Creating Webs and Chains to Model Ecological Relationships: Educator Handout

OVERVIEW

In this hands-on activity, students will identify producers and consumers in their own state of Wisconsin. Using a set of "Snapshot cards," they will then create a food chain to show the flow of energy in that system, introduce an ecological force or disturbance (e.g., flooding), and predict how that force would impact energy flow. Lastly, students will construct a more complex model of the flow of energy by depicting multiple relationships in a food web and again make a prediction about the impact of introducing an ecological force.

KEY CONCEPTS

- All organisms need energy to survive that they obtain from their environment, including by eating other organisms.
- Ecosystems are dynamic, experiencing shifts in population compositions, abundance, and changes in the physical environment over time. These factors can impact the stability and resilience of the entire system.
- Ecological forces or disturbances can have natural or anthropogenic causes.
- An ecosystem can be represented by different types of models, each of which may have different strengths and drawbacks.

LEARNING OBJECTIVES

Students will be able to:

- Classify organisms based on their roles in the transfer of energy in an ecosystem.
- Create a model (e.g., a food chain) showing feeding relationships among organisms.
- Evaluate different models that depict relationships among organisms in a community.
- Predict how ecological forces or disturbances may impact their models and justify their claim with evidence.

CURRICULUM CONNECTIONS

Curriculum	Standards
NGSS (November 2013)	MS-LS2-1, MS-LS2-4, MS-LS2-2, HS-LS2-1, HS-LS2-2, HS-LS2-4, HS-LS2-6
AP Biology (2012-13)	2.A.2, 2.A.3, 2.C.2, 2.D.1, 2.D.3, 4.A.5, 4.A.6, 4.B.3, 4.B.4, 4.C.3
IB Biology (2009; 2016)	5.1.4, 5.1.5, 5.1.6, 5.1.7, 5.1.8, 5.1.10, 5.1.11, 5.1.12; 4.1, 4.2, C.2, C.3
Wisconsin's Standards for Science	SCI.LS2.A.m, SCI.LS2.B.m, SCI.LS2.B.h, SCI.LS2.C.m, SCI.LS2.C.h, SCI.SEP1.A.m, SCI.SEP2.A.m

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KEY TERMS

producer, consumer, herbivore, carnivore, omnivore, energy flow, primary consumer, secondary consumer, tertiary consumer, quaternary consumer, rule of 10 percent

TIME REQUIREMENTS

Approximately 1-1.5 hours

SUGGESTED AUDIENCE

This activity is appropriate for middle school life sciences and general high school biology

PRIOR KNOWLEDGE

Students should know that predators eat prey and that most organisms have multiple sources of food. They should also be aware that the sun is the primary source of energy for all but a few unique ecosystems. Light energy is converted to a more usable source of energy by plants, or primary producers.

MATERIALS

Each group of students will need:

Student handout

Snapshot cards (to be cut out and folded, 22 total)

Paper and pencil (or white boards and markers) for indicating arrows for energy flow

PROCEDURES

1. Divide the students into working groups and provide each group with a complete set of Snapshot cards.
2. Students can work with their cards on tables, desks, or other workspace and record written answers on the worksheet provided.

TEACHING TIPS

- It may be beneficial to do a quick review of food chains, energy pyramids, and food webs with your class.
- Students often reverse the direction of the arrow to show that an animal is eating a plant or other animal rather than using the arrow to show the direction of energy flow. You might want to remind students of that relationship.
- If you would like students to make several food chains or webs, you might consider having the students represent arrows on sticky notes for easy recombination. Or have students use white boards as a placemat so arrows can be drawn and erased quickly.

- You might also prompt a discussion of what regulates population sizes at different trophic levels. Populations of organisms at lower trophic levels are commonly regulated by predation, whereas organisms at higher trophic levels may be regulated by prey availability and/or may be more sensitive to habitat disruptions.

ANSWER KEY

Part 1: Identifying relationships and creating a food chain

Separate the ecological disturbance cards from the organism cards, and then sort the organism cards into two piles that represent producers and consumers.

1. How many producers do you have? ____3____
2. How many consumers do you have? ____14____
3. A food chain is a model that identifies the feeding relationships and the flow of energy in an ecosystem. Select a producer and a consumer from your piles, then fill in the blanks below and select which model (A or B) correctly shows the flow of energy.

A. _____ → _____
consumer producer

or

B. _____ → _____
producer consumer

4. Justify why you chose A or B as the correct model.

Students should choose B, which accurately shows that energy flows from producer to consumer. Their justification should include the reasoning that since consumers eat producers energy flows from the producer to the consumer. Students' answers will vary depending on their particular choices. For example, students may write, "Deer (consumers) eat fruit and leaves from trees (producers), so energy flows from trees to deer."

5. Select four cards to create a food chain, starting with a producer. Label the trophic level of each organism in your food chain as follows: producer, primary consumer, secondary consumer, tertiary consumer. Record your food chain in the space below using species names and arrows.

Answers will vary, but two possibilities are plant → insect → wild turkey → coyote *or* fruit → mouse → bird → red fox

6. Ecosystems include both biotic (living) and abiotic (nonliving) components that can influence food chains. In this activity, the abiotic components are referred to as an ecological force or disturbance. Choose one of the disturbance cards, read the information provided, and then make a prediction about how it might impact the food chain you created above.

Answers will vary. Example below is based on a food chain of plant → insect → wild turkey→ coyote

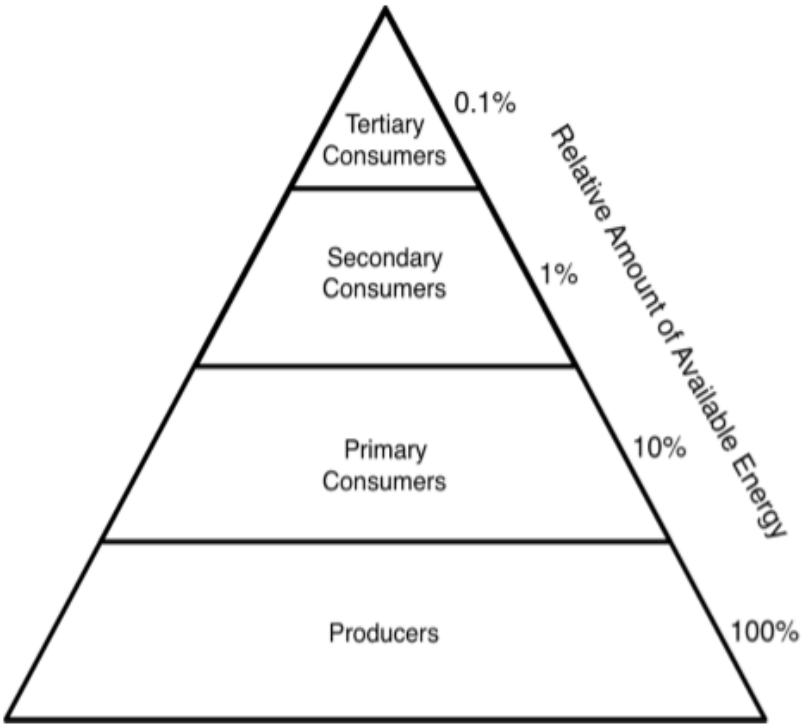
Disturbance (list the title)	Brainstorm some ecosystem impacts that could result from your disturbance	Predict how these impacts would affect each trophic level
Flooding	Floods can transport necessary resources, such as food or materials for building shelter, away from animals Plants may be inundated or swept away by the water Individual species may be transported in flood, breaking up families or social groups Nests may be disturbed, young may be lost or killed	Producer: Plants may be swept away or killed by flood Primary consumer: Decreased food availability will cause increased competition among insects, and could lead to population decreases from starvation Secondary consumer: Wild turkey may need to shift their diets or expand ranges to get enough food from insects. Increased ranges make them more prone to predators Tertiary consumer: Coyote may initially benefit from the increased ranges of wild turkey, making them easier to capture. As wild turkey populations decrease, coyote will need to shift their diet or expand ranges as well

7. Not all disturbances have negative consequences for all trophic levels. In one or two sentences, describe a possible benefit that one trophic level in your food chain may gain from the disturbance you selected.

Answers will vary but should be consistent with logic from each student's food chain. Answers could include: predators may initially benefit from their prey needing to spend more time foraging/out in the open, making them easier to find.

Part 2: Quantifying energy flow and the rule of 10 percent

Three hundred trout are needed to support one man for a year. The trout, in turn, must consume 90,000 frogs, that must consume 27 million grasshoppers that live off of 1,000 tons of grass. -- G. Tyler Miller, Jr., American Chemist (1971)



Only a small fraction of energy available at any trophic level is transferred to the next trophic level. That fraction is estimated to be about 10 percent of the available energy. The other 90 percent of the energy is needed by organisms at that trophic level for living, growing, and reproducing. This relationship is shown in the energy pyramid above. It suggests that for any food chain, the primary producer trophic level has the most energy and the top trophic level has the least.

8. Why is a pyramid an effective model for quantifying energy flow?

The pyramid shape shows a hierarchy but also relative amounts at each level.

9. Place the organisms from your original food chain on the pyramid provided (located on final page).

10. Using the rule of 10 percent in energy transfer, record the species names for each trophic level and the amount of energy available at that level if your producer level had 3,500,000 kilocalories of energy/area.

Organisms filled in will vary, but amounts for each trophic level, starting at the bottom of the pyramid, should be 3,500,000 kilocalories, 350,000 kcal, 35,000 kcal, 3500 kcal.

11. In one or two sentences, describe how the available energy may affect the population sizes of organisms at different trophic levels.

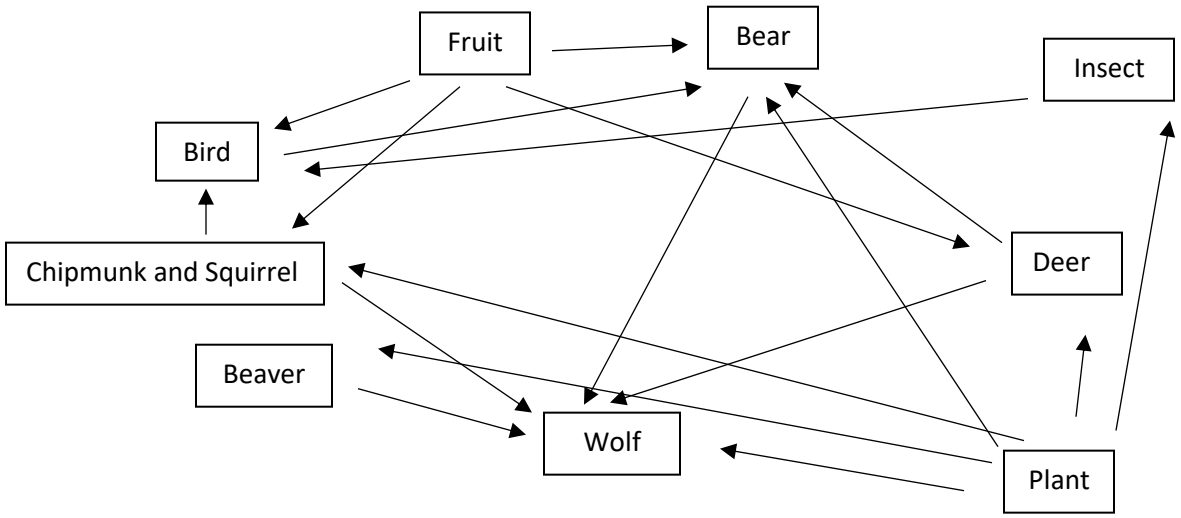
Students should observe that since the energy available at each trophic level decreases, the populations of animals at higher trophic levels will be smaller than the populations at lower trophic levels. For example, many deer can support relatively few wolves.

Part 3: Creating a food web

Food chains are simple models that show only a single set of energy-transfer relationships, but many organisms obtain energy from many different sources and in turn may provide energy to several different consumers. A food web illustrates all these interactions and is a more accurate model of how energy moves through an ecological community.

12. Starting with your original food chain (question 5), add another plant and four more animal cards to construct a food web that shows how energy flows from producers through primary consumers, secondary consumers, tertiary consumers, and possibly a quaternary consumer. When making your food web, you can have more than one arrow leading to and from each organism. Draw a version of your food web below.

Answers will vary, but should depict similar relationships to the food web below.



13. In one or two sentences, describe any patterns you notice in the relationships between trophic levels.

Possible answers could include that the wolf has more prey species that provide energy to it than the bear, and the deer has even fewer. Another answer is that small mammals, such are mice or squirrels, provide energy to many species.

14. Now choose and read a different disturbance card and predict its impact on your food web. Complete the table below:

Disturbance (list the title)	Brainstorm some ecosystem impacts that could result from your disturbance	Predict how these impacts would affect each trophic level
Fertilizer runoff	Excess fertilizer could cause plants in lakes and streams to become overgrown Toxic algae blooms could kill aquatic animals Overgrown plants may block sunlight from reaching deeper into the water column Certain fertilizer may be harmful to heath of wildlife	Producer: Aquatic plants may experience increased growth from excess nutrients Primary consumer: Herbivores may benefit from increased abundance of plants. But also, fish or other primary consumers may be killed off from toxic algal blooms Secondary consumer: Otter and bears rely on fish for food, and may need to find other food sources or expand range if fish populations decrease Tertiary consumer: Wolves may have an easier time capturing otter from their expanded ranges at first, but as otter populations decrease wolves may need to adapt their diet

15. Describe whether some trophic levels benefit from the disturbance while others do not. If humans caused the disturbance, was it negative or positive for each trophic level in the food chain?

Answers will vary, but students should grasp that negative impacts at one trophic level might act as positive impacts on lower trophic levels. In ecology, this is called a trophic cascade.

Part 4: Model evaluation

In science, models are used to represent explanations and predications. The food chain, food web, and energy pyramid are all models that show feeding relationships and allow us to make predictions. Compare and contrast the strengths and weaknesses of each model by filling in the table below.

Model	List two things this model is useful for illustrating or predicting	Identify one feature that this model lacks or one that could lead to a misconception
Food chain	Possible answers 1. Identify levels and easy to see relationship 2. Trophic levels easily identifiable	Does not show that animals eat more than one thing, very simple
Energy pyramid	1. Shows hierarchy of trophic levels 2. Relative amount of energy or organisms is indicated by space of pyramid level for each trophic level	Does not show that animals eat more than one thing, very simple
Food web	1. Multiple feeding relationships depicted 2. Consumers that are specialized (limited prey choices) versus more general consumers (multiple prey choices) can be depicted	Trophic levels are not easily observed The hierarchy shown in previous models might not be as easily maintained in a food web. Some prey might appears physically higher than their predator(s), making it look like it is a higher trophic level

16. Select the model that you think is most effective in representing relationships among organisms in Wisconsin and justify your choice in two or three sentences.

One possible answer is that the food web best represents the relationship in Wisconsin, as it allows for multiple prey species for the second- and third-level consumers. This is more realistic, as most carnivores eat more than one prey animal. Some carnivores might have a preferred prey species but will switch prey depending on conditions and availability.

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OPTIONAL ACITIVTY

As mentioned during the lesson plan, only a small fraction of energy available at any trophic level is transferred to the next trophic level. That fraction is estimated to be about 10 percent of the available energy. The other 90 percent of the energy is needed by organisms at that trophic level for living, growing, and reproducing. This relationship is shown in the energy pyramid above. It suggests that for any food chain, the primary producer trophic level has the most energy and the top trophic level has the least. To test this theory, we are going to run a short, kinesthetic activity.

MATERIALS

Small, tossing balls or kick balls

PROCEDURE

1. Break the students up into groups. For example, in a class size of 20 students you would break up the students similar to this:
   60% - producers (12 students)
   20%- primary consumers (4 students)
   15% - secondary consumers (3 students)
   5% - tertiary consumers (1 student)
2. Have the groups pick a representative plant or animal for their group. For example, the producers could be a daisy, the primary consumers a chipmunk, the secondary consumers a raccoon and a tertiary consumer a coyote. Since they already explored actual trophic cascades, this is more for fun.
3. Have the students line up in a pyramid like formation. For example, have the producers line up in a line facing the primary consumers. Have the primary consumers line up with the secondary consumers facing them. Have the tertiary consumers line up facing the secondary consumers. Have the students keep about 10 feet between each line.
4. To demonstrate the flow of energy in an ecological pyramid, we are going to toss the balls between different trophic levels. The balls represent energy.
5. Give the producers (about 60% of the class) toss-able balls.
6. You, the teacher, will be the sun. When you are ready, send sun energy (this can be a goofy movement or dance) to the producers.
7. Instruct the producers to toss their energy to the primary consumers. Not all primary consumers will capture a ball. This demonstrates that small fraction of energy is transferred to the next energy level.
8. Instruct the primary consumers to toss the balls to the secondary consumer, and so on.
9. Once the tertiary consumer receives one ball of energy, prompt the class with the following discussion questions:
   a. Did we end up with more or less energy balls than we started?
   b. How does this connect to what we learned in the handout?