Web of Life

Adapted from: "Marsh Market" in WOW!: The Wonders of Wetlands. The Environmental Concern Inc., 1995. AND All the Rivers Run. Cuyahoga Valley Association and National Park Service, 1996.

Grade Level: Basic

Duration: 40 minutes

Setting: Classroom, outside, gym

Summary: Students research organisms in a wetland food web then make a living food web by linking themselves with yarn, learning their organism's role in the ecosystem.

Objectives: Students will become familiar with organisms' roles in wetland food webs and how energy is passed through the system. They will understand the interconnected-ness of an ecosystem.

Related Module Resources:

- Module activities:
  -"Treatment Plants"
  -"This Plant Key is All Wet"
- Poster: *Invertebrates of Ponds and Wetlands*

Vocabulary: food chain, food web, trophic level, producer, autotroph, consumer, heterotroph, herbivore, primary consumer, secondary consumer, carnivores, tertiary consumer, top carnivore, top predator, detritivores, detritus, scavengers, decomposers, biomass, primary productivity, energy pyramid, bioaccumulation / biomagnification

Materials (Included in Module):

- Wetlands field guides / books: [Book Box]
  - The Book of Swamp and Bog
  -Plants in Wetlands
  -Through the Looking Glass: A Field Guide to Aquatic Plants
  -Common Marsh, Underwater & Floating-leaved Plants
  -Birds of Lake, Pond, & Marsh
  -Wetlands
- Ball of yarn [Web of Life Module Activity Envelope]
- Organism Cards (laminated) with yarn attached [Web of Life Module Activity Envelope]
- Web of Life Organism Menus Handout

Additional Materials (NOT Included in Module):

- Index cards (optional)

ACADEMIC STANDARDS (ENVIRONMENT AND ECOLOGY)

7th Grade

4.3.7.C. Explain biological diversity.
- Explain the complex, interactive relationships among members of an ecosystem

4.6.7.A. Explain the flows of energy and matter from organism to organism within an ecosystem.
- Explain energy flow through a food web
- Identify niches for producers, consumers and decomposers within an ecosystem

10th Grade

4.1.10.C. Describe the physical characteristics of a stream and determine the types of organisms found in aquatic environments.
- Identify terrestrial and aquatic organisms that live in a watershed.

4.6.10.A. Explain the biotic and abiotic components of an ecosystem and their interaction.
- Explain energy flow in a food chain through an energy pyramid.
- Evaluate the efficiency of energy flow in a food chain.
- Explain trophic levels.

4.7.10.A. Explain the significance of diversity in ecosystems.
- Explain the role that specific organisms have in their ecosystem

12th Grade

4.6.12.A. Analyze the interdependence of an ecosystem.
- Analyze the relationships among components of an ecosystem
- Evaluate the efficiency of energy flow within an ecosystem.

BACKGROUND:

A **food chain** is a series of organisms linked by their feeding (predator / prey) relationships. A food chain is usually a simple linear progression where the first organism is eaten by a second, the second by a third, and so on. However in ecosystems, creatures do not usually eat just one type of organism, they have a varied diet. So food chains branch apart and interconnect to create more complicated **food webs.** Webs may involve more than 100 species, with predators often taking more than one type of prey, and prey often being pursued by several different predators. The relations in a food web are important dimensions to an ecosystem.

Food chains and webs help illustrate how energy is passed through an ecosystem, such as a wetland ecosystem. Food webs are composed of a series of feeding levels or **tropic levels**. Organisms are placed into tropic levels based on the number of "steps" their food energy passed through.

The energy starts with the sun. Light energy is captured and transformed into chemical energy through photosynthesis and is used to make organic molecules. The organisms that first capture this light energy to make their own food are called **producers** or **autotrophs**. Autotroph is Greek for "self-feeder." Plants, algae, and some bacteria are the producers in wetlands. Producers are the foundation of many wetland food chains and represent the first trophic level because they obtain their energy directly from the sun.

An organism is assigned to the second tropic level if it eats a plant because the obtained energy passes through two steps in the food chain. Organisms that cannot photosynthesize and that obtain their energy-storing molecules by eating other plants and animals are called **consumers** or **heterotrophs** ("other-feeders").

Consumers can be broken down into numerous categories. Organisms that eat plants or algae are called **herbivores**. They are classified as **primary consumers** because they are the first link in the food chain that eats another organism for food. Of the organic material consumed by herbivores, much is eliminated undigested. Most chemical energy is "lost" maintaining essential life functions and activities. A small fraction of the chemical energy is converted to new animal biomass, which represents energy available to the next trophic level.

Secondary consumers eat primary consumers and represent the third trophic level. These organisms are **carnivores**, animals that eat other animals. Only a small amount of the organic substance present in the body of the herbivore becomes incorporated into the body of a carnivore. **Tertiary consumers** eat secondary consumers and make up higher trophic levels. A tertiary consumer may be classified as a **top carnivore** or **top predator** if the animal itself is free of predation.

It is important to realize that these categories are broad. Some organisms fit into more than one group. For example **omnivores** eat both plants and animals. Therefore they may be a primary consumer in one food chain and a secondary consumer in another.

Although some tertiary consumers are carnivores, many are **detritivores,** organisms that live on the refuse or **detritus** (freshly dead or partially decomposed organic matter) of a community. This can include dead leaves, branches, tree trunks, roots of annual plants, feces, carcasses, and even discarded exoskeletons. Detritivores can include **scavengers**, which eat dead prey rather than living prey. Detritivores can also include **decomposers**, such as fungi, bacteria, and some insects. Decomposers can be considered consumers, but they are different because they have specialized abilities to utilize sources of chemical energy, such as cellulose and nitrogenous waste products, that cannot be used by other animals. Decomposers help release nutrients back into the soil, allowing more plants to grow.

Energy is inefficiently transferred between trophic levels in a food chain. Approximately only 10% of energy stored in a plant is converted to animal mass by the consumer. A similar 10% energy passage relationship exists between other or consecutive trophic levels. The actual percentage of energy passed on can range from

1% to 20% and usually depends on the species involved. Each creature uses the energy to make structural molecules, conduct life process, and some energy is lost as heat, a natural by-product of most life processes. So 100 calories of solar energy captured by algae may yield only 10 calories available to an herbivore that eats the algae, and only 1 calorie to the carnivore that eats the herbivore. A scientific study conducted by Lamont Cole of Cornell University on Cayuga Lake further illustrates this energy loss concept. He calculated that for every 1,000 calories of light energy utilized by algae, only 150 calories were transferred to small aquatic creatures. Of this amount, smelt, the principal secondary consumer fish, obtained only 30 calories. If a trout eats a smelt, it has only 6 calories available. If a human as the top predator caught the trout, only 1.6 calories were available of the original 1,000 calories.

Because of this significant loss of available energy between trophic levels, food chains rarely exceed four or five links. At any higher trophic levels, it becomes too difficult to obtain sufficient energy levels. That predator most likely will expend more energy obtaining food than the food will actually yield and/or cannot obtain enough nutrition and energy to sustain itself. That is why there are no non-human predators for adult eagles, bears, lions, or killer whales.

The energy relationships between the trophic levels determine the structure of an ecosystem in terms of both the numbers of organisms and the amount of **biomass** (total weight of ecosystem organic material) present. The rate at which plants and other producers build biomass or organic matter is called the ecosystem's **primary productivity**. Different ecosystems vary considerably in their productivity, but the primary productivity level does influence how much energy is available within an ecosystem.

The flow of energy through a food chain in an ecosystem can be depicted as an **energy pyramid**, which shows maximum energy at the base with steadily diminishing amounts at higher levels. Energy pyramids help to visualize why most food chains are limited to three to five levels. Only a small fraction of energy stored by photosynthesis reaches the small block at the top of the pyramid representing tertiary consumers. Biomass can also be used to illustrate the relationship in a biomass pyramid and number of organisms in each trophic level can be used in a pyramid of numbers. In a biomass pyramid, the overall biomass or tertiary consumers decreases, but the biomass per organism usually increases. For instance, most top predators are large organisms (bears, mountain lions, eagles), but they usually have a lower total population than organisms at lower trophic levels (there are more trout out there than eagles). This is because there is not enough food and energy to support large populations of tertiary consumers.

The loss of energy described above is often the reasoning used by people choosing to eat foods that are lower on the food chain, thus gaining more energy value from it. They would eat the smelt instead of the trout or eat vegetables (producers) instead of meat (consumers).

Just as energy is passed from trophic level to trophic level, so can pollutants and toxins be passed on. One of the benefits of wetlands is that wetland vegetation can take up pollutants in the water and sometimes even transform them into less toxic forms. As described in the module activity, "Treatment Plants," however, toxins that are taken up by wetland plants have not disappeared. They can reenter the wetland food chain when the plant dies and is consumed by detritivores or when the plant is eaten. Depending on the type of toxin, the pollutant stored in the plant tissue could then be incorporated into the tissues of the organism that consumed the plant. Were that organism to be consumed, it too would pass along its pollutant load to its predator, and so on, resulting in significant pollutant loads in the tissues of the top predator of the food chain. This phenomenon is referred to as **bioaccumulation** or **biomagnification**. An example of bioaccumulation in a wetland ecosystem would be if a mosquito larva consumed detritus from plant matter that was contaminated with a toxin, that toxin load could potentially be passed along to a minnow that consumed the mosquito larva. Were the minnow to consume many contaminated mosquito larvae, it would eventually develop a significant toxin load in its tissues. Were a heron to feed on this minnow or other contaminated minnows, it would develop an even higher toxin load.

OVERVIEW:

Students become connected in a wetland food web that they create. They will wear organism illustrations around their necks and pass yarn to an organism that they eat or are eaten by, learning their organism's role in the ecosystem. How energy and potentially toxins are passed through the food web is also discussed.

PROCEDURE:

Teacher Preparation:

Locate the Web of Life Organisms Cards with yarn attached, the ball of string, and the Web of Life Organism menus list at the end of this activity write-up.

Student Activity:

1. Make a list the plants and animals that live in a wetland community – be as specific as possible for the group involved. (Include such things as birds, fish, insects, amphibians, reptiles, crayfish, algae, and even humans.)

2. Bring out the Web of Life Organism Cards and show them all the different types of creatures that could be on the list. Assign each student to be one of the organisms that is on the Web of Life Organism Cards.

3. Have them research the food preferences and predators of that organism. If you think they may forget, you may want them to write down their findings on an index card.

4. Categorize the organisms as primary producers, herbivores, carnivores, omnivores, scavengers, or decomposers. This can be done by making a list on a chalkboard or could be done later in the activity.

5. Have the students put the Organism Cards around their neck.

6. Have the class stand in a circle. Pick a student who is representing a plant/algae/ primary producer. Give them a ball of yarn and have them wrap the end once around their hand. You might want to ask the group why you chose this student to begin the food web.

7. Have them pass the ball of yarn to an organism that eats that plant. That person should also then wrap the yarn around their hand and pass the ball on again to an organism that they would eat or be eaten by. They should try to pass it to someone who has not received the yarn yet. The students that did the research on the organism can help to decide where the ball should be passed. For reference, enclosed is a list of the organism represented on the cards with their diets and what they are eaten by.

8. Toward the end, if students are having trouble finding something they eat or are eaten by, you may need to ask them to find something that they interact with in some other way (ie. Two insects might live under the same rock, a raccoon relies on the insects to feed the fish, which the raccoon eats).

9. When all possible connections have been made, the web is completed. At this point, have the students move in a manner that stretches the web taut.

10. Discuss what would happen if an organism disappeared from the web. How might this happen?

11. As the students come up with ideas that might harm or eliminate a member of the chain, have that member pull the string. Then, anyone who feels the string move should raise his or her hand. These people should all tug on the string in unison and everyone who has been affected, by that tug should raise their hand. OR
Have the eliminated person drop his or her string. Now make the web taut again, which will require the people connected to the person who dropped out to move back away from the circle – reshaping / disrupting the web. Eliminate another, creature/person and reshape again. [Note: You might also discuss biomagnification/bioaccumulation at this point. Introduce a pollutant/toxin at some point in the food web—potentially to a wetland plant that had taken up polluted water. Ask who might eat the pollutant-loaded organism and have those organisms raise their hands. Explain that the pollutant load from the contaminated organism could potentially be passed onto the consumers of that organism. Then have organisms that would eat the newly contaminated organisms raise their hands. If these organisms consume more than one contaminated organism, they would accumulate an even larger toxin load in their bodies. Continue this process to show how the pollutant would bioaccumulate in organisms' tissues as it moved through the food web.]

DISCUSSION:

Have the students talk about what ways the organisms would be affected by those that pulled/dropped the string. Help them come to the conclusion that the organisms are all connected in some way and are therefore dependent on each other. [If illustrated during the activity, review the concept of biomagnification / bioaccumulation.]

Discuss the roles that different organisms played in the food web - primary producer, primary consumer, secondary consumer, omnivore, scavenger, decomposer, herbivore, carnivore, etc.

There was no card for bacteria in the activity. What role would it play in the food web? *It would be a detritivore and more specifically a decomposer.*

What role could humans play in the food web? *In some cases, we are a predator and in some cases we may overharvest a particular organism. We also can indirectly affect the food web by destroying aquatic habitats that some of the creatures may rely on, by adding pollution to the aquatic system, by introducing a non-native species into the ecosystem that outcompetes the native organisms for food.*

This activity allows for a great follow up discussion about how energy is passed through a wetland ecosystem and is lost from one trophic level to another. *See background section and visual aids enclosed.*

If herbicides were added to the wetland and they killed all the wetland plants and algae, how might this affect herons living in the wetland? *Herons may eat fish that rely on insects that eat wetland plants for food. Without the plants, these insects may not survive, and so neither would the fish or ultimately the heron unless they find a new food source. In addition, there may be a concern of bioaccumulation of toxins in the heron if they eat fish that have eaten insects that have ingested herbicides.*

EVALUATION:

- Identify an organism's role in a food chain – ie. tertiary consumers, decomposer, etc.
- Recognize that the members of a community interact in a number of ways that make them interconnected.
- Identify the food and predators of a number of organisms in a wetland community.
- Provide a list of wetland organisms and have students create a food web using the list.
- Describe how a number of members of a wetland community can be affected when one organism is disturbed.
- List a creature in each of the following categories: primary producer, primary consumer, secondary consumer, omnivore, scavenger, decomposer, herbivore, carnivore.

EXTENSIONS AND MODIFICATIONS:

- Change cards and do the activity again.
- You may want to have students take notes on the different roles that organisms play in a food web, keep the notes with them during the activity, and identify their role as they create the web.
- Have the students decide and research what organisms they would like to represent. Instead of using the enclosed creature pictures, have them create their own picture. This can be done from magazines or with a simple drawing.
- Repeat the activity in specific types of wetlands. Students will need to create their own pictures or simply where a tag with the name of their creature in this case.
- Have student figure out a way to visually represent an energy pyramid or biomass pyramid for 4 or 5 organisms. Perhaps they make 500 cards (or scraps of green paper) for the organism on the bottom of the energy pyramid, which would be enough to feed 50 of the organism on the next highest level of the food pyramid, which would be enough for 5 individuals at the 3rd level, barely enough for 1 individual at the 4th, which would be a good appetizer for an individual at the 5th food pyramid level.

NOTES (TEACHERS, PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

Activity Version: June 2003

HANDOUT: WEB OF LIFE – ORGANISM MENUS

This list may not include the complete diets of the organisms below; some food choices may have been omitted. But this chart is an excellent reference to help facilitate the Web of Life Activity.

Organism	It Eats…	It Is Eaten By…
Alderfly Larvae	Predaceous, eats other insects larvae including other Alderfly Larvae	Fish, Other Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Aquatic Sowbug	Plants, Detritus, Dying Animals	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Beaver	Plants and Fungi- Grass, Ferns, Mushrooms, Duckweed, Algae, Leaves, Roots and Stems of Plants, Cattails, Water Lilies, Bark, Twigs, and Tree Buds	Bears, Bobcats
Black Bear	Fruit, Mast (acorns and beechnuts), Leaves, Grasses, Insects, Plant Roots, Amphibians, Reptiles, Small Mammals, Fish, Carrion	--
Blackfly Adult	Blood from biting mammals	Fish, Damselflies, Dragonflies, Frogs, Salamanders, Toads, Birds
Blackfly Larvae	Filter feeder – on Phytoplankton, Micro-organisms, Plant Debris, Detritus	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Blue Heron	Animals- Fish, Frogs, Crayfish, Snakes, Invertebrates, Small Rodents	Foxes, Minks, Hawks, Eagles, Raccoons
Caddisfly Adult	Plant Nectar	Fish, Damselflies, Dragonflies, Frogs, Salamanders, Toads
Case-making Caddisfly	Detritus, Algae, Aquatic Micro-Organisms	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Cattail	Autotrophic- Photosynthesis	Beaver
Coarse Particulate Organic Matter	--	Detritivore Aquatic Macroinvertebrates
Common Carp	Aquatic insect larvae, mollusks, crustaceans, Plants, algae, Fish Eggs, some detritus	Predatory Mammals and birds
Cranefly Adult	Plant Pollen	Dragonflies, Frogs, Birds, Fish

Organism	It Eats…	It Is Eaten By…
Cranefly Larvae	Small microorganisms (plants and animals), Periphyton and Phytoplankton, Detritus, plants, even wood	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Crayfish	Plants, Leaves, Aquatic Macroinvertebrates, Aquatic Worms, Small fish, Detritus –Coarse Particulate Organic Matter, Fine Particulate Organic Matter	Raccoon, Fish, Hellbenders
Damselfly Nymph	Predaceous – eats Tadpoles, Insects, Other Aquatic Macroinvertebrates, worms, small crustaceans	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Predatory beetles, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Birds, Raccoons, Turtle
Dragonfly	Predaceous – eats Tadpoles, Insects, Other Aquatic Macroinvertebrates, worms, small crustaceans	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Predatory beetles, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Birds, Raccoons, Turtle
Eagle	Fish (60-90% of diet), Birds, Small Mammals	--
Egret	Fish, Small Mammals, Amphibians, Insects	Foxes, Minks, Hawks, Eagles, Raccoons
Elodea	Autotrophic- Photosynthesis	Ducks, Aquatic Insects that eat plants, Beavers, Fish that eat plants
Fine Organic Particulate Matter	--	Detritivore Aquatic Macroinvertebrates, Some Fish
Frog	Insect Adults and Larvae, Arachnids	Raccoons, Snakes, Small Mammals, Predatory Fish and Birds
Fungi	Dead Plants	Beaver, Snails
Giant Water Bug	Predaceous – eats Aquatic Macroinvertebrates, Tadpoles, Crustaceans, Tadpoles, Fish	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Leaf	Autotrophic- Photosynthesis	Anything that eats detritus or coarse particulate organic matter – aquatic insect larvae, snails, crayfish and smaller crustaceans, some fish, filter feeders will eat fine particulate organic matter of leaves in water column

Organism	It Eats…	It Is Eaten By…
Leech	Scavenge or prey on aquatic insects, mollusks, and aquatic worms. Some are blood suckers of fish, amphibians, reptiles, waterfowl	Predaceous Fish, predaceous aquatic insects
Mayfly Larvae	Plant pieces and Detritus, algae, a few eat other aquatic insects	Fish, Crayfish, Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Mosquito Adult	Adult Female- Blood; Adult Male- Plant Pollen	Birds, Fish, Toads, Salamanders, Frogs
Mudpuppy	Crayfish, Worms, Aquatic Invertebrates, Small Fish, Fish Eggs	Predatory mammals and birds
Mudworm	Detritus, Algae, Bacteria, Protozoa	Fish and Birds
Muskrat	Roots and Stems of Aquatic Plants (Cattails), Legumes, Grasses, Grains, Garden Crops, Fruits, Crayfish, Fish, Frogs, Carrion, Dead Muskrats	Predatory mammals
Periphyton (Algae)	Autotrophic- Photosynthesis	Any aquatic insect larvae that eats algae (grazers), some fish, snails, crayfish
Phytoplankton (Algae)	Autotrophic- Photosynthesis	Zooplankton, snail, Aquatic Macroinvertebrates
Raccoon	Vegetables and Plants- Berries, Fruit, Nuts/Mast, Leaves, Earthworms, Insects, Fish, Frogs, Crayfish, Mice, Carrion	Large Predatory Mammals
Riffle Beetle	Periphyton, Detritus	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Roundworms	Plants and Animals	Aquatic Insects, Crayfish, Fish
Salamander Egg Mass	--	Fish, amphibians, birds, raccoons
Scud	Detritus, Vegetation	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtle
Snail	Algae, Moss, Fungi, Bacteria, Rotifers	Fish, Birds, Mammals, and Parasitic Worms

Organism	It Eats…	It Is Eaten By…
Stonefly	Plants and Detritus, periphyton, fungi and bacteria on decomposing leaves	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtles
Toad	Insects, Arachnids	Snakes, Small Mammals, Fish
Tubiflex Worms	Detritus	Small Fish, Aquatic Macroinvertebrates
Turtle	Adult and larvae insects, Seeds, Berries	People, Other Turtles, Predatory Mammals
Whirligig Beetle	Small Organisms, Scavenger on floating organic matter, zooplankton, small insects on surface	Fish, Alderfly Larvae, Crayfish, Damselflies, Dragonflies, Other Predatory Aquatic Macroinvertebrates, Frogs, Salamanders, Toads, Raccoons, Turtles
Wood Duck	Vegetation- pondweeds, eloeda, wild rice, water lilies, grapes, berries, nuts, insects, spiders	Mink, Raccoons, Hawks, Eagles, Owls
Zooplankton	Microscopic organic debris or Fine Particulate Organic Matter, Bacteria, Phytoplankton, Periphyton	Fish, especially young fish, Aquatic Macroinvertebrates