Khan Academy

Food chains & food webs

Key points:

Producers, or autotrophs, make their own organic molecules. **Consumers**, or heterotrophs, get organic molecules by eating other organisms.

A **food chain** is a linear sequence of organisms through which nutrients and energy pass as one organism eats another.

In a food chain, each organism occupies a different **trophic level**, defined by how many energy transfers separate it from the basic input of the chain.

Food webs consist of many interconnected food chains and are more realis c representa on of consump on rela onships in ecosystems.

Energy transfer between trophic levels is inefficient (with a typical efficiency around 10%). This inefficiency limits the length of food chains.

Introduction

Organisms of different species can interact in many ways. They can compete, or they can be symbionts (long-term partners with a close associa on). Or, of course, they can do what we so often see in nature programs: one of them can eat the other. (Chomp!) That is, they can form one of the links in a food chain.

In ecology, a **food chain** is a series of organisms that eat one another (so that energy and nutrients flow from one to the next). For example, if you had a hamburger for lunch, you might be part of a food chain that looks like: grass → cow → human. But what if you had lettuce on your hamburger? In that case, you're also part of a food chain that looks like: lettuce → human.

As this example illustrates, we can't always fully describe what an organism (such as a human) eats with one linear pathway. For situa ons like that, we may want to use a **food web**, which consists of many intersec ng food chains and represents the different things an organism can eat, and be eaten by.

In this article, we'll take a closer look at food chains and food webs, seeing how they represent the flow of energy and nutrients through ecosystems.

Autotrophs vs. heterotrophs

What basic strategies do organisms use to get food? Some organisms, called **autotrophs** ("self-feeders"), can make their own food – that is, their own organic compounds – out of simple molecules like carbon dioxide. There are two basic types of autotrophs:

> **Photoautotrophs**, such as plants, use energy from sunlight to make organic compounds
> (sugars) out of carbon dioxide in photosynthesis. Other examples of photoautotrophs include algae and cyanobacteria.
>
> **Chemoautotrophs** use energy from chemicals to build organic compounds out of carbon dioxide (or similar molecules). This is called chemosynthesis. For instance, there are hydrogen sulfide-oxidizing chemoautotrophic bacteria found in undersea vent communi es (where no light can reach).

Autotrophs are the foundtion of every ecosystem on the planet. That may sound drama c, but it's no exaggera on! Autotrophs form the base of food chains and food webs, and the energy they capture from light or chemicals sustains all the other organisms in the community. When we're talking about their role in food chains, we can call autotrophs **producers**.

Heterotrophs ("other-feeders") such as humans can't capture light or chemical energy to make their own food out of carbon dioxide. Instead, they get organic molecules by ea ng other organisms or their by-products. Animals, fungi, and many bacteria are heterotrophs. When we're talking about their role in food chains, we can call heterotrophs **consumers**. As we'll see shortly, there are many different kinds of consumers with different ecological roles, from plant-ea ng insects to meat-ea ng animals to fungi that feed on debris and wastes.

Food chains

Now, we can take a look at how energy and nutrients move through a ecological community. Let's start by considering just a few "who eats whom" rela onships – that is, by looking at a food chain.

A **food chain** is a linear sequence of organisms through which nutrients and energy pass as one organism eats another. Let's look at the parts of a typical food chain, star ng from the bottom
(the producers) and moving upward.

At the base of the food chain lie the **primary producers**. The primary producers are autotrophs, and are most o en photosynthe c organisms (such as plants, algae, or cyanobacteria).

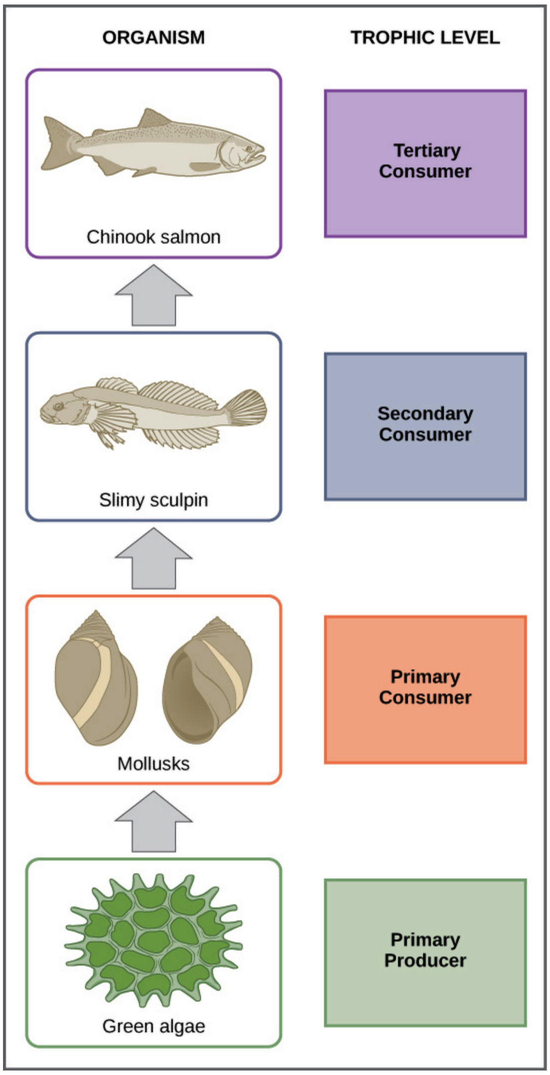
The organisms that eat the primary producers are called **primary consumers**. Primary consumers are usually **herbivores** (plant-eaters), though they may be algae or bacteria eaters.

The organisms that eat the primary consumers are called **secondary consumers**. Secondary consumers are generally meat-eaters (**carnivores**).

The organisms that eat the secondary consumers are called **ter ary consumers**. These are carnivore-ea ng carnivores, like eagles or big fish.

Some food chains have addi onal levels, such as **quaternary consumers** (carnivores that eat ter ary consumers). Organisms at the very top of a food chain are called the **apex consumers**.

We can see examples of these levels in the diagram below. The green algae are primary producers that get eaten by mollusks (the primary consumers). The mollusks then become lunch for the slimy sculpin fish, a secondary consumer, which is itself eaten by a larger fish, the Chinook salmon (tertiary consumer).



Each of the categories above is called a **trophic level**, and it reflects how many transfers of energy and nutrients eparate an organism from the food chain's original energy source, such as light. As we'll explore further below, assigning organisms to trophic levels isn't always clear-cut. For instance, humans are omnivores that can eat both plants and animals.

Decomposers

One other group of consumers deserves
men on, although it does not always appear in drawings of food chains. This group consists of **decomposers**, organisms that break down dead organic material and wastes.

Decomposers are some mes considered their own trophic level. As a group, they eat dead matter and waste products that come from organisms at various other trophic levels (for instance, they would happily consume decaying plant matter, the body of a half-eaten squirrel, and the remains of a deceased eagle). In this sense, the decomposer level kind of runs in parallel to the standard hierarchy of primary, secondary, and ter ary consumers.

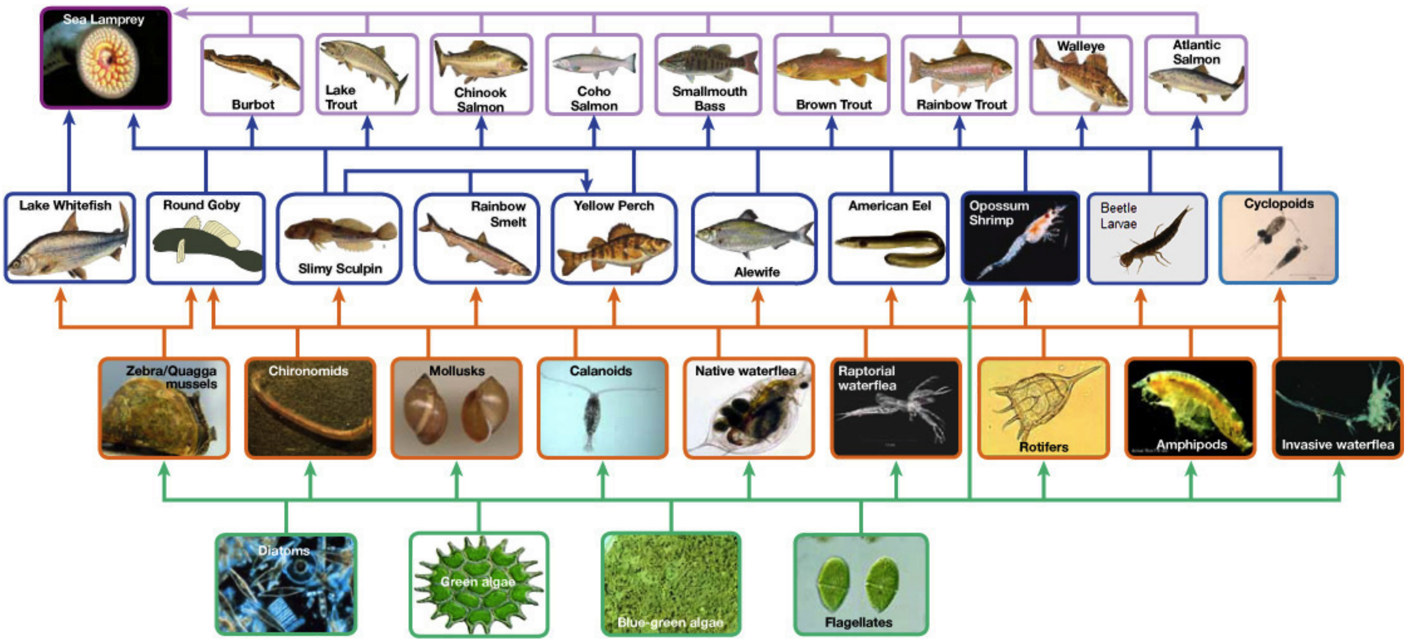
Fungi and bacteria are the key decomposers in many ecosystems, using the chemical energy in dead matter and wastes to fuel their metabolic processes. Other decomposers are **detri vores** (detritus- or debris-eaters). These are usually mul cellular animals such as earthworms, crabs, slugs, vultures, etc. They not only feed on dead organic matter, but often fragment it as well, making it more available for bacterial or fungal decomposers.

Decomposers as a group play a critical role in keeping ecosystems healthy. When they break down dead material and wastes, they release nutrients that can be recycled and used as building blocks by primary producers.

Food webs

Food chains give us a clear-cut picture of who eats who. However, some problems come up when we try and use them to describe whole ecological communities. For instance, an organism can some mes eat multiple types of prey, or be eaten by multiple predators, including ones at different trophic levels. This happens, for instance, when you eat a hamburger patty (cow = primary consumer) with a lettuce leaf on it (lettuce = primary producer).

To represent these rela onships more accurately, we can use a **food web**, a graph that shows all the trophic (ea ng-related) interac ons between various species in an ecosystem. The diagram below shows an example of a food web from Lake Ontario. Primary producers are marked in green, primary consumers in orange, secondary consumers in blue, and ter ary consumers in purple.



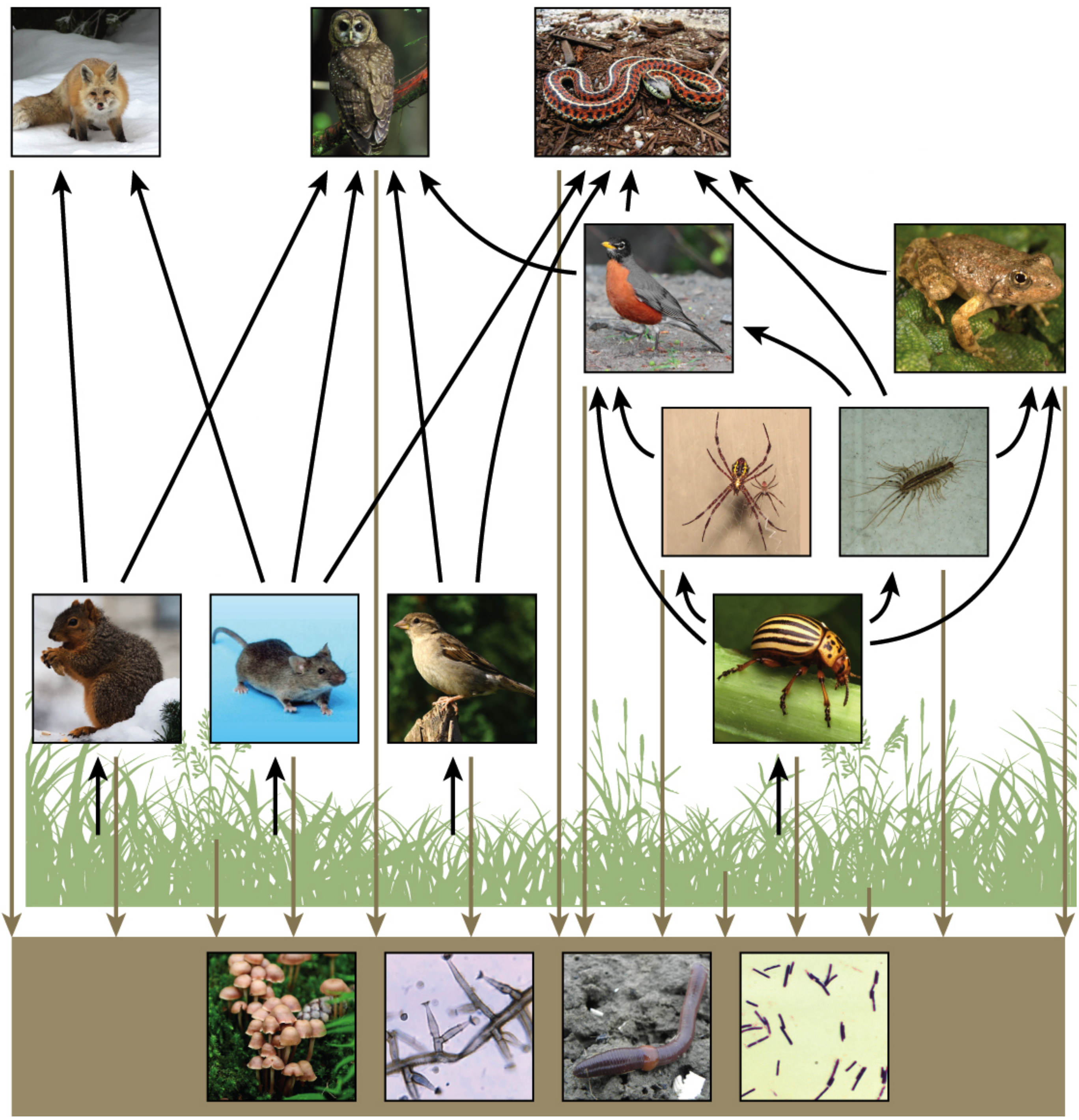
In food webs, arrows point *from* an organism that is eaten *to* the organism that eats it. As the food web above shows, some species can eat organisms from more than one trophic level. For example, opossum shrimp eat both primary producers and primary consumers.

Bonus ques on: This food web contains the food chain we saw earlier in the article (green algae → mollusks → slimy sculpin → salmon). Can you find it?

Grazing vs. detrital food webs

Food webs don't usually show decomposers (for instance, the Lake Ontario food web above does not). Yet, all ecosystems need ways to recycle dead material and wastes. That means decomposers are indeed present, even if they don't get much air me.

For example, in the meadow ecosystem shown below, there is a **grazing food web** of plants and animals that provides inputs for a **detrital food web** of bacteria, fungi, and detritovores. The detrital web is shown in simplified form in the brown band across the bottom of the diagram. In reality, it would consist of various species linked by specific feeding interac ons (that is, connected by arrows, as in the grazing food web aboveground). Detrital food webs can contribute energy to grazing food webs, as when a robin eats an earthworm.



Energy transfer efficiency limits food chain lengths

Energy is transferred between trophic levels when one organism eats another and gets the energy-rich molecules from its prey's body. However, these transfers are inefficient, and this inefficiency limits the length of food chains.

When energy enters a trophic level, some of it is stored as biomass (as part of organisms' bodies). This is the energy that's available to the next trophic level, since only energy stored as biomass can get eaten. As a rule of thumb, only about 10% of the energy that's stored as biomass

in one trophic level (per unit me) ends up stored as biomass in the next trophic level (per the same unit me). This 10% **rule of energy transfer** is a good thing to commit to memory.

As an example, let's suppose the primary producers of an ecosystem store $20{,}000$ $\mathrm{kcal/m^2/year}$ of energy as biomass. This is also the amount of energy per year that's made available to the primary consumers, which eat the primary producers. The 10% rule would predict that the primary consumers store only $2{,}000\ \mathrm{kcal/m^2/year}$ of energy in their own bodies, making energy available to their predators (secondary consumers) at a lower rate.

This pattern of frac onal transfer limits the length of food chains: after a certain number of trophic levels (generally, 3 - 6), there is too little energy flow to support a popula on at a higher level.

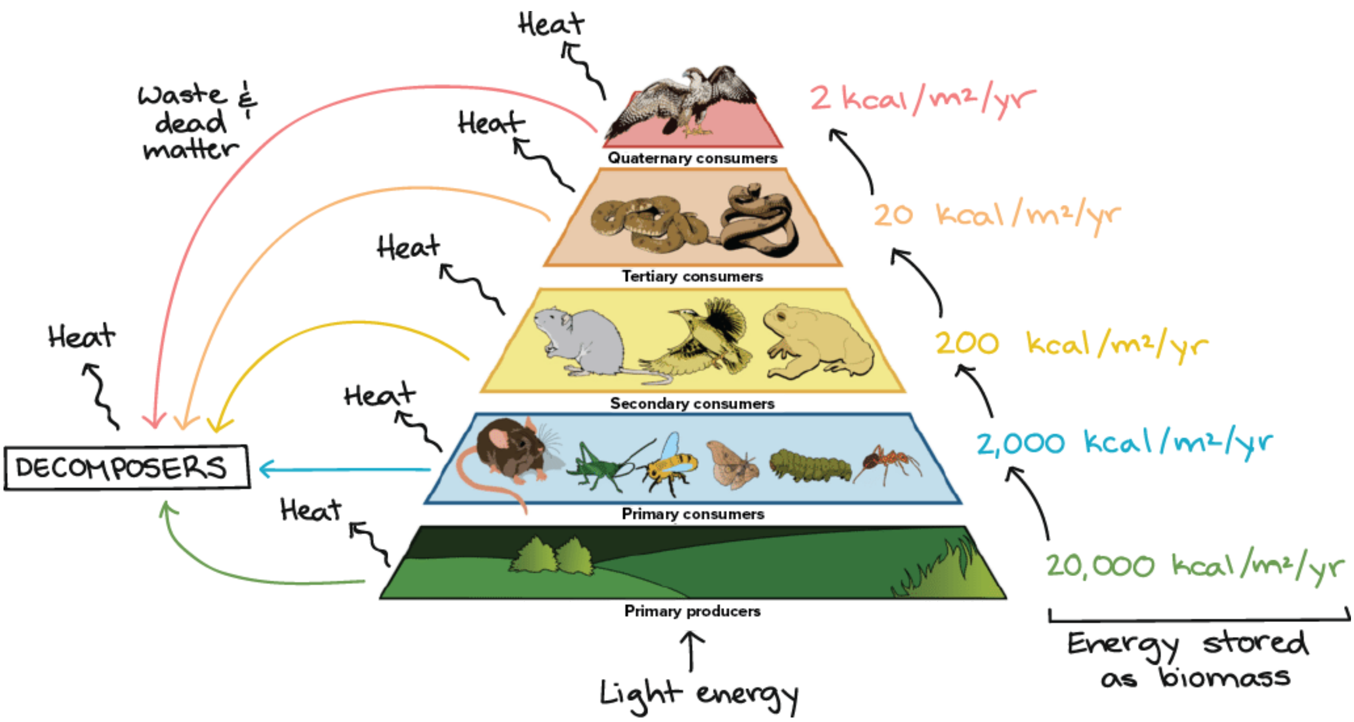


Image modified from "Ecological pyramid," by CK-12 Founda on, CC BY-NC 3.0.

Why does so much energy exit the food web between one trophic level and the next? Here are a few of the main reasons for inefficient energy transfer[1,2]:

In each trophic level, a significant amount of energy is dissipated as heat, as organisms carry out cellular respira on and go about their daily lives.

Some of the organic molecules an organism eats cannot be digested and leave the body as feces (poop) rather than being used.

Not all of the individual organisms in a trophic level will get eaten by organisms in the next level up. Some instead die without being eaten.

The feces and uneaten, dead organisms become food for decomposers, who metabolize them and convert their energy to heat through cellular respira on. So, none of the energy actually disappears – it all winds up as heat in the end.

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