean floor?

33. Describe the organisms that draw their energy from underwater volcanoes.

34. What is unusual about this group of organisms?

Locator: Hot Springs, New Zealand

35. How are hot springs formed? How is boiling mud produced?

Locator: Hot Springs, Yellowstone Park

36. Describe the algae mats and the community that develops on the algae mats.
(grubs are insect larvae)

37. How are the algae mats and their residents destroyed?

Locator: Rift Valley, Africa

38. What is the primary animal that harvests the single cell algae found in the hot spring lakes in the Rift Valley? How many tons of algae are harvested each day?

Locator: Basalt Lava Flow

39. How are basalt lava flows eventually colonized by plants?

40. Describe lava tunnels (actually called lava tubes). How are they formed? Describe the vegetation and animals that are found in the lava tubes. How have these animals adapted to the conditions of the lave tubes?

Locator: Mount St. Helens

41. Why is the colonization of volcanic ash difficult for plants?

42. Describe the appearance of Mount St. Helens in 1982.

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ADDITIONAL INFO: Within a short period of time, plants began the colonization period. As Attenborough explains in his book (pg 36), one flowering plant, the fire-weed, regularly colonizes volcanic ash. As fire-weed and other herbaceous plants took hold, the conditions of the ash changed. As the plants bloomed and died, their decomposing bodies provided nutrients for other plants, such as shrubs, to move into the area and become established. Within 5 years, dogwoods, blackberries and blueberries had colonized the slopes. Over time, trees may eventually replace the shrubs and flowering plants, thus replacing the original forests that were destroyed.

This illustrates the ecological concept of **succession.** Succession refers to change in community structure over time. The first plants to move into an area are usually called **pioneer** species. As the conditions change, pioneer species are usually replaced by other plants that can now grow in the "changed" conditions. As new plants move in, the environment continues to change. Often, this continues until the **climax community** moves in. The climax community is a mixture of plants that will grow and be replaced by their own offspring, as opposed to other types of plants. Once the climax community is established, succession is over ... until a disturbance (such as fire or drought or hurricane or volcanic eruption) occurs.

Check out more recent information (and pictures) about the recovery of this area at:
http://www.fs.fed.us/gpnf/mshnvm/ Then, click on 25 years of Change.

Question from the video: Name one pioneer plant from Mount St. Helens.

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Locator: Krakatau's Child (Identified as Anak earlier in the tape)

43. Describe the conditions of Anak. What plants have colonized this relatively new island? (the name of the tree is casuarina)

Locator: Rakata (island remnant of Krakatau)

44. Describe the changes in vegetation and animal life that have occurred on Rakata, the remaining island fragment of Krakatau, since the volcanic eruption 100 years ago.

45. Which types of animals are NOT found on Rakata?

Locator: Indian Plate Moving Towards Asia (Return to Himalayas)

46. How did the movement of continental plates create the Himalayas?

47. How fast is the Indian plate still moving north into Asia?

48. Are the Himalayas growing, shrinking or staying the same?

49. How was the valley formed by the Kali Gandaki River?

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ADDITIONAL INFO: The subjects of molten centers, continental plates and plate movements is nicely covered in the January 1996 issue of *National Geographic* (pages 100-111). The May 1998 issue of *National Geographic* also discusses the Earth and includes an incredible map supplement entitled the Physical Earth showing plate movements.

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CONCEPTS FOR EPISODE 2: THE FROZEN WORLD

COLD AND WINDY PLACES

There are three regions of the Earth that experience extremely cold and windy conditions. These are (1) high mountain peaks, (2) polar regions, and (3) tundra.

Polar regions are areas where surface ice and snow remain frozen year round. There are two polar regions: Antarctica and the Arctic Ocean. Antarctica is the huge polar continent of the Southern Hemisphere. It is surrounded by a permanent ice pack and the land is permanently buried by a mile or so of glacier ice. The Arctic Ocean is the ocean that covers the North Pole, which has a permanent ice pack on its surface.

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Authors' Note: The region on Earth is the Ar**c**tic. Artic is an ice-beer. Why is this word butchered by the beer company? Well, your guess is as good as ours. Perhaps, no one taught the ad people how to spell. Perhaps there is a trademark on "Arctic". Perhaps someone thought it was cute. In this class, if you misspell Ar**c**tic (place) as Artic (beer), your answer will be graded on the basis of the beer.

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Tundra is found in areas where the climate is warm enough in summer to melt surface ice and snow and thaw a few inches of the soil. A permanently frozen layer (the permafrost) is located beneath the surface of the soil. Arctic tundra occurs on the northernmost lands of North America and Eurasia. Between the arctic tundra and the North Pole is the frozen pack ice described above. Alpine tundra occurs high on mountains, but not necessarily on top of the mountain. On the tops of very high mountains the snow never melts and the soil, if there is any, never thaws. Tundra only refers to areas where the surface soil thaws briefly in the summer

All three regions experience intense cold and high winds. The polar and arctic tundra regions experience long periods of darkness as well. The earth's axis points toward the sun in the summer and away from the sun in the winter. During the winter, within 30 degrees of the pole, there is complete darkness for several months.

The polar regions were not always cold. 140 million years ago, the polar regions were warmer because the continents were located in different positions. This allowed the ocean currents to bring warm water all the way to the poles, preventing the water there from freezing.

At that time, the continent of Antarctica wasn't at the South Pole, either. It was part of a supercontinent called **Gondwana,** along with South America, Africa, Australia and New Zealand. Gondwana was located close to the equator. Then the continents split apart and drifted away from each other. Antarctica moved to its present position over the south pole, cutting off the flow of warm ocean currents, freezing the oceans around the continent and creating the intensely cold, windy conditions that exist there today.

PROBLEMS THAT FACE ORGANISMS THAT LIVE IN COLD PLACES

Two main problems face organisms living in extremely cold places. First, extreme cold kills cells. When the liquid water inside a cell freezes and ice crystals form, the cell membrane and/or cell walls rupture as the ice crystals expand, killing the cells.

Extreme cold also slows down vital biochemical reactions. The rate at which chemical reactions occur is dependent on temperature. This rule applies not only to simple chemical reactions in a chemistry laboratory, but also to the complex biochemical reactions that occur inside living organisms. Up to a certain point, the higher the temperature, the faster a chemical reaction will run. Applied in reverse, the lower the temperature, the slower the chemical reactions, which can be a serious problem to living things.

In many animals, such as lizards and insects, body temperature is controlled in part by the temperature of the environment and in part by behavior. These animals are called **ectotherms.**

At night, a lizard's body temperature falls and it becomes sluggish as the biochemical reactions that fuel its muscles slow down. During the day, it basks in the sunlight to raise its body temperature to a level at which its biochemical reactions can occur at a rate fast enough that it can become active and hunt for food.

In extremely cold conditions, the lizard faces two problems. Body temperature becomes so low that its biochemical reactions become extremely slow. Also, its cell membranes would solidify to the point that its nerves would not be able to transmit signals. Without a properly functioning nervous system, the lizard would not be able to regulate important body processes, such as breathing and heart rate. The lizard would die.

Birds and mammals have a different approach to solving these same problems. They do not rely on the sun to heat them up. They generate their own body heat by burning lots of fuel inside their cells. These animals are called **endotherms.**

Because they generate their body heat internally, they can survive at cold temperatures without their biochemical reactions slowing down. However, they can only survive if they can find enough food to fuel the furnaces inside their cells. As the temperature drops, more heat is lost from the surface of their bodies, and the lost heat must be replaced by eating more food. If they cannot meet the high demands for food, they will begin to cool off.

Unlike lizards and insects, birds and mammals cannot tolerate large changes in their body temperature. Their brain and other complex organs are fine-tuned to normal body temperature and will not operate properly if the body temperature is a few degrees higher or lower than normal. Thus, only a small amount of cooling will cause these organs to fail in carrying out their usual functions. Without these organs working properly, the animal dies.

ADAPTATIONS TO THE PROBLEMS OF LIVING IN COLD PLACES

Organisms have evolved a variety of solutions to solve these problems. One solution is adding **antifreeze** to body fluids. This is one way to prevent ice from forming. Antifreeze lowers the freezing point of water by adding chemicals to the water. For example, automotive antifreeze contains the chemical ethylene glycol which, when added to the water in a car radiator, lowers the freezing point so that the water will not freeze and rupture the radiator. The animals still get very cold, it's just that their body fluids don't freeze as readily when they contain some kind of antifreeze.

In animals, antifreeze molecules are chemicals that lower the freezing point of the body fluids and prevent ice crystals from forming within the body. For example, the blood of the Antarctic icefish, *Trematomus*, contains a glycoprotein that is 200-500 times more effective than salt at lowering the freezing point of water. Watch for other examples of animals that use antifreeze in the videotape.

Insulation is another solution to these problems. Endotherms use layers of insulation to trap as much of their body heat as possible next to the surface of their skin. By trapping heat in this way, the animals do not have to eat as much to replace lost heat.

Mammals use **fur** as insulation. In mammals that live in cold areas, there are two layers of fur. The outer layer consists of **guard hairs,** usually long and coarse. The inner layer, the **undercoat,** consists of a thick layer of fine wooly hairs. The undercoat traps air in the spaces between the hairs. Air does not transmit heat very readily, so the trapped air prevents the rapid loss of heat. Mammals that live in extremely cold climates have thicker fur than those that live in less frigid areas. Humans have taken advantage of this in the past by hunting the animals of the Arctic regions for their fur to make insulating layers (coats) for people.

All mammals can make their insulating layer thicker by fluffing up their fur. Tiny muscles at the base of each hair contract, pulling the hair more perpendicular to the skin, and making the insulating layer thicker. The fur traps more air, and less heat is lost. Many mammals change the thickness of their insulating layer with the seasons. They grow a thick undercoat as winter approaches, and shed it in the spring, as warmer weather approaches. Look for the following examples of fur as insulation as you watch the videotape: the snow leopard, the hyrax, the vicuña and the guanaco, and the fur seal.

Birds use **feathers** as insulation. Again, there are two layers of feathers. The outer layer consists of **contour feathers.** Contour feathers are smaller versions of the familiar wing feathers. They cover the inner layer of feathers, the down. **Down feathers** do not have a long quill or vanes like wing and contour feathers do. Instead, they have a short quill with fluffy tufts that excel at trapping air, thus establishing an insulating layer just like in the mammals. Humans have long taken advantage of the insulating properties of down feathers by plucking geese and ducks and using the down

in feather pillows, coats, mattresses, etc. Birds can fluff their feathers to increase the thickness of the insulating layer, so on a cold day, they look larger than on a warm day. Look for the sunbirds fluffing up their feathers as you watch the videotape.

Swimming birds and mammals have more trouble with insulation than land animals, because water is much more efficient at transmitting heat than the air. Thus, birds and mammals that swim tend to have thick insulation layers. Penguins are swimming birds. Their feathers are especially adapted to provide excellent insulation. Long and thin, with tips that point inward towards the body, the contour feathers have tufts at the base that mat together to make a barrier that water cannot penetrate. They also have feathers covering almost their whole bodies, including almost all the way down their legs. Adelie penguins even have feathers on their beaks! Most birds do not have such complete coverage.

Another type of insulation is **blubber.** Blubber is a thick layer of fat underneath the skin that forms a blanket trapping heat within the body. (Like air, it transmits heat less efficiently than water.) The whales are a great example of mammals that use blubber for insulation. Whales have little body hair and rely on blubber for all their insulation as they swim in cold ocean water. Consequently, their blubber layers are very thick. Humans have taken advantage of whale blubber in the past, by using the blubber to produce whale oil which was burned in lamps. Even today, the Inuit (Eskimos) hunt whales and consider the blubber an excellent food. Look for these animals which use blubber as insulation as you watch the videotape: the true seals, such as the elephant seal, and the penguins. Be sure to note how their blubber allows the elephant seal to dive to great depths, and why the fur seal must stay in surface waters.

Animals are not the only organisms that use insulation to protect themselves from the cold. When you watch the videotape, note how the two different species of lobelia use different methods of insulation to protect themselves from freezing temperatures.

Body size can also be a solution to the problems of extreme cold. Large animals have a smaller amount of surface relative to their volume than do smaller animals. Thus, they have less surface across which heat can escape, and they lose heat less rapidly to their environment than do small animals. Therefore, animals that live in extremely cold areas are often larger than their relatives that live in milder climates. Look for these examples as you watch the videotape: the polar bear, the king penguin and the emperor penguin.

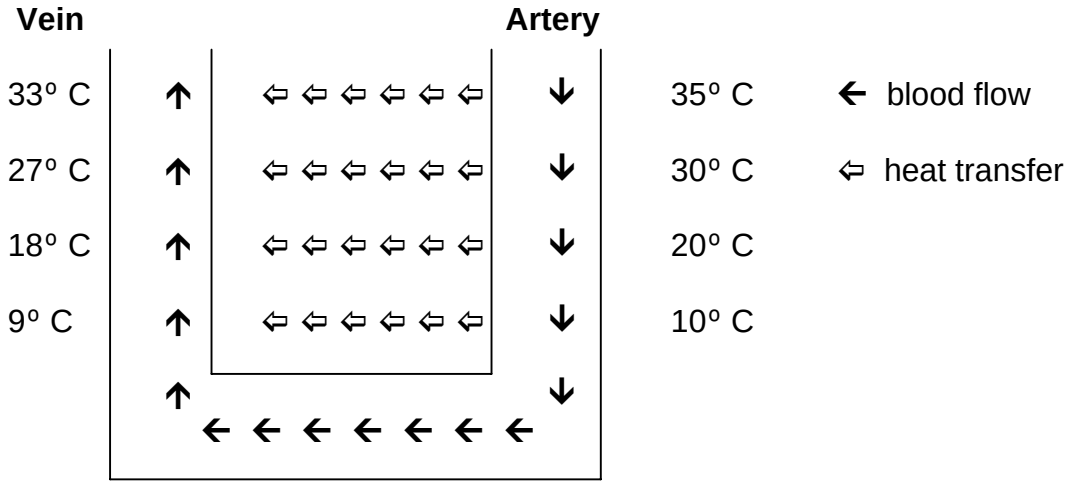
The **coloration** of an organism can help it protect itself from the intense cold. Dark colors such as black or deep brown absorb most of the light that hits them. The light energy is transformed into heat that can be used to warm an animal or plant. Light colors, on the other hand, reflect much of the light that hits them. Look for the following examples of organisms that use dark colors to help them stay warm as you watch the videotape: the primitive insects that live at high altitude on mountains; blue-green algae in Antarctica.

The color of an organism can also be used for other purposes. Many animals use **camouflage,** in which their coloration matches that of the background. Animals that hunt use the camouflage to avoid being seen by their prey, and plant-eating animals use camouflage to avoid being eaten by predators.

Many mammals and birds that live in snowy places are white to match their white background. Because they generate their own body heat, they do not need dark coloration to help them stay warm. Mammals and birds that live in tundra areas where the snow melts in the summer often change their coloration from white to brown so that they remain camouflaged. Look for the following animals that use coloration for camouflage while you watch the videotape: the Arctic fox, the polar bear, the snowy owl, the ptarmigan. Which of these animals change colors with the seasons?

Polar bears are well camouflaged by their white coloration. And they use it to ambush seals, as you will see as you watch the videotape. But their white coloration is an exception to the rule of white reflecting more light. They look white because their hair is transparent, which allows the sunlight to penetrate their thick fur to the skin, where the light is absorbed and transformed into heat which is used to warm the body.

Birds that live in the polar regions do not have feathers on their feet or, except for penguins, on their legs. Because they lack insulation in these areas, it seems like they should lose a lot of heat through their feet. They can stand barefoot on a glacier and not freeze to death because of the arrangement of blood vessels in their legs. Arteries bring warm blood from the body to the feet and veins return cold blood from the feet to the body. As they return to the body, the veins pass close to the arteries. **HEAT** is transferred from the warm blood in the arteries to the cold blood in the veins, and is carried back into the body instead of being lost to the environment. This is called **countercurrent exchange,** the exchange of materials or heat between two fluids flowing in opposite directions. [**PLEASE NOTE: HEAT** is transferred, not blood.]



Hibernation is another method used by animals to deal with extremely cold conditions. When an animal hibernates, it finds a safe place, usually a protected burrow or other hole in the ground, and settles in for the winter. The animal's **metabolic rate** (the rate at which it burns fuel) decreases and its body temperature drops. By decreasing its metabolic rate, it can avoid eating during a time of the year when food would be very difficult to find.

Many of the tundra area residents do not stay there year round. They escape the extreme cold through **migration.** The winters are too severe, so they migrate towards the equator to less severe climates. You may wonder why they ever go to the tundra at all. They migrate to the tundra areas in the summer to breed because food is very abundant and, because the sun does not set, they can feed all day long.

DIFFERENCES BETWEEN ANIMAL COMMUNITIES OF THE ARCTIC AND ANTARCTIC

Even though they are both polar regions, the animal communities of the Arctic and Antarctic regions differ in many ways. In Antarctica, there are no large terrestrial predators. Once animals such as seals and penguins are on the land, they are relatively safe from predators. (However, their young are still vulnerable to predators such as the skua, a large predatory seagull which attacks penguin chicks and eggs, or to other members of their species, such as the large bull seals which may trample or attack seal pups.)

Why aren't there any large terrestrial predators in Antarctica? No large terrestrial predators were present on the continent when it split from the rest of Gondwana. Because it is isolated from other continents by the Southern Ocean and because its climate is so harsh, no large terrestrial predators have been able to colonize the area.

The Arctic region does have large terrestrial predators such as the polar bear and the Arctic fox. In this area, the large continents of North America, Europe and Asia extend into the Arctic region from warmer regions further south. Large terrestrial predators have been able to move into this area. Thus, the animals that live in the Arctic must have adaptations for defense against these large predators. An example is the guillemots and auks; although they look and behave much like penguins, they have retained their powers of flight, which they can use to escape from large terrestrial predators.

The lack of isolation of the Arctic region also means that land animals such as the caribou can migrate to and from the area. They migrate north in the summer to take advantage of the rich food supply and south in the winter to escape the harshest cold and windy conditions. Many Antarctic animals migrate, too, but they must all be able to swim or fly.

CONCEPTS STUDY QUESTIONS FOR EPISODE 2 (The Frozen World):

1. Describe and compare the two polar regions with respect to types of ice and presence or absence of land.

2. Compare the locations of arctic and alpine tundra.

3. Describe the two main problems for organisms living in extremely cold places.

4. Compare ectotherms and endotherms. Describe the advantages or disadvantages of being an ectotherm or an endotherm living in a cold climate.

5. Describe the various adaptations to cold that are used mostly by endotherms.

6. Compare the animal life of the Arctic and the Antarctic.

VIDEO STUDY QUESTIONS FOR EPISODE 2 (The Frozen World):

Locator: Mt. Rainier

1. What is the significance of red snow? How do these organisms produce food? What do they need in order to grow and reproduce?

2. Describe the yearly movements of ladybugs at Mt. Rainier.

3. What do the permanent insect residents use as food?

4. What is unusual about the grylloblattids?

Locator: Mt. McKinley

5. How do the other animal inhabitants, such as the Dahl sheep and ground squirrels, cope with the winter months?

6. What are the problems that face plants that live on steep, high slopes?

Locator: Himalayas

7. Describe the blue sheep.

8. Describe the snow leopard and its adaptations to life in the cold mountain environment.

Locator: Mountains of Africa

9. At what altitude do you find the giant groundsels and giant lobelias?

10. What conflicting problems do plants that live on Mt. Kilimanjaro and Mt. Kenya face?

11. Describe the lobelias that form rosettes. How do they protect themselves from freezing and desiccation?

12. How do the tall lobelias protect themselves from freezing and desiccation?

13. Describe the sunbirds. What is their relationship to lobelias?

14. Describe the hyrax that live among the rocks. Why do they come out during the day?

Locator: Mountains of South America

15. How do these mountains differ from the mountains in Africa?

16. Describe the vicuña and its adaptations to mountain life.

17. What is the guanaco? How do the people of the Andes use it? At what altitudes does it live?

18. What change occurs to the permanent snowline of the Andes as you start at the equator and travel south, towards Patagonia and Tierra del Fuego?

19. Explain why the poles are colder than the equator.

Locator: South Orkneys

20. Describe the two flowering plants that are found on these remote cold islands. (The name of one of the plants is “thrift”)

21. How do the mosses and lichens survive the extreme cold of these remote islands? What animals live in the mosses and lichens? How do they survive?

22. How is pack ice different from the ice in icebergs?

Locator: Antarctica

23. Describe the valleys found in the interior of Antarctica. What are the conditions in these valleys? How does this differ from the rest of Antarctica?

24. Describe the life forms that live between the valley stones. How have they adapted to the harsh conditions?

Locator: Antarctic Glaciers

25. How are pools and streams formed in the Antarctic interior?

26. What life forms are found in these pools and streams? How do they get food?

Locator: Antarctica Coast

27. Where does life flourish in the Antarctic?

28. Describe the fur seals. What do they eat? How do they differ from true seals? What adaptations allow them to swim and feed in the surface waters?

29. Why are fur seals not able to dive to great depths?

30. Describe the elephant seals and their adaptations to the cold waters. What do they eat?

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CLARIFICATION: Elephant seals are **one** type of "true seal".

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31. Why do the elephant seals have to leave the water once a year?

Locator: South Georgia

32. Where did penguins evolve? Where are penguins found today?

33. What adaptations are found in penguins?

34. What are some of the differences between these penguins: Macaroni penguins, jackass penguins, king penguins and emperor penguins.

35. What is the advantage of large size? What is one disadvantage that faces king penguins?

36. Describe the Emperor penguins.

37. Describe the manner in which Emperor penguins incubate their eggs and rear their young. What is unusual about the timing?

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ADDITIONAL INFO: There is an excellent emperor penguin article in the March 1996 issue of *National Geographic*.

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Locator: North Pole

38. Describe the guillemots. What adaptations are seen in the auk family?

39. Why do auks and penguins look similar? Are they closely related?

40. How is the Arctic different from the Antarctic? How does this affect the animal life of the Arctic?

41. Describe the Arctic fox. What does it eat?

42. Describe the polar bear. What do they eat? What are polar bears related to?

43. What adaptations to cold are found in the polar bears?

44. What Arctic animals are scavengers?

45. Why do ringed seals have ice holes? What is the problem with having regular ice holes?

46. Describe the old lifestyle of the Eskimos (Inuit).

47. What conditions are responsible for the cold, enclosed polar seas? What effect does this have on the nearby land masses?

Locator: The Tundra

48. Describe the tundra.

49. What causes ridges shaped like polygons to form in the tundra?

50. What is permafrost? What makes permafrost a significant factor in the tundra ecosystem?

51. How is a pingo formed?

52. How long is the summer growing season in the tundra?

53. How have small flowering plants adapted to life on the tundra?

54. What tree is found growing on the Arctic tundra? What is unusual about this tree?

55. Describe the lemming. What is unusual about their reproductive capability?

56. What is the major predator of the lemming?

57. Describe the migration of the caribou. Why do they migrate north? Why do they return south in the fall?

58. Describe the migration of the snow geese. Why do they migrate north? Why do they migrate south in the fall? Where do they spend the winter? (Note: a gosling is a young goose)

59. What type of animal is a ptarmigan? What do ptarmigan eat?

60. What do caribou eat?

61. Describe the insects that grow during the summer: mosquitoes and black fly.

62. What does the red-necked phalarope eat?

63. A square yard of fresh water in the tundra can produce _____ insects in a season.

64. How do caribou sustain themselves over the winter? Where do they spend the winter?