TEACHER'S GUIDE

Supplies

- Powerpoint presentation that follows the Background Information section
- Article on aquatic biodiversity
- Handouts for each small group
    - Background information
    - AIS fact sheets
    - Group discussion questions

Time Required

- One class period, with or without homework (45-60 minutes)

Implementation Ideas

- Teachers can present the powerpoint presentation with the background information (15-20 min) and then move on to the small group work.
- Teachers can assign the background information as reading homework for students the night before the small group classroom activity.
- Teachers can assign small groups ahead of time and have each of them research their assigned aquatic invasive species outside of class.
- Small groups can either present their findings to the rest of the class, or prepare a report to hand in.

Student Objectives

1. Understand that energy is transferred through an aquatic food chain by producers, consumers, and decomposers.
2. Understand how decomposers recycle nutrients from dead plants and animals.
3. Understand predator-prey relationships in a lake ecosystem.
4. Understand carrying capacity.
5. Understand balance in a lake ecosystem.
6. Understand how organisms in a food chain depend on one another for survival.
7. Understand how AIS disrupts the balance in an aquatic ecosystem.

Sources

This lesson has been modified from the DNR's MinnAqua program (Lesson 1:2).
http://www.dnr.state.mn.us/minnaqua/leadersguide/lg_online/index.html#front

Activity

Familiarize the students with the background information through preparatory reading homework or the powerpoint presentation.

Divide the class into small groups. Assign each group 1-2 aquatic invasive species, and have them work through the discussion questions together. Then at the end of the class you can leave time for them to present their AIS information to the rest of the class, or have them write up a short report to turn in.

Fact sheets on each AIS are provided, but it may be interesting to challenge the students to try answering the group discussion questions first before referencing the fact sheets. This promotes critical thinking.

Aquatic invasive animals

- Zebra mussel
- Quagga mussel
- Asian carp
- Faucet snail
- Spiny waterflea

Aquatic invasive plants

- Curly-leaf pondweed
- Flowering rush
- Eurasian watermilfoil
- Hydrilla

Small Group Discussion Questions

1. What link is your AIS in the food chain (what does it eat and what eats it)?
2. How does this species affect the aquatic ecosystem in the short term?
3. How does this species affect the aquatic ecosystem in the long term?
4. Are there any methods of control for this species?

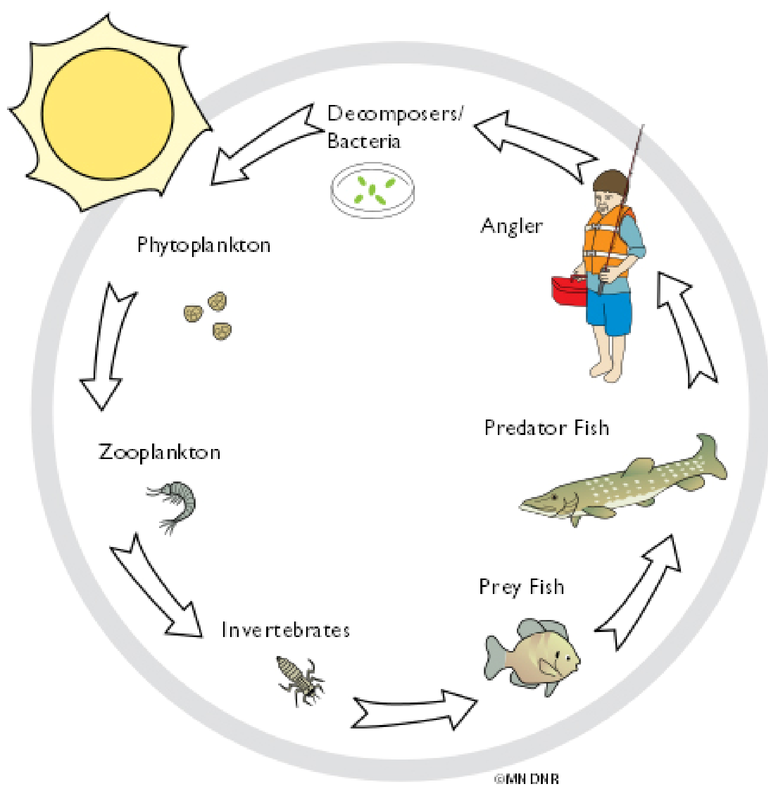
Background Information

All things on the planet—both living and nonliving—interact. An Ecosystem is defined as the set of elements, living and nonliving, that interact, over time, within a defined locale. A food chain demonstrates one way in which ecosystem elements interact in a systematic manner.

Food Chains

In an ecosystem, numerous interactions between organisms result in a flow of energy and cycling of matter. Food chains, the nitrogen cycle, and the carbon cycle are examples of these interactions. A **food chain** is the sequence of steps through which the process of energy transfer occurs in an ecosystem. All organisms need a continuous supply of energy. Energy flows through an ecosystem in one direction—through food chains.

Food chains illustrate how energy flows through a sequence of organisms, and how nutrients are transferred from one organism to another. Food chains usually consist of producers, consumers, and decomposers. If a food chain has more than one consumer level, its consumers are defined as primary, secondary, or tertiary consumers. Primary consumers eat plants, secondary consumers eat primary consumers, and tertiary consumers eat secondary and primary consumers.

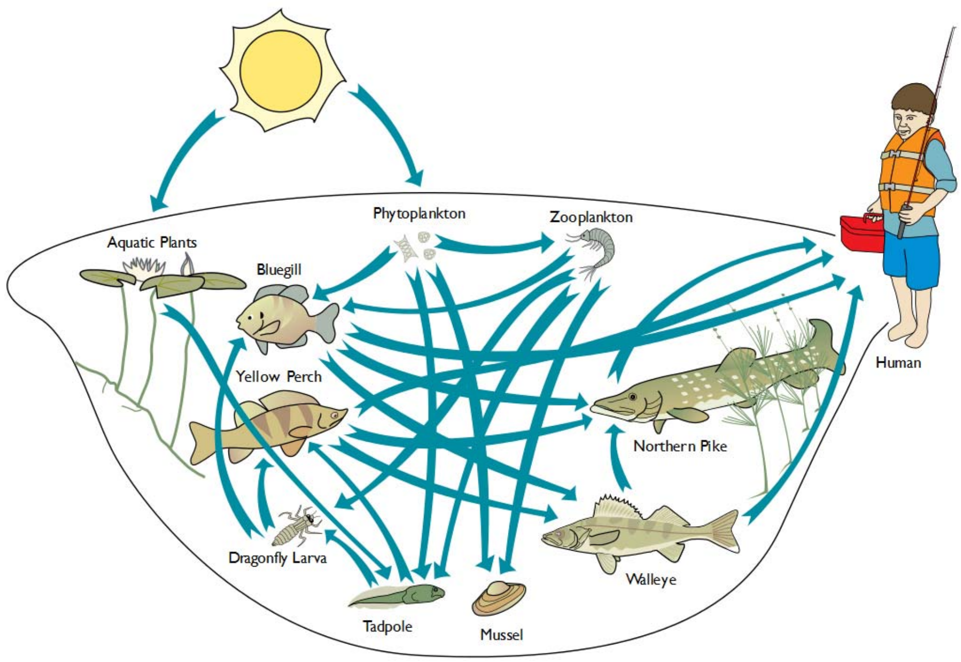


A food chain illustrates the movement of energy in an ecosystem.

The sun is the ultimate source of energy for all food chains. Through the process of photosynthesis, plants use light energy from the sun to make food energy. Energy flows, or is transferred through the system as one organism consumes another.

Food Webs

The concept of a food chain is an abstraction or generalization. Ecosystems are more complicated than a single food chain would indicate. Most aquatic ecosystems contain many more species than those in a single food chain, and all of these species interact and are interdependent. Like people, most aquatic organisms consume more than one type of food. A **food web** is a diagram of a complex, interacting set of food chains within an ecosystem.



A food web illustrates complex feeding relationships within an ecosystem. All organisms in a food web are interdependent. A food chain is just one strand of a food web.

Parts of a Food Chain

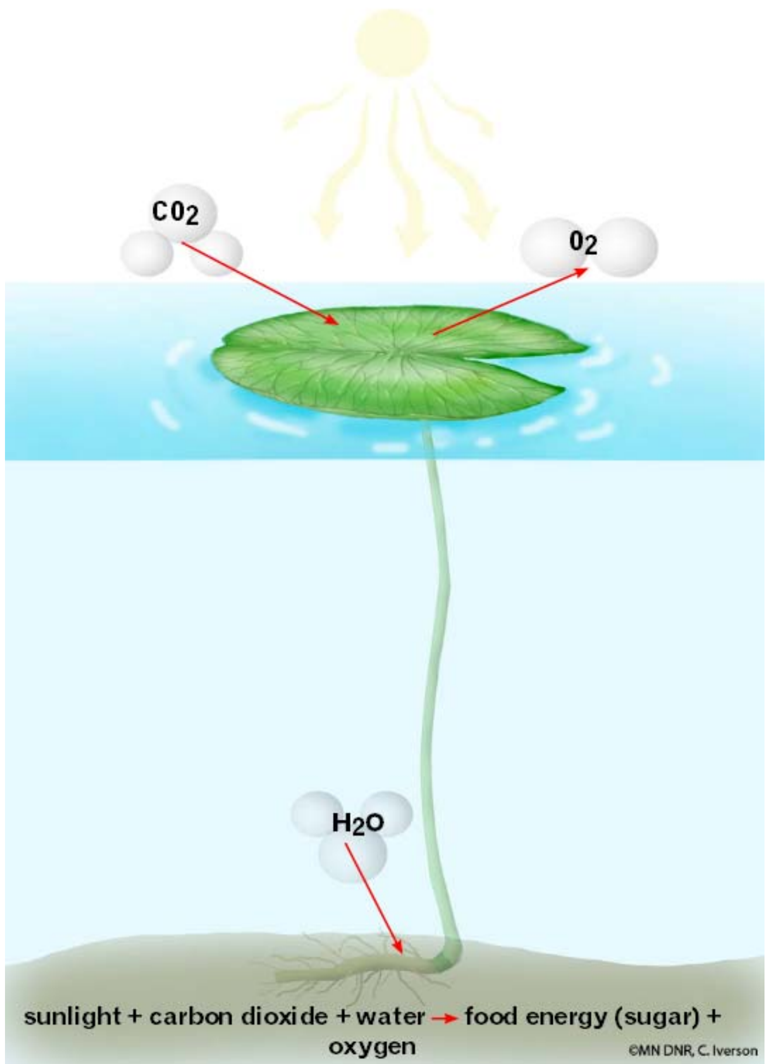
A food chain includes the sun, plants, primary consumers, secondary consumers, and decomposers. The sun provides light energy (radiation), the ultimate energy source for all freshwater aquatic food chains.

Plants are the next link in a food chain. **Plankton** are among the smallest living organisms in ponds, lakes, rivers, and streams. This group includes tiny free-floating plants, animals, and some forms of bacteria. They range in size from microscopic bacteria and single-celled organisms to larvae and invertebrates large enough to be visible to the unaided eye. With little or no swimming ability, most plankton floats freely with the currents in open water.

Phytoplankton are free-floating microscopic plants and bacteria suspended in the water that, like other plants, produce food energy directly from the sun's light energy. Plants (including phytoplankton) are called **producers** because they can produce simple nutrients and sugars (food energy) directly from the sun's light energy through the process of photosynthesis. As the base of food chains, phytoplankton populations are indicators of aquatic health. The food energy produced by phytoplankton supports much of the other life in the water.

By their sheer numbers, phytoplankton are the main producers in the lake. If you could weigh all of these microscopic plants, they would weigh more than macroscopic plants.

Plants contain the green pigment chlorophyll and other pigments known as carotenoids. These pigments capture the sun's light energy, which plants convert to chemical energy (carbohydrates or sugar) through the process of photosynthesis. Other organisms consume plants to obtain the chemical energy that fuels life processes, including respiration, movement, growth, and reproduction. Plants obtain additional substances necessary for photosynthesis (carbon dioxide and hydrogen) from the air, water, and soil. Oxygen is a by-product of photosynthesis. Producers are the first link in every food chain, and they support all forms of animal life, including people.



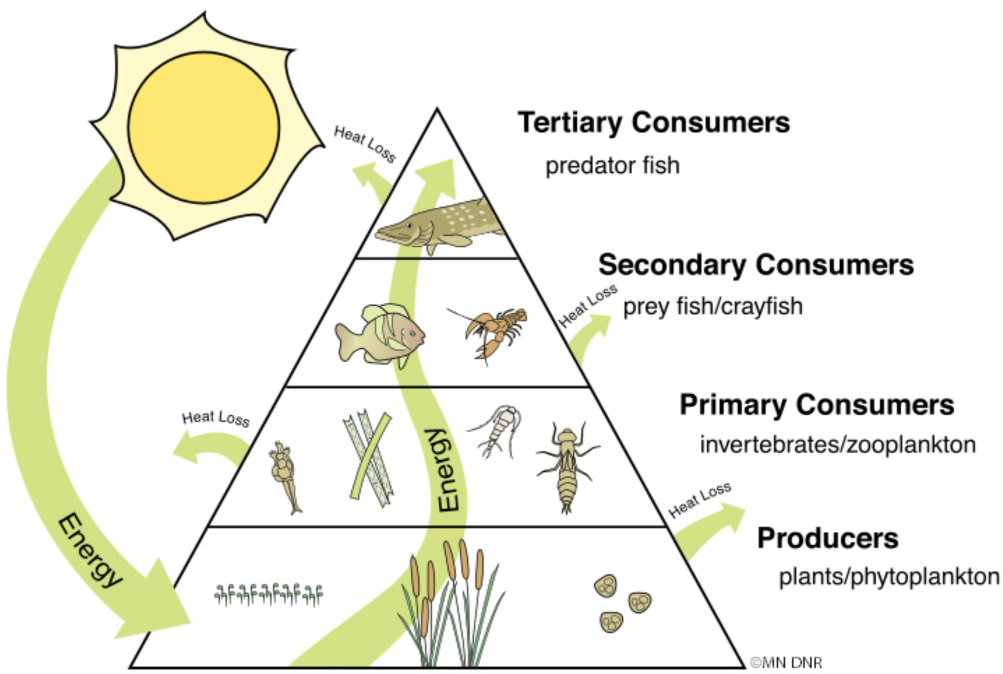
The chemical description of photosynthesis is:

LIGHT ENERGY	+	$6CO_2$	+	$6H_20$	=	$C_6H_{12}0_6$	+	60_2
		carbon dioxide		water		simple sugars or food energy		oxygen

Food energy transfers to microscopic aquatic animals, or **zooplankton**, as they consume phytoplankton. The zooplankton population in a lake or river can be a useful indicator of future fishery health because zooplankton are an important food for small fish (such as minnows) that are next in line in the food chain. Many larger fish, such as yellow perch, depend on a diet of smaller fish.

A **consumer** is an organism that obtains energy from eating other plants or animals. A relatively large quantity of plant material is required to support primary consumers. Animals that eat only plants (or phytoplankton) are primary consumers, or herbivores. Primary consumers, in turn, support a relatively smaller number of secondary consumers, or carnivores—animals that eat other animals. In food chains, most of the food energy consumed by organisms fuels growth and other functions. As an organism uses energy, food energy is converted to heat energy, which is lost from the system. Some food energy is stored in the tissues of organisms, and is, in turn, consumed and used by other organisms in the food chain.

Some carnivores can also be called piscivores, which are animals that eat fish.



This aquatic food pyramid illustrates energy transfer and relative biomass (defined below) in an aquatic ecosystem. Producers make up the greatest biomass in the system, and support all other life forms. Producers convert light energy from the sun into food energy. This food energy is transferred through the levels of the food pyramid, or trophic levels, as one organism consumes another. At each level in the food pyramid, energy is lost to the surrounding environment as heat as the organisms use food energy to feed, respire, grow, and reproduce. For this reason, each trophic level can only support or provide energy for a smaller biomass of organisms. Energy is also lost as heat on each level as organisms eat, move, grow, and reproduce. The sun continually replaces the energy in the system. Because energy is lost at each level, most food pyramids contain, at most, four trophic levels.

BPreiomass describes any organic plant or animal material available in an ecosystem on a renewable basis. A large biomass of producers at the bottom of the food pyramid supports a relatively smaller biomass of consumers, which support an even smaller biomass of secondary consumers. Energy flows from one level to the next as the organisms use it.

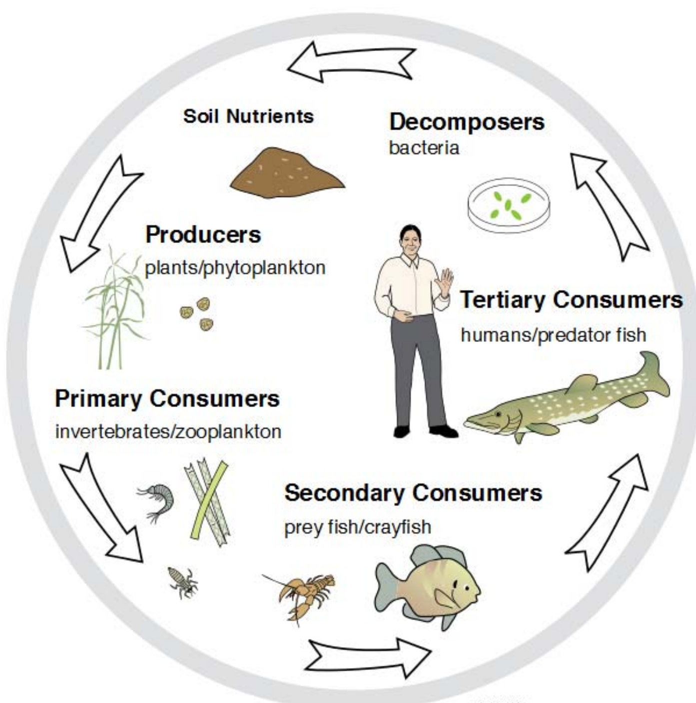
An animal that hunts, captures, and consumes other animals is a predator. Northern pike and eagles are **predators**, for example. An animal consumed by a predator is described as **prey**.

Decomposers, such as bacteria and fungi, complete the food chain by consuming dead plants and animals and breaking them into nutrients. One nutrient by-product of decomposition is carbon dioxide, a simple substance that producers need to create food energy. Decomposers are the crucial last link in a food chain—they put nutrients back into the ecosystem. They also keep the landscape tidy—imagine what it would be like if decomposers didn't break down dead plants and animals!

Food Energy and the Nutrient Cycle

Nutrients are continually recycled in all ecosystems, but energy flows one way.

Nutrients are the materials required for life, and they build and renew organisms as they cycle through food chains. For example, carbon dioxide and water (which contains carbon, hydrogen, and oxygen), which plants use to convert the sun's energy into carbohydrates, also cycle through consumers as the consumers eat plants. (They also cycle through other consumers.) When consumers die, bacteria and fungi decompose them, releasing these and other nutrients (phosphorous, nitrogen, and sulfur) into the soil, water, and air. These nutrients are available to plants again, which use them to convert the sun's energy into carbohydrates. Decomposers are often referred to as **nutrient recyclers** because they break down dead material to provide the nutrients producers need to continue the cycle. Each plant, animal, and person is composed of nutrients that have been—and will be—used by other organisms in a continuous cycle. This sharing and recycling of nutrients is known as the **nutrient cycle**.



In an aquatic nutrient cycle, energy and vital elements (nutrients) transfer through trophic levels.

A Food Chain Is a System

Producers, primary consumers, secondary consumers, and decomposers are connected and interdependent by means of habitat needs and simple food chains. Loss or damage to just one link in a food chain eventually affects all organisms in the food chain system.

A food web is a larger, more complex system. But, as in food chains, loss or damage to a single strand in the food web impacts the entire system.

The food chain system is composed of parts, including the sun, plants, herbivores (plant-eaters or primary consumers), carnivores (animal-eaters or secondary consumers) and decomposers. A food chain illustrates how the various parts of a natural system have functional as well as structural relationships. Two main processes occur in this energy transfer system. One involves the movement of energy—in the form of light energy or radiation from the sun—to plants through photosynthesis. The second involves the movement of energy, in the form of organic molecules or food energy, from plants to herbivores to carnivores through consumption of biomass, as illustrated in the food pyramid model.

The parts of a food chain work together efficiently and demonstrate integration. Through the process of evolving together over time, present-day species of plants, herbivores, carnivores, and decomposers have developed ecological relationships. These relationships—of one species to another and between each species and its environment—maintain population levels and balance within ecosystems.

Carrying Capacity

The maximum number of individuals or inhabitants that an environment can support without detrimental effects on the habitat or to the organisms over time is referred to as carrying capacity. Aquatic habitats contain limited amounts of necessary food, water, cover, space, and other resources. The quantity and quality of these resources influence the carrying capacity of a habitat. Because resources are limited, the population growth of a given species slows as its population approaches the habitat's carrying capacity. At times, a population may exceed carrying capacity but it will decrease eventually. Population numbers tend to fluctuate over time, depending on seasons and changes in weather, climate, and other environmental shifts. Other influences include excessive predation, the introduction of exotic species, disease, pollution, over-harvesting, poaching, development, agriculture, and recreation.

If a fish population grows dramatically, becoming larger than the carrying capacity of the lake ecosystem, the fish consume resources much faster than they can be naturally replenished. Eventually, this can result in serious habitat degradation and a reduced carrying capacity.

Because all organisms are interconnected and depend on one other for survival, other populations of organisms are impacted, too. Excessive numbers of one type of fish competing for food and other resources will eventually lead to the death of many individuals if balance isn't restored. Fish sometimes emigrate (leave an area) and the size of the population in the habitat decreases. This, in turn, affects the predators that normally depend on that type of fish for food. This eventually impacts the entire food chain.

Balance

An ecosystem that can sustain itself over time through the interrelationships of its living and nonliving components is said to be in balance. Food chains are one type of interaction among organisms, and are part of a larger system of cycles, checks, and balances that maintain stable ecosystems—those that function continuously and remain viable over time. An ecosystem in balance is sustainable.

Aquatic Invasive Species (AIS)

The terms "exotic", "alien", and "nonnative" can all be used to describe a species that does not naturally occur here, and has been brought here either accidentally or intentionally. In contrast, "native" species occur naturally and are fully integrated into the ecosystem.

Not all alien plants are harmful, but those that are can disrupt the natural ecosystem and out-compete native species. These species are considered "invasive" and "nuisance" species. **Aquatic invasive species** can get out of control because there is nothing in the ecosystem naturally to keep the population in check. When invasive species take over a lake or wetland, the biodiversity in the ecosystem can decrease, meaning that there are fewer different kinds of plants and animals that can live there. It can also change the habitat, making it less suitable for native species.

In short, Aquatic invasive species upset the balance in an ecosystem.