

Food For Life: Nutrients and Energy

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Student Handout

“Plants get their energy, in other words their fuel, from the sun. They make batteries of energy (sugar) from carbon dioxide and water using the sun’s energy, and as a by-product of this process produce oxygen, which is what we animals need.” Tim Smit, Eden Project, 2001

Objectives

1. Where do organisms obtain nutrients and energy?
2. How are inorganic nutrients cycled within ecosystems?
3. What are the principal components of a food web?
4. How is energy transferred in an ecosystem?
5. What does an energy pyramid depict?

Ecojargon - some terms for this topic

Ecology - a study of the relationships among organisms and their environments.

Biosphere - the regions of the earth that support life, including the lower atmosphere (air), the hydrosphere (water) and the lithosphere (land).

Biome - a region dominated by a particular vegetation type and by animals that are adapted to that vegetation type.

Ecosystem - an arbitrarily defined portion of the landscape including all of its biotic and abiotic (non-living) components.

Community - all of the organisms that live in a particular place.

Pole Mountain Ecosystems

Pole Mountain is located in the Medicine Bow Mountains between Laramie and Cheyenne, Wyoming. This area is home to a wide range of wildlife species that are organized into at least four different ecosystems. One of the first questions you might ask is “What is an ecosystem?” An ecosystem is made up of all of the living things (organisms – plants, bacteria, and animals, for example) and all of the non-living things (such as minerals, soil, rocks and water) that are found in the same place. Pole Mountain area contains a forest, a prairie, a wetland and a pond ecosystem. The “eco” part of the word refers to the word ecology which is the study of the way that organisms are connected to each other and to their physical environment. The “system” part of the word explains that all of the parts work together.

All of these different ecosystems in the Pole Mountain area are connected to each other in some way. This makes it much more difficult to study them, but much more fun too – it is somewhat like putting a puzzle together from its scattered pieces. Ecosystems are connected together in many different ways. Animals such as squirrels and deer that roam back and forth from the prairie to the forest connect these two ecosystems. Water that flows from the forest, across the prairie, through the wetland, and into the pond connects all four of these ecosystems together.

When animals travel from one ecosystem to another they carry minerals and energy along with them. Consequently, the non-living parts of these ecosystems can go from one to another too. Minerals include things like calcium, iron, and water. Energy comes from the sun to the organisms on the earth. Only plants can use energy directly from the sun. Fortunately, they can change sunlight into food so the rest of the organisms in the ecosystem can use it, as well. Of course, any organism that contains chlorophyll (plants, some protists and some bacteria) can trap sunlight); however, we will use plants as our energy trappers in this scenario.

Plants are called producers because their energy comes from sunlight that they convert into food. You could say the sunlight is their “food.” It is misleading to call fertilizer “plant “food.” The “food” in fertilizer is really not food at all because it does not contain any energy that organisms can use, it contains only minerals. Organisms other than plants are called consumers because they use the food the plants have made. Special types of consumers are called decomposers because they use the energy in the bodies of organisms after they have died. When they do this they consume the remaining usable energy and convert the rest to heat. In addition to extracting the last bits of energy contained in a dead body, decomposers release minerals that plants can reuse. It is important to understand that energy cannot be reused – it is either used or converted to heat. Heat energy cannot provide nourishment to sustain life. Consequently after the decomposers have consumed the dead organisms, there is no usable energy left. Additional energy will need to come from the sun.

Pole Mountain Organisms

Table 1 lists some of the common organisms that live in the Pole Mountain area and shows the habitat ecosystem (or ecosystems) occupied by each one. The last few columns in the chart explain how each of the organisms get the energy they need to live. As mentioned above, decomposers “eat” dead plants and animals. Because all organisms will eventually die, decomposers are connected to all other organisms within an ecosystem. Bacteria are decomposers and so are many of the fungi that live in soils. We will use bacteria to represent the decomposers in the pole mountain ecosystems. Mushrooms live in association with the roots of trees and shrubs. They give the plants extra water and minerals and the plants give them sugar. Thus the mushrooms are symbionts in the Pole Mountain Ecosystems. Plants are producers. Producers don’t eat other organisms. Instead they capture sunlight and change it into food. Consumers eat other organisms. Some consumers eat only plants; we call these herbivores or vegetarians. Do you know any people that are vegetarians? Other consumers only eat animals and we call them carnivores. Are you a carnivore? Still other consumers eat both plants and animals and we call them omnivores because they aren’t so picky! Perhaps you are an omnivore.

Please note that this is only a partial list of the different species of organisms you might find in these four ecosystems. If you were able to take a hike in the area, you might be lucky enough to see other interesting species that aren’t already on the list.

Table 1. The species of Pole Mountain. The ecosystem or ecosystems for each species is noted as are the life styles of the organisms.

<i>Species</i>	<i>Name of Ecosystem</i>				<i>Role of Organism in its Ecosystem</i>			
	Forest	Prairie	Wetland	Pond or Stream	Decomposer	Symbiont	Producer	Consumer
bacteria	X	X	X	X	X			
mushroom	X	X	X			X		
aspen	X	X	X	X			X	
lodgepole pine	X						X	
Engelmann spruce	X						X	
juniper	X						X	
sagebrush	X	X					X	
grass	X	X	X				X	
cactus		X					X	
clover		X	X				X	
lichen (a fungus and a green bacteria that live together)	X					X		
thistle		X					X	
willow			X	X			X	
algae				X			X	
pondweed				X			X	
deer	X	X	X					X
elk	X							X
red squirrel	X	X						X
chipmunk	X	X						X
beaver				X				X
waxwing	X							X
woodpecker	X	X	X					X
red-tailed hawk	X	X	X					X
turkey vulture	X	X	X					X
garter snake	X	X	X					X
jack rabbit	X	X						X
leopard frog			X	X				X
brook trout				X				X
leech				X				X
scud				X				X
grasshopper	X	X	X					X
beetle	X	X	X	X				X
caddis fly				X				X
dragon fly				X				X
water boatman				X				X

Pole Mountain Decomposers

bacteria – Many bacteria live in the soil of all of the ecosystems at Pole Mountain. These decay dead plants, animals and other organisms so that the minerals in the bodies of the dead organisms are released and can be used over again by new organisms in the ecosystem. Bacteria are very important in keeping the soil fertile (in good condition for plants).

Symbionts

mushrooms – Mushrooms live in association with tree roots. They obtain photosynthate from the tree and, in turn, they give the tree extra water and minerals.

Pole Mountain Producers

plants – (aspen, lodgepole pine, Engelmann spruce, juniper, sagebrush, grass, cactus, clover, thistle, willow, and pondweed). ALL of the plants in the Pole Mountain Ecosystems use the sun's energy to make their own food.

algae – Algae are tiny organisms that can change sunlight into food, like plants do.

lichen – Lichens are made of two parts an algae part and a fungus part. The fungus doesn't decompose other organisms when it is part of a lichen.

Pole Mountain Consumers

deer – Deer eat many different kinds of plants including, aspen, willow, sagebrush, clover, and lichens.

elk – The elk's diet includes plants such as willow, aspen, sagebrush, clover and lichens – much like the deer.

red squirrel – Red squirrels like pinenuts, the nuts from spruce cones, mushrooms and grasshoppers and beetles.

chipmunk – Chipmunks like plants such as clover. They eat all of its parts, the roots, stems, leaves, flowers and fruits. They also eat beetles, grasshoppers, juniper berries, and mushrooms.

beaver – Beavers are engineers of pond ecosystems. They eat aspen, willow and pondweeds

waxwing – Waxwings are birds that eat juniper berries and other fruit.

woodpecker – Woodpeckers eat the beetles they find in the bark of trees.

red-tailed hawk – Red-tailed hawks eat chipmunks and squirrels.

turkey vultures – Vultures eat animals (not including insects) that have died.

garter snakes – Garter snakes sometimes eat insects such as beetles and grasshoppers. More of the time they eat frogs.

jack rabbit – Jack rabbits feed on juicy green vegetation (thistle, cactus and clover) and the bark and buds of sagebrush.

leopard frog – Leopard frogs like to eat insects such as caddis flies and water boatman.

brook trout – Trout like scuds and most aquatic insects, such as dragon flies, caddis flies, and water boatman.

leech – Leeches eat the tissues and blood of frogs and fish.

scud (amphipod) – Scuds are small animals that live in ponds. They eat dead algae and small bits of dead pondweed.

grasshopper – Grasshoppers eat clover and grasses.

beetle – Beetles eat mushrooms and many kinds of plants.

caddis flies – Caddis flies eat small bits of plant material and algae.

dragon flies – Dragon flies eat scuds and tadpoles.

water boatman – Water boatman eat small bits of plant material and algae.

Food Webs within the Pole Mountain Ecosystems

An example of a food web for an aquatic ecosystem at Pole Mountain is shown below. Use this example as a guide to illustrate the food web for the ecosystem that you are assigned.

Other food webs can be illustrated by putting the names of the organisms on a sheet of paper then connecting the organisms to one another as shown for the pond ecosystem. If you have an artist in the group, the names can be replaced with drawings.

Illustrate the connections in a food web as follows: 1. The names of the organisms are in place on the sheet you will use. 2. Remember that arrows should point from the organisms that are consumed to the organisms that consume this food. 3. Be sure to show how energy enters the food web to begin with! 4. Color code your diagram: Use yellow or orange to indicate input to the producers from the sun. Use Green to show consumption of producers by the primary consumers. Use black to indicate consumption of consumers by other consumers. Use red or purple to show connections from all of the organisms to the decomposers. Or make up your own scheme and supply a key.

The Energy Pyramids of Ecosystems

Energy pyramids often are used to illustrate the way energy flows through ecosystems. One of these is shown below. You will place the following labels on the pyramid and then discuss how energy flows from one level to the next: producer, primary consumer, secondary consumer, tertiary consumer, decomposers, heat loss.

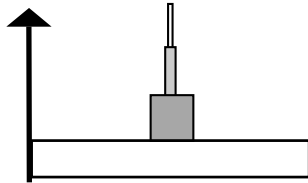


Figure 1: The typical energy pyramid.

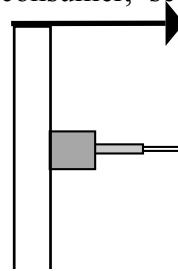


Figure 2: We are going to look at the pyramid on its side so that the input of the sun can be better illustrated.

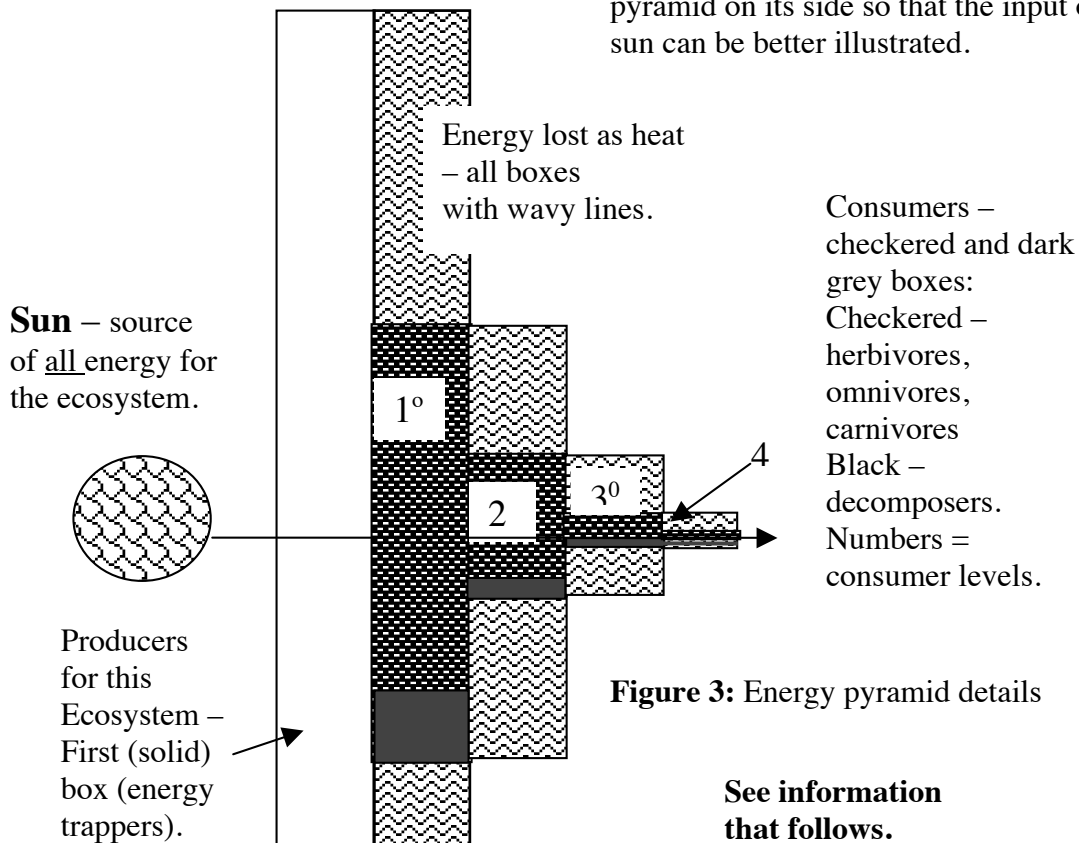


Figure 3: Energy pyramid details

See information that follows.

You have, no doubt, noticed that the size of the levels of the pyramid decrease as they proceed upward. Only $1/10$ of the energy of a given level is passed to the organisms of the next level upward or is used by the organisms of that level. The rest of the energy is converted to heat and lost to the organisms of the ecosystems. A great deal of energy ($9/10$ s) is lost as heat during the process of respiration that all organisms must do to release energy for themselves to use. All of the energy, whether used within a level, transferred as usable energy to the next level, or lost as heat to the atmosphere is shown on the diagram. The usable energy is either white (in producers), checkered (in consumers other than the decomposers), or black (in the special category of consumer, the decomposer). The energy that is lost as heat is shown by wavy lines. Note that the size of the next box up always equals the size of the box below. The next box up is then divided into usable energy and energy lost as heat.

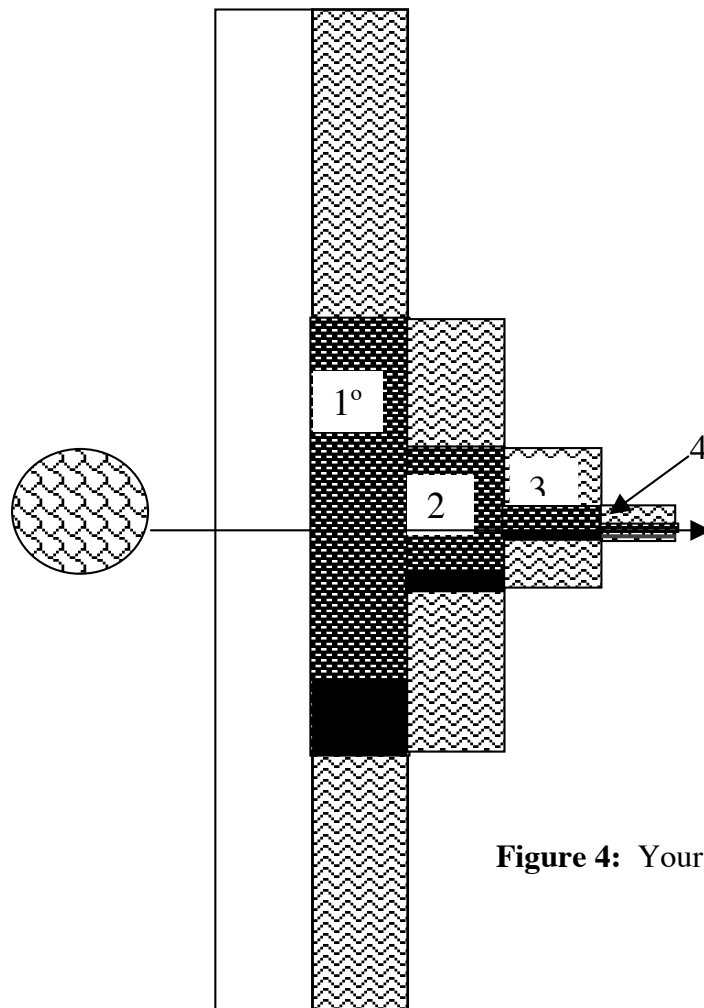


Figure 4: Your additions

Now it is your turn to illustrate energy flow. *Place the organisms of the Forest ecosystem in their correct locations on the energy pyramid outline – or list the organisms that go with each level according to its color and pattern and number. (Note: one type of organism may occupy more than one energy (trophic) level.) Refer to each level as follows: white – producers; checkered – consumers – 1, 2, 3, 4 (other than decomposers); black – decomposers – 1, 2, 3, 4. Indicate whether the consumers and decomposers occupy level 1, 2, 3, or 4, or more than one of these.*

Minerals in Ecosystems

In sharp contrast to energy which flows through ecosystems as it is used by organisms or converted to heat, minerals are returned to the soil and recycled. Minerals include things such as water, carbon, nitrogen, phosphorous, etc. None of these minerals contain energy that organisms can use; they are used for structural purposes. Plants take minerals up from the ground and use them in the compounds they construct during photosynthesis (using the sun's energy). Other organisms obtain minerals through food consumption, and when organism die decomposers tear apart the compounds of the dead organisms and release the minerals into the soil or water. Sometimes these minerals are referred to as nutrients – which is misleading because they do not contain usable energy as food does, and we often refer to food as nourishment!

The water cycle

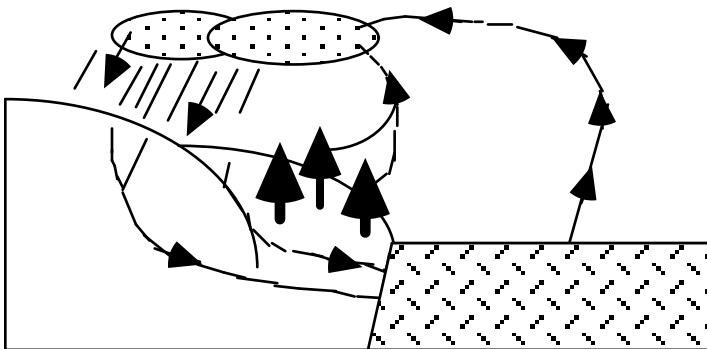


Figure 5. The water cycle

Other cycles:

Carbon, nitrogen, and phosphorus are examples of other mineral nutrients that are cycled within ecosystems. *Use your textbook to help you illustrate one of these.*

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