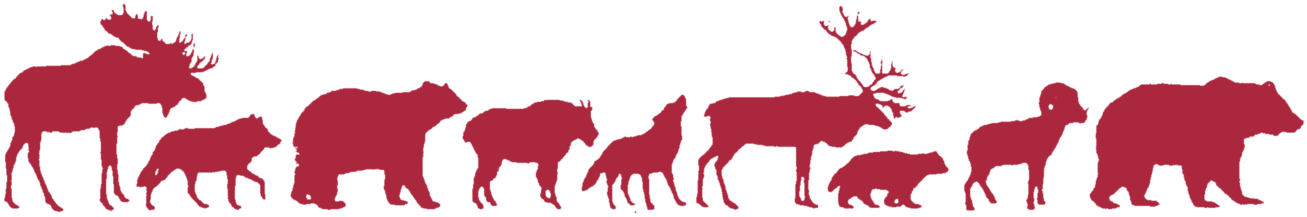
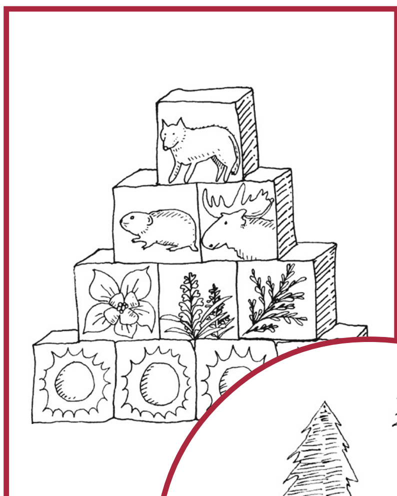


Alaska's Ecology

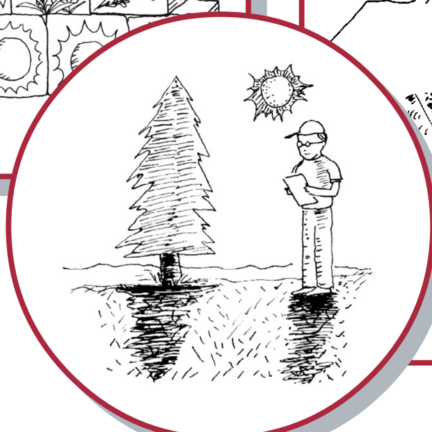
ALASKA WILDLIFE CURRICULUM TEACHER'S GUIDE



K-12

Teacher Background Information, Illustrations, and Resources, Student Activities and Investigation

Correlated to the State Standards



Alaska Department of Fish and Game

Alaska's Ecology

REVISION 2018

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The *Alaska Wildlife Curriculum* is a resource for educators teaching today's youth about Alaska's wildlife. We dedicate this curriculum to you and your students.

Alaska's Ecology was revised from the original 1986 unit "Web of Life" of the Alaska Department of Fish and Game's Alaska Wildlife Week series. Alaska's Ecology is from a set of materials called Alaska Wildlife Curriculum. The following materials are currently available:

Alaska's Forests and Wildlife
Alaska's Tundra and Wildlife
Alaska's Wildlife for the Future
Alaska Ecology Cards

Susan Quinlan, Alaska Department of Fish and Game, wrote, illustrated and produced the original Alaska Wildlife Week materials on each of the above topics. Each has been revised.

The Alaska Department of Fish and Game has additional information and materials on wildlife conservation education. We revise the Alaska Wildlife Curriculum periodically. For information, or to provide comments on this book, please contact us:

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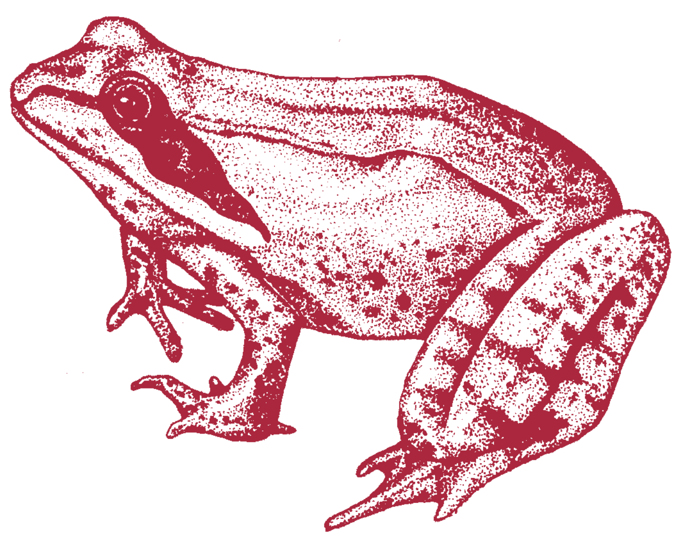
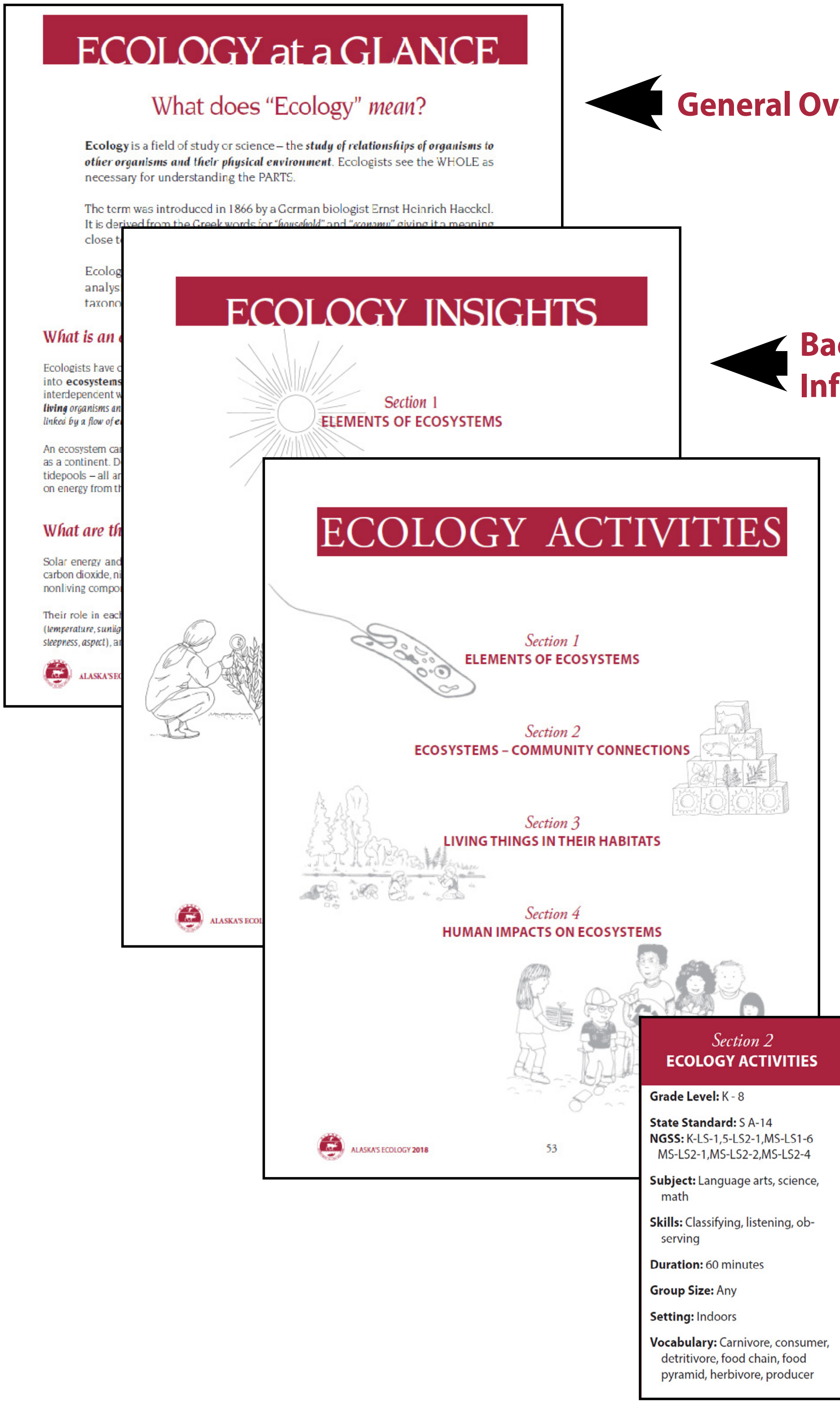


Alaska's Ecology is dedicated to the memory of Val Chabot

Val was the kind of teacher whose enthusiasm for the natural world inspired her students and everyone around her. She motivated students to recognize, celebrate, and take responsibility for their roles in ecosystems. Val edited and improved these teaching materials after she moved to Alaska in 1993.

Val's accidental death in 1994 while banding peregrine falcons in Interior Alaska was a profound loss for education. We hope this booklet and other materials in the Alaska Wildlife Curriculum will inspire and support teachers like Val.

How to use this curriculum



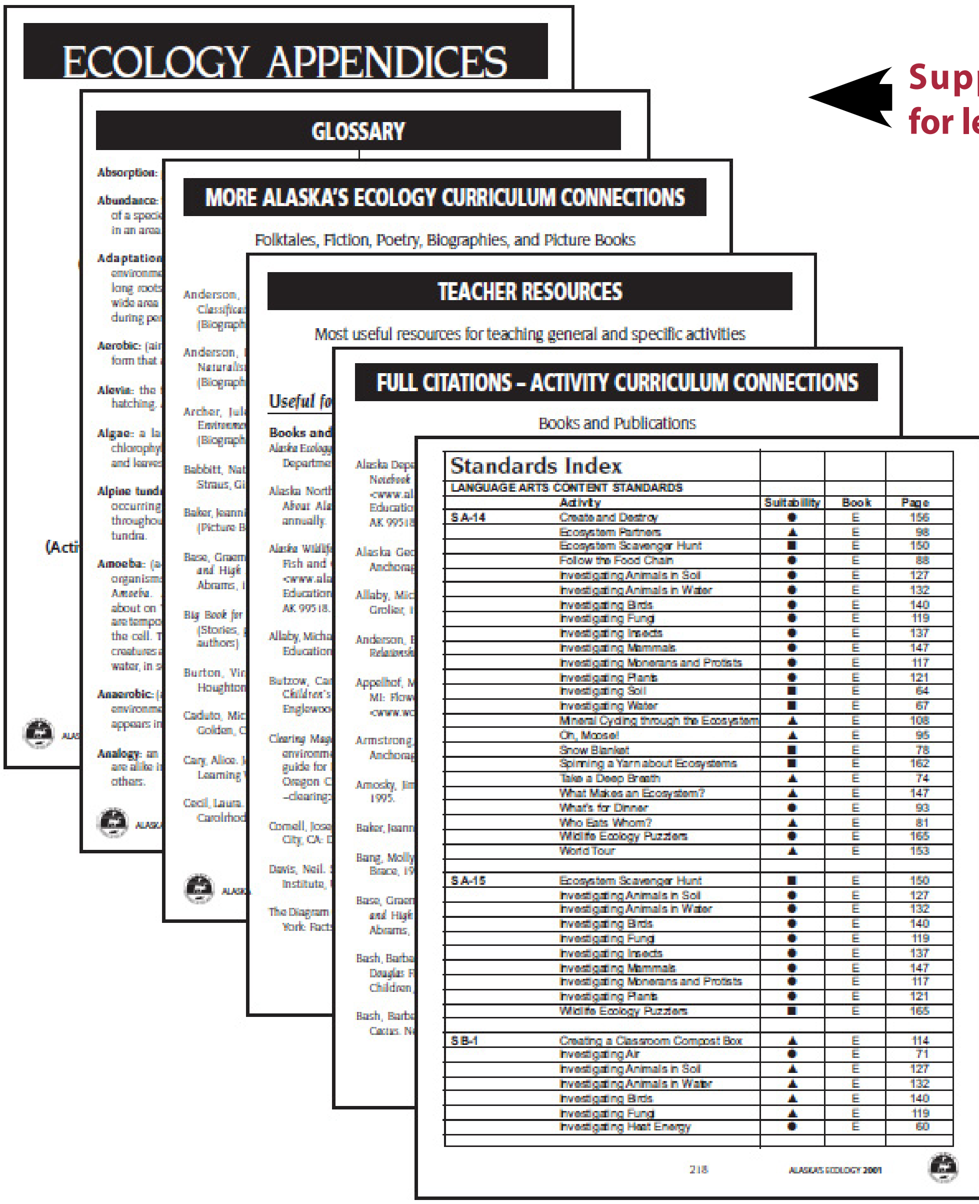
General Overview

Background Information

Activities

Student activity boxes provide a quick planning reference

How to use this curriculum CONTINUED



Standards Index

LANGUAGE ARTS CONTENT STANDARDS	Activity	Suitability	Book	Page
S A-14	Create and Destroy	●	E	156
	Ecosystem Partners	▲	E	98
	Ecosystem Scavenger Hunt	■	E	150
	Follow the Food Chain	●	E	88
	Investigating Animals in Soil	●	E	127
	Investigating Animals in Water	●	E	132
	Investigating Birds	●	E	140
	Investigating Fungi	●	E	119
	Investigating Insects	●	E	137
	Investigating Mammals	●	E	147
	Investigating Monerans and Protists	●	E	117
	Investigating Plants	●	E	121
	Investigating Soil	■	E	64
	Investigating Water	■	E	67
	Mineral Cycling through the Ecosystem	▲	E	108
	Oh, Moose!	▲	E	95
	Snow Blanket	■	E	78
	Spinning a Yarn about Ecosystems	■	E	162
	Take a Deep Breath	▲	E	74
	What Makes an Ecosystem?	▲	E	147
	What's for Dinner	●	E	93
	Who Eats Whom?	▲	E	81
	Wildlife Ecology Puzzlers	●	E	165
	World Tour	▲	E	153
S A-15	Ecosystem Scavenger Hunt	■	E	150
	Investigating Animals in Soil	●	E	127
	Investigating Animals in Water	●	E	132
	Investigating Birds	●	E	140
	Investigating Fungi	●	E	119
	Investigating Insects	●	E	137
	Investigating Mammals	●	E	147
	Investigating Monerans and Protists	●	E	117
	Investigating Plants	●	E	121
	Wildlife Ecology Puzzlers	■	E	165
S B-1	Creating a Classroom Compost Box	▲	E	114
	Investigating Air	●	E	71
	Investigating Animals in Soil	▲	E	127
	Investigating Animals in Water	▲	E	132
	Investigating Birds	▲	E	140
	Investigating Fungi	▲	E	119
	Investigating Heat Energy	●	E	60

218 ALASKA'S ECOLOGY 2001

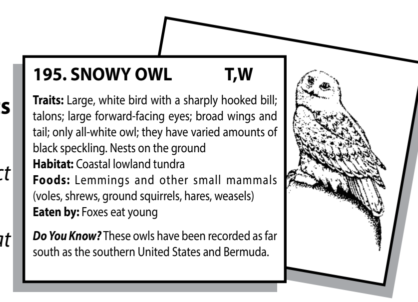
Support materials for lesson planning.

ALASKA ECOLOGY CARDS

Alaska Ecology Cards **– Student-directed learning resources in ready-to-copy sheets applicable to all books in the** ***Alaska Wildlife Curriculum***

Several lessons require or may be improved by use of the Alaska Ecology Cards. *To order, contact the Division of Wildlife Conservation/Wildlife Education.*

For more animal facts, refer to the Alaska Wildlife Notebook Series *available on the Web at* **www.adfg.alaska.gov**



Alaska's Ecology

Table of Contents

Student Activities

ECOLOGY AT A GLANCE

What does "Ecology" *mean*?

Ecology is a field of study or science – the ***study of relationships of organisms to other organisms and their physical environment***. Ecologists see the WHOLE as necessary for understanding the PARTS.

The term was introduced in 1866 by a German biologist Ernst Heinrich Haeckel. It is derived from the Greek words for "household" and "economy" giving it a meaning close to the *economy of nature*.

Ecology draws on many other sciences including climatology, hydrology, soil analysis, oceanography, physics, chemistry, geology, biology, physiology, taxonomy, and mathematics.

What is an ecosystem?

Ecologists have classified the world's environments into **ecosystems** and each can be studied as an interdependent whole. An ecosystem *is the complex of* ***living*** *organisms and their* ***nonliving*** *(physical) environment linked by a flow of* ***energy*** *and a cycling of materials*.

An ecosystem can be as small as a pond or as large as a continent. Desert, rainforest, tundra, wetlands, tidepools – all are examples of ecosystems. All run on energy from the sun.

What are the nonliving parts?

Solar energy and elements such as water, oxygen, carbon dioxide, nitrogen, and other nutrients are vital nonliving components of every ecosystem.

Their role in each ecosystem is shaped by **climate** (temperature, sunlight, wind, rain), **topography** (elevation, steepness, aspect), and **soil** (composition, depth, permafrost).

What are the living parts?

All nonliving elements determine what living things can survive in each ecosystem.

There are five kingdoms of living things – from microscopic, one-celled organisms (**monerans** and **protists**) to mosses and trees (**fungi** and **plants**) to 80-foot-long whales (**animals**). All five kingdoms exist in Alaska.

How does energy link the system?

Producers (green plants and algae) can make their own food energy from the nonliving environment – solar energy, carbon dioxide, and water – through the process of **photosynthesis**. All other life forms **consume** this energy, either directly or indirectly.

Herbivores (moose, snowshoe hares, some whales, geese) are the next link in a **food chain** as they eat the producers. **Carnivores** (humans, wolves, hawks) eat herbivores and other carnivores. **Omnivores** eat both herbivores and carnivores.

Last in a food chain are **detritivores** or **decomposers**. They obtain their energy by eating waste materials and dead organisms. Detritivores are a critical link in all ecosystems because they return minerals stored in the food chains to the soil for reuse by producers. Without detritivores, producers would soon run out of the minerals they need to make food, and an ecosystem would smother in tons of debris.

Are there other interactions?

Any organism that can get more water, more minerals, more energy, more space, or better shelter than its neighbors will grow better and leave more offspring. **Competition** can occur within and between species.

Opposite of competition is **symbiosis** — when at least one of two organisms cannot survive without the other.

Symbiosis takes three forms: mutualism, commensalism and parasitism. **Mutualism** is a symbiosis where both of the organisms involved benefit by living together. **Commensalism** is a symbiosis in which one of the organisms involved benefits, and one is not affected. **Parasitism** is a symbiosis where one of the organisms (the parasite) benefits, while the other (the host) is harmed.

What impacts ecosystems?

Change comes from three general sources: **physical elements** such as floods, drought, volcanic eruptions, fire, and earthquakes.

Biological catalysts such as population explosions of a species. The most visible example is the spruce bark beetle outbreak that killed white spruce trees in Alaska's forests.

Human-caused change has been accelerating in the past century. We are responsible for changes varying from extinction of species *(the Steller's sea cow in Alaska, for example)* to clearing of forests or filling of wetlands to pollution that spreads through many ecosystems.

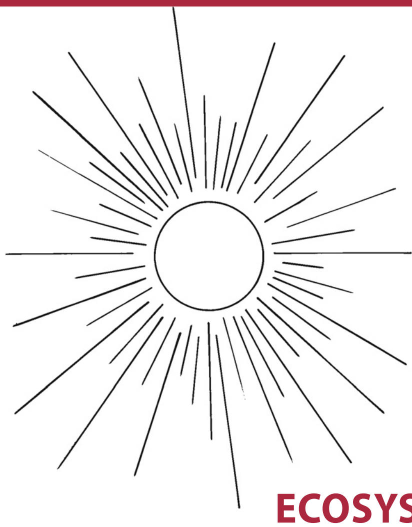
What about the future?

The variety and abundance of living organisms in an ecosystem or habitat – its **biological diversity (biodiversity)** – can provide flexibility to withstand some damage or change. The greatest threat to biodiversity is loss of habitat.

Because all living things are inter-connected within their ecosystem, impact has a radiating effect. Removing a species or a habitat shakes the whole web of life.

We are still learning about all the interactions in ecosystems. Our decisions and actions regarding wildlife and habitat today may have consequences tomorrow that we do not currently understand.

ECOLOGY INSIGHTS



Section 1

ELEMENTS OF ECOSYSTEMS

Section 2

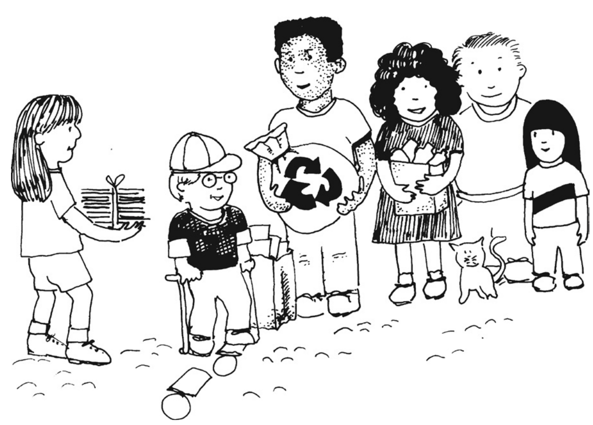
ECOSYSTEMS - COMMUNITY CONNECTIONS

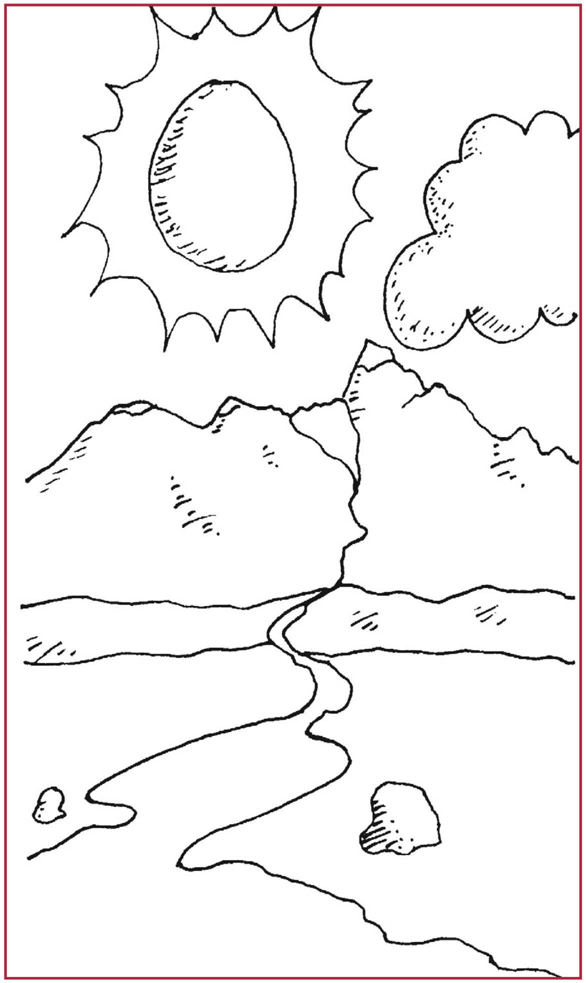
Section 3

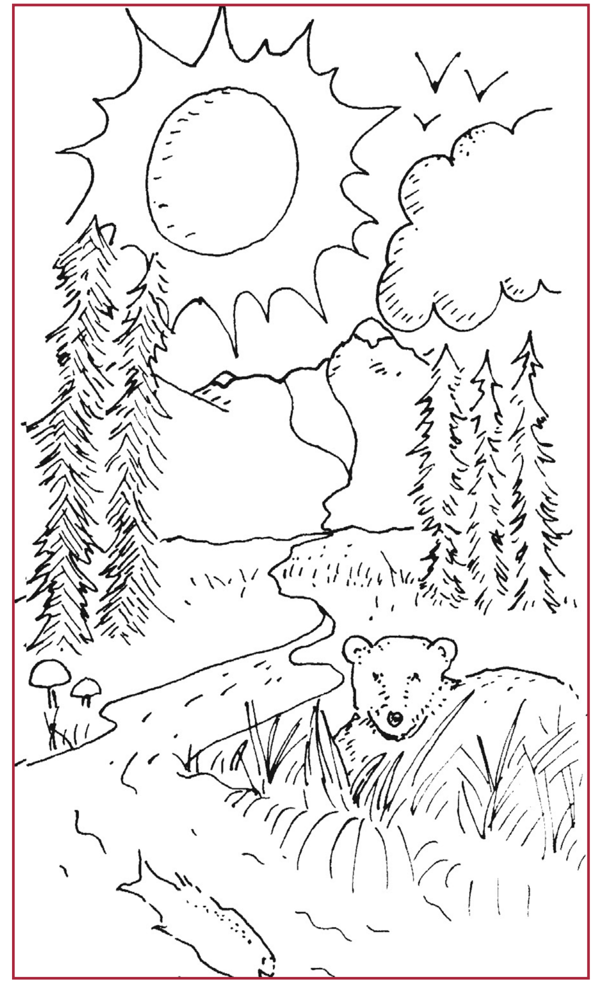
LIVING THINGS IN THEIR HABITATS

Section 4

HUMAN IMPACTS ON ECOSYSTEMS







NON-LIVING THINGS + LIVING THINGS + ECOSYSTEMS

Elements of ECOSYSTEMS

Section 1
ECOSYSTEM INSIGHTS

Climate (temperature, sunlight, wind, rain), topography (elevation, steepness, aspect), and soil (composition, depth, permafrost) are the major nonliving elements that shape ecosystems for all living things and the energy exchange that links them.

Imagine a landscape devoid of living things. In a way, a lunar landscape, but with familiar landmarks. That is the canvas for painting an ecosystem – the complex of living organisms and their physical environment. These living and nonliving elements are linked by a flow of energy and a cycling of materials.

An ecosystem can be as small as a pond or as large as a continent. Prairie, rainforest, tundra, wetlands, coral reef – all are examples of ecosystems. All run on energy from the sun.

SUN'S ENERGY - ESSENTIAL FOR LIFE

Energy from the sun heats the surface of the earth to temperatures where life can exist. Both the amount of energy that reaches the surface and the duration of time the energy is present determine the **temperature**. The tilt of the earth's axis changes both of these factors on a daily and seasonal basis. This sets the stage for world **climate** differences, a major determinant of whether our local ecosystem is tundra, trees, or desert.

CLIMATE & ECOSYSTEMS

The sun's energy not only warms the environment to a degree where life can occur, but is a key ingredient in **photosynthesis** (food production from light energy, water, and carbon dioxide). This food production serves as the foundation for all life.

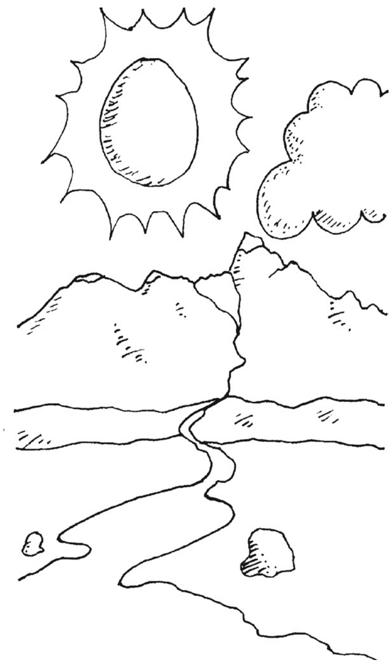
Photosynthesis Process. Plants and fungi absorb photons of sunlight from dawn to dusk. The energy contained in the photons is used by the cells to restructure chemical bonds and manufacture food sugars from mineral nutrients and water from the soil and carbon dioxide from the air.

Winter Dormancy. Plants cannot photosynthesize at temperatures below 19.4°F (-7°C). Other metabolic processes such as respiration also do not occur at temperatures much below this point. When cold temperatures and meager sunlight halt photosynthesis, growth stops and plants become dormant.

Summer Growth Surge. When temperature and sunlight allows, Alaska's plants grow more rapidly in order to complete their cycle in the short time available. Scientists studying white spruce in Alaska and Massachusetts found that the Alaska trees produced the same number of a certain cell, but in half as much time.

Comparative Study. Ironically, when scientists moved Alaskan trees to the Lower 48, they grew very slowly. In order to make them grow as fast as they do in Alaska, the length of daylight has to be increased to match Alaska summers.

ALASKA'S LANDSCAPE ICE AND FIRE



Glaciers and volcanoes have played major roles in shaping Alaska's landscape. About 100,000 glaciers still exist in Alaska, covering about 29,000 square miles or 5 percent of the state. Active volcanoes number more than 80.

Superlatives. Alaska's 365 million acres encompass about 34,000 miles of marine coastline, more than 3 million lakes, 39 mountain ranges (including North America's tallest mountain at 20,320 feet), places with more than 200 inches of precipitation annually, and places receiving as little as 5 to 7 inches of total precipitation.

Extremes. Alaska spans the latitudes of 51°13' to 71°23' north. The state experiences temperatures ranging from the 30s to 90s during the summer to the 50s to minus 70s during the winter. Daily sunlight varies from several months of total darkness to several months of total daylight above the Arctic Circle.

Permafrost Enhances Precipitation. Areas of **permafrost** *(perennially frozen ground)* which underlie a majority of Alaska keep water on or near the surface. Water seems abundant because snowmelt and rain cannot drain away. Because of that, even though **precipitation** in Arctic and Interior Alaska is similar to that of deserts, it is enough to support plant growth.

Rainy Coast. By contrast, Southeast and Southcentral Alaska's coastal lands are awash in rainfall. There is no permafrost. The rain makes the area prone to erosion if vegetation is stripped from the steep slopes.

ALASKA'S SNOWY BLANKET

Precipitation in Alaska comes from snow as well as rain. Snow affects the ecosystem in several ways.

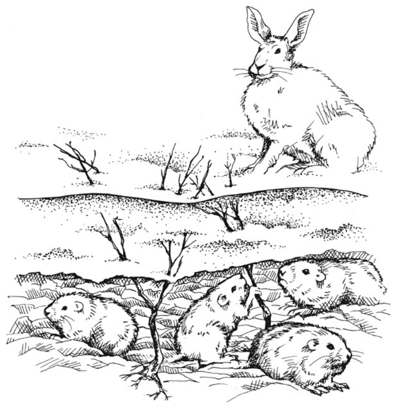
1. **Extends Darkness.** Deep snow cover significantly reduces the amount of sunlight reaching buried plants, extending the period of darkness and reducing the time available for photosynthesis. *(See adaptation fact sheets in Alaska's Tundra & Wildlife,* INSIGHTS *Section 3.*)

2. **Protects or Scours.** In many wind-blown areas, snow helps to shape vegetation patterns. Under its protective drifts, more plants can survive and thrive. On exposed ridges, wind-blown snow acts as an abrasive to scour away all but the most hardiest or smallest plants.

3. **Retains Earth's Heat.** Snow has great insulating qualities that help life survive in severe environments. Snow is a good insulator because air is trapped in between snow crystals. The trapped air, a poor conductor of heat energy, insulates the ground from winter temperatures

When snow falls in autumn it covers soil that has stored heat energy over the summer. Without additional input of radiant energy from the sun, the ground cools gradually, but **uncompacted** snow acts as an insulating blanket and traps some of the heat given up by the ground. As a result, the ground stays warmer than winter air, remaining close to 32°F (0°C) – as long as there is a sufficient covering of snow. The ground cools, or gives up heat energy relatively slowly as winter progresses.

Life Under Snow. Some animals are **subnivean** and remain active under the snow. Voles, shrews, and lemmings burrow under the snow and dig paths between feeding and resting sites. Ptarmigan and grouse fold their wings and dive into loose snow for protection from cold and predators.



Some dormant insects rely on the insulating properties of snow to protect them from cold and wind. Insect eggs, cocoons and adults find shelter under vegetation and in the soil.

TOPOGRAPHY & ECOSYSTEMS

Sea Level to Mt. McKinley. Since Alaska rises from sea level to the highest mountain on the continent, the topography of the land plays an important role in shaping the pattern of our weather and our ecosystems. Mountain ranges block rain systems, make their own weather and winds, or concentrate rainfall.

Drainage or Pooling? Steep slopes drain moisture quickly and hamper soil development, limiting what can grow there. Low-lying areas or flats may be underlain by permafrost, creating boggy soils that limit plant growth by drowning their roots. Plant growth on dry sites are different from those on wet sites.

Look for a Sunny Slope. The **aspect** or compass direction of a slope determines exposure to sunshine or wind, how soon the soil warms in spring, and if snow will be scoured away or lay as a protective blanket. Plant communities on north-facing slopes have different members from those on south-facing slopes.

SOIL & ECOSYSTEMS

Alaska's Young Soils. Recent glaciation over much of Alaska left behind coarsely crushed rock and fine rock flour devoid of organic material. These **young soils** lack variety and depth.

Other Plants Prepare a Base. Plants need a foundation for their roots. Trees especially depend on many years of other plant growth and accumulation of plant debris to form the **organic soils** that will support their growth.

Permafrost's Chilling Effect. Permafrost is most common in areas with a mean annual soil temperature below 27°F (-3°C). Locally, on south facing slopes or in areas of good drainage, no permafrost may exist.

Roots Need to Breathe. Soil depth and standing water affect a plant's ability to "breathe." Cells in leaves and the branches absorb **oxygen** from the air, but the cells in the roots must absorb oxygen from the soil. Trees literally drown if their roots become waterlogged. Even in arid environments like the Interior, trees and other plants can become waterlogged because permafrost does not permit water to drain away from their roots.

Cold Creates Treeless Muskeg Soils. Cold temperatures slow the growth and decay of plant materials and that slows the development of organic soils. If dead plants accumulate faster than they can be decomposed, an acidic basin called a **muskeg** forms. Muskeg soils, often found within boreal forests, are notoriously poor environments for most tree and plant growth.

Bacteria Make Nutritious Soil. Plants must also have **nitrogen** in order to grow. Most of the nitrogen on earth is in the air, but plants are only able to use nitrogen that is in the soil. Without the soil's nitrogen provided by microscopic bacteria called "nitrogen- fixers," plants could not survive.

LIVING THINGS – 5 KINGDOMS

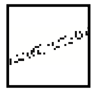
To the various nonliving environments we now add a cast of living things. Living things can move in response to their surroundings they grow and they reproduce. The presence or absence of certain nonliving things dictates which living creatures will survive in a certain area.

Stars are Easier to Count. It is said that scientists have a better understanding of how many stars are in our galaxy than how many species are on Earth. Estimates range from two million to 100 million. New species are still being discovered.

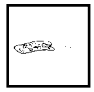
Hey, You! Only 1.4 million species have been named. Only a small fraction of the insects, fish, and non-animal species have been scientifically described and cataloged.

Naming Things. The Swedish naturalist, Carolus Linnaeus, was the first person to devise a method of naming living things. Linnaeus used two categories or **kingdoms** to classify all living things: **Plants** and **Animals**. His system has been modified many times, evolving along with the expanding knowledge of biologists.

More Kingdoms. While scientists are still debating about how to classify some organisms, they now agree on the following five classifications of living things:



Monerans (one-celled organisms such as blue-green algae and bacteria)



Protists (one-celled organisms including algae and protozoans)

Fungi (such as mushrooms and lichens)

Plants

Animals

The following fact sheets explain the characteristics of each kingdom and highlight some of its members found in Alaska.

1 AND 2 – MONERANS AND PROTISTS

Small but mighty

Monerans and protists create soil and clean up forest debris. Until recently, these microscopic living things were considered to be small versions of plants and animals. But the more scientists learned about them, the less they seemed to fit in either category.

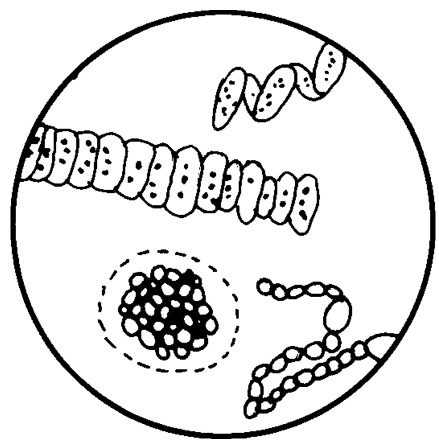
Given Their Own Kingdoms. Some not only make their own food, like plants, but also move around and catch and eat other living things. Additionally, their cell structure is quite different from those of either plants or animals.

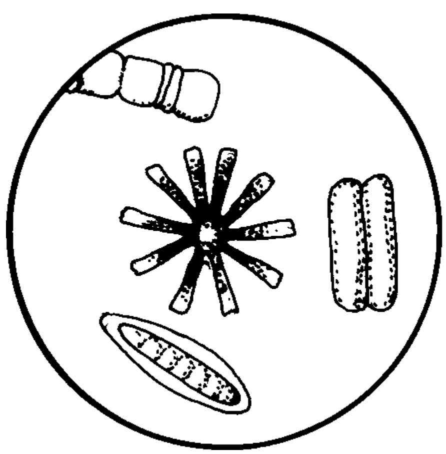
MONERANS, the smallest microscopic organisms, do not have nuclei in their cells. **Bacteria** and **cyanobacteria** (or **blue-green algae**) are examples of monerans. *A million monerans would fit on the head of pin.*

PROTISTS are larger microscopic organisms that have cell nuclei. These include **algae**, **paramecia**, **amoebas**, and many others. *Some protists live together in large groups that can be seen without a microscope,* but the individual organisms are microscopic.

All Ecological Roles. Some monerans and protists are **producers**. Like plants, they are able to photosynthesize *(to make food from air, water, and sunlight)* and are food for very small animals. Others are **herbivores** or **carnivores**.

Unsung Heroes. The majority, however, are **detritivores**, especially monerans. Some are "nitrogen-fixers," taking nitrogen from the air and converting it to a form usable by plants. These unsung heroes recycle waste and dead things. Their recycling allows life to continue.





Microscopic organisms are abundant and important in all ecosystems, including forests. The majority are detritivores that replenish the soil with recycled nutrients.

3 – FUNGI

An out of body phenomenon

Fungi are by far the most prolific of all the **detritivores** in our forests because they are adapted to acidic soils. Mushrooms, shelf fungi, and less noticeable molds, mildews, and rots are some examples.

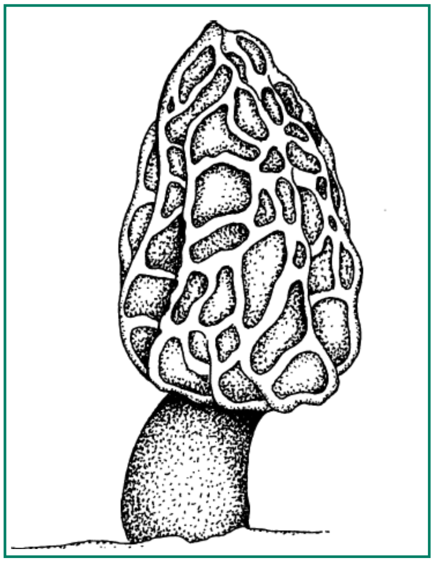
Fungi are similar to plants in that they are immobile. In fact, scientists used to consider them to be plants. But fungi are very different from plants in cell structure and in the ways they live, so scientists now place them in a separate kingdom of living things.

More Than Meets the Eye. Usually, we see only the fruiting, or reproductive part of a fungus *(a mushroom, for example).* Its main body is hidden from view. The body of a fungus is made up of **hyphae**, microscopic hair-like structures that reach out through the wood, soil, leaf litter, roots, or other material on which the fungus is growing. A handful of forest soil may contain over two miles of fungal hyphae!

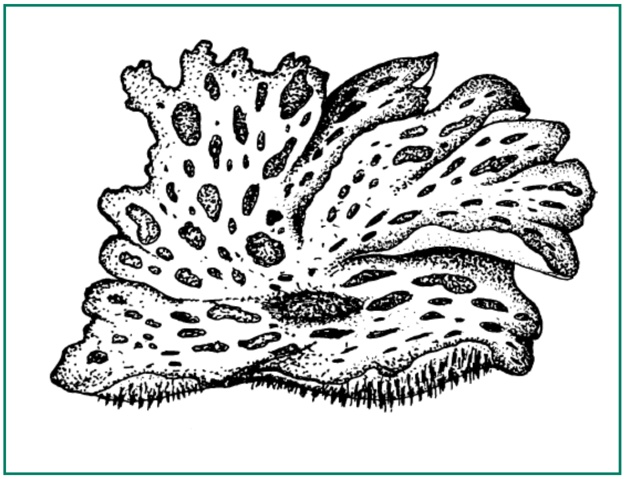
Unusual Way of Eating. Fungi use their hyphae and digest their food outside their bodies! The cells of fungal hyphae give off digestive enzymes like those found in our own stomachs. These enzymes break down wood, leaves, and other material. Then the fungal hyphae absorb the scattered sugars and minerals and use them to grow.

Trading Minerals for Sugars. Some fungi form symbiotic associations with plants and help them obtain needed minerals *(nitrogen, potassium, phosphorus)* from the soil in exchange for the sugars the plant produces. More than 90% of the plants in Alaska, including all our trees and berry-producing plants, could not grow without these mycorrhizal fungi.

Mutual Symbiosis. Lichens, one of the most visible fungi in forests, are actually a partnership between a fungus and alga or cyanobacteria. The fungus provides the structural protection, and the alga produces the food.



Mushrooms are the fruiting, or reproductive parts of certain fungi. Tiny hair-like structures, called hyphae, are the main body of many fungi.



Lichens are the most visible fungi in forest ecosystems.

4 – PLANTS

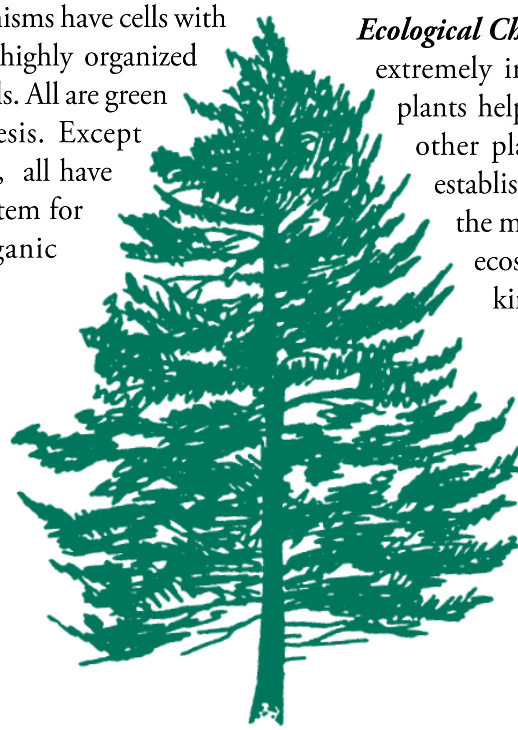
From small to tall

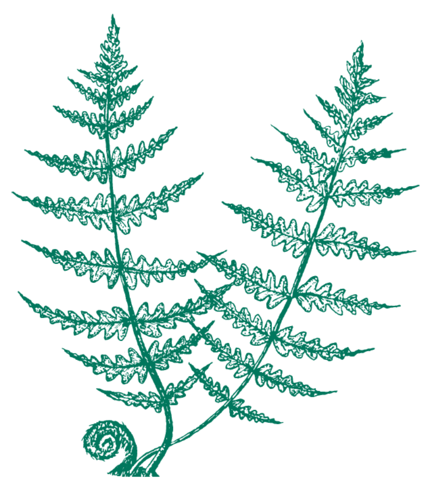
Trees are the dominant plants in forest ecosystems. Nevertheless, the texture of the forest is rich with many other plants as well. This kingdom includes small to tall – mosses, liverworts, ferns, and horsetails to spruce and birch trees.

Green Producers. These organisms have cells with nuclei and a cell wall and a highly organized arrangement of their many cells. All are green and capable of photosynthesis. Except for the mosses and liverworts, all have leaves, roots, stems, and a system for transporting water and organic materials among the cells.

Help Accepted. All plants live a stationary life. Many rely on wind, insects, birds, and some mammals to pollinate their flowers or to help carry their seeds to new areas. Plants can live for a remarkably long time. Some bristlecone pines are more than 4,000 years old.

Ecological Champions. Plants are extremely important ecologically. (1) **Pioneer** plants help to create the organic soils that all other plants need before they can become established in a new location. (2) They are the major **producers** *(of food)* in terrestrial ecosystems. Without them, the animal kingdom would not survive.





5A – ANIMALS (Invertebrates)

Mind-boggling multitudes

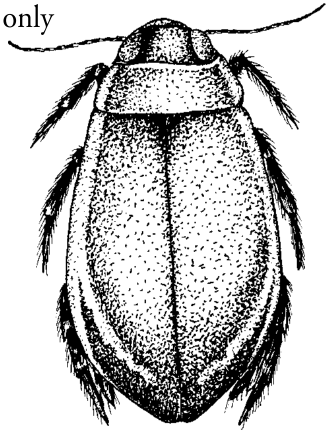
Invertebrates animals are multicellular organisms that lack a backbone or spinal column. They make up the majority of the animal kingdom, both in number of species and in populations.

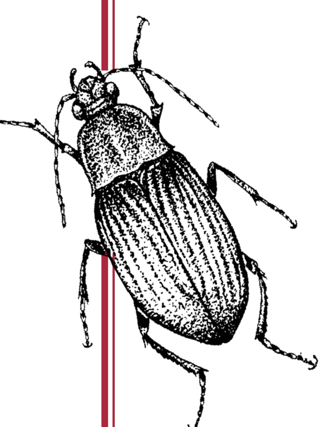
Like other animals, invertebrates obtain energy and minerals by eating other living things – plants, fungi, or other animals. They are **consumers**. Many also function as **detritivores**, helping to recycle the minerals and nutrients in dead organic material.

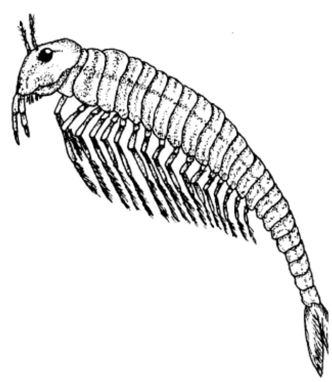
Need External Warmth. Invertebrates need external warmth to function. Forest invertebrates are only active during the warmer months which in the boreal forest is limited to a few summer months. Even then, despite their numbers, few humans notice them.

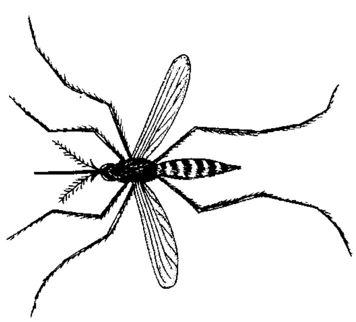
Mosquitoes and Other Buzzing. Arthropods *(spiders, centipedes, millipedes, and insects)* are the most conspicuous. Flying insects include butterflies, bumblebees, moths, ichneumonid wasps, crane flies, and midges. Mosquitoes, blackflies, and other biting flies can occur in great abundance.

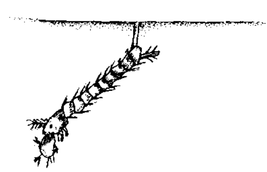
Look Under Bark, Logs. Forest invertebrates also include segmented worms, snails, and slugs. Sawflies, aphids, bark beetles, carrion beetles, and ground beetles are among the insects that live on plants or in the leaf litter. *For a more complete list and illustrations, see the Alaska Ecology Cards.*

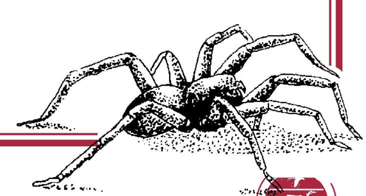






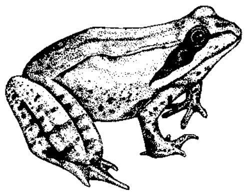


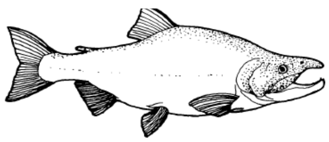


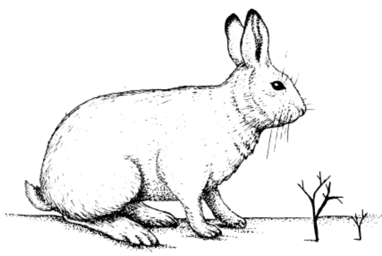


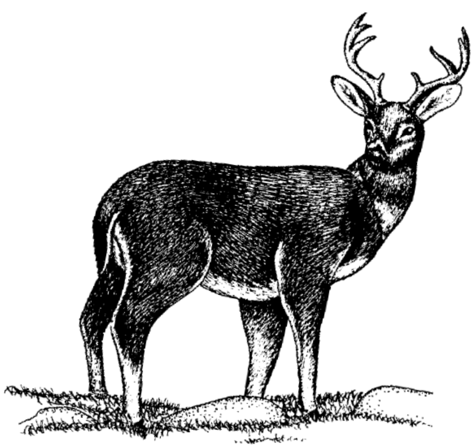
5B – ANIMALS (Vertebrates)

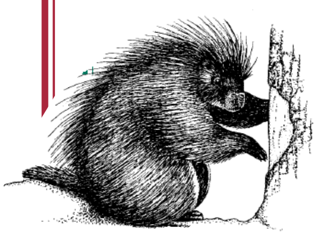
Frogs, Bats, Hummingbirds – in Alaska!

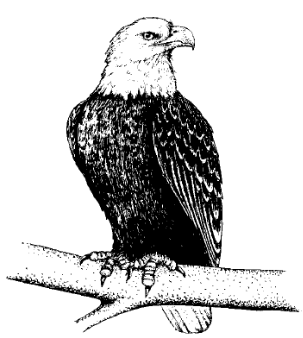












Vertebrate animals are multicellular organisms with a backbone or spinal column. Alaska's forest vertebrate animals include humans and other mammals, birds, fishes, and all five of the state's amphibians *(wood frog, spotted frog, western or boreal toad, long-toed salamander, and rough-skinned newt).*

Reptiles are the only major group of vertebrate animals absent from Alaska and its forest ecosystems.

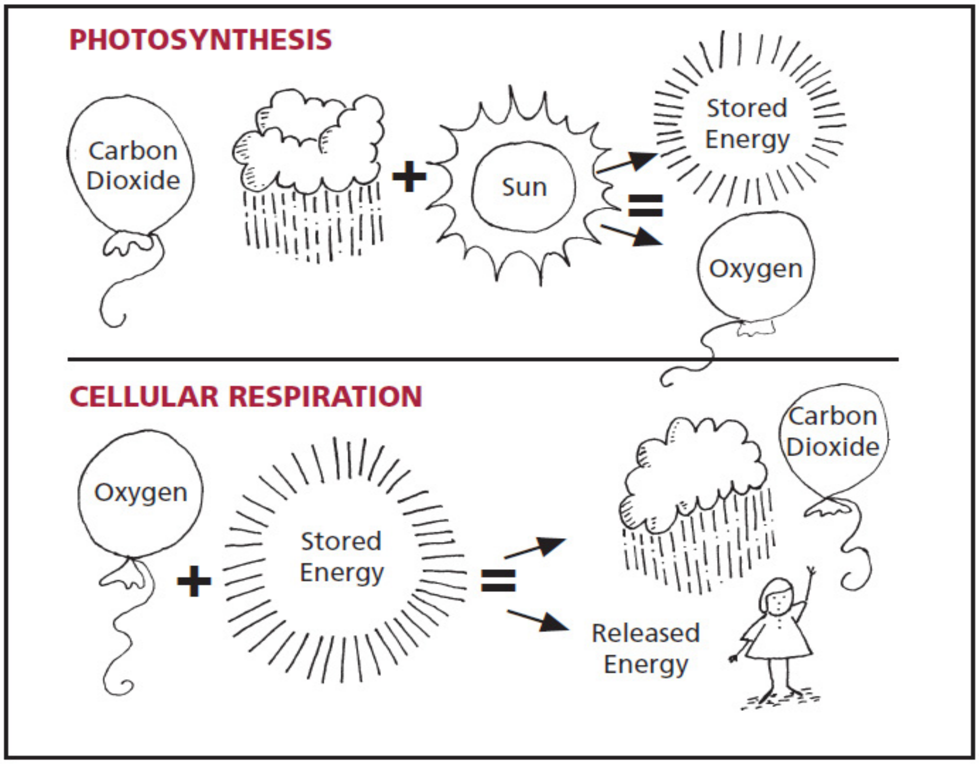
No Producers, Only Consumers. All animals obtain energy and minerals by eating other living things – plants, fungi, or other animals. They are mainly **herbivores** and **carnivores**. Vertebrate animals can move about and actively search for food.

Fishy Habitat. Lakes and rivers in forested areas are prime habitat for Alaska's fishes including lake trout, whitefish, and the salmon species that hatch in the clear, cool waters and then migrate to the ocean before returning to spawn.

Stick Nests and Plenty to Eat. Bald eagles feast on those fish and nest in the huge trees. Forest birds are abundant and varied, including the northern goshawk, at least five species of owls, three species of grouse, the rufous hummingbird, and woodpeckers and other songbirds that eat insects or seeds.

Forests Fit Many. Red squirrels, flying squirrels, snowshoe hares, porcupines, coyotes, wolves, black bear, Sitka black-tailed deer, moose, marten, mink, and river otters are forest animals. Little brown bats also live here. *For a more complete list and illustrations, see the Alaska Ecology Cards.*

ECOLOGY FACTS - ENERGY EXCHANGE



Energy and its exchange are the glue that hold living and nonliving things together in an ecosystem.

Energy (the capacity to move or do work) is present in various forms in both living things and their nonliving surroundings. Examples include sunlight, heat, electricity (both static and lightning), wind, and motion. Energy is also stored in the bonds between atoms in molecules.

TAKE A DEEP BREATH

We breathe in oxygen because our cells need oxygen to release the energy stored in food. This process is called cellular respiration. It is similar to the process of combustion in which oxygen combines with fuel to release heat (as in the burning of candle wax) or explosive force (as in gasoline engines).

The living cells of plants and animals combine some types of digested food with oxygen to produce energy and carbon dioxide.

Photosynthesis is, in some ways, a reversal of the process of respiration. In photosynthesis, energy (from sunlight) combines with carbon dioxide to make stored energy and oxygen.

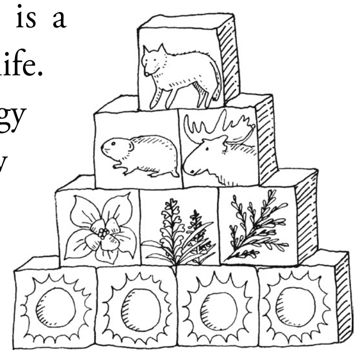
Will We Run Out of Oxygen? Since almost all living cells use oxygen from the air, it might seem possible that growing populations of respiring organisms would eventually consume all the oxygen in our atmosphere. Fortunately, the photosynthesizing aquatic plankton and terrestrial plants resupply much of the oxygen in the earth's atmosphere.

Cellular Respiration:
Oxygen + stored energy (sugars) =
Carbon dioxide + water + released energy

Photosynthesis:
Carbon dioxide + water + sunlight =
Stored energy (sugars) + oxygen

ECOSYSTEMS – Community Connections

Where the next meal comes from is a constant priority in any organism's life. The following pages trace how energy is transferred in ecosystems and how materials are recycled. (*Recycling in ecosystems is not just an option, but is critical to continued survival.*)



Section 2
ECOSYSTEM INSIGHTS

FOOD WEBS – *WHO EATS WHOM?*

[*See the "5 Living Kingdoms" fact sheets in* INSIGHTS, *Section 1, and the Alaska Ecology Cards for species illustrations*]

Producers. A plant is exquisitely equipped to convert the nonliving — air, water, minerals, and sunlight — into food for itself and others through **photosynthesis**. Plants and algae that make food from nonliving materials are called **producers**.

Consumers. All other living things in an ecosystem depend on food manufactured by producers. Called **consumers**, they use a process called **cellular respiration** to convert the carbohydrates, fats and proteins found in plants or other animals into another form of energy that their cells can use (see INSIGHTS Section 1: "Energy"). organisms that eat dead or decaying material).

Consumers are divided into four groups:

- **Herbivores** (organisms that eat plants)
- **Carnivores** (animals that eat other animals)
- **Omnivores** (animals that eat both animals and plants)
- **Detritivores**(organisms that eat dead or decaying material)

The pathway of **energy** and **minerals** from the nonliving environment, through producers, to consumers, and back again through detritivores creates a **food chain**. All the food chains of an ecosystem are connected into a **food web** – the energy circulatory system of that ecosystem.

Energy. At each intersection in the web, some energy is returned to the nonliving environment as heat. That energy is not passed on and cannot be reused by living things. The lost energy is replaced during photosynthesis by the capture of energy from the sun.

Minerals. Minerals are always passed along at each web intersection until the detritivores return them to the environment in their original form. The producers can use them again to make new food.

PRODUCERS CONVERT RAW MATERIALS

Using the process of **photosynthesis**, producers combine energy from sunlight with carbon dioxide from the air and minerals from water, soil, and rocks to produce the sugars and oxygen that help all other living things survive. They are the first living link in all food chains.

Plants are the main producers in forest and tundra ecosystems, while algae (including seaweeds) are the main producers in ocean ecosystems. Both plants and algae are important in wetlands. Some monerans are also producers.

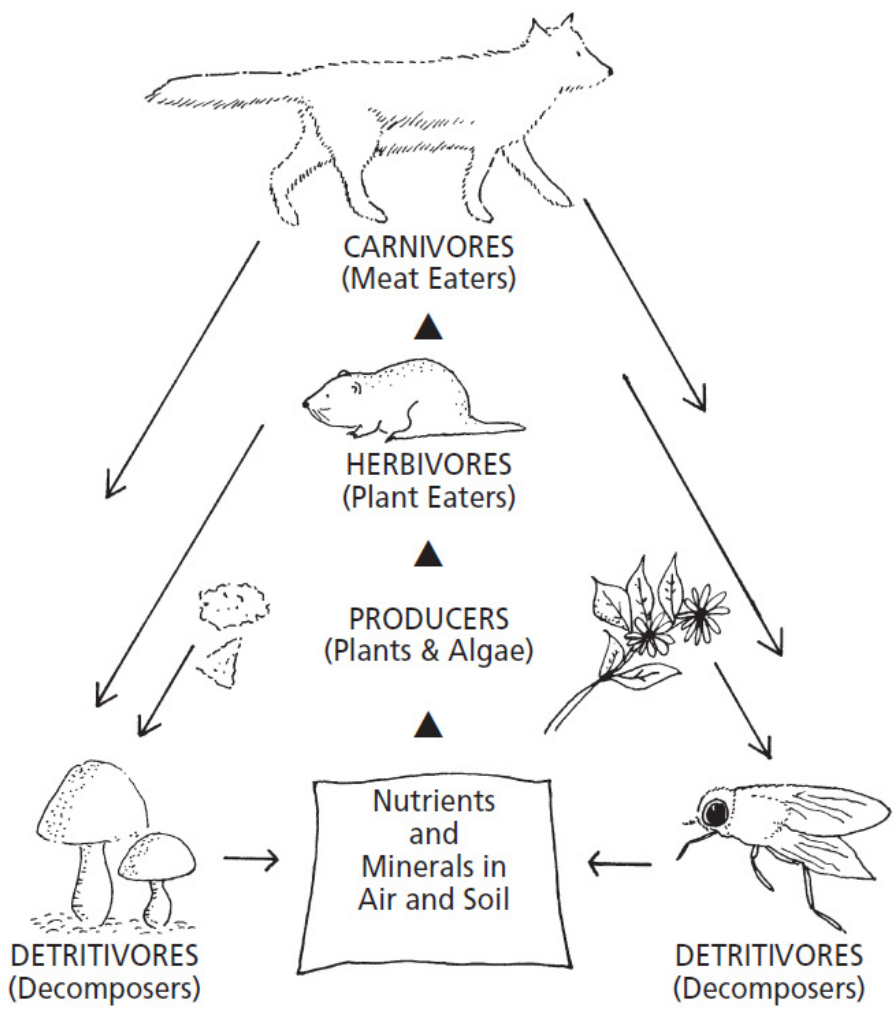
HERBIVORES EAT PRODUCERS

Herbivores are the next link in the food chain and come in all sizes. Moose, deer, and snowshoe hares receive all their nutrition from the stems, bark and leaves of plants. Caribou survive harsh winters by eating lichens. Red squirrels and pine grosbeaks prefer seeds.

Yet, these "common" wildlife examples are overwhelmed in number by the smallest herbivores – the millions of leaf-eating, wood-drilling, sap-sucking, twig-boring insects and other often overlooked invertebrates.

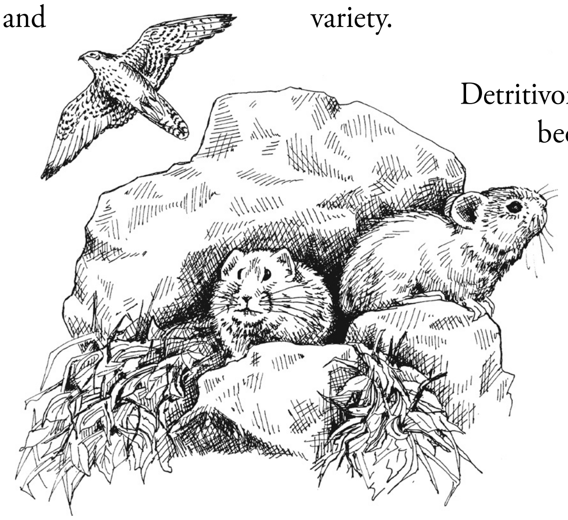
Each herbivore is adapted to eat specific kinds of plants and cannot live in an ecosystem or area where those plants are absent.

FOOD WEB



CARNIVORES EAT HERBIVORES – AND EACH OTHER

In the next link in the food chain, the plant-eating herbivores become food for carnivores (flesh-eaters).Owls, spiders, centipedes, woodpeckers, foxes, and wolves are examples of carnivores. Another name for carnivore is predator, one that kills and eats other living things.



Carnivores do not limit themselves to dining on herbivores. All will eat each other if the opportunity arises. This represents a second carnivore link on longer food chains.

Carnivores cannot survive without adequate populations of prey. So the numbers and kinds of herbivores in an ecosystem help to determine the presence and abundance of carnivores.

OPPORTUNISTIC OMNIVORES

Food in an ecosystem can be scarce, especially for big eaters. Therefore, consumers that eat a variety of foods have a better chance of survival.

Bears are good examples. They eat roots, grasses, herbs, and berries as well as small and large mammals, insects, fish, and carrion. With an omnivorous diet, bears are well-adapted to food is available.

Chickadees and many other birds eat plant seeds as well as insects. Waterfowl young gain their initial growth from aquatic insects before turning to marsh vegetation later in the summer.

Mosquitoes are infamous for their abundance in Alaska. Both male and female mosquitoes sip plant nectar as herbivores, but the female is omnivorous. She needs a blood meal from a warm-blooded animal to produce the eggs she will lay on the surface of any nearby water.

DETRITIVORES REUSE AND RECYCLE

Last in a food chain – but certainly far from "least" – are detritivores, or decomposers. They obtain their energy by eating waste materials and dead organisms. They overshadow all other consumers in both number and variety.

Detritivores are a critical link in all ecosystems because they return all the minerals stored in the food chains to the soil for reuse by producers. Without detritivores, producers would soon run out of the minerals they need to make food, and an ecosystem would smother in tons of debris.

Bald eagles, crabs, ravens and other large creatures that **scavenge** dead animals are detritivores because they eat dead flesh. But the most important detritivores are tiny, extremely numerous – and ignored. These include animals that live in the soil, slime molds, many **fungi**, and hundreds of thousands of **microscopic organisms**.

(*For more information about the Five Living Kingdoms including Fungi, Protista, and Monera, Plants, and Animals see* INSIGHTS *Section 1, Elements of Ecosystems.*)

Animal detritivores eat more plants than moose! In one square mile of boreal forest, the mass of detritivores equals the body weight of 43 moose.

ECOLOGY FACTS - ALASKAN FOOD CHAINS AND WEBS

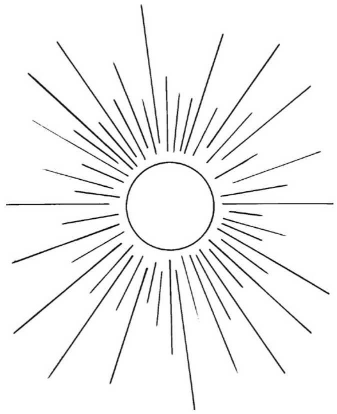
Six food chain examples for forest, tundra, wetland, and ocean are shown in bold letters. Make food webs by using the other foods of each living thing (listed in small letters below its name) to find other interconnections.

	Producer	Herbivore	Carnivore 1	Carnivore 2	Detritivore
Forest	1. White Spruce	**Red Squirrel** Berries, mushrooms	**Marten** Voles, bird eggs		**Mushroom** Any dead plant
	2. Willow	**Snowshoe Hare** Birch, grass, fireweed	**Lynx** Voles, squirrels		**Raven** Any dead animal
	3. Grass Seed	**Red-backed Vole** Berries, fireweed	**Boreal Owl** Flycatcher, woodpecker		**Fly** Any dead animal
	4. Lingonberry	**Pine Grosbeak** Spruce and birch seeds	**Goshawk** Squirrel, flycatcher, woodpecker		**Bacteria** Any dead thing
	5. Fireweed	**Moth** Flies, beetles	**Alder Flycatcher**	**Merlin** Pine grosbeak	**Beetle** Any dead animal
	6. White Birch	**Bark Beetles** Spruce	**Downy Woodpecker** Moth, berries		**Shelf Fungus** Any dead wood
Tundra	1. Lichen	**Caribou** Dryas, willow, sedge	**Brown Bear** Sedge, grass, blueberry		**Bacteria** Any dead thing
	2. Dryas	**Dall Sheep** Willow, sunflower, sedge	**Wolf** Caribou, marmot		**Raven** Any dead animal
	3. Willow	**Redpoll** Willow, sunflower, sedge	**Arctic Fox** Singing vole, any dead animal		**Flies** Any dead animal
	4. Grass	**Singing Vole** Sedge, sunflower, dryas	**Short-tailed Weasel** Redpoll		**Springtail** Any dead wood
	5. Sunflower	**Butterfly** Blueberry, mountain avens	**Golden Plover** Flies, springtail, blueberry	**Jaeger** Redpoll, vole	**Bacteria** Any dead thing
	6. Sedge	**Marmot** Grass, sunflower	**Wolverine** Fox, any dead animal		**Mushroom** Any dead plant
	7. Blueberry	**Willow Ptarmigan** Willow, sedge	**Golden Eagle** Marmot, weasel, sheep (lamb only)		**Fly** Dead producers, protozoans
Wetland	1. Algae	**Water Fleas** Dead plants, protozoans	**Stickleback** Midge, rotifer	**Common Loon** Frog	**Bacteria** Any dead thing
	2. Pondweed	**Pintail** Algae, seeds of sedges	**Peregrine Falcon** Phalarope		**Rotifer** Dead producers, protozoans
	3. Algae	**Midge** Algae, dead plants	**Wood Frog** Flies, mosquitoes	**Sandhill Crane** Stickleback, sedges	**Water Flea** Any dead producer, rotifer
	4. Sedges	**Muskrat** Pondweed	**Mink** Stickleback, phalarope		**Bacteria** Any dead thing
	5. Willow	**Moose** Willow, sedge	**Wolf** Muskrat, pintail		**Flies** Any dead animal
	6. Algae	**Mosquito Larvae** Protozoans	**Red Phalarope** Midge, water flea, rotifer	**Parasitic Jaeger**	**Protozoans** Any dead material, algae
Ocean	1. Green Algae	**Sea Urchin** Kelp	**Sea Otter** Crab, sculpin, sea star		**Tanner Crab** Any dead animal
	2. Kelp	**Snails** Green algae	**Sea Star** Sea urchin, sea cucumber, shrimp		**Flatfish** Dead animals, snails, fish
	3. Diatom (algae)	**Amphipod** Other algae, kelp	**Sculpin** Shrimp, sand lance	**Sea Anemone** Sand lance, snails	**Shrimp** Any dead material
	4. Sea Grass	**Brant** Green algae	**Bald Eagle** Herring, guillemot, dead animals		**Marine Worm** Any dead plant, algae
	5. Brown Algae	**Copepods** Other algae, sea grass	**Sand Lance** Amphipod, euphausids	**Pigeon Guillemot** Sculpin, herring	**Sea Cucumber** Any dead thing
	6. Red Algae	**Euphausids** Other algae, diatoms	**Herring** Copepods, sand lance	**Harbor Seal** Sand lance, flatfish	**Gull** Any dead animal

ECOLOGY FACTS - TRACK THE ENERGY

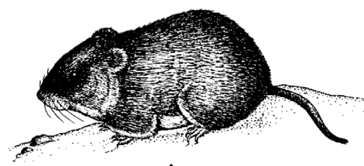
When living things consume food, they consume **energy** as well as mass. All living things use energy to move, respond to the environment, reproduce, grow, and keep warm. As a result, less energy is available to pass on at every link in a **food chain**.

WHO EATS WHOM?

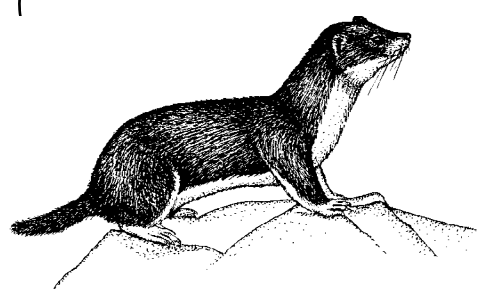


Producer. Through photosynthesis *(water, carbon dioxide, and **energy from the sun**)*, a spruce tree feeds itself and produces seeds in cones.

Herbivore. A vole eats fallen spruce cone seeds containing 1000 calories of energy. Although the vole uses most of this energy for moving about and for staying warm, some of the energy goes through the vole's digestive system as waste, and the rest (*about 10% of the original 1000 calories, or 100 calories*) is stored in the vole's tissues, ready to be passed on to the next consumer in the food chain.



Carnivore. Suppose that the next consumer is a weasel who eats the vole. The 100 calories (*10% of the original 1000 calories*) from the spruce seeds stored in the vole's body are passed to the weasel. The weasel uses those calories to move, reproduce, and stay warm. Some calories from the vole are excreted as waste, and the rest (10% of the 100 calories) is stored in the weasel.



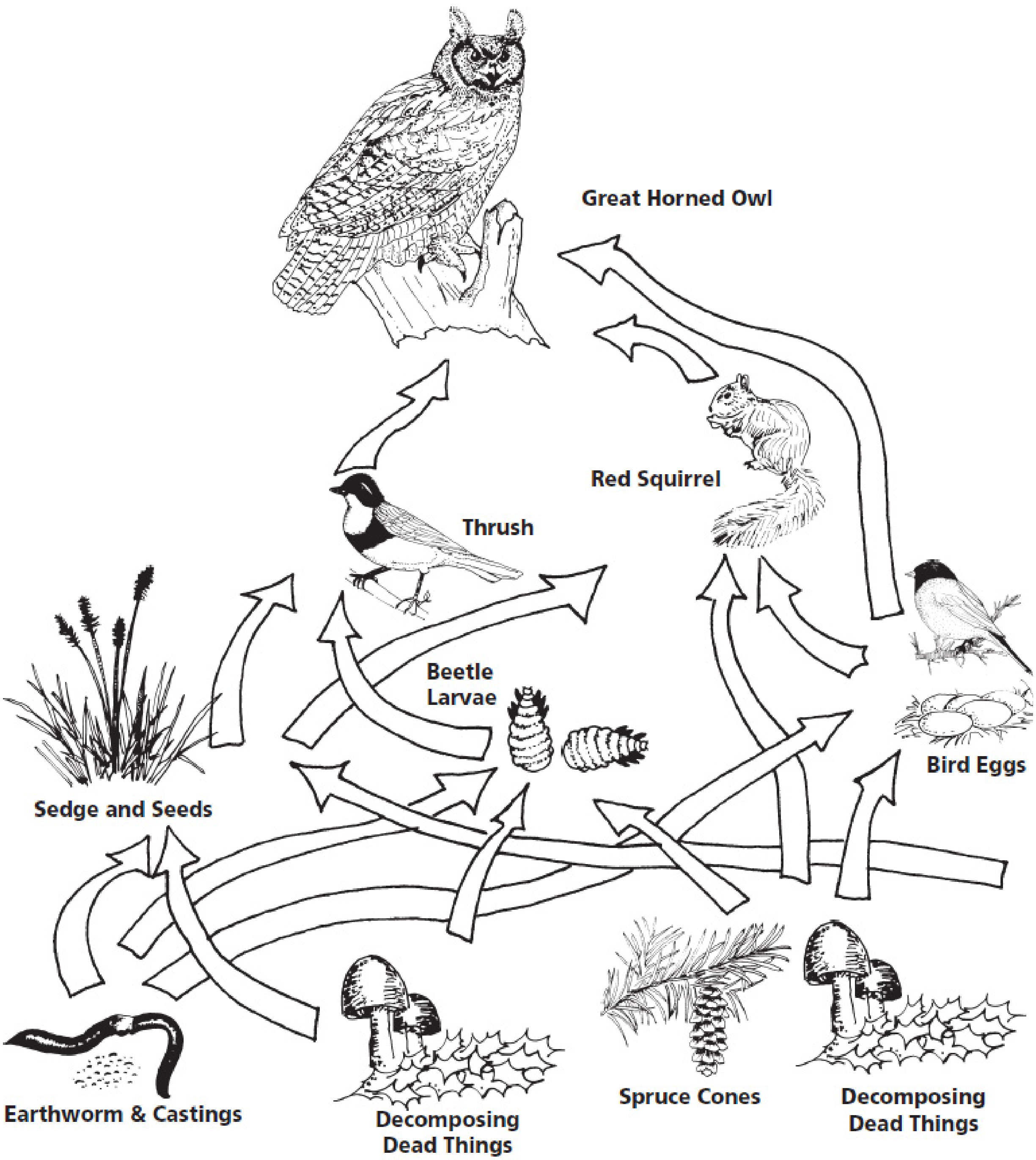
Second Carnivore. A hawk catches and eats the weasel. Only 10 of the original calories remain to used by the hawk. *Less energy is available to pass on at every link of a food chain. As a result, carnivores are less numerous than herbivores, and food chains rarely have more than four links.*

Detritivores. When the hawk dies, the 1 calorie of original energy that remained is used as the detritivores break down the body. They return only the minerals to the ecosystem.

Thanks to the Sun, new energy is on its way!

Producers (Again!). Green plants, algae, and some **monerans** will change the sun's energy and minerals from the nonliving surroundings into forms other living things can use.

ECOLOGY FACTS - ALASKA GREAT HORNED OWL FOOD WEB



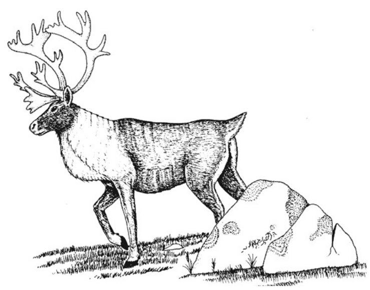
Alaska's great horned owl is a nocturnal predator in woodlands that might be seen at dawn and dusk. The illustration traces one of its food webs. Evidence of the owl's diet can be found by examining a pellet of bones and feathers coughed up after a night of hunting. (*See the activity "Follow a Food Chain" in Section 2.*)

GROWTH HAS LIMITS

The size of each ecosystem's "web" is limited. Limiting factors control the number and variety of plants, animals, and other organisms that can live in an ecosystem. Limiting factors include climatic elements, disease, and competition for scarce resources (food, water, shelter, or space).

Domino-Effect in Arctic
In the Arctic, the entire tundra ecosystem is limited by the length of the growing season, the extreme low temperatures, and the lack of liquid water. As a result of the long, cold winter in which light and warmth are scarce, plants can only photosynthesize and grow three to four months each year.

Detritivores are **dormant** during the winter in the Arctic as well. Therefore, mineral recycling is very slow, impoverishing the soil and limiting the rate and size of plant growth.



In turn, reduced plant growth limits the number and length of food chains. Arctic animals such as the caribou must migrate great distances to obtain enough food and not deplete an area's resources.

Tropical Plenty?
One might assume that a warmer, wetter climate with more daylight hours in winter months would produce a limitless ecosystem. A tropical rainforest, in contrast to the arctic tundra, does have more variety and abundance of plants and animals. Yet even a tropical rainforest is limited by its physical environment.

In areas of very high rainfall, precipitation leaches minerals from the soil's surface making them unavailable for plants. Although dead material rots and returns to the soil quickly in tropical climates, the recycled mineral nutrients are taken up immediately by the roots of existing rainforest canopy trees, shrubs, and vines. These plants monopolize the mineral nutrients, leaving little available for new growth.

Thus, both rainforests and arctic tundra are examples of ecosystems that are limited because something is unavailable – in this case, enough minerals in the soil.

COMPETITION IS A CONTEST

Competition over scarce resources, one of the limiting factors, is another thread of ecosystem community interactions. Any organism that can get more water, more minerals, more energy, more space, or better shelter than its neighbors will grow better and leave more offspring. The competition can occur within and between species.

For example, plants compete with each other for water, soil minerals, and access to sunlight. Tall trees shade any young trees trying to grow below. Seedlings of cottonwood and alder trees cannot survive in the shade of spruce trees. Hemlock seedlings, however, are shade-tolerant and can grow in a dark spruce forest.

Thick-billed murres, a cliff-nesting seabird, compete among each other for the most secure and sheltered nesting sites. Bull moose, caribou, and fur seals compete with males of the same species for the chance to breed with the females.

SYMBIOSIS – LIVING TOGETHER

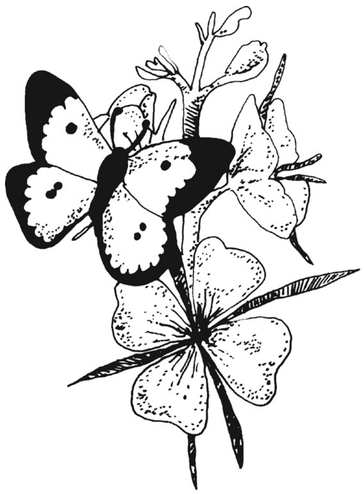
Opposite of competition is symbiosis — when at least one of two organisms cannot survive without the other.

Symbiosis takes three forms: mutualism, commensalism and parasitism. Mutualism is a symbiosis where both of the organisms involved benefit by living together. Commensalism is a symbiosis in which one of the organisms involved benefits, and one is not affected. **Parasitism** is a symbiosis where one of the organisms (the parasite) benefits, while the other (the host) is harmed.

Predation might, at first look, be considered a form or parasitism, or vice versa. But parasites, in contrast to predators, are usually much smaller than their hosts, and generally harm rather than kill their hosts. Also, in parasitic relationships, the parasite must live either on, or in its host.

The following are examples of symbiotic relationships that can be found in Alaska's ecosystems. ***See also the activity "Ecosystem Partners" in Section 2 for more examples illustrated on cards***.

Examples of Mutualism – the friendly symbiosis



- Many plants need to exchange pollen to create seeds. Wind carries some pollen, but many plants depend on animals to perform this task. These plants produce colorful or sweet-smelling flowers and nectar (a sugary liquid) that attracts bees, butterflies, moths, and hummingbirds. While sipping the nectar, these animals get a dusting of pollen which they then carry to other flowers.

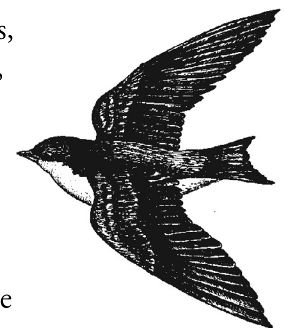
- Blueberry, dogwood, raspberry, and cranberry plants produce edible berries that animals eat for the berries' fleshy outer coats. The hard-coated seeds inside pass through the herbivore's digestive tract intact and are deposited in a new area – with a bit of fertilizer. Some seeds do not germinate readily unless passed through an animal's digestive tract.

- Spruce and birch trees, blueberry, cranberry (and perhaps 80 percent of all plants) depend on mycorrhizal fungi to give them needed minerals from the soil in exchange for sharing some of the sugars the plants produce. The fungi (the underground hyphae of mushrooms) live in or on the roots of the plants.

- Lichens are the ultimate examples of mutualism. Two separate living things, a fungus and a **cyanobacterium** (formally called blue-green algae), join forces. The fungus provides the structure and ability to retain water; the alga photosynthesizes food. By living together they can grow in harsh environments where neither could live alone.

Examples of Commensalism – no harm done

- Some plants enlist animals to carry their seeds without aiding the animal. These plants produce seeds with small hooks or awns that catch in animal fur. In this way they get a free ride to a new area.



- In Alaska's forests tree swallows, American kestrels, buffleheads, golden eyes, boreal and saw-whet owls, and flying squirrels nest in dead trees. These animals cannot dig their own nest holes. Instead, they have to find holes already made by some other living thing – especially woodpeckers.

- The woodpeckers dig new nesting and roosting holes for themselves each year. But not just any dead tree will work. Woodpeckers can only excavate a hole if the wood is partly decayed or rotted. Thus woodpeckers depend on fungi that rot and decay wood.

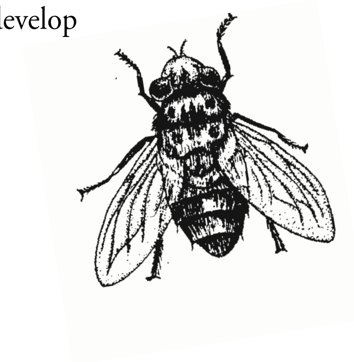
- Most fungi can only eat dead wood. So these fungi rely on other organisms to kill the trees. They depend on insects that parasitize and kill trees, microscopic organisms that cause tree diseases, and large animals (beavers or porcupines) that kill trees as they gather food.

Examples of Parasitism – a win/lose situation

- A fungus (the parasite) lands on a tree (the host) and penetrates the bark. The hyphae of the fungus spread up and down from their entry point. As they grow, the hyphae break down and digest the tree trunk. The tree fights back by walling off the sections invaded by the parasite. The tree resists the fungal invasion and survives for many years, but eventually some fungi kill the tree.

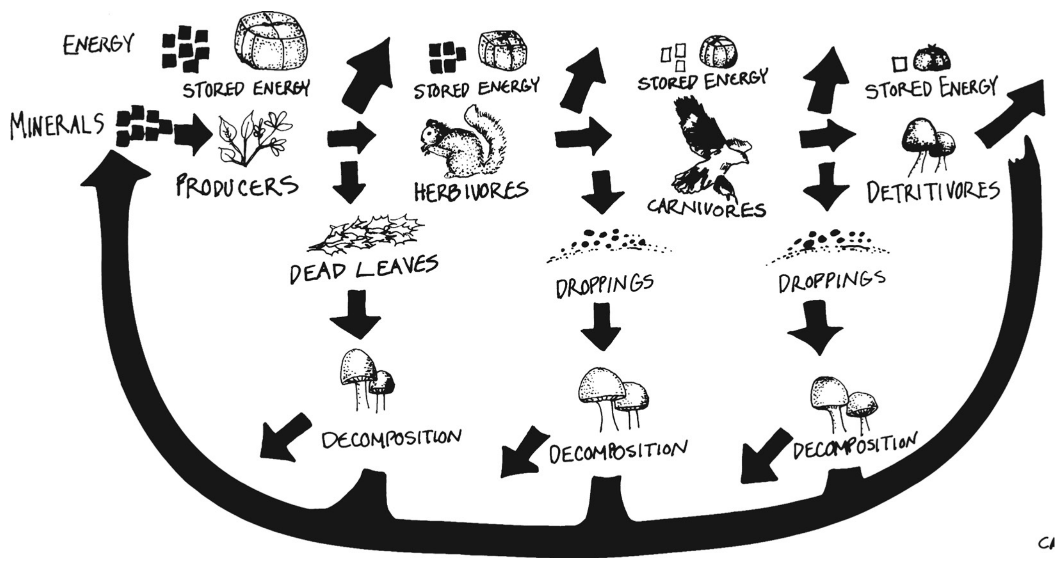
- Warble flies need a host to carry their eggs. They lay them on caribou hair. The larvae burrow under the animal's skin and then feed on its tissues. The following spring, they emerge, drop off and develop into adult warble flies on the ground. The warble fly larvae derive food and shelter from the caribou, and the caribou are harmed by loss of tissue and the open sores caused by the larvae emerging through their skin.

- Botflies are another parasite living on caribou. These insects inject their larvae into the nasal passages of the caribou. The larvae develop into pupae in the throat of the caribou and are coughed out in spring. After a few weeks, they develop into adult botflies and begin the cycle again.



An ecosystem is more than a place and its inhabitants. What defines an ecosystem are all the invisible strands connecting the living organisms and their nonliving surroundings. Break a strand and the whole web shakes.

ECOLOGY FACTS - MINERAL CYCLING THROUGH THE ECOSYSTEM



Living things need **energy** to survive, but energy alone is not enough. All living things need nonliving **minerals** – element such as iron or carbon. Minerals are limited in supply but can be reused.

Let's look at (1) how minerals occur in nature, (2) how they are taken up and used by living things, and (3) how they **cycle** through the ecosystem.

(1) Natural Forms. Minerals occur as **solid** substances in rocks and soil, as **liquids** (such as water), as **solutions** dissolved in water, and as **gases** in the atmosphere (*such as* **carbon dioxide** *or* **nitrogen**). Minerals can either exist as a single element (*such as nitrogen or carbon*) or as a **compound**, which is a mixture of elements (*such as water or carbon dioxide*).

> **Amazingly, 99% of all living matter is made of only 6 elements in different combinations.** These six elements are carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur. Combinations of these elements make up the three most important elements on earth: water, air, and soil.

(2) Pathways. Important minerals occur in soil, water, or air but the form must be just right for use by each organism. For example, most organisms need oxygen for **cellular respiration**. Fish can absorb through their gills the oxygen dissolved in water. Humans cannot. Mammals, birds, plants, and fungi need oxygen as it occurs in air. The usable form determines the path from the nonliving environment through living things.

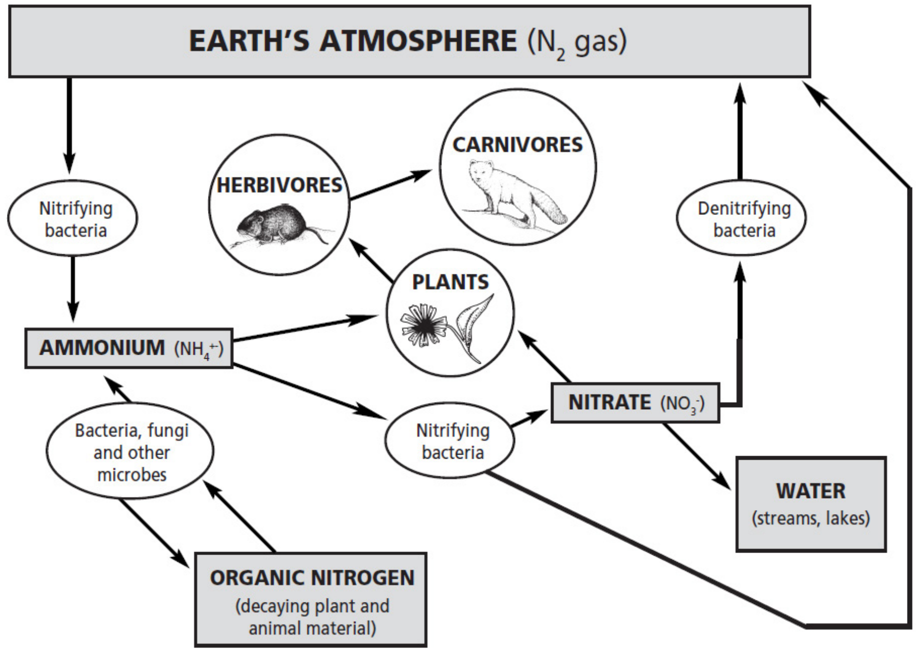
(3) Cycling. Pathways vary, but minerals cycle through food webs repeatedly. Minerals taken from the nonliving environment by living things (typically plants or **producers**) may pass through **herbivores** to **carnivores**, but eventually they are returned to the nonliving environment by **detritivores**. Then another producer can use it to start a new cycle.

IMPORTANCE

If the cycle were somehow interrupted, the supply of usable minerals would soon be used up and new living things couldn't survive. We see an example in the rainforest after it is cleared. The land is fertile for agriculture for several years and then no crop will grow. The big trees that held most of the minerals are no longer replenishing the forest and rain leaches remaining minerals out of reach.

(*See the activity "Mineral Cycling through the Ecosystem" in Section 2.*)

ECOLOGY FACTS - THE NITROGEN CYCLE



Nitrogen is an essential nutrient of most living organisms. It is an important component of amino acids – the building block of proteins. Proteins make up enzymes, which are important for chemical reactions. Therefore, most organisms require nitrogen for every day activities. Unfortunately, available nitrogen is in short supply in most ecosystems. Nitrogen in fact, is a limiting factor, especially in Alaska's boreal forest.

Much of the nitrogen on earth is in the atmosphere in the form of gas. Seventy-eight percent of earth's atmosphere is nitrogen gas (N2). However, very few organisms are able to use nitrogen in this gaseous form. Rather, animals absorb nitrogen when they eat plant material, and plants absorb nitrogen from the soil through their roots. Nitrogen in the soil comes mainly from microorganisms, which absorb nitrogen when they decompose animal waste, animal carcasses and dead plant material.

Unlike these microorganisms, plants cannot make use of the organic nitrogen in decaying material. Plants instead rely on decomposing microorganisms such as bacteria and fungi to convert nitrogen from the organic form to a mineral form that can be taken up by the roots – ammonium (NH4+). The microbes take what ammonium they need for themselves. Remaining ammonium is used by the plants.

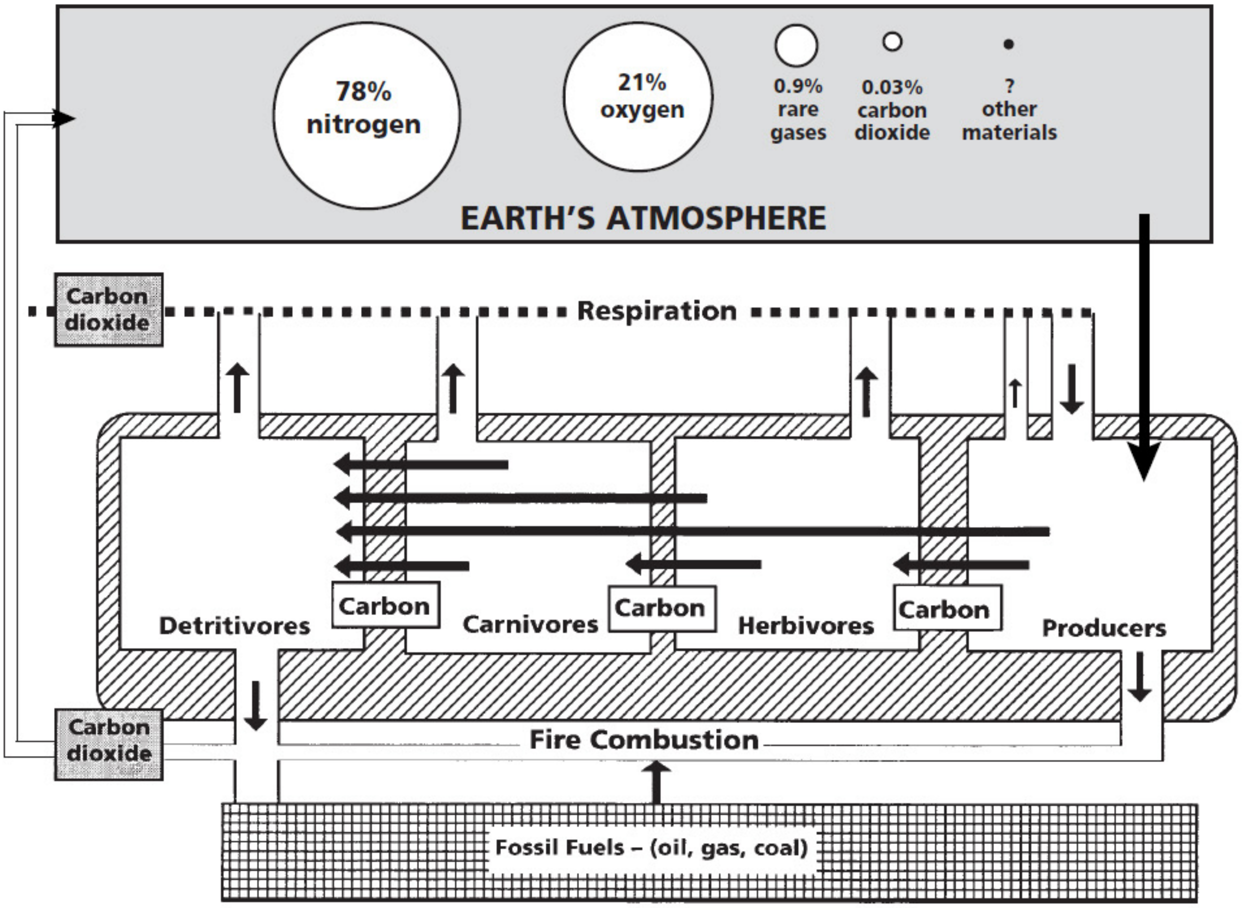
A different group of bacteria called nitrifiers converts ammonium into nitrate (NO3-) – the other form of mineral nitrogen plants can use. This process is called nitrification. Nitrate is also the most common source of fertilizer nitrogen that farmers use on their crops. Unfortunately, nitrate dissolves easily in water, and thus is often leached away from the ecosystem as soon as precipitation occurs. During nitrification, some nitrogen gas also escapes to the atmosphere.

In some soils, a third group of bacteria called denitrifiers will convert nitrate to nitrogen gas in the process of denitrification. This process allows nitrogen to be returned to the atmosphere. Dentrification is also a source of N2O, which is a very potent "greenhouse" gas (a gas that traps heat in the atmosphere and causes global warming).

So how does nitrogen get from the atmosphere to the soil? In the process of biological nitrogen fixation, some bacteria, called nitrogen-fixing bacteria, are actually able to convert atmospheric nitrogen gas into ammonium, but this process requires very large amounts of energy. Therefore, the bacteria often team up with a plant. The plant supplies energy to the bacteria, in exchange for nitrogen from the atmosphere. Plants having a mutualistic arrangement with nitrogen-fixing bacteria include all members of the pea family, alders, some members of the rose family, and a few other shrubs.

Humans have also figured out how to convert nitrogen gas into ammonium and nitrate for fertilizer. Once again the process is very energy intensive, requiring the use of fossil fuels. Lightning also contains enough energy to change the nitrogen gas. Lightning storms are thus another way nitrogen can be transferred from the atmosphere to the soil. However, these two processes are far less significant to the nitrogen cycle than biological nitrogen fixation.

ECOLOGY FACTS - THE CARBON CYCLE



Respiration – Sugar is combined with oxygen to release carbon dioxide gas, water, and energy.

Photosynthesis – Carbon dioxide, water, and sunlight energy are combined to make oxygen and carbon chains or sugar.

Carbon is present in the nonliving environment as the gas, carbon dioxide, and in a dissolved form in the sea. Carbon from the nonliving environment is incorporated into living things by producers through photosynthesis. This carbon is then passed through food chains. Some carbon is returned to the environment at each link in the food chain by respiration.

Huge amounts of carbon are stored in fossil fuels – the wastes and remains of the living things of past millennia (includes oil, gas, and coal). Large amounts are also trapped in sea sediments, wood, and detritus. This stored carbon is slowly returned to the nonliving environment through respiration by detritivores. It is also returned to the nonliving environment very quickly by fire (combustion).

Nearly all living things are dependent on the carbon cycle. Three billion years ago (before photosynthetic life forms evolved), the earth's atmosphere contained a large amount of carbon dioxide and no oxygen. Today, due to photosynthesis by producers, the atmosphere is about 21% oxygen and about 0.03% carbon dioxide.

Mini Food Web Lesson

DEFINITIONS

Compost – a mixture of *decomposing* **organic** material (*formerly living*) typically used to fertilize soil.
Humus – *decomposed* organic material. The end product of composting.
Soil – mixture of humus and **inorganic** (*sand, clay, dust, rock*) material.

WHY?

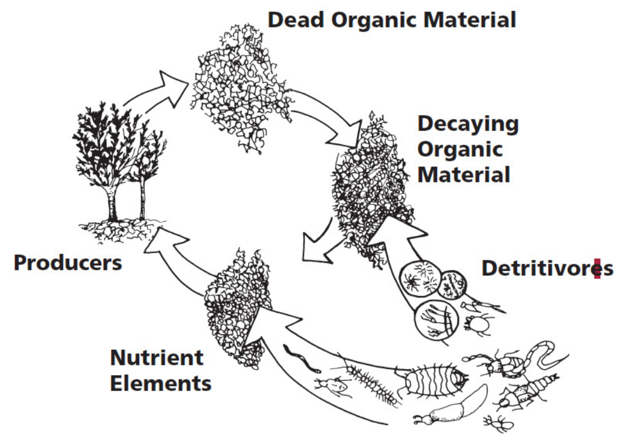
Plants need humus in soil because it provides the **nutrients** for growth and survival. Just as we get nutrients by eating plants, plants get their nutrients by "drinking" them from the soil.

The natural process of **decomposition** (*breaking down formerly living things into their nutrient molecules*) is critical in the natural world. Imagine what would happen if all of the plants and animals that died before now were still around!

Detritivores (including bacteria, fungi, worms, and other insects) are the world's natural recyclers. They feed on what we would call garbage and turn it into humus, rich with minerals and nutrients that plants can use for new growth.

METHODS OF COMPOSTING

1. **Aerobic – with oxygen**. The detritivores here need oxygen to do their job. Worms are the most common aerobic detritivores. They break down organic waste quickly, usually within three or four weeks.
2. **Anaerobic – without oxygen**. Detritivores adapted to working without much oxygen break down the compost at a much slower rate – **several years**! Bacteria are the most common anaerobic detritivores. They typically produce the soil at the bottom or edges of bogs, marshes, ponds, and swamps. Examine the top layer of "muck" or "peat" from wetlands, and you will find a high percentage of only partially decomposed material because detritivores cannot devour the supply fast enough.



CLASSROOM COMPOSTING BOX

An aerobic composting worm box, kept in the garage or in a classroom, is an easy way to recycle vegetable food waste while learning about food webs. Food and yard wastes make up about 30 percent of our garbage in the United States.

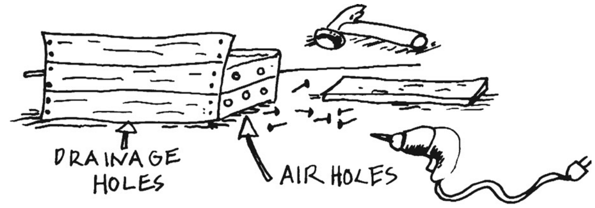
Low Maintenance. Redworms (*detritivore of choice in indoor composting*) eat their weight in garbage everyday. The worm box takes minimal maintenance. Worms can be fed weekly. Little or no watering is required once the process starts because worms can get moisture from food scraps. *Meat and fat scraps should NOT added because they require different detritivores and attract scavengers*.

Mini Ecosystem Balance. Redworms multiply rapidly. They lay eggs which hatch in 14 to 21 days and reach maturity in 85 to 100 days. Eight worms will multiply into 1,500 in six months (*if none dies*). The compost pile, however, is a mini ecosystem. If worms multiply beyond the amount of food you supply, they will simply die and become food for other worms. Thus, the worm population will achieve a balance suitable to the amount of food that is available.

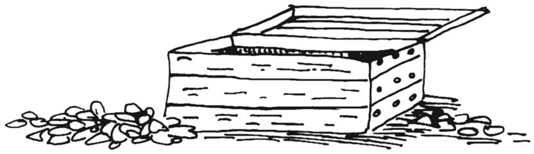
(*See the activity "Create a Classroom Compost Box" in Section 2*)

ECOLOGY FACTS - AS THE WORM CHURNS

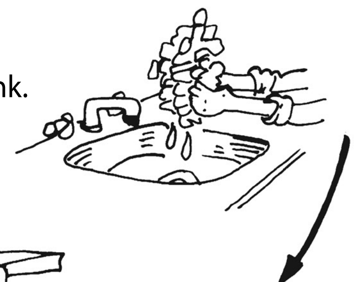
1. Build or obtain a container. Drill holes in 2 sides and on the bottom.



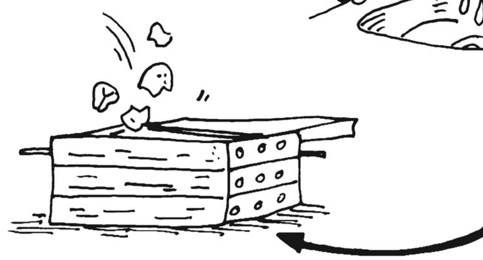
2. Shred paper for bedding.



3. Wet the bedding and squeeze out excess water in the sink.

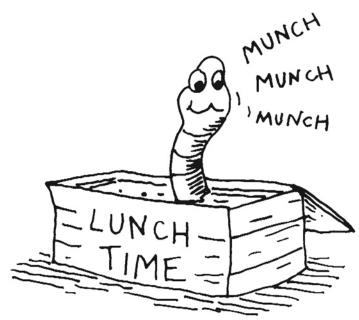


4. Put bedding material in the bottom of the box. Sprinkle in 1 or 2 eggshells.

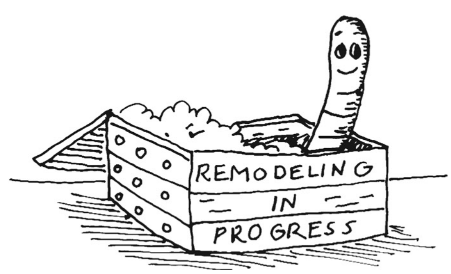


5. Place worms in the box.

6. Bury garbage for food once a week (be sure you rotate the placement of the garbage).



7. Change the bedding every 3-6 months and remove the newly made soil.



*Adapted with permission from Away With Waste: A Waste Management Curriculum for Schools. 1989. Washington State Department of Ecology, 300 Desmond Drive SE, P.O. Box 47600, Olympia, WA 98504-7600

LIVING THINGS in their Habitats

What is in your local ecosystem? There is no better way to know) your environment than by going out and taking a close look. It be the beginning of an *ecological study.*

ORIGINS OF "ECOLOGY"

The term **ecology** was introduced in 1866 by a German biologist Ernst Heinrich Haeckel. It is derived from the Greek words for "*household*" and "*economy*" giving it a meaning close to the *economy of nature*.

Ecology is now defined as the **study of relationships of organisms to other organisms and their physical environment**. The science developed in part from Charles Darwin' studies of adaptations of organisms to their environment and from plant geographers' studies of world plant distribution.

Alaska's earliest scientific study was conducted in 1741 by Georg Steller, the naturalist on Vitus Bering's voyage.

Steller was allowed less than a day ashore on Kayak Island east of Prince William Sound. In that time, however, he determined the land they saw was indeed North America – because he found a bird in the jay family he knew to exist only on this continent. (*That bird is now known as the Steller's jay.*)

ECOLOGY TODAY: Modern ecologists are still asking questions about how each organism interacts with its fellow species, with other species, and with all the elements of its nonliving environment.

Support from Many Fields of Study. In the quest for answers, ecology draws on other sciences — geology, climatology, hydrology, oceanography, soil analysis, physics, and chemistry, biology, animal behavior, taxonomy, physiology, mathematics, — and many more.

TYPES OF ECOSYSTEMS

Ecologists have identified hundreds of types of ecosystems in the United States and the world, defining many to very specific levels at specific locations. Each system is a collection of interdependent parts functioning as a unit.

Also Called Biomes**.** Often ecosystems are identified by their **biomes** – their living community of plants and associated animals. For use in this text, however, we use the concept of ecosystems in order to explore the nonliving components, the interactions, the energy flow, and the mineral cycling.

Alaska has four major ecosystem types: tundra, forests, wetlands, and ocean. Within each major category are further divisions.

TUNDRA: Alaska has both alpine or high elevation (mountain) tundra and arctic or (high latitude) tundra. Alpine tundra exists anywhere in the world there are mountains – even on the equator. Climate and other nonliving elements prevent the growth of trees. The name tundra came from the Finnish word meaning treeless.

Adapted for the Physical Environment. The plants and wildlife that do live in tundra ecosystems have adaptations to survive freezing temperatures, short summers, and slow mineral cycling. Rainfall is so low, tundra would qualify as a desert.

Some birds fly thousands of miles to partake in the tundra's summer abundance of insect life. These birds and some of the mammals (such as caribou) then **migrate** elsewhere for the winter. Others find life under the snow a cozy way to survive harsh winters.

Where to Find More Information. The Alaska's Tundra & Wildlife is a companion book in the Alaska Wildlife Curriculum series with detailed information and student activities using tundra environments to study ecology.

FORESTS: Alaska has two main forest ecosystems – boreal forest and temperate rainforest. The boreal forest reaches to the lower edge of the tundra and its organisms face some of the same rigorous climatic conditions.

Trees Protect their Environment. The temperate rainforest fringes the coastline. In keeping with its name, Some coastal rainforest areas collect more than 200 inches of rain. Forests protect our water table and our streams by preventing erosion. Trees also play a major role in the water cycle by returning water vapor to the atmosphere.

More than any other ecosystem, forests help to maintain the balance of oxygen and carbon dioxide in our atmosphere, keeping the air breathable for all living things.

Multiple Layers, Multiple Homes. With many layers – from sky-scraping tree tops to mossy ground cover, forest ecosystems provide homes to a variety of wildlife. The increased plant life supports greater populations of **herbivores** and they, in turn, support more **carnivores** than in tundra ecosystems. The **detritivores** are plentiful – and busy.

Alaska's Forests & Wildlife is a companion book in the *Alaska Wildlife Curriculum* series with detailed information and student activities using forest environments to study ecology.

WETLANDS: Wetland ecosystems are found within tundra and forest ecosystems and many others. Coastal wetlands types include estuaries, river deltas, and saltwater marshes. Inland wetlands include stream and river corridors, marshes, ponds, lake shores, bogs, muskegs.

What Makes It a Wetland? Three factors help to define what makes a wetland.

1. How much water is present (the water regime),
2. Water-retaining soil,
3. Plants adapted to growing in soils with low or no oxygen.

Alaska's wetland ecosystems are some of the most productive wildlife habitats. For example, many of our commercial fisheries depend on fish hatched in freshwater streams. Alaska's wetlands are also the primary nursery for much of our nation's waterfowl.

Large Food Base. Wetlands are so productive for the larger, more visible wildlife because this ecosystem includes an abundance of microscopic organisms and small invertebrates that serve as food for high level consumers.

Wetlands & Wildlife, K-12 Curriculum, is a good source of information and student activities about wetlands by the US Fish & Wildlife Service and the Alaska Department of Fish and Game.

OCEAN: With 34,000 miles of marine coastline, Alaska has all varieties of ocean ecosystems from tidal flats and lagoons to deep sea trenches and sea mount upwellings.

Zooplankton to Whales. The ocean ecosystems are highly productive despite Alaska's harsh climate. They support a **food web** that ranges from tiny zooplankton to humpback whales.

Millions of seabirds are a vital part of the ocean ecosystem. They spend nine months of the year at sea, coming to land only to nest. Salmon, herring, halibut, and pollock are some of the major fishes.

Calling all Ecologists. But Alaska's marine ecosystems have shown signs trouble. In some areas the once abundant Steller sea lion and sea otter have declined sharply, for reasons yet unclear. Ecologists have been called to discover the causes.

Sea Week Curriculum by the University of Alaska – Fairbanks is a good source of information and student activities about the ocean ecosystem. *Alaska Oil Spill Curriculum* published by the Prince William Sound Science Center is another source, as is *Learn About Seabirds*, by the U.S. Fish & Wildlife Service.

HOME SWEET HABITAT

Who lives in each ecosystem? Only the organisms that find suitable **habitat** (*food, water, shelter, and space*) within a particular ecosystem. (*Some wildlife use multiple habitats, either daily, periodically, or seasonally.*)

The Right Stuff. Sitka black-tailed deer cannot survive in the arctic tundra ecosystem even though there are food, water, shelter, and space – they are NOT *the right kind* of food, water, shelter, and space for a temperate rainforest mammal. The environment that meets all of the needs of an animal is called its habitat.

The habitat of the red squirrel, for example, is a spruce forest – a place where trees provide plentiful seeds to eat, hiding places to escape from predators, and nesting areas to raise young squirrels.

Different in Different Seasons. An animal's habitat requirements may be different at different seasons and times in its life. Here are two examples. A female polar bear will den (*shelter*) from November through April to give birth to cubs. After the cubs are old enough to emerge from the den, she will not use a den again until the next time she is pregnant.

A brown bear will dine hungrily on tender roots and sedges in spring when few other foods are available. When salmon swim into nearby streams from the ocean, the brown bear will walk past sedges to fish for the high protein salmon. In early fall, the bear will gorge itself on berries.

Where Do I Find It? The key to understanding habitat – and knowing where to find an animal – is to look at each animal's specific needs and where in nature those needs are met. The Alaska Ecology Cards available as part of this curriculum are handy references for habitat and food requirements of Alaska organisms from all five kingdoms.

SMALL IS INTERESTING TOO – TIPS FOR INVESTIGATING

When Alaskan's hear the word "animal," we think about large furry **mammals** such as moose or bears. The investigations included in this section remind students to take a close look at all living organisms to discover the richness of the local ecosystem.

SOIL ANIMALS: There are many animals that live on and in the soil including **insect larvae**, snails, worms, spiders, and small mammals. These animals spend most of their life in the dark, living on other animals or nutrients found in the soil.

Many of the soil critters that students might find have special **adaptations** that allow them to thrive on or in the soil. While investigating the soil habitat, look for evidence left by soil animals, as well as for the animals themselves.

WATER ANIMALS: Not all water animals are fish, ducks, or sea otters. Ponds, streams, rivers, and other wetlands are rich with kinds of animal life that we seldom see.

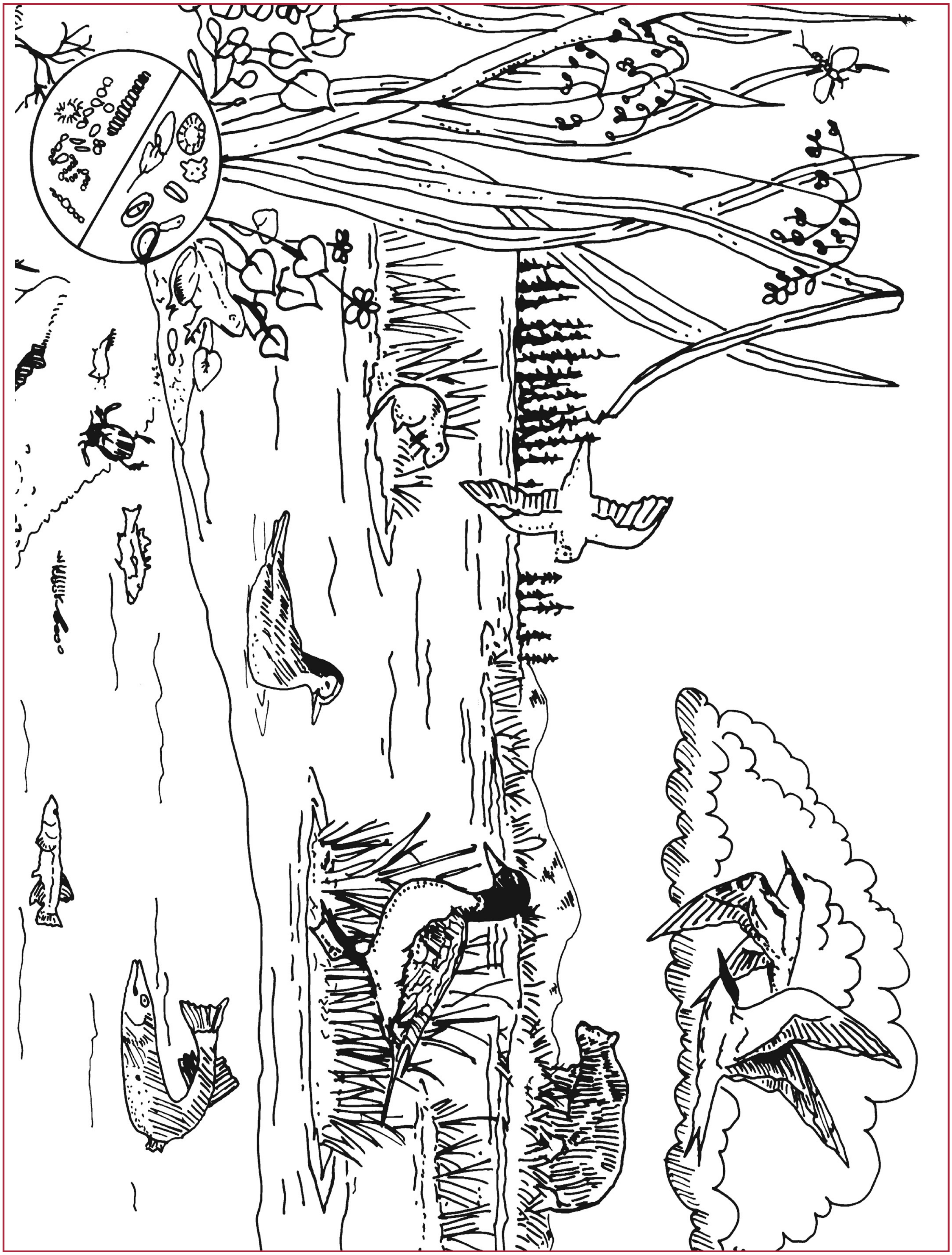
Each spring as ice thaws, wet areas in Alaska erupt with young **invertebrates** (*animals such as worms and insects that have no backbone*). These invertebrates are extremely important food sources for many of the fish that other animals eat (including humans).

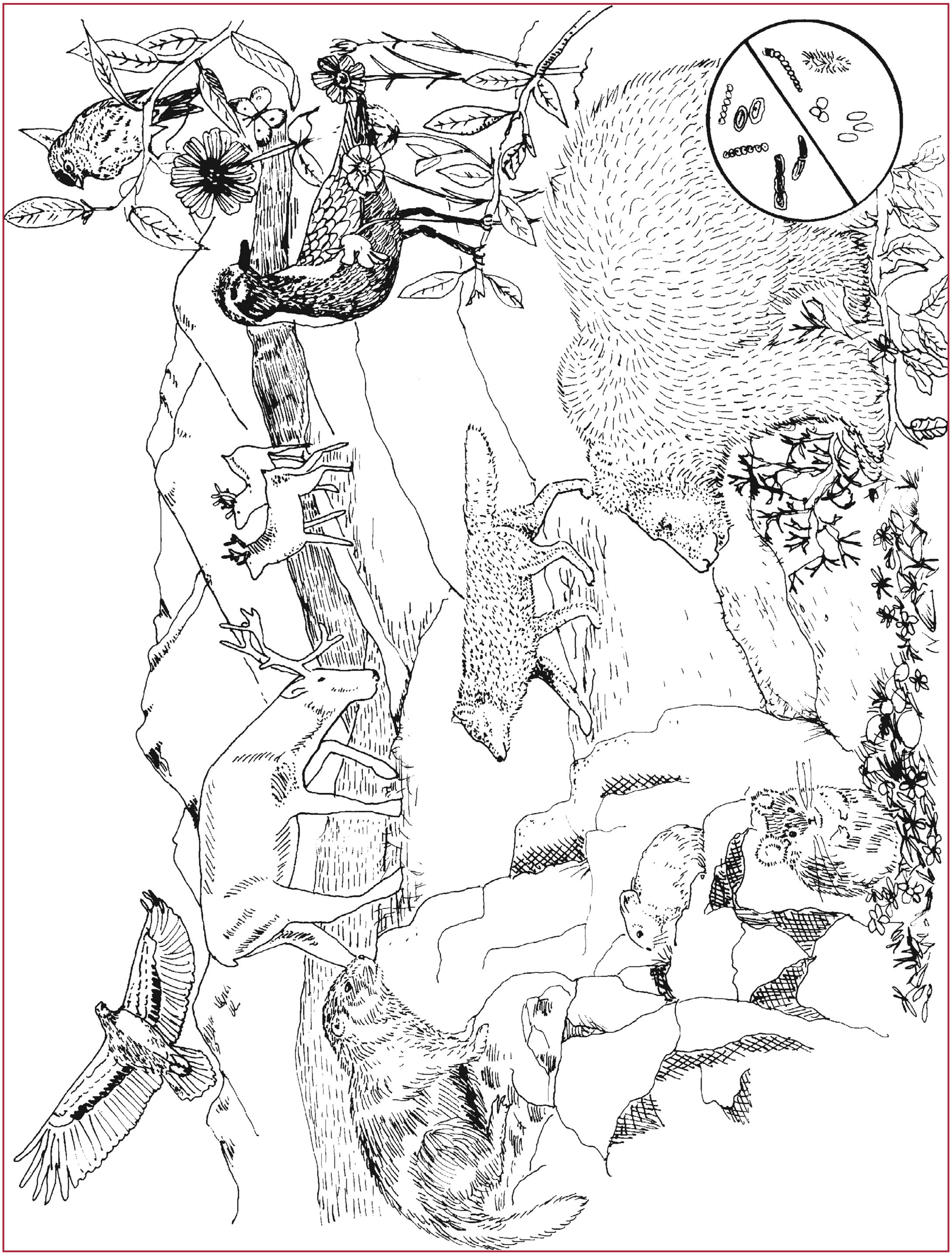
Don't Forget Mosquitoes! Many of the easily recognizable flying insects in Alaska such as mosquitoes and dragonflies lay their eggs in water. **Larvae** and **pupae** develop from these eggs and carry on complex predator – prey, and consumer – consumed relationships.

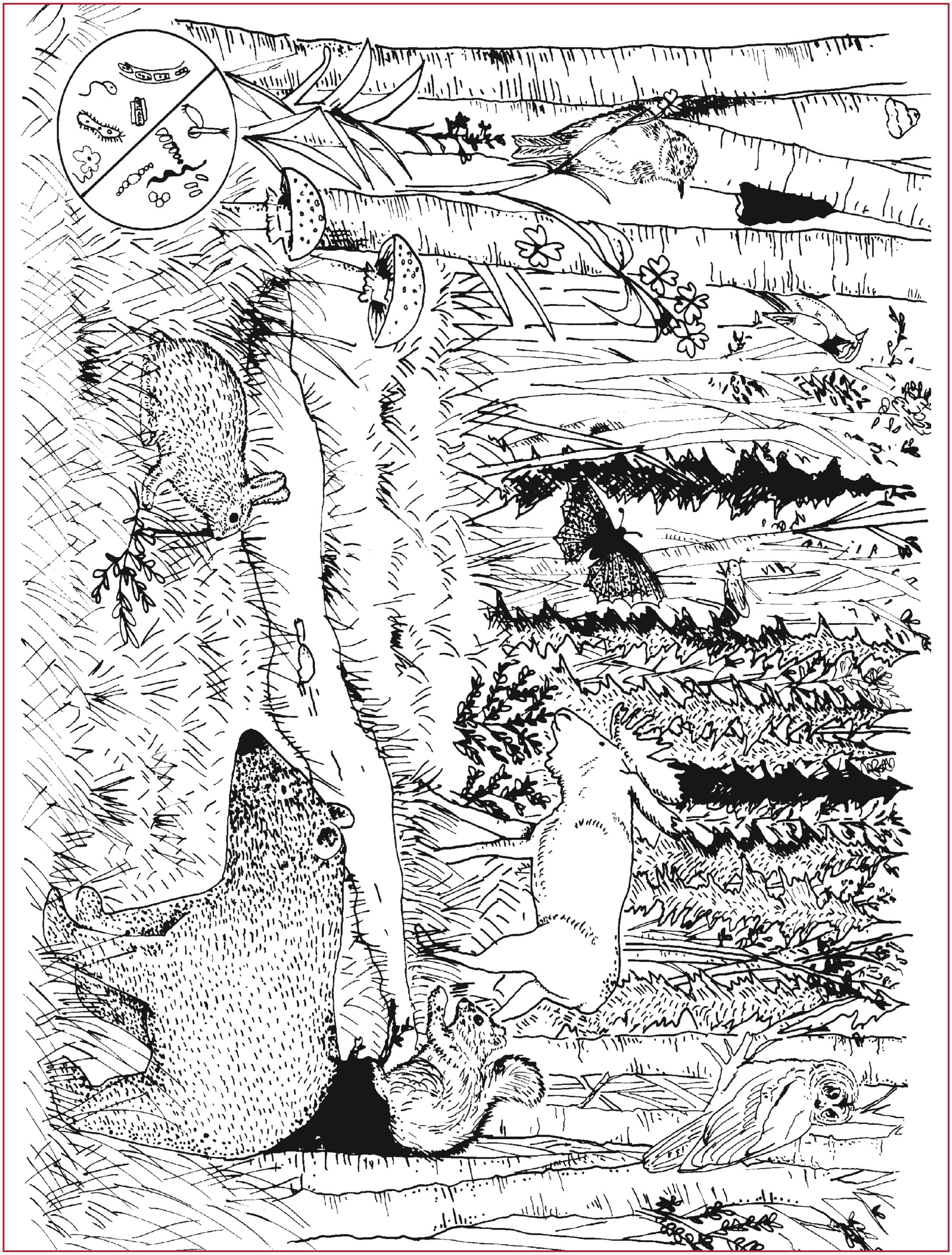
Investigating water habitats reveals usually hidden creatures that form essential links in the food chains of wetland ecosystems. A pond will never seem so ordinary again!

PLANTS: Within one calendar year **annual plants** grow from seeds or buried roots, flower, produce new seeds, and die. In fall and winter only remnants of annual plants such as dead leaves, tubers, seed pods, and roots are left as evidence of their presence. They are providing energy for the decomposers and detritivores.

While investigating the plants in your local ecosystem, look also for evidence of perennial plants such as fireweed, dwarf dogwood, and cow parsnip. Though their summer appearance is fleeting, plants are vital in the web of ecosystem interactions of living and nonliving things.





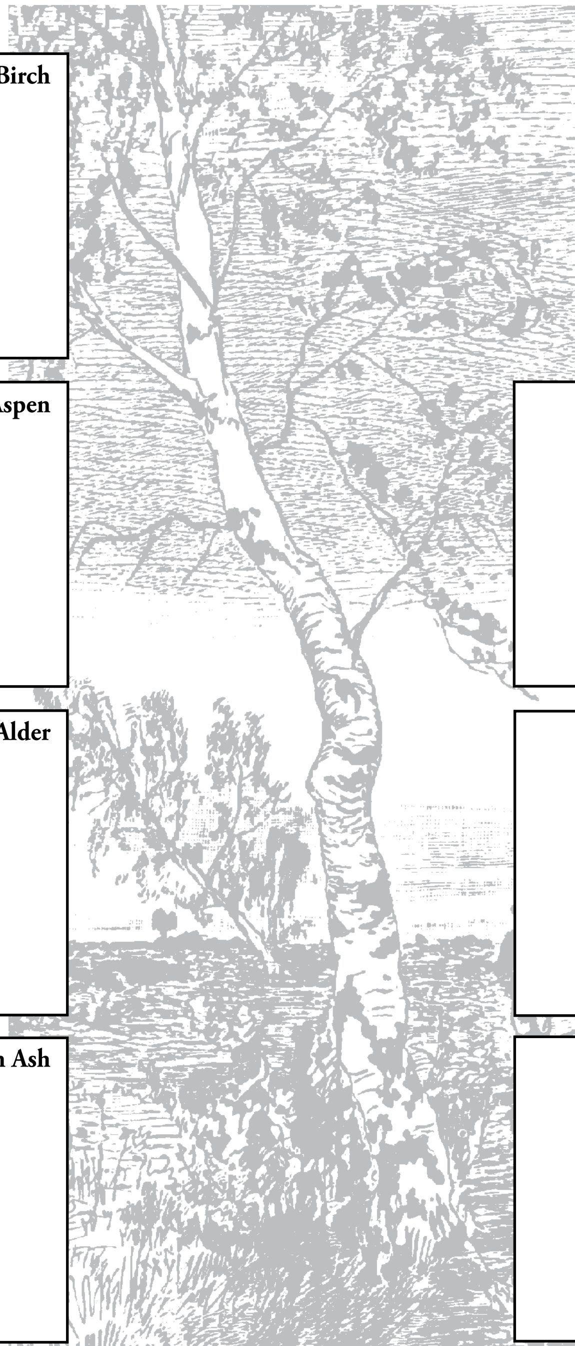


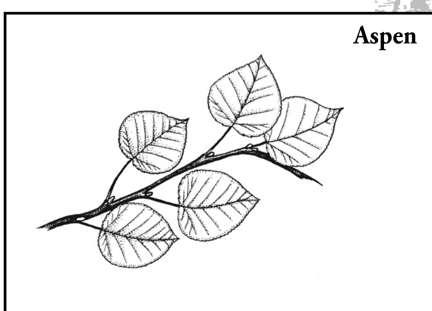
ALASKA'S BROADLEAF TREES

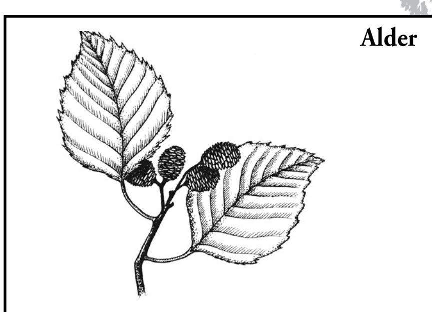
Look at the leaves.
• If they are broad, flat leaves, the tree is a **broadleaf, angiosperm,** or **hardwood**.

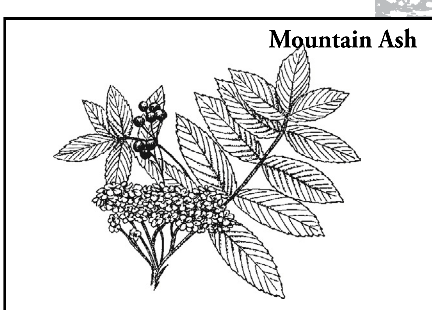
Broadleaf trees have flowers as well as broad, flat leaves. Flowers on a majority of Alaska's broadleaf trees are small and green and do not look like a typical flower petal.

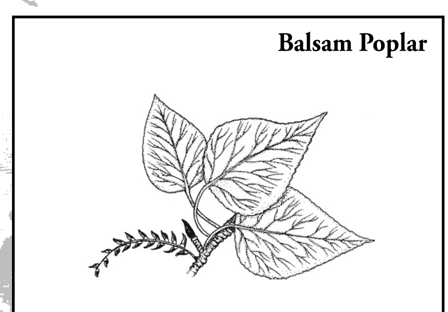
Broadleaf trees in Alaska are **deciduous**, losing their leaves in the fall. They become **dormant** as an **adaptation** to the cold and reduced daylight.

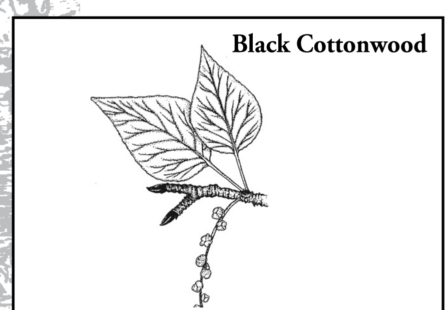












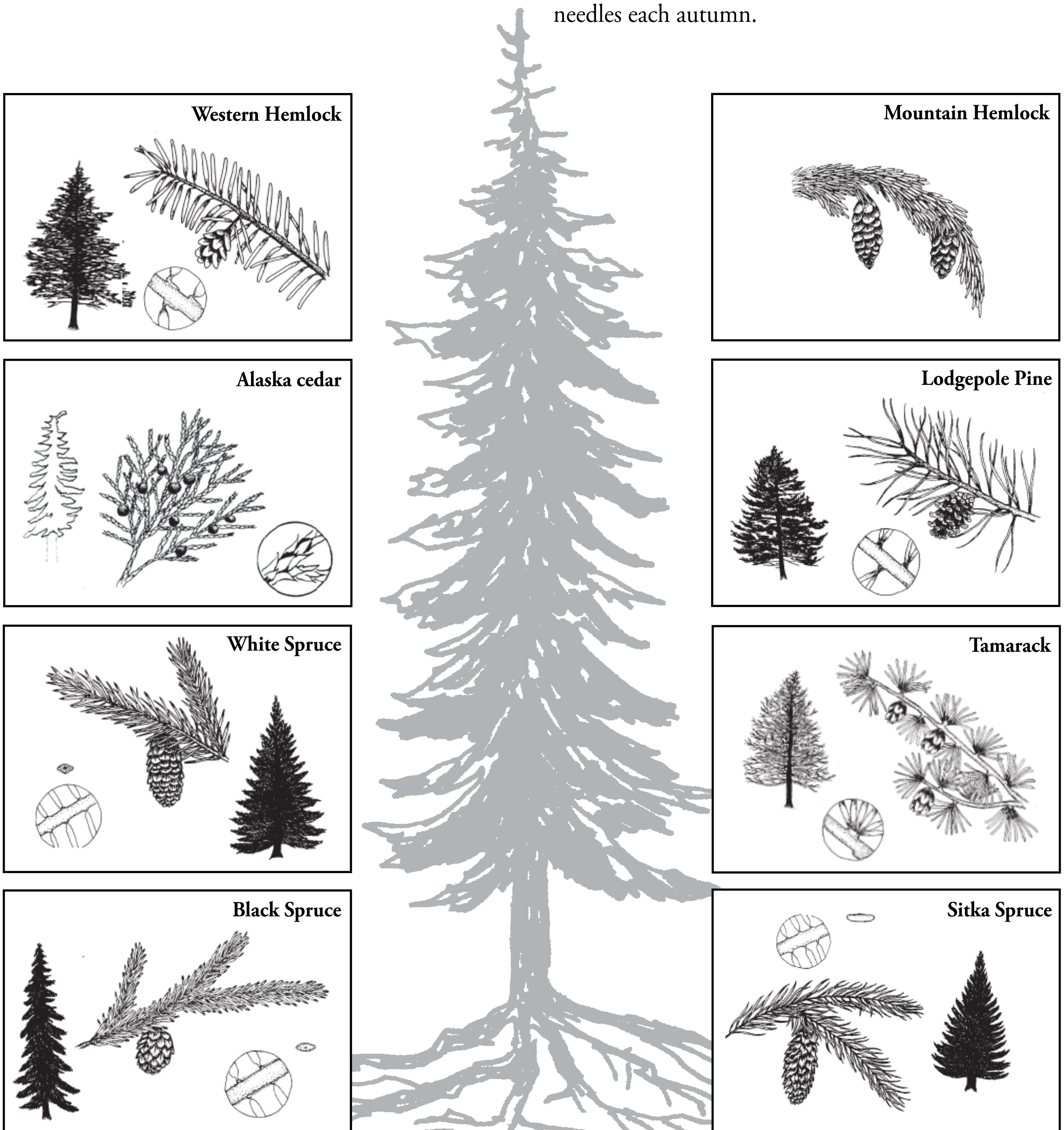
ALASKA'S CONIFER TREES

Look at the leaves.

- If the leaves look like needles or scales – just picture a Christmas tree – the tree is a **conifer, gymnosperm**, or **softwood.**

Conifer seeds grow inside **cones** rather than flowers and sometimes hang on the tree for several years. The tree's **crown** looks like a cone as well.

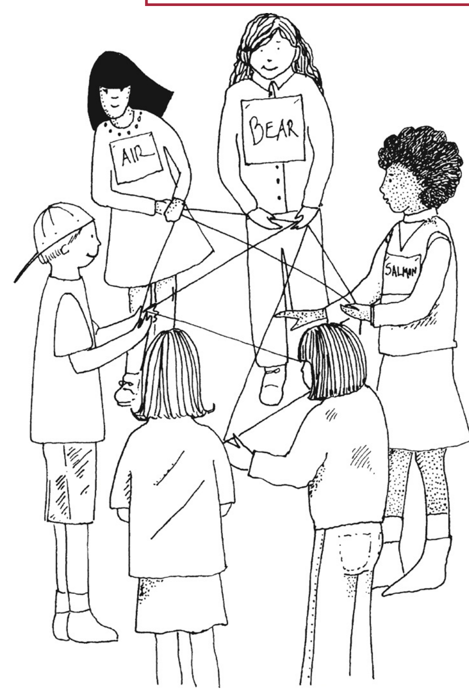
Since conifers typically keep their narrow, needle leaves all winter they are also called **evergreens**. One Alaskan conifer – the tamarack – is **deciduous** and loses its needles each autumn.



Human Impacts on ECOSYSTEMS

In tracing the web of connections within an ecosystem, ecologists are explaining how changes in the nonliving environment affect every living member of that ecosystem – because all things interact, either directly or indirectly.

Section 4
ECOSYSTEM INSIGHTS



PHYSICAL CATALYSTS

Alaska has an example of ecological change in geologic time and scale. Until 13,000 years ago, much of the world's northern areas were covered by glaciers and ice sheets while the interior of Alaska was ice-free. Woolly mammoths and steppe bison thrived in this grassland steppe ecosystem.

Prehistoric Global Warming. As the climate warmed over thousands of years, the ice sheets melted and the glaciers retreated. Grassland steppe ecosystems gradually became forests and tundra ecosystems. Some scientists theorize that woolly mammoths and other prehistoric animals could not adapt to life in forests, and therefore became extinct.

Similarly, but on smaller scales and shorter timeframes, flooding, drought, volcanic eruptions, fire, and earthquakes can change local ecosystems.

Quakes Shake Ecosystems. Alaska's 1964 earthquake uplifted some lands and drowned others, so each area is changing to organisms that can survive in different water regimens – wetlands changing to shrubs along the coast of the Copper River Delta; forests and former townsites turned into tidal marshes at old Valdez and along Turnagain Arm.

BIOLOGICAL CATALYSTS

Sometimes an animal's abundance triggers an ecological change. The spruce bark beetle is one recent example.

The Beetle that Roared. Weather and other natural factors allowed rapid expansion of this parasitic beetle's population. In mass, they kill large white spruce by boring into the trunk to feed and lay their eggs. Large numbers overwhelm a tree's normal defenses. Next spring all those newly hatched beetles fly to more trees and soon a forest is under siege.

Miles and miles of spruce forest in Southcentral Alaska fell victim to the swarms. As a result, the forest ecosystem is changing. Former dense spruce forests are becoming grassy meadows or changing to birch and aspen-dominated forests.

Caribou Migrate for a Reason. Alaska's caribou herds are another example of population explosions changing an ecosystem.

Caribou, always on the move, migrate hundreds of miles each year. As they move, they graze on plants and lichens. By this habit, they don't eat all their favorite plants in one area nor crush the fragile lichen that take decades to grow.

When caribou populations expand rapidly, a population crash is usually not far behind. Too many caribou eat or destroy their food sources, leading to low reproduction and starvation. They leave an ecosystem out of balance, with plant communities depleted and predators looking for new prey.

HUMAN CATALYSTS

Throughout our history, we have records of human caused changes in ecosystems. From extinction of species (the Steller's sea cow in Alaska, for example) to clearing a forest or filling of wetlands.

Oil Spill Starts Changes. The Exxon Valdez oil spill in 1989 introduced about 11 million gallons of North Slope crude oil into the marine ecosystem of Prince William Sound and west along the Gulf of Alaska to the Alaska Peninsula. Many kinds of wildlife immediately began washing up dead or dying on the beaches.

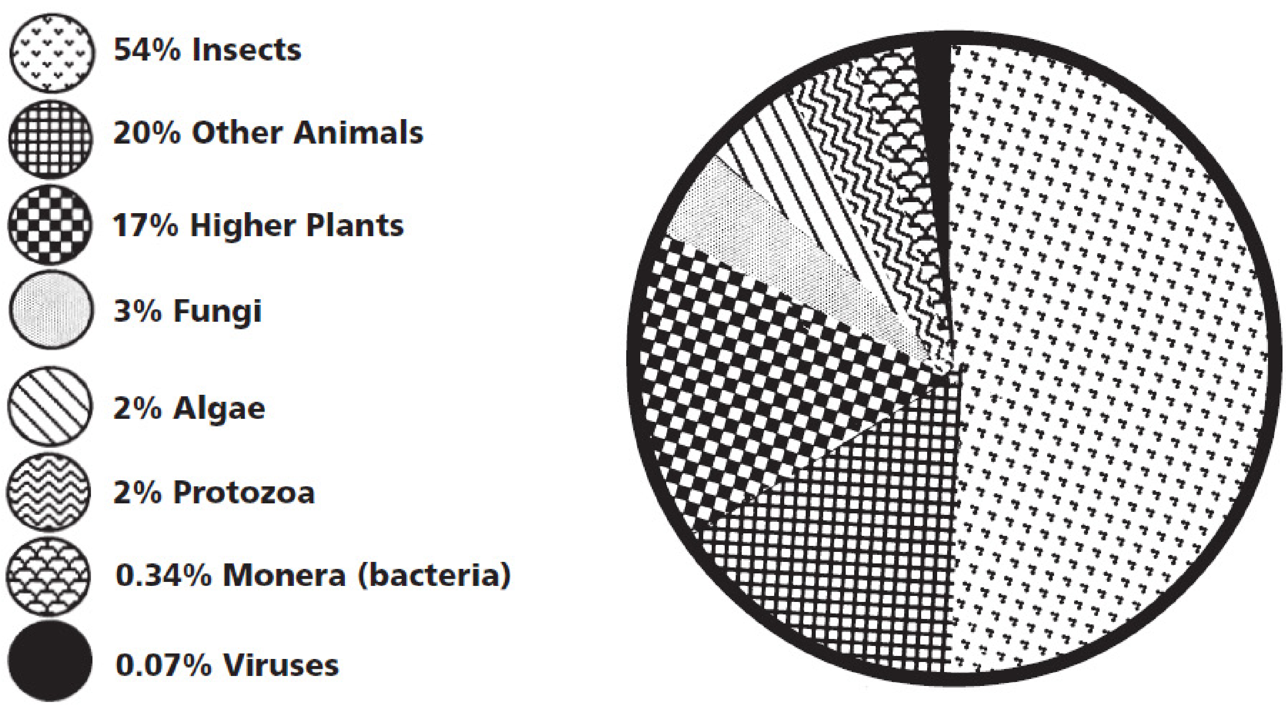
Shaking the Whole Food Web. Less visible were the deaths and changes in health of the many invertebrates and microscopic organisms so vital to the smooth running of an ecosystem. Because they are the foundation for all other consumers, their losses or damage continued to be felt years after the spill.

Are the Effects Over? In addition, hydrocarbons of oil remained present in the substrate of beaches and in the water column. Scientists continue to study and puzzle over the ecological changes.

(*See the Alaska Oil Spill Curriculum published by the Prince William Sound Science Center for student activities and further background.*)

Biodiversity Kingdoms

Source: E.O. Wilson. Biodiversity. 1988 (Washington, D.C. Nat'l Academy Press)



Other examples of human-caused changes in ecosystems can be found in the fact sheets with the student activity "Ecology Puzzlers" in Section 4.

BIODIVERSITY – SIGN OF HEALTHY ECOSYSTEMS

The variety and abundance of living organisms in an ecosystem or habitat determine its **biological diversity** or **biodiversity**.

Why is Diversity Important? Like the old saying "variety is the spice of life," a diversity of plants, animals, and microscopic organisms fills all the "jobs" in an ecosystem.

Abundance and variety of parts give an ecosystem flexibility. That flexibility insures the smooth and continued functioning of the whole as, over time, an ecosystem is buffeted by change and damage.

Radiating Effects of Loss. Nevertheless, since all living things are connected to others in their ecosystem, impacts have a radiating effect. Removing a species shakes the whole web of life.

Scientists are still learning about all the interactions in ecosystems. Our decisions and actions regarding wildlife today may have consequences tomorrow that we do not currently understand.

Habitat Key to Diversity. The greatest threat to biodiversity is loss of habitat. Destroying habitats can threaten the extinction of species and the destruction of entire ecosystems.

Humans are reducing the world's biodiversity at an increasing rate. In the United States scientists estimate that more than 125 types of ecosystems are either threatened or endangered.

CONSERVATION – USE FOR THE FUTURE

Conservation is the *use of miner in a way that assures their continuing availability to future generations.*

Two Categories of Resources. Resources are **renewable** if they have the capacity to replenish themselves over time through natural processes. Solar energy and wind are examples of inexhaustible resources. Pure water, plants, and animals are renewable resources – provided humans practice conservation and do not pollute or consume them faster than they are naturally reproduced.

Nonrenewable resources are limited in supply and can only be replaced in geologic time, not human time. Examples include oil, coal, copper, and gold. They require humans to think and conserve for all future generations.

THE BIODIVERSITY OF ALASKA

How many species ... a sampling

	ALASKA	WORLD
Amphibians	6	+4,200
Birds	452	+9,000
Fishes	430	+18,800
Mammals	108	+4,000
Plants	+1,500	+248,000
Reptiles	0	+8,300

NO HUMAN IS EXEMPT

People often see themselves as separate from the surrounding wilds. Like all other living things, however, humans are a part of the Earth's ecosystems.

Can We Do Without Land, Oxygen, Food? We need water, minerals, and air from the nonliving environment. We need plants and algae to produce oxygen and maintain the composition of our atmosphere. We also need these producers to make food for animals and ourselves.

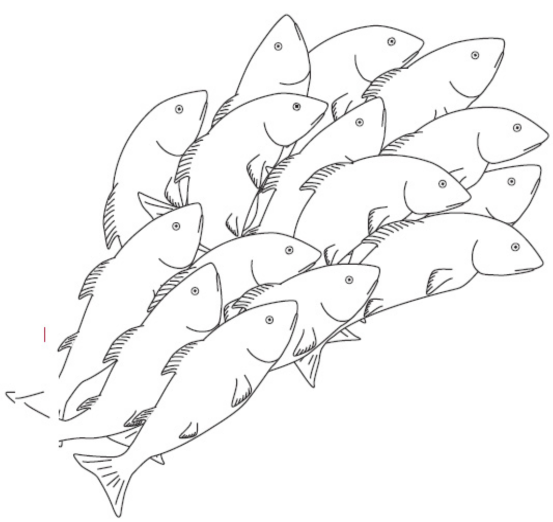
We depend on plants to reduce soil erosion, moderate our climates, and maintain the water cycle. We depend upon nitrogen-fixing bacteria and denitrifying bacteria to maintain the nitrogen cycle.

Global Garbage Recyclers. We need other bacteria and fungi to break down waste materials to replenish the soil for plant growth. About 80% of each year's biological production (leaf litter, dead animals, fecal wastes, for example) is ultimately broken down by **detritivores**. Without detritivores, all that biomass would accumulate in a mountain of waste.

Humans also use certain chemicals produced by bacteria, fungi and other organisms as medicines. We need many of the materials made by plants and animals for clothing, shelter, and tools (*for example, wood, paper, cotton, silk, wool, rayon, rubber, certain oils*).

Balance in the System. We also depend on predators,

CONSERVATION CASE STUDY



What does it take to ensure a future for something we value? Let's look at salmon. During the life cycle of a salmon, it uses the following ecosystems:

- Clean, cool **streams** water and gravel beds (where the salmon eggs are laid and hatched).
- Unobstructed, clean **rivers** that the salmon use to migrate to and from the sea.
- Food-filled, unpolluted **ocean** (where the salmon feed and grow to adult size).

The salmon also depends on the following nonliving and living parts of these ecosystems:

- Non-acidic rain water (to fill the stream and river).
- Organisms that produce the oxygen in the water (so the salmon can breathe –phytoplankton and aquatic plants).
- Shrubs and trees that grow beside the stream (to provide cover and shade that keeps water cool)
- All the living things the salmon eat (stoneflies and other aquatic insects –after salmon hatch; herring and sand lance –as adults)
- The organisms that feed these prey species (dead plant materials and zooplankton)
- Detritivores that recycle minerals, the animal pollinators and seed carriers, and the fungi or bacteria that help them obtain certain minerals.

Thus, if we intend to conserve salmon populations, we must also conserve the entire ecosystem in which they live.

parasites, and disease-causing microscopic organisms to keep populations of other organisms in check. *Predators, parasites and disease-causing micro- organisms also effect humans, but not enough to limit human population growth in modern times.*

Changes in the earth's ecosystems, therefore, have direct effects on people as well as all other living things. Even an activity that seems to affect only insects, only fungi, only the upper atmosphere, or only ground water supplies can have far-reaching consequences. Can we live with each change or the cumulative effects of many changes? What kind of environment will future generations inherit?

SOLVING PROBLEMS LOCALLY

If your students notice something is askew in the ecosystem around your school, then you have a great opportunity to make learning both tangibly productive and fun. Your class can transform creative thinking into problem-solving actions that make a difference in your school and your community.

Ecology contributes to the understanding of environmental problems.

I Can Make a Difference! Students should not feel responsible for solving all the world's problems. But that doesn't mean they can't try to solve some. Vital steps that give students a feeling of "I can make a difference" include the following.

- **SINGLE PROBLEM:** Allow students to choose a single problem to solve.
- **MANAGEABLE FOCUS:** Help students keep the size of the problems manageable.
- **BUILD SKILLS:** Help students build the skills they need for accomplishing each step.
- **TIME:** Give students time and resources to work on their problem.
- **SUPPORT:** Help students gather community support.

Perhaps the school uses disposable packaging for school lunches. Students might propose that the school purchase reusable plates and a dishwasher, and look for ways to raise money to purchase them.

Perhaps your town or village has a problem with drinking water pollution by leaking gas storage tanks. Students could mount a campaign to encourage clean-up and prevention of leaks.

Perhaps your community has a problem keeping garbage away from bears. Students could survey possible solutions such as incinerator installation or bear-proof cans or dumpsters.

Problems that seem small, such as moose browsing in a playground near young children, may be excellent research subjects that lead to resolution by the students. Students could solve the moose problem by providing moose with better access (for example, snow removal) to an alternative browse area. Trees and shrubs that attract moose could be replaced by plants less attractive to moose.

Chosen (Owned) by Students. Whatever the problem, it is important that it be identified by students. Teachers may think a particular project is fascinating, but it does not capture the interest of students. Then the teacher gets exhausted trying to motivate and invigorate their class.

Ask students to look around their ecosystem and see if there's anything that bothers them. Their own energy can be limitless (while your energy may not be!).

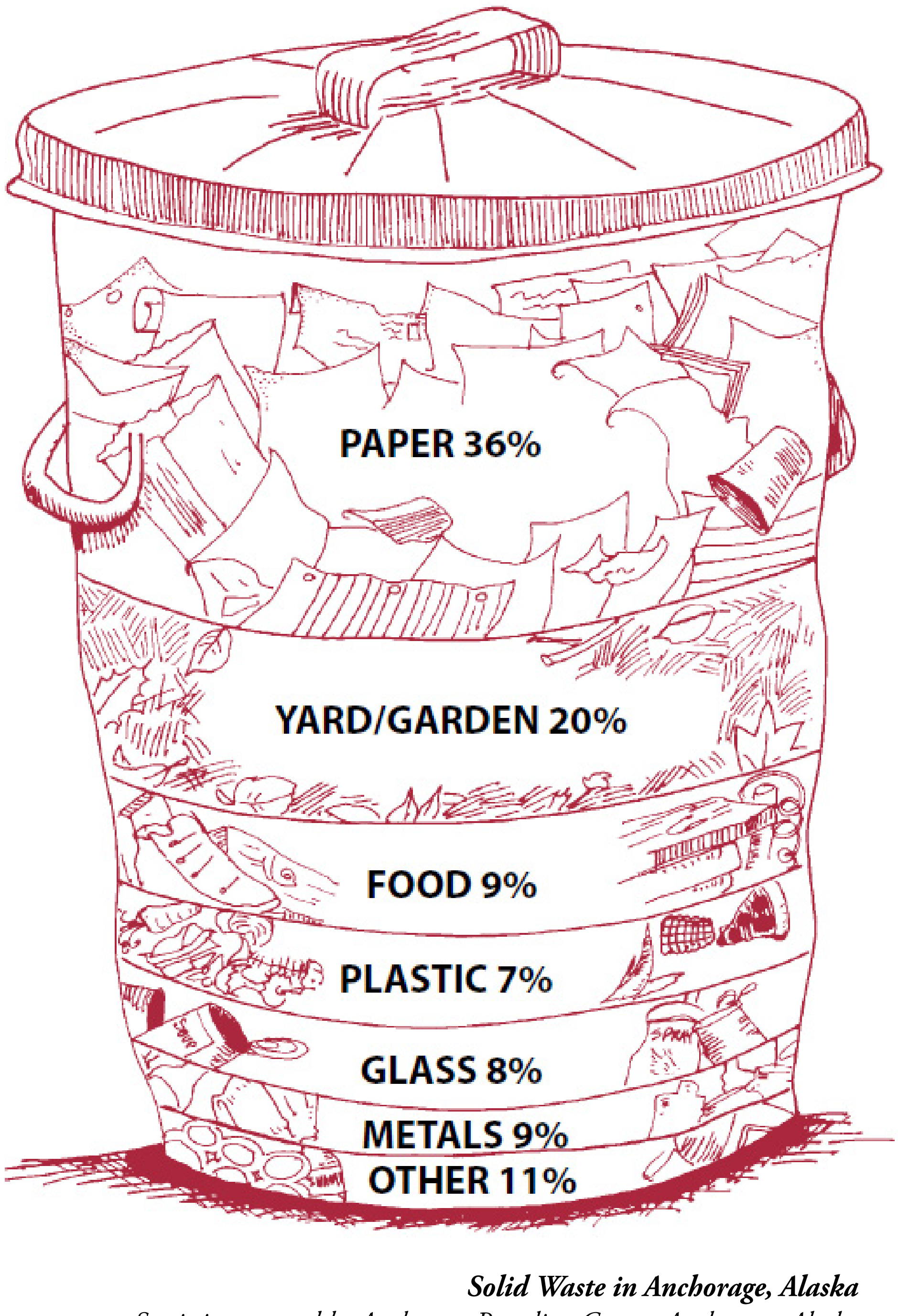
ECOLOGY FACTS - WATCHING YOUR WASTE

Our human population has grown so large that the amount of garbage we produce overwhelms the population of naturally-occurring detritivores that decompose and recycle dead things.

Detritivores are absolutely essential to ecosystems because they provide renewed sources of mineral nutrients and help keep our surroundings clean. But they cannot keep up with our wastes without our help.

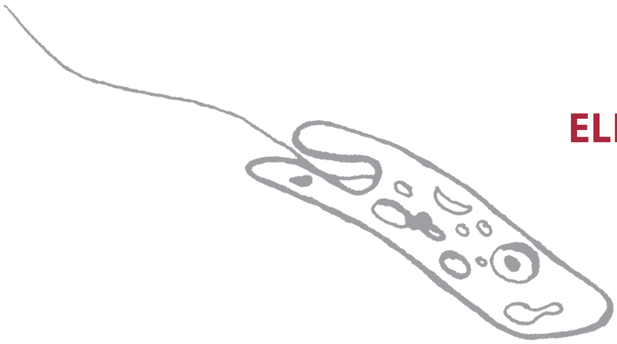
The average American generates about 1,300 pounds of solid waste (other than bodily waste) each year. This material has to go somewhere! Much of our food and sewage waste is recyclable back into the soil with detritivore help. But humans produce a lot of synthetic waste, such as plastics, that detritivores don't eat.

Many synthetic goods are produced from nonrenewable resources (limited in nature like aluminum). If materials are not recycled, future generations may run out of them. We can make some waste items available for reuse just as the detritivores do if WE practice recycling.



Solid Waste in Anchorage, Alaska
Statistics reported by Anchorage Recycling Center, Anchorage, Alaska

ECOLOGY ACTIVITIES



Section 1
ELEMENTS OF ECOSYSTEMS

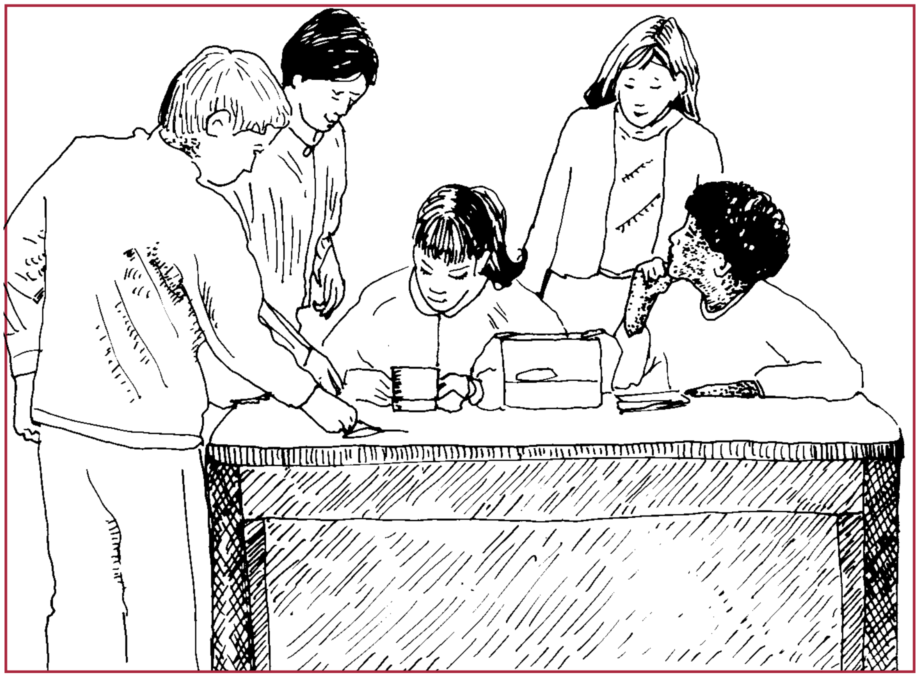
Section 2
ECOSYSTEMS – COMMUNITY CONNECTIONS

Section 3
LIVING THINGS IN THEIR HABITATS

Section 4
HUMAN IMPACTS ON ECOSYSTEMS

It's Alive! Or is It?

1 EXTENSION



Section 1
ECOLOGY ACTIVITIES

Grade Level: 3 - 12

State Standards: S B-1, S B-2, S B-5, S B-6
NGSS: MS-LS1-1

Subject: Science, language arts

Skills: Observing, classifying, note-taking, predicting

Duration: One or two 50-minute periods over one week

Group Size: 2-3

Setting: Indoors

Vocabulary: Ecosystem, living, microscopic, mold, nonliving, organism, spores, yeast

Objectives:

1. Given a variety of living and nonliving objects, students will be able to identify some of the differences between living and nonliving things.

2. Students will work in groups to describe and perform some experiments to determine whether an object is living or nonliving.

Teaching Strategy:

Students examine and classify a variety of living and non-living things and then test their conclusions.

Complementary Activities:

"Five Kingdoms But No King," "Investigating Heat Energy," "Investigating Soil," "Investigating Water," "Investigating Air," *and* "Take a Deep Breath" *in this section. All the* "Investigating ..." activities *in Section 3, Living Things in Their Habitats.*

Materials:

A jar of water, a jar of air, soil, a rock, a ray of sunlight *(if possible),* a wind-up toy, a group of rocks *(two large and several small),* sugar crystals *(a jar of water with sugar dissolved in it and a string – allow to set for a day prior to class).* Photocopies of data sheet – one per group per station *(following),* microscopes, slides and covers, hand lenses, or bug boxes.

A small bird or mammal, several different live insects and/or other invertebrates *(such as flat worms, shellfish),* microscopic organisms, yeast, bread mold, spores from a fern or mushroom, and various kinds of plant seeds. Try to include at least some small living things that are unfamiliar to your students. Number the objects.

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems.*

Procedure:

IN ADVANCE: at least one day earlier, dissolve sugar in hot water and hang a string into the water so that crystals will form. Number the objects to be identified and label them or their containers with any specific rules *(e.g. "Do not open" or "Handle Gently").*

BEFORE CLASS: place the selected materials at numbered stations around the room.

1. *IN CLASS,* discuss the differences between living and nonliving things. *All living things are able to move, to reproduce in some way, to change, and to respond to stimuli from their outside environment.* Use examples of things commonly found in the classroom as a basis for discussion.

2. On the chalkboard, create a class list of the traits of living things.

3. Explain that students are scientists from another planet, and that the items placed around the room were found on Planet Earth by their expedition. As scientists, they must create and use tests to determine which of the objects are living and which are nonliving.

4. Discuss a few questions that might be asked in these tests to start the students thinking. *Does the object die without sun, water, or oxygen? Does it move? What happens when you poke it?* The students may conclude that further tests are needed, but they must describe these further tests.

5. Divide into groups. Each group determines the tests that it will use to decide whether an object is alive.

6. Groups then visit each station, performing their tests on each object and recording the results. Tasks can be divided so that all students are involved in testing and recording data during the experiments.

(Teachers may want to model how to take data and summarize findings into conclusions before sending groups out to the stations.)

7. Before leaving each station, students should summarize their conclusions regarding which objects are living and which are not, based on the tests performed by their group. Before students switch stations, give them five minutes to write their summaries. Remind the scientists that before they return to the spaceship, all data must in writing!

8. After students have visited all stations, tally the class findings for each item on the blackboard.

9. Ask students to explain why their group classified the item as living or nonliving. What tests did they conduct and what were the results? What other tests might they conduct to better determine the classification of items? *Prompt students to think of observing the questionable objects over time to see if they grow, change or reproduce.*

10. Keep the stations in question in place for several days or a week, so students can compare the items over time. You may want to grow the seeds and the spores to prove they are alive, but explain they need to be placed in the proper environment to grow.

11. Ask whether further observations change any opinions about the classification of the various items. In the end, reveal the actual classification of the items, and discuss any discrepancies between the students' conclusions and the facts.

Evaluation:

1. Students name living and nonliving things in their report as space scientists and tell what tests they used as the basis for their conclusions.

2. Give students a set of new, ambiguous objects. Have them tell or write how they would test the objects to see if they are living or nonliving.

3. Students write their own definitions of the terms "living" and "nonliving."

EXTENSION:

Living and nonliving charades. Review the differences between living and nonliving things *(the ability to move, respond to environment, grow, and reproduce)* with the class. Place drawings, photos, or names of various living and nonliving things in a jar. Divide the class into groups and have each group choose an item from the jar. Allow the group time to decide how to pantomime their item. Groups take turns performing.

Each group in the audience has one chance to determine if the item is a living or nonliving thing. Each group should either write down its answer or tell it to the teacher. Each group that answers living or nonliving correctly, gets one point. The actors receive one point for each group that answered correctly, indicating that they were good actors.

You may choose to award bonus points to both the actors and answering groups if any can identify the pantomimed item more specifically *(i.e., animal, plant, fungi, microscopic organism, seaweed, or other categories)*. Play one or more rounds. The group with the most points wins.

Curriculum Connections:
(See appendix for full citations)

Books:
Ecology (Pollock)

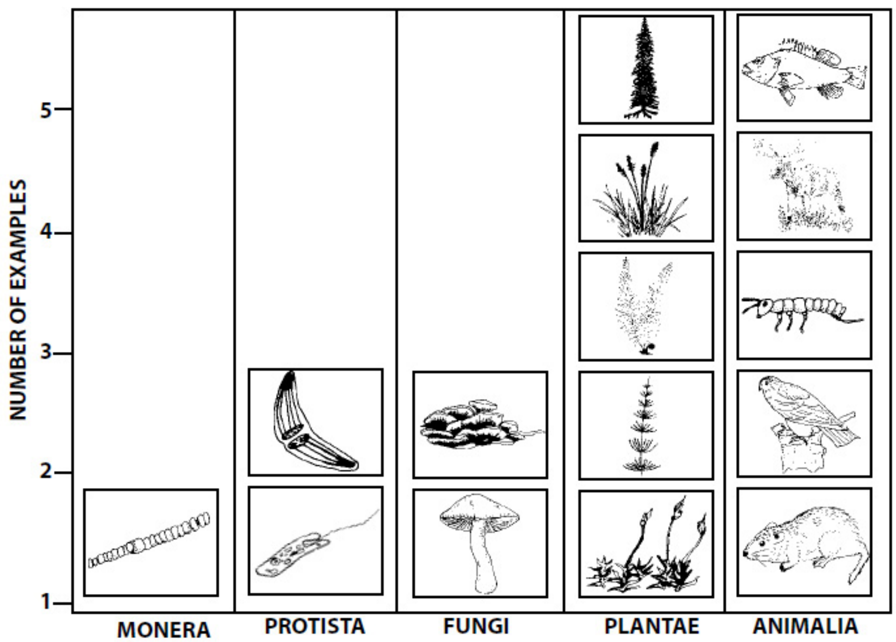
DK Science Encyclopedia (also on CD)

How Nature Works (Burnie)

Teacher Resources:
(See appendix)

Five Kingdoms But No King

ALERT: ALASKA ECOLOGY CARDS OPTIONAL



Section 1
ECOLOGY ACTIVITIES

Grade Levels: 1 - 6

Subjects: Science, language arts, art

NGSS: 3-LS1-1, MS-LS4-2

Skills: Classifying, applying, drawing, listening, sorting

Duration: Two 30-minute periods

Group Size: Any

Setting: Indoors

Vocabulary: Algae, Animalia, bacteria, detritivores, eukaryotic, Fungi, living things, kingdoms, Monera, nonliving things, Plantae, prokarotic, Protista

Objectives:

1. Students will name the five kingdoms of living things.

2. Students will be able to identify an example from each kingdom.

Teaching Strategy:

Students become more familiar with living and nonliving things in an ecosystem and with the five kingdoms by classifying sets of pictures.

Complementary Activities:

"It's Alive, Isn't It?" *in this section. And all* "Investigating...." *living things in their habitats* activities *in Section 3.*

Materials:

"Five Living Kingdoms" fact sheets *(from* INSIGHTS *Section 1). Alaska Ecology Cards* or magazines and/or books *(that can be cut)* with pictures of nature or wildlife. Index cards (3x5 or 5x7) at least five per student, glue, crayons or markers, and something to represent each of the five kingdoms *(pond water for protists, mushrooms and lichens for fungi, microscope slides of bacteria for monerans).*

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems.*

Procedure:

1. Review definitions for the terms **living** and **nonliving**. Brainstorm with students a list of living and nonliving things. Introduce the Five Kingdoms of Living Things and discuss the differences between each. Ask students to think of representatives of each kingdom.

VARIATION FOR YOUNGER STUDENTS

For younger students, teachers may want to focus on the plant and animal kingdoms, or on the concepts of "living" and "nonliving."

2. *This step may be done in class, as homework, or as preparation by the teacher:* Ask students to go through the resource materials and make a collection of pictures of living things from the five kingdoms and some nonliving things. Encourage students to look for microscopic living things as well as large, easily recognizable things.

3. Students draw or paste their pictures on separate index cards. Each student makes five cards, one image per card.

If appropriate, students write the name of the pictured item on the card. Collect the cards.

3. Divide the class into teams or have students play individually. Shuffle all the cards together.

4. Pass 5-10 cards to each team, leaving a small class pile in the center. Explain that the object of the game is for each team to get rid of all its cards by correctly classifying the item pictured.

5. Depending on grade level and experience, the cards can be classified as living or nonliving, or by kingdoms. The teacher calls out a category, living or nonliving (or plants, animals, fungi, etc.).

6. If a team has a card that fits the category, the students should hold it up. If their classification is correct, they discard the card to the central pile. If their classification is wrong, they have to draw another card from the pile and they can't discard. Allow the teams time to come to a decision among themselves about which card to hold up.

7. The first team to discard all of its cards wins.

Evaluation:

1. Students list the five kingdoms of living things and give an example for each.

2. The teacher posts a blank bar graph of the Five Kingdoms of Living Things. Each student randomly chooses any five cards and sorts them according to the appropriate kingdom. Students glue their cards on the graph in the appropriate column. The teacher checks each student's placement.

Curriculum Connections:

(See appendix for full citations)

Books:

DK Science Encyclopedia (also on CD)

How Nature Works (Burnie)

Nature (Rainis)

Website:

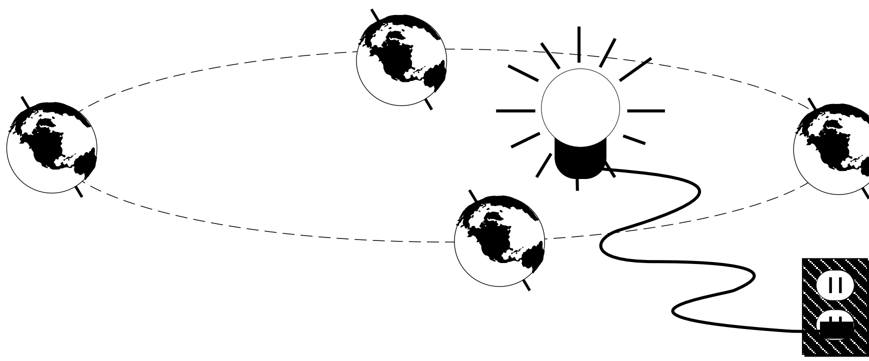
Natural Perspective (on-line periodical) <www.perpective.com/nature>

Teacher Resources:

(See appendix

Investigating Heat Energy

2 ACTIVITIES and 1 EXTENSION



Section 1
ECOLOGY ACTIVITIES

Grade Level: 4 - 12

State Standards: S B-1, S B-5, S B-6, Geo C-1
NGSS: 4-PS3-2, MS-PS3-3
Subjects: Science, language, arts, geography

Skills: Measuring, inferring, predicting, synthesizing, reading, writing

Duration: 45-60 minutes per station

Group Size: Small

Setting: Indoors

Vocabulary: Atmosphere, boreal forest, tundra, solar energy

Objective:
Students will explain how sunlight differs in its heating potential in different parts of the world.

Teaching Strategy:
Students make observations and measurements in two experiments and then make predictions about the distribution of cold environments on the earth.

Prerequisite:
Familiarity with the earth's rotation and revolution, day and night, and seasons *(see* INSIGHTS *Section 1, Elements of Ecosystems).*

Materials:
An atlas showing world environments, a world almanac, and the following materials to set up each experiment:

HEAT ENERGY AND THE SUN
Materials: An incandescent lamp or direct, bright sunlight; modeling clay; two metal lids from frozen juice containers, both painted black; one or two thermometers; a flashlight; a piece of cardboard; a ball or globe.

Setup: Place two lumps of clay and the rest of the materials and the "Science Card" *(following pages)* at a station.

WIND AND AIR TEMPERATURE
Materials: An electric fan; two thermometers; two identical empty cans; pail of warm water; pan of ice.
Setup: Place the materials and the "Science Card" *(following pages)* at this station.

Background:
See INSIGHTS, *Section 1, Elements of Ecosystems.*

Procedure:
IN ADVANCE: set up the two stations as described above.

1. *IN CLASS:* either have all groups of students do all investigations, or have separate groups do separate investigations and then report their findings to the class.

2. The last questions on each of the "Science Cards" require students to apply their findings to make predictions. Discuss each of these beforehand to ensure that students understand the questions and arrive at reasonable predictions.

3. Ask students to test their predictions. (They may initially think they need to go to various places on the earth and test the intensity of solar radiation or the rate of heat loss.) Encourage them to question how the amount of solar energy and the rate of heat loss of a particular site would affect its climate and ecosystem.

4. Can students infer that the places on the earth that receive the least solar energy and that lose heat most quickly have the coldest climates? Based on their experimental findings, what regions of earth would have cold environments? Ask students to use an almanac or web search to determine the climate at various latitudes and elevations on earth.

5. Explain that **tundra** and **boreal forest** ecosystems are the environments found in the parts of the earth with the coldest climates.

6. Ask students to look at an atlas showing photos of tundra and boreal forest environments throughout the world.

Evaluation:

1. Write a paragraph explaining why environments at high latitudes are cold.

2. Predict how cold temperatures might influence the living things in cold ecosystems.

EXTENSION:

Create another planet. Students work individually or in teams of 2-4 to create a planet similar to Earth, using balloons and paper-mâché or drawing paper. After marking continents and land forms, students label tundra areas and state their reasoning.

Curriculum Connections:

(See appendix for full citations)

Books:

Atlas of the World (National Geographic Society) or any other world atlas

DK Science Encyclopedia (also on CD)

Facts on File Environment Atlas (Wright)

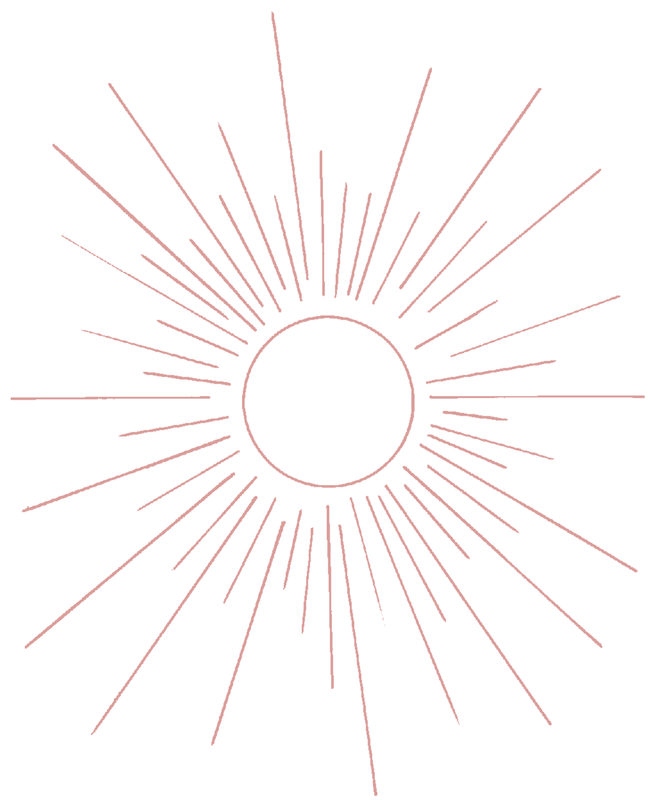
World Almanac

Websites:

Various atlas websites <www.maps.com > or <www.3datlas.com>

Teacher Resources:

(See appendix)



SCIENCE CARD

Heat Energy and the Sun

Sunlight is made of heat and light energy. When sunlight strikes molecules in the air or on a solid surface, its energy is either reflected or absorbed as heat. Each ray of sunlight contains the same amount of heat and light energy.

Question?

How does the angle at which sunlight strikes an object – the *angle of incidence* – affect the amount of heat and light energy received? This experiment will help you find out whether your ideas are correct.

1. Stand two metal can lids, painted black, at different angles, using modeling clay as a base. *(See the diagram)*. Place these an equal distance from an incandescent light bulb (but within a short enough distance that you can feel the heat of the light bulb on your hand), or in direct, bright sunlight.

Wait 15 minutes (go on to the next step while waiting), then feel the temperature difference with your fingers. Which one is warmer? Which one received the most light and heat energy?

2. Shine a penlight against a piece of cardboard. Keep the light close enough that you can see a distinct circle of light. First hold the cardboard straight up and down, and note the size of the circle of light. Then, slowly tilt the cardboard either toward or away from the light. What happens to the circle of light?

Considering the amount of light generated by the flashlight has remained the same, how do you think the amount of light energy received per unit area changes as the **tilt** of the cardboard (angle of incidence) increases?

Based on this investigation, can you predict what difference you will find when you measure the temperature of the lids in Step 1?

3. Imagine the penlight represents the sun. Keeping in mind the earth tilts on its **axis**, shine the penlight on the globe or ball (representing the earth). Hold the light so that the beam of light is *perpendicular to the equator*. Hold the light close enough to the globe that you can see a small, distinct circle of light.

Compare the size of the circle that appears when the light is shown on the equator to the size of the circle when the light is shown at the poles. Be sure to hold the light beam *perpendicular to the equator* in both cases.

Based on your observations, what regions of earth receive the most solar energy per unit area (the highest intensity of solar energy)? Which regions receive the lowest?

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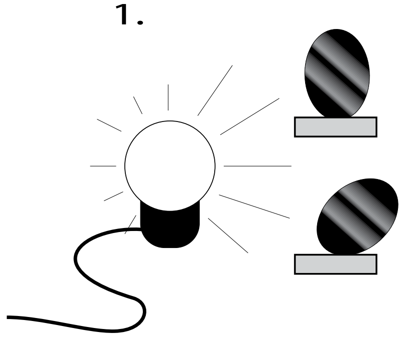

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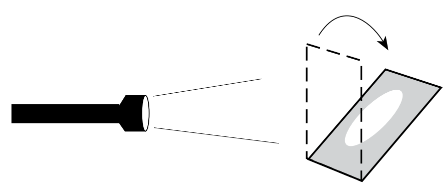

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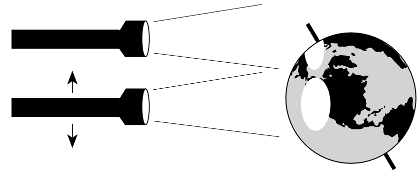


SCIENCE CARD

Wind and Air Temperature

Question?

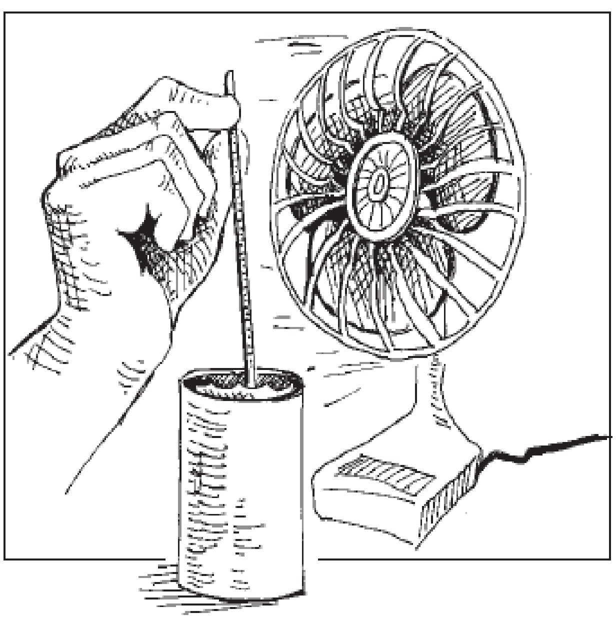
Do you think wind affects the temperature of our environment? This experiment will help you find out whether your ideas are correct.

1. **Experiment A.** Measure the air temperature about 2 feet (.61 meters) in front of the electric fan, but with the fan turned off. Record this temperature.

2. Turn the fan on high and measure the air temperature again. Wait a few minutes to allow the thermometer to respond to any change. Record any changes.

3.**Experiment B.** Fill the two cans with warm water and place a thermometer in each one. Record the starting temperature of each. This is important because even if the water temperature in the two containers is the same, the two thermometers may register slightly differently.

Place one can of water aside, away from the fan, and the other one in front of the fan. Wait about 15 minutes, then record the temperature of the water in both containers again. Did the temperature in both containers drop the same number of degrees? Which one dropped further? The drop in temperature is a measure of heat loss. After this experiment, how do you think wind affects the temperature of the environment?



4.**Experiment C.** Repeat the step above, placing a pan of ice between the fan and the can. Wait 15 minutes. Did the temperature in this can drop more, less, or the same amount as in the last experiment? Did it drop more, less, or the same amount as the temperature of the other can? Explain why. What do you predict would occur if you placed a heated surface between the fan and the can?

5. Based on what you observed in these experiments, choose the scenario from each of the following in which a living thing would have the most difficulty keeping warm:

(a) coastal environment with winds blowing toward the shore OR coastal environment with winds blowing toward the sea?

(b) cold, calm environment OR cold, windy environment?

Investigating Soil
2 EXTENSIONS

Section 1
ECOLOGY ACTIVITIES

Grade Level: 4 - 12

State Standards: S B-1, S B-5, S B-6, S A-15
NGSS: 5-LS2-1, 5-ESS2-1, MS-ESS-1
Subject: Science, math, language arts

Skills: Observing, recording, computing, analyzing, describing, drawing

Duration: 100 minutes

Group Size: 2-4

Setting: Outdoors /indoors

Vocabulary: Dormant, ecosystem, leaf litter, living things, habitat, nonliving things, soil, temperature

Objectives:
1. Students will describe soil as an element of the local ecosystem.

2. Students will observe the relationship between soil (nonliving) and the living elements of the local ecosystem.

Teaching Strategy:
Students observe and collect data on soil, then evaluate their data, and make predictions about living things and soil.

Complementary Activities:
"Investigating Air," "Investigating Water," *and* "Investigating Heat Energy" *in this section. Also* "Investigating Fungi Habitat," "Investigating Plant Habitat," "Investigating Animals in Soils," *and* "Investigating Insects" in *Section 3.*

Materials:
For each student: a journal or paper, pencil, a hard surface to write on. For each group: trowel, container to carry soil, yard or meter stick, thermometer, several bags for holding soil samples, hand lens or microscope, at least one copy of the Science Card.

OPTIONAL: Laminate the Science Cards.

Background:
See INSIGHTS, *Section 1, Elements of Ecosystems.*

Procedure:
IN ADVANCE: determine an outdoor area suitable for digging soil pits.

1. *IN CLASS:* review the definition of **ecosystem.** Tell students they will be investigating **soil** – one of the **nonliving** elements of ecosystems that must be present for most **living things** to survive.

2. Give each team the "Science Card: Investigating Soil."

Classroom Follow-Up:
1. Students either work together or alone to evaluate their data and make predictions about which living things might use the nonliving environment of soil and why.

Students can use examples of living things they noticed while investigating soil, but should note why these living things can live in this environment. *For example, if their environment is cold, dry, and dark in the winter, then only plants that are **dormant** in the winter should live there.*

Student predictions can be expressed in writing and/ or with drawings. Encourage students to think creatively and imagine the environments throughout the year and under unusual circumstances. *For example, a bear might be comfortable in the nonliving environment of the schoolyard, but may not choose to live there for other reasons.*

2. Students present their information to a small group or to the class. Information can be mounted on a mural, poster, or bulletin board. If each student focused on only a small area within the local ecosystem, a class mural could be made, resulting in a overall picture of a larger, nonliving area. These displays can be combined later with experiments on the living environment for a complete illustration of an ecosystem.

Evaluation:

1. Collect soil data and present findings to the class.

2. Summarize data and draw conclusions on the nature of their nonliving environment.

3. Make predictions about which living organisms might thrive in their local soil and why.

4. Given examples of organisms that would not thrive in their local soil, students will determine why these living things could not survive.

EXTENSIONS:

A. Students return to the site of their explorations at different times of the year to note changes in the soil and perform similar experiments with different results.

B. Discuss how living things might change to adapt to the changes in the soil.

Curriculum Connections:

(See appendix for full citations)

Books:

Ecology (Pollock)

Handful of Dirt (Bial)

How Nature Works (Burnie)

One Small Square: Backyard (Silver)

Our Endangered Planet: Soil (Winckler)

Rocks and Soil (Snedden)

The Science of Soil (Bocknek)

Teacher Resources:

(See appendix)

SCIENCE CARD

Investigating Soil

1. Dig a hole in the soil 12-18 inches deep. Make a large enough hole so you can see layers in the soil.

2. Draw a side view of the hole, labeling the different layers where the color or texture of the soil changes.

3. Measure the width of each layer and note the measurement on your drawing. Stop digging if you encounter water or ice and measure the distance from the surface to the water.

4. Take the temperature of each layer of the soil and record it on your drawing.

5. Take samples of each layer, label them, and bring them back to the classroom for further investigation.

Questions:

NOTE: Each of you answer the following questions in your own journal. Everyone can contribute ideas.

(a) Write what you see when you look at each layer of soil using a microscope or hand lens. You may make a drawing in addition to your written observations. How far is each layer is from the surface? How thick is each layer?

(b) Of what does the soil in each layer seem to be made? Is the soil made of rocks? Gravel? Dirt? Leaf litter?

(c) Take a handful of soil from each layer. What does it feel like? Does it hold together if you squeeze it? Describe the texture of each layer.

(d) What color is the soil in each layer?

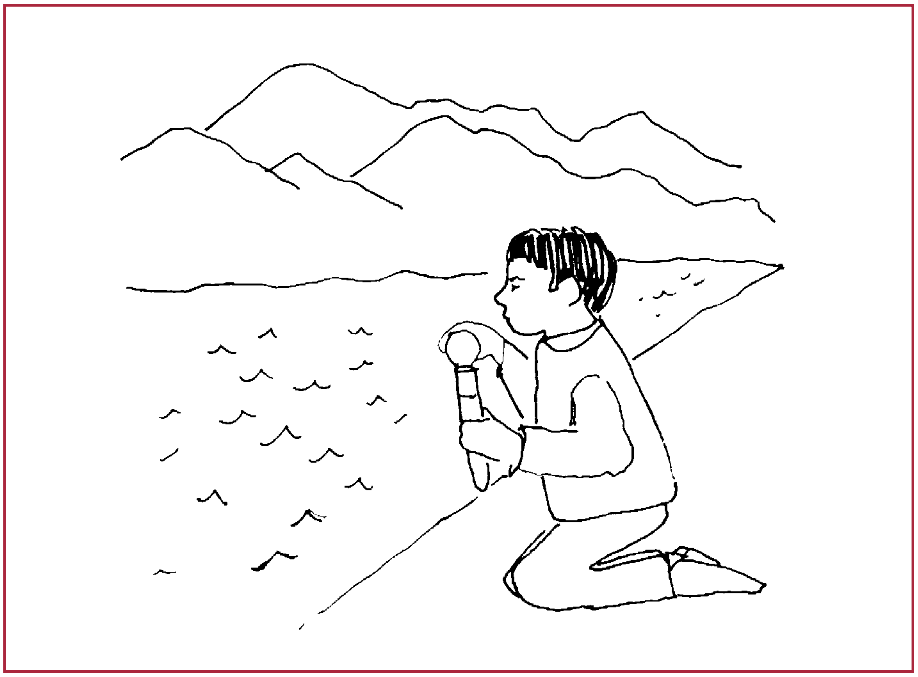
(e) Do any of the soil layers have a smell?

(f) Do you think it's easy for water to flow through this soil layer? Why or why not?

(g) Did you find any evidence of humans in your soil sample? Did you notice any evidence of plants or animals in your sample? If so, describe, and note the layer in which you found the human evidence.

Investigating Water

1 ACTIVITY, 2 EXTENSIONS



Section 1
ECOLOGY ACTIVITIES

Grade Level: 4 - 12

State Standards: S B-1, S B-5, S B-6, S A-15
NGSS: 5-LS2-1, 5-ESS2-1, MS-LS2-1, MS-LS2-5, 5-ESS3-1, MS-ESS3-3

Subject: Science, math, language arts

Skills: Observing, recording, computing, analyzing, describing, drawing

Duration: 100 minutes

Group Size: 2-4

Setting: Outdoors

Vocabulary: Acidic, basic, ecosystem, living things, neutral, nonliving things, pH, water

Objectives:

1. Students will describe water as an element of the local ecosystem.

2. Students will observe the relationship between water (nonliving) and the living elements of the local ecosystem.

Teaching Strategy:

Students observe and collect data on water, then evaluate their data, and make predictions about living things and water.

Complementary Activities:

"Snow Blanket," "Investigating Wind and Air Temperature," "Investigating Soil," *and* "Investigating Air" *in this section. Also* "Investigating Plant Habitat" *and* "Investigating Animals in Soils" in *Section 3.*

Materials:

Paper and pencil, thermometer, pH paper, containers to collect samples, masking tape and marker, ruler, hand lens or microscope, instructions on how to measure pH *(following page),* and a copy of the Science Card *(following)***.**

OPTIONAL: Laminate the Science cards.

Background:

See INSIGHTS, ***Section 1, Elements of Ecosystems.***

Procedure:

IN ADVANCE: determine an outdoor area suitable for water investigations.

1. *IN CLASS:* review the definition of **ecosystem.** Tell the students they will be investigating **water** – one of the **non-living** elements of ecosystems that must be present for most **living things** to survive.

2. Give each team the "Science Card: Investigating Water."

Classroom Follow-Up:
1. Students either work together or alone to evaluate their data and make predictions about which living things might use the nonliving environment of water and why.

Students can use examples of living things they noticed while investigating water, but should note why these living things can live in this environment.

Student predictions can be expressed in writing and/ or with drawings. Encourage students to think creatively and imagine the environments throughout the year and under unusual circumstances.

2. Students present their information to a small group or to the class. Information can be mounted on a mural, poster, or bulletin board. If each student focused on only a small area within the local ecosystem, a class mural could be made, resulting in a overall picture of a larger, nonliving area. These displays can be combined later with experiments on the living environment for a complete illustration of an ecosystem.

Evaluation:

1. Collect water data and present findings to the class.

2. Summarize data and draw conclusions on the nature of their nonliving environment.

3. Make predictions about which living organisms might thrive in their local water and why.

4. Given examples of organisms that would not thrive in their local water, students will determine why these living things could not survive.

EXTENSIONS:

A. Students return to the site of their explorations at different times of the year to note changes in the water and perform similar experiments with different results.

B. Discuss how living things might change to adapt to changes in the water.

Curriculum Connections:

(See appendix for full citations)

Books:

The Drop in My Drink (Hopper)

A Drop of Water (Wick)

How Nature Works (Burnie)

Keeping Water Clean (McLeish)

Our Endangered Planet: Rivers and Lakes (Hoff)

River and Stream (Sayre)

Rivers, Ponds, and Lakes (Ganeri)

Teacher Resources:

(See appendix)

How To Measure pH

Background:
The pH of a solution is a measure of how many hydrogen ions (OH) are in that solution. The pH of most solutions ranges from 0 to 14. This scale separates acids, bases, and neutral solutions into regions.

The middle point, pH = 7, is neutral. A solution with a pH of 7 is neither an acid nor a base.

Acids have pH of less than 7. The stronger the acid, the lower the number on the pH scale. *For example the pH of lemon juice is about 2.3, while tomato juice, which is less acidic, has a pH of 4.*

Bases have a pH higher than 7. The higher the number above 7 on the pH scale, the stronger the base. *Sea water is slightly basic, having a pH of 8. Drain cleaners are strongly basic solutions, having a pH of 14.*

Many plants and animal are sensitive to changes in pH in both water and soil. Most lake water has a pH between 6 and 7, which makes it slightly acidic.

Materials:
Either pH paper or a water chemistry kit:
1. The pH paper is the cheapest and simplest tool for measuring pH. A supply of universal indicator pH paper, adequate for several classes, can be obtained for under $15 from most chemical supply houses. Use according to accompanying instructions.

2. Water chemistry kits are also available from chemistry supply houses. These include pH indicator solutions and instructions that junior high or high school students can follow.

SCIENCE CARD

Investigating Water

1. Examine your local ecosystem for water. Water can be found in puddles, on leaves, in streams or ponds, at the bottom of a hole that you've dug, or in snow.

2. Collect the following data for each area where you find water, completing as many as time allows. Use a separate piece of paper or page in your notebook for writing about each area of water.

(a) Describe the location of the water.

(b) Describe the color of the water.

(c) Where do you think the water came from?

(d) Put the thermometer in the water, if possible, and record the temperature after a few minutes.

(e) Record the pH of the water. Is the water acidic, basic or neutral? (pH at 7 is neutral, pH greater than 7 is basic (alkaline), and pH less than 7 is acidic.)

(f) How deep is the water in your sample? (Give an estimate if the water is too deep to measure.)

(g) Is the water moving or stationary?

(h) Take a sample of the water and put a label on the sample container that tells where it came from. If possible, examine the water with a hand lens or microscope in the classroom. Is there anything floating in the water?

(i) Perform the same experiments on snow, if available.

Investigating Air

Section 1
ECOLOGY ACTIVITIES

Grade: K - 12

State Standards: S B-1, S B-5, S B-6
NGSS: K-ESS2-1,K-ESS2-2, 3-LS4-4. 5-LS2-1,5-ESS2-1, MS-LS2-3, MS-ESS2-4
Subjects: Science, social studies

Skills: Observing, measuring, predicting, comparing, contrasting, inferring

Duration: 2 days, 30 minutes classroom, 60 minutes outdoors each day

Group Size: 2

Setting: Outdoors/indoors

Vocabulary: Carbon dioxide, hypothesize, oxygen, plant, transpiration

Objectives:
After conducting an identical set of experiments in densely vegetated and lightly vegetated sites on the presence of wind, dust, and water vapor (transpiration), students will compare the results.

Complementary Activities:
"Snow Blanket," "Investigating Wind and Air Temperature," "Investigating Soil," *and* "Investigating Water" *in this section. Also* "Investigating Plant Habitat" in *Section 3.*

Materials:
Small plastic bags, rubber bands, petroleum jelly, index cards, string, pinwheels or wind gauges, and hand lenses for each site. Clipboards and writing paper or field note books, pencils or pens for each student. "Science Cards" for both vegetated and non-vegetated sites *(following pages).*

Background:
See INSIGHTS, *Section 1, Elements of Ecosystems.*

Procedure:
IN ADVANCE: locate 2 sites for taking measurements, one vegetated and one without much vegetation *(for example: forested and non-forested; tundra and rocky or sandy; or shrubs and grass).*

DAY ONE

1. Brainstorm potential differences between your two sites. Lead the discussion to the differences in wind, dust, and water vapor.

2. Introduce the experiment by asking for ideas on how to measure the differences.

3. Introduce the tools that will be used: wind gauge, petroleum-jelly-smeared cards, and plastic bags. Explain that the students will use these to conduct identical experiments at two different sites.

4. Introduce the Science Cards.

5. Have students prepare their observation notebooks by writing the heading "Air in Ecosystems" across the top of a page. Tell them to draw a line down the center of the page, and put the heading "Ecosystem #1" at the top of the left side and "Ecosystem #2" at the top of the right side.

6. OUTDOORS: Each team will set up its experiments at the sites and take initial wind measurements.

7. ***At the densely vegetated site***, each team places plastic bags around a plant – leafy branches of a tree, bush, flowers, or clump of grass – and some vegetation that is dead – a dead stick or fallen leaf or brown grasses. Tightly seal each bag around the object with a rubber band. *This experiment will work well only if the ground is thawed.*

8. Each team ties an index card to a branch of a tree or shrub or a clump of grasses, and then spread petroleum jelly over it. This will trap dust in the air.

9. Using the pinwheels or a wind gauge, measure the wind at the site. Students record in their notebooks *(under the appropriate column)* whether they observe any wind at this site and whether the wind caused the gauge or pinwheel to turn: (1) not at all, (2) very slowly, (3) slowly, (4) fairly quickly, or (5) very quickly.

10. ***At the lightly vegetated site***, each team places plastic bags around a leafy branch, grasses, and a dead stick. Tightly seal each bag around each object with a rubber band. *This experiment will work well only if the ground is thawed.*

11. Each team ties an index card to a plant (or tie it to a stick shoved into the ground if no standing vegetation). Then spread petroleum jelly over it. This will trap dust in the air.

12. Using the pinwheels or a wind gauge, measure the wind at the site. Ask students to record in their notebooks *(under the appropriate column)* whether they observe any wind at this site and whether the wind caused the gauge or pinwheel to turn: (1) not at all, (2) very slowly, (3) slowly, (4) fairly quickly, or (5) very quickly.

DAY TWO
Go OUTDOORS. Using the Science Cards as format, students observe, collect, and record data from both sites.

Classroom Follow-Up:
Compare the two sites. Discussion questions include:
(a) Did one site have stronger wind? Which one? Why do students think there was a difference? If students did not observe a difference, do they think they would have found a difference on a windy day? Which do students **hypothesize** (guess) would be more windy? Why do they hypothesize this?

(b) Which site had the least dust? Why do students think this difference occurred? Did the leaves of any plants trap dust? How might this affect the air quality?

(c) Based on the bags sealed on branches, did students conclude that the plants were putting moisture into the air (**transpiration**)? *If they did, their answer is correct. For example, a tree may pump 80 gallons of water into the air in a single day.* Which of the two sites do they think is most likely to have moist air?

Students should find less wind and less dust in the densely vegetated site, and predict that the densely vegetated site would have the most moisture in the air. Students should conclude that plants break the wind, remove dust from the air, and add moisture. They should remember that trees and other plants add **oxygen** and remove **carbon dioxide** from the air.

Curriculum Connections:
(See appendix for full citations)

Books:
How Nature Works (Burnie)

The Lorax (Seuss)

Our Endangered Planet: Air (Yount)

Media:
The Lorax

Teacher Resources:
(See appendix)

SCIENCE CARD

Air in Ecosystem #1

1. Record the data under the column “Ecosystem #1” on the page “Air in Ecosystems.”

2. Measure the wind on this day also. Hold the pinwheel or wind gauge over your head and slowly turn around. If there is any wind, the gauge or wheel will turn. Record whether you observe any wind at this site and whether the wind caused the gauge or pinwheel to turn: (1) not at all, (2) very slowly, (3) slowly, (4) fairly quickly, or (5) very quickly.

3. The card tied on the tree or plant is a trap for dust in the air. Use a hand lens to look at it closely. Record the amount of dust it has collected: (1) none, (2) a few specks, (3) 10-20 specks, (4) 20- 50 specks, (5) over 50 specks.

4. Look at the leaf of a tree or plant using a hand lens. Record the number of dust specks on it using the same scale as above.

5. Look at the leaf of a different kind of tree or plant for dust specks. Record the number of dust specks on the leaf using the same scale.

6. The plastic bags that are tied around live branches or plants and a dead branch or plant were all dry when tied to these objects. Record which, if any, bags now contain water. How do you think this water got into the bag?

SCIENCE CARD

Air in Ecosystem #2

1. Record the data under the column “Ecosystem #2” on the page “Air in Ecosystems.”

2. Measure the wind on this day also. Hold the pinwheel or wind gauge over your head and slowly turn around. If there is any wind, the gauge or wheel will turn. Record whether you observe any wind at this site and whether the wind caused the gauge or pinwheel to turn: (1) not at all, (2) very slowly, (3) slowly, (4) fairly quickly, or (5) very quickly.

3. The card tied on the tree or plant is a trap for dust in the air. Use a hand lens to look at it closely. Record the amount of dust it has collected: (1) none, (2) a few specks, (3) 10-20 specks, (4) 20- 50 specks, (5) over 50 specks.

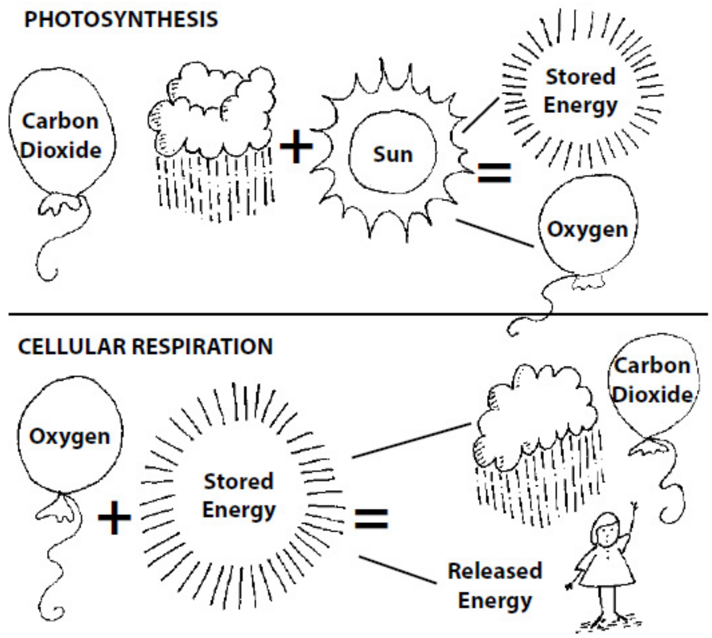
4. Look at the leaves of a plant using a hand lens. Record the number of dust specks on it using the same scale as above.

5. Look at grass blades for dust specks. Record the number of dust specks using the same scale.

6. The plastic bags that are tied around live plants and a dead stick were all dry when tied. Record which, if any, bags now contain water. How do you think this water got into the bag?

Take A Deep Breath

2 EXTENSIONS



Section 1
ECOLOGY ACTIVITIES

Grade level: K - 6

State Standard: S A-14
NGSS: K-LS1-1.,K-ESS3-1,5-LS1-1 5-LS2-1, MS-LS2-3,5-PS3-1
Subjects: Science

Skills: Inferring, generalizing, applying, predicting

Duration: 50 minutes

Group Size: small

Setting: Indoors

Vocabulary: Carbon dioxide, cellular respiration, energy, gas, living things, minerals, oxygen, photosynthesis, respire

Objective:

Students will explain that plants are needed by all other living things to survive.

Teaching Strategy:

Students play a card game that involves holding their breath to demonstrate photosynthesis.

Materials:

For each student: 4 or 5 Carbon Dioxide and Oxygen Cards *(following).* Table or floor space.
OPTIONAL: Stopwatch or watch/clock with a second-hand.

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Energy Exchange."*

Procedure:

1. Time students while they hold their breaths. Record the lengths of time if desired.

2. With the class, discuss why students had to stop and breathe. Explain that most **living things** need **oxygen** in order to use the **energy** and **minerals** in their foods. *Humans and most other living things, including plants and algae, breathe in oxygen and breathe out* ***carbon dioxide*** (this is called **cellular respiration** - *see the extension at the end of this activity*). The teacher may want to pantomime this process.

3. Spread the Oxygen and Carbon Dioxide Cards on a table or on the floor. Explain that each card represents the air of an ecosystem.

4. Ask 4 students to volunteer to be "animals," to model what might happen if there were no plants on earth to produce oxygen.

5. As each "animal" takes a turn, it breathes in, turns over an Oxygen Card into Carbon Dioxide, and breathes out to show the exchange of gasses that occurs when we breathe.

6. Animals must hold their breath until the next turn. Each animal can continue playing as long as it can hold its breath and as long as it has oxygen to breathe.

7. Ask the class to guess what will happen to the players. Play the game to find out. (*Students will run out of breath as they deplete the oxygen cards.*)

8. Explain that plants and algae are very special because they take the carbon dioxide out of the air and put oxygen back in. No other group of living things does this to the extent plants and algae do. Explain that when plants and algae **photosynthesize**, they remove carbon dioxide from the air, combine it with water and sunlight, and make food (which they use) and oxygen (which they put into the air).

NOTE: *Although plants **respire** (take in oxygen and release carbon dioxide), they produce much more oxygen through photosynthesis than they take in through cellular respiration.*

9. Ask for 4 more volunteers to act like plants and algae in the game. Pair each animal with a plant or algae and place partners across the table from each other.

10. Take turns and breathe as before, but this time, the animals can breathe not only when they turn over an Oxygen Card, but also when their plant/algae partner turns over his or her plant/algae Carbon Dioxide Card.

11. Ask the class to predict what will happen when they replay the game with some players who are plants and algae and others who are living things. Replay the game to test the prediction.

VARIATION FOR OLDER STUDENTS

12. Play several rounds of the game and ask the students to adjust the number of plant players so that just enough oxygen get produced to support the cellular respirators, and just enough carbon dioxide gets produced to support the plants.

13. Discuss the need for a balance between the population of plants and animals as it relates to current environmental concerns (*human over-population, deforestation, ongoing development, pollution, etc.*)

Evaluation:

Students draw a picture or describe in writing the relationship between plants, animals, and the oxygen and carbon dioxide found in the air.

EXTENSION:

A. **Experiment with plants.** Put a well-watered potted plant inside a plastic bag and seal the bag (with a twist-tie or tape). Put the plant in a sunny or well-lighted spot. Observe what happens to the inside surface of the bag. Ask students where the water droplets came from. Discuss cellular respiration *(reverse of photosynthesis).*

B. ***Discuss The Lorax.*** *Read The Lorax* by Dr. Suess aloud to the students. Ask them to describe in writing, if possible, what problem wasn't discussed in the book when the Oncelers cut down all of the trees (*the depletion of oxygen*). Students should defend their ideas.

Curriculum Connections:

(See appendix for full citations)

Books:

The Air I Breathe (Kalman)

Ecology (Pollock)

The Lorax (Seuss)

Photosynthesis (Silverstein)

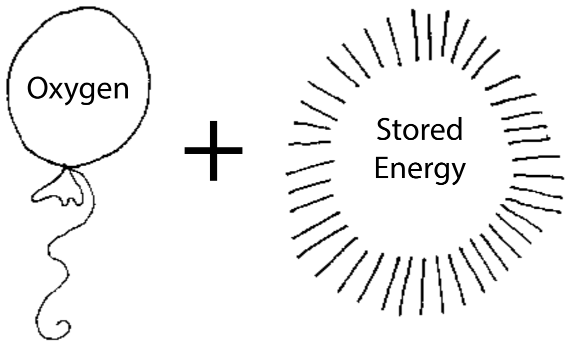
Media:

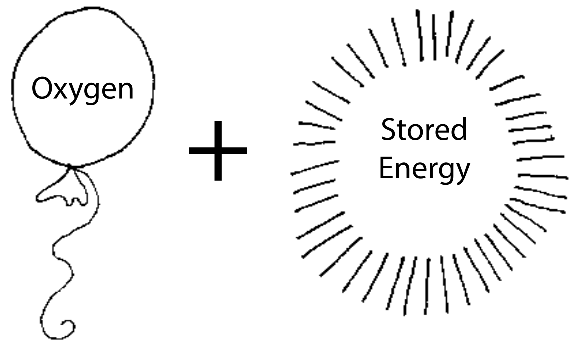
The Lorax

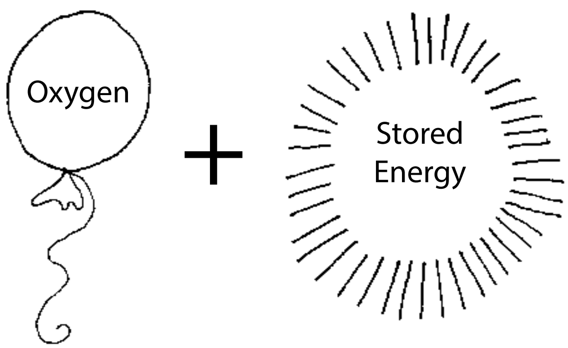
Teacher Resources:

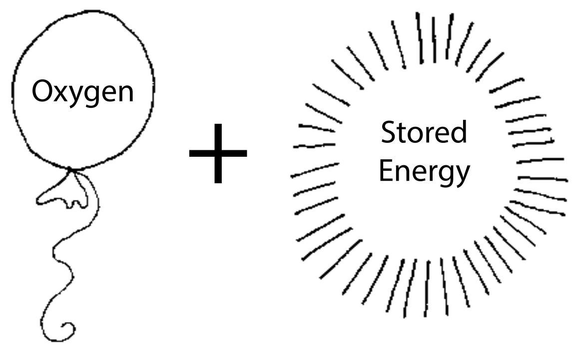
(See appendix)

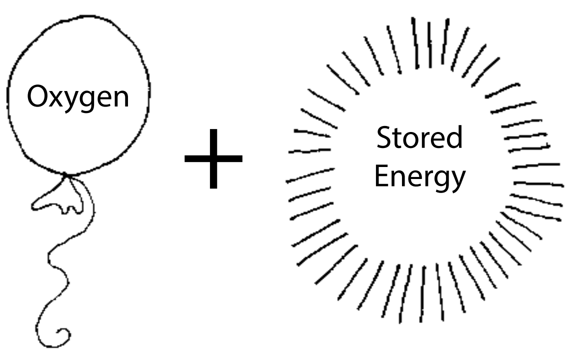
Oxygen Cards for "Take A Deep Breath"

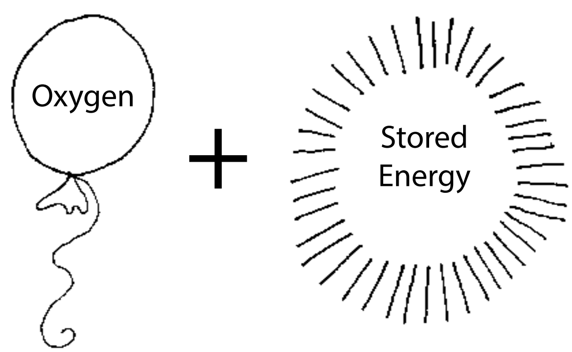


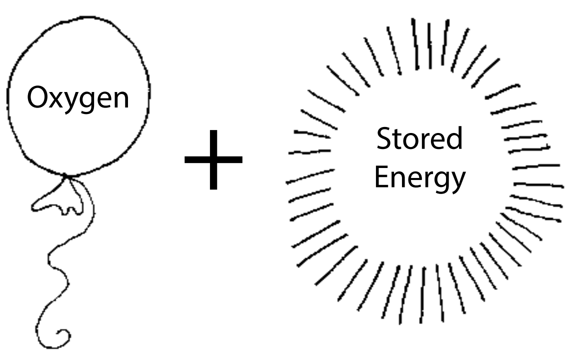


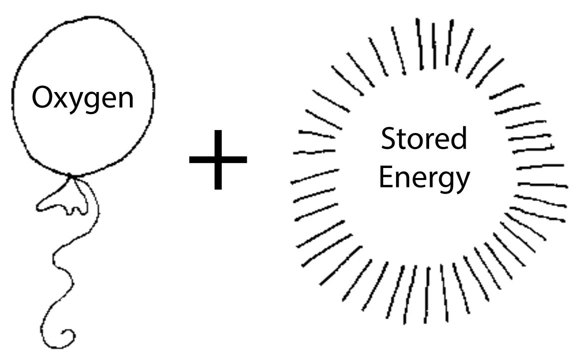




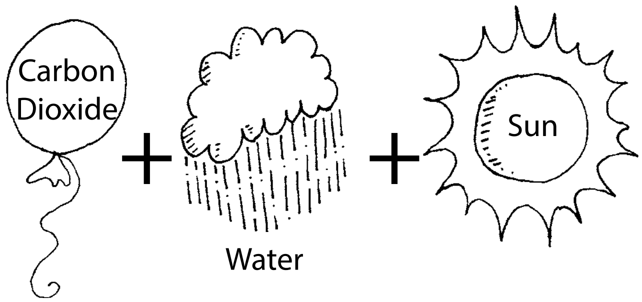


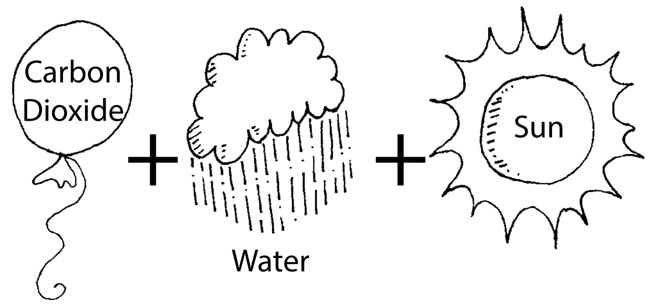


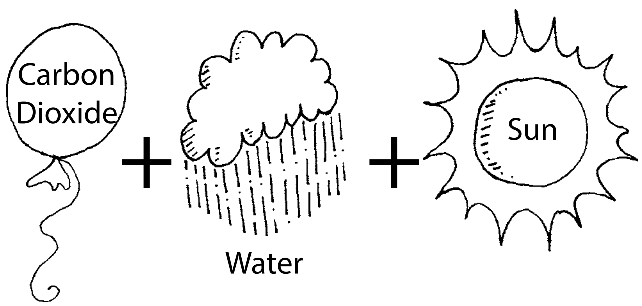


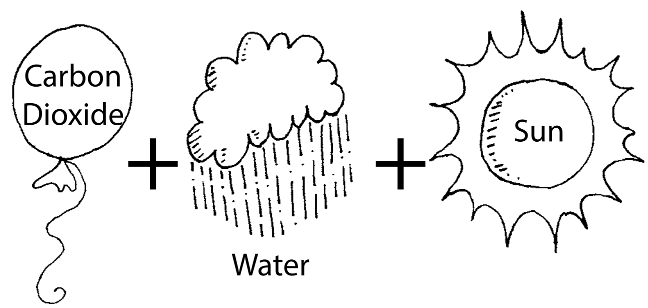


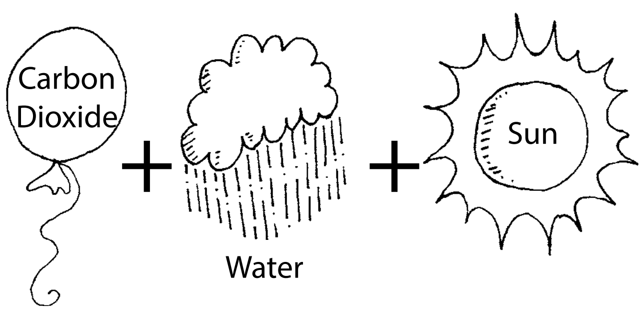
Carbon Dioxide Cards For "Take A Deep Breath"

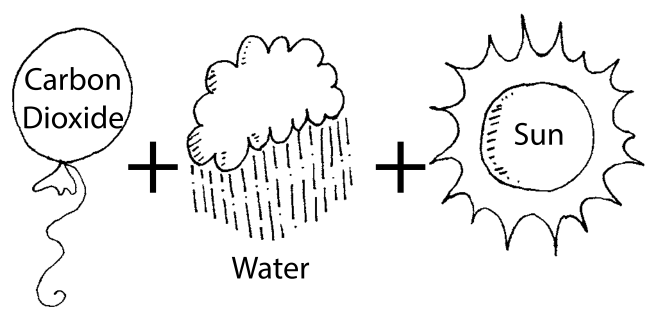


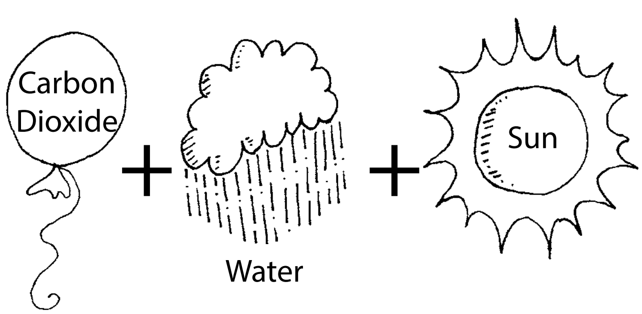


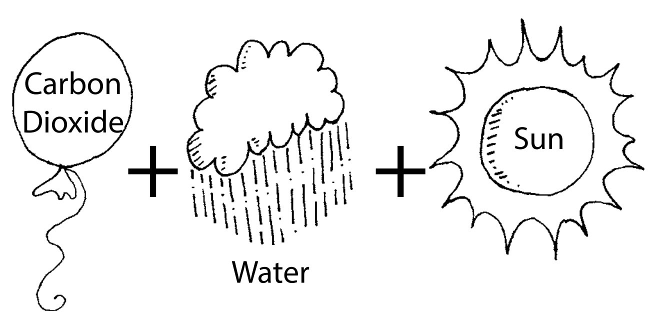




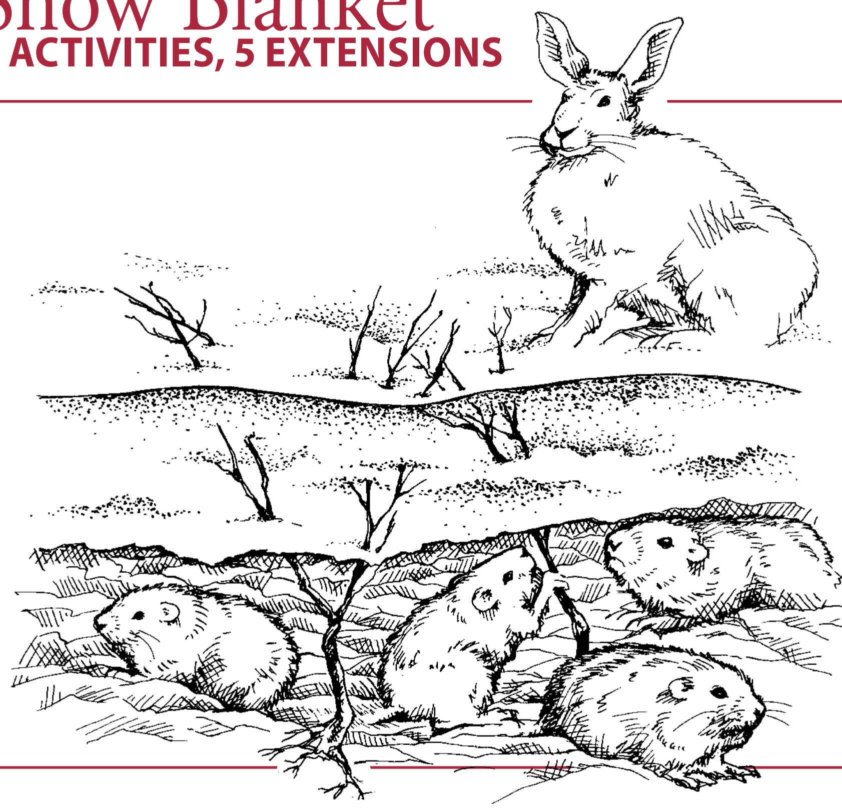








Snow Blanket
3 ACTIVITIES, 5 EXTENSIONS



Section 1
ECOLOGY ACTIVITIES

Grade Level: K - 9

State Standards: S A-14, S B-1, S B-2, S B-5, S B-6
NGSS: K-LS-1,3-LS4-3

Subjects: Science

Skills: Analyzing, estimating, predicting

Duration: Two one-day sessions of 45 minutes

Day two: 45 minutes

Group Size: 2-3

Setting: Indoors/outdoors

Vocabulary: Air, conductor, heat energy, insulator, snow crystals

Objective:
Students will describe the insulating function of snow in an ecosystem.

Teaching Strategy:
Students perform a series of simple experiments to show that snow insulation can keep animals warm.

Complementary Activities:
"Investigating Wind and Air Temperature" *and* "Investigating Water," *in this section. Also* "Investigating Plant Habitat," *and* "Investigating Animals in Soils" in *Section 3.*

Materials:
For each group: two clear jars, marking pen or tape, box of corn flakes, two film canisters or margarine tubs (at least one container per group should have a lid), powdered gelatin, two thermometers, snow shovel or trowel.

OPTIONAL: hand lenses, embroidery hoops, down-filled clothing or sleeping bag, clear plastic or dark fabric.

Background:
See INSIGHTS, *Section 1, Elements of Ecosystems: "Snow Blanket."*

Procedure:
DAY ONE
EXPERIMENT A
Optional: IN ADVANCE, prepare enough hand lenses and snow catchers so that each team of 2-3 students has one of each. Tie hand lenses to a yarn necklace. Make snow catchers by stretching clear plastic wrap or dark fabric over a small embroidery hoop.

1. Ask students to pretend they have a visitor from a hot sunny country who has never seen snow. Ask them to describe snow to the visitor. Make at least three categories on the board as you record their ideas. For example, students may describe snow's appearance, the games they play in it, and the effects it has on our lives or animals' lives.

2. Take the class outside to look at falling snowflakes. Tell students they will measure snow. A volunteer should carry a clear jar or pitcher to collect fresh snow. Explain

that each snowflake snow crystal has six sides, but no two snowflakes are identical.

3. Students may "catch" snowflakes on their jacket sleeves (darker colors show the snow better) or other snow catchers, and examine each flake's design. If possible, students should use hand lenses.

4. Collect a snow sample in the jar and mark the level of snow on its side by using a marking pen or tape.

5. After returning to the classroom, ask students to estimate how many minutes it will take for the snow to melt. Record all of the students' estimates on the board.

VARIATION
Collect two samples and place one near the heater and one near the window.

6. Ask one student to be the official "snow checker." She will announce when the snow has melted. After the snow has melted, check the students' estimates to discover who was closest to the right time.

7. Mark the level of water in the jar with a marker or tape. Ask students what they think was taking up the space between the snow mark and the water mark. *Snow crystals are solid water molecules separated by air until they melt. Liquid water molecules have little or no air between them.*

EXPERIMENT B
1. Prepare for the next demonstration by asking students to brainstorm another way to do the first experiment using something besides snow flakes. Suggest food items containing air. For example, anything that is whipped or frothy like whipped cream; or, anything dry that can be crushed or squished to lesser volume like crackers or cold cereal.

2. Fill a jar or pitcher with a box of corn flakes. Mark the fill level on the jar. Ask a volunteer to crush the flakes to simulate melting snow. Mark the new level of flakes in the jar and discuss how much space in the jar (and in the cereal box) was taken by air.

3. Help students generalize and apply what they've observed in the above demonstrations. Some animals such as mice, lemmings and insects live beneath the snow in the winter. How can the air in the snow help these animals? Explain that *they can breathe the air and the trapped air insulates them from the cold.*

DAY TWO
EXPERIMENT C
1. Choose a shaded area and perform this experiment early in the day to avoid the warmth of direct sun.

2. Explain to the students that they will be working with a powder called gelatin that dissolves in hot water and thickens when cooled.

Snow is a good insulator because air is trapped between snow crystals. Air is a poor conductor of heat; therefore, objects surrounded by snow-trapped air stay warm

3. Fill a measuring cup with hot water. Empty one package of gelatin into water and stir thoroughly. Fill all film canisters or margarine tubs half full with the gelatin solution.

4. Divide students into groups of 2 or 3. Each group chooses a shaded site to dig a snow pit one foot deep. Give each group two film canisters, one lid, and two thermometers. Students place the canister without the lid on the surface of the snow and bury the other canister with the lid one foot deep in the snow. Place one thermometer next to each of the canisters.

5. After five minutes, check the surface canisters for signs of jelling. When they begin to jell, students dig up the buried container and compare the progress of the two. *(The container above the snow should have jelled first.)*

6. Check the thermometers. Students should find the top layer of snow is cooler than the deeper, more thickly insulated levels.

7. Discuss with the students that snow acts as an insulator, just like a blanket or a jacket. Some animals depend on snow to keep them from getting too cold in the winter. For example, lemmings in the Arctic spend their entire winter under the snow, not hibernating, but actively scurrying around eating, avoiding predators, and having babies.

8. Discuss the basic similarity between snow and many common insulation materials such as down and Styrofoam. *(They all trap air!)*

Evaluation:

1. Finish the sentence "Snow is like a blanket because…."

2. Could people live under the snow? Why or why not?

3. Windblown ridges in the North are often barren of plant life. Apply what you know about snow to speculate why plants don't grow on these ridges.

EXTENSIONS:

A. **How much insulating air is in compacted snow?** Fill two clear containers, one with fresh snow and one with snow that has been crammed into the container by students to represent compacted snow. Fill to the same level. Allow the snow to melt and compare the amount of air in the fresh snow to the lesser amount in the compacted snow.

B. **Compare the insulating value of tracked and untracked snow.** Repeat the DAY TWO part of this activity in compacted snow. Choose a site that has been trodden by people or vehicles. Be sure to read thermometers carefully.

C. **Make "Baked Alaska!"** Follow cookbook directions to prepare this delicious dessert. Baked Alaska is a layer of cake topped by a thick layer of ice cream, covered by an inch of meringue (whipped egg whites), and then baked for 3-5 minutes! The ice cream does not melt because the meringue is a poor heat conductor. Like snow, meringue is full of air bubbles that don't carry heat well. Meringue insulates the ice cream from the oven's heat.

D. **Design a make-believe "animal" that could thrive under or in the snow** during the winter *(see also "Design Your Tundra Animal" in Alaska's Tundra & Wildlife, Section 3).*

Credit:
EXPERIMENT C of this activity was adapted and reproduced from Hands-On-Nature, 1986, with permission of the publisher: Vermont Institute of Natural Science, 27023 Church Hill Road, Woodstock, VT 05091.

Curriculum Connections:

(See appendix for full citations)

Books:
One Small Square: Arctic Tundra (Silver)

Scholastic's The Magic School Bus in the Arctic: A Book About Heat (Cole) (Gr. K-3)

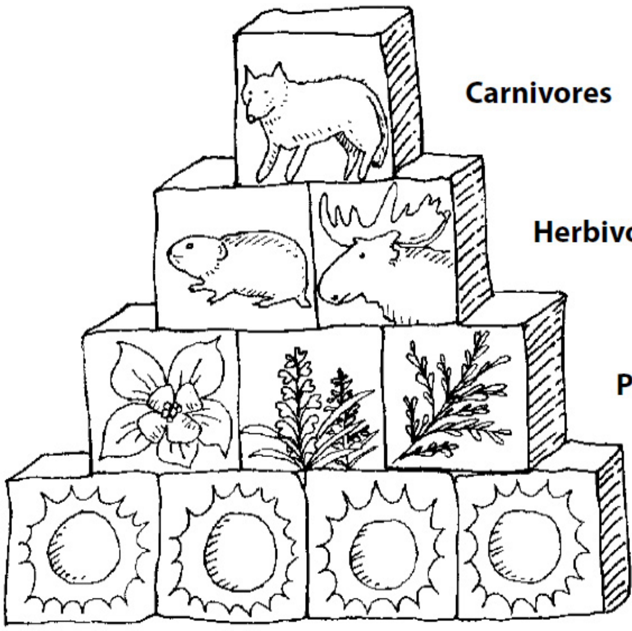
The Secret Language of Snow (Williams)

Teacher Resources:

(See appendix)

Who Eats Whom?

4 EXTENSIONS ***ALERT: ALASKA ECOLOGY CARDS OPTIONAL***



Section 2
ECOLOGY ACTIVITIES

Grade Level: K - 8

State Standard: S A-14
NGSS: K-LS-1,5-LS2-1,MS-LS1-6 MS-LS2-1,MS-LS2-2,MS-LS2-4

Subject: Language arts, science, math

Skills: Classifying, listening, observing

Duration: 60 minutes

Group Size: Any

Setting: Indoors

Vocabulary: Carnivore, consumer, detritivore, food chain, food pyramid, herbivore, producer

Objective:
Students will describe how energy is passed from producers to consumers in food chains.

Teaching Strategy:
Students build a biotic pyramid with milk carton blocks to model a food chain.

Complementary Activities:
"Take a Deep Breath" *in Section 1. All the* "Investigating (Living Things)" *activities,* "What Makes an Ecosystem," *and* "Ecosystem Scavenger Hunt" *in Section 3. Also* "Create and Destroy" and "Spinning a Yarn about Ecosystems" in Section 4.

Materials:
For the class: 10 empty paper milk cartons (quart or half gallon size); pictures of plants, seeds, algae, herbivores, carnivores, humans (*see following pages* or *Alaska Ecology Cards)*, construction paper – yellow and other colors, scissors, pencils, markers, rulers; yarn or string, pencil and paper.

Background:
See INSIGHTS *Section 2, Ecosystems – Community Connections* and its *"Track the Energy"* fact sheet.

Procedure:
NOTE: Teachers of younger students may need to build the boxes in Steps 4 and 5 *in advance.*

1. Hold a class discussion about students' favorite foods and list them on the board. How many of the listed foods are made of plants (**producers**)? How many are from animals that eat plants (**herbivores**)? How many of the listed foods are from animals that eat other animals (**carnivores**)? *(For example, arctic char and trout eat insects.)*

2. Through class discussion, follow some of the students' favorite foods back through a **food chain** so students recognize that all the food we eat is ultimately based on the consumption of plants. Plants, in turn, depend on the **nonliving** environment *(sun, water, and nutrients)*.

3. Tell students they will build an example of a food web to follow the path of the sun's energy through an ecosystem.

4. Working in pairs, students cut the top off a milk carton and measure one side of the bottom of the carton. Using that measurement from the bottom of the carton, measure the same distance up the sides of the carton. Cut the carton to get two square boxes, one open on both ends, and the one open on just one end.

5. Stuff the open-ended box sideways into the other box to form a cube. Tape the cube so that it is closed. The class should make 10 milk carton cubes to complete the set.

6. Decorate four of the cubes with pictures of the sun or put yellow paper on all sides.

7. Paste or draw pictures of Alaska plants and seeds on three of the cubes.

8. Put pictures of plant-eating animals (such as moose or caribou) on two cubes, and use the last block for meat-eating animals. Encourage students to include humans in these last two steps.

9. Have students build a food pyramid as a class. Place the four sun cubes side-by-side as the base, then stack the three plant cubes on top of the sun cubes. Place the herbivore (plant-eating) cubes on the third layer, and the carnivore (meat-eating) cube on top. Discuss what the class has created.

10. Discuss why there are more plants and seeds than plant-eating animals, and why there are even fewer carnivores. *The amount of available energy limits the number of living things in a particular ecosystem. Less energy is available to pass on at every link of a food chain. As a result, carnivores are less numerous than herbivores, and food chains rarely have more than four links.*

11. Ask students to take away one plant block. *At least part of the structure should fall.* What happens when you remove a sun block? What happens if you take out a meat-eater? (*It's not a pyramid anymore.*)

12. Talk about the biotic pyramid as a model of the balance worked out by nature. What happens to that balance if there are no meat-eaters? (*The population of herbivores would eat all the plants, because predators would not limit the population.*)

13. Explain that nature is not as simple as their model of the biotic pyramid. What major role is missing? (*Something to recycle dead things –* **detritivores**.*) There are so many connections that a* **food web** *is a more accurate model to show how energy and minerals are passed from the nonliving surroundings to living things.*

VARIATION
Cut strips of construction paper one-half inch wide; use one color *paper (except yellow)* for each level of the food chain pyramid. Write the name, or draw or glue a picture of a living thing on each strip. Staple or glue the strips together to form chains.

When each student (or pair) has finished making a chain, ask where the chains really start. What is missing from the chains? (*The sun's energy.*) Use a large yellow circle as the sun, and have students attach their chains to the sun with a yellow link. Hang across a corner or from the ceiling to model several food chains.

Evaluation:

1. Given a list of producers, omnivores, carnivores and the sun, students will draw their own food chains or biotic pyramids and label the different levels.

2. *For older students:* Students list the different levels of a biotic pyramid. They explain why a food chain or a food web is a better model for showing the connections between the levels.

3. Give each student a piece of lined paper and strips of construction paper, including yellow. List an example of each of the five food chain levels on the board (producers, herbivores, carnivores, omnivores, detritivores). Have students build their chains independently. What would happen if another chain were added? (*It would become a food web.*) What would happen if you took a link away? What link represents the most energy consumption and why?

EXTENSIONS:

A. **Role play the layers of a biotic pyramid.** Students become the "cubes" of the food pyramid by stacking themselves on top of one another on their hands and knees. Students wear name tags that indicate whether they are producers, herbivores, or carnivores.

B. **Expand knowledge of food chains.** Ask students if they know a name for animals which eat both plants and animals (**omnivores**). Ask what fungi eat or what scavenging herring gulls eat. How do these living things fit in a food chain? *Explain that dead things and wastes from all levels of the pyramid return energy and nutrients to the soil where the energy becomes available again to producers. Suggest fertilizer as an example of waste that provides nutrients for producers.*

C. **Research their cube organisms.** Older students might research organisms for their cubes, to determine living and nonliving things that their plants or animals need to survive.

D. **Complete food chain worksheets.** Students complete one of the food chain worksheets (*following pages*).

Credits:

Adapted with permission from Earth Child by Kathryn Sheehan and Mary Waidner. Tulsa: Council Oak Books, 1992.

Curriculum Connections:

(See appendix for full citations)

Books:

Ecology (Pollock)

Food Chains (Silverstein)

The Hunt for Food (Ganeri)

The Magic School Bus Gets Eaten: A Book About Food Chains (Reif)

What are Food Chains and Webs? (Kalman)

Who Eats What? Food Chains and Food Webs (Lauber)

Media:

All Things are Connected (Video) (North Carolina Wildlife Commission)

Into the Forest, Krill, Onto the Desert, Predator (Nature's Food Chain Games) (Ampersand Press)

The Magic School Bus Gets Eaten (Video)

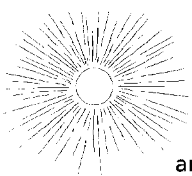
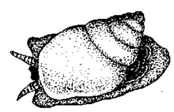
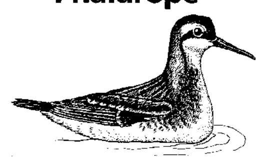
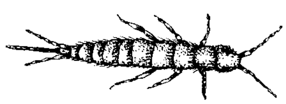
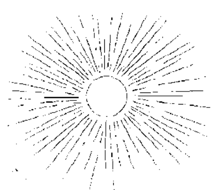
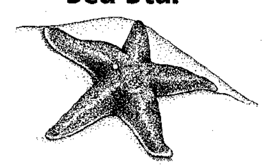
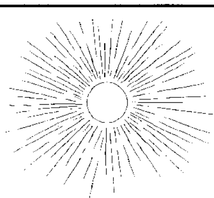
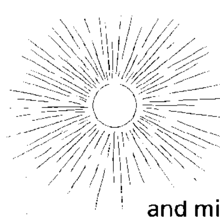
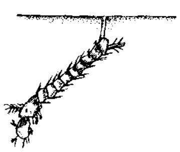
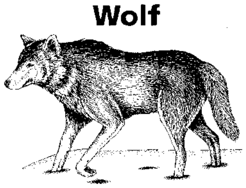
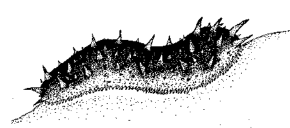
Teacher Resources:

(See appendix)

K-3 Food Chains

Name: ______________________________

Color and cut out the cards below and put them in order to make 4 food chains found in Alaska ecosystems.

1	2	3	4
 and minerals	**Kelp**  I make food from energy and minerals.	**Snail**  I eat kelp.	**Dwarf Dogwood**  I make food from energy and minerals.
Merlin  I eat pine grosbeaks.	**Pine Grosbeak**  I eat the berries of a dwarf dogwood.	**Bacteria**  I eat waste. I live in a wetland.	**Phalarope**  I eat mosquito larvae.
Mushroom  I eat dead things in forests.	**Springtail**  I eat dead things on the tundra.	 and minerals	**Sea Star**  I eat snails.
 and minerals	**Alpine Sunflower**  I make food from energy and minerals.	 and minerals	**Mosquito Larvae**  I eat algae.
Wolf  I eat Dall sheep lambs.	**Algae**  I make my food from energy and minerals.	**Dall Sheep**  I eat moss campion.	**Sea Cucumber**  I eat wastes in the sea.

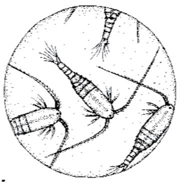
4-8 Food Chains

DIRECTIONS: Color the producer cards green, the herbivore cards yellow, the carnivore cards red, and the detritivore cards blue. Then cut the cards apart, find the four food chains, and paste the food chains onto another sheet of paper. Write your name on your food chain paper.

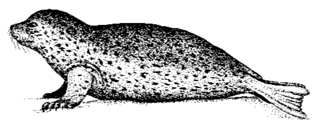
This is a diatom.
It photosynthesizes its food.

This is a redpoll.
It eats birch seeds.

This is a Pholiotus mushroom. It gives off chemicals that digest dead plants and wastes. Then it soaks up the digested material.



This is a copepod.
It eats diatoms.

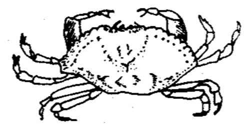


This is a harbor seal. It eats ocean fish such as herring.

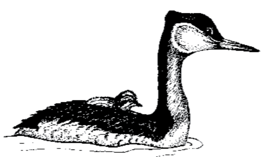
This is a birch tree. It photosythesizes its food.

This is a Dall sheep. It eats low-growing alpine plants like alpine avens.

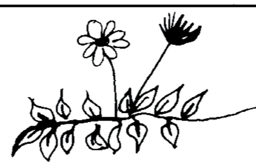
This is a merlin.
It eats small birds.



This is a crab. It eats dead things and waste material on the ocean floor.



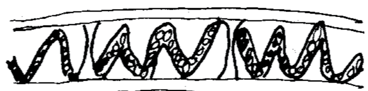
This is a grebe. It eats small fish like sticklebacks.



This is an alpine avens.
It photosynthesizes its food.

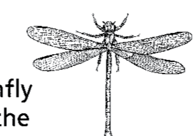
This is a killer whale. It eats fish and sometimes other marine mammals.

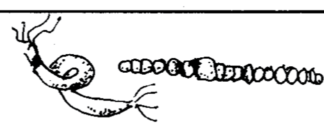
This is a raven.
It feeds on dead animals.



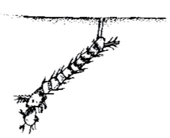
This is algae, a type of protist.
It photosythesizes its food.

This is a dragonfly larvae. It eats the aquatic larvae of other insects such as mosquitos.



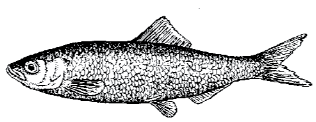


This is bacteria. It feeds on dead plants and animals and waste materials.

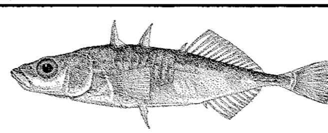


This is mosquito larvae. It eats protists such as algae.

This is a wolf. It eats moose, caribou, and sheep, especially young animals.



This is a herring. It feeds on zooplankton such as copepods.

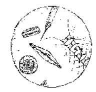
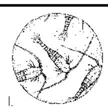
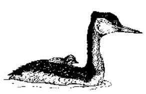
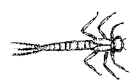
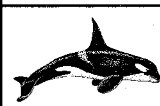
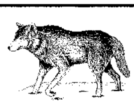
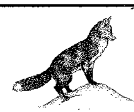
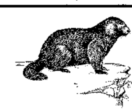
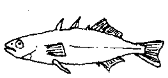
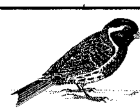
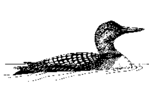


This is a 3-spine stickleback.
It eats aquatic insects like dragonfly larvae.

This is a fox. It eats just about anything it can catch, including small mammals, small birds, bird eggs, and dead animals.

9-12 Food Chains

Place a P next to the producers, an H next to the herbivores, a C next to the carnivores, a D next to the detritivores, and an O next to the omnivores. How many food chains can you find on this worksheet? On a separate piece of paper, diagram an ocean, wetland, forest, or tundra food web that shows all the organisms (pictured or listed) on this worksheet, plus at least 10 others that you know.

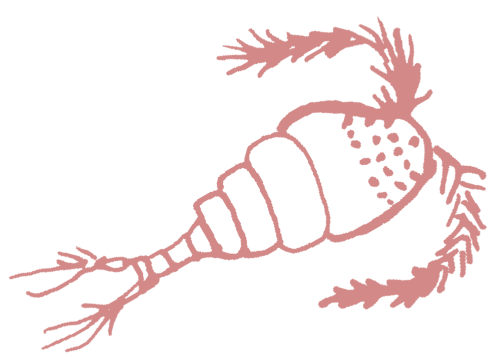
	This mushroom secretes chemicals to digest dead plants and wastes. It absorbs the digested material.		This a diatom, a type of protist. It photosynthesizes its food.
	This is a copepod. It eats diatoms.		This is a redpoll. It eats the seeds of birch, willow, and other shrubs and trees.
	This is a birch tree. It photosynthesizes its food.		This is a harbor seal. It eats ocean fish such as herring.
	This is an alpine avens. It photosynthesizes its food.		This is a Tanner crab. It eats dead things and waste material on the ocean floor.
	This is a grebe. It eats small fish, like sticklebacks in fresh water, or sandlance in ocean water.		This is a Dall sheep. It eats low-growing alpine plants like alpine avens.
	This is a merlin. It eats small birds in forests or tundra areas.		This is a dragonfly larvae. It eats the aquatic larvae of other insects such as mosquitos.
	This is algae, a type of protist. It photosythesizes its food.		Killer whales eat fish (herring and salmon especially) and sometimes seals, sealions, and other whales.
	This is a raven. It feeds primarily on dead things (called "carrion").		This bacteria lives in the soil. It feeds on dead plants and animals and waste materials.
	This is a mosquito larvae. It eats protists such as algae.		This pika is a small mammal that lives in alpine areas and feeds on grasses and herbs.
	This is a wolf. It eats moose, caribou, and sheep, especially young animals.		Red foxes eat just about anything including small mammals, small birds, bird eggs, berries, and dead animals.
	This is a sandlancel It feeds on zooplankton such as copepods, amphipods, and euphausids.		Marmots are small mammals that live in alpine areas and feed on grasses and herbs.
	This is a 3-spine stickleback. It eats aquatic insects like dragonfly larvae.		Golden eagles live in alpine areas and feed on ptarmigan, small mammals, and (occasionally) newborn Dall sheep lamb, mountain goat kid, and caribou calf.
	This is a shrike. It eats small birds, insects, and small mammals in tundra and forest areas.		Adult longspurs feed on insects and the seeds of various tundra plants.
	This is a loon. It eats mainly small fish in fresh and saltwater. They occassionally eat large aquatic insects.		This amoeba eats other protists, including algae and protozoans.

Answers to Food Chain Worksheets

Grades K-3: The four food chains all begin with sunlight and minerals. After these two cards they are as follows: 1. kelp—snail—sea star—sea cucumber; 2. dwarf dogwood—pine grosbeak—merlin—mushroom; 3. algae—mosquito larvae—phalarope—bacteria; 4. alpine sunflower—Dall sheep—wolf—springtail.

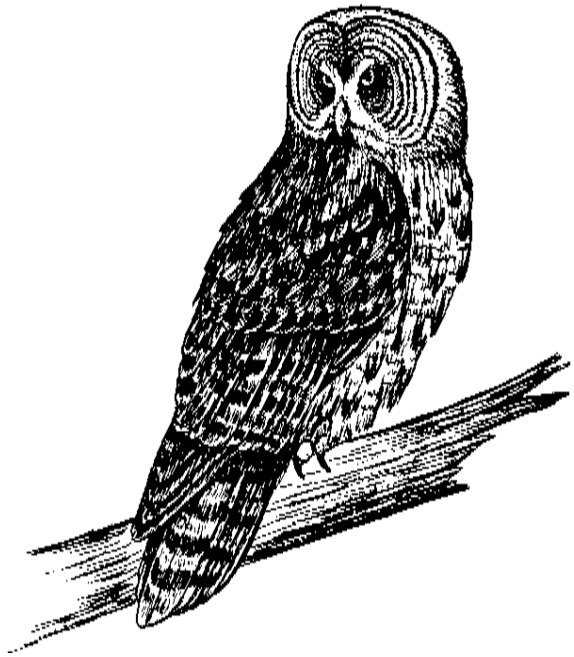
Grades 4-8: 1. diatom—copepod—herring—seal—killer whale—crab; 2. birch—redpoll—merlin—mushroom; 3. alpine avens—Dall sheep—wolf —raven; 4. green algae—mosquito larvae—dragonfly larvae—stickleback—grebe—fox—bacteria. The bacteria and raven can be interchanged.

Grades 9-12: 1. mushroom-D, copepod-H, willow-P, alpine avens-P, grebe-C, merlin-C, green algae-P, raven-D, mosquito larvae-H, wolf-C, sandlance-C, stickleback-C, shrike-C, loon-C, diatom-P, redpoll-H, seal-C, crab-D, Dall sheep-H, dragonfly-C, killer whale-C, bacteria-D, pika-H, red fox-O, marmot-H, golden eagle-C, longspur-O, amoeba-C.



Follow a Food Chain

2 EXTENSIONS ***ALERT: ALASKA ECOLOGY CARDS OPTIONAL***



Section 2
ECOLOGY ACTIVITIES

Grade level: K - 12

State Standard: S A-14
NGSS: K-LS-1,-LS2-1,MS-LS2-1. MS-LS2-2,HS-LS2-4.

Subjects: Science, language arts, math

Skills: Dissecting, observing, inferring, listening, measuring, puzzle-building

Duration: 50 minutes

Group Size: Any

Setting: Inside

Vocabulary: Carnivore, detritivore, food chain, herbivore, owl pellets, predator, prey, producer

Objectives:

1. Students observe one link in a food chain by examining owl pellets. They use this evidence to infer other links in the chain.

2. Students will work in cooperative groups to make observations and collect data and draw conclusions.

Teaching Strategy:
Students dissect owl pellets, put together a skeleton of owl prey, and identify prey animals.

Complementary Activities:

"Investigating Birds" *and* "Investigating Mammals" *in Section 3. Also* "Create and Destroy" and "Spinning a Yarn about Ecosystems" in Section 4.

Materials:

One owl pellet (**see note at end of activity*) per pair of students, dissecting tools (or toothpicks), diagrams of small animal skeletons and skulls. Glue for mounting, sample data sheet (*following*). Guided Imagery *(following).* OPTIONAL: Poster board, *Alaska Ecology Cards.*

Background:

See INSIGHTS *Section 2, Ecosystems – Community Connections* and the *"Owl Food Web"* fact sheet.

Natural History Tips:
Owls usually eat all of their **prey**. Often they swallow small prey whole – feathers or fur and all. What they cannot digest, the owl spits up or "casts" in a pellet 12-16 hours after each meal. These "packages" contain remnants of the birds, small mammals, and insects the owl ate. Pellets reveal the secrets of the owls' diets.

Scientists *(and students)* can learn about owls and their prey by examining and classifying the contents of pellets. The remains of animals found in pellets tell researchers what animals are found in an owl's hunting territory.

Pellets also give clues about growth and decline of rodent populations. For example, if a vole population changes from abundant to scarce, over time fewer vole bones would be found in owl pellets in the area.

Constructing **food chains** based on animals found in an owl's pellet can lead backward to green plants eaten by a vole. Predators on owls include ravens that eat owl eggs and other owls. **Detritivores** always are the last link in the chain.

Procedure:

1. Read the guided imagery. Ask students to predict what they will find in their owl pellets. Write these predictions on the board.

2. Students work in pairs or small groups with specific roles such as chief investigator, supply manager, skeleton construction expert. Remind students that they are to use proper laboratory procedures, which include not eating or drinking while working, and washing hands before and after examining the owl pellet.

3. Distribute one data sheet per group. Ask students to collect some data before dissecting the pellet. Compare each group's observations of pellet length, circumference, shape, texture, and color.

4. Ask students to separate fur or feathers from the bones. Every member of each group should participate in bone classification. Try to identify the teeth and/or skulls of the animal meal. The skulls and teeth will give clues about the owner's identity and its eating habits. Provide posters of rodent, shrew, and bird skeletons as references to aid in identification. A bone-sorting chart is available from Pellets, Inc. (*see* Teacher Resources *in the Appendix*).

Feathers give clues about the size of the bird eaten by the owl. Pellets that have feathers in them may also have bird bones. The longer, larger bird bones can be distinguished from mammal bones because they are hollow and light.

6. Check to see whether there are remains of more than one animal in each pellet. Try to figure out how many of each type of animal is present.

7. Try to set out the bones to form a skeleton of the prey animal. Glue the bones to poster board, if desired.

8. Have groups compare the number and type of different skulls found in each pellet. Results can be compared on a chart or graph.

9. Review each group's data and hold a class discussion. What causes the differences in the appearance and content of the pellets? Why are different animals and different numbers of each type of animal found in each pellet?

10. Focus the class discussion on food chains. What evidence of a food chain is found in an owl pellet? What do owls' prey eat? Extend the discussion of the food chain until students include sun, plants, and **detritivores**.

11. Ask students to draw a food chain based on the evidence they found in their owl pellets. What happens to owl pellets in the wild?

Evaluation:

1. Students draw a food chain to show the owl, what it ate and what the prey ate. Compare chains made by other students in the class.

2. Give students a list of 5-10 things an owl eats. Students build at least two food chains using paper and pencil or 3-dimensional construction showing the missing links in the chain.

EXTENSION:

A. **Study owl pellets as a scientist.** *For older students:* Students design an in-depth study of owl pellets using the scientific method. The question for analysis might be "What are the most common prey of owls?" The study design should include a sample size *(number of pellets analyzed)*, methods section, results and discussion, conclusion, and literature cited.

B. **Analyze the results mathematically.** Prey remains can be sorted into large categories such as mice, birds, and shrews. If a biologist or expert is available, the remains may be analyzed to determine species. Can students determine the mean number of prey per pellet? What is the mean ratio of bone weight to total pellet weight?

Credits:

Adapted with permission from "Owl Pellets," Project WILD, Western Regional Environmental Education Council, 1992. Shaw, Donna Gail, "Sample Lesson Plan – Owl Pellets," Associate Professor, School of Education, University of Alaska, Anchorage, 1992.

Curriculum Connections:

(See appendix for full citations)

Books:

All about Owls (Arnosky) (Gr. K-3)

Book of North American Owls (Sattler)

Guide to the Birds of Alaska (Armstrong)

Owl (Steffof)

Owl Moon (Yolen)

Owls: A Wildlife Handbook (Long)

What are Food Chains and Webs? (Kalman)

Teacher Resources:

(See appendix)

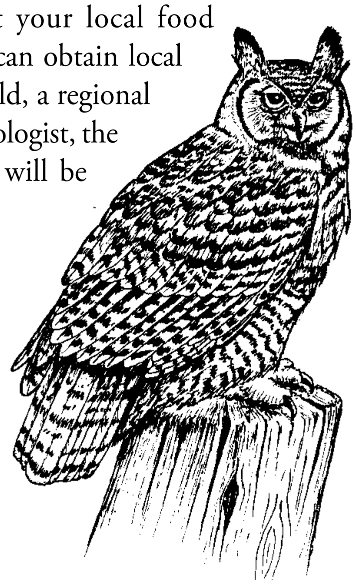
NOTES ON PELLETS

Where to obtain pellets

Pellets can be collected below roosting sites *(tall rocks or tundra tussocks, trees, or cliff edges),* from a raptor rehabilitation center, or from a scientific supply house *(see appendix for* Teacher Resources).

Non-local diets from commercial sources

Pellets from commercial sources may include small mammals that do not live in your area. This may make inferring about your local food chain difficult. If you can obtain local owl pellets from the wild, a regional raptor center, or area biologist, the impact of your lesson will be more direct.



IMPORTANT SAFETY NOTE

Any commercial owl pellet supplier should guarantee that their pellets have been sterilized. If you collect owl pellets on your own, sterilize them to kill bacteria that can be passed on to anyone who handles the pellets. Microwave on "high" for 20 seconds for about five pellets. Or place on a cookie sheet in a 350-degree oven for 20 minutes. Don't overcook.

To ensure the safety of students *(especially when using pellets from the wild)*, also have students soak the pellets in a water/chlorine solution which prevents dust. Students then strain the solution so they can pick through the remaining wet hair and bones.

Guided Imagery: An Owl

Adapted from "Flight of Fancy" by Donna Gail Shaw and reprinted with permission from Ranger Rick's NatureScope, *"Birds, Birds, Birds!"*

Close your eyes. You are going to make a flight to a fantasy world. Before you go, though, your body must change because you are much too heavy to fly.

Let's start the change with your feet. Think about your feet and notice how they feel. Wiggle your toes and bend your ankles. Now imagine that each foot is being squeezed together and stretched until it is long and skinny and extends upward like a leg. Your ankle looks like a knee, but it bends the wrong way. You must stand and walk on your toes, but there are only four of them. One has disappeared. You have unusual control of the four that remain. Three face forward and one sticks out the back, but you can move the outer toe on the front so that it sticks out the back, too. A sharp, curved toenail or talon grows from the end of each toe. The skin on your feet and ankles changes from smooth skin to rough, bumpy scales.

Now your legs become shorter and your knees pull up close to your body. You feel your body grow shorter and your insides shrink.

Suddenly your hands and arms start to change. Your fingers must dissolve and your hands grow until they are long, flat and wide. Your hands and arms have become wings. Flap them a few times and feel how they move.

Now your head begins to change. Your teeth disappear and your nose and mouth grow together to form a hard, strong, sharp, hook-like beak. Your eyes become more difficult to turn in their sockets. You must turn your head to look around. Now your chin disappears and your outer ears fall off. Nevertheless, you're able to hear quite well.

More changes happen very quickly now. Each lung changes and air sacs appear in many places in your body. They are like balloons connected to your lungs. Your bones grow hollow to make them much lighter than they were. The small hairs all over your body begin to change into feathers. Soft downy feathers grow close to your body, and longer, wider feathers cover them. Larger feathers give shape to your wings.

Your body change is complete and you hop to the nearest open door. As you face outside, the wind calls to you and you jump, flapping your wings quickly with great force but hardly any sound.

As evening approaches, you feel extremely hungry. For some reason a mouse sounds like it might taste good. Funny, you've never wanted to eat a rodent before. In the gathering darkness, you hear a soft rustle of the leaves and you spot a mouse. You swoop down, grab it, and fly to a nearby tree to find out you've forgotten all your manners – you swallow the mouse whole! You think to yourself – I can't believe I ate the whole thing – hair, bones, and all! You find that you're still hungry and you're not satisfied until you eat two more small mammals and a bird.

You tire and fly back to your house to rest. Several hours later something begins to happen. You cough hard and, suddenly, you realize what you have become – you're an owl and you have just coughed up your first owl pellet. You wonder to yourself, what would I find inside the pellet if I were to examine it?

Think.

Slowly return to yourself and open your eyes. Today we are going to examine owl pellets (*write owl pellets on the board*). What do you think we will find?

Data Sheet: Owl Pellets

Before dissecting the pellet.

1. Length of pellet: __________
2. Circumference of pellet (use string): __________
3. Draw the shape of the pellet:
4. Colors(s) of pellet: ____
5. Texture of pellet: ____

Begin dissecting a pellet.

6. Number of skulls found in pellet: _________
7. Describe the kinds of animals found:

____

____

____

8. Describe things other than bones or fur found in or on the pellet:

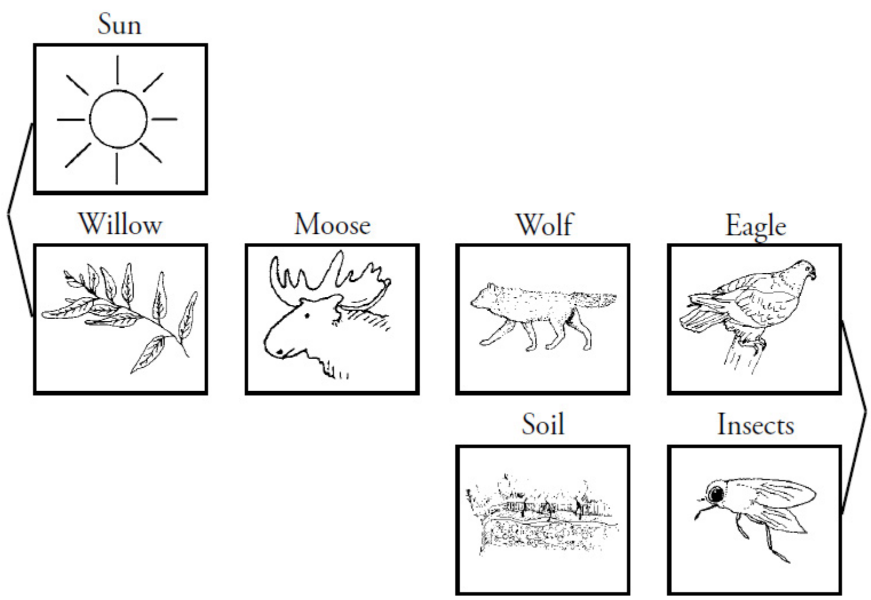
____

____

____

What's For Dinner?

2 EXTENSIONS ***ALERT: ALASKA ECOLOGY CARDS REQUIRED***



Section 2
ECOLOGY ACTIVITIES

Grade Level: 3 - 8

State Standard: S A-14
NGSS: 5-LS2-1, MS-LS2-1, MS-LS2-2

Subjects: Science

Skills: Organizing, synthesizing, analyzing

Duration: 50 minutes

Group Size: 2-4

Setting: Indoors

Vocabulary: Consume, consumer, predation, predator, prey

Objective:

1. Students will identify consumer – consumed relationships.

2. Students will construct their own food relationships and construct their own food chain using only those interactions.

Teaching Strategy:

Student groups brainstorm and create the longest consumer-consumed food chain possible using either magazine pictures or research materials.

Complementary Activities:

All the "Investigating" activities and "Ecosystem Scavenger Hunt" *in Section 3. Also* "Create and Destroy" and "Spinning a Yarn about Ecosystems" in Section 4.

Materials:

Alaska Ecology Cards, wildlife and nature magazines, 5 x 8 index cards, tape, research materials.

Background:

See INSIGHTS *Section 2, Ecosystems – Community Connections.*

Procedure:

1. Define the terms **predator**, **prey**, **consumer**, and **consumed** with the class. Brainstorm examples of consumer-consumed relationships.

2. Ask each group to make the *longest* possible food chain to illustrate consumer-consumed relationships. *For example, an insect like an aphid consumes plants; the aphid is eaten by a spider; the spider is eaten by a bird; the bird is eaten by a goshawk....*

3. Students cut out or draw pictures of each animal in their chain from magazines (or use *Alaska Ecology Cards)* and tape one stage of the food chain on each 5 x 8 index card.

4. Connect the cards with tape or string. The students should either use the *Ecology Cards*, other resource materials, or ask the teacher to verify that each consumer-consumed relationship could exist.

If appropriate, students indicate which relationships are predator-prey as they make their chains.

5. Each group presents their completed and verified food chain to the rest of the class. The group with the longest chain of consumption gets a hand from the class!

Evaluation:

1. Students define predator, prey, consumer, and consumed.

2. Students give two examples of consumer-consumed relationships.

EXTENSION:

A. **Guard against predation.** Brainstorm with students the various ways animals protect themselves from predation. For instance, a bee stings, a skunk squirts a foul smelling liquid, and many animals such as snakes, moths, and lizards use camouflage.

B. **Sing a food chain.** Read or sing the folk song, "I Know an Old Lady Who Swallowed a Fly." Students replace items eaten in this consumer-consumed chain with Alaskan creatures. Sing the new version of the song in the class. If possible, obtain the Pacific Northwest version of the tale, *I Know an Old Lady Who Swallowed a Trout,"* for the students to look at afterward.

Credit:

Activity contributed by Steve Kemp, Anchorage, Alaska.

Curriculum Connections:

(See appendix for full citations)

Books:

The Case of the Missing Cutthroats (George)

Food Chains (Silverstein)

I Know an Old Lady Who Swallowed a Fly (Westcott)

The Old Lady Who Liked Cats (Greene)

There Was an Old Lady Who Swallowed a Trout (Sloat)

What are Food Chains and Webs? (Kalman)

Who Eats What? Food Chains and Food Webs (Lauber)

Who Really Killed Cock Robin? an Ecological Mystery (George)

Media:

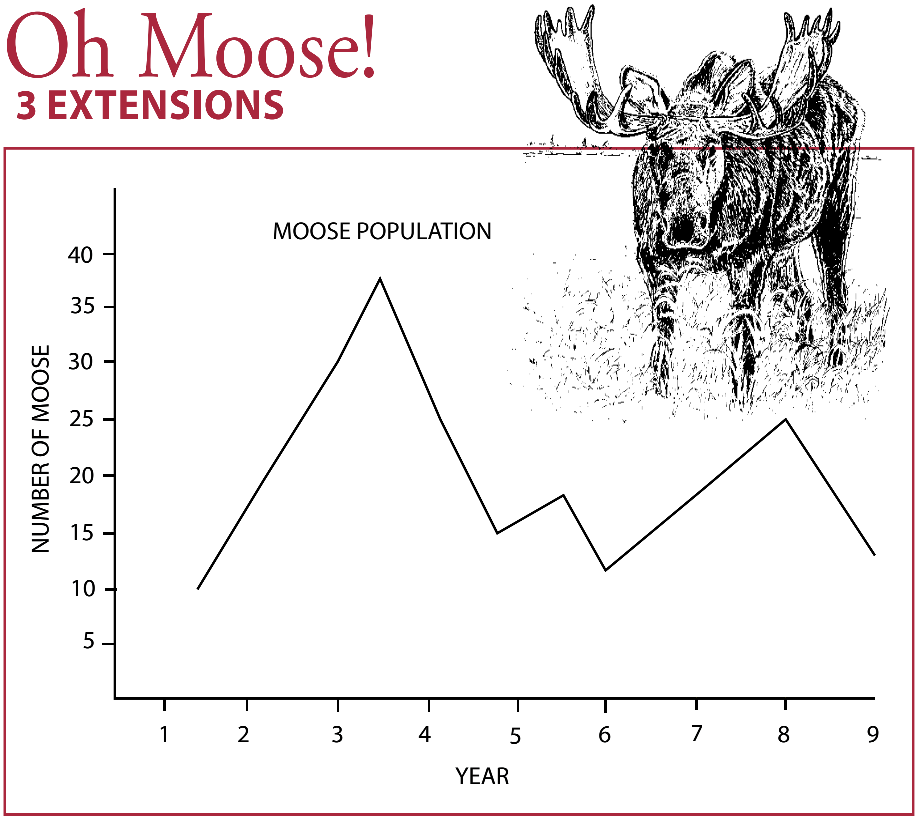
Into the Forest, Krill, Onto the Desert, Predator (Nature's Food Chain Games) (Ampersand Press)

Teacher Resources:

(See appendix)

Oh Moose!

3 EXTENSIONS



Section 2
ECOLOGY ACTIVITIES

Grade level: 4 - 12

State Standard: M A-3, M A-4, M A-6, S A-14

NGSS: MS-LS1-5,MS-LS2-1,MS-LS2-2,MS-LS2-4, HS-LS2-1. HS-LS2-2, HS-LS2-6.

Subjects: Science, math, social studies, physical education

Skills: Applying, comparing, generalizing, graphing, observing

Duration: 45-60 minutes

Group Size: 15 or more

Setting: Indoors/ outdoors (large area)

Vocabulary: Ecosystem, habitat, herbivore, limiting factors, population, predator

Objectives:

1. Students will identify at least three things in an ecosystem necessary for an animal to survive.
2. Students will define "limiting factors," and identify which parts of an ecosystem can limit the growth of a population.
3. Students will describe how and why a population changes as its ecosystem changes.

Teaching Strategy:

Students participate in a game which shows how populations change in relation to the supply of food, water, and shelter.

NOTE: This activity is simplified to cover the basic concepts of habitat and limiting factors. For older students, please refer to the Extensions on page 17.

Complementary Activities:

"Create a Classroom Compost Box" *in this section.* "Investigating Mammals" *in Section 3. Also* "Create and Destroy" and "Spinning a Yarn about Ecosystems" in Section 4.

Materials:

Large area for running or walking; flip chart or chalkboard; writing materials.

Background:

See INSIGHTS *Section 2, Ecosystems – Community Connections.*

Procedure:

1. Ask students what animals need to survive? Review that all animals need **habitat** (*food, water, shelter, and space in which to live*). If animals do not have these necessities, they will die. Tell students that this activity involves finding these essentials for moose.

2. Separate the class so that 1/4 of the class becomes "moose" and 3/4 become the "habitat" components. Mark two lines parallel to each other and 10 to 20 yards apart. The moose stand behind one line. All habitat students stand behind the other line.

3. Each moose needs to find three habitat essentials: food, water, shelter. *In this game, assume that moose have adequate space to live (represented by the 10 to 20 yard space between the moose and habitat).*

- FOOD: When a moose is looking for food, it holds its hands *(hooves)* over its stomach.
- WATER: When a moose is looking for water, it holds its hands over its mouth.
- SHELTER: When a moose is looking for shelter, it holds its hands over its head.

4. At the beginning of each round of the game, a moose can decide what to look for. Once each moose has chosen what to look for, it cannot change until the beginning of the next round. This is very important for the activity to be successful.

5. Each player in the habitat group randomly chooses to be one of the essentials – food, water, or shelter – at the beginning of each round. Once chosen, the habitat essential cannot be changed until the next round. These students use the same hand gestures as the moose to indicate their identity. *If all the habitat players decide to be water one round, they could represent a flood year in that ecosystem.*

NOTE: For younger students, there may be a problem with changing roles during a round. You could hand out color-coded tokens to represent food, water, and shelter. Students choose the color corresponding to their habitat essential at the beginning of each round and return it to the supply at the end.

6. At the beginning of a round, all the students line up on their lines with their backs facing the players on the opposite line.

7. The teacher or leader asks all the players to make the appropriate hand gestures for food, shelter or water.

8. Count "One, Two, Three," and all the students turn around to see the other group. Moose continue to hold their hand gestures and walk to a player at the other line displaying the same habitat hand gesture. They escort the habitat essential person (food/water/shelter) back to the moose line.

- *Successful moose survive and are able to reproduce. If a moose does not obtain its needed essential, it "dies" and turns into a habitat component for the next round.*

- *If more than one moose picks the same habitat element, the one arriving first is the survivor.*

- *If habitat components are not used by the moose, they stay at their line for the next round, when they can choose to represent a different habitat component.*

9. Have one student keep track of the number of moose at the beginning of each round of play. Play the game for 8-15 rounds, keeping track of the numbers of moose.

10. At the end of the game, ask the players to tell what they observed happening to the moose population during the game.

- *They should note that the moose population increased for several rounds, while the herd found plenty of food/water/shelter.*

- *After a few rounds, however, the larger herd would not find enough to satisfy its needs. The moose herd would decrease due to lack of water, food, or shelter.* The causes of the moose population decline are called **limiting factors**.

11. Individually or as a group, students graph the numbers of moose as if each round was a year. The graph will show the ups and downs of the moose population as the supply of food/water/shelter changed. *It is important to realize that a healthy habitat means a healthy wildlife population.*

12. In class discussion, ask what animals need to survive. How does the supply of each habitat component affect the population of moose? Does a population always stay the same? Or is there some other pattern to describe what happens over time? How does the idea of "balance" in nature apply to the habitat and population of an organism? Is there actually a constant balance in an ecosystem or is there another way to describe what actually happens?

Evaluation:

1. Students give three examples of factors that limit the size of a particular population and describe what is meant by the term "limiting factor."

2. Students graph the changes in population numbers over time.

3. Students define a balanced population or "the balance of nature."

EXTENSIONS:

A. **Play the game with predators.** As the game progresses, introduce one predator such as a wolf, bear, or human who has to hop or skip *(for safety)*. A predator can "catch" *(tag)* its moose prey with two hands as the moose runs toward the food/ water/shelter.

Once the moose is tagged, the predator takes the moose off the playing field, to a designated area to eat, cache, or butcher the animal. The "dead"moose then become an additional predator and both predators return to the game.

As with the moose, if a predator does not obtain food, it dies and becomes a habitat component. Have the student recorder keep track of the number of predators as well as the number of moose. Later, this information can be added to the graphs.

With older students, study concepts of predator/prey relations as they effect population, in depth. Have students investigate and discuss the complexities of predator management in Alaska. Allow time for research, opinion writing, and possible debate. For assistance with such resource, contact your local Fish and Game office or the Division of Wildlife Conservation's Wildlife Education Program.

B. **Discuss reproductive capacity (with older students).** In the above activity all moose are treated as females capable of only one offspring. Contact your local Fish and Game office for more information on moose reproduction. Have older students re-design the activity taking reproduction into account with some moose as male, others as female. Identify years where reproductive rates are high or low to illustrate the impacts of reproductivity on population.

C. **Discuss and graph local population data.** Population records may be available for certain species in your area. Contact your local ADF&G office to request this data for use in the activity. Discuss past trends and changes in your local population.

D. **Describe limiting factors for other species.** Students describe some limiting factors of other species including humans. What habitat components are affected by flood, fire, volcanic eruption, pollution, human development, and human recreational activity? How do hunting/trapping/ viewing affect wildlife populations?

Credits:

Adapted from "Oh, Deer!" Project WILD Activity Guide. Western Regional Environmental Education Council, 1992.

Curriculum Connections:

(See appendix for full citations)

Books:

Deneki (Berry)

Disappearing Lake: Nature's Magic in Denali National Park (Miller)

Moose for Kids (Fair)

Our Endangered Planet: Life on Land (Hoff)

Out Among Wolves (Murray) (Essay "The Importance of Predators" by David Rains Wallace and "Thinking Like a Mountain" by Aldo Leopold)

Wolves, Bears, and Their Prey in Alaska by the Committee on management of Wolf and Bear Populations in Alaska.

Media:

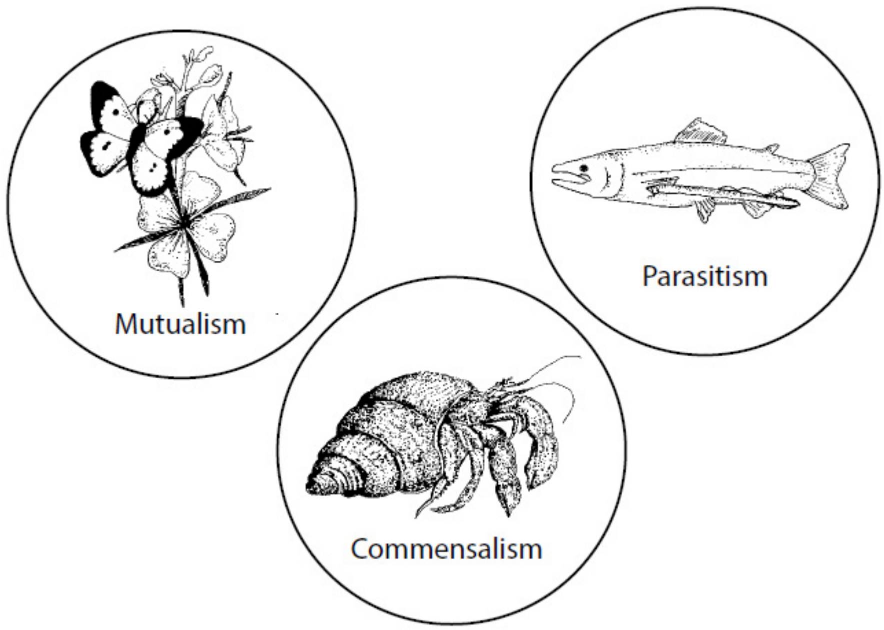
Into the Forest, Krill, Onto the Desert, Predator (Nature's Food Chain Games) (Ampersand Press)

The Wolf Kit. Contact the Division of Wildlife Conservation/Wildlife Education for loan information at (907) 267-2168.

Teacher Resources:

(See appendix)

Ecosystem Partners
4 EXTENSIONS



Section 2
ECOLOGY ACTIVITIES

Grade level: 4 - 12

State Standard: S A-14
NGSS: 5-LS2-1,-LS2-2

Subjects: Science, language arts

Skills: Reading, analyzing, describing, defining, categorizing

Duration: 50 minutes

Group size: 8+

Setting: Indoors

Vocabulary: Commensalism, mutualism, parasitism, symbioses, symbiotic relationship

Objective:
1. Students will define and categorize relationships in which living things depend on one another for food, shelter, and reproduction.

2. Students will identify Alaska examples of three symbiotic relationships: mutualism, commensalism, and parasitism.

Teaching Strategy:
Students play a matching game in which they find pairs of living things that need each other to provide food, shelter, seed transportation, pollination, or spore distribution.

Complementary Activities:
"Follow a Food Chain" *and* "Mineral Cycling" *in this section.* "Ecosystem Scavenger Hunt" *in Section 3.* "Spinning a Yarn about Ecosystems" *in Section 4.*

Materials:
Ecosystem Partner Cards and Practice Worksheets (*following*), bulletin board, pins or tacks, three headings for bulletin board as follows:
Title: "Symbiotic Relationships: Living Closely Together."
(1) **Mutualism:** A relationship where both species benefit and are dependent on each other.
(2) **Commensalism:** A relationship where one species is dependent on another without harming the other species or providing anything in return.
(3) **Parasitism:** A relationship in which one species lives in or on another, getting food and shelter from its host, and causing harm to the host as it does so.

Background:
See INSIGHTS *Section 2, Ecosystems – Community Connections.*

Procedure:
IN ADVANCE: create a bulletin board using the headings described under Materials. Students will later use the board to display examples of these relationships.

1. Review the concept of **ecosystems**.

2. Ask students to brainstorm relationships between organisms *(including humans)* dependent on each other in some way. Make a class list. *(Human relationships might include dog mushers and their dogs.)*

3. Discuss how to categorize the items on the list. Some animals have to compete for limited resources. *(See "Oh Moose")* Other animals have a predator/ prey relationship. *(See "What's for Dinner")*

4. Introduce the idea that some living things cannot live without the help of another. Discuss the terms, **symbiotic relationships**, **mutualism**, **commensalism**, and **parasitism**.

5. Ask students to think of human examples of these types of relationships to reinforce the idea. Ask students if any of the relationships they brainstormed earlier would fit into the three categories of **symbiosis**. You can also discuss the relationships that don't fit into these categories, determining why they don't fit. (*They may be examples of predator-prey or competitive relationships.*)

6. Use the sample worksheet to provide practice for students in classifying the symbiotic relationship between some Alaskan species. Students may work independently, in groups, or as a class to practice using the terms "mutualism," "commensalism," and "parasitism."

7. Distribute one "Ecosystem Partners Card" to each student. Tell them each living thing shown on a card interacts with the other living things that are represented on other cards in the classroom.

8. Explain that there is one special organism with which they have a symbiotic relationship. The object of the activity is for the students to (1) find this special organism, (2) determine what type of symbiotic relationship they have, and (3) explain why.

9. Students circulate the room, looking for their symbiotic organism. (*NOTE: There are symbols on the cards which match, to help younger students to determine their partners more easily.*)

10. Ask each pair to read the cards to the class and explain the interactions of the organisms on the cards. As a group, decide in which symbiotic category to place each interaction.

11. After each interaction is classified, have the pair write the names of the partner organisms under the correct category on the board, or mount the cards in the proper place on the board.

12. Review the different kinds of associations when the board is completed.

VARIATIONS

A. For younger students: Ask one student to stand and read her card, or read it for her. Ask any other student who thinks he has a living thing that helps or is helped by the first to come and link arms with the standing student. Ask the second student to read his card, and have the class decide if it is a good match. If the match is good, the second student stays standing, but if the match is not right, the student returns to his seat. Repeat until a partner is found.

B. Reproduce several decks of cards, each having 20 pairs showing symbiotic relationships. Divide the class into groups of 5 or 6 and give a deck of cards to each group. Play the game "Alaskan Buddies" using the following rules (much like "Go Fish"):

- Deal the cards. Play starts to the left of the dealer and rotates clockwise.
- On your turn, draw a card from the hand of the player to your left. If possible, match it with a card in your own hand *(according to symbiotic relationships)* and lay down the pair.
- When a player lays down all of his or her cards, the game is over. The player with the largest number of pairs is the winner. An extension would be to have students create their own cards for future games.

Evaluation:

1. Students pantomime symbiotic relationships, giving examples of commensalism, mutualism, and parasitism.

2. Students describe symbiotic relationships, give an example of each type of relationship, and identify what makes symbiotic relationships different from competitive or predator-prey relationships.

3. Given some mismatches created by the teacher from the Ecosystem Partner Cards, students can explain why these examples are not symbiotic relationships.

4. Students work in teams of 2-4 to create a mural of certain categories of symbiotic relationships.

EXTENSION:

A. **Add competition and predator-prey relations to the game.** The Ecosystem Partners Cards include examples of competitive and predator-prey relationships. Repeat the game using these cards, allowing the students to establish as many relationships as they can with other organisms. Include bulletin board headings for **competition** and **predation** so students can include these categories as they classify their relationships.

B. **Find schoolyard examples.** Take students outside, looking for examples of interactions within an ecosystem. Challenge students to find evidence of the various types of symbiotic relationships. Examples include mosses that rely on the shade of large trees to keep them moist, plants, and insects that rely on each other for pollination and food, or fungi that obtains its habitat from a dead or live tree. Students list examples and bring the list inside to add to the bulletin board.

C. **Compare an ecosystem to a orchestra.** Brainstorm similarities and differences of an orchestra and an ecosystem. (*In both cases, all the players are a part of the whole; each one does something different, but all are important to one another.*) How does the beauty we perceive when looking at a forest, tundra, ocean, or wetland compare to the beautiful sounds of a symphony? What happens to the music if one or several instruments are removed? How might this relate to what happens in a living ecosystem?

Credits:

Adapted from "Good Buddies," Project WILD, Western Regional Environmental Education Council, 1992.

Curriculum Connections:

(See appendix for full citations)

Books:

Ancient Ones, The World of the Old-Growth Douglas Fir (Bash)

Desert Giant, The World of the Saguaro Cactus (Bash)

Incident at Hawk's Hill (Eckert)

Secret Language of Snow (Williams)

Symbiosis (Silverstein)

Tree of Life, The World of the African Baobab (Bash)

Teacher Resources:

(See appendix)

ANSWER KEY FOR ECOSYSTEM PARTNER CARDS
(to use if the coded graphics are erased from the cards)

Worksheet

1. Tree swallows – Downy Woodpeckers (commensalism)
2. Fireweed – Butterflies (mutualism)
3. Adult lamprey – Salmon (parasitism)

Commensalism, Mutualism and Parasitism Cards

1. Junco – Cowbird (parasitism)
2. Beavers – Goldeneye ducks (commensalism)
3. Bracket fungi – Flickers (commensalism)
4. Birch trees – Mushrooms (mutualism)
5. Mountain goats – Plants with seed hooks (commensalism)
6. Algae – Sea anemone (commensalism)
7. Common eiders – Arctic terns (commensalism)
8. Raspberry – Voles (mutualism)
9. Barnacles – Whales (commensalism)
10. Butterfly pupae – Wasp (parasitism)
11. Hermit crab – Snail (commensalism)
12. Lupine – Bacteria (commensalism)

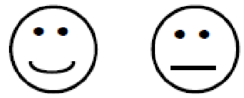
Competitors and Predators

1. Merlins – Pine grosbeaks (predation)
2. Hydra – Protozoans (predation)
3. Marten – Red Squirrels (predation/competition)
4. Bladderwort – Fly (predation)
5. Brown bears – Black bears (predation/competition)
6. Blue mussels – Barnacles (competition)

Ecosystem Partners Practice Worksheet

Read me first: There are three types of symbiotic relationships between pairs of living things on this page:

MUTUALISM
Both organisms benefit.

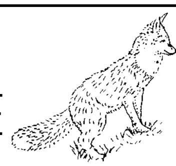
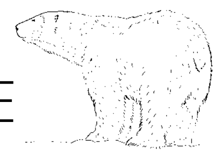


COMMENSALISM
One thing benefits,
the other is unaffected.

PARASITISM
One organism benefits,
the other is harmed.

DIRECTIONS: Read about each of the organisms in the pairs below. Write the name that describes the symbiotic relationship between the pair.

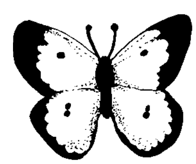
example:

Arctic Fox	**Polar Bear**
	

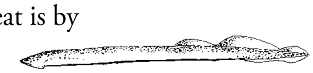
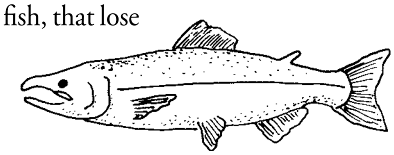
Symbiotic Relationship? **Commensalism**

Tree swallows nest in small holes in dead trees, but they cannot dig their own holes. 	Downy woodpeckers dig small holes in trees for nesting and roosting. Other small birds can use the holes in the future. 

Symbiotic Relationship? ____________________

Fireweed needs to have its pollen carried to another fireweed plant. It has nectar to feed the animal that helps spread its pollen. 	Butterflies eat flower nectar. They help plants by carrying pollen between flowers. 

Symbiotic Relationship? ____________________

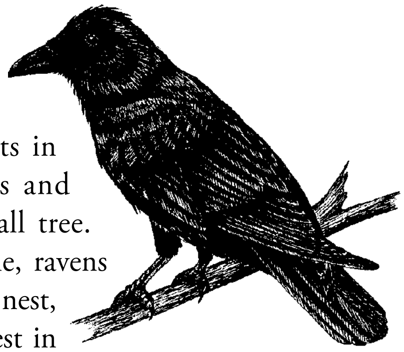
Adult lamprey fish can not catch their own food. The only way they can eat is by attaching themselves to a larger fish and sucking its blood. 	Salmon are a large fish, that lose blood to sucking lamprey. 

Symbiotic Relationship? ____________________

Ecosystem Partners Cards

Mutualism, Commensalism and Parasitism

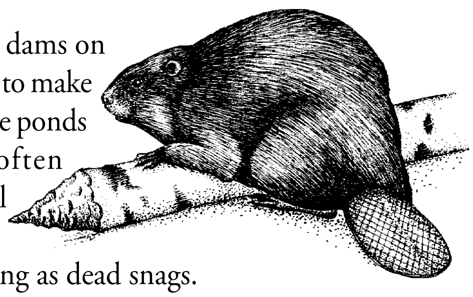
PHOTOCOPY, LAMINATE, AND CUT-OUT



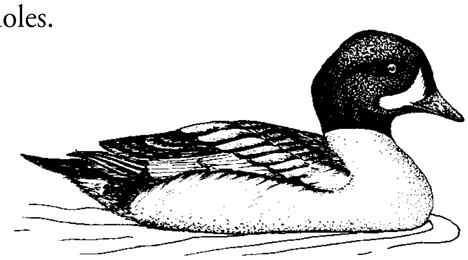
Ravens build nests in trees using sticks and the crotch of a tall tree. From time to time, ravens will abandon their nest, building a new nest in the area.

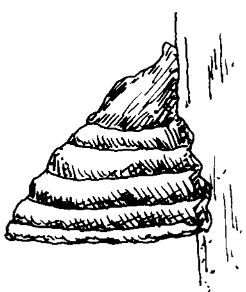
Great horned owls will make their homes in old raven nests, when available.

Beavers build dams on rivers in order to make big ponds. The ponds they make often drown and kill trees that are left standing as dead snags.



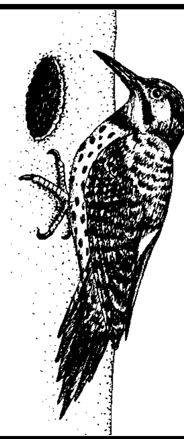
Goldeneye ducks need ponds in the forest and a large hole in a dead tree for nest. They can't dig their own nest holes.



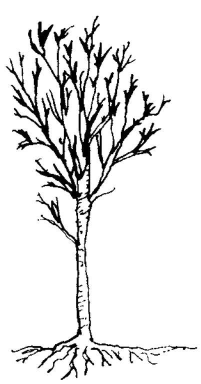


This bracket fungus makes wood soft by eating the wood.

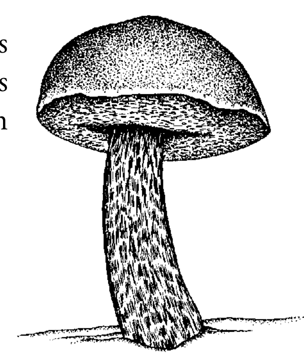
Flickers dig large holes in dead trees for nesting and roosting, but they can only dig in dead, soft wood.



This birch tree needs many minerals from the soil, but its roots can't get enough minerals. It can make food to give to another living organism that helps its roots get minerals.



The underground parts of this mushroom can help the roots of a tree get minerals from the soil.

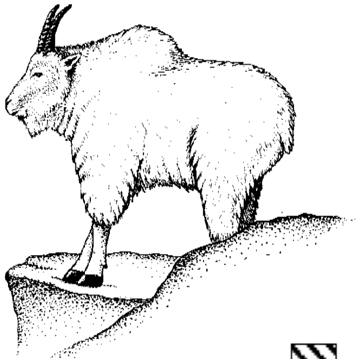


Ecosystem Partners Cards

Mutualism, Commensalism and Parasitism

PHOTOCOPY, LAMINATE, AND CUT-OUT

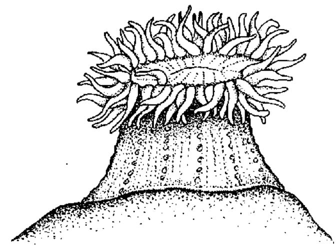
Mountain goats have long, shaggy hair. They travel from one mountain to another in the alpine tundra.



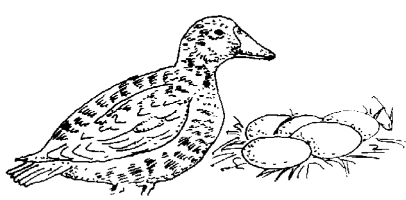
This burr reed's seeds have hooks that get caught on animals that pass by. Those animals then carry the seeds to other areas.

This algae needs a place to live in the ocean where limpets, chitons, sea urchins, and other predators can't reach it. The algae will produce oxygen and food for the living organism that protects it.

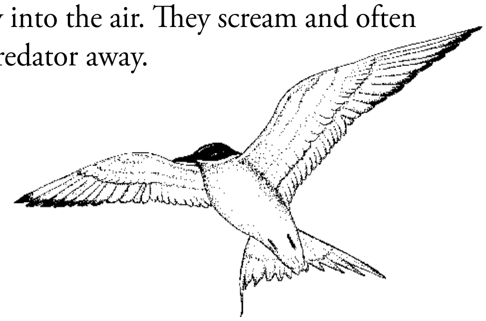
This sea anemone lives attached to rocks in the sea. It allows certain algae to live inside its stinging tentacles. It protects the algae from predators.

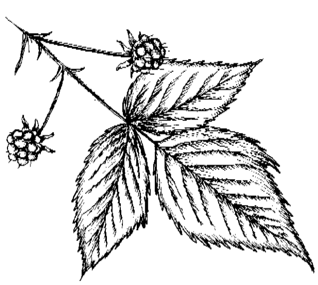


Common eiders nest on the ground in colonies. Foxes and jaegers sometimes get into the colonies and eat the eider's eggs. The eiders need something to warn them if a fox is around and to scare the fox away.



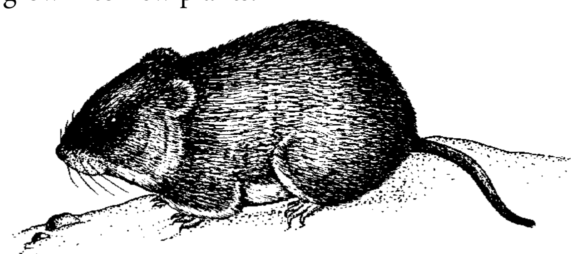
Arctic terns nest in colonies. Whenever a predator, like a fox or jaeger, gets near their nesting colony, all the terns fly into the air. They scream and often chase the predator away.





This raspberry needs an animal to carry its seeds to a new area. Its seeds are inside a big red berry.

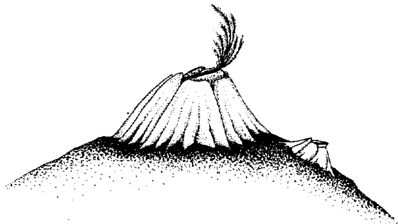
This red-backed vole eats berries for food and nourishment. It then deposits raspberry seeds elsewhere, where they grow into new plants.



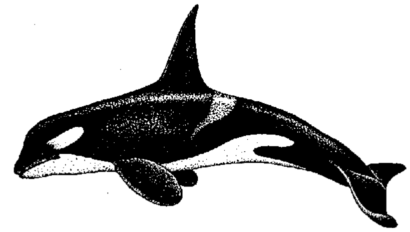
Ecosystem Partners Cards

Mutualism, Commensalism and Parasitism

PHOTOCOPY, LAMINATE, AND CUT-OUT

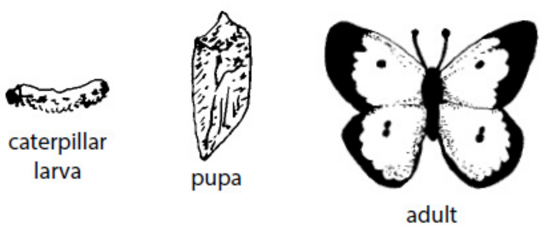


This barnacle eats tiny animals and algae that live in sea water. As an adult it may attach to the skin of an animal that carries it around the sea to good feeding places.

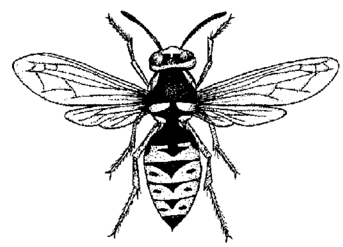


This whale eats small animals that live in the sea. It travels hundreds of miles around the ocean to places where the water is full of tiny animals and algae.

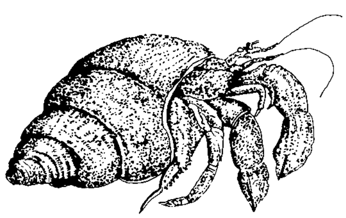
These caterpillar larvae change into pupae. The pupae are encased in a shell and do not move or feed. If they survive, they will become adult butterflies.



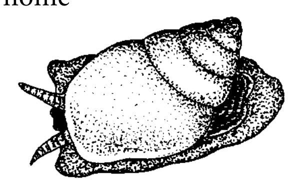
This hornet needs to find a butterfly pupa in order to lay its eggs. When the wasp larvae hatch, they burrow into the pupa. The shell-like case protects them from predators and they eat the butterfly pupa.



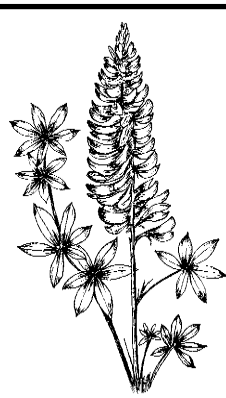
This hermit crab needs a strong shell to protect it from predators.



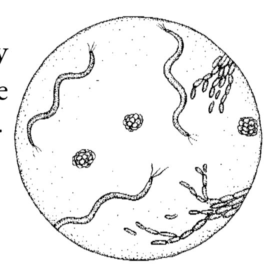
When this snail dies, its body will be eaten by other living things. Its shell is made of strong material that cannot be eaten. The shell could make a home for some other animal.



Lupine plants can only get nitrogen from the soil. But there isn't a lot of nitrogen in the soil where lupine grow.



These microscopic (very small) living organisms are called **nitrogen-fixing bacteria**. These bacteria take nitrogen from the air and put it into the soil.



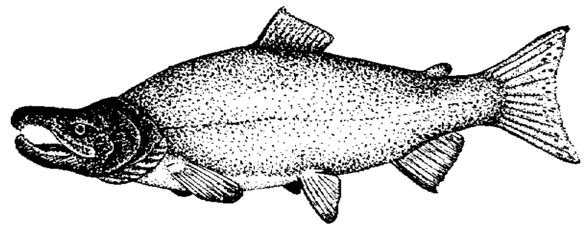
Ecosystem Partners Cards

Mutualism, Commensalism and Parasitism

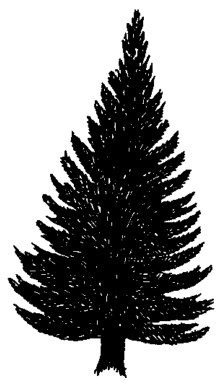
PHOTOCOPY, LAMINATE, AND CUT-OUT

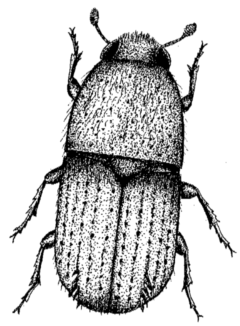
Adult lamprey fish can not catch their own food. The only way they can eat is by attaching themselves to a larger fish and sucking its blood.

Salmon are large fish that lose blood to sucking lamprey.



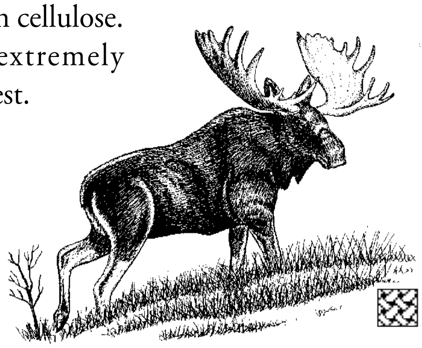
This is a spruce tree.



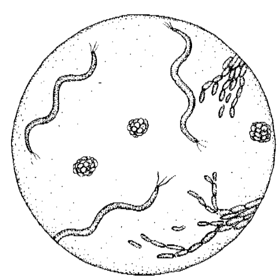


Engraver bark beetles attack and kill weakened spruce trees by laying larvae that feed on the trees.

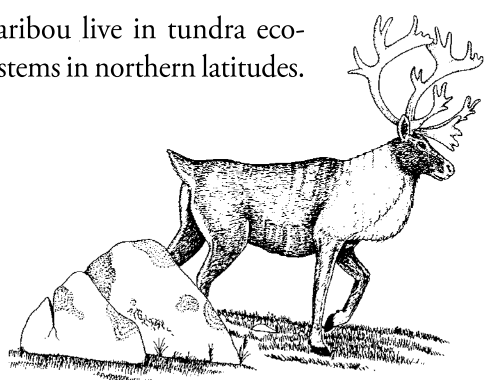
Moose eat plant material which is high in cellulose. Cellulose is extremely difficult to digest.



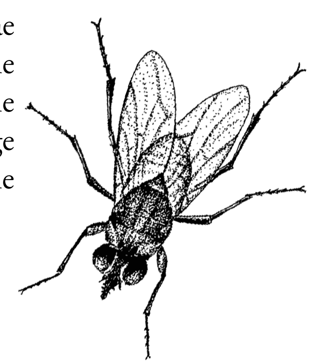
Some kinds of bacteria make their homes inside the guts of moose. These bacteria can digest cellulose and make nutrients available for the moose.



Caribou live in tundra ecosystems in northern latitudes.



Bot flies deposit their larvae in the noses of caribou. The larvae then grow inside the caribou's nasal cavity. Large infestations can impede the caribou's breathing.



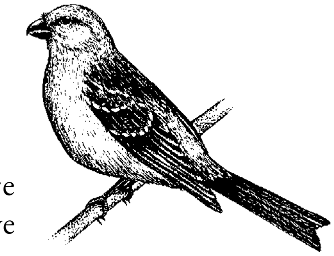
Ecosystem Partners Cards

Competition and Predation

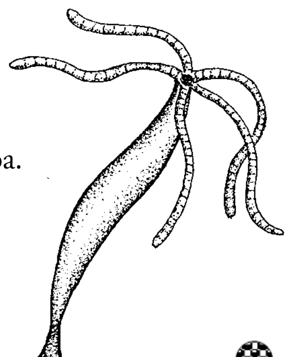
PHOTOCOPY, LAMINATE, AND CUT-OUT

Merlins are birds that live in mixed birch and spruce forests. They eat small birds.

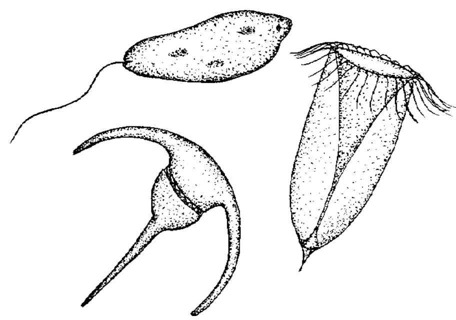
Pine grosbeaks are small birds that live in spruce forests.



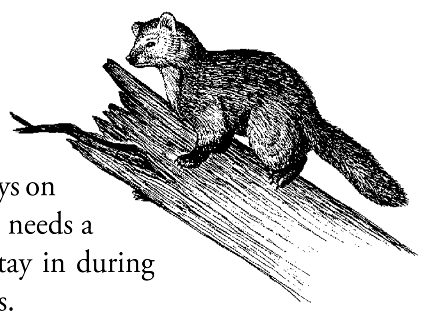
This hydra uses its stinging tentacles to capture protozoa.



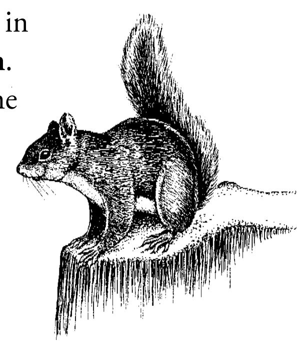
These are protozoa.



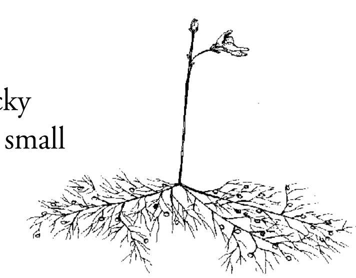
This marten preys on squirrels. It also needs a warm hole to stay in during cold winter days.



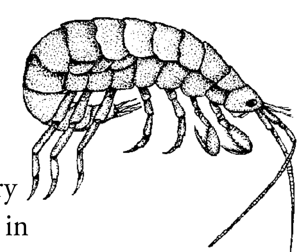
Red squirrels store hundreds of spruce cones in a big pile called a **midden**. They dig holes through the midden. The cone pile insulates the holes from cold air, and therefore creates a warm hole.



This aquatic plant is a bladderwort. It has sticky bladders that trap very small animals. The bladder produces enzymes that digest the insects that get stuck.



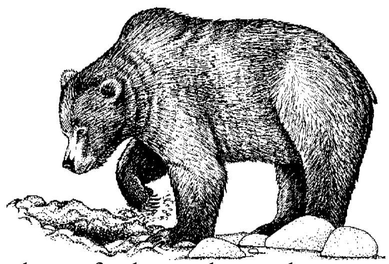
This amphipod is a very small animal that lives in the ocean.



Ecosystem Partners Cards

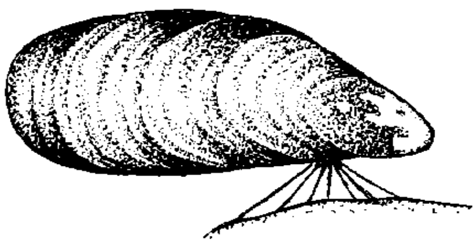
Competition and Predation

PHOTOCOPY, LAMINATE, AND CUT-OUT

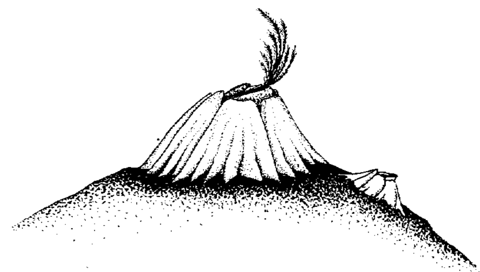


Brown bears feed mainly on the roots of plants and berries. They also eat ground squirrels, fish, moose and caribou calves, and dead animals.

Black bears feed mainly on the roots of plants, and berries. They also feed on fish, small animals, and dead animals.

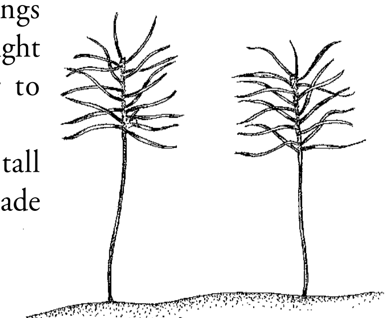


In order to feed and survive, blue mussels must attach themselves to rocks along a wave-washed shore.



In order to feed and survive, barnacles must attach themselves to rocks along a wave-washed shore.

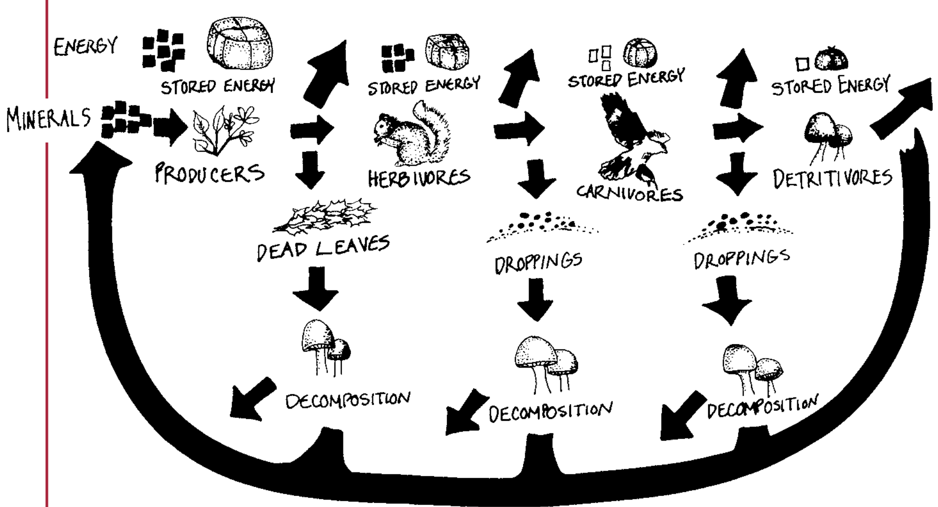
Young spruce seedlings need fresh soil, sunlight and room in order to develop and grow. Once they become tall enough, they can shade out other plants.



Canada Blue-joint grass grows thick and tall in Alaska if it has lots of light. It often covers the ground densely.

Mineral Cycling through the Ecosystem

3 EXTENSIONS ALERT: ALASKA ECOLOGY CARDS OPTIONAL



Section 2
ECOLOGY ACTIVITIES

Grade Level: 6 - 12

State Standards: S A-14, Geo C-1

NGSS: MS-LS2-3.,HS-LS2-4.

Subjects: Science, math

Skills: Applying, describing, analyzing

Duration: 60 minutes

Group Size: Whole class

Setting: Indoors /outdoors

Vocabulary: Carbon dioxide, carnivore, cellular respiration, cycle, denitrify, detritus, detritivore, eroded, herbivore, minerals, nitrify, nitrogen, oxygen, producers, solution

Objectives:

1. Students will describe the passage of energy and minerals through a food web.

2. Given a worksheet or through the construction of a diagram, students will demonstrate understanding of the cycles that occur in an ecosystem.

3. Students apply knowledge of mineral cycling to an analysis of current issues which affect ecosystems.

Teaching Strategy:

Students participate in a game that illustrates energy and mineral cycling through a food web.

Complementary Activities:

"Take a Deep Breath" *in Section 1.* "Create a Classroom Compost Box" *in this section.* "*Also* "Watching Your Waste" *and* "Spinning a Yarn about Ecosystems" *in Section 4.*

Materials:

Photocopies of energy and minerals cards *(following),* color coded name tags labeled "producer," "herbivore," "carnivore," and "detritivore" *(see next page for number cards & name tags). For reinforcement or evaluation:* "Ecosystem Cycles Worksheet" *(following),* paper clips, pencils. OPTIONAL: *Alaska Ecology Cards,* "Nitrogen Cycle" and "Carbon Cycle" overhead transparencies or hand-outs *(in* INSIGHTS *Section 2).*

Background:

See INSIGHTS *Section 2, Ecosystems – Community Connections: "Mineral Cycling," "Carbon Cycle,"* and *"Nitrogen Cycle"* fact sheets.

Procedure:

1. Review the food web concept. What do the various organisms pass on to one another? Is it only energy?

2. Remind students that our bodies are made of minerals and all living things need **minerals** to survive. These can be obtained from the air, water and food – if they are in a usable form.

3. Introduce the definition of a mineral: *any nonliving substance that occurs naturally as a single element (nitrogen) or as a compound of various elements (water or carbon dioxide.)*

4. Discuss which minerals are most important in living organisms. Ask students to hypothesize where living things get each of these minerals – oxygen, carbon, hydrogen, nitrogen, phosphorous, sulfur. (*This question should stimulate students to wonder where and how abundant these minerals are in the nonliving environment.*)

	Number of students				
	10-14	15-19	20-24	25-29	30-34
Nametags					
Producers	6	10	13	17	20
Herbivores	2	2	3	4	5
Carnivores	1	1	1	1	1
Detritivores	1	2	2	3	3
Cards					
Energy:	30	45	60	75	90
Mineral:	10	15	20	25	30

5. Have the class stand and make a food web to demonstrate the need for recycling minerals. This can be done quickly: begin with one student as the sun, and then ask students to "attach" to the web as they identify a plant or animal which might come next in each food chain. Another option is to assign roles, passing out pre-made, color-coded name tags (*also used in "Spinning a Yarn about Ecosystems," in Section 4*) or *Alaska Ecology Cards*.

6. Once the web is made, give the energy cards to the student representing the sun. Scatter the mineral cards on the floor around the sun.

7. **Explain the following directions to each of the role players:**

Sun:

• Pass out energy cards as needed to the producers.

Producers:

• Producers are the only organisms that can obtain energy and most minerals from the nonliving environment. Stand in a large circle within arm's reach of the sun. You represent algae and plants.

• Gather separate energy and mineral cards and paper clip one of each together to represent food. You may use only mineral cards that have not already been clipped to an energy card.

• Producers must make **two** sets (each set has one energy and one mineral card with four squares) during each round to survive.

• Since it takes energy to make food, producers must cross out one of the energy squares on each of the two sets during each round.

• After crossing out energy squares, you should keep one set, and toss the other to the floor as waste.

Herbivores:

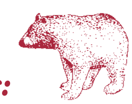
• Herbivores should courteously take two sets from the producers.

• Because energy was used to gather food, you must cross out one energy square on each set.

• Drop one set to the floor as waste.

• If you can find only one set by the end of the round, then you die and drop your set to the floor. If no sets are found, you die and must wait until there are enough sets during another round.

Carnivores:



• Carnivores follow the same directions as the herbivores, but they obtain their food sets from the herbivores.

Detritivores:

• Detritivores must pick up two "waste" sets from the floor.

• Due to energy used to consume food, you must cross out one energy square on each set.

• Put the whole set back on the floor where another detritivore can pick it up and cross out energy squares. When the four energy squares are filled, leave the sets on the floor.

8. Call out the beginning of each round. A round ends when either every player has two sets or all the sets at any level are used.

9. Play new rounds until something goes wrong. For example, the producers may run out of minerals and everyone will be unable to get food. How many turns does the game last before all the players are out?

10. Discuss what happened in the game. Lead students to think about why we don't run out of minerals in nature. They should guess one of two reasons: (a) *that there are so many minerals, that organisms never run out*; or (b) *that minerals are recycled.*

11. Discuss the limited availability of minerals in usable forms. For example fresh water, fresh air, and rich soil are limited. Discuss the geological cycle of soil formation (*see also* INSIGHTS *Section 1). Unless something prevents erosion of the fine-grained materials and the subsequent leaching of minerals that can dissolve in water, these elements are flushed out of the area and into another ecosystem (the ocean, for example).*

12. As a group, students diagram the cycling of minerals found in the soil as they travel through the ecosystem. Teachers may choose to use *Alaska Ecology Cards,* the samples of nitrogen or carbon cycling, or the "Ecosystem Cycles Worksheet."

VARIATION
If time permits, replay the game, this time with the detritivores taking the sets apart to illustrate returning minerals to the soil.

Instruct the detritivores to look carefully at the number of "X" marks on each card. If the energy card is filled with four "Xs," remove the paper clip and put the mineral card on the floor. The energy card is "used up," and must be discarded when all four of the energy squares are filled.

How many turns does the game last now? Could it go on indefinitely if the sun was still giving off energy? (*Yes.)*

VARIATION FOR OLDER STUDENTS
Make hand-outs or over head transparencies of the "Nitrogen Cycle" or "Carbon Cycle." Study of these two cycles deepens students' understanding of the interrelationship of the living and nonliving components of ecosystems.

Evaluation:

1. Students construct a diagram to apply the concepts learned in the mineral cycling game to real examples of how minerals cycle through an ecosystem.

2. Students answer the following questions and defend their theory (written or verbal): (a) How does large scale erosion (caused by human or natural causes) change an ecosystem? (b) What would happen to the soils in an area if a farmer, logger, or miner continued to work that area year after year? How can people use the land without stripping the soils away? (*Rotating crops, re-seeding, mitigation following mining are examples.*)

EXTENSIONS:

A. **Write about a mineral as it travels.** Students write an essay about the journeys of a mineral molecule, using "Odyssey" by naturalist Aldo Leopold (an essay in the book *Round River*) as a source of ideas.

Read the first half of the essay to the class (or have a student read it). Discuss Leopold's ideas. Was he writing about a unit of energy? (*No, remember energy is not recycled – it passes through an ecosystem only once.*)

Do students think he was writing about a carbon, water, phosphorous, or nitrogen molecule? Assign students one of these molecules and ask them write their own imaginary story about the journeys of this molecule through the earth's ecosystems. Students could start their story in their local ecosystem.

B. ***Magic School Bus* reading.** For younger grades, read together *The Magic School Bus Inside the Earth.*

C. **Work the worksheet.** Students use the "Ecosystem Cycles Worksheet" to show their understanding of the cycles that occur in nature.

Curriculum Connections:

(See appendix for full citations)

Books:
Ecology (Pollock)

Magic School Bus Inside the Earth (Cole)

Magic School Bus at the Waterworks (Cole)

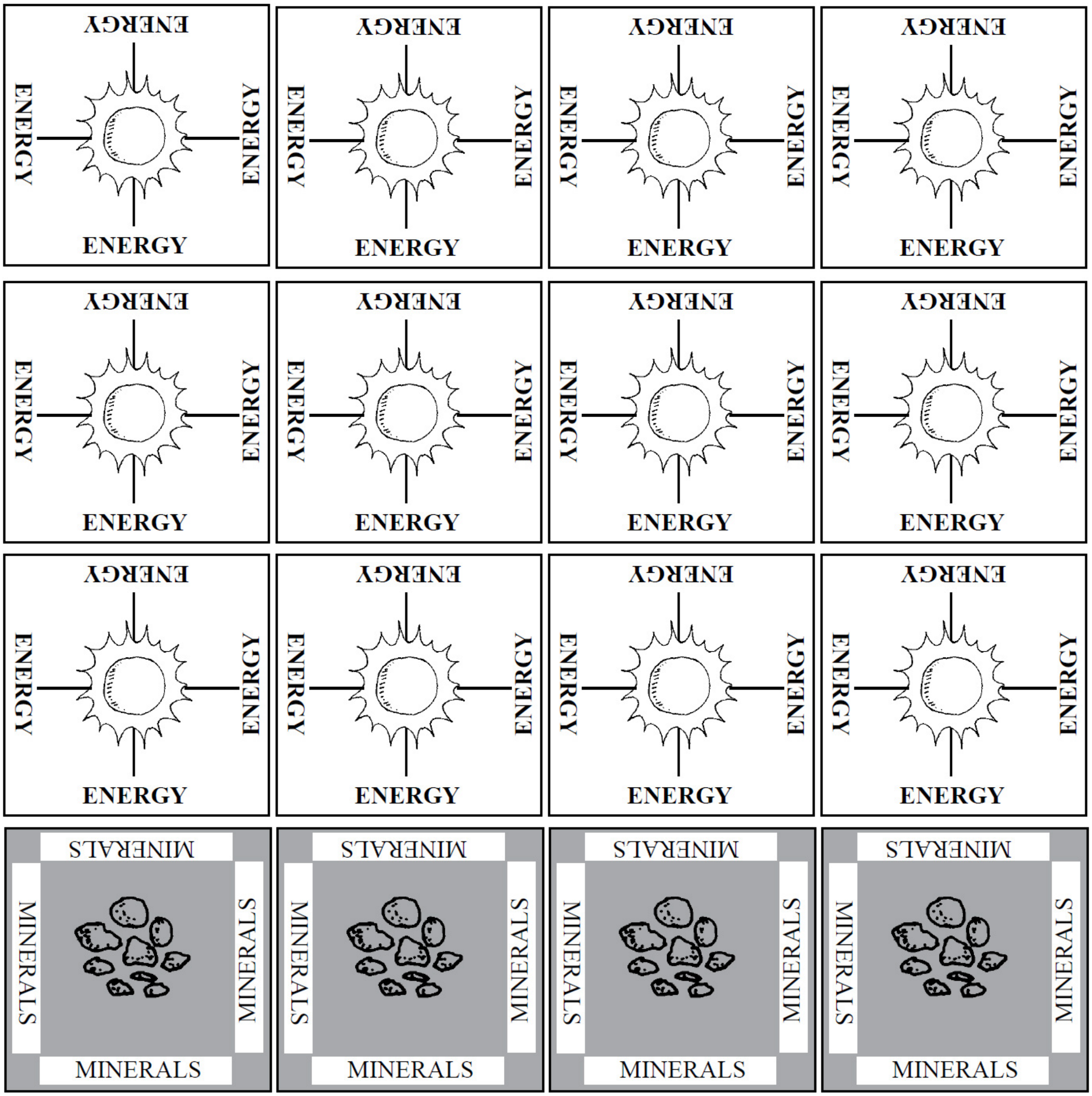
Photosynthesis (Silverstein)

Teacher Resources:

(See appendix)

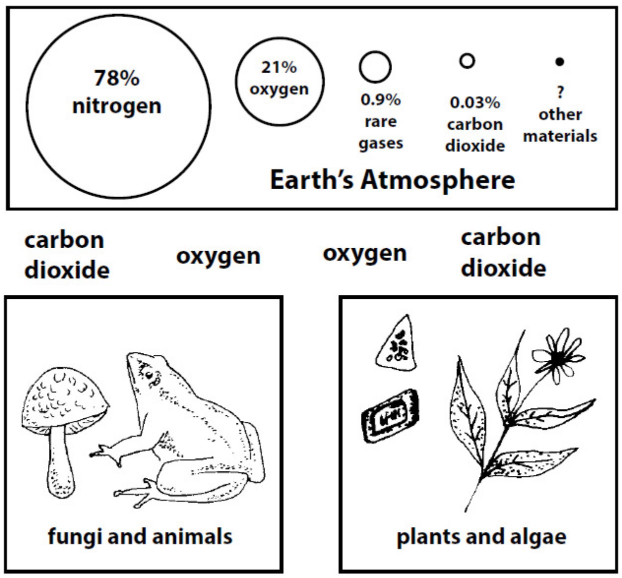
Energy and Mineral Cards

DIRECTIONS FOR THE TEACHER: Photocopy and cut up six sets of cards (for a class of 30) to make 90 energy cards and 30 mineral cards. Laminate and use washable markers so that energy cards can be reused.

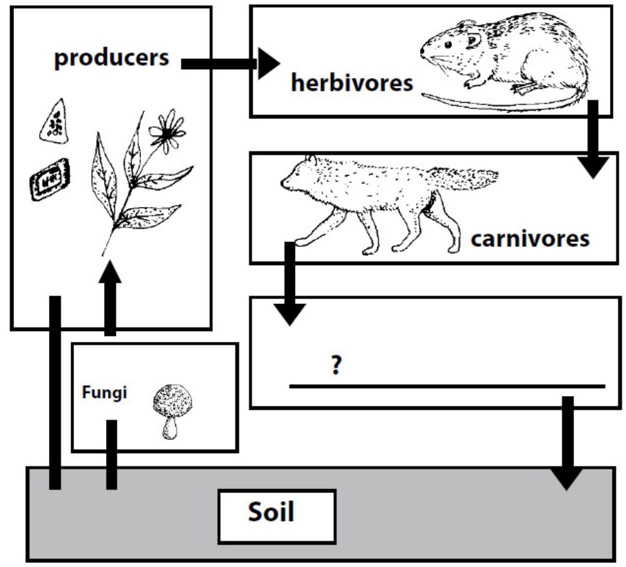


Ecosystem Cycles Worksheet

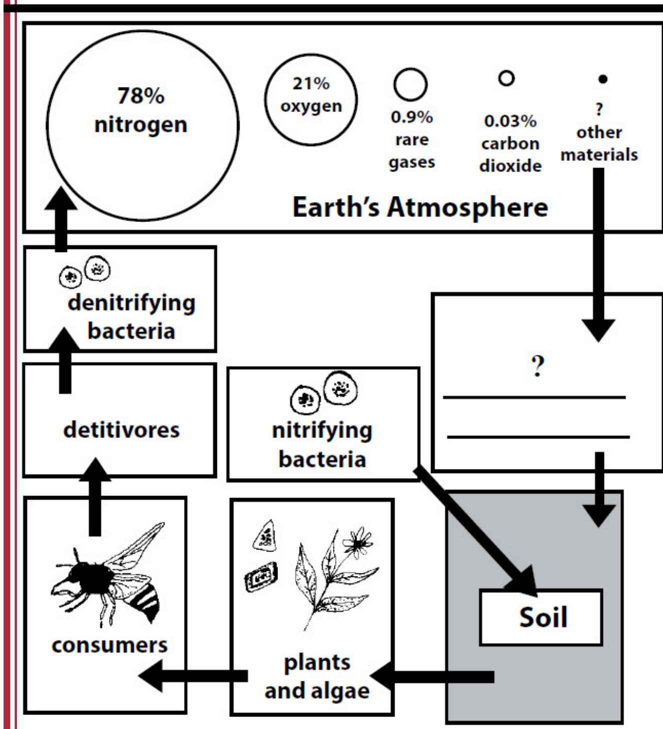
Name: ____



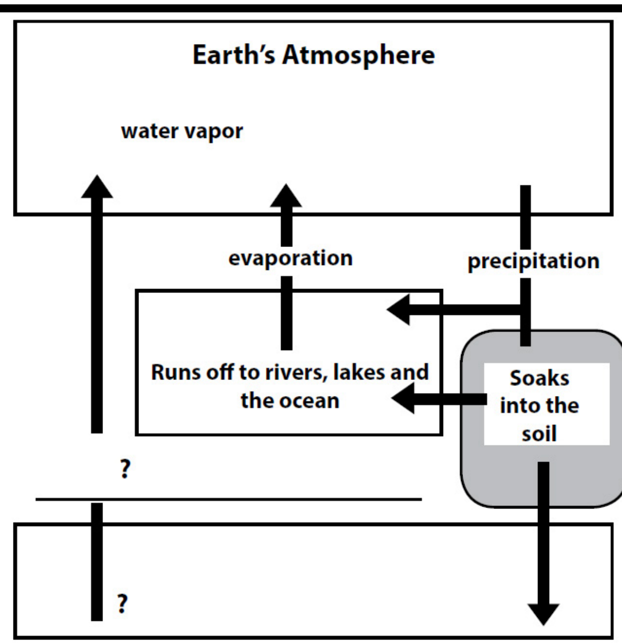
Draw arrows between the atmosphere and these living things to show whether each takes in or gives off oxygen and carbon dioxide. What would eventually happen to the atmosphere if plants and algae stopped growing and reproducing?



What kinds of living things are the missing link in this diagram of the phosphorous cycle in an ecosystem? What would happen if these kinds of living things disappeared?



This shows the nitrogen cycle. If it were not for the activities of the missing living things, plants would soon run out of nitrogen. What are they?



This is a diagram of the water cycle. One part of the cycle involves certain living things. Draw in an example of these living things and name the process by which water is returned to the atmosphere. What happens to the amount of water in the atmosphere if these living things are not present or are removed?

* *Percentages have been rounded up.*

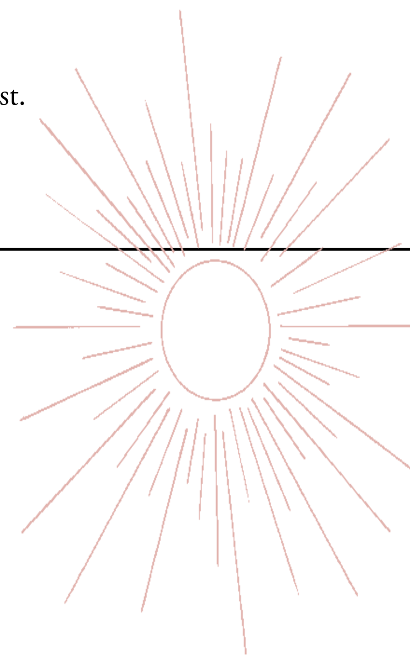
ANSWERS FOR ECOSYSTEM CYCLES WORKSHEET

Top left – fungi and animals breathe in oxygen and give off carbon dioxide; plants and algae actually breathe in and give off both gases, but they give off more oxygen than carbon dioxide.

Top right – detritivores – the mineral cycle would break down without them and plants would run out of needed minerals.

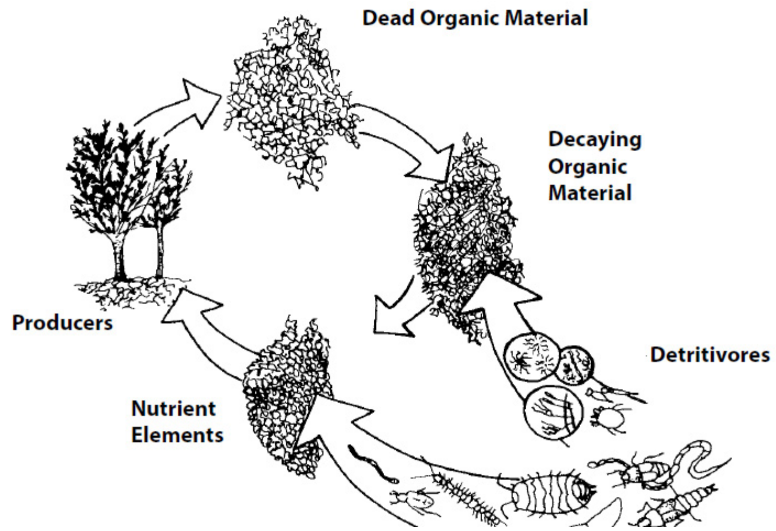
Lower left – nitrogen-fixing bacteria.

Lower right – plants, transpiration, the amount of moisture in the air would decrease, meaning less precipitation and more airborne dust.



Creating A Classroom Compost Box

4 EXTENSIONS



Grades: 3 - 12
State Standards: S B-1, S B-5, S B-6
NGSS: 5-LS2-1,MS-LS2-3, -LS2-4.
Subject: Science, language arts
Skills: Observing, analyzing, applying, writing
Group size: Whole class
Duration: Minimum of two 50-minute sessions, plus observation for 6 weeks
Setting: Indoors
Vocabulary: Aerobic, anaerobic, compost, detritivore, decomposition, fertile, gizzard, humus, landfill, nutrients, organic, solid waste

Objectives:

1. Students will understand and be able to describe the decomposition process of organic waste.

2. Students will evaluate the importance of decomposers (detritivores) as contributors to fertile soil.

3. Students will describe the importance of detritivores to ecosystems.

Teaching Strategy:

Students build and maintain a composting worm box to observe and record detritivores as they break down food waste. Students extend this experience by comparing home waste to waste deposited in landfills.

Complementary Activities:

All activities in this section. "Investigating Plant Habitat" *and* "Investigating Animals in Soil" *in Section 3. Also* "Watching Your Waste" and "Spinning a Yarn about Ecosystems" *in Section 4.*

Materials:

- *WOODEN BOX:* about 1-ft. deep, with holes drilled in the bottom panel. *(The size of the box depends on how much composting you want to do. A 2x2 foot box will handle 3.5 pounds of kitchen scraps a week, the amount typically produced by a two- person family. A 2x3 foot box typically suits the organic waste output of a family of four.)* The box should have drain holes, and a tray beneath.
- *BEDDING MATERIALS:* such as torn newspaper, corrugated cardboard pieces, sawdust, peat moss, or leaves. Mix about one-third peat moss into bedding at the beginning to aid in moisture retention. Total bedding should weigh 4-6 pounds for a 2x2 foot box, and 9-14 lbs. for a 2x3 foot box.
- *REDWORMS:* 500 to 1,000 worms. Redworms are available for $15-25 from garden supply companies and through mail order.
- *FOOD WASTE:* 1-2 gallons of finely shredded scraps including vegetables, grains, fruit scraps, breads, coffee grounds and filters. (*NO meat scraps or oily substances*)

- *WATER:* for watering the box and keeping it moist.
- *PAPER and PENCILS:* for student observations.

Background:

See* INSIGHTS *Section 2, Ecosystems – Community Connections: "Composting Basics" and "As the Worm Churns" fact sheets.

Procedure:

1. Hold a class discussion about what happens to plants and animals in nature when they die. What would happen if nothing ever broke down or decomposed? *(What would happen if no one took out the wastebasket all year in the classroom?)*

2. Discuss the process of natural **decomposition** and how dead **organic** matter is recycled by **detritivores** into nutrients and minerals in the soil that plants need in order to grow.

3. How much waste does each household and/or classroom produce? If possible, watch the videocassette "The Rotten Truth" or "Its Gotten Rotten."

4. One way to reduce solid waste and benefit the ecosystem is to compost. Composting mimics the natural decomposition process. Ask students what elements are needed for this process. *(We need a waste-eater or detritivore. We need to make a* **habitat** *suitable for the detritivore by providing it with food, water, shelter and space.)*

BUILD THE "HABITAT"

1. Build a class worm box *(follow instructions in "Materials" section)*. The class can collect bedding, shelter, and food materials (1x3 strips of newspaper and food scraps from lunch).

2. To start the box, add the bedding, along with several handfuls of soil to provide grit for the **gizzards** of the worms. Water the bedding so that it is moist, but not dripping.

3. Add the worms, and stir gently.

4. Weekly add food scraps in the form of small pieces, burying them among the bedding. The smaller the food pieces, the faster they will decompose.

5. **Covering the food waste with a layer of dirt will eliminate any potential aroma from the box.** Usually, the only smell emitted from the box occurs when the topsoil layer is broken to put in new good **solid waste**, or when waste is left on top of the soil.

6. Add eggshells occasionally to add calcium to the soil and to lower the acidity.

7. Keep the bedding moist by watering it as needed. You will not need to water too often, as the fruit and vegetable scraps should provide sufficient moisture. Be careful not to drown the worms!

NOTE: Worms thrive when their environment is warm and dark, so cover the box. Make sure there is adequate air circulation.

STUDENT OBSERVATIONS

1. Students should keep a journal over several weeks. There are two types of observations that can be made about the box:

- *Behavior and description*

(a) Pictures, writings, and predictions about what will happen to the food waste.
(b) Note the appearance and behaviors of the redworms.
(c) Research worm biology, using reference materials.
(d) Do simple experiments that won't harm the worms. *For example, note their reaction to light, certain types of food or soil.*
(e) Write a summary of observations.

- *Measure and quantify*

(a) Observe and record the population growth of the worms. Find a measuring receptacle of known volume that you can reuse *(perhaps a 1-pound coffee can)*.
(b) Randomly sample the compost in the box, filling the measuring receptacle loosely.
(c) Dump the sample onto newspapers and count the number of worms in the contents. *At first you may not find any worms in a sample.* Record this as "zero worms on ____(date)."
(d) Repeat this measurement twice a week and record the findings.
(e) Graph the growth of the worm population on a bulletin board.

2. As a class, weigh the amount of food waste that is added to the box. Compare the amount and type of material with the growth of the population. Develop some hypotheses about the amount of food necessary to keep the population growing.

3. As students observe the redworms, also ask them to note the changes that occur in the *compost* in the worm box. The bedding will get darker and the volume of the box will slowly decrease as waste is digested and worm **castings** increase.

NOTE: You need to add new bedding every four months to keep the balance healthy for the worms. Without new bedding the box will contain only worm castings, as the worms will starve.

4. Harvesting the worms can be done after a few months, if desired. Dump some of the contents of the bin onto a large sheet of plastic, arranging it into small mounds. Shine a light onto a pile, and leave it alone for 5-10 minutes. The worms will dig down to get away from the light. Remove the outer surface material of each pile. Repeat until you have just a pile of worms.

5. Get other classrooms involved by giving them worms for their own box. Or, have students start a compost box at home.

6. Mix your humus with some soil in the schoolyard and plant a tree!

Evaluation:

1. Evaluate journals for thoroughness, quality of observations, and on their summaries and conclusions.

2. Describe the habitat (food, water, shelter, and space) needs of red worms.

3. Write a story about what would happen to soil, plants and wildlife if there were no detritivores. Consider the impact on humans if there were no worms.

4. List three ways that worms have a positive effect on soil.

EXTENSIONS:

A. **Promote school /family composting.** Develop a composting program. **Make sure your compost bins are animal-proof.** In bear country this is especially important! <www.alaska-bears.alaska.gov>

B. **Grow vegetables with your humus.** Use the humus from your compost box to grow radishes, beans, or other plants in the classroom. Experiment with the proportion of soil (inorganic) and organic material for different plants and make observations about the best proportions of each for growing healthy plants.

C. **Expand community awareness.** Sell worms and distribute information to local businesses about composting in an effort to create community awareness and involvement in composting.

D. **Write a big book or story.** Write a big book or children's story about the process of decomposition and the role of detritivores.

Credit:

This activity was researched and modified by Val Chabot, Eagle River.

Curriculum Connections:

(See appendix for full citations)

Books:

Compost Critters (Lavies)

The Worm Cafe: Mid-Scale Vermicomposting of Lunchroom Waste (Payne)

Worms Eat My Garbage (Applehof)

Media:

It's Gotten Rotten (Video) (Gr. 9-12)

The Rotten Truth (Video) (Children's Television Workshop)

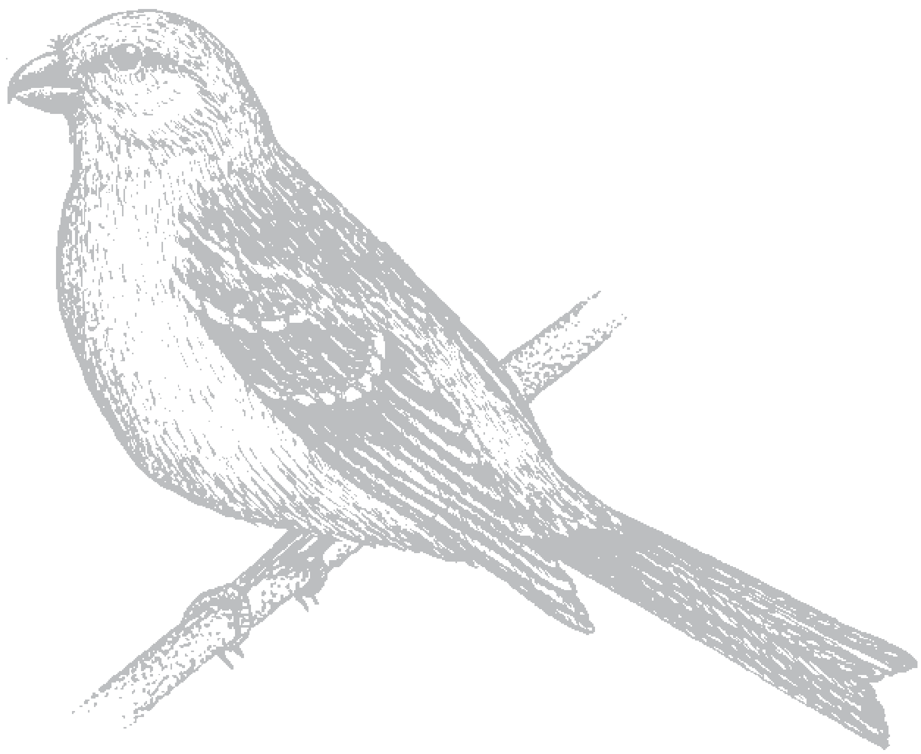
Wormania! (Video)

Website:

Alaska Cooperative Extension. *Composting Dog Waste, Fairbanks, Alaska* <www.uaf.edu/coop-ext/compost/dogs.html> *Composting Organic Waste in the Anchorage Area* <www.uaf.edu/coop-ext/compost/anchorage.html>

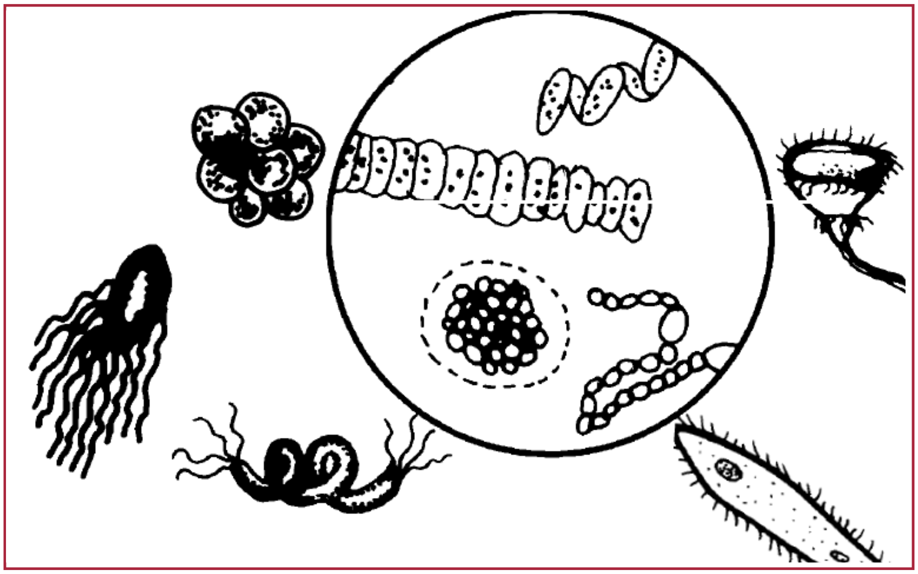
Teacher Resources:

(See appendix)



Investigating Monerans and Protists

2 EXTENSIONS ***ALERT: ALASKA ECOLOGY CARDS OPTIONAL***



Section 3
ECOLOGY ACTIVITIES

Grade Level: 4 - 12

State Standards: M A-3, M A-6, S A-14, S A-15, S B-1, S B-5, S B-6
NGSS: MS-LS1-1.

Subject: Science, math, language arts, art

Skills: Observing, recording, analyzing, describing, drawing, computing, measuring, estimating, identifying

Duration: 2 50-minute sessions

Group Size: 2-4

Setting: Indoors /outdoors

Vocabulary: Amoeba, cilia, cyanobacteria, euglena, habitat, microscopic organism, Monera, paramecia, Protista

Objectives:

1. Students will observe and describe one-celled organisms in their local ecosystem, noting their visible characteristics in writing.

2. Students will describe some of the habitats where monerans and protists can be found.

Complementary Activities:

"Five Kingdoms But No King," "Investigating: Soil," "Investigating Water," and "It's Alive or Is It?" *in Section 1, Elements of Ecosystems. Also all the* "Investigating (Living Things)" *in this section.*

Materials:

Microscopes for each pair of students, slides and cover slips, eye droppers, several small jars or containers, masking tape and a marker, boiled rice grains, paper and pencil. OPTIONAL: guidebook for identifying protists or appropriate *Alaska Ecology Cards.*

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Monerans & Protists"* fact sheet; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:

1. Introduce the fact that many living things in our environment are seldom noticed and best seen under a microscope. Members of the Kingdoms **Monera** and **Protista** fall in that category of living things.

2. Ask students to predict if there are microscopic living things around the school or even in the classroom. *Although all individual monerans and many protists are microscopic, it is sometimes possible to see some types when many are gathered in one spot.*

3. Ask students in what environment what microscopic living things might be found? *Water is a reliable environment to find these organisms.*

4. GO *OUTDOORS* to collect several samples of water from around the school. *Roadside ditches, puddles, pools*

formed by melting snow or ice, ponds, lakes, streams are possible places to collect water. IF WINTER, a neglected vase of flowers might also provide an adequate sample.

5. Tell students to put the water samples in separate jars, marking the source and the water level with masking tape. Collect an extra jar of water from each site (marking the source) as a refill supply *(per step #8).*

6. *BACK IN CLASS,* students place the jars in indirect light (not direct sun). Add 2-3 grains of rice to each sample to feed any organisms in the water.

7. *FOR SEVERAL DAYS,* let the samples stand uncovered or with the lids open part way.

8. Ask students to keep the water level at the original mark by adding water from the original source, if possible. Tap water will work, but make sure it has been standing for several days.

9. *AFTER 3-4 DAYS,* examine the samples through the microscope. Use the eyedropper to take samples of water at the top, middle and bottom of the jar. Demonstrate to the students how to make a wet-mount. *(Procedures for making simple wet mounts are found in most basic science text books.)*

Note: Organisms may dive to the bottom of the wet mount. Make sure students adjust the focus on the microscope at different levels in the mount so that they can see the bottom as well as the top of the drop of water.

10. Ask students to draw the organisms they see in each sample. Count (or estimate) the organisms on each slide. Look at three slides representing the bottom, middle, and top of the jar and make a count for each one.

11. Share results and discuss the drawings. Determine similarities and differences between the organisms, noting things like the existence of **cilia**, method of movement, or how the organisms might gather food.

12. Brainstorm and draw a chart on the board that lists the food, water, shelter, and space characteristics – **habitat** – of each source.

Evaluation:

Draw or describe at least three kinds of microscopic organisms and their food, water, shelter, and space requirements.

EXTENSION:

Observe a colony of protists and conduct experiments.
Many protists are available for purchase from scientific supply companies. If you choose to order live protists, students can create their own ecosystems and transplant the living protists into their water samples.

- Students create ecosystems in jars, using distilled water, mud, rocks, a pinch of yeast, and the purchased protists.

- Students observe and keep journals on their ecosystems, noting changes on a daily basis.

- Students may also develop hypotheses and perform experiments on their ecosystems. For example, what happens when the ecosystem is denied oxygen? How does the ecosystem respond to light? What happens if there is an oil spill in the ecosystem? How do ecosystems respond to fertilizers or phosphates?

This is a good way to incorporate the scientific method: students test their own hypotheses by designing an experiment, collecting data, presenting results, and drawing conclusions from their experiments.

Curriculum Connections:

(See appendix for full citations)

Books:
Guide to Microlife (Rainis)

Monerans & Protists (Silverstein)

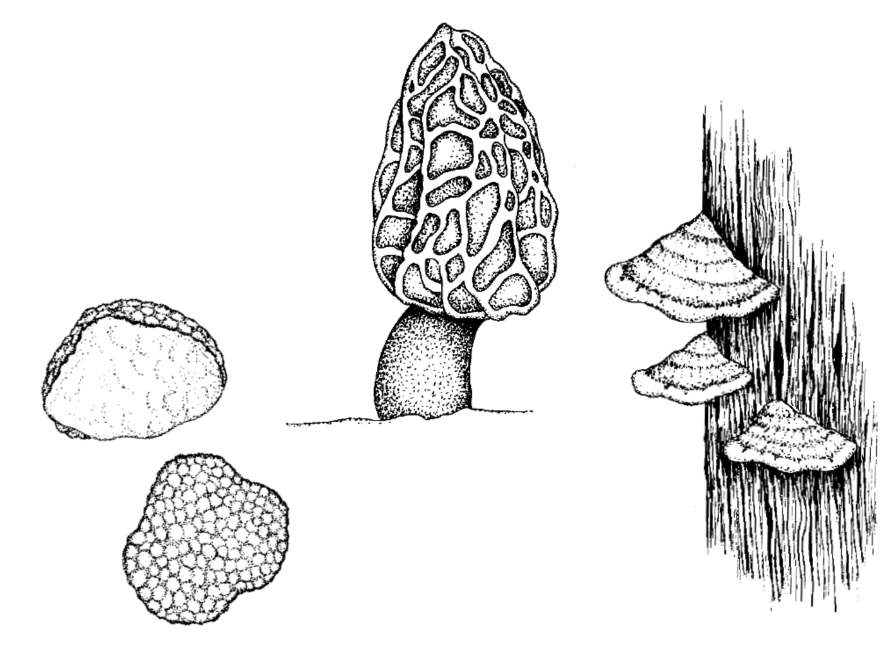
Website:
Protist Image Data <megasun.bch.umontreal.ca/protists/protists.html>

Teacher Resources:

(See appendix)

Investigating Fungi

ALERT: ALASKA ECOLOGY CARDS OPTIONAL



Section 3
ECOLOGY ACTIVITIES

Grade Level: 4 - 12

State Standards: M A-3, M A-6, S A-14, S A-15, S B-1, S B-5, S B-6
NGSS: 4-LS1-1.,5-LS2-1.,MS-LS2-3. HS-LS2-4.

Subject: Science, math, language arts, art

Skills: Observing, recording, analyzing, describing, drawing, computing, measuring, estimating, identifying

Duration: 60 minutes

Group Size: 2-3

Setting: Indoors /outdoors

Vocabulary: Absorption, algae, detritivore, detritus, fungus/fungi, lichen, mold, photosynthesis

Objectives:

1. Students will describe and locate places in an ecosystem where fungi might grow.

2. Students will identify a fungus and determine the non-living elements needed for survival.

Complementary Activities:

"Five Kingdoms But No King," "Investigating: Soil," "Investigating Water," and "It's Alive or Is It?" *in Section 1, Elements of Ecosystems. Also all the* "Investigating (Living Things)" *in this section.*

Materials:

Hand lens, microscope, moist bread, plastic bag or container, slides and cover slips, paper and pencil.
OPTIONAL: Appropriate *Alaska Ecology Cards.*

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Fungi"* fact sheet; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:

1. Ask students to think about the words **fungus** (singular) or **fungi**, sharing any information or examples of fungi with the class. Discuss the Kingdom Fungi and some of its more common members *(mushrooms and bread mol*d).

2. Explain to students that most of these organisms (with the exception of lichens) recycle organic material from dead or waste materials to obtain their food.

3. Fungi can be found anywhere that dead plants are found, especially in moist places. Discuss possible locations of **detritus** (dead organisms) that students might find fungi *(dead standing trees, decayed logs, leaf litter on the groun*d.)

4. To identify fungi, students should look for things that are spongy (such as mushrooms and shelf fungus), things that look like silt or dust (such as mold), or things that are hard and brittle growing very close to the ground or on rocks (such as lichens).

****CAUTION!**** Many people are allergic to molds. Some molds may cause infections or even blindness. Only teachers, not students, should handle molds in the classroom.

You should avoid direct contact with mold and keep mold cultures away from your face to avoid breathing of mold spores.

9. The teacher may prepare a slide of the bread mold for students to observe, or a bioscope might be used for class viewing.

5. *OUTDOORS,* take a walk in the area near your school. Students work in groups of 2-3 to look for examples of fungi. Students draw pictures of what they find, bringing small samples inside. Make notes of where each fungus was found.

6. Students share drawings or samples, noting similarities and differences. Discuss the nonliving elements of the ecosystem that are critical to the survival of these organisms.

7. Discuss what might happen if these organisms did not exist? What would happen if things didn't decay?

8. *IN CLASS,* grow your own fungus. Place some moist bread in a sealed plastic bag or container. In several days, you will have a healthy culture of bread mold, a common fungus.

10. Students draw a picture of the bread mold. As a class, identify the **hyphae** and the **spores** which are common to fungi. What nonliving elements does bread mold need to survive? What happens to bread mold if left in an airtight container for an extended time period?

11. Identify human uses of fungi.

Evaluation:

1. Given several examples and non-examples of fungi, determine which examples belong to the Kingdom Fungi and why.

2. Draw and label a picture of a mold (if applicable).

3. Describe three places in the local environment where fungi might grow.

Curriculum Connections:

(See appendix for full citations)

Books:
Guide to Microlife (Rainis)

Mushrooms (Parker)

Slimes, Molds, and Fungi (Pascoe)

Fungi (Silverstein)

Fungi (Tesar)

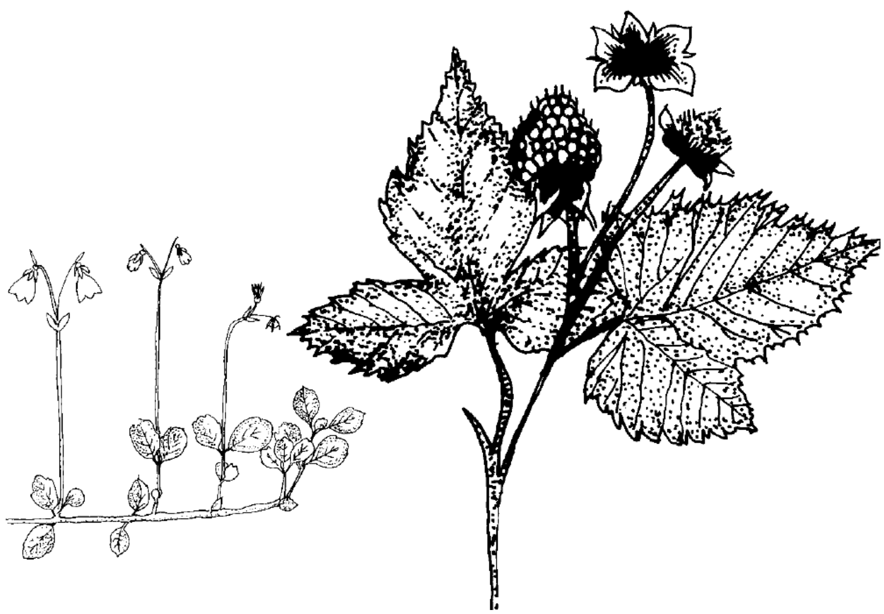
Website:
Introduction to the Fungi
http://www.ucmp.berkeley.edu/fungi/fungi.html

Teacher Resources:

(See appendix)

Investigating Plants

2 EXTENSIONS ***ALERT: ALASKA ECOLOGY CARDS OPTIONAL***



Section 3
ECOLOGY ACTIVITIES

Grade Level: 4-12

State Standards: M A-3, M A-6, S A-14, S A-15, S B-1, S B-5, S B-6
NGSS: 4-LS1-1.,5-LS1-1.,MS-LS1-4.
Subject: Science, math, language arts, art

Skills: Observing, recording, analyzing, describing, drawing, computing, measuring, estimating, identifying

Duration: 90 minutes

Group Size: 2-5

Setting: Outdoors /indoors

Vocabulary: Abundance, annual plants, chlorophyll, dominant plants, dormant, fruit, habitat, multi-cellular, transect

Objectives:
1. Students will recognize and identify some plants from their local ecosystem, including plant signs during the non-growing seasons.

2. Students will describe the differences in abundance of plants in their local environment.

Complementary Activities:
"Five Kingdoms But No King," "Take a Deep Breath," *and all the* "Investigating(Nonliving Things)" *in Section 1, Elements of Ecosystems. Also* "Who Eats Whom," "Mineral Cycling," *and* "Create a Classroom Compost Box" *in Section 2. Also all the* "Investigating (Living Things)" *activities in this section.*

Materials:
For each student: hard surface for drawing or recording data. For each group: one copy of the "Science Card" several copies of the "Plant Data Sheets I and II" *(see following pages*), paper for drawing, field guide to plants or *Alaska Ecology Cards*, small plastic cup or container for collecting soil, and a transect line made with a 3-meter *(or shorter – see step #5)* piece of rope or string.

OPTIONAL: a journal for drawing and recording names of plants.

Background:
See INSIGHTS, *Section 1, Elements of Ecosystems: "Plants"* fact sheet; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:
1. *IN CLASS:* review how plants are different from fungi, monerans, and protists. *(Plants are* ***multi-cellular*** *and have* ***chlorophyll*** *for performing photosynthesis*). Explain to the class that they will investigate their local ecosystem for **diversity** and **abundance** of plants.

2. Explain that students will be locating and drawing as many plants as they can find along **transect** lines. They will include any plants within five centimeters to each side. Demonstrate how to draw a plant and note which characteristics help to identify one plant from another. *Shape,*

size, edges, and texture of leaves are important.

3. Give examples of questions to ask as students draw and take notes about plants they find: *Do leaves form a pattern such as three leaves on a stalk? Are leaves found opposite one another on a stalk or do they alternate? Does the plant hold dried flowers or* ***fruit****? Is the plant stem woody or easily bent? Does this plant grow under trees, on rocky soil, or in wet places?*

4. Discuss "annual plants" *that grow from seeds or buried roots, flower, produce new seeds, and die in one calendar year*. What evidence do these organisms leave behind? *Dead leaves, tubers, seed pods, and roots*. Instruct students to include such evidence when they identify plants along their transect lines.

5. *OUTDOORS:* if you are studying an area with a high **biodiversity** *(i.e. many different plant types),* use a shorter piece of **transect** line so that students won't get overwhelmed.

6. Distribute the "Plants Data Sheets I and II" to each group.

7. Ask each group to lay its transect in a straight line. You may want to challenge the groups to lay their rope so that it touches the highest number of kinds of plants and still maintains a straight line. Have students identify their working area of 5 centimeters to each side of the line.

8. The following roles could be rotated so everyone experiences each assignment: Project Coordinator *(makes sure everything runs smoothly and watches for duplication in plants that are drawn),* Plant Illustrator, Plant Counter, a Plant Classifier *(to key out names for plants),* and a Plant Recorder *(to record the group's answers to the worksheet)*.

9. Students begin surveying. They will describe each kind of plant and then keep a tally of how many of each kind grow along their transect. Students can each draw plants, if desired, checking with the coordinator to avoid duplication. After the observation/drawing session is complete, the Plant Recorder should collect all drawings.

10. When all plants along the transects are drawn and recorded, distribute the Science Cards and ask the groups to sit together and answer the questions.

11. Give each group a small container (such as a paper cup) to collect soil to take back to the classroom to make a "mystery garden."

12. *IN CLASS,* share information and drawings on the plants. Was there a pattern in where the groups found certain plants growing? Why do certain plants grow better in some places than others? Focus the discussion on the **habitat** of the plants.

VARIATION
Instead of a making a transect line, have groups make study plots. Cut a 4-meter piece of string and tie the ends together. Instruct students to make a square out of their length of string, thus creating a one-meter-square plot. Students examine all the plants within the plot.

Evaluation:

1. Given drawings, pictures, or specimens, recognize and identify abundant local plants.

2. During discussion, demonstrate awareness of the dominant plants in the local ecosystem.

3. Give examples of evidence of annual plants during the non-growing season.

EXTENSIONS:

A. **Use the drawings to create a display.** Have the students sort through the drawings to find samples of each kind of plant found along their transects. Use those to create posters or a display of schoolyard plants. Students research plant facts from field guides, the *Alaska Ecology Cards,* and other sources.

B. **Make a school herbarium.** Students collect and press *one example* of each plant found. Herbarium specimens may be used by future groups or classes to help identify plants on their transect studies.

NOTE: Before collecting any living thing, discuss with the students the importance of preserving the environment and disturbing the area as little as possible.

- For small plants, collect the entire plant including the root, flowers, stems, and leaves if possible. Shake off any loose dirt.

- For trees and shrubs, collect sample branches, leaves, flowers or seeds. Make rubbings of bark by using paper and crayons or charcoal.

- Press samples in a plant press (between sheets of cardboard and newspaper, bound with rubber bands or weighted with heavy books), changing the newspaper every few days.

- When samples are dry, students mount them on poster board and label with the plant's name, where it was found, who collected it, and the date that it was collected. Also identify plants using local names and uses.

Curriculum Connections:

(See appendix for full citations)

Books:

How Nature Works (Burnie)

Plant (Eyewitness) (Burnie)

Plants (Silverstein)

Science of Plants (Bocknek) (Gr. 4-6)

Website:

Plants Database <plants.usda.gov/plants/home_page.html>

Teacher Resources:

(See appendix)

SCIENCE CARD

Plant Transect

1. **Biodiversity.** How many kinds of plants did you find along your transect line?

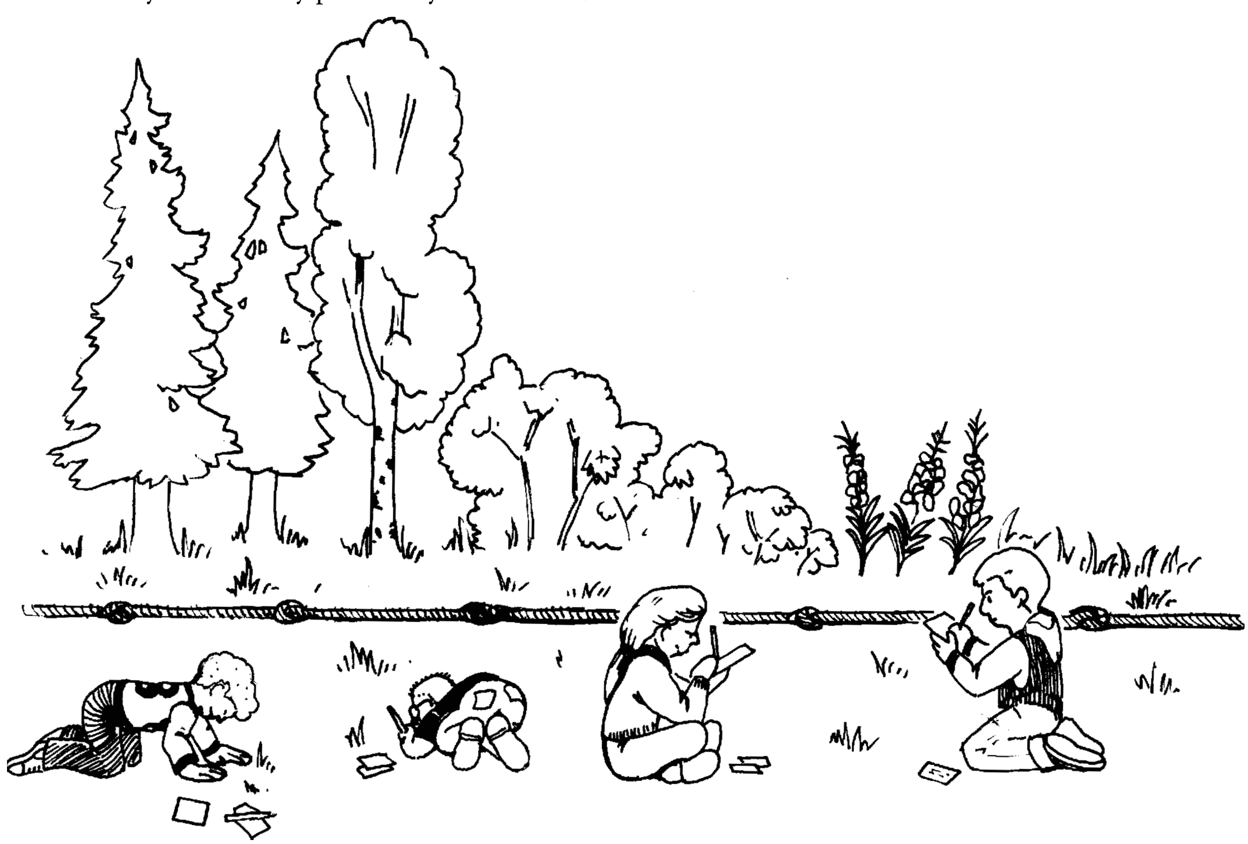
2. **Identification.** If you haven't already, try to identify the most common plants by using a field guide to plants. If you cannot find the name of the plants in your guide, or if a field guide is unavailable, record details about the plant to help you identify it later.

3. **Dominant species.** Which three kinds of plants were the most abundant on your transect? These "dominant" species will have the highest numbers in the third column of your "Plant Data Sheet I." *Make sure that you have counted individual plants, not every leaf or stem. Count a moss clump as one plant.* Write the total for each plant on its drawing.

4. **Dormant annual plants.** Depending on the time of year and where you are, many plants may be dormant, which means you won't clearly see their leaves, flowers, or even stems. Describe the kind and amount of the following plant remnants that you found on your transect:

(a) Dead leaves or needles
(b) Dead flowers
(c) Seeds
(d) Roots above the ground

5. **Mystery gardens.** You can find out more about what plants are in the soil as seeds by taking a small sample of soil back to the classroom, putting it in an open container (an empty milk carton, for example), watering it well, covering it with plastic, and placing it in a sunny spot. Watch your mystery garden closely for 2-3 weeks and record what happens.



Plant Data Sheet I

LIST OF PLANTS

Names ______________________________ Date ____________

Location of Site ______________________________

Plant Number	Plant Name or Description	Number of Individual Plants
(Example)	Fireweed	~~||||~~ |||

Plant Data Sheet II

PLANT DRAWINGS

Plant # ____ **Name** ______________________

Plant # ____ **Name** ______________________

Plant # ____ **Name** ______________________

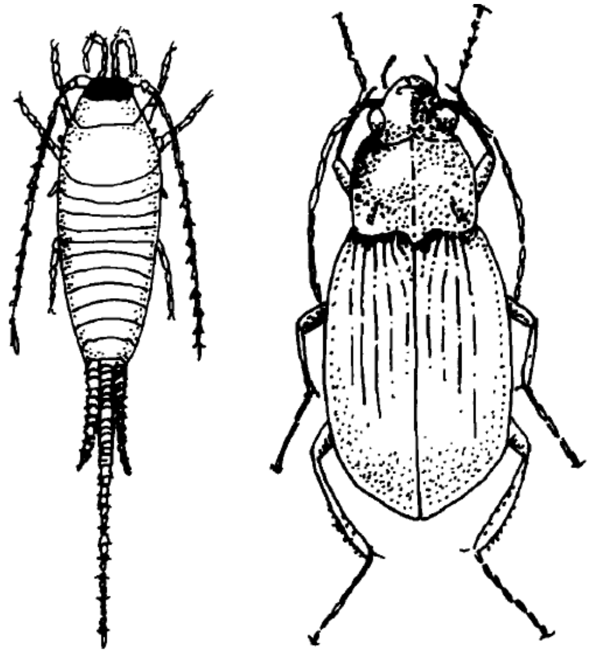
Plant # ____ **Name** ______________________

Plant # ____ **Name** ______________________

Plant # ____ **Name** ______________________

Investigating Animals in Soil

1 EXTENSION ***ALERT: ALASKA ECOLOGY CARDS OPTIONAL***



Section 3
ECOLOGY ACTIVITIES

Grade Level: 4 - 12

State Standards: M A-3, M A-6, S A-14, S A-15, S B-1, S B-5, S B-6
NGSS: **4**-LS1-1.

Subject: Science, language arts, art

Skills: Observing, recording, analyzing, describing, drawing, computing, measuring, estimating, identifying

Duration: 90 minutes

Group Size: 2-4

Setting: Outdoors /indoors

Vocabulary: Adaptations, domesticated, habitat, insects, larvae, mammals

Objectives:

1. Students will describe signs of animal activity in the soil.

2. Students will describe and name some animals found in local soil habitats.

Complementary Activities:

"Five Kingdoms But No King," "Take a Deep Breath," *and all the* "Investigating (Nonliving Things)" *in Section 1, Elements of Ecosystems. Also* "Who Eats Whom," "Oh Moose," "Mineral Cycling," *and* "Create a Classroom Compost Box" *in Section 2. Also all the* "Investigating (Living Things)" *in this section.*

Materials:

For each group OUTDOORS: coffee can or similar container with holes in the bottom, plastic bag, 4-meter lengths of string, copies of the "Soil Animals Data Sheets I and II" *(see following pages*), paper, pencil.

INDOORS: microscope or hand-lens, field guides if available, graduated cylinder, white tray. Field guides or *Alaska Ecology Cards.*

OPTIONAL: light, funnel, flask for Berlyse Funnel *(see following).*

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Animals (Invertebrate)"* fact sheet; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:

1. *IN CLASS:* review the five kingdoms. Remind students there are many members of the animal kingdom that are very small and seldom seen by humans. Challenge the class to list some tiny animals. *(shrews, mice, weasels, insects, snails, spiders, worms, etc.)*

2. Discuss what kind of habitat or environment would be safe for very small animals. Lead the discussion toward life underground. *Some animals are* ***adapted*** *to spending most of their life in the dark, living on other animals or nutrients found in the soil.*

3. Explain that the students will become scientists, looking for animals and their signs in the soil. Show students pictures of **larvae**, casings, and other evidence that they

may find in the soil.

4. *OUTDOORS:* direct each group to "stake out" a square study plot, 1-meter by 1-meter, using their string as the boundary. Challenge them to examine the area carefully. *Look for small holes or tunnels dug into the ground, droppings, or leaves that seem to have been bitten by a small animal.*

5. Each group has the following duties that may be rotated: Mapmaker, Recorder, Classifier, Counter/Estimator.

6. The Mapmaker draws a map of the plot, noting large rocks, large plants or trees, hills, and depressions.

7. The Recorder writes down evidence of animals that the group finds, noting the location on its plot map. When soil animals are found, the Recorder includes the information on the "Soil Animals Data Sheets I and II."

8. Using an empty can as a sampling tool, one member of each group presses the open end into the soil until the can is at least half buried. Turn the can right side up and dig out the soil marked by where the can was, filling the can half full.

9. Empty the soil into a plastic bag for transport to the classroom *(since the can has holes in the bottom).*

10 *IN CLASS,* each group places its soil in a tray and sorts through it, looking for animals, larvae, or any other evidence of life in the soil.

11. All members of the groups draw the organisms they find.

12. Challenge students to identify their creatures by using field guides. The Classifier keeps track of the kinds of creatures so that the same animal is not named twice. If field guides or the *Alaska Ecology Cards* are unavailable, ask students to make up their own descriptive names for each species.

13. Wrap-up the investigation with a class discussion concerning the **habitat** of these small animals. What special **adaptations** do soil animals have that help them to live on or in the soil?

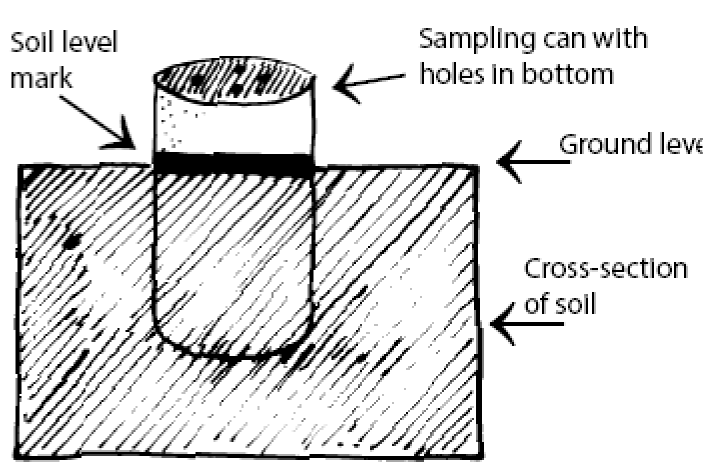
Evaluation:

1. Complete drawings and name animals found in the soil of the local ecosystem.

2. Describe possible signs of animal activity in the soil of their local ecosystem.

EXTENSION:

Use a Berlyse funnel to find more animals. Set up the Berlyse funnel as illustrated for each group (or rotate one for each group to use on succeeding days.) Leave a light shining on the funnel contents overnight. Many of the



Core Sampler

living things in the soil will move away from the warm, bright light and fall into the collecting bottle.

Curriculum Connections:

(See appendix for full citations)

Books:
Handful of Dirt (Bial)

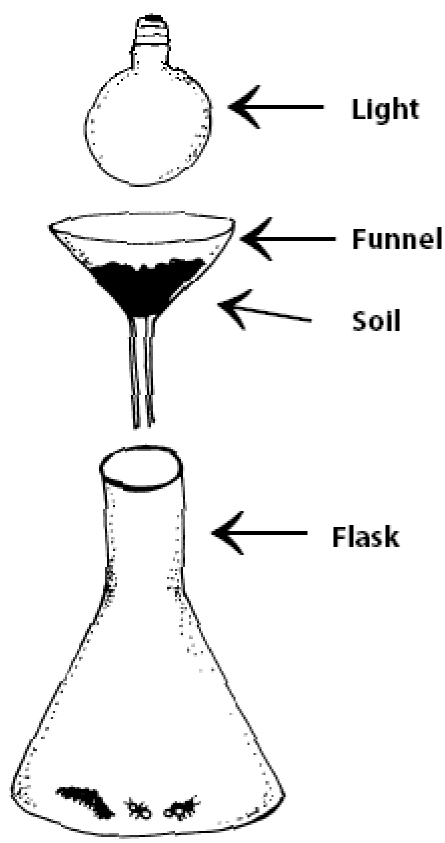
One Small Square: Backyard (Silver)

Our Endangered Planet: Soil (Winckler)

Media:
Dirt Made My Lunch (Audio Tape or CD) (Banana Slug String Band)

Teacher Resources:

(See appendix)



Berlyse Funnel

Soil Animals Data Sheet I

LIST OF ANIMALS

Names ______________________________ Date ______________

Location of Site ______________________________

Characteristics

Animal Number	Number of Legs	Number of Wings	No. of Body Segments	Mouth Parts	Length in mm	Color	Other Information

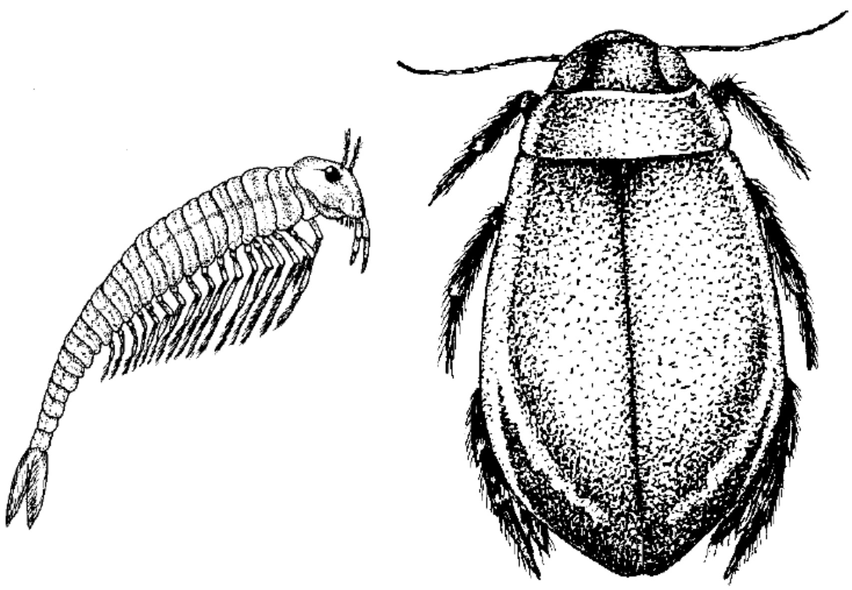
Soil Animals Data Sheet II

ANIMAL DRAWINGS

Animal # _______Name __________________	Animal # _______Name __________________
Animal # _______Name __________________	Animal # _______Name __________________
Animal # _______Name __________________	Animal # _______Name __________________

Investigating Animals in Water

1 EXTENSION   ALERT: ALASKA ECOLOGY CARDS OPTIONAL



Section 3
ECOLOGY ACTIVITIES

Grade Level: 4 - 12
State Standards: M A-3, M A-6, S A-14, S A-15, S B-1, S B-5, S B-6
NGSS: 4-LS1-1.
Subject: Science, language arts, art
Skills: Observing, recording, analyzing, describing, drawing, computing, measuring, estimating, identifying
Duration: 90 minutes
Group Size: 3-4
Setting: Outdoors/indoors
Vocabulary: Invertebrates, larvae, pupae, sediments, wetlands

Objectives:

1. Students will recognize and identify some local water animals.

2. Students will predict and describe the habitats where water animals can be found.

Complementary Activities:

"Five Kingdoms But No King," "Take a Deep Breath," *and all the* "Investigating (Nonliving Things)" *in Section 1, Elements of Ecosystems. Also* "Who Eats Whom " *and* "Mineral Cycling" *in Section 2. Also all the* "Investigating (Living Things)" *in this section.*

Materials:

For each group: underwater viewer, kick sampler, sweep net *(illustration following*), copies of "Water Animals Data Sheets I and II" *(see following pages*).
OPTIONAL: Field guides or *Alaska Ecology Cards.*

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Animals (Invertebrates)"* fact sheet; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:

1. *IN CLASS:* review the five kingdoms. Remind students there are many members of the animal kingdom that are very small and seldom seen by humans. Challenge the class to list some tiny animals that *(mice, minnows, insects, snails, spiders, worms, etc.)*

2. Discuss what kind of habitat or environment would be safe for very small animals. Lead the discussion toward life in ponds, streams, **wetlands.** *Each wet area in Alaska erupts with young **invertebrates** (animals such as worms and insects that have no backbone) each spring as ice thaws. These invertebrates are food for fish. Who eats fish?*

3. Explain the students will become scientists, looking for animals in the water. *Many of the easily recognizable flying insects in Alaska such as mosquitoes and dragonflies lay their eggs in water. **Larvae** and **pupae** develop from these eggs.*

4. *OUTDOORS:* in groups, students place the underwater viewer on the water surface and look for fish, insect larvae, worms, or other creatures. Record the invertebrates that they see on the "Water Animals Data Sheet I" under the column "Surface Sample."

5. Students pick up rocks both at the water's edge and in the water and look on the underside of them. *Remind students to put the rocks back in the same place so the animals that live there will still have their home.* Record any evidence of water animals on the "Water Animals Data Sheet I" under the column "Bottom Sample."

6. One student from each group places the kick sampler at the bottom of a stream with the open end facing the current. Another student "kicks" or disturbs the rocks upstream from the sampler.

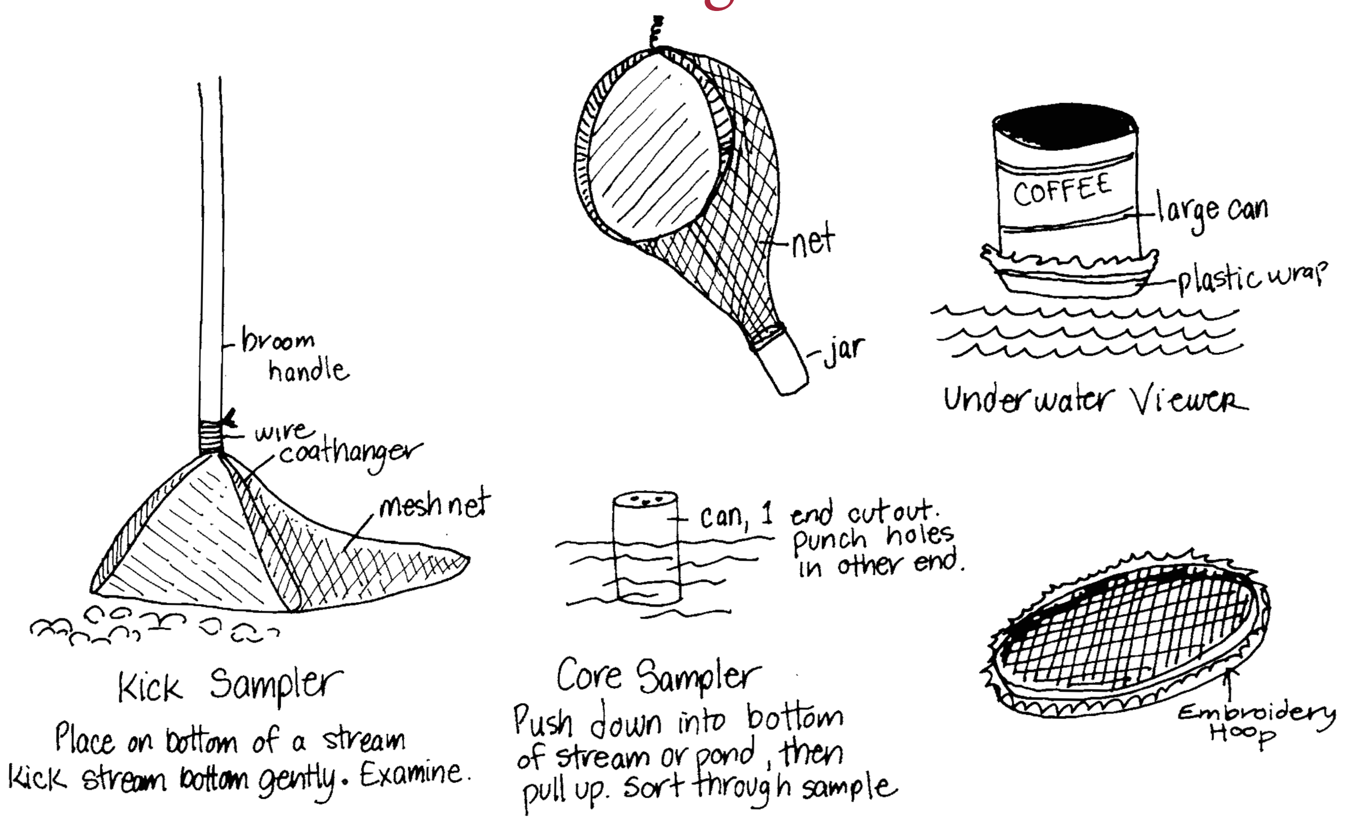
7. Take the sampler out of the water and check for invertebrates. Students describe and record the invertebrates on the "Water Animals Data Sheet I" under "Kick Sample." *Be sure to treat the creatures gently and to return them to their homes after examining them.* Check field guides to help identify insect larvae and other invertebrates.

8. Use the "core sampler" to examine animals that live in **sediments**. Each group pushes the can into the bottom of a stream or pond and then pulls it up. Sort through the sample for invertebrates. Describe and record creatures on the "Water Animals Data Sheet I" under the column "Core Sample."

9. When all groups are together, discuss any similarities they found among their water critters. Identify any features that have helped water critters to adapt to their environment.

10. Discuss the habitat of these small animals, focusing on elements critical to their survival. How might human activity affect this environment?

Water Investigation Tools



Evaluation:

1. Complete the "Water Animals Data Sheet I and II" and describe where water animals can be found in the local environment.

2. Identify some local water animals and describe their role in your ecosystem.

EXTENSION:

Predict and calculate density. Predict the number of animals in the water by estimation. Students measure the volume of water or sediment that they collected in a measuring beaker or a graduated cylinder. Count the number of organisms found in that sample. Students might also count the number of organisms found per rock examined. Record the number of organisms located per unit area.

Curriculum Connections:

(See appendix for full citations)

Books:

Insects: A Guide to Familiar American Insects (Cottam)

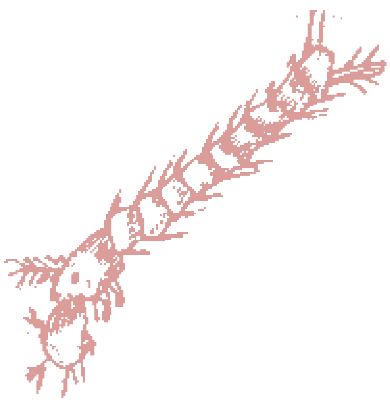
National Audubon Society Field Guide to North American Insects and Spiders (Milne)

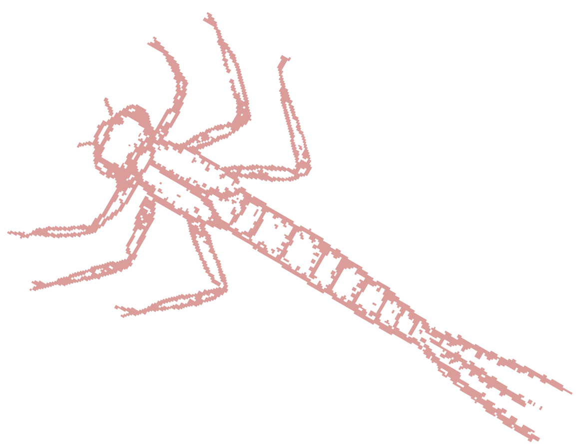
Pond and River (Eyewitness Book) (Parker)

Water Insects (Johnson)

Teacher Resources:

(See appendix)





Water Animals Data Sheet I

LIST OF ANIMALS

Names ______________________________ Date ______________

Location of Site ______________________________

Number Observed

Animal Number	Surface Sample	Bottom Sample	Kick Sample	Core Sample	Total Number
Total Number Observed					

Water Animals Data Sheet II

ANIMAL DRAWINGS

Animal # _______ **Name** __________________

Animal # _______ **Name** __________________

Animal # _______ **Name** __________________

Animal # _______ **Name** __________________

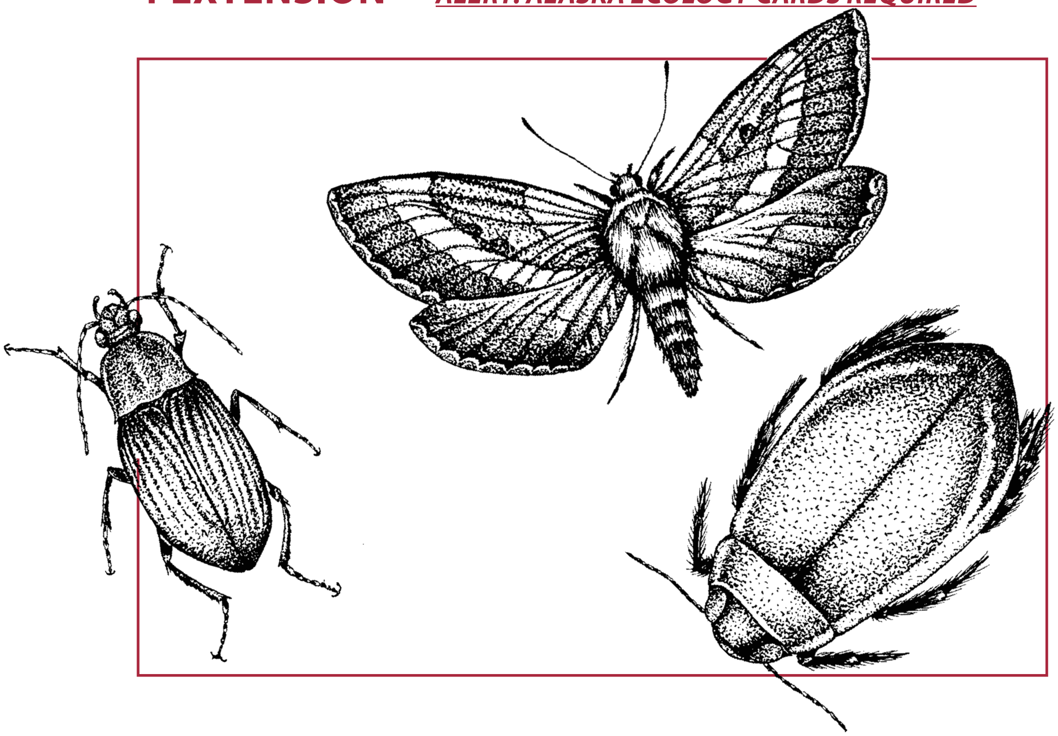
Animal # _______ **Name** __________________

Animal # _______ **Name** __________________

Investigating Insects

1 EXTENSION

ALERT: ALASKA ECOLOGY CARDS REQUIRED



Section 3
ECOLOGY ACTIVITIES

Grade Level: 4 - 12

State Standards: M A-3, M A-6, S A-14, S A-15, S B-1, S B-5, S B-6
NGSS: 5-LS2-1,MS-LS2-3,HS-LS2-4.

Subject: Science

Skills: Observing, comparing, inferring, identifying

Duration: 50 minutes

Group Size: Individuals

Setting: Outdoors & indoors

Vocabulary: Cambium, consumer, food chain, gall, habitat, larvae, names of insects, predator, prey, sap

Objective:

Students will identify signs of insect activity and determine its role in a local ecosystem.

Complementary Activities:

"Five Kingdoms But No King," "Take a Deep Breath," *and all the* "Investigating (Nonliving Things)" *in Section 1, Elements of Ecosystems. Also* "Who Eats Whom," "Follow a Food Chain," *and* "Ecosystem Partners" *in Section 2. Also all the* "Investigating (Living Things)" *in this section.*

Materials:

Copies of "Insect Signs Chart" and "Insect Signs Science Card" *(next page)* for each student, hand lens, clipboards and writing paper or field note books, pencils or pens. *Alaska Ecology Cards* of forest insects.

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Animals (Invertebrate)"* fact sheet; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:

IN ADVANCE: locate a nearby site with a variety of live plants (trees, shrubs, and groundcover) and dead leaves. Look for a spot that shows galls *(see illustration on Insect Signs Chart)* on plants, or a tree with bark engravings or reddish brown sawdust at its base. Record the number and location of insect signs you find for later comparison with student notes.

1. *IN CLASS:* discuss the role of insects in an ecosystem. Are insects **consumers**? What do they consume? Where are they represented on a **food chain**?

2. Using the information on the *Alaska Ecology Cards* of forest insects, review some of the traits, **habitats**, **prey**, and **predators** before going to the forest site.

Classroom Follow-Up:

1. Students should discuss and compare their findings. Where do the found insects fit in the food chain? Students can use the *Alaska Ecology Cards* to learn more about these insects to enhance the discussion.

2. Ask if they think they might find more or less insect signs at other seasons of the year. Why? How does this affect decomposition in the local ecosystem?

3. If they have studied other ecosystems (tundra, rainforests, wetlands, etc.), students compare what they found in their local ecosystem to the work and abundance of insects elsewhere.

EXTENSION:

Research forest insects and create a display. Students use the *Alaska Ecology Cards* or other "Curriculum Connections" resources *(below)* to find out more about their local insects. They use this information along with sketches of the insect signs they found to make posters or a display of local wildlife.

Curriculum Connections:

(See appendix for full citations)

Books:

Insects: A Guide to Familiar American Insects (Cottam)

Insects and Diseases of Alaskan Forests (Holsten)

National Audubon Society Field Guide to North American Insects and Spiders (Milne)

Website:
Alaska Science Forum <www.gi.alaska.edu/ScienceForum>

Teacher Resources:

(See appendix)

SCIENCE CARD

Insect Signs

Insects are some of the most important **consumers** in many ecosystems. The "Insect Signs Chart" shows some of the evidence insects leave behind. How many of these signs can you find in this area?

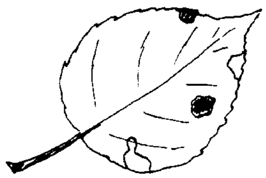
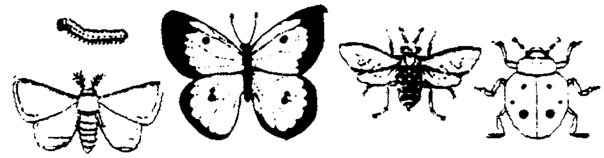
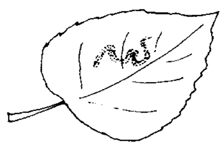
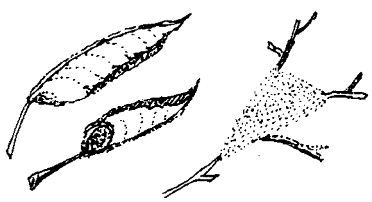
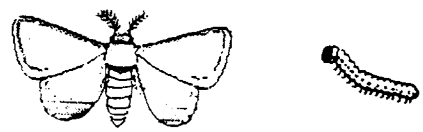
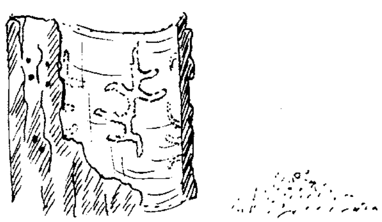
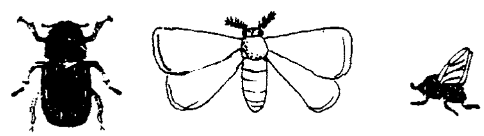
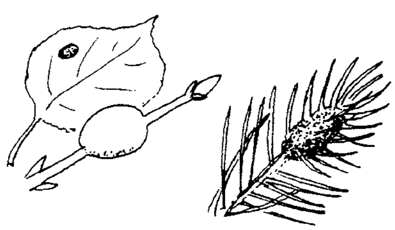
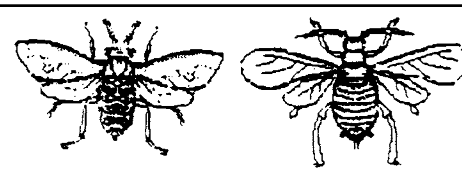
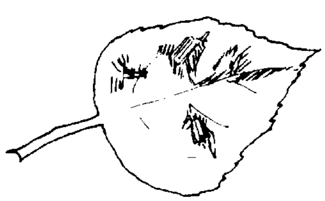
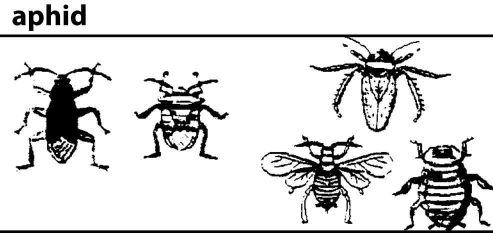
1. Write the heading "Insect Signs" on a page in your field notebook. Record the number of different types of insect signs you find in this area.

2. List each type of insect for which you find evidence. Draw a sketch to remind you what its sign looked like. Your sketch or its label should include the leaf, plant, or type of wood where you found the sign – the insect's **habitat**.

3. Where do the insects whose evidence you found fit in the food chain? Would another kind of forest have different insects? Record your answers in your notebook.

4. If you find the insects themselves, draw a picture of them in your notebook to help you identify them later.

Insect Signs Chart

FEEDING METHOD	SIGNS	EXAMPLES OF INSECTS THAT LEAVE THESE SIGNS
Leaf-chewing Insects		 Larvae of moths, butterflies, sawflies, and beetles
Leaf-mining Insects		 Tiny larvae of moths, beetles, flies, and wasps
Leaf-rollers and Tent Caterpillars		 Larvae of moths
Cambium-eating Insects		 Larvae of bark beetles, a few moths, and some flies
Gall-making Insects		 Wasps, flies, sawflies, gall-making aphids, and spruce aphid
Sap-sucking Insects		 Adult Insects

Investigating Birds

2 EXTENSIONS <u>ALERT: ALASKA ECOLOGY CARDS OPTIONAL</u>

Bird landing and walking in snow

Section 3
ECOLOGY ACTIVITIES

Grade Level: 4 - 12

State Standards: M A-3, M A-6, S A-14, S A-15, S B-1, S B-5, S B-6
NGSS: 4-LS1-1.

Subject: Science

Skills: Observing, identifying, inferring

Duration: 50 minutes

Group Size: 2

Setting: Outdoors

Vocabulary: Bird names, habitat, nocturnal

Objective:

Students will recognize bird signs and identify the species and behavior of birds in the area.

Complementary Activities:

"Five Kingdoms But No King," "Take a Deep Breath," *and all the* "Investigating (Nonliving Things)" *in Section 1, Elements of Ecosystems. Also* "Who Eats Whom," "Follow a Food Chain," *and* "Ecosystem Partners" *in Section 2. Also all the* "Investigating (Living Things)" *and* "Ecosystem Scavenger Hunt" *in this section.*

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Animals (Vertebrate)"* fact sheet; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Materials:

"Bird Signs Chart," and "Bird Signs Science Card" for each student, clipboards and writing paper or field note books, pencils or pens.
OPTIONAL: Field guides to birds and animal tracks, binoculars, and *Alaska Ecology Cards.*

Procedure:

IN ADVANCE: locate nearby sites where you can find evidence of several birds. Good choices may be near open water, sites with snow, and areas with a variety of shelter. *It is okay to salt the area you choose with a feather or raptor casting.*

Record the number and kinds of bird signs you find for later comparison with student observations and notes. Fill in the number of signs on the "Bird Signs Science Card."

2. *IN CLASS:* brainstorm what kind of birds live nearby. Discuss what birds obtain from where they live *(food, shelter, water, space —* ***habitat****)* and why this habitat is important for their survival.

3. Tell the students they will go in search of birds. Students may not see specific birds, but they could find bird signs such as feathers, nests, whitewash (droppings), or tracks.

4. Give each student the "Bird Signs Science Card" and the "Bird Signs Chart."

Classroom Follow-Up:

1. Students discuss and compare their findings. Based on what they found, what habitat do their birds use in the ecosystem?

2. Ask if they think they might find more or less bird sign at other seasons of the year. Why?

3. Where might they go to find the birds or their signs illustrated on the Chart that were not found during class? What does that habitat offer that the class habitat does not offer?

EXTENSIONS:

A. **Research local birds and create a display.** Students use the *Alaska Ecology Cards* or other "Curriculum Connections" resources to find out more about their local wetland, ocean, tundra, or forest birds. They use this information along with sketches of tracks or signs to make posters or a display.

B. **Set up a winter bird feeding station visible from the classroom.** If bird habitat is near your classroom window, depending on grade level, students set up a winter bird feeding station after researching the best devices, food, and location through their local Alaska Fish and Game office, Audubon Chapter, or "Curriculum Connections."

Students keep a class chart of the kinds of birds that come to their feeding station, how often they are seen, and note their behaviors. Before the school year ends, students calculate the results and discuss the seasonal changes in bird visits.

Curriculum Connections:

(See appendix for full citations)

Books:

Alaska Wildlife Notebook Series (ADF&G)

Guide to the Birds of Alaska (Armstrong)

The National Audubon Society North American Birdfeeder Handbook (Burton)

Website:

A Guide to Building and Placing Birdhouses
adfg.alaska.gov/species/livingwithwildlife/birds

Teacher Resources:

(See appendix)

SCIENCE CARD

Bird Signs

You have heard of mammal tracks. Did you know birds leave signs too? Open your eyes and look carefully, you will be able to find ____ bird signs that are in this area.

1. Write "Birds" at the top of a page in your notebook.

2. Record the number of birds whose evidence you find at this site. Then list them by name along the left side of the page.

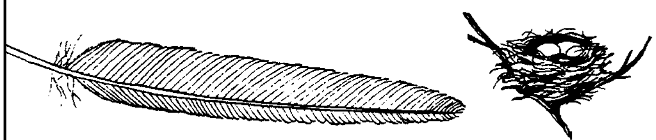
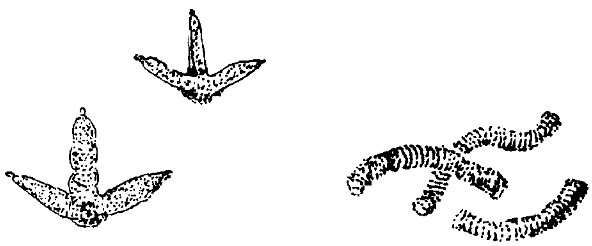
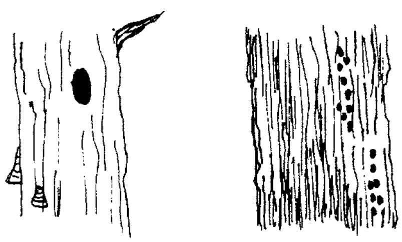
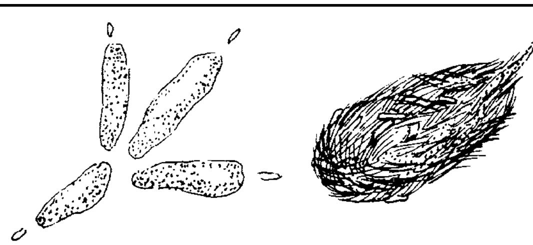
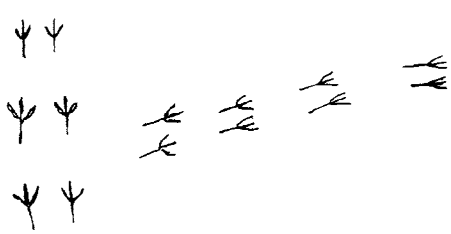
3. Listen and look carefully, for these birds may still be nearby. Make a "shhh, shhh, shhh" sound. Sometimes birds will move or call when they hear this sound.

4. If you see birds, watch them. Can you identify them using the guide book? Watch and record their behavior. What habitat do they like most? Are they eating? What are they doing? Record what you see in sketches or words.

5. If you found signs of grouse or woodpeckers, look for these groups in a field guide to birds. Based on the season and the habitat you are in, can you figure out which kind of grouse or woodpeckers might be in this area? List the species you think are most likely to have made the signs.

6. If you find signs of other birds enroute to the site, make notes of your findings in your notebook.

Bird Signs Chart

BIRD	SIGNS	
Signs Left by Many Birds		Feathers, sticks or grass nests
Grouse		Grouse make 3-toed tracks on solid snow or wet soil, but in deep soft snow they make a trail that looks like a ditch in the snow. Their droppings seem dry and are shaped like fat worms. Listen for their hooting or low drumming calls.
Woodpeckers		Listen for tapping or drumming sounds. Look on live and dead trees for small or large holes that look like something drilled into the bark of the tree. Also look for flakes of bark around the base of trees.
Raven		Droppings and tracks around a dead animal. Hoarse croaking sounds.
Hawks and Owls		Hawks and owls regurgitate pellets of fur, feathers, and other indigestible bits of the prey. These pellets are cleaned of all meat, so that they smell and feel clean.
Songbirds		Listen for twittering, chirping, or other calls and songs.

Investigating Mammals

2 EXTENSIONS ALERT: ALASKA ECOLOGY CARDS OPTIONAL

SHREW TRACKS IN WET MUD

Section 3
ECOLOGY ACTIVITIES

Grade Level: 4 -1 2

State Standards: M A-3, M A-6, S A-14, S A-15, S B-1, S B-5, S B-6
NGSS: 5-ESS3-1,MS-LS2-1. MS-LS2-2.

Subjects: Science, language arts

Skills: Observing, identifying, inferring, comparing, descriptive writing

Duration: 50 minutes

Group Size: Individuals

Setting: Outdoors

Vocabulary: Animal names, habitat, nocturnal

Objective:

Students will use a variety of signs to identify the presence of specific mammals and determine their diet.

Complementary Activities:

"Five Kingdoms But No King," "Take a Deep Breath," *and all the* "Investigating (Nonliving Things)" *in Section 1, Elements of Ecosystems. Also* "Who Eats Whom," "Follow a Food Chain," *and* "Oh Moose," *in Section 2. Also all the* "Investigating (Living Things)" *in this section.*

Materials:

Copies of "Mammal Signs Chart" *(following pages*) and "Mammal Signs Science Card" for each student, clipboards and writing paper or field note books, pencils or pens. OPTIONAL: *Animal Tracks of Alaska* and *Alaska Ecology Cards.*

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Animals (Vertebrate)"* fact sheet; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:

IN ADVANCE: locate nearby sites where you find evidence of two or more mammals. Good choices may be near open water, sites with snow, and areas with a variety of shelter.

Record the number of signs you find on the instruction card below as an incentive for students. Make a separate record of the mammal signs at these sites for later comparison with student notes.

1. *IN CLASS:* brainstorm what kind of mammals live nearby. Discuss what these wildlife obtain from where they live *(food, shelter, water, space — **habitat**)* and why this habitat is important for their survival.

2. Tell students they will go in search of local mammals. Many mammals move around over large areas and try to stay hidden, and some are **nocturnal**. But they leave signs of their presence. Students will look for animal droppings, tracks, hair, plants that have been nipped or browsed, and dens.

3. Discuss student behavior that will enhance chances of seeing mammals. *It is important for students to be quiet – talking and moving fast and noisily will scare animals away.*

4. Give each student the "Mammal Signs Science Card" and the "Mammal Signs Chart."

Classroom Follow-Up:
1. Students discuss and compare their findings. Based on what they found, what habitat do their mammals use in the ecosystem?

2. Ask if they think they might find more or less mammal sign at other seasons of the year. Why?

3. Where might they go to find signs of mammals illustrated on the Chart that were not found during class? What does that habitat offer that the class habitat does not offer?

EXTENSION:

A. **Research local mammals and create a display.** Students use the *Alaska Ecology Cards* or other "Curriculum Connections" resources to find out more about their mammals. They use this information along with sketches of tracks and signs to make posters or a display of forest wildlife.

B. **Make plaster casts of animal tracks.** Details are given in the activity "Track Casting" in Section 3 of the companion book *Alaska's Forests & Wildlife.*

Curriculum Connections:
(See appendix for full citations)

Books:
Alaska's Mammals (Smith)

Alaska Wildlife Notebook Series (ADF&G)

Animal Tracks of Alaska (Sheldon)

Animal Tracks of Alaska (Stall)

Mammals of Alaska (Alaska Geographic)

Website:
Animal Diversity Web <animaldiversity.ummz.umich.edu/index.html>

Teacher Resources:
(See appendix)

SCIENCE CARD

Mammal Signs

1. Write "Mammals" at the top of a page in your field notebook. Record the number of mammals whose evidence you find in this area.

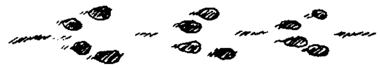
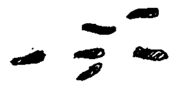
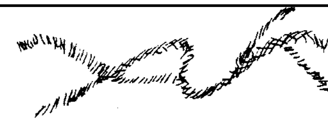
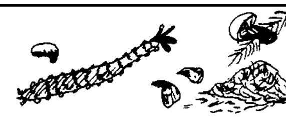
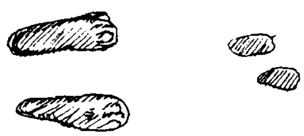
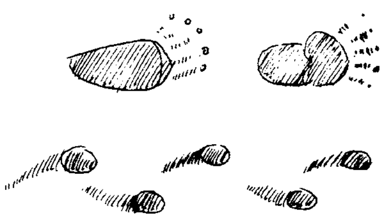
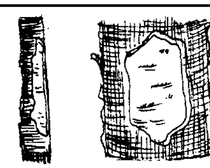
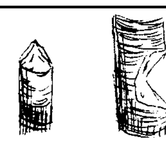
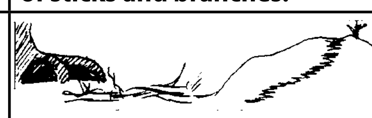
2. List mammals whose evidence you find along the left side of your page.

3. Write what you think they eat based on the signs you find on the right side of the page. Do they eat plant or other animals?

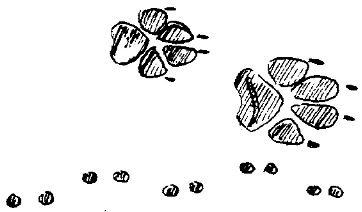
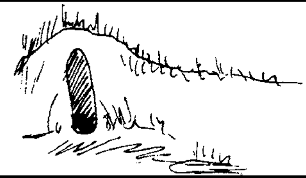
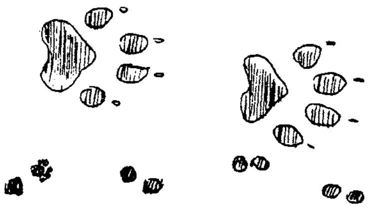
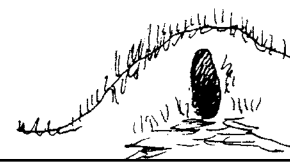
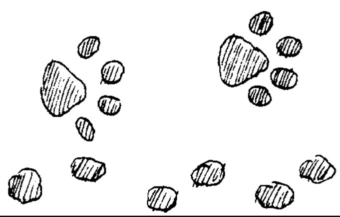
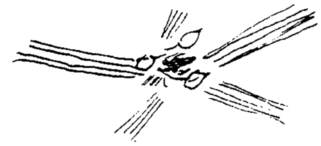
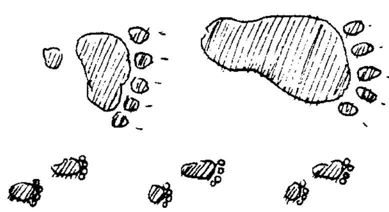
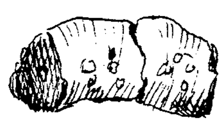
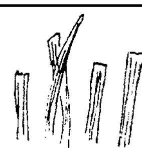
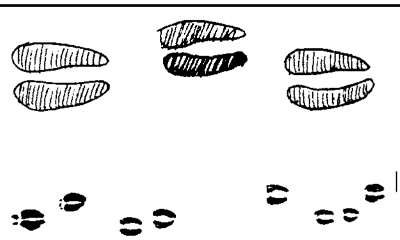
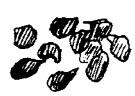
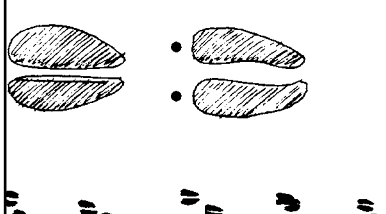
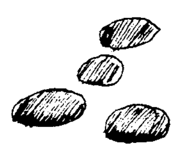
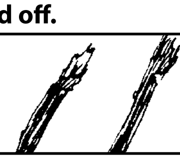
4. Write a short description of the signs next to each animal's name. Try to compare each sign to something familiar. Make a rhyme, or a humorous statement in order to help you remember which sign is evidence of which animal. *(For example: Deer droppings look like big chocolate chips. Hare-browsed willows are sharp. Ow!)*

5. If you find signs of other mammals while walking to or from this site, make notes of your findings on the page. The "Mammal Signs Chart" shows evidence of mammals that you might find in this forest. There are signs of at least ____ kinds of mammals in this area. Can you find these signs and identify them?

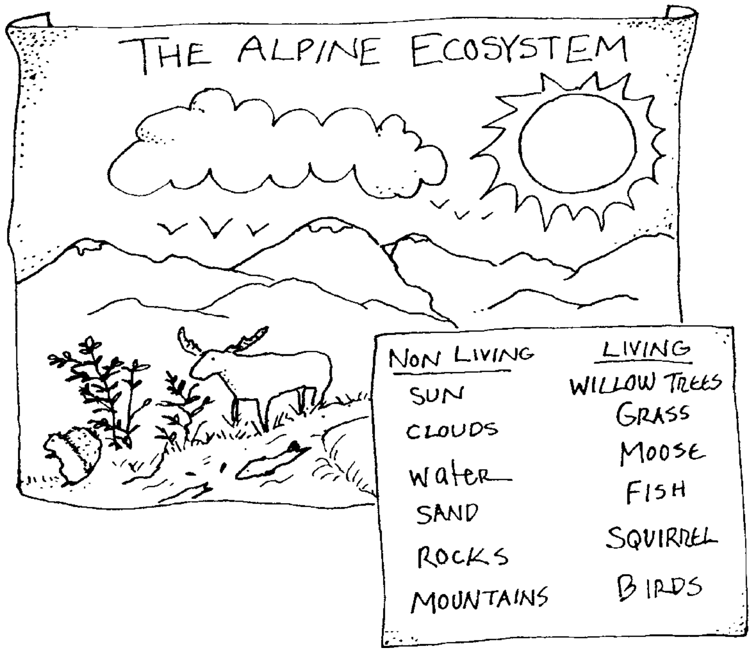
Mammal Signs Chart

ANIMAL	TRACKS	DROPPINGS	OTHER SIGNS
Shrew			
Vole, Mouse, or Lemming			 **Tunnels under the snow or, after the snow melts, small piles of grasses lying in patterns like tunnels.**
Squirrel			 **Middens or large piles of cones, cone scales, and cone cobs. Also, mushrooms hanging in trees.**
Snowshoe Hare			 **Willows, birch, rose, aspen, or other plants with stems neatly clipped.**
Porcupine			 **Large strips or patches of bark missing from a tree trunk.**
Beaver			 **Tree stumps or branches with gnawing marks; lodges or dams of sticks and branches.**
River Otter			 **Strong odor; trampled grasses and plants, dens under tree roots, and sledding trails on small slopes.**

Mammal Signs Chart

ANIMAL	TRACKS	DROPPINGS	OTHER SIGNS
Marten			
Fox or Coyote			 Dens
Wolf			 Dens
Lynx			 Scraping around droppings
Bear			 Grasses and sedges that have been grazed or clipped off. Skunk cabbage that is torn or dug up.
Deer			 Huckleberry or other shrubs with stems that appear to have been chewed off.
Moose			 Birch, aspen, willow, or other plants with stems roughly browsed (not neatly clipped).

What Makes an Ecosystem?
2 PARTS & 1 VARIATION



Section 3
ECOLOGY ACTIVITIES

Grade Levels: 3 - 6

State Standard: S A-14
NGSS: 5-ESS3-1.,MS-LS2-1. MS-LS2-2.

Subjects: Science, language arts

Skills: Listening, visualizing, writing, observing

Duration: 60 minutes

Group Size: Any

Setting: Indoors

Vocabulary: Ecosystem, energy, living, nonliving

Objective:
Students will be able to identify the living and nonliving components of an ecosystem and how they interact.

Teaching Strategy:
Students take an imaginary or real walk through the schoolyard and create their own imaginary ecosystems.

Complementary Activities:
"Five Kingdoms But No King," "Take a Deep Breath," *and all the* "Investigating (Nonliving Things)" *in Section 1, Elements of Ecosystems. Also* "Who Eats Whom," "What's for Dinner?" "Ecosystem Partners," *and* "Create a Classroom Compost Box" *in Section 2. Also all the* "Investigating (Living Things)" *in this section.*

Materials:
Alaska ecosystem posters from INSIGHTS, *Section 3, Living Things in their Habitats,* or pictures of Alaskan natural environments. Examples of living and nonliving things (plants, rocks, plastic), paper and crayons.

Background:
See INSIGHTS, *Section 1, Elements of Ecosystems: "Five Living Kingdoms"* fact sheets; INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:
PART ONE

1.Review the terms **living** and **nonliving**. Use the classroom to point out examples. Ask students to think about what makes something "alive" and write a class definition for "living things."

2. Ask the students to visualize a wild area near their school with which they are familiar. Some examples might be the tundra, forest, wetlands, stream or river valley, ocean, or park near the school. Each student, working alone, makes a list of all of the living and nonliving elements of this local habitat.

3. Make a class list of all of the elements of the local habitat, under the categories "living" and "nonliving."

4. Review the definition of the **ecosystem** *(a community of living things and its nonliving surroundings linked together by energy and nutrient exchange)*. Discuss how your local wild area fits this ecosystem definition.

5. Work together to show the connection between the parts of the ecosystem, showing how each part depends on another. If possible, take a walk into the ecosystem surrounding the school and look for things to add to the class list. *Some nonliving things require creativity to "see." Energy is observable in the form of heat, sunlight, wind, and the movement of body parts and body fluids in living things.*

PART TWO

6. Discuss how different ecosystems have different *nonliving environments* and therefore, different living things. *Some ecosystems are dominated by hot or cold temperatures, lots of rain or hardly any rain, for example.* Can a fish that lives in an ocean ecosystem also live in a desert ecosystem?

7. If appropriate, show poster or picture examples of Alaskan ecosystems.

8. Challenge the students, working in groups or as a class, to create their own real or imaginary ecosystem as a drawing, mural, model, or a collage. The ecosystems should include at least 5-10 living things and the nonliving things on which the living things depend.

Students might start by listing the living and nonliving things that might be a part of their ecosystem and how they are connected or interdependent. The living creatures can be fictional, but must stick to the definition of "living" that the class discussed earlier. Nonliving elements must be present on earth. If using fictional creatures, students should provide a description, including what the creatures need to live.

The murals or drawings should clearly show the connections between the living and nonliving parts. The imaginary ecosystems may include a descriptive paragraph entitled "A visit to the ________ ecosystem."

7. Students share their ecosystems, pointing out the living and nonliving elements, and how they are connected. After sharing their paragraphs, students discuss whether or not they would like to live in their ecosystems.

VARIATION FOR YOUNGER STUDENTS

1. Ask students to close their eyes, listen carefully, and imagine themselves walking in a wild area nearby, in an "ecosystem." Ask them to imagine that they have extraordinary senses and can see and feel everything that is going on around them.

2. Explain that you will read a few lines to get them thinking, but then they will continue their walks in their own imaginations. Read the following passage aloud to the class:

"What a beautiful day to spend outside.
Most of the winter snow has melted,
leaving the ground wet and muddy.
The air is still a little chilly, but the sun breaks
through the big fluffy clouds and warms my face.
High above me, a flock of geese honk wildly,
heading to their nesting places.
I have the whole day to enjoy this!
I wonder what I will find ..."

3. Wait a few minutes. Then ask students to write a list or a paragraph describing what they saw, felt, and heard in the wild area. Younger students can do this verbally, as a class.

4. Ask a few students to read their list/paragraphs. List on the board the things that were mentioned in the reading passage that the students observed, *such as sunshine, clouds, water, snow, and geese.*

Encourage students to share the things they imagined on their own after listening to the passage, *such as plants, animals, people, and man-made things.* Note whether students visualized any interactions between the living things.

5. Using the list on the board as examples, brainstorm the differences between living and nonliving things. Summarize the differences.

6. Give each student a box of objects representing living and nonliving things. Students divide objects into living and nonliving piles.

7. Students choose two objects from each category to draw and label an imaginary ecosystem for the objects.

Evaluation:

1.Students identify living and nonliving parts of an ecosystem and explain their interaction.

2. Students identify what makes ecosystems different and provide examples using the created, imaginary ecosystems.

Curriculum Connections:

(See appendix for full citations)

Books:

Ecology (Pollock)

A Caribou Journey (Miller)

A Dead Log (Green)

Disappearing Lake: Nature's Magic in Denali National Park (Miller)

Earthwatch: Earthcycles and Ecosystems (Savan)

A Freshwater Pond (Hibbert)

One Small Square Series (Silver)

Polar Bear Journey (Miller)

The River of Life (Miller)

A Tidal Pool (Steele)

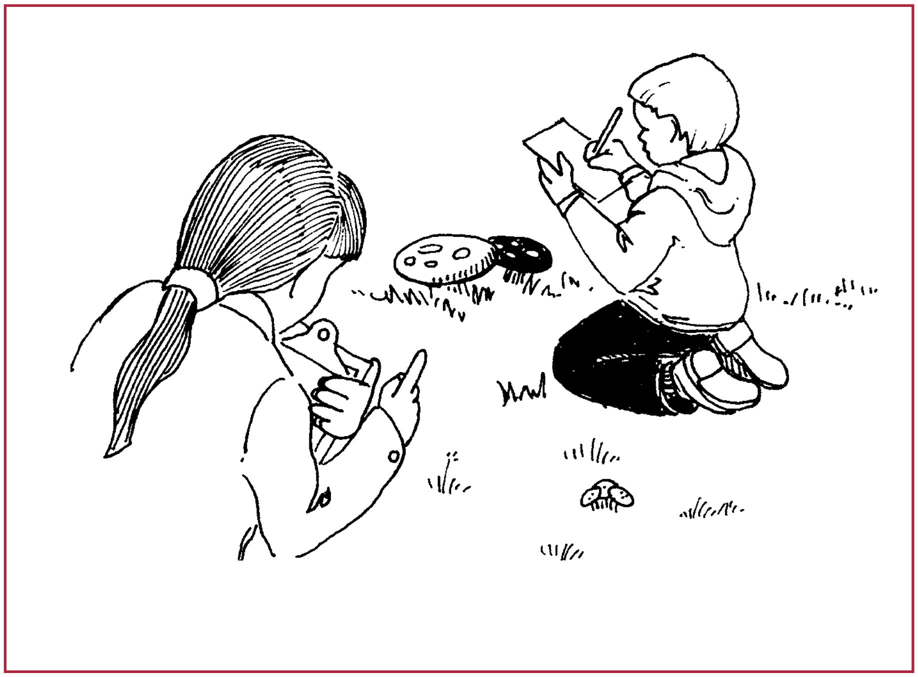
Under a Stone (Green)

Teacher Resources:

(See appendix)

Ecosystem Scavenger Hunt

ALERT: ALASKA ECOLOGY CARDS OPTIONAL



Section 3
ECOLOGY ACTIVITIES

Grade Level: 5 - 9
State Standards: S A-14, S A-15
NGSS: 5-LS2-1,MS-LS2-2., MS-LS2-3.
Subjects: Science
Skills: Observation, inferring, application
Duration: 45 minutes or more
Group Size: 3-5
Setting: Outdoors
Vocabulary: Carbon dioxide, carnivore, commensalism, consumer, detritivore, ecosystem, erosion, fungus, herbivore, interdependence, invertebrate, mammal, microscopic organism, oxygen, moss, mutualism, nonliving element, omnivore, parasitism, photosynthesis, predation, producer, recycle, respiration, symbiosis

Objective:

Students will identify concepts and components of their local ecosystem.

Teaching Strategy:

Students participate in a scavenger hunt to identify and review roles of organisms in a local ecosystem.

Complementary Activities:

"Five Kingdoms But No King," "Take a Deep Breath," *and all the* "Investigating (Nonliving Things)" *in Section 1, Elements of Ecosystems. Also* "Who Eats Whom," *and* "Create a Classroom Compost Box" *in Section 2. Also all the* "Investigating (Living Things)" *in this section.*

Materials:

Copy of the scavenger hunt list for each group *(following pages).*
OPTIONAL: *Alaska Ecology Cards.*

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems: "Five Living Kingdoms" fact sheets;* INSIGHTS, *Section 2, Community Connections; and* INSIGHTS, *Section 3, Living Things in their Habitats.*

Procedure:

IN ADVANCE: before distributing the scavenger hunt list, add specific animals, plants or other items which represent your local area.

1. Review the list of items together. Help students define unfamiliar terms.

2. Explain that some items on the "Ecosystem Scavenger Hunt List" require creative thinking. *For example, students may not see specific animals, but they could find animal signs such as droppings, browse marks or tracks. Similarly, students will not see **carbon dioxide**, but they can deduce its presence by their own presence or the presence of animals that breathe it out, or by plants which use it in **photosynthesis** and **respiration**.*

*Evidence of **symbiosis** might include a **parasitic** growth on a plant, a deer or moose (which requires **microscopic organisms** to digest its food), a swallow (which must have* *holes in trees made by woodpeckers or fungi to survive), or seeds that stick to someone's socks.*

3. Explain the rules: (a) Although students can review the *Alaska Ecology Cards* or the Glossary, they may not write anything down until the hunt begins. (b) When students find an item, they are to **write each "find" on their list rather than collecting it**. (c) Students can use the same item more than once on the list as long as the item fits more than one category. (d) The search ends when any team finds one example of each item on the list, or at the end of a specified time.

4. Once the class is outside, set clear boundaries for the hunt. Remind students to respect wildlife and the local ecosystem by leaving plants as they find them.

5. When the search ends, the first team finished reads aloud its list, explaining why their items are examples or evidence. Other teams follow with items that thy found which were different from the first team's list.

6. All teams cross from their list anything that another team also listed. Any incorrect answers must also be crossed off. Each team then adds the number of allowed items remaining on its list and scores one point per item. The team with the most points wins.

Evaluation:

Students write a description of their local ecosystem using the scavenger hunt list. Students explain the interconnections.

Curriculum Connections:

(See appendix for full citations)

Books:

Ecology (Pollock)

Dead Log Alive (Kittinger)

A Dead Log (Green)

One Small Square: Backyard (Silver)

Under a Stone (Green)

Teacher Resources:

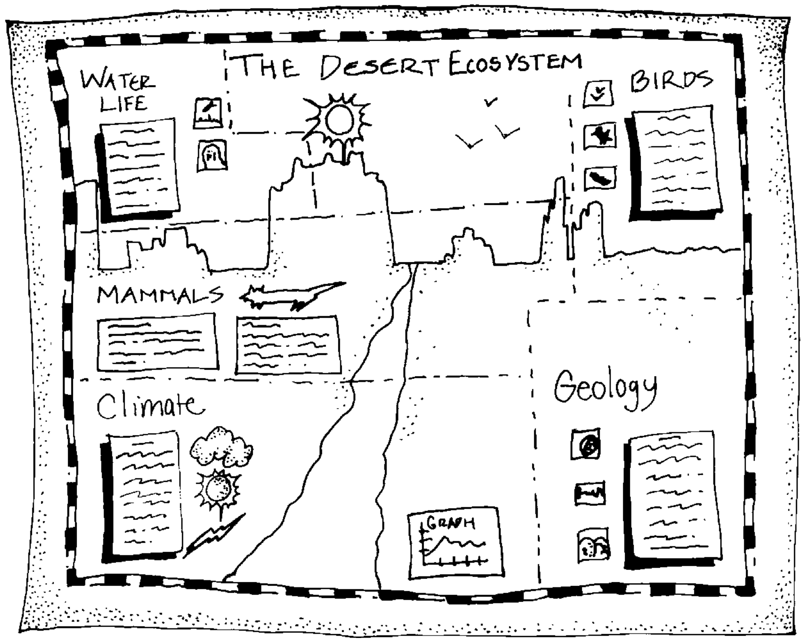
(See appendix)

Ecosystem Scavenger Hunt List

Find examples or evidence of the following and list them in the space at the right or on another sheet of paper:

a producer
a carnivore
a symbiosis
photosynthesis
parasitism
an insect
a detritivore
an herbivore
mutualism
predation
commensalism
an omnivore
an animal
a fungus
a plant
microscopic organisms
a nonliving element
an invertebrate
a mammal
interdependence
a consumer
a tree
water
erosion
a bird
oxygen
humans
carbon dioxide
recycling of minerals
a tree that died
moss

A World Tour
2 VARIATIONS and 3 EXTENSIONS



Section 3
ECOLOGY ACTIVITIES

Grade Level: 4 - 10

State Standards: S A-14, Geo C-1, Geo C-3

NGSS: 5-LS2-1,MS-LS2-2, MS-LS2-3.

Subjects: Science, social studies, art

Skills: Observing, listening, hypothesizing, comparing, writing

Duration: 100 minutes

Group Size: Whole class and small groups

Setting: Indoors

Vocabulary: Biomes, ecosystem

Objectives:

1. Students compare and contrast characteristics of different ecosystems.

2. Using photographs and reference materials, students in small groups will recognize that the nonliving components of an ecosystem affect the characteristics of the living things in that ecosystem.

3. Students identify and connect nonliving and living components of different ecosystems.

Teaching Strategy:

Working in groups, students create posters showing different ecosystems. Students "visit" them by going on a "world tour" in which they observe and record the similarities and differences between the systems and draw conclusions on the impact of the nonliving surroundings on the living things.

Complementary Activities:

This is a good synthesis, so all previous activities apply. Also "What Makes an Ecosystem" *in this section; and* "Create and Destroy" *and* "Spinning a Yarn about Ecosystems" *in Section 5, Human Impacts.*

Materials:

Drawings, photos, films, or videos of wild areas around the world; reference materials about wildlife and the environment of a variety of ecosystems *(desert, rainforest, tundra, prairie, forest, etc.)*; cardboard or tagboard for making posters; crayons, markers, paints; collage materials for making posters; 3 x 5 cards for taking notes.

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems;* INSIGHTS, *Section 2, Community Connections;* and INSIGHTS, *Section 3, Living Things in their Habitats.* Also see Alaska's Tundra & Wildlife – INSIGHTS, *Section 3: Adaptations fact sheets.*

Procedure:

IN ADVANCE: choose several ecosystems from around the world. *Ideas include the Mojave desert, tropical rainforests, Antarctica, prairies, redwood or eastern deciduous forests, lakes or rivers, Florida everglades, and coral reefs.*

Gather background and reference materials about your chosen ecosystems. *(See Teacher Resources in appendix.)* You may wish to photocopy pictures and information from reference material to provide background for the groups. *See also VARIATIONS A & B.*

1. *IN CLASS:* review the term **ecosystem**. Discuss how ecosystems differ and why. What makes nonliving things different in different places? *Focus the discussion on climate, geology, latitude, and altitude.*

2. Students list as many ecosystems as they can that are found in Alaska and then in the world. Compile the list on the board.

3. Tell each group to choose an ecosystem from the lists on the board. Students will be (a) researching their ecosystem, (b) discovering what living things exist there and describing their nonliving surroundings, and (c) how they are connected.

4. Challenge groups to create a poster that reflects the nonliving and living components that make their ecosystem *unique.*

For example, wetlands are characterized by year-round water, the nesting and growth of young insects and animals, specific kinds of vegetation such as sedge grass and willows, and migrant waterfowl.

5. Posters can include drawings, writing, collage, or real samples of living and nonliving elements. Posters should clearly show the connections between the components and how the different members of an ecosystem depend on one another. Posters may include an identification of geographic locations of their ecosystem on a world or state map.

6. Assign each member of the group a specific research responsibility. Some suggestions for dividing research responsibilities are as follows:
- Climate (average rainfall, average summer and winter temperatures, snow accumulation
- Geology of rocks and soil conditions (pH, amount of soil accumulation)
- Plants, algae, and fungi
- Fish
- Reptiles and amphibians
- Birds
- Mammals (including humans)

7. Students can record data on 3 x 5 cards which they may later tape to the ecosystem posters.

8. Ask all groups to follow a similar poster format so that the information in the posters may be compared.

9. When finished, groups present their posters to the rest of the class. Place the posters around the room and offer a world tour of the ecosystems.

10. Working individually or in small groups, students analyze each ecosystem compare and contrast the nonliving and living components.

11. After the world tour, brainstorm about the similarities and differences that the students noted.
- Where were certain plants and animals most numerous?
- Where were certain plants and animals non-existent (or very small in number)?
- Why can't all plants and animals live in all the ecosystems?
- Are there similar animals in several ecosystems that have slightly different characteristics (size, shape, color, or length of appendages)? (*For example, tundra hares have shorter ears than desert jack rabbits because they need to conserve heat.*)

11. Conclude the discussion by emphasizing the impact that the physical environment *(the nonliving components of the ecosystem, such as soil, rainfall, temperature, wind, etc.)* has on determining the living components of the ecosystem.

VARIATIONS

A. If the teacher uses posters from previous classes or collects pictures and creates the collages, (without words or information) the activity can begin with the "world tour." Use strategies for viewing real wildlife on the classroom tour *(no loud noises, safe and appropriate distance, no harassing, etc.)*. Following the tour, students can pick one poster and determine what makes it different from the other ecosystems.

B. Use photos or pictures of wild areas around the world to show to the class and identify the sites on a globe or map. Divide the students into small groups to examine all the photos and decide what the areas have in common (*air, water, soil, sun, plants, animals, etc.*). Students guess whether they might find other similarities if they visited the areas. Would they all have insects? Microscopic living things? Fungi?

Evaluation:

1. Students name five animals and five plants which could be found in their particular ecosystem. Students name nonliving elements that all ecosystems share and which are vital to the survival of living things in their ecosystem.

2. Given a certain plant or animal (an imaginary one made up by the teacher works well) with certain adaptations, students will place it in an appropriate ecosystem.

3. Students understand why the nonliving elements of an ecosystem differ.

Extensions:

A. **Compare living kingdoms in ecosystems.** Divide into groups to compare particular groups of organisms *(the five kingdoms – birds, mammals, fish, and invertebrates, or specific groups – rodents, hawks, frogs, etc.)*. Have students research the similarities and differences of the groups in different ecosystems.

• Are the number and variety of species, their physical appearances *(color, size, shape, appendages),* food habits, habitat preferences, timing of breeding, and number of young produced per year the same or different?

• Are there any trends or any generalities about the differences in the living things found in the different environments?

• If so, hypothesize why such differences exist and try to think of a way to test these hypotheses.

B. **Predict animal adaptations.** Examine and discuss some of the adaptations of animals to the Arctic. *(See Alaska's Tundra & Wildlife* INSIGHTS, *Section 3: Adaptation fact sheets.)* Then have students predict the adaptations of animals that live in a desert or tropical forest.

C. **Link to a class in another ecosystem.** Locate a teacher and a class in a different part of Alaska or elsewhere in the world willing to study the ecosystem of their area. Exchange observations with your class.

Credits:

Adapted from "Graphanaminal," Project WILD *K-12 Activity Guide*, Western Regional Environmental Education Council, 1992.

Curriculum Connections:

(See appendix for full citations)

Books:

Biomes of the World (Allaby)

Exploring Earth's Biomes series (Sayre)

One Small Square series (Silver)

Our Natural Homes: Exploring Terrestrial Biomes of North and South America (Collard)

Webs of Life series (Fleisher)

What is a Biome? (Kalman)

U-X-L Encyclopedia of Biomes (Weigel)

Media:

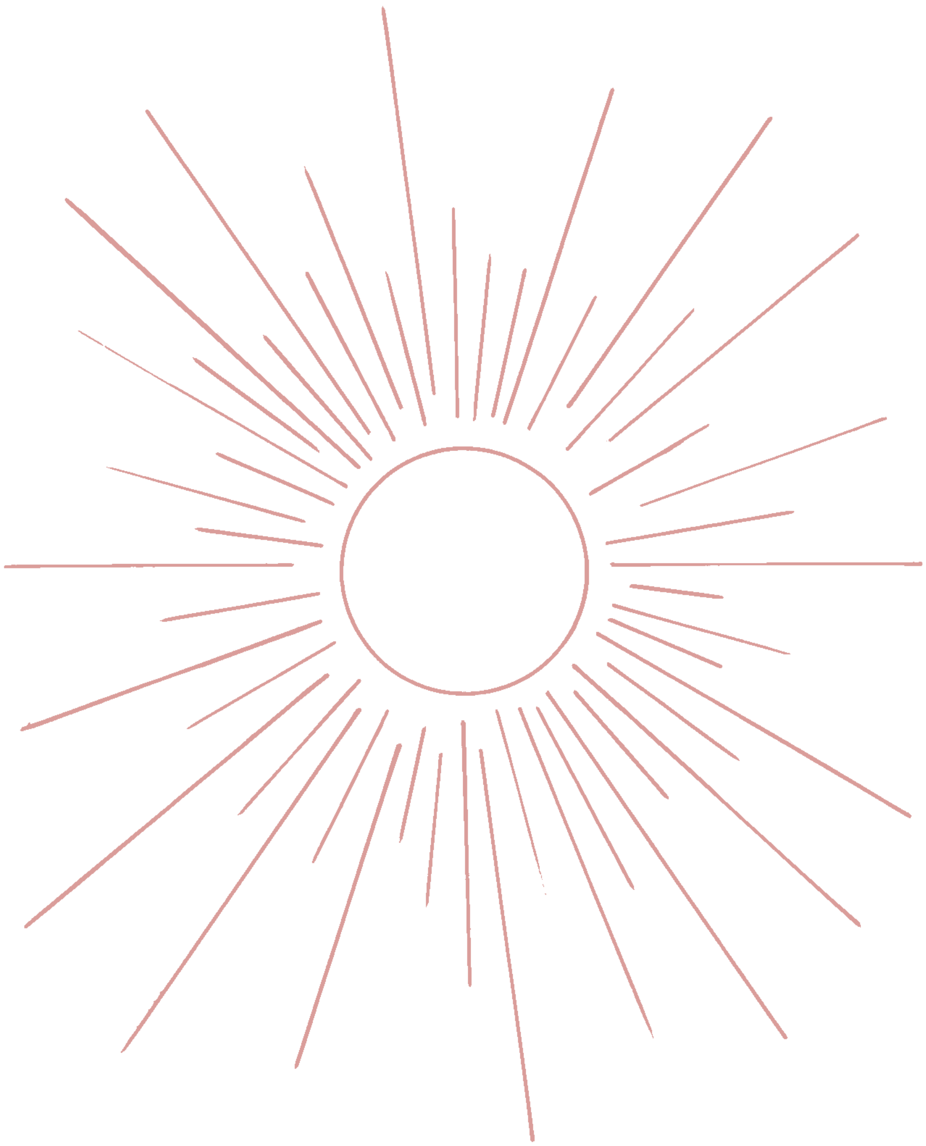
Songs of the Earth (Audio Tape or CD) (Banana Slug String Band)

Website:

Biomes of the World <www.ucmp.berkeley.edu/glossary/gloss5/biome>

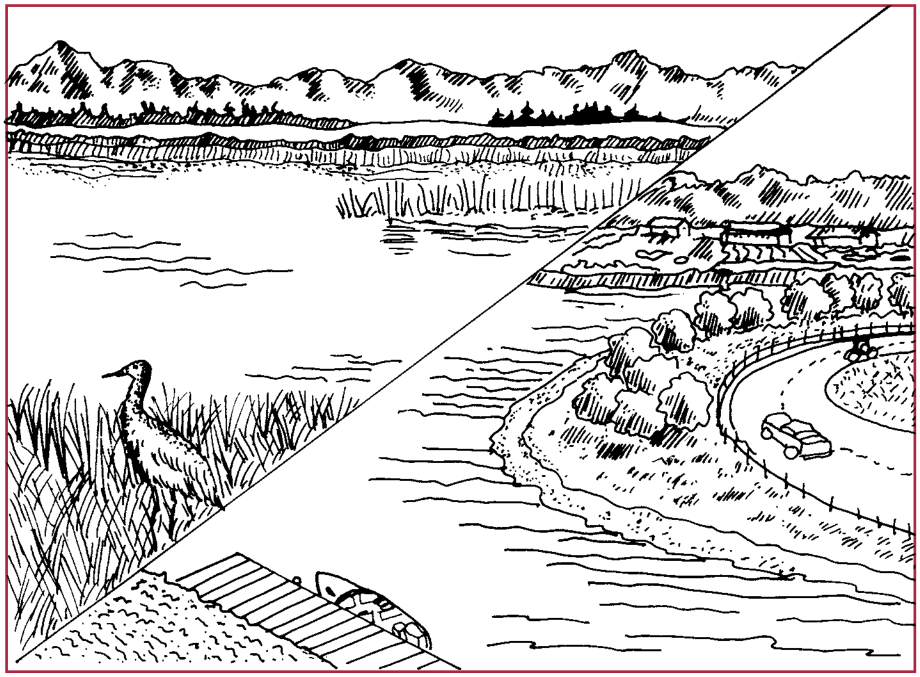
Teacher Resources:

(See appendix)



Create and Destroy

3 EXTENSIONS



Section 4
ECOLOGY ACTIVITIES

Grade: 4 - 12

State Standards: S A-14, Geo E-5
NGSS: MS-ESS3-3, MS-ESS3-4., HS-ESS3-3.,MS-ESS3-4HS-ESS3-4

Subjects: Social studies, science, art

Skills: Analyzing, classifying, interpreting, drawing

Duration: 45-90 minutes

Group Size: 2-4 and whole class

Setting: Indoors

Vocabulary: Conservation, create, destroy, habitat, nonrenewable resources, rehabilitate, renewable resources

Objectives:

1. Students will define and give examples of **conservation**.

2. Students identify and describe factors that change or destroy **habitat**.

3. Students will recommend methods for easing habitat destruction and rehabilitating destroyed habitat.

Teaching Strategy:

Students create an image of a beautiful environment, destroy it, put it back together, and discuss the relative time that it takes to **create**, **destroy**, and **rehabilitate**.

Complementary Activities:

This is applicable to all activities in this book.

Materials:

For each group: large sheets of newsprint or butcher paper, colorful drawing implements (markers, crayons, pastels, etc.), roll of masking or transparent tape.

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems;* INSIGHTS, *Section 2, Ecosystems – Community Connections;* INSIGHTS, *Section 3, Living Things in their Habitats;* and INSIGHTS, *Section 4, Human Impacts.*

Procedure:

1. Divide your class into groups and distribute the art supplies *(but not the tape)*. Tell students they will make group pictures of the most beautiful place they can imagine.

2. Brainstorm some items they might draw – things like rainbows, lakes, colorful sunsets, tundra, mountains, or forests. You may want to direct them to draw only natural objects instead of man-made items. Encourage them to include wildlife.

3. Tell the students that you will be timing the class as they **create** their pictures.

4. After 20 minutes or when the students are finished *(whichever comes first),* collect the markers and have a spokesperson from each group describe their picture to the entire class.

5. Ask the groups to exchange drawings so that each group ends up with another group's creation.

6. Tell the students that they will have *5 seconds* to **destroy** the creation in front of them. Do not give them tools such as scissors. *Most kids figure out how to destroy the drawings without help!* Students may not touch the paper until you give the signal.

7. When the ripping frenzy is over, distribute a roll of masking or transparent tape to each group. Return the originals to their creators. Ask each group to re-construct its creation *as close to its original form as is possible*. Tell the groups that you will time this process, too.

8. As the groups finish, display their reconstructed drawings at the front of the room.

9. Draw a chart on the board with the times needed to **create**, **destroy**, and **rehabilitate** each drawing.

10. Ask students to compare the times in each of the columns. Were students able to restore any of these destroyed habitats perfectly?

11. Ask the class the following questions.

- What were your feelings when you were creating your beautiful place?
- How did you feel when you saw it destroyed?
- Did you have difficulty getting your creations back together perfectly?
- Are the drawings the same as they were before destruction?
- Is it possible for humans to live in this world without destroying some habitat?
- Do we ever destroy habitat needlessly?
- How can we prevent habitat destruction?

12. Brainstorm a list of beautiful natural habitats and add them to the class chart. Discuss human actions or natural phenomena that affect their list of habitats. *For example, road-building and forest fires*. Students will have to estimate the time it takes to create and destroy each habitat unless they've already done some research.

13. Discuss **renewable** and **nonrenewable** resources. *A renewable resource is a naturally occurring raw material or form of energy which has the capacity of replenishing itself through ecological cycles and sound management practices. The sun, wind, falling water, plants, and many animals are renewable resources. Nonrenewable resources such as oil, coal, copper, and gold can only be replaced in geologic time, not human time.*

14. Discuss the word **conservation** — the use of mineral, plant and animal resources in a way that assures their continuing availability to future generations.

How can habitat conservation reduce habitat destruction? What are some current examples of (a) **habitat destruction** (*clearing a forest for a school or mall, fishing on unprotected river banks, etc.*), (b) **conservation** (*prescribed burns, planning for human access, etc.*) and (c) **rehabilitation** (*river bank improvement projects, rehabilitation following mining and logging*)?

Evaluation:

1. Write a paragraph or poem describing your feelings about environmental destruction and rehabilitation.

2. Name five types of environmental destruction and five ways that humans can rehabilitate a habitat following this destruction.

EXTENSIONS:

A. **Schoolyard rehabilitation project.** Students consider how they can rehabilitate the environment around their neighborhood or school and develop a class project based on class suggestions.

B. **Research, design, present solution to dilemma.** Students write to a local, state, or national government official or governing body presenting a position, solution, and defense to a real conservation dilemma. The students will need to research an area which is being affected, design a plan to conserve the area, estimate costs of the rehabilitation plan, and defend his/her idea in writing.

View points should come from the students' values, interest, and knowledge gained through research. Opinions may vary from student to student on how lands should be conserved. Create an acceptable environment for students to have differing viewpoints.

C. **Turn thoughts into poetry.** Share the following poem with students. Students may want to write their own poetry following a discussion of the poem.

The Peace of Wild Things
by Wendell Berry

When despair for the world grows in me
and I wake in the night at the least sound
in fear of what my life and my children's lives may be,
I go and lie down where the wood drake
rests in his beauty on the water, and the great heron feeds.
I come into the peace of wild things who do not tax their
lives with forethought of grief.
I come into the presence of still water.
And I feel above me the day-blind stars
waiting with their light. For a time
I rest in the grace of the world, and am free.

From *Collected Poems, 1957-1982*, Berkeley, California North Point Press, 1985.

Credit:
Contributed by Colleen Matt, Alaska Department of Fish and Game, Division of Wildlife Conservation.

Curriculum Connections:
(See appendix for full citations)

Books:
Farewell to Shady Glade (Peet)

Kid's Guide to Social Action (Lewis)

Little House (Burton)

Miss Rumphius (Cooney)

Sign of the Sea Horse (Base)

Window (Baker)

The Wump World (Peet)

Website:
Preventing Waste for Schools
http://www.stopwaste.org/preventing-waste/schools
Recycling in Alaska
http://dec.alaska.gov/eh/solid-waste/recycling-in-alaska.aspx

Teacher Resources:
(See appendix)

Watching Your Waste

3 EXTENSIONS

Section 4
ECOLOGY ACTIVITIES

Grade Level: 2 - 9

State Standards: S B-1, Gov E-6
NGSS:K-2-ETS1-1,5-ESS3-, MS-ESS3-3, MS-ESS3-4, HS-. ESS3-3,HS-ESS3-4

Subject: Social studies, science, math, language arts, art

Skills: Observing, recording, analyzing, applying

Group Size: Small or Individual

Duration: Teacher determines

Setting: Indoors

Vocabulary: Decomposers, detritivores, limited resources, nonrenewable, recycle, renewable, synthetic

Objectives:

1. Students will measure, describe, and evaluate their household's or school's output of waste materials.
2. Students will make a waste reduction plan for home or school.

Complementary Activities:

"Create and Destroy" *in this section; and* "Mineral Cycling through an Ecosystem" *and* "Create a Classroom Compost Box" *in Section 2, Ecosystems – Community Connections.*

Materials:

Pencil and paper, bathroom scale, containers for separating and weighing trash.

Background:

See INSIGHTS, *Section 4, Human Impacts* and INSIGHTS, *Section 2, Ecosystems – Community Connections.*

Procedure:

1. Ask students to think about things that are thrown away in our homes and schools everyday. Generate a class list of categories that make up our garbage at school or at home *(i.e. food waste, paper waste, plastics, aluminum, etc.).* Ask students to predict the percentage of their home garbage that falls into each category.

2. Ask students to inventory the waste materials produced by the class or the school, their households or community:

- ***At home***, students and their families separate their waste by category for a day or a week, weighing each on a bathroom scale. Students can record their daily waste production by category. These data can be presented in a chart, with category percentages.

- ***At school,*** classes monitor waste produced by the lunchroom or office as well as in a classroom.

- ***In the community***, a study of waste produced by the town could include a trip to the dump or to the sewage treatment plant.

3. As a class, evaluate the origin of the largest percentage of household or school trash. Choose a common item from this category and follow its cycle from its basic elements to its eventual disposal. Where does this item go after we use it? What is it made from? Is that material recyclable?

See if your item is a part of a cycle, or reaches a dead end for years at a landfill.

4. To set the stage for the discussion stage of this activity, show "The Rotten Truth" or "Its Gotten Rotten" or share a resource book with students from the list of references to focus students on the need to reduce dead-end waste.

5. How does your community deal with waste? How long will waste materials last? Will they ever decay? Are any recycled? Which waste materials will decompose quickly in nature?

6. Discuss the concept of **limited resources** and list some examples that students or others in the community frequently use *(old-growth timber, fresh water, and products that rely on a lot of agricultural land)*.

7. Contrast these with **nonrenewable resources** such as oil and metals such as gold and aluminum. Nonrenewable resources are also limited. *They will only be replaced naturally within geologic time, not human time.*

8. What changes can people make to become less reliant on nonrenewable resources and conserve them for the future? Focus the discussion on ideas relating to reducing use, reusing old materials, recycling, or rethinking ways to conserve our limited resources.

9. You might want to incorporate a discussion of **renewable resources** here. *(Resources that replace themselves over time such as trees or that are inexhaustible such as sunshine and wind).* Discuss what might make Alaska unique in terms of waste disposal.

10. Working in small groups, students design a plan to recycle either all or one of the waste elements that currently are discarded by their home, school, or community. Encourage them to think of ways to recycle both the organic and inorganic wastes.

11. Each student (or group of students) writes up a proposal that includes how the plan would work, what would be recycled (also what could not be recycled), and how much implementation of the plan would cost. Include a statement of advantages and disadvantages of each plan.

12. If possible, set up a compost box either in the classroom or at the lunchroom. *See Section 2 activity "Create a Classroom Compost Box" for instructions and suggestions.*

Evaluation:

1. Present recycling and waste reduction ideas to others in the class. The class decides the best system considering feasibility, costs, and effectiveness. Present ideas to the appropriate administrators and building support staff.

2. Represent data collected on a household or school waste survey in a table or graph. From this information, students can write summary statements and draw conclusions.

EXTENSIONS:

A. **Create skits or big books.** Students create skits or plays to present to the class or to other classrooms that deal with reduction of waste. Big books could also be created by older students to share with those at younger grade levels.

B. **Send a community message.** Students create an illustrated pamphlet, radio message, or video for the community, incorporating ideas on diminishing waste. *(One idea might be using popcorn instead of Styrofoam when mailing items Outside.)*

C. **Research hazardous waste disposal.** Older students research hazardous waste products, determining which of these products exist in the home. Students research the "life cycle" of these products, discovering how these products are usually disposed of in their community. A plan could be developed toward educating community members on the least harmful disposal of hazardous waste items.

Credit:

This activity was modified by Val Chabot, Eagle River, Alaska.

Curriculum Connections:

(See appendix for full citations)

Books:

50 Simple Things Kids Can Do to Recycle (EarthWorks Group)

Chattanooga Sludge (Bang)

Compost Critters (Lavies)

Just a Dream (Van Allsburg)

Kid's Guide to Social Action (Lewis)

The Lorax (Seuss)

The Paper Bag Prince (Thompson)

Reducing, Reusing and Recycling (Kalman)

The Worm Cafe: Mid-Scale Vermicomposting of Lunchroom Waste (Payne)

Worms Eat My Garbage (Appelhof)

Wump World (Peet)

Media:

It's Gotten Rotten (Video) (Gr. 9-12)

The Rotten Truth (Video)
(Children's Television Workshop)

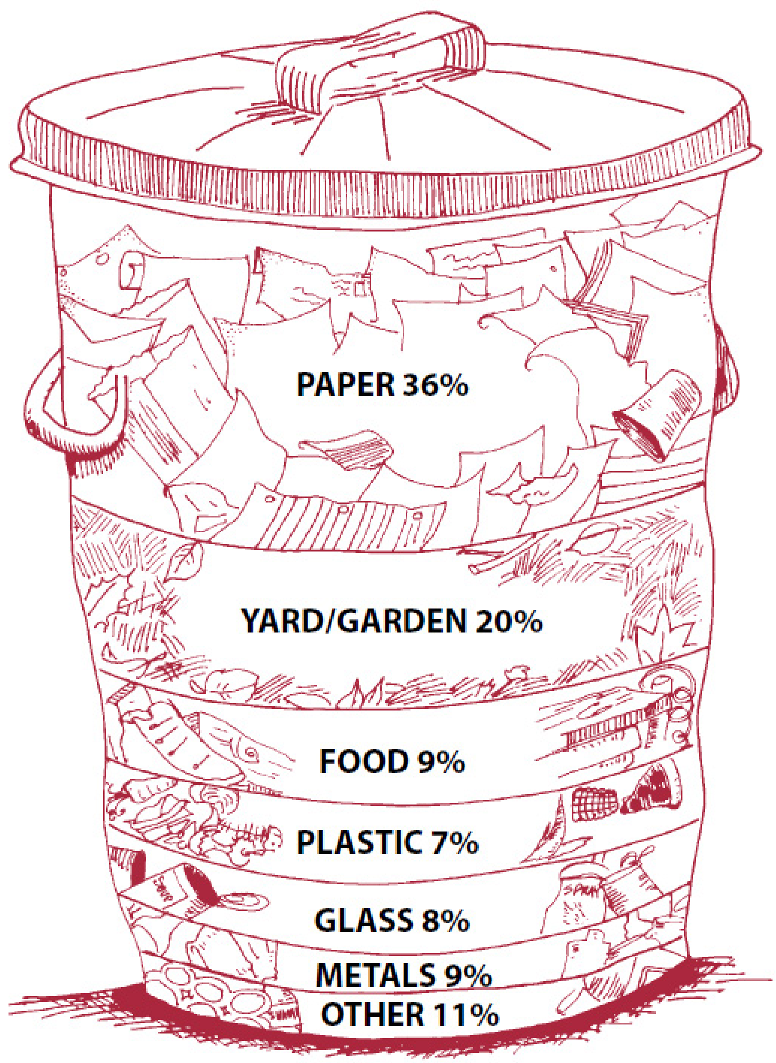
Website:

EPA Office of Solid Waste. *Students' and Teachers' Page* <www.epa.gov/epaoswer/osw/students.htm>

School Resources for Waste Prevention and Recycling <www.deq.state.ok.us/waste/education/resources2.html>

Teacher Resources:

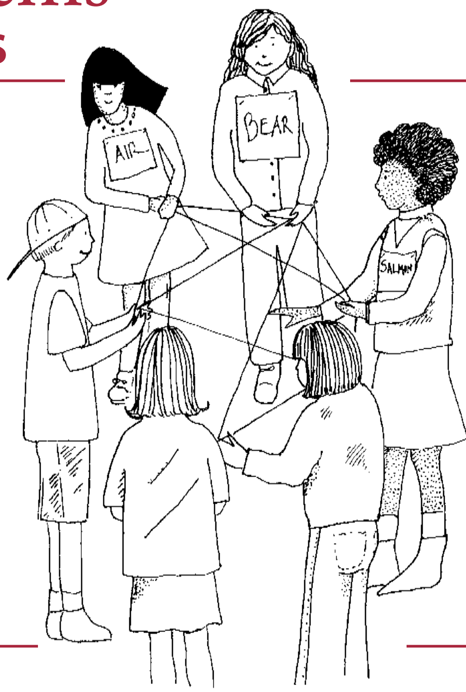
(See appendix)



Solid Waste in Anchorage, Alaska
Statistics reported by
Anchorage Recycling Center,
Anchorage, Alaska

Spinning a Yarn about Ecosystems

4 EXTENSIONS



Section 4
ECOLOGY ACTIVITIES

Grade level: K - 12

State Standard: S A-14
NGSS: K-ESS3-1,5-LS2-1, MS-LS2-2, MS-LS2-3, MS-ESS3-4, HS-LS2-4, HS-LS2-5, HS-LS2-6.

Subjects: Science, art, language arts

Skills: Analyzing, applying

Duration: 30 minutes

Group Size: Groups and whole class

Setting: Outdoors or indoors

Vocabulary: Carnivore, consumers, detritivore, ecosystem, herbivore, omnivores, producer

Objective:
Students will be able to describe why changes in one part of an ecosystem can affect other, seemingly unrelated parts.

Teaching Strategy:
Students standing in a large circle represent an ecosystem. Each student represents a different part of an ecosystem. Yarn connects all of the students in an intricate web.

Complementary Activities:
This is a good synthesis, so all activities in this book apply.

Materials:
One large ball of yarn, scissors, name cards representing living and nonliving parts of an ecosystem (pre-made or students can make them), a list of Alaska organisms from "Alaska Food Chains and Webs" from INSIGHTS *Section 2.*

Background:
See INSIGHTS, *Section 1, Elements of Ecosystems;* INSIGHTS, *Section 2, Ecosystems – Community Connections;* INSIGHTS, *Section 3, Living Things in their Habitats;* and INSIGHTS, *Section 4, Human Impacts.*

Procedure:
1. Divide the class into five groups: nonliving things *(sun, water, minerals)*, producers, herbivores, carnivores, and detritivores.

2. Using a list of Alaskan organisms and nonliving things, assign or have each student choose a different organism or nonliving thing that they will represent from their group.

3. Each student should create a name tag for his choice (*for example, the nonliving groups can choose to be sun, water, air, soil*). The name tag should include the name of the organism or nonliving element in large letters. Students may also draw what they want to represent on the nametags.

4. Students should work in groups combining their knowledge or using reference materials to determine how their organism or element relates to other parts of the food

web. Each student should be aware of what their element needs to survive, and what other elements rely on it for survival.

(For example, a mosquito could eat nectar from plants or blood from warm-blooded animals and, in turn, they are eaten by bats and birds. Mosquitoes also need warmth from the sun, air for flying, and fresh water for eggs and larvae.) Have students include this type of information on the back of the card, if appropriate.

5. After students have donned their name tags, have the groups break apart and mingle randomly with the other students. Students "introduce themselves" as the organisms or elements represented on their cards. Following introductions, arrange the students in a large circle, arms distance apart.

6. Hand the ball of yarn to the sun and instruct the sun to say "I am the sun and plants need me in order to live." Holding on to the end, the sun then should pass the ball of yarn to a plant. For example, the sun might hand the ball of yarn to a willow.

7. As the web begins, be very explicit that no one is to throw the yarn or pass it without the complete attention of the other class members. Explain that one organism (or nonliving thing) must "interact" with another by first stating the relationship between the two, and then by passing the ball of yarn to the next person in the food chain. *For example, the willow would say, "I am a willow, (a producer) and I am eaten by a moose."*

8. The receiving organism (or nonliving thing) should then wrap the ball of yarn **loosely** around a finger and continue the chain. **Remind students not to pull on the yarn!**

9. Review the rules of the game until each student understands the procedure.

10. Continue until all the students are holding the yarn at least once. Get as many "interactions" as possible so that there will be a net of yarn connecting the students.

11. Reinforce the concept that all living and nonliving things are connected, as has just been demonstrated. Ask the students to predict what would happen if one organism or nonliving thing was removed from the web.

12. Pick one member of the web, (*for example, a salmon*) and ask students to identify other web members that would be affected if this animal disappeared. Reinforce that each member of the web is connected and cannot leave without affecting every other part of the ecosystem.

13. Have pairs of scissors ready and cut students free of the yarn when the activity has demonstrated the connections in ecosystems. Collect the yarn and cards and ask students to reproduce their webs in a bulletin board or mural display.

Evaluation:

1. Students draw a food web from their own local ecosystem or from another area. They explain the relationships between the elements in the web.

2. Students list all possible relationships for their web element. *For example, a willow* needs *sun, soil, water, air, and detritivores to break down organic material for minerals. A willow is* needed *by moose, hares, birds (for nesting), carnivores (for cover), and detritivores (after the willow leaves fall or the plant dies).*

EXTENSIONS:

A. **Reflect on activity in words or drawings.** Students describe in words or pictures the interconnections depicted by the web, including what happens if the web is broken or one of the web members is missing.

B. **Experiment with "What Ifs" in the yarn web.** After the web has been established, instruct one of the migratory animals (bird, salmon, or caribou) to move. The entire web will need to move or be modified in order to survive. What are the closest connecting elements to the migratory animals?

While the class is still attached in the web, discuss what happens in a real ecosystem when migratory animals move away. What about animals that hibernate in the winter? How are other members of the ecosystem affected? What happens if pollution occurs in a part of the ecosystem? What if the population of one element grows too large for the ecosystem to support?

C. **Describe their living kingdom.** If students have studied the five kingdoms of life, have each web element describe their kingdom.

D. **Trace pollution through the food web.** Simulate an environmental disaster once the web has been set up. Show how toxins, like oil or lead, can be passed by consumers through an ecosystem until almost all members have been affected.

Credits:

Activity contributed by Steve Kemper, Anchorage, and modified by Val Chabot, Eagle River.

Curriculum Connections:

(See appendix for full citations)

Books:
One Small Square Series (Silver)

Webs of Life Series (Fleisher)

What are Food Chains and Webs? (Kalman)

Who Eats What? Food Chains and Food Webs (Lauber)

What is a Biome? (Kalman)

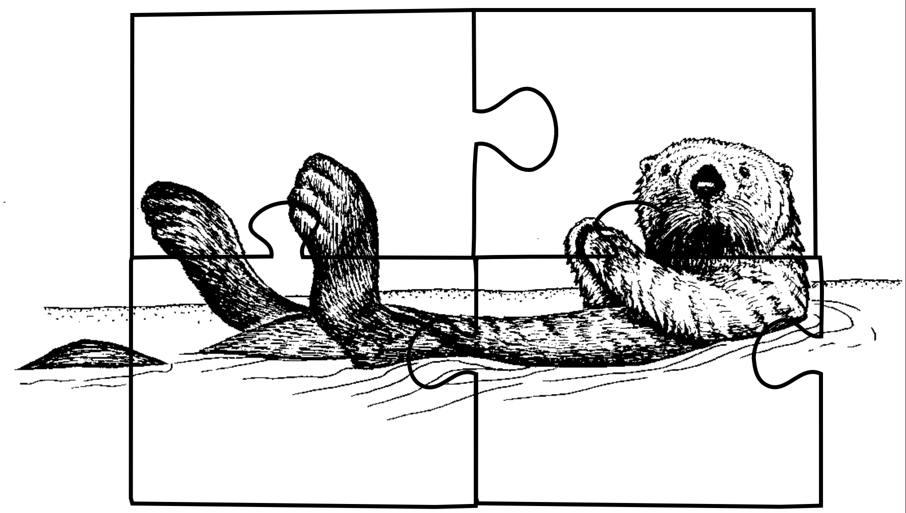
Media:
Into the Forest, Krill, Onto the Desert, Predator (Nature's Food Chain Games) (Ampersand Press)

Teacher Resources:

(See appendix)

Ecology Puzzlers

1 EXTENSION



Section 4
ECOLOGY ACTIVITIES

Grade Level: 7 - 12

State Standards: S A-14, S B-15, Geo E-5
NGSS:
Subjects: Science, social studies, language arts

Skills: Reading, analyzing, hypothesizing, concluding

Duration: 60-120 minutes

Group Size: 2-4

Setting: Indoors

Vocabulary: See each Puzzler

Objective:

Given an environmental dilemma, students will be able to analyze causes and effects.

Teaching Strategy:

Students work in small groups on "Ecology Puzzlers" which describe actual situations.

Complementary Activities:

"Create and Destroy" *in this section.* "Investigating (Nonliving Things)" *in Section 1;* "Who Eats Whom," "Oh Moose," *and* "Mineral Cycling" *in Section 2; and* "Investigating (Living Things) *in Section 3.*

Materials:

Copies of the Ecology Puzzlers (*following pages*).
OPTIONAL: research materials.

Background:

See INSIGHTS, *Section 1, Elements of Ecosystems;* INSIGHTS, *Section 2, Ecosystems – Community Connections;* INSIGHTS, *Section 3, Living Things in their Habitats;* and INSIGHTS, *Section 4, Human Impacts.*

Puzzler Concept:

The following Puzzler pages are intended to encourage students to think and apply their knowledge of ecology. They must use their understanding of food webs and chains, mineral cycling, and symbiosis in order to answer the puzzle questions. All of the examples are real world ecological problems.

"What Really Happened" follows with a summary of the observations and opinions of scientists who have studied these ecology problems *(with the original reference citation included)*. Some of the problems are evolving, with final resolutions still to be written. For research suggestions, contact the Division of Wildlife Conservaton/Wildlife Education.

Procedure:

1. Give each group a different Ecology Puzzler. Ask each group to read the facts and try to solve the puzzle featured at the bottom of the page. Tell them to record their answers on paper. Do not give them the section, "What Really Happened."

2. Each group should research their problem, define difficult vocabulary, and prepare a presentation to the entire class.

3. Groups make their presentation to the whole class about their puzzle. Be sure that each group gives both the causes and effects of their ecological problem.

4. Groups could take suggestions for solutions from the class at this time. As part of their report, groups should give the solutions that they suggest for their own puzzle.

5. Hand out the appropriate "What Really Happened" information sheets to each group. Were the "real" solutions as good as each group's solution? Why would the real solutions differ from the students' hypothetical solutions?

6. After reviewing and discussing the puzzles, ask students to discuss how they might be affected individually by an ecosystem change. How might humans in general be affected? Ask students to discuss how they might **contribute** to each specific ecological problem.

- For example, placer mining affects stream ecosystems. Is gold used in any material used by students *(jewelry, computers and other electronics, tooth fillings)*?
- Pesticide pollution is a problem. Do students eat foods from agricultural crops that are raised with the use of pesticides?
- The increasing amount of carbon dioxide in the atmosphere is a problem. Do students (or their families) burn fossil fuels?
- Plastic particle pollution (caused by ocean dumping) is a problem. Do students use plastics?

7. Ask students to discuss how and whether they, individually, or collectively as a community, could help **solve** or **reduce** these ecological problems.

Evaluation:

Choose one of the puzzlers and describe the problem, its cause and effects, and describe possible solutions.

EXTENSION:

Research a local cause and effect. As a research project, students (individually or in groups) select a local human activity and evaluate its effects on local ecosystems. Students must decide what facts they need, then gather them through resource materials, by interviewing experts, and/or by making observations and collecting data. Students individually or in groups write a report that includes:

- A description of the effects of the activity on the ecosystem based on their knowledge of ecology.
- An evaluation of the advantages and disadvantages of the human activity (from the perspective of both humans and wildlife)
- Possible methods of reducing or preventing the undesirable effects.
- Suggestions of legislation needed. Students might write letters to local representatives.

Curriculum Connections:

(See appendix for full citations)

Books:

The Case of the Mummified Pigs; and Other Mysteries of Nature (Quinlan)

Chattanooga Sludge (Bang)

Ecological Mystery Series (George)

Endangered Species (de Koster)

Extinction is Forever (Silver)

Nuclear Power: Promise or Peril? (Daley)

Our Endangered Earth (Langone)

Pollution: Examining Causes and Effect Relationships (Anderson)

Websites:

Alaska Statewide Databases, accessed through your local library website or <sled.alaska.edu >

Anchorage *Daily News* <www.adnsearch.com> Staff written newspaper articles, current and past. Article citations can be located at no charge. For full text, a fee must be paid.

Environmental News Network <www.enn.com> Searchable by subject. Good for current news articles.

Fairbanks *Daily News-Miner* <www.newsminer.com> Staff-written newspaper articles, current and past, no fee.

ADFG Wildlife News. http://www.wildlifenews.alaska.gov

<u>This "Otter" Be Examined</u>

Books:

Sea Otters (Silverstein)

Websites:

Environmental News Network <www.enn.com> For recent articles including some on the problem with the orcas preying on the sea otters.

<u>Cracked Eggshells</u>

Books:

Frightful's Mountain (George)

Websites:

Tundra Peregrine Falcons in the North Yukon <www.taiga.net/coop/indics/peregrin.html>

U.S. Fish and Wildlife Service <refuges.fws.gov > From the home page select *Wildlife* and then *Species Account,* then *Birds.* From there you can find information on the arctic peregrine falcon.
U.S. Fish and Wildlife Service <endangered.fws.gov/peregrin.html> Information on the peregrine falcon.

<u>Pass It On</u>

Books:

Air Alert: Rescuing the Earth's Atmosphere (Miller)

Website:

University of Alaska Fairbanks Reindeer Research Program <reindeer.salrm.alaska.edu/index.htm>

Some Plastic Rap

Websites:

Plastics in Our Oceans <www.umassd.edu/Public/People/Kamaral/thesis/plasticsarticle.html>

<u>All That Glitters Is Not Gold</u>

Books:

Come Back Salmon (Cone)

The River of Life (Miller)

Websites:

Adopt-a-Stream <www.streamkeeper.org/opportun/links.htm> Has links for stream restoration, resource protection, and water quality.

Streambank Revegetation and Protection: A Guide for Alaska http://www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.intro

<u>Rainforests, Volcanoes, and Glorious Sunsets</u>

Books:

The Amazon Rain Forest (Johnson)

Our Endangered Planet: Atmosphere (Hoff)

Websites:

EPA Climate Change: https://www.epa.gov/climate-indicators/weather-climate
explorezone<explorezone.com>

The US Global Change Research Information Office <www.gcrio.org/gwcc/toc.heml>

Yahoo Geocities <yahoo.geocities.com> Type in the subject box *Greenhouse Effect* and/or *Global Warming* for numerous websites.

Teacher Resources:

(See appendix)

Ecology Puzzler

This "Otter" be examined

THE FACTS

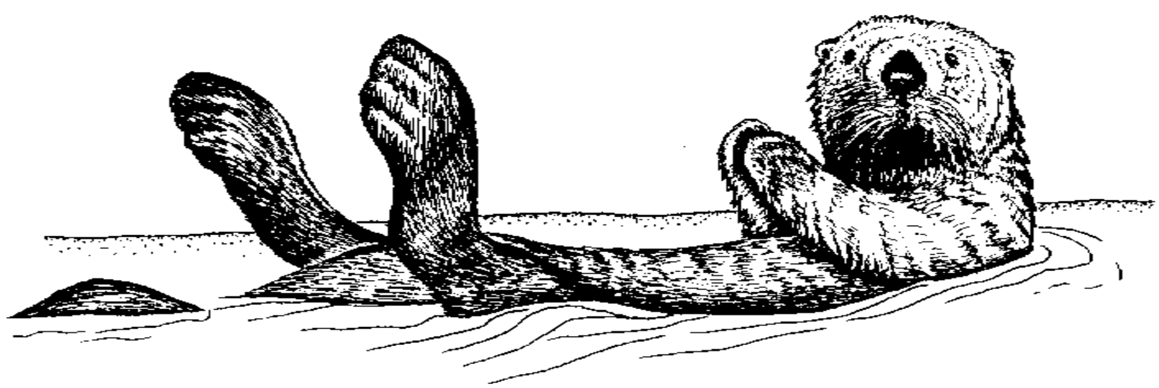
Sea otters feed on a variety of marine **invertebrates**, including crabs, clams, mussels, limpets, sea stars, and sea urchins. They also eat some fish.

Crabs, limpets, sea stars, and sea urchins live along rocky, wave-washed coastlines. Limpets and sea urchins feed on algae and kelp.

Dense stands of algae and kelp can reduce the force of waves, so that floating algae and **detritus** (decaying plant and animal material) are trapped and deposited on the sea floor.

Amphipods, isopods, and some shrimp live in dense kelp beds and feed on algae and detritus. Many predatory fishes feed on amphipods, isopods, and shrimp.

Sea otter **populations** were reduced to near **extinction** due to overharvesting between 1750 and 1900 by Russians, Americans, and other traders who sold their fur. After sea otters and their habitat were protected by international treaty, laws, and refuge designation, the population **recovered** in much of Alaska.



THE PUZZLE

Explain how you think the aquatic ecosystem might have changed when sea otter populations were reduced. What changes probably occurred when sea otters were re-established

Ecology Puzzler

This "Otter" be examined

WHAT REALLY HAPPENED

Since there were no studies of the marine ecosystems in 1700 prior to the decline of sea otters, the effects of removing them at that time are not certain. In some areas where sea otters were killed off, it appears that populations of sea urchins and limpets increased. These **herbivore** populations then reduced the amount of kelp and sessile algae *(stationary)* growing in nearshore waters.

Alaska's Aleutian Islands were a center for early exploitation of sea otters. Because there are so many islands, however, and some are hard to approach, several small **populations** of sea otters survived. They slowly grew and slowly spread to nearby islands.

From 1970 to present biologists recorded changes in the ecosystem that occurred as sea otters repopulated islands in the Aleutians.

The sizes and numbers of limpets and sea urchins (both grazing herbivores) were reduced due to sea otter **predation**. This reduced grazing pressure on kelp and algae and allowed dense underwater forests to develop.

These kelp forests reduced the force of wave action and trapped silt and detritus. Limpets and mussels cannot hold fast to silty rocks so they became fewer in number. The kelp forests provided a good environment for filter-feeding herbivores (amphipods, isopods, and shrimp) that eat **detritus** and algae floating in the water. These in turn provided food for predatory fishes, so they moved into the area.

The changes observed did not necessarily occur in all areas, however. A variety of factors, including the force of the incoming waves, the bottom, and the relative abundance of the various **producers** and herbivores combine to cause different kinds of ecosystem responses in some areas. Large sea otter populations have been known to depress populations of prey (including sea urchins, crabs, and abalone) in other areas.

NEW 2000 MYSTERY: In 2000 biologists surveying sea otters in the Aleutian Islands found a 70 percent decline in sea otter numbers in less than a decade. What is happening in the Bering Sea and North Pacific Ocean to cause this magnitude of change?

The sea otters seem healthy and their food seems to be plentiful. Orcas (killer whales) have been preying on sea otters as never before seen. But can that account for such great loss of numbers? Scientists have yet to discover the answer.

Ecology Puzzler

Cracked Eggshells

THE FACTS

DDT is a pesticide used to kill problem insects. It was widely used on farmlands *(to kill insects that ate crops)* and on wetlands *(to kill mosquitoes)* in the Lower 48 and Europe from 1946 until 1969, when its use was outlawed in the United States, Canada, and most European countries. It is still being used extensively in South America and Asia.

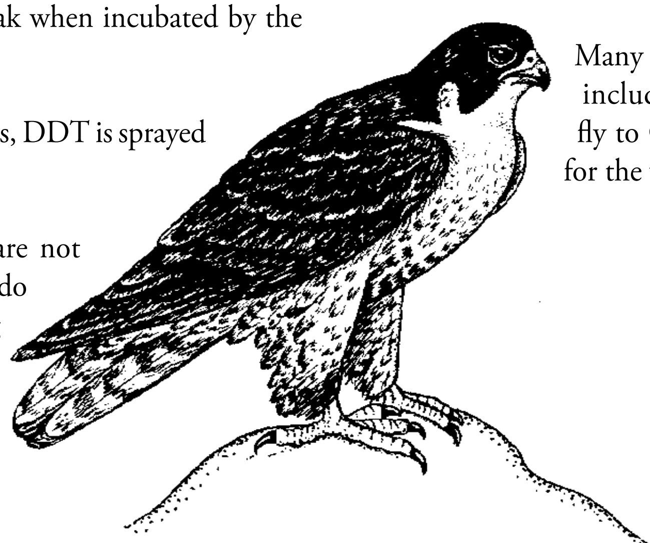
DDT is very poisonous to most living things, including humans. Concentrations of less than 10 parts per million cause bird eggs to be thin-shelled. This makes the eggs more likely to break when incubated by the parent.

When used to control insects, DDT is sprayed on plants from the air.

Because DDT molecules are not very soluble in water, but do dissolve in oil, most living things are not able to excrete DDT in waste materials. Instead it accumulates in body fat and tissues.

DDT is broken down extremely slowly, if at all, by detritivores and weathering. Thus, any DDT applied to the environment continues to exist and remains poisonous for decades.

Peregrine falcons prey on small birds, particularly shorebirds and ducks.



Many of Alaska's migratory birds including shorebirds and ducks fly to Central and South America for the winter.

THE PUZZLE

1. Based on what you know about ecology, why is DDT now found in the systems of nearly all living things, including penguins in Antarctica, humans in Alaska, and in other areas where it was never used?
2. Why do you think that peregrine falcons nesting in northern Alaska continued to have poor nesting success for several years after the few remaining falcons in the Lower 48 appear to have improved nesting success

Ecology Puzzler

Cracked Eggshells

WHAT REALLY HAPPENED

DDT is now found in living things around the world because it was spread in the atmosphere by winds and deposited with rain from the Arctic to the Antarctic. Particles were washed into rivers, lakes, and oceans where currents continued the spread. Since DDT breaks down so slowly, repeated applications of the chemical rapidly increased the amount present in the earth's environment.

A marsh in New York that was sprayed with DDT for 20 years had DDT residues amounting to 32 pounds per acre. Almost all the DDT eaten by a living thing remains in its system for life, concentrating in tissues and fats. An **herbivore** that eats a producer with DDT in it, retains all the **producer's** DDT and stores it in its own system. A **carnivore**, after eating dozens of herbivores – each with a small store of DDT – ends up with a much higher concentration of DDT than any one of its prey.

Top carnivores that eat other contaminated carnivores concentrate the poison even further – and end up with toxic concentrations. For example in the New York marsh mentioned above, plankton in the water had concentrations of .04 parts per million (ppm), while minnows had 1 ppm, and a gull (carnivorous scavenger) had 75 ppm in its body.

Since DDT use has been halted in the Lower 48 for about 25 years, the concentration of DDT in the environment is decreasing. What remains is spread by winds and water over a larger area. Some of it is becoming trapped in the bottom of lakes and on the bottom of the ocean. The amount of DDT accumulating in **food chains** is decreasing in the Lower 48.

While it is illegal to use DDT in the U.S. (except by special permit), it is still being manufactured and exported to other countries where it is used as a pesticide. In winter, peregrines migrating to other countries eat local birds that ingest DDT. In summer, peregrines may ingest more DDT because the birds they eat in Alaska migrate from other countries to nest here. The use of DDT in peregrine wintering habitat is decreasing and the damaging effects on these falcons, such as eggshell thinning, have declined.

Peregrine falcons are increasing in number and locations in the United States and Canada. One subspecies in Alaska and Canada, the Arctic peregrine, was removed from the federal Endangered Species List in 1994. Another subspecies, the American peregrine falcon was removed in 1999 when its populations reached conservation goals.

Ecology Puzzler

Pass It On

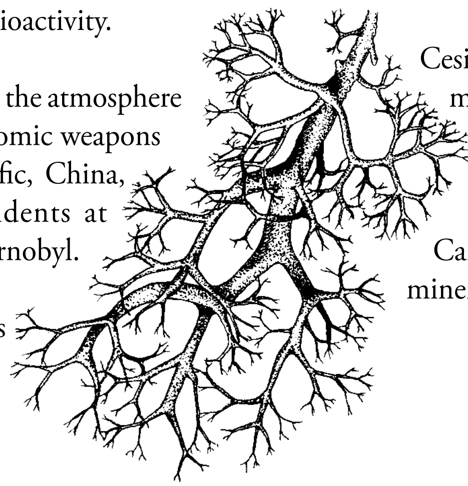
THE FACTS

The radioactive isotope cesium 137 is a product of atomic fission reactions such as the explosion of nuclear weapons. It has a **half-life** of 30 years, which means that it loses half of its radioactivity every 30 years. After 60 years, it still has 1/4 of its original radioactivity, and after 90, it has 1/8 its original radioactivity.

Cesium 137 has been released into the atmosphere by above-ground explosions of atomic weapons in the United States, South Pacific, China, Russia, and Japan and by accidents at nuclear power plants such as Chernobyl.

Air circulation and magnetic fields around the globe cause more Cesium 137 to be deposited in the Arctic than elsewhere.

The effects of radiation from radioactive materials on living things depends on many variables, such as the intensity of the radiation and the length of exposure.



Prolonged exposure to even low levels of radiation can cause cancer and other diseases in living things.

Cesium 137 has chemical properties that make it react with other chemicals in ways similar to potassium.

Cesium 137 accumulates in tissues as it moves up the **food chain**. Potassium is an essential mineral in the cells of living things.

Caribou eat lichens. Lichens obtain the minerals they need from rain water.

THE PUZZLE

Based on what you know about ecology, explain why you think some humans living in arctic regions have had concentrations of cesium 137 in their tissues over three times the concentration found in precipitation in their area.

Pass It On

WHAT REALLY HAPPENED

Atmospheric testing and explosions of atomic weapons sent cesium 137 and other radioactive isotopes high into the earth's atmosphere. They were spread widely and quickly by air currents. The isotopes were eventually washed out of the atmosphere by rain and deposited on vegetation, land, and water.

In part due to the patterns of air circulation, and in part due to the earth's magnetic fields, more Cesium 137 has been deposited in the Arctic than elsewhere.

Lichens are a dominant **producer** in the Arctic. These **symbiotic** organisms get most of their nutrients from rainwater, so they absorb much of the Cesium 137 that has been deposited.

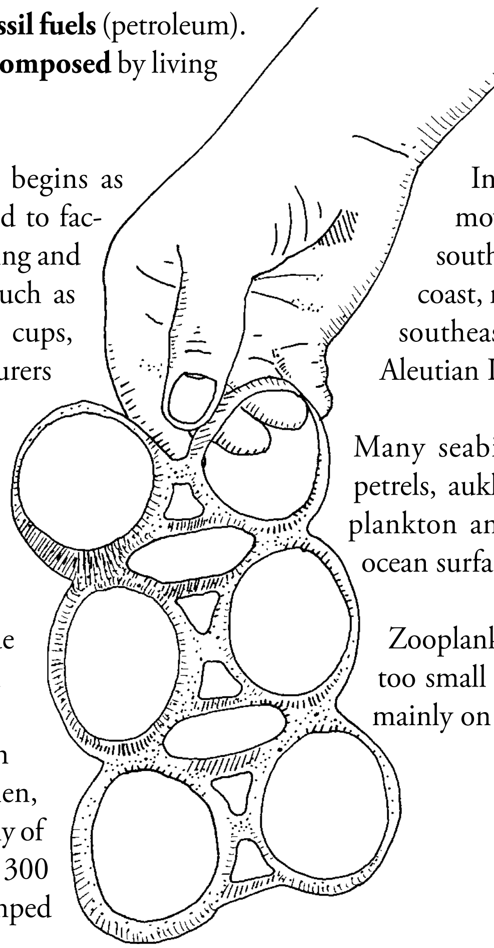
During winter, caribou eat mainly lichens. All the Cesium 137 in those lichens accumulates in their body tissues and fats. Some caribou that were examined had concentrations of 15 **microcuries** of cesium 137 per gram of tissue.

Humans who ate caribou accumulated their Cesium 137 and ended up with concentrations of 30 microcuries per gram of tissue. Wolves and foxes that fed on the caribou sometimes contained 45 microcuries of cesium 137 per gram of tissue. The health risks of this concentrated exposure are poorly known.

Ecology Puzzler

Some Plastic Rap

THE FACTS



Plastic is a material made from **fossil fuels** (petroleum). It cannot be broken down or **decomposed** by living things.

Much of the plastic produced begins as small particles which are shipped to factories around the world for melting and forming into plastic products such as toys, buckets, bags, food wrap, cups, gadgets. Major plastic manufacturers are located in California, Japan, and other Pacific Rim nations. Alaska did not manufacture any plastic until 1985.

STUDENT ACTIVITY
Some of the plastic particles made by the producers are lost at sea in shipping accidents. Plastic materials are also dumped in the ocean by ocean-going vessels, fishermen, and others. The National Academy of Science estimates that more than 300 million pounds of plastic are dumped in the ocean every year.

Plastic particles float on the surface of the water.

In the North Pacific Ocean, currents move in a counter-clockwise direction southeast past Japan toward the California coast, northwest past British Columbia and southeast Alaska, then southwest past the Aleutian Islands.

Many seabirds including shearwaters, storm petrels, auklets, and puffins feed on small zooplankton and cephalopods that float near the ocean surface.

Zooplankton and cephalopods are, in general, too small to ingest plastic particles. They feed mainly on algae and smaller zooplankton.

THE PUZZLE

Based on your knowledge of ecology, would you expect to find plastic in the stomachs of Alaskan seabirds? Explain why or why not.

Ecology Puzzler

Some Plastic Rap

WHAT REALLY HAPPENED

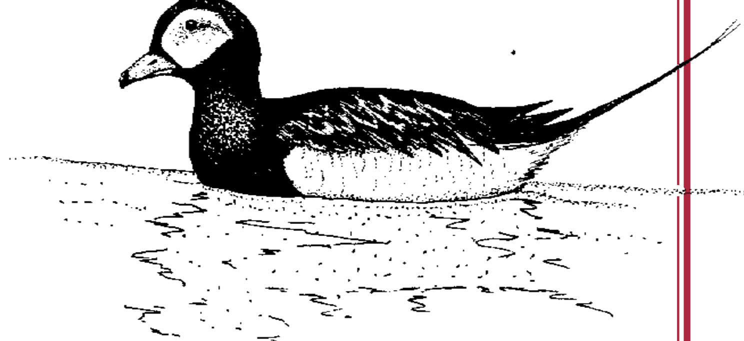
Even though there were no plastic manufacturers in Alaska until 1985, plastic was imported, and plastic particles have been found in Alaskan seabirds. Plastic particles have been found in the digestive tracts of 21 of the 37 species of Alaskan seabirds examined. In some species, 40-50 percent of the birds examined had plastic in their digestive tracts. The puffins, auklets, storm petrels, fulmars, and shearwaters found with plastic particles feed mainly on crustaceans and cephalopods (squid) which are too small to eat the plastic particles.

Scientists do not know why seabirds are picking up the plastic, but hypothesize that the birds are mistaking the plastic particles for zooplankton or fish eggs. Different species of birds seem to pick up different kinds of plastic particles.

Alaskan seabirds find and eat the plastic particles while migrating through waters off Japan and California where plastic manufacturing occurs. They also find plastics in Alaskan waters where plastic particles have become concentrated as a result of ocean currents. A visit to any outer coast beach of Alaska will quickly show that industrial plastic pollution is not the only source of the problem. The beaches are littered with plastic of all descriptions, from six-pack rings and disposable lighters to rope.

The plastic particle problem appears to be a recent phenomenon, at least in Alaska. Parakeet auklets nesting on St. Lawrence Island in the Bering Sea did not have any plastic particles in their digestive tracts in the mid 1960s. By the mid 1970s, 50 percent of the birds in the area contained plastic. The effects of the plastics on the seabirds are unknown. There is some evidence that seabirds with digestive tracts packed with plastic may have trouble digesting real food and starve.

A recent report by the National Academy of Sciences indicated that, worldwide, an estimated 1 to 2 million birds and 100,0000 marine mammals may die each year as a result of plastic pollution. This figure refers mainly to birds and mammals that become entangled in discarded or lost commercial fishing nets and lines.



Ecology Puzzler

All That Glitters Is Not Gold

THE FACTS

Most of the food **energy** and nitrogen available to stream **food chains** comes from leaf litter that falls from stream-side trees and shrubs and from **deciduous** trees and shrubs in upstream wetlands. A small amount of food energy is also made available by aquatic **producers** – algae and aquatic plants.

The main **herbivores** in stream **ecosystems** are aquatic insect **larvae**, such as the larvae of caddis flies, mayflies, and blackflies. These organisms filter **detritus** *(decaying material such as leaf litter)* and algae that float past in the water.

Insect larvae are the main food for fish including salmon fry, sticklebacks, whitefish, trout, and grayling. Most of these fish locate their prey by sight.

The amount of oxygen dissolved in stream water is determined by the speed the water is traveling and the temperature of the water. Fast-flowing, cold water is able to carry much more oxygen than slow-moving, warm water.

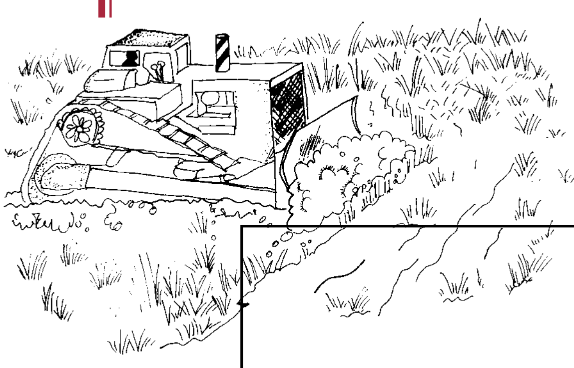
Stream-associated birds include kingfishers, mergansers, and osprey. These birds feed mainly on fish which they locate by sight. Another bird, the American dipper, feeds mainly on aquatic insects. It locates these by sight also. Dippers search for insects while walking underwater against the current and while swimming from one "lunch counter" to another.

The temperature of the stream water is affected by the amount of solar radiation that reaches the stream. Stream-side vegetation keeps water temperatures cool by shading the stream.

Stream-associated mammals include river otters, mink *(both of which feed mainly on fish)* and beaver *(which feed on stream-side shrubs and trees).*

Salmon, grayling, and other fish lay their eggs amid gravel on the stream bottom. Spaces in the gravel provide a place safe from predators for the eggs and **alevin** *(newly hatched fish)* to develop. Water moving between the gravel particles delivers a continuous supply of dissolved oxygen.

Placer mining, the main gold mining method used in Alaska, involves removing streamside vegetation, then washing the gravel and soil of a stream bed and adjacent areas with water. In the washing process, gold, which is heavier than other materials, settles out first. If dirt particles and other minerals are carried away by the stream, they cloud the water, slowly settle out, and cover the stream bottom with silt.



THE PUZZLE

Based on your knowledge of ecology, predict how placer mining affects stream ecosystems.

Ecology Puzzler

All That Glitters Is Not Gold

WHAT REALLY HAPPENED

Unregulated placer mining severely disrupts stream ecosystems. The most serious problem is the **sediments** in the water that affect nearly all the living things present by the following:

(1) The increased **turbidity** *(cloudiness)* reduces the amount of light available for producers such as algae.
(2) The cloudiness hampers predators that use vision in locating their **prey** *(fish, mammals, and birds);* **predators** cannot find and capture food.
(3) Turbidity clogs the feeding mechanisms of filter-feeding organisms.
(4) Silt irritates the tender gills of fish thus interfering with their ability to breathe.
(5) The fine-grained particles that settle on the bottom fill the air spaces between gravel particles. This smothers the eggs and **alevin** that live in these spaces.

Removal of stream-side vegetation reduces the amount of leaf litter. This means less energy is available for all organisms in the food chain. This may not be a serious problem at the site of the placer mine if upstream vegetation remains intact; however, it affects ecosystem production below the mine site.

Removal of stream side vegetation may increase water temperatures *(due to reduced shading)* and thus decease the amount of oxygen available to aquatic organisms. Vegetation removal also can cause soil erosion in addition to the sediments released in the mining process. This erosion continues until vegetation is reestablished, perhaps long after the mining operation is over. If vegetation is not reseeded by miners, it can take decades for nature to reseed the sterile tailings.

The amount of turbidity and sedimentation caused by placer mining can be significantly reduced if miners construct a series of settling ponds. Turbid water is stored in the settling ponds temporarily to allow some of the sediments to settle. Then it is returned to the stream. Settling ponds can be difficult and expensive for a miner to build and maintain.

Current regulations make settling ponds mandatory. Miners no longer wash gravel and discharge silt directly into streams.

Ecology Puzzler

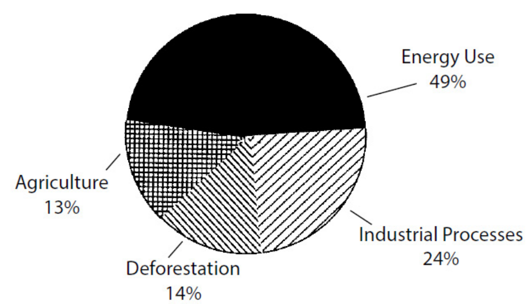
Rainforests, Volcanoes, and Glorious Sunsets

THE FACTS

Billions of years ago, the earth's atmosphere contained little or no free **oxygen**. Instead it contained much more **carbon dioxide**. Today it is made of 79% nitrogen, 21% oxygen, 0.9% rare gases, and 0.03% carbon dioxide.

Scientists hypothesize that the carbon dioxide originally in the atmosphere was converted into carbon chains by photosynthetic organisms *(plants, trees)*. Oil, coal, and petroleum are all made of the ancient remains of living organisms. Most of the carbon on earth is now tied up in these fossil fuels, in deep sea sediments, and in wood.

Contributions to Global Warming by Human Activity
(percentage of global warming)



Source: World Resources Institute in collaboration with the United Nations Environment Programme and the United Nations Development Programme, *World Resources 1990-91* (Oxford University Press, New York, 1990), Table 2.4,P. 24.

The processes of **photosynthesis** and **respiration** have maintained a balance for millions of years. The atmosphere provides the oxygen we breathe and the carbon dioxide needed by photosynthetic organisms. The atmosphere also affects the climate of the earth by absorbing and reflecting light energy. Light is reflected by dust in the atmosphere. Carbon dioxide, unlike most other components of the atmosphere, absorbs heat from the sun's rays.

Worldwide, forests are being cut for wood products, fuel, and to make room for farmland, industry, and cities at the rate of about 18-20 million hectares (7.2-8 million acres) per year.

Currently, combustion of oil, gas, coal, and wood releases 5-6 billion tons of carbon dioxide into the atmosphere annually. Combustion also releases heat into the atmosphere.

The amount of dust in the air is increased by volcanic eruptions, combustion of fossil fuels and wood, pollution, and wind erosion of soil where vegetation was removed.

THE PUZZLE

Use your knowledge of ecology and the above facts to predict whether the earth's climate is likely to warm, cool, or stay the same. If you predict it will change, explain why and the effects of these changes.

Ecology Puzzler

Rainforests, Volcanoes, and Glorious Sunsets

WHAT REALLY HAPPENED

The amount of carbon dioxide in the atmosphere has been increasing at the rate of 0.2% per year since about 1850, and this rate is accelerating. The main reason for this increase is the use of the combustion engine, along with the increased use of fossil fuels. The amount of dust in the atmosphere has also been increasing. Scientists agree humans are conducting a gigantic ecological experiment with the earth as the test tube. Almost all scientists agree that the increased amount of carbon dioxide is going to result in something happening. It is the "something" that is not agreed upon.

Some ecologists predict that the increased amount of carbon dioxide will trap more heat from sunlight (in addition to the additional heat released by combustion) which will cause a warming of the earth's climates. This is called the **greenhouse effect**. They theorize that this greenhouse effect of **global warming** would melt the polar ice caps and raise the level of the oceans by several feet, flooding much of the coastal land currently inhabited by people. It would also flood or change the climate in most of the lands where food crops for humans are raised.

Other ecologists theorize that due to the increased amount of dust in the atmosphere, the earth's atmosphere will reflect more sunlight and absorb less, which will result in a cooling of the climate and another ice age.

Even small changes in the temperature of the earth, in either direction, would result in major difficulties for humans and most living things.

Some scientists suggest that there will be no change because the increased amount of carbon dioxide in the atmosphere will allow more **photosynthesis** by **producers**, which will counteract the increasing carbon dioxide.

The problem of what will happen is complicated by the chemical reactions to various pollutants of many other atmospheric gases, such as ozone.

ECOLOGY APPENDICES

GLOSSARY

TEACHER RESOURCES
(General and Section Specific)

FULL CITATIONS – ACTIVITY CURRICULUM CONNECTIONS

MORE CURRICULUM CONNECTIONS
(Folktales, Fiction, Poetry, Biographies, and Picture Books)

GLOSSARY

Absorption: passage of nutrients into living cells.

Abundance: the total number of individuals, number of a species, or the amount of resources present in an area.

Adaptation: the process of adjusting to the environment. For example, a plant with unusually long roots that enable it to absorb water over a wide area has an adaptation that helps it survive during periods of drought.

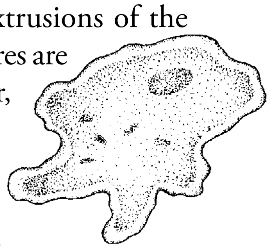
Aerobic: (air-o-bik) needing or using oxygen in the form that appears in air.

Alevin: the first stage of fish development after hatching. Alevin still have a yolk sac.

Algae: a large group of primitive plants with chlorophyll, but lacking true roots, flowers, stems, and leaves.

Alpine tundra: cold, windy, treeless environments occurring at high elevations above tree line throughout the world. Also called high elevation tundra.

Amoeba: (a-me-ba) any one-celled organisms from the genus *Amoeba*. Amoebas move about on "false feet" which are temporary extrusions of the cell. These microscopic creatures are found in fresh and salt water, in soil, and as parasites.



Anaerobic: (ann-air-o-bik) living or functioning in an environment that lacks oxygen in the form that appears in air.

Analogy: an inference that if two unrelated things are alike in some ways they are probably alike in others.

Animal: a living thing that takes in food, moves about, and is made of many cells. Unlike plants, animals do not have to stay in one place. They cannot make their own food. Jellyfish, clams, mosquitoes, ravens, salmon, bears, and people are all animals.

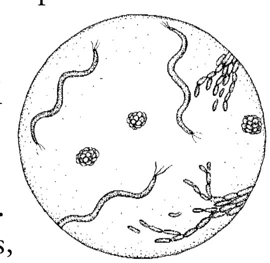
Annual plant: a plant that completes its life cycle, from seed to reproductive stage, in only one year or season.

Arctic tundra: the cold, windy, treeless environment found in the Arctic and maritime Subarctic. Also called high latitude tundra and lowland tundra.

Autotroph: (aw-tow-troaf) an organism that can make its own food.

Bacteria: tiny living cells. Bacteria are so small that they can only be seen through a microscope. Some bacteria cause diseases. Others do useful things, like making soil richer.

Biodiversity: the variety and abundance of living things in a habitat, ecosystem, or specific area. Also called **biological diversity**.



Biome: (bi-om) a major regional plant community and its associated animal life. A way to classify regions of the Earth. Examples include grasslands, forests, tundra, and deserts.

Blue-green algae: now called *cyanobacteria*, they are single-cell organisms without a nucleus classified in the Kingdom Monera. They photosynthesize like plants but are structurally similar to other photosynthetic bacteria.

Carbon: an element that forms a major building block of all living things.

Carbon dioxide: a colorless, odorless gas that passes out of the lungs in respiration; compound made of carbon and oxygen. Needed by plants for photosynthesis.

Carnivore: an animal that eats other animals; meat eater.

Camouflage: (kam-o-flaj) coloration and patterning (or, rarely, behavior) that provides a disguise from predators.

Cellular respiration: the living cells of animals and plants combine some types of digested food with oxygen to produce energy, water, and carbon dioxide.

Chlorophyll: (klor-o-fill) a group of pigments that produce the green color of plants; essential to photosynthesis.

Cilia: (sil-ee-a) tiny, hair-like projections found on some cells.

Classify: to sort into groups.

Climate: the average condition of the weather *(temperature, wind velocity, precipitation, sunlight)* at a location over many years.

Cold: absence of heat; something that has a temperature which is lower than the surrounding area.

Commensalism: (co-men-sa-lism) a form of symbiosis; a relationship between two kinds of living things, where one benefits and the other is not harmed or helped.

Community: a group of plants, animals, and other organisms that live together in the same area and depend on each other for survival.

Compound: a combination of elements, such as "H_2O" (water) or "CO_2" (carbon dioxide).

Compost: a mixture of decomposing vegetable refuse, plant detritis, and manure that make soil better for growing plants.

Conservation: the use of natural resources in a way that assures their continuing availability for future generations. The wise and intelligent use or protection of natural resources.

Consume: to eat and digest and thereby gain the eaten organism's energy and minerals.

Consumer: a living thing that obtains energy and minerals by eating other living or dead things.

Cover: protection from the elements for many purposes including hiding, traveling, resting, and nesting. Also referred to as **shelter**. One of the four elements necessary for survival.

Create: to bring into being; to cause to exist.

Cycle: events that happen in the same order, over and over again. Spring, summer, autumn, and winter are the cycle of the four seasons of the year.

Cyanobacteria: *see blue-green algae.*

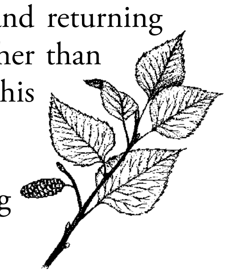
Deciduous: (dee-sid-you-us) a tree that loses all of its leaves during some time of year, usually in fall. Birch trees are deciduous. Spruce trees are not.

Decomposer: an organism that breaks down organic materials. (All consumers fit this category, but it is used to refer to organisms that break organic material down completely and return the raw materials to the environment.)

Decomposition: an act of breaking down or separating into basic components or parts.

Defense: the act of defending against attack, danger, or injury; a means or method of defending or protecting.

Denitrify: breakdown of ammonia (from the decomposition of organic debris) and returning the nitrogen to the atmosphere rather than the soil. Denitrifying bacteria do this job. *See also nitrify.*



Destruction: the act or process of tearing down; demolishing.

Detritivore: a living thing that eats wastes and living things that have died.

Detritus: (dee-tri-tus) organic waste material, such as dead or partially decayed plants and animals, or excrement. Detritus can also be small particles of minerals such as sand or silt.

Diversity: the variety of living things that fill different jobs or niches in an ecosystem.

Domesticated: formerly wild plants or animals that now receive all their habitat needs (food, water, shelter, and space) from humans.

Dominance: priority access to preferred or limited resources.

Ecologist: a scientist who studies the inter-relationships of living things to each other and to the environment.

Ecology: the study of the inter-relationships among and between living things and their nonliving surroundings.

Ecosystem: (ee-co-sis-tem) a community of living things and its nonliving surroundings linked together by the flow of energy and by nutrient exchange.

Element: one of the materials from which all other materials are made. Each element has its own kind of atom. There are more than one hundred known elements. Iron, oxygen, gold, and carbon are elements.

Energy: a nonliving part of the environment that can be observed in the form of electricity, heat, light, and motion in living and nonliving things. It has the capacity to move, do work, or change something.

Environment: the complex of physical, chemical, and biotic factors (as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival.

Erosion: the wearing away of the land surface by wind or water.

Euglena: (u-glE-na) green freshwater flagellates often classed as algae. One-celled animals from the kingdom Protista. Euglenas have qualities of both plants and animals: they photosynthesize their own food but many can also eat tiny particles of food. They have 1-3 flagella for swimming and lack a rigid cell wall typical of most plants.

Eukaryote: (u-kar-E-ott) descriptive term for an organism composed of one or more cells containing visibly evident nuclei and organelles. All higher unicellular and multicellular organisms are eukaryotes.

Extinct: an organism no longer alive anywhere on earth. Gone forever.

Extinction: the process by which species become extinct; the condition of having been removed from existence. A plant or animal facing extinction is one in danger of vanishing from our world forever.

Fertile: able to produce young, seeds, fruit, pollen, spores. Producing abundantly.

Food: energy and minerals in a form living things can use. One of the four elements necessary for survival.

Food chain: the transfer of food energy from living things in one nutritional level to those in another. In a simple food chain, for example, a mammal eats a bird that ate an insect that ate a plant.

Food pyramid: also called an "energy pyramid," a diagram representing the loss of available energy at each trophic level in a community of living things. Generally, 90% of the usable energy in each transfer between producers, herbivores, and carnivores is lost as heat.

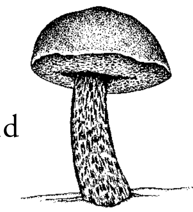
Food web: many interconnecting food chains.

Forest: any ecosystem that contains many trees.

Fossil fuel: the remains of prehistoric plants and animals that are burned to obtain energy; includes oil, natural gas, and coal.

Fruit: the ripe ovary of a seed plant that includes both the seeds and the coverings.

Fungi: (fun-jee) living things in the Kingdom Fungi, one of the five major groups of living things. Includes mushrooms, yeasts, molds, fungi, lichens, and slime molds. All are detritivores and feed by absorption, not photosynthesis. Singular: fungus.



Gas: a substance, without shape or volume, that tends to expand indefinitely. Air is a gas.

Gizzard: the second stomach of a bird; it has thick muscular walls and a tough lining for grinding food that has been partially digested in the first stomach.

Habitat: the place where an animal lives that provides food, water, shelter (or cover), and space in a suitable arrangement that an organism needs to survive.

Half-life: the time it takes for something to lose half of its radioactivity.

Herbivore: (erb-uh-vor) any living thing that eats producers (plants and algae).

Heterotroph: (het-er-o-troaf) a living thing that cannot make its own food, but instead eats (consumes) other organisms.

High latitude tundra: another term for lowland or arctic tundra; refers to the cold, windy, treeless environment found in the Arctic and Subarctic.

Host: an organism that serves as the habitat for a parasite.

Humus: (hyoom-us) the brown or black part of the soil that comes from decayed plants and animals; a highly complex mixture of organic and inorganic substances.

Inorganic: any substance that was not formed by living things.

Insect: a class of animals that has an exoskeleton divided into head, thorax, and abdomen. The thorax bears three pairs of legs and in most species, two pairs of wings.

Insect: a class of animals that has an exoskeleton divided into head, thorax, and abdomen. The thorax bears three pairs of legs and in most species, two pairs of wings.

Interaction: when one thing affects another.

Interdependence: needing each other.

Invertebrates: (in-vert-a-brets) animals without a backbone or internal bony skeleton. Includes insects, crustaceans, worms, corals, and mollusks.

Kingdom: the highest classification or taxonomic division of living things. Today, living things are grouped into five kingdoms: Monera, Protista, Fungi, Plantae, and Animalia – characterized by their cell structure.

Landfill: the disposal of garbage by burying it under a shallow layer of ground. A specially engineered site for disposing of solid waste on land, designed to confine the refuse to the smallest practical area.

Larvae: any of the immature forms of living things that undergo metamorphosis. Tadpoles, grubs, and caterpillars are all in the larval stage that is radically different from the adult frogs, beetles, and butterflies that they become after metamorphosis. Singular: larva.

Latitude: a measure of the distance of a given point on earth from the equator.

Lemming: small arctic rodent. Lemmings resemble mice but have short tails and fur-covered feet.

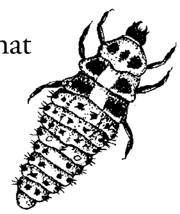
Lichen: (like-en) a living thing formed by an alga and fungus growing in symbiosis. They often grow in harsh conditions that are too exposed for other plants. Because of their sensitivity to air pollution, many are useful as air quality indicators.

Limited resources: resources that may be irreplaceable when diminished.

Limiting factor: something that keeps a population of animals or other organisms from increasing such as a shortage of food, water, shelter, or space. Other examples include diseases, predation, climatic conditions, pollution, hunting, poaching, and accidents that affect either the number of births, the number of deaths, or both.

Liquid: a substance that flows; it has volume, but no shape and does not expand much. Water is a liquid.

Living thing: any organized material that responds to the environment, moves, and is able to reproduce itself.



Mammals: a class of vertebrate animals that are warm-blooded, have hair or fur, and suckle their young.

Microscopic: so small as to be invisible except through a microscope.

Migration: the periodic movement of animal populations from one region to another and back again.

Minerals: any substance found in nature that is not living; may be a single element (nitrogen) or a compound (carbon dioxide, water).

Mold: a downy or furry growth on the damp surfaces of living or decayed things. Mold is a fungi.

Monerans: organisms that make up the Kingdom Monera (one of the five groups of living things). Monerans are single-celled and do not have a nucleus. Bacteria and cyanobacteria (blue-green algae) are monerans.

Multicellular: living things made of more than one cell. The cells in multicellular living things usually have specialized functions.

Mutualism: (mute-chew-al-ism) a kind of symbiosis. An interaction between two kinds of organisms from which both species benefit.

Mycorrhizae: (my-cor-rise-zee) fungi that live in or on the roots of plants and assist the plant in absorbing minerals from the soil. They are nitrogen-fixers.

Nitrogen: a chemical element that is absorbed by producers and used in the formation of all living things. Earth's atmosphere is 78% nitrogen.

Nitrogen-fixing: taking nitrogen gas from the air and changing it into a form that dissolves in water. This soluble nitrogen is deposited in the soil and can be used by plants. Nitrogen-fixing bacteria do this job.

Nitrify: breakdown ammonia (from the decomposition of organic debris) and release nitrogen into the soil in a form that can be dissolved in water and used by plants. Nitrifying bacteria do this job. *See also denitrify.*

Nocturnal: (nok-turn-al) becoming active only after dark.

Nonliving: any thing which cannot reproduce itself.

Nonliving environment: the air, water, and minerals that surround a person, animal, or plant.

Nonrenewable resources: nonliving resources such as rocks, oil, and minerals that are not able to regenerate themselves. Once used, they cannot be replaced.

Nutrient: (new-tree-ent) something that an organism takes in and assimilates, thereby promoting growth and replacing worn or injured tissue.

Omnivore: (ahm-nee-vor) a living thing that eats plants and other animals.

Organic: having to do with or coming from living things.

Organism: a living thing.

Owl pellets: indigestible parts of an owl's meal (fur, feathers, bone) that is regurgitated.

Oxygen: a colorless, tasteless, odorless element that most living things breathe and need in order to live; plants and algae produce this gas during photosynthesis.

Parasitism: (pair-i-sit-ism) a win/lose kind of symbiosis. An interaction between two kinds of living things from which one species benefits and the other is harmed.

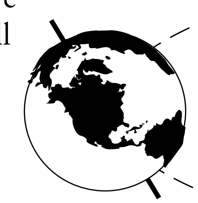
Peat: (peet) moist, semi-decayed organic matter.

Permafrost: soil that is 32°F (0°C) or less all year round. It may or may not contain ice. In the arctic tundra, permafrost may extend anywhere from a few feet to more than 1,000 feet below the surface.

Phosphorous: an element that is needed by living things.

Photosynthesis: (foto-sin-this-iss) the combining of sunlight, water, and carbon dioxide to create sugars. Oxygen is a by-product. Photosynthesis takes place in the leaves of plants and in algae.

Plants: one of the five kingdoms of living things; includes all the living things that have leaves, roots, and stems. Nearly all plants are green and live without moving from place to place. Nearly all plants are producers. Trees are plants.



Population: the number of people, animals, or plants living in a place.

Predation: the act of hunting and eating other animals.

Predator: an animal that kills and eats other animals.

Prey: animals that are killed and eaten by other animals.

Producer: any living thing that is able to make food from nonliving things such as air, water, sun, and soil. Plants and algae are examples of producers.

Prokaryotic: (*"before kernels or nucleus"*) descriptive term for organisms whose cells have no enclosed nucleus nor special cell structures. Monerans (bacteria, cyanobacteria) are prokaryotae.

Protist: (pro-teest) one of the five kingdoms of living things. The majority of these organisms are single-celled (with a nucleus) but lacking in specialize cell structure. Protists include microscopic protozoans and slime molds as well as large seaweed and kelp.

Pupa: a stage in the metamorphosis of some kinds of insects between larvae and adult forms. Plural: pupae.

Radioactive isotope: a chemical element with the same atomic number and identity as another element but differing in atomic weight. Radioactive isotopes tend to disintegrate and emit particles. These particles often give scientists evidence about the age of substances.

Revolution: the journey that the earth takes around the sun. One revolution is 365 days, or one year, and has four seasons.

Recycle: to reuse the remains of things; to make fit to be used again.

Rehabilitate: to restore to its former condition.

Renewable resources: living resources, such as plants and animals, that have the capacity to renew themselves when conditions for survival are favorable.

Respiration: the opposite of photosynthesis; the process whereby sugar and oxygen are converted into water and carbon dioxide with a release of energy.

Rotation: the spinning or turning of the earth on its axis. The earth rotates once every 24 hours.

Sediments: a general term for particles that are left behind by an agent of transport such as water, ice, or wind.

Shelter: protection from the elements for many purposes including hiding, traveling, resting, and nesting. Also referred to as **cover**. One of the four elements all living things need to survive.

Soil formation: the making and mixing of small particles of inorganic minerals and organic (formerly living) particles to form the layer of material on the surface of the earth that is the natural medium for plant growth.

Solar energy: heat and light from the sun.

Solid waste: material that has shape and dimension (not liquid or gas) that has been thrown away or left over.

Solution: a mixture formed by a substance dissolved in a liquid. Salt in water forms a solution.

Spores: (sporz) any small organism or cell that can develop into a new individual. Ferns, mushrooms, bacteria, and certain other living things produce spores.

Sulfur: a pale-yellow, nonmetallic chemical element.

Symbiosis: (sim-by-o-sis) the relationship of two or more different organisms living in close association, often (but not necessarily) to the advantage of each.

Taiga: the sparse forests of stunted trees near the edge of the tree limit before the start of tundra. Russian for *land of little sticks*.

Temperature: the degree of hotness or coldness as shown by a thermometer.

Tilt: the relationship of the earth's axis to the sun. The earth's axis is angles at 23.44 degrees.

Transect: a straight line or profile that makes a cross-section of plant life in an area that is useful for studying the number and types of plants.

Tundra: the windy, treeless, and periodically cold environments that occur at high latitudes and at high elevations.

Vertebrates: animals with backbones. Humans, birds, fish, and bears are examples of vertebrates.

Wetlands: areas of land that have waterlogged soils, support plants adapted to wet soil, and are covered by water for a least part of the year. Examples include swamps, bogs, freshwater and saltwater marshes, and river or stream banks.

Yeast: tiny single-celled fungi that produce air bubbles as they live.

TEACHER RESOURCES

Most useful resources for teaching general and specific activities in Alaska's Ecology

Useful for All

Books and Publications:

Alaska Ecology Cards – Alaska Wildlife Curriculum. Alaska Department of Fish and Game, 2000.

Alaska Northwest Books. *The Alaska Almanac: Facts About Alaska*. Anchorage: Author, published annually.

Alaska Wildlife Notebook Series. Alaska Department of Fish and Game. Available to download on-line <www.alaska.state.us/adfg> or from Wildlife Education, ADF&G, 333 Raspberry Rd. Anchorage, AK 99518.

Allaby, Michael. *Biomes of the World.* Danbury CT: Grolier Educational, 1999. (9 volumes)

Butzow, Carol. *Exploring the Environment through Children's Literature: an Integrated Approach.* Englewood, CO: Teacher Ideas Press, 1999.

Clearing Magazine. A bi-monthly Pacific Northwest environmental education resource and activity guide for K-12 teachers. Address: P.O. Box 5176, Oregon City, OR 97045 *or* <www.teleport.com/~clearing>

Cornell, Joseph. *Sharing Nature with Children.* Nevada City, CA: Dawn Publishing, 1998.

Davis, Neil. *Science Nuggets.* Fairbanks: Geophysical Institute, University of Alaska. Reprinted 1999.

The Diagram Group. *Facts on File Biology Handbook.* New York: Facts on File, 2000.

The Diagram Group. *Nature Projects on File.* New York: Facts on File, 1992.

DK Science Encyclopedia. New York: Dorling Kindersley, 1998. (also on CD)

Ewing, Susan. *The Great Alaska Nature Factbook: A Guide to the State's Remarkable Animals, Plants, and Natural Features.* Anchorage: Alaska Northwest Books, 1996.

Gardner, Robert. *Science Projects about the Environment and Ecology.* Springfield, NJ: Enslow Publications, 1999.

The Green Teacher. A magazine for inspiration and classroom materials in environmental education. Address: 95 Robert St. Toronto, Canada M5S2K5 *or* <www.web.net/~greentea>

Hefner, Christine. *Literature-Based Science: Children's Books and Activities to Enrich the K-5 Curriculum.* Phoenix: Oryx Press, 1995.

Junior Environment on File. New York: Facts on File, 1996.

Lingelbach, J. *Hands-On-Nature Information and Activities for Exploring the Environment with Children.* Woodstock, VT: Vermont Institute of Natural Science, 1986. Available <www.vinsweb.org>

Macmillan Encyclopedia of the Environment. New York: Macmillan, 1997. (6 volumes)

National Audubon Society. *Audubon Adventures: Alaska.* Address: National Audubon Society, 700 Broadway, New York, NY 10003 *or* <www.audubon.org> *or* 212-979-3183.

Roberts, Patricia. *Language Arts and Environmental Awareness: 100+ Integrated Books and Activities for Children.* New Haven, CT: Linnet Professional Publications, 1998.

Sheehan, Kathryn. *Earth Child 2000: Games, Stories, Activities, Experiments & Ideas about Living Lightly on Plant Earth.* Tulsa: Council Oak Books, 1998.

USDA Forest Service. *Investigating Your Environment.* Available for download <www.fs.fed.us/outdoors/nrce/iye/contents.htm>

VanCleave, Janice. *Janice VanCleave's Ecology for Every Kid: Easy Activities that Make Learning Science Fun.* New York: Wiley, 1996.

Weigel, Marlene. *U-X-L Encyclopedia of Biomes.* Detroit, MI: U-X-L, 2000. (3 volumes)

Media:

Environmental Media Corporation. Variety of media to support environmental education. Some with free teaching guide. Contact <www.envmedia.com> *or* 1102 11th St., Port Royal, S.C. 29935-2304.

Bullfrog Films. Environmental videos. Contact <www.bullfrogfilms.com> *or* P.O. Box 149, Oley, PA 19547 *or* 610-779-8226 *or* 800-543-3764.

Websites:

Alaska Native Knowledge Network <www.ankn.uaf.edu> *Alaska Standards for Culturally Responsive Schools* and *Guidelines for Preparing Culturally Responsive Teachers for Alaska's Schools* are available on-line. Ordering information for *Curriculum Resources for the Alaskan Environment* and *Inuuqatigiit* (curriculum from the Inuit perspective) are also available. Science Projects are available from <www.ankn.uaf.edu/Alaska_Alive>

Alaska Natural Heritage Program <www.uaa.alaska.edu/enri/aknhp_web> Current status of Alaska's biodiversity, annotated species at risk project, and excellent links to Alaska biodiversity.

Alaska Science Forum <www.gi.alaska.edu/ScienceForum> Treasure of new and archive articles written for general audiences answering science questions and highlighting Alaska's natural science phenomena and research.

Alaska Sea Grant Program <www.uaf.edu/seagrant> Has a useful list of Marine Education publications. Includes ordering information for the Alaska Sea Week Curriculum materials.

Alaska Statewide Databases, accessed through your local library website or <sled.alaska.edu > Magazine and newspaper articles from more than 2,000 magazines and journals, 100 newspapers, plus other information.

Anchorage *Daily News* <www.adnsearch.com> Staff-written newspaper articles, current and past. Article citations can be located at no charge. For full text, a fee must be paid.

Audubon On Line Field Guides <www.enature.com> Has on-line field guides and habitat information.

BLM Environmental Education homepage <www.blm.gov/education>

EE-Link <eelink.net> Environmental education resources on the Internet.

Environmental News Network <www.enn.com> Searchable by subject. Good for current news articles.

Fairbanks *Daily News-Miner* <www.newsminer.com> Staff-written newspaper articles, current and past, available on file, no fee.

National Wildlife Federation <www.nwf.org> Has information on environmental education programs including the *Animal Tracks* Program, *NatureScope,* and National Wildlife Week information.

Project Learning Tree <www.plt.org> Environmental education curriculum K-12 of the American Forest Foundation <www.affoundation.org> Locally supported by the Alaska Department of Natural Resources.

Project WILD <www.projectwild.org> Environmental education curriculum K-12 of the Western Regional Environmental Education Council. Supported locally by the Alaska Department of Fish and Game.

US Geological Survey. Alaska Biological Science Center <www.absc.usgs.gov>

USDA Forest Service <www.fs.fed.us> Resource, career, and special issue information and photos including Nature Watch and Woodsy Owl. Alaska Region <www.fs.fed.us/r10>

Section 1: Elements of Ecosystems

Books and Publications:

Brady, Nyle and Ray R. Weil. *The Nature and Properties of Soils.* Upper Saddle River, NJ: Prentice-Hall, 1996.

Margulis, Lynn. *Five Kingdoms: an Illustrated Guide to the Phyla of Life on Earth.* New York: W.H. Freeman, 1998.

Websites:

Animal Diversity Web <animaldiversity.ummz.umich.edu/index.html>

Protist Image Data <megasun.bch.umontreal.ca/protists/protists.html>

Section 2: Ecosystems – Community Connections

Books and Publications:

Caduto, Michael and Joseph Bruchac. *Keepers of the Animals: Native American Stories and Wildlife Activities for Children.* Golden, CO: Fulcrum Publishing, 1995.

Leopold, Aldo. *Round River: From the Journals of Aldo Leopold.* New York: Oxford University Press, 1972.

Murray, John. *Out Among Wolves: Contemporary Writings on the Wolf.* Anchorage: Alaska Northwest Books, 1993.

National Wildlife Federation. *Birds, Birds, Birds!* (Ranger Rick's NatureScope) Washington, DC: Author, 1989. Contact <www.nwf.org> for ordering information.

Trautmann, Nancy and Marianne Krasny. *Composting in the Classroom: Scientific Inquiry for High School Students.* Dubuque, IA: Kendall/Hunt Publishing, 1997. Contact 800-228-0810 *or* <www.kendall-hunt.com>

Media:

Bird Treatment and Learning Center. Captive owls may be available for classroom visits. Contact 907-562-4852 *or* <www.birdtlc.org>

Into the Forest, Krill, Predator, Onto the Desert (Food Chain Games). Ampersand Press, 750 Lake St., Port Townsend, WA 98368 *or* 800-624-4263 *or* 360-379-5187 *or* <www.ampersand.com>

Owl Pellets from a variety of commercial suppliers, for example:
Acorn Naturalists <www.acornnaturalists.com/p2262.htm>
Carolina Biological Supply Company <www.carolina.com>
Pellets, Inc. < www.pelletsinc.com>

Redworm suppliers can be found on the Internet by searching "redworms" and include <www.wormwoman.com> and <www.wormwrld.com>

Websites:

Composting in Schools. Cornell Composting <www.cfe.cornell.edu/Compost/schools.html>

OBIS: Outdoor Biological Instructional Strategies <www.lhs.berkeley.edu/OBIS/OBISpubs.html> Outdoor activities revolving around ecosystems developed by Lawrence Hall of Science, University of California, Berkeley.

Section 3: Living Things in Their Habitats

Books and Publications:

Alaska Department of Fish and Game. *Alaska Wildlife Curriculum: Alaska's Forests & Wildlife* and *Alaska's Tundra & Wildlife* (companion books to *Alaska's Ecology*). Wildlife Education, ADF&G, 333 Raspberry Rd., Anchorage, AK 99518. (also on CD) Can be ordered from Wizard Words, P.O. Box 1125, Homer, AK 99603 *or* 907-235-8757.

Alaska Sea Grant College Program. *Alaska Sea Week Curriculum.* (Curriculum Guides include *Discovery: an Introduction,* Kindergarten; *Animals of the Seas and Wetlands,* Grade 1; *Shells and Insects,* Grade 2; *Birds and Wetlands of Alaska,* Grade 4; *Fish and Fisheries,* Grade 5; and *Marine Mammals: Coastal and River Issues,* Grade 6. Can be ordered from <www.uaf.edu/seagrant/Pubs_Videos/edu.html> or Alaska Sea Grant College Program, P.O. 755040-INT, Fairbanks, AK 99775-5040 *or* 907-474-6707 *or* 888-789-0090.

US Fish and Wildlife Service-Alaska. *Wetlands and Wildlife: Curriculum.* Separate sets (teacher's guide, activities, field trip manual) available for grades K-6 and grades 7-12. For information on this curriculum and others available<www.r7.fws/ea/curricu.html> Can be ordered from Wizard Words, P.O. Box 1125, Homer, AK 99603 *or* 907-235-8757.

Media:

National Geographic Society <www.nationalgeographic.com> Has videos available which cover regions of the world. National Geographic Society, P.O. Box 98199, Washington, DC 20090.

Websites:

Animal Diversity Web <animaldiversity.ummz.umich.edu/index.html> Includes an internet activity on mammals. *The State of the Nations' Ecosystems* <www.us-ecosystems.org>

Section 4: Human Impacts in Ecosystems

Books and Publications:

American Forest and Paper Association. *National Wood Recycling Directory—Wood Recycling Resources, How to Recycle Waste Paper, Youth Action Kit, posters and pamphlets* are available by calling 800-244-3090 *or* <www.afandpa.org>

Endangered Species: Critical Issues, Critical Thinking. (ES0030) Part of the National 4-H Council's "On Common Ground" series. Booklet contains role-playing activities for students in which all sides are examined. Available from On Common Ground, National 4-H Council, 7100 Connecticut Avenue, Chevy Chase, MD 20815. (For ages 12-14)

Hungerford, Harold. *Investigating and Evaluating Environmental Issues and Actions: Skill Development Program.* Champaign, IL: Stipes Publishing Co., 1996.

Jay, Tom and Brad Matsen. *Reaching Home: Pacific Salmon, Pacific People.* Anchorage: Alaska Northwest Books, 1994.

Lewis, Barbara. *The Kid's Guide to Social Action: How to Solve the Social Problems You Choose – and Turn Creative Thinking into Positive Action.* Minneapolis, MN: Free Spirit Publishing, 1998.

Milner, Alexander and Mark W. Oswood. *Freshwaters of Alaska: Ecological Syntheses.* New York: Springer, 1997. Chapter 10 "Gold Placer Mining and Stream Ecosystems of Interior Alaska."

Moses, S. *Changing Waste in Changing Times: Solid Waste and Natural Resources Issues in Rural Alaska – A Teacher's Guide* (Gr. 9-12). Seattle: Northwest Renewable Resources, 1994. Address: Northwest Renewable Resources Center, 1411 Fourth Ave., Suite 1510, Seattle, WA. 98101-2216 *or call* 202-623-7361

US Fish and Wildlife Service. *Sea Otter Conservation: Report from the Sixth Joint US-Russian Sea Otter Workshop.* Technical Report MMM 00-1, 2000. Available from the Marine Mammals Management office: 800-362-5148.

Media:

Alaska Resources Kit: Minerals and Energy. Alaska Department of Education. For information contact Jennifer at 907-276-0700 *or* coggins@bmol.com. For a listing of the contents of the kit, see <www.eed.state.ak.us/tls/minerals/akresources.html>

Bullfrog Films. P.O. Box 149, Oley, PA, 19547 *or* 610-779-8226 *or* <www.bullfrogfilms.com> Numerous videos are available for purchase or rent including these titles useful with the Ecology Puzzler activity:
Drumbeat for Mother Earth (Toxic chemicals and the survival of Indigenous Peoples) (Gr. 7-12)
Global Warming: Turning up the Heat (Gr. 7-12)
The Green Zone (About the riparian zone along streams) (Gr. 7-12)
Silent Sentinels (Global Warming) (Gr. 7-12
Troubled Waters: Plastic in the Marine Environment (Gr.7-12)
Turning Down the Heat (Global Warming) (Gr. 7-12)

Websites:

Alaska Department of Natural Resources, Division of Mining, Land and Water. <www.dnr.state.ak.us/mine_wat/index.htm> For information of statutes and regulations pertaining to Alaska lands. Division of Geological & Geophysical Surveys <www.dggs.dnr.state.ak.us> For information on the Alaska mining industry.

Alaska Science Forum. *Plastic Pollution in North Pacific Seabirds.* Article #388. <www.gi.alaska.edu/ScienceForum>

American Forest Foundation. *Exploring Environmental Issues: Municipal Solid Waste.* Washington, DC: Project Learning Tree, American Forest Foundation, 1997. <www.affoundation.org>

Anchorage Recycling Center www.anchoragerecycling.com> For information on school recycling programs. Also, 6161 Rosewood, Anchorage, AK 99518 *or* 907-562-2267.

Cincinnati Zoo. *Project Action* <www.cincyzoo.org/mainhtm/3c1a.htm> Describes an environmental problem-solving process.

Citizens for Recycling Solutions <www.recyclingsolutions.org> Alaska organization, publications for download, links to other recycling projects.

Environmental News Network <www.enn.com> Searchable by subject. Useful for the Ecology Puzzler activities.

EPA Office of Solid Waste. *Students' and Teachers' Page* <www.epa.gov/epaoswer/osw/students.htm>

School Resources for Waste Prevention and Recycling <www.deq.state.ok.us/waste/education/resources2.html> Has a list of resources for students and teachers.

University of Alaska Fairbanks. *Reindeer Research Program* <reindeer.salrm.alaska.edu/index.htm>

US Fish and Wildlife Service. *Biological Sources* <www.r7.fws.gov/sitepg.html> For other useful biology websites.

US Fish and Wildlife Service. *Where Can I Find It? Endangered Species Resources for Educators and Students* <endangered.fws.gov/kids/wherfind.htm>

US Fish and Wildlife Service. Marine Mammals Management <www.r7.fws.gov/mmm/seaotter.html> For sea otter information. Also, for a listing of available literature on sea otters <www.r7.fws.gov/mmm/otter/lit.html> *or* 800-362-5148.

US Geological Survey. Alaska Biological Science Center <www.absc.usgs.gov> For information on their Sea Otter Research Program.

World Resources Institute <www.wri.org> information, ideas, and solutions to global environmental problems.

FULL CITATIONS - ACTIVITY CURRICULUM CONNECTIONS

Books and Publications

Alaska Department of Fish and Game. *Alaska Wildlife Notebook Series.* Available to download on-line <www.alaska.state.us/adfg> or from Wildlife Education, ADF&G, 333 Raspberry Rd. Anchorage, AK 99518.

Alaska Geographic Society. *Mammals of Alaska.* Anchorage: Author, 1996.

Allaby, Michael. *Biomes of the World.* Danbury, CT: Grolier, 1999. (9 volumes)

Anderson, Bob. *Pollution: Examining Causes and Effect Relationships.* San Diego: Greenhaven Press, 1992.

Appelhof, Mary. *Worms Eat My Garbage.* Kalamazoo, MI: Flower Press, 1999. Can be ordered on-line <www.wormwoman.com>

Armstrong, Robert. *Guide to the Birds of Alaska.* Anchorage: Alaska Northwest Books, 1995.

Arnosky, Jim. *All About Owls.* New York: Scholastic, 1995.

Baker, Jeannie. *Window.* New York: Greenwillow, 1991.

Bang, Molly. *Chattanooga Sludge.* New York: Harcourt Brace, 1996.

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Bash, Barbara. *Tree of Life, The World of the African Baobab.* San Francisco: Sierra Club Books, 1989.

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Cole, Joanna. *Scholastic's The Magic School Bus in the Arctic: A Book About Heat.* New York: Scholastic, 1998.

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Cooney, Barbara. *Miss Rumphius.* New York: Viking, 1982.

Cottam, Clarence. *Insects: A Guide to Familiar American Insects.* Golden Books, 1987.

Daley, Michael J. *Nuclear Power: Promise or Peril?* Minneapolis: Lerner, 1997.

de Koster, Katie. *Endangered Species.* San Diego: Greenhaven Press, 1998.

DK Science Encyclopedia. New York: Dorling Kindersley, 1998. (also on CD)

Earthworks Group. *50 Simple Things Kids Can Do to Recycle.* Berkeley, CA: EarthWorks Press, 1994.

Eckert, Allen W. *Incident at Hawk's Hill.* New York: Little Brown, 1998.

Fair, Jeff. *Moose for Kids: (Moose Are Like That).* Minocqua, WI: Northwind Press, 1992.

Fleisher, Paul. *Alpine Meadow (Webs of Life).* Tarrytown, NY: Marshall Cavendish, 1999.

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George, Jean Craighead. *The Case of the Missing Cutthroats: an Ecological Mystery.* New York: HarperCollins, 1995.

George, Jean Craighead. *Frightful's Mountain.* New York: Dutton, 1999. (Fiction)

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Grade Index

	Book	Page	K	1	2	3	4	5	6	7	8	9	10	11	12
Create a Classroom Compost Box	E	114				•	•	•	•	•	•	•	•	•	•
Decomposition and Cold	T	97	•	•	•	•									
Create and Destroy	E	156					•	•	•	•	•	•	•	•	•
Ecosystem Partners	E	98					•	•	•	•	•	•	•	•	•
Ecosystem Scavenger Hunt	E	150						•	•	•	•	•			
Five Kingdoms But No King	E	58		•	•	•	•	•	•						
Follow a Food Chain	E	88	•	•	•	•	•	•	•	•	•	•	•	•	•
Investigating Air	E	71					•	•	•	•	•	•	•	•	•
Investigating Animals in Soil	E	127					•	•	•	•	•	•	•	•	•
Investigating Animals in Water	E	132					•	•	•	•	•	•	•	•	•
Investigating Birds	E	140					•	•	•	•	•	•	•	•	•
Investigating Fungi	E	119					•	•	•	•	•	•	•	•	•
Investigating Heat Energy	E	60					•	•	•	•	•	•	•	•	•
Investigating Insects	E	137					•	•	•	•	•	•	•	•	•
Investigating Mammals	E	143					•	•	•	•	•	•	•	•	•
Investigating Monerans and Protists	E	117					•	•	•	•	•	•	•	•	•
Investigating Plants	E	121					•	•	•	•	•	•	•	•	•
Investigating Soil	E	64					•	•	•	•	•	•	•	•	•
Investigating Water	E	67					•	•	•	•	•	•	•	•	•
It's Alive, or Is It?	E	55						•	•	•	•	•	•	•	•
Mineral Cycling Through the Ecosystem	E	108							•	•	•	•	•	•	•
Oh Moose!	E	95					•	•	•	•	•	•	•	•	•
Snow Blanket	E	78	•	•	•	•	•	•	•	•	•	•			
Spinning a Yarn About Ecosystems	E	162	•	•	•	•	•	•	•	•	•	•	•	•	•
Take a Deep Breath	E	74	•	•	•	•	•	•	•						
Watching Your Waste	E	159			•	•	•	•	•	•	•	•			
What Makes An Ecosystem?	E	147				•	•	•	•						
What's for Dinner?	E	93				•	•	•	•	•	•				
Who Eats Whom?	E	81	•	•	•	•	•	•	•	•	•	•			
Wildlife Ecology Puzzlers	E	165								•	•	•	•	•	•
World Tour	E	153					•	•	•	•	•	•	•		

Topic Index

R

Alaska's Ecology &Wildlife (Revision 2024)
Alaska Department of Fish and Game
Division of Wildlife Conservation