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North American Biomes

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by Lois Van Wagner

This unit on North American biomes will be a comparative study of each of the biomes' biotic and abiotic factors. We will look at representative species of both plants and animals for each of the biomes, and try to develop food chains from those organisms. Since an understanding of the physical environment is important to the understanding of the special adaptations some plants and animals have evolved with, we will also examine such things as temperature ranges, amount of moisture, presence of extremes of wind, sunlight or lack of sunlight, and soil types. Wherever possible live animals and plants will be examined and kept for observation terrariums. On our collecting expeditions I hope to find various small plants, insects, caterpillars, etc. that we can safely keep for a while in aquariums or terrariums.

Within each area we will focus on the healthy environment and discuss some of the contemporary problems that each area is facing in regards to pollution, habitat reduction, and poaching. Classroom discussions will be extended to include the African and South American biomes and their special animals, adaptations, and problems.

An important part of the unit will be the hands-on activities that can be incorporated into the lessons. For each biome there will be a special activity that is either observational or participational. Each student will produce a Biome book of their own as a result of a group study of the biome. The students will work cooperatively to produce a better product of their own.

Videos will be an important part of their lessons to present a more complete picture of the various biomes. There are numerous well done studies of specific animals or of whole ecosystems that can introduce the beginning student to the tremendous diversity of life in our world.

This unit will be used with my seventh grade Life Science students. It is designed with very low ability level students in mind although any of it could be easily adapted to average students.

Biomes

A biome is a community of animals and plants spreading over an extensive area, sometimes thousands of miles in length or width, with relatively uniform climatic conditions. The presence of broad temperature and precipitation belts determine the boundaries of each biome. If we look at a geophysical map of North America we will immediately notice some significant features; the mountain ranges of both the west and east coast, the extensive central lowland, plateaus, and the coastal plain.

The children should be given outline maps of North America to study and color in the important geophysical features. Atlases or their Social Studies text will be helpful for this exercise and will emphasis the interdisciplinary nature of environmental studies. Using the same type of outline map have the children also find the approximate boundaries and color in maps showing temperature ranges, precipitation, and vegetative types. These maps should be kept in a special Biomes folder. After all the maps are completed some time should be designated for comparison and discussion of relationships between these physical and biological factors. The eye-catching weather maps of U.S.A. Today newspapers are great resources and by saving seasonal examples the children can see the climates in the various biomes over time. Generalized maps of both climate and biomes can be found in the Appendix.

As the children focus in on the biomes map they will see large areas along the Arctic Ocean with little plant life and much snow cover. Moving southward will be broad expanses of deep green pine trees with even more southerly pointing fingers of pine in the mountains of the east and west. Between these fingers of pine are regions of vegetation determined largely by the level of precipitation; leafy deciduous forests in the east fading into the grasslands of the central states and finally the dry deserts of the west. The concepts of the prevailing westerly winds and the effect of the mountains should be briefly explained here. The southern most tip of Florida, parts of Hawaii, and Puerto Rico illustrate the concepts of tropical ecosystems, and the western coast of Washington state harbors a splendid temperate rainforest. The biomes we will focus on are the desert, grasslands, tundra, coniferous forest, deciduous forest, and the rainforest, both tropical and temperate.

The Desert

The desert regions of North America are largely mountain-barrier deserts, precipitation is prevented from reaching them by the Sierra Nevadas, the Coast Range and the Rockies. There are a large number of cloudless days, and the solar radiation is intense. Hot dry winds blow down out of the mountains causing dust storms which have a definite impact on the life forms there. We find that vegetation, plant size, and plant diversity are all positively correlated to precipitation. Where there is little rainfall all of those characteristics decline. The desert is also a relatively stable habitat which also results in little species variation, the desert plants that have succeeded are where they are due to adaptations to their specific environment. The correlation of species' diversity with rainfall also exists for animal groups such as ants, grasshoppers, and mammals. Surprisingly one group does not follow this parameter, reptile diversity is at its peak in North American deserts. North American deserts can be subdivided into three large categories based on seasonal rainfall, and types of successful vegetation. Due to localized variations they can all be further subdivided into semi-arid or true deserts within each class. This more specific breakdown of areas is surely too much for seventh graders but the three larger groups should be of interest to them as they can be seen in so many of the movies that

they watch on television. The charts below give some of the details of the three desert areas.

	vegetation types; desert altitude	rainy season	total rainfall	and examples
Sonoran	0-1200 m	summer	100-300 mm	thorny succulents; saguaro cactus
Mojave	800-2000 m	winter-summer	100-300 mm	pygmy woodland; Artemesia, yuccas, Joshua trees
Chihuahua	700-1600 m	summer	200-400 mm	open shrub and thicket; cactus, yucca, agave

Temperatures can vary dramatically, with an extremely low—14.4°C at Kingman, Arizona to an extremely high 50.6°C at Gila Bend. The “hot” desert’s boundaries are roughly approximated by the distribution of the creosote bush (Larrea tridentata).

Desert annuals survive by remaining in the seed stage during the summer and sprouting during the rainy season. They then grow rapidly, flower, and produce seed. The seeds may remain dormant for years until the conditions are right again. Some plants are able to store water that is collected during the rainy season and use it slowly. These plants often maintain a dwarf form and space themselves out over an area. Still other types of plants, such as ocotillos, elephant trees, and jatrophas, are able to control leafing out until rainy weather, and then shed those leaves when it becomes dry again. Mesquite plants have extremely long tap roots, sometimes 30 feet long, which reach deep into the ground for water. And cacti, such as the saguaro and the barrel cacti, have a unique accordion-like shape that allows them to expand into a bloated water container during the rainy season and then draw from that source during the dry times. Some leaf adaptations include the ability to curl, or twist the narrow edge up reducing the surface area exposed to the sun. Hairy leaves or stems catch moisture from the air and shiny or waxy leaves trap and hold the moisture they have. And in some desert plants the leaves are absent and the stems take over leaf function.

Some physiological adaptations of desert plants include the ability to survive with very little water, the ability to control water-using life functions such as transpiration and photosynthesis, a tolerance for high concentrations of salts in the body tissues and special salt excreting organs.

The animals of the desert share many of the same adaptive behaviors and physiological traits. Some of the most common are nocturnal lifestyle, burrowing, obtaining water from prey, ability to derive sufficient fluid from seeds or other vegetative material or low metabolic needs. Some animals have special salt-excreting glands, or produce semi-solid urine. Birds function at a higher body temperature, and are able to fly at high (cooler) altitudes. Their feathers sometimes act as insulators from excessive sun or radiant heat. They can of course travel great distances to obtain water and some can “carry” water in their breast feathers and down. Like mammals of the desert, birds are most likely to be active early in the morning or at dusk when it is cooler. Mammals are likely to be nocturnal and live in burrows. Small mammals such as the rodents are able to get their water needs filled by their seed diet, but larger mammals must have liquid water. Some of the larger carnivores get substantial amounts of their water requirement from their prey. Most mammals have relatively low metabolic rates (compared to mammals in other biomes) and their food requirement is low, their urine output is low, and they can go a long time without water. Animals that burrow to avoid the sun in the summer also must be able to survive relatively cold winters. Many of them hibernate through the cold season. An adaptation of desert animals to the blowing winds would be their small ear openings with hair or scales, long eyelashes, and thickened eyelids. Some even have nostrils with closure valves. Many desert animals tend to be pale in color, but scientists disagree as to whether this is an adaptation for camouflage or for heat radiation.

An example of the types of animals to be found in a typical square kilometer of North American hot desert would include about ten small mammal species including varieties of ground squirrels, mice, hares, rabbits,

and gophers. There would be four to nine bat species, and at least one representative of the following; fox, coyote, skunk, and badger. The birds would be represented by five to twenty-five breeding species; including quail, dove, roadrunner, owl, night hawk, vulture, woodpecker, raven, wren, and flycatcher species. The reptile group would be well represented by the spadefoot toad, tortoise, gecko, iguanids, lizards, rattlesnakes, racers, longnose, king, and bullsnakes. This would not be the end of the species list as there would also be some eight hundred to twelve hundred arthropod species. Invertebrates would include worms, scorpions, spiders, beetles, bees, termites and ants.

The desert is a very complex environment despite its lack of rain. Desert species have a high rate of predation and it appears that the number of organisms is limited more by the amount of resources and the very high degree of competition than by the degree of harshness of the physical environment.

Many examples of the types of plant adaptations to the desert biome can be found in plants easily available in local nurseries and stores. A good activity to do with the children is to set up a desert terrarium with a variety of cactus and succulent plants. Directions for a terrarium are given in Activity 1.

Grasslands

The North American grasslands (prairie) make up about 1.4 million square miles or 15% of the continent. They cover about one thousand miles of the center of our country, from the Rocky Mountains to the state of Indiana, and can be sub-divided into three broad categories of grass types. These categories are determined by the amount of rainfall.

Shortgrass prairie

10 in. rain

200 miles wide

eastern Wyoming, western South Dakota, Nebraska, and Kansas

grasses; blue grama, buffalo grass

Mixedgrass prairie

20 in. rain

400 miles wide

Most of Kansas, Nebraska, the Dakotas, Oklahoma

little blue stem, side oats grama

Tallgrass prairie

40 in. rain

200 miles wide

eastern Iowa, Missouri, Illinois

big blue stem, golden rod, asters

The interior of the continent is affected by wide daily temperature swings and extremes of weather including drought, dust storms, hail, blizzards, and tornadoes. The frost-free season varies widely ranging from 100 to 300 days a year. Growth is affected by both temperature and rainfall. Trees are absent due to the lack of rain, lower humidity, extremes of temperature, and the hot dry winds that come during the summers. The soil can vary from a few centimeters in the west to two meters deep in the eastern regions. It can range from a brown to a dark brown to black as the organic composition increases, usually in a west to east pattern along with the increasing rainfall. The original native vegetation produced the best soils, and increased agricultural use has promoted serious soil erosion and declining soil quality. Despite this American grasslands annual crops average about $150 billion. About 70% of the harvested crops are classified as grasses, including wheat, corn, rice, barley, millet, sorghum, and sugar cane.

Native grasses vary in size from the seven foot tall grasses with roots extending down into the soil six feet to the shortgrasses growing to a height of only eight or ten inches. These short grasses can have roots that extend three feet down. The grasses die back to their roots annually and the soil and the sod insulate the roots and the new buds from the winter cold. The air temperature above ground can fall to Ð40°F in some areas. These deep roots also are protected from the temperature extremes of a prairie fire. At a height of three feet the air temperature can reach 400°F while an inch or two below the ground the temperature may rise only a few degrees. Some of the grasses survival techniques include the ability to curl their leaves to reduce moisture loss, and rapid early spring growth while moisture is available. The seeds will be produced later in the spring and then become semi-dormant to make it through the hot summer and the cold winter. In areas that excessive grazing takes place grasses that are very drought-tolerant are more successful and annual grasses are favored over perennials. The prairie also is home to some spectacular displays of flowering plants such as the daisylike composites and the sweet peas, legumes.

If we look at the animals of the grasslands from the bottom up we will first focus on the creatures beneath the grass, the soil-makers known as earthworms. These animals mix and aerate the soil and enrich it with their droppings. Earthworms on a single acre pass an amazing fifteen tons of soil and vegetation through their digestive systems in a single year! The organic matter they take in and pass out is broken down into nitrogen, phosphorus, and potash which are essential nutrients for plant growth. Other subterranean animals include flightless insects and grubs, and the many burrowing mammals; rodents, mice, gophers, prairie dogs and rabbits. Of these the prairie dog is an interesting representative species. It is actually a ground squirrel, not a dog at all. It communicates with a sharp yipping sound and its predators are rattlesnakes, hawks, ferrets, and coyotes. The prairie dog has a highly organized colony broken into family groups taking up about 7/10 of an acre with large numbers of these families congregating together. One fantastic colony was studied in 1900 in Texas. This prairie dog town took up 25,000 square miles of burrows and an estimated population of 400 million prairie dogs!

Grasshoppers are another animal found in abundance on the prairie. They are usually kept in check by birds and other predators on them. In humid areas parasites and diseases control their numbers. But sometimes their population increases rapidly to create a problem. In 1870 a warm Fall to increase egg production and a cool Spring which delayed the hatching until abundant food germinated was compounded by dryness which reduced disease and prompted the birds to migrate away for water. All these conditions worked together to

create a locust plague of historic proportions in the United States. The eastward moving swarm travelled at five miles per hour and witnesses say it took about six hours for the swarm to pass over. The group was thirty miles deep, one hundred miles wide and one mile high. The population was estimated to be about 124 billion locusts! A group large enough to do more damage than a prairie fire. It is very unlikely that a plague of such proportions would occur today due to improved use of pesticides, better communication, and early intervention techniques.

Grassland animals that live above the surface of the ground include birds and mammals. These have developed some adaptations to increase their success in this biome. Many of the birds nest on the ground, and are strong-legged walkers. They drink less and have a seed diet which provides much of their fluid requirement. A number of the birds are predators on the abundant rodent population which serves the dual ecological purposes of providing a food source and preventing overpopulation and overgrazing. The mammals of the grasslands originally were the herbivores; bison and pronghorn. The bison was well adapted to the extreme climate of the prairie in winter with his large size, thick fur coat, and large herd size. When snow covered the ground the bison swept it away with his huge head to get at the buried vegetation. When threatened by a predator the herd would gather together around the juveniles with their heads, horns, and hooves facing outward presenting a daunting front. Less impressive in size but equally well adapted to their environment are the pronghorn antelope. Their diet consists of the flowering plants, shrubs, and cactus of the shortgrass prairie. They have extremely good vision and can spot a predator up to two miles away. They can run at speeds from 45 to 60 mph with their long legs, enlarged heart, and wide trachea. They run with their mouths wide open gulping air to increase their stamina.

Today the grassland biome is much changed from when Europeans first arrived. The bison are gone, and antelope are greatly reduced. These niches have been filled by domesticated cattle and sheep. The tallgrass prairie is gone, replaced by agriculture plants, and the shortgrass prairie is extensively grazed.

Tundra

In many ways the tundra is similar to the desert or the grasslands. The plant and animal life must find ways to adapt to a rigorous climate that provides little rain, and frequent extremes in temperature. In the tundra the average annual rainfall ranges from 12 to 20 inches, but the permafrost keeps this small amount of moisture near the surface. About 85% of Alaska and 50% of Canada has this permafrost and it is one of the defining characteristics of the tundra. During the summer months the top layer of the soil thaws only a few inches down and so the water is trapped on the surface forming numerous shallow lakes, ponds, and bogs. Although the winter temperatures can reach Ð60°F, the temperatures in the summer can climb well into the 60s and 70s. This summer heat and the moisture it releases, as well as the extremely long day, make a surprisingly abundant quantity of vegetation possible. The growing season may be as much as two to three and a half months long but in many places the soil temperature rarely gets much above the freezing point. Generally the soil is rather thin as the cold temperatures inhibit the growth of bacteria and other soil-producing organisms. Despite the cold conditions some plants need only a few days above 32 °F to survive. The lichens, mosses, and algae are among the most common plants to be found there. Lichens are a symbiotic partnership of fungi and algae; the fungi anchors itself to a rock and its spongy tissue holds large quantities of water, while the algae lives inside this moist shelter photosynthesizing food which it shares with the fungus. Most lichens grow at a remarkably slow rate, in some cases as little as one mm per year. One type of lichen called reindeer moss

does grow relatively quickly and may be six inches tall. It often forms dense mats of vegetation that provide nourishment for caribou and musk ox.

Flowering plants in the tundra require at least two months of growing season although there are a few hardy souls that can manage on only a few weeks. Since even the summer season may present the challenge of an overnight freeze most of the successful plants are perennials which will have many years over which they may try to produce flowers and seeds. Some arctic plants have virtually given up reproduction by seed and spread exclusively by vegetative means. Many of the hardy plants have most of their body tissue below ground waiting for spring. Even the new buds may be formed in the fall and stored underground until warm temperatures arrive. The warm weather signals the plant to produce flowers and seeds quickly using the reserves stored from the previous year for growth. After the seeds are formed the plant can then renew itself by photosynthesis. Some of the other adaptations these plants have evolved include a low growing stature. Some willows, alders, and birches will be only a few inches tall but spread over a wide area, ten to fifteen feet across. Some plants have large leaves that angle toward the sun for maximum solar reception, the leaves or flowers may also be relatively dark in color to be more heat absorptive. The stems can be hollow using less nutrients in their growth, and the stems or leaves might be wooly to insulate themselves from the cold. Many of the tundra plants are found growing in masses or cushions to deflect the wind and conserve heat energy.

The rigors of arctic life are equally trying for the animals of the tundra. With very few exceptions the animals are all warm-blooded. When the temperature around them drops to freezing they are able to maintain the appropriate body temperature by metabolizing large quantities of stored fat or taking in sufficient amounts of food. Although this production of body heat is an ongoing constant need, arctic animals have evolved several ways to hold onto much of the heat they generate. Their primary heat-preserving mechanism is insulation; a layer of fat just beneath the skin and a thick layer of fur or feathers over the skin. Often these feathers or fur hairs are hollow which acts even more efficiently as an insulating layer. Some animals are able to live comfortably under the snow in tunnels they have made, living on caches of seeds and leaves safe from most predators (until their snow home melts in spring). Some animals are true hibernators that curl up in dens for the winter. Their body temperatures may drop almost to the freezing point and their stored fat provides the small amount of nourishment their bodies need while in this suspended state. Many of the tundra inhabitants migrate to more favorable environments. The classic example is the Arctic tern which flies between its summer and winter homes in the Arctic and Antarctica every year. It is on the wing about seven months of every year and flies some 21,000 miles. It has chosen the Arctic tundra for its mating and nesting habitat!

Many kinds of migratory birds, including geese, swans, ducks, gulls, ravens, and owls, have claimed the tundra as their favored nesting site. The abundance of open water provides an ideal breeding ground for millions of insects. This means a generous source of food for the birds and their offspring and the almost continuous daylight enables the parents to gather food night and day resulting in very rapid fledgling growth. An interesting arctic bird is the ptarmigan. It is a year-round resident and finds a variety of things to eat, chiefly berries and new shoots in the summer and willow buds in the winter. The ptarmigan is considered good-eating by a number of tundra predators and so the ptarmigan has evolved protective coloration, camouflage, to protect itself. In the summer its feathers are brown-speckled blending in with its ground cover surroundings, and in the winter new feathers come in that are snow white making it almost impossible to spot. Another well camouflaged bird is the snowy owl. It stays year-round also and nests and lays its eggs while the snow is still on the ground. One of its main prey species is the lemming, which is active year round.

Lemmings are the favorite meal of many of the tundra’s predators. They mate and produce young most of the year, as many as eight litters of five to ten young pups each year. Lemmings eat grasses and seed constantly

producing an abundance of wastes which fertilize the grass growth. But sometimes they take so much that the area is striped bare of plant life and it can take years to regrow. As the lemming population grows it migrates in its search for more food, as it travels the group grows in size and the damage it does to the vegetation is considerable. As the population peaks in number hormonal and chemical changes seem to cause a mass die-off and the animals disappear from the scene for awhile. They do not however as legend has it jump into the sea in a mass suicide frenzy.

Caribou and musk ox are two of the tundra's large herbivores that have found ways to survive the hostile climate. The caribou migrates over five hundred miles in its travels from winter to summer grounds. The caribou has large hooves so they won't sink into the muddy ground or the snow. Their fur is a thick coat of hollow hairs and both males and females have antlers. Their calving grounds are in the tundra where they feed on sedges, grasses, willow, birch, and even a trampled lemming or two. In the winter they move further south and feed on lichens in forested areas. Golden eagles and bears prey upon the calves, and wolves will take an adult especially if it is old or weakened. Insects also prey upon the caribou and can take four ounces of blood from one animal in a day. A more rare animal of the tundra is the musk ox. It feeds on grasses and willows and although it moves from upland to lowland areas during the year it stays within the tundra biome. Its long curly fur covers another layer of soft wooly fur making an almost perfect insulating coat. It spends much of its day conserving energy by sleeping on the ground. The snow beneath these shaggy beasts compacts but does not melt proving the efficiency of their fur.

An occasional visitor to the tundra from its pack ice home is the polar bear. It spends most of its time on ice floes or in the water where its thick layer of fat and dense coat of oily fur keep it warm and the favored prey, seals and fish can be constantly obtained. On the polar bear's rare visits to regions on land it will feed on berries, grasses, and rodents. A pregnant female bear will find a cave in the ice to hibernate in. She gives birth to her cubs during the winter. A seven hundred pound polar bear mother delivers a two pound offspring which she will care for for at least two years.

An activity that would fit in with the study of the tundra is the examination of lichens and mosses. Many varieties are available for easy collection and could be maintained in a terrarium in the classroom. Activity 2 gives some suggestions for looking at both lichens and mosses.

Rainforests

The rainforests of the world are part of a 3.4 million square mile band of green that encircles the equator, and are home to over half of all living things. Some of the most incredible animal and plant life can be found in these regions and the children will be shown several video tapes that focus on the rainforests of South America as enrichment activities. The North American rainforests are much more limited in their numbers of species due to their island nature. Hawaii and Puerto Rico received their plant and animal inhabitants by chance, carried by wind or water from other regions over millions of years. The earliest immigrants found a new home with few competitors and were able to establish themselves and adapt to the special conditions of the islands. In Hawaii five million years of evolution has allowed a limited number of species to adapt to a wide variety of habitats and niches. An outstanding example is the variation among the Hawaiian honeycreepers which the children will study further in an activity. To understand the incredible diversity of the rainforest in general we must go back in time about 30 million years when the climate of the world was much drier in the equatorial regions. Isolated wet regions were surrounded by dry barriers, this resulted in the evolution of

species in individual pockets of habitat that were quite different from one another. As the climate changed and became more uniformly wet, these isolated pockets expanded and ran into each other creating a mix of life-forms that is the most diverse in the world.

The equatorial location of rainforests means more solar radiation, no winter, no reduced daylength, and therefore a relatively stable 70-80°F temperature year-round. The abundant rainfall is the defining characteristic of this biome, with the island of Kauai, the oldest of the Hawaiian chain receiving a staggering average of 486 inches per year making it perhaps the wettest place on earth! Most of the world's rainforests receive between 70 and 110 inches of rain per year which is generally distributed evenly throughout the year. Of that about 25% evaporates from the canopy 40% trickles down limbs and bark being absorbed and evaporated, and only about 10% actually reaches the forest floor. This slow movement of moisture downward through the trees results in extremely high humidity, 70% in the canopy and 90-95 % at floor level. This constant cycling of water through rainfall and evaporation keeps several thousand gallons of water in the atmosphere per acre of rainforest each day.

The abundant rainfall has a significant impact on the formation of the soil also. The daily rains and warm temperatures cause the leaves that fall to break down very quickly. Humus does not have a chance to collect and organic nutrients would be washed away if it were not that the rainforest vegetation is well adapted to taking up those nutrients immediately. The plants have extensive shallow root systems and in the poorest soils the root mat may be only 15 to 40 cm. deep. In experiments done on these root systems there was 99.9% absorption of cations sprinkled there and of radioactive tracers on fallen leaves none leached through the root mat.

Unlike the forests of the drier temperate regions, in the rainforest most of the nutrients are tied up in the trees themselves. As much as 75% of the carbon in this system is in the wood and leaves. Decomposition occurs rapidly and whole trees may completely disappear in ten years or less, once they have fallen to the ground. Decomposition does not only take place on the ground however. As dead leaves fall through the canopy they often land on outstretched branches where hosts of bacteria, worms, and insects break the leaves down into rich humus soil. Some of the trees are able to send out a kind of aerial root to absorb nutrients that never even made it to the ground.

On the forest floor the remainder of the leaves break down and are quickly taken up by the vegetation and by various insects and worms. One study showed that 32% of the leaf litter was taken up by termites every week. The remaining soil is rich in aluminum and iron oxides giving it a distinctive red coloration and an acidic nature. Once the overlaying vegetation is removed the nutrient cycle comes to a screeching halt and the soil is virtually useless.

The plants of the rainforest are the key to its fertility. Every conceivable corner of the biome is utilized by plant growth. The canopy, or upper layer of tree growth, rises 150-180 feet up in the air from the forest floor. Most of these giant trees are about 100 feet tall but a few super giants tower above them at heights of up to 200 feet. These trees are very vulnerable to wind due to their shallow root systems and have developed a unique kind of buttress root that extends into the ground only a few feet but reaches out laterally many feet. These buttressing roots may emerge from as high as thirty feet up the side of the trunk providing the tree with great stability.

Many other plants have found a home high in the upper level of the canopy by taking advantage of the structure of the tall trees. Woody vines rooted in the ground climb up the trunks of the trees to reach the sun and wind around the high branches, sometimes reaching a length of 300 feet or more. Epiphytes rest on

outstretched branches taking their nutrients from the rain and falling debris that collect on every surface. These include orchids, ferns, cacti, and bromeliads.

Beneath the canopy an understory of trees, saplings, bushes, and shrubs grow as high as 50 to 80 feet tall. Their growth is limited by the lack of sunlight until one of the old giants falls clearing an opening for new growth. On the forest floor itself the shade is very deep, less than 10% of the sunlight reaches this level. Very little low growth is possible in such sparse light so the floor is relatively bare and open.

In Hawaii, tree ferns are the most common type of forest vegetation. They are not true woody trees, but rather more like a rosette of ferns living atop their own dead stem. The epiphytic vegetation is mostly ferns, mosses, and liverworts. These particular plants are successful colonists because their spores are tiny and light; easily carried by the wind in large numbers. The flowering plants of the Hawaiian rainforest tend to have white or light green flowers attractive to the tiny pollinators looking for a light spot in the shade of the forest. Although pollinators like bees and hummingbirds seem to be attracted by red and orange showy flowers there are few of those kinds of pollinators on Hawaii.

The native animals of Hawaii were limited to those that could be caught in strong winds and carried to the islands. Insects, birds, and bats were the first arrivals. Snails also appeared perhaps carried on mats of reeds or brush. From the few successful travellers evolved a wide variety of forms to fill every niche. From some 250 insect arrivals evolved 3,722 separate species and varieties. 22 snails evolved into 1,064, and 15 bird species took on 70 variations from the originals.

The honeycreepers are a good example of how a single species of bird evolved into many variations based on adaptations to fill many niches. The beak shape has changed over time to permit feeding on insects; beetles, caterpillars, and larva, or nectar from a variety of flowers. Some are adapted to feed on seeds and others on fleshy fruits. Activity 3 provides an outline sheet of beak shapes and suggested food sources the children can choose from for each bird. A discussion of beak shape should take place before the sheets are handed out.

There are no native mammals in Hawaii except the forest-dwelling hoary bat. All other mammals now found there are considered introduced species brought by man. Pigs, dogs, cats, mongoose, rats, and goats have changed the environment in many serious ways. Rats strip away bark killing the trees, pigs root through the vegetation tearing up the soil, goats overgraze areas. Alien species of plants have been brought in for landscaping and have taken over native species habitat. Animal activity has accelerated the erosion process in many areas removing valuable topsoil, flushing the silt into streams and eventually the ocean.

Rainforest preservation is an important topic that should stimulate a good classroom discussion. The children probably have an understanding of the carbon dioxide-oxygen cycle played out there, and some knowledge about the cutting and burning of rainforests for agriculture and cattle. Concepts of biodiversity are more difficult but should be brought up, as should soil depletion caused by removal of trees. Economic and humanitarian issues can also be brought into the discussion, their significance made very clear by the recent Earth Summit held in Rio de Janeiro.

Temperate Rainforest

In the northwest corner of the United States, in Washington and Oregon, there is an area with cool winters and mild summers and an incredible 100 to 200 inch annual precipitation. This is a rainforest of a different sort, a temperate rainforest. Here one would find tall conifers, mosses and ferns on the ground, and sitka spruce. These trees are among the largest in the world many with trunks ten feet in diameter and 300 feet tall. Some record setters are; western red cedar—diameter 21 feet, sitka spruce—diameter 13 feet, and douglas fir—diameter 14 feet. The fallen trees in the temperate rainforest are soon covered with mosses, ferns, fungi, and lichens. Hemlock and spruce seedlings sprout from the decaying wood. Over time the trees grow and the "nurse log" decays away leaving the new young trees on "stilts". Some of the resisent animal life includes black bear, deer, Roosevelt elk, and marmots. A terrarium can be set up to represent a rainforest biome. There are many plants that can be purchased at a nursery that are suitable for terrarium display, and various kinds of frogs and salamanders can be added to make the habitat more interesting. Directions can be found in Activity 4.

Deciduous Forest

The deciduous forest covers most of the eastern half of the United States, extending from the Great Lakes to the middle of Florida. Much of this great forest has been cut for agricultural and building needs, especially during the first 100 years of our nation's history. In many areas the forest is now being allowed to come back due to less agricultural use, but increasing population will never allow the great forests of the past to revive completely. In the regions of the deciduous forest the temperature varies widely, however the summers are generally quite hot. The average annual rainfall is 45-50 inches distributed throughout the year. The type of forest is often determined predominantly by the water-holding properties of the soil, and this is determined by the parent-rock below. A study in the forests of Maryland showed that regions based on granite or gneiss had thick soils that hold large quantities of moisture and regions based on schists had soils that due to their large-grained nature could not retain much of the available rainfall. Succession in the deciduous forest results in mature forests composed of tall high-canopy trees such as beeches or oaks, a lower layer of maples or birches, and beneath these a lower layer comprised of dogwoods, hawthorne, and hollies. This assemblage of trees shades the forest floor excluding most ground shrubs and flowers. But there are some shade-loving plants that take advantage of the humus-rich soil and bring surprises of color to the forest. These include trillium, lady slippers, mountain laurel, blue anemone, and fringed gentian.

The leaves that fall from the deciduous trees spread out on the ground where bacteria and fungi begin breaking down the vegetative matter. Other creatures; beetles, millipedes, springtails, and earthworms creep through the leaf litter further mixing and breaking it down. This produces the typically rich humus found in the forest. Into this rich soil burrows mice, moles, voles, woodchucks, marmots, and chipmunks.

There is a rich array of medium and large animals inhabiting the deciduous forest. Many of these animals are limited by the intrusion of man into their habitat. Hawks, owls, black bears, bobcats, and beavers have greatly declined in numbers. The mountain lion once roamed the forests but no more. Elk and moose are quite scarce and wolves are gone. Some animals have increased in number however. This includes the white-tail deer, often a nuisance in populated areas now. Raccoons and opossums have adapted very well to life in populated areas and numbers of woodchucks, red foxes, cottontail rabbits, and songbirds have grown. The successful

animals are generally animals that inhabit the forest edges, open areas increase their food supplies and wooded areas provide shelter.

The animals of the deciduous forest have adapted to the cold non-productive season of winter in a variety of ways. Some remain active, living off their hoard of collected nuts and seeds. Others collect a winter store and go underground. Bears find a rock hollow or cave to curl up in but their hibernation is not deep and they can respond to changes in the weather or the presence of a threat. The burrowing animals vary in their depth of sleep also, ranging from simple reduction of activity to entering a deep almost death-like sleep. Even the most deeply affected animals will rouse from hibernation if the weather warms or on the other hand chills below the freezing point in their den. The additional cold could kill them so they awaken enough to feed on their winter cache and warm up. All the hibernators depend on their layers of stored body fat to get them through the winter so the fewer the disturbances to their rest the more healthy the animal will be in the spring. A major disturbance in a hibernating animal's rest could cause its death before spring arrives.

One animal of the deciduous forest that has increased dramatically in number is the white-tail deer. When settlers arrived in New England the white-tail deer provided a valuable source of meat and hides. Over time hunting and clearing of the land for agriculture reduced the deer population greatly. But the institution of hunting limitations, the regeneration of the forests on abandoned agricultural land and the removal of natural predators has resulted in a population explosion among out at night and feed on orchard fruit or garden vegetables, eating and trampling as they move through residential areas. Where roads and highways wind through wooded areas or meadows the sudden appearance of a deer in the headlights of a car can prove a disaster for both the deer and the driver. In many areas new hunting seasons have been instituted to thin out the herds. This has proven to be very controversial with high emotion flowing on both sides of the debate. This topic is a good discussion starter as many of the children will have strong feelings about hunting, both pro and con. For children who have heard much about the killing of animals and the resultant extinction or endangerment of species this topic will bring in some other concepts, range management and overpopulation. More information about this debate is available from both wildlife protection agencies and hunting organizations. These are listed in the Appendix.

One other mammal of the deciduous forest that is important to tell the children about is the raccoon. This animal has adapted exceedingly well to the suburban and even the urban environment of man. The raccoon feeds on a wide variety of natural foods such as crayfish, frogs, mollusks, mice, worms, eggs, berries, nuts, and grains. In the country it will feed on farmer's corn and in the city it will forage in garbage pails. The raccoon does not insist on washing its food as many have heard, however given the opportunity it does seem to like to eat moistened food. Raccoons have become a problem in Connecticut over the last few years as a carrier of rabies. This started on the western border of the state and has moved eastward steadily. Since rabies is a fatal but preventable disease children should be sure their family pets (dogs and cats) are vaccinated and must be warned to stay away from any mammal that is acting strangely (wild animals out during the day in plain sight, or dogs or cats that are unknown to the child). They should also be aware that a dead animal can harm them if they handle it and come in contact with the bacteria. There is an excellent educational program that has been developed by the state Humane Society on rabies. More information is available by contacting them. The address is in the Appendix.

Coniferous Forest (Taiga, Boreal forest)

Between the tundra to the north and the deciduous forest to the south lies the vast expanse of the North American boreal forest, second largest forest in the world with only the great Siberian forest exceeding it in size. Although the temperatures there can dip to a low of 40 ° C below zero, the average summer temperature rises to 10 ° C, warm enough to support the growth of trees. The trees that grow there must face long periods of cold and drought, winds, and very poor soils. The soil is not only thin in depth, scraped away by the movements of glaciers, but also very acidic. This acidity comes from the pine needles themselves as they decompose on the forest floor. The acids in the black humus seep down through the layers of soil leaching valuable minerals and nutrients to below the root zone. The absence of earth churning invertebrates, like earthworms, means the soil becomes hard and compacted. The conifers do have an ally however. Certain kinds of fungi live among the root hairs of the trees. The fungi are able to decompose the leaf litter and make the nutrients available to the trees, and the trees contribute carbohydrates in return. Conifers have several adaptations that make them well suited to their northern environment. Their needles are thin and waxy protecting them from dessication, the deep green color helps them absorb the maximum warmth from the sun. Their branches are flexible and down-drooping to prevent breakage by heavy snowfalls, and because they retain their needles year-round they are ready for food-production (photosynthesizing) as soon as the sunlight is adequate.

The most common evergreens in the taiga are the spruce, balsam fir, and pine. Other types include hemlock, cedar, redwood, and juniper which can be found at varying latitudes. Just as latitude influences species, so also does altitude. In the northern Rocky Mountains the lower slopes may be dominated by ponderosa and sugar pine. At about 4,000 feet Douglas fir and white fir appear, and above 9,000 feet alpine fir and whitebark pine can be found. In the southern Rockies a most unusual pine is found, the bristlecone pine. Some of these gnarled and stunted trees are as much as 4,000 years old and they are generally found above the 10,000 foot mark, where the soil and the climate are very inhospitable to all but the toughest survivors.

Evergreens can survive in areas that are far too cold or dry for deciduous trees due to their effective conservation of moisture. However in some places there is sufficient rainfall for deciduous growth but conifers are able to take over because of another set of adaptations which allow them to not only survive but benefit from the occurrence of fire. Pines have a pulpy bark that does not easily burn and protects the inner layers of the tree from heat. Buds are protected by a cloak of long needles which will burn, but slowly, and with less heat-generation. Other adaptations to fire include cones that only release their seeds when dried and split open by the heat. The needles that the pines shed decay very slowly but are very flammable, so wildfire spreads over the ground quickly killing competing plants, harmful insects and fungi, and releasing the nutrients tied up in the fallen needles to the pinetrees roots. Fire in a forest is not necessarily a bad thing. Fire has been used by nature to clear away shrubby growth, return nutrients to the soil, open clearings in dense forests to allow new growth which provides wildlife with new food sources, and allow heat-sensitive cones and seeds to germinate. In forests that have been allowed to burn periodically the large healthy trees have little damage done to them and most wildlife is able to outrun or burrow in long enough to make it. It is when man over many, many years has “protected” a forest from fire and a great deal of deadwood and low shrub material has accumulated that a forest fire is harmful to the ecosystem. However even a hot devastating fire merely opens up new opportunities for a whole new set of plants and animals to move into.

The vegetative offerings in the coniferous forest are not very palatable to most animals. Pine needles are eaten by very few of the forest’s inhabitants with the exception of certain caterpillars and grubs. The seeds in

the cones are more desirable but not easy to extract. One kind of bird, the crossbill, has a specialized beak that allows it to pry the cone open and a type of nutcracker bird has a bill that is large and powerful enough to break the cones open. There are several small mammals; squirrel, voles, and lemmings, that feed on the pine seeds also. They are the mainstay of the taiga food web. Their amazing birthrate keeps their numbers up even as they are heavily preyed upon as long as sufficient food is available to them. Pedators that will feed on the small mammals include owls, wolves, fishers, weasels, and wolverines. The largest predators, grizzlies, lynx, and mountain lions, will feed on the smaller mammals as well as moose or elk when they can pick out a young or weakened individual.

Part of America's history is tied to the animal inhabitants of the coniferous forest. Early trappers travelled throughout this area hunting for the valuable furred mustelideas; martens, fishers, weasels (ermine), mink, otters, and wolverines. They of course would also take beaver, wolves, and bears. The early settlers depended on moose, elk, and bears for their hides and for the quantity of food they provided for the winter. But the biggest threat to the animals of the coniferous forest has been the increased population and habitat reduction that resulted as America grew and expanded west and northward.

In order for the children to better understand the nature of the forest we will go the two representative areas, the hemlock forest and the deciduous forest in East Rock Park. A variety of activities will be undertaken there, leaf collecting, insect hunts, bird-watching, and soil sampling. These are described in the Activity section.

Activity 1

Setting up a "desert" terrarium

Materials

10 gallon aquarium with a lighted hood cover or a screen pottery bowl or glass ashtray potting soil

vermiculite

peat moss

sand

box for shade and hiding

rocks for decoration

plants; cacti and succulents

gravel

Procedure

1. Spread a 1 inch layer of gravel over the aquarium floor, if desert lizards will be introduced do not use charcoal layer.

2. Mix the soil in the following proportions; potting soil-1, sand-3, vermiculite-1, peat moss-1. Spread a 2 inch layer of this soil mix over the gravel base sloping it uphill toward the back of the aquarium. Decorate with rocks and small branches.
3. Set the water dish firmly into the soil, but be sure it can be easily removed for cleaning.
4. Select a variety of cacti and succulents from a nursery or florist to place in the terrarium.
5. The type of animals available to inhabit a desert terrarium varies from pet store to pet store. They are sometimes quite expensive. Ask the pet store owner for suggestions and complete care instructions. They are usually very happy to help, and usually will be more concerned with a good match of owner and pet than just a sale.
6. Many desert animals like to bask for a few hours in very warm (95°F) temperatures. This can be provided by a lamp with a reflector, but there must always be a place for the animal to get out of the light if it wishes. Very warm conditions are necessary for desert reptiles to digest their food properly. A cold lizard will starve to death slowly even though food is provided. Before buying an animal for classroom use be sure you buy a book about that animal!

Extension activity Get the children to really look at the special adaptations of desert plants by having them model the various kinds of cacti and succulents out of clay and toothpicks. Be sure they include the roots. The finished products could be displayed in a shoebox diorama created by small groups or the whole class.

Activity 2

Objective to study a representative group of pioneer plants, the mosses and lichens.

Materials

samples of mosses and lichens microscopes, hand lenses

slide, cover slip

forceps, dissecting needle

Procedure

1. Place a piece of the lichen on your slide. Add a drop of water and gently pull the lichen open.
2. Look at the lichen under low power of the microscope. Try to identify the algae part and the fungi part. Sketch what you see below.
3. Place a piece of the moss on your slide. Add a drop of water and examine your sample with the hand lens. Draw what you see below.
4. Now place a coverslip over a very small piece of the moss and look at it under low power with the microscope. Draw what you see below.
5. Use your textbook or other resource books to help you label your drawings.
6. The lichen is an example of a symbiotic relationship. Define *symbiosis* :___ _____ _____

7. What does the algae give to the relationship?_____
_____
_____
What does the fungi give to the relationship?_____
_____
_____

Drawings

Lichens Moss (hand lens) Moss (microscope)

Teacher notes Lichens and mosses can be collected locally in wooded areas or near streams. Old rock walls are a good place to look for lichens. In addition Connecticut Valley Biological, 82 Valley Road, P.O. Box 326, Southampton, Ma. 01073, Phone (413)527-4030 or Science Kit & Boreal Lab., Tonawanda N.Y. 14150, Phone 1-800-828-7777, are both good sources of living specimens.

Activity 3

Objective to look at the bills of the Hawaiian honeycreeper to see how over time evolution enables a species to adapt to fill a variety of available niches.

Materials outline drawings of honeycreeper heads sketches or illustrations of specific Hawaiian flowers illustrations of various kinds of birds

Procedure

1. Discuss the terms niche and adaptation. Have the children name some animals and their adaptations to their niches.
2. Show the children pictures of different kinds of birds; eagles, hawks, parrots, hummingbirds, and discuss the kinds of food they eat. Focus on the shape of the bill and the diet.
3. Hand out the drawings of honeycreeper heads and the sketches of Hawaiian flowers, seeds, and beetles. Have the children work together in small groups to try to match the bird with its main food source. Encourage them to guess if they are stuck and then think about why they chose a particular match-up.
4. Discuss the results of their match-ups and their reasons with the whole class.

Evaluation Ask the students to think about other body parts that show adaptations such as bird claws, or mammal teeth. Have them explain how the adaptation helps the animal within its niche.
Teachers note: Although the specific answers are less important than the discussion in this lesson, the correct answers are below;

1. koa—G. beetles
2. ou—A. large seeds
3. akialoa—E. nectar from long tubular flowers
4. amakihi—G. insects

5. apapane—C. nectar from small flowers, and F. caterpillars
6. mamo—D. tubular flowers
7. ual—B. fruits
8. iiwi—C. nectar from small flowers
9. crested honeyeater—C. nectar from small flowers, and F. caterpillars

Directions Match the variety of Hawaiian Honeycreeper bird with its main food source by looking at the bill shape.

(figure available in print form)

Activity 4

Setting up a "rainforest" terrarium

Materials

10 gallon aquarium with lighted hood cover pottery bowl or glass ashtray (glue stone chips on the edges with silicon aquarium cement to improve the appearance) potting soil vermiculite

peat moss

sand

horticultural charcoal

rocks and woodchips for decoration

plants

2 chameleons

pebbles or coarse gravel

Procedure

1. Spread a 1 inch layer of gravel over the aquarium floor, cover this with 1/2 inch layer of charcoal. (The charcoal keeps the soil filtered and "sweet")
2. Mix the soil in the following proportions; Potting soil-6, vermiculite-2, peat moss-2, sand-1, charcoal-1. Spread a 2 inch layer of soil mix over the gravel/charcoal base, slope uphill toward the back of the aquarium. Decorate with the rocks and wood chips.
3. Set the water dish firmly into the soil, but be sure it can be removed for cleaning.
4. Select moisture-loving plants from a nursery or florist shop and place them in the soil, with the pot or without.
5. Chameleons (American anoles) will be very happy in this damp green world. Crickets or meal worms can be purchased at a pet store for their dinner. If the room you will be keeping this terrarium in will be cool the addition of a heated rock (sold at pet stores) is an important addition for the health of the animals.

6. The plants will need light to grow, special bulbs are available, but do not leave the light on all the time (the chameleons will suffer) and do not place the terrarium in a sunny window (everything will overheat). Check the temperature and moisture level daily until you are sure that it is stable.

Extension activity If you are able to obtain a good supply of tropical plants you can use the remaining soil to make mini-terrariums in 2 liter soda bottles with the whole class at a very reasonable cost. The children may want to decorate their bottle worlds with small plastic or ceramic animals instead of real ones (which need more room).

Activity 5

Materials

soil samples from a meadow, hemlock forest, deciduous forest test tube with rubber stopper hand lens pH paper

watch glass

forceps

dilute HCl in dropper bottle

distilled water

Procedure

1. The soil from each site will be tested and examined separately following the steps below.
2. Place a small amount of soil on the watch glass and examine it carefully with the hand lens. Note the color of the grains, the size of the grains, the presence of decayed organic matter, etc. Record this information on the chart below.
3. Using the dropper from the acid bottle carefully place a drop of acid on the soil sample. Do this on several areas of your soil sample. Watch for bubbles which would indicate the presence of calcium carbonate. Record your findings.
4. Mix a small spoonful of fresh soil with about 10 ml. of distilled water in the test tube. Stopper the tube and shake well. Use the forceps to lower a piece of the pH paper into the water. Match the color forceps to lower a piece of the pH paper into the water. Match the color of the pH paper to the chart on the side of the paper tape roll to determine the pH of the soil sample. Record your results.

meadow soil hemlock forest soil deciduous forest soil

color of soil size of grains organic matter? calcium carbonate? pH of sample other features

Evaluation question All the samples came from East Rock Park, why are there differences in the kinds of plant-life in such a small area?

Activity 6

Objective to study the variations in leaves and plant growth in different biomes.

Materials
leaves from tropical house plants (rainforest) leaves from New Haven native plants (deciduous forest) samples of cacti and succulents (desert)

Procedure
1. Look carefully at a sample leaf from each biome. Record your observations below for each feature.

	presence	presence	of surface	tickness	of a waxy	features (hairs,	edges smooth	color	of leaf	covering	spines, etc)	or jagged
Rainforest	1.	2.	3.									
Deciduous	1.	2.	3.									
Desert	1.	2.	3.									

Evaluation of data Do you see any similarities among leaf types of any of the biomes? What are they?_____

_____

_____

Activity 7

Objective to determine the degree of understanding the student has attained about biomes each child will create a Biome Book of their own.

Materials
textbook, library books on biomes old magazines (National Geographic, National Wildlife, etc.)

Construction paper

scissors, glue sticks

Procedure

1. Each child will select a biome to work on. After their selection they will assemble in groups to brainstorm about their biome. Lists of animals and plants to be searched for can be made up as a group. The lists must be handed in as part of the assignment.
2. Once the children feel they have enough data they can begin looking for their biome pictures in the magazines. They should look for at least two representative animal and plant species for their biome. Some of the students may wish to draw the plants and animals themselves.
3. Using their text and the library books each student must write at least one page about the plants and animals of their biome, and one page about adaptations, climate, and foodchains in their biome.
4. All of the pages the student has produced should be assemble in a construction paper cover, titled and attractively illustrated.

5. Each biome group is to select one or two students to show their book and talk about their biome to the class.

Extension activity Have the children make dioramas to go along with their biomes. These can be made in shoe boxes with clay, paper maché, or even paper cut-outs. Encourage their creativity by having cotton balls, sticks, toothpicks, pipecleaners, fabric,etc available.

Evaluation Ask the student to think about how the climate affects what would be found in a particular biome.

(figure available in print form)
Temperature Belts of North America
(figure available in print form)
Biomes of North America

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Laycock, George, *North American Wildlife* , Exeter Books, New York, 1983. A beautifully illustrated collection of animals presented

within a specific biome. Each animal is thoroughly described in a very interesting way.

Page, Jake, *Forest* , Time-Life Books, Alexandria, Va., 1983. Another well-illustrated, well-written book that older children will enjoy.

Rabies information

Connecticut Humane Society, P.0.Box 6066 Station A, Hartford, Ct. 06106 or Headquarters; Russell Rd., Newington, Ct. Phone; 666-3337

State of Connecticut Department of Health Services, 150 Washington St., Hartford, Ct. 06106 (Epidemiology Section)

Hunting information

Department of Environmental Protection, State Office Bldg., 165 Capitol Av., Hartford, Ct. 06106, Wildlife Division; Phone 566-4683.

DEP publishes the *Connecticut Hunting and Trapping Field Guide* annually. Organizations that are pro-hunting/trapping can be found in this pamphlet.

Ducks Unlimited, P.0.Box 66300, Chicago, Ill., 60666. Information on habitat preservation and development for hunting purposes.

The International Association of Fish and Wildlife Agencies, P.O. Box 59, Riverside, Ct. 06878. Has a teaching packet called “Wildlife for Tomorrow; the Story of Our Un-endangered Species”. Order from 1075 Post Rd. Riverside, Ct. 06878.

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