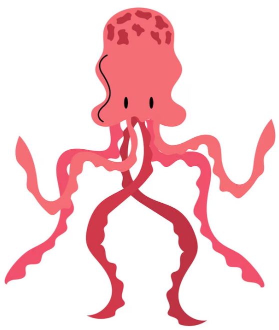
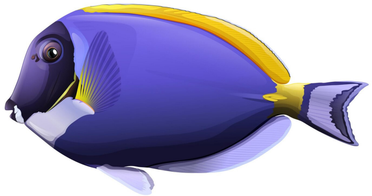
Introduction: Food Chains and Food Webs—Energy Production and Transfer



Marine animals perform a variety of activities in their daily struggle for survival. Squid use jet propulsion; scallops clap their shells; fish dart in and out of seagrasses and coral banks. In order for these animals to carry out these tasks, they must use energy. Animals get energy from food.



Plants obtain energy for survival from the sun. Plants convert the sun's energy into a food source. Animals cannot make their own food an therefore must consume food to satisfy their energy needs. Food provides useful chemical compounds or **nutrients** for plants and animals. Proteins, sugars, starches, fats, vitamins, **minerals**, and water are the basic nutrients needed by plants and animals to maintain their energy levels. Plants and animals break down and utilize these nutrients through a process called **metabolism**.

Cells of living organisms are composed of **proteins**, **carbohydrate**s, and **lipids** (also known as *fats*). Living organisms obtain these compounds from the foods they consume. Proteins are made up of tiny building blocks called *amino acids*. There are 20 different amino acids. Growth in animals occurs when amino acids join together inside the cell to make proteins.

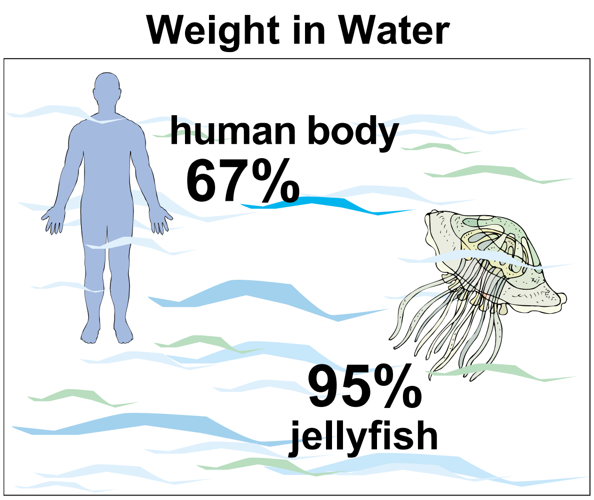
There are two nutrients that organisms can obtain energy from quickly. These two nutrients are sugars and starches. Together, sugars and starches make up carbohydrates. Carbohydrates are compounds that contain the elements carbon, hydrogen, and oxygen in specific proportions. An example of a simple sugar compound is glucose. Glucose has the molecular formula $C_6H_{12}O_6$. The molecular formula represents how many atoms of each element are present. In a molecule of glucose, $C_6H_{12}O_6$, there are 6 carbon atoms, 12 hydrogen atoms, and 6 oxygen atoms. When glucose is not being used in the body, it is changed into and stored as starch. Starches can be changed back into molecules of glucose when a plant or animal needs energy. The process of changing starch back into glucose is a chemical reaction called **hydrolysis**. Hydrolysis is a breaking down process and occurs when food is digested. During the breaking down process, energy is released when the chemical bonds of the molecules are broken. Living cells perform these important chemical reactions to fulfill their energy needs.

Fats and oils are high energy nutrients called *lipids*. Because a lipid molecule has a greater number of carbon-hydrogen bonds, it contains more energy than that of a carbohydrate molecule. During hydrolysis, the breaking down process, the carbon-hydrogen bonds in fats are broken and energy is released.

Vitamins are organic compounds that are needed, in trace amounts, to sustain good health. Vitamin D is an example. Vitamin D is necessary for healthy bone growth and is produced in small amounts in marine mammals when ultraviolet light reacts with the fat located just under the marine mammals' skin. Many animals and humans consume marine plants. Marine plants are a rich source of vitamins A, E, K, and B.

Living things need to take in proteins, carbohydrates, lipids, and vitamins, but living things also need minerals and water for their survival. Elements and compounds found in water and soil that do not contain the element carbon are minerals. An example of a mineral found in seawater is sodium chloride, NaCl, or salt. Marine plants obtain the minerals they need by absorbing the minerals from the water. Marine animals that eat marine plants absorb the plants' minerals into their body tissues. Sodium and chloride ions found in seawater are utilized in the muscles and nerves of many marine animals. Other minerals found in seawater include silica, the main ingredient in the manufacture of glass, found in the cell wall of microscopic diatoms.

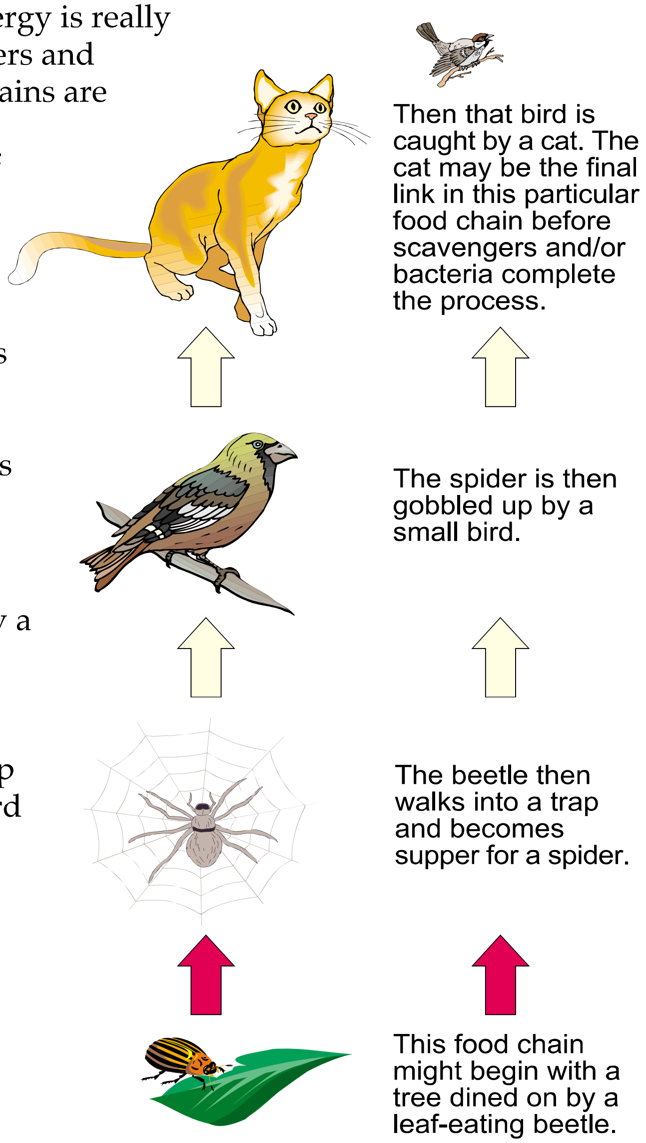
Water is the most abundant nutrient in most living organisms. About 80 percent of an organism's weight is water. The exact amount of water varies from one species of organism to another. To illustrate, the human body is about 67 percent water while the jellyfish is about 95 percent water. Water contains and transports many dissolved substances within the bodies of living organisms. Water is also necessary for chemical reactions such as **photosynthesis** to occur.



Water is the most abundant nutrient in most living organisms.

The Food Chain

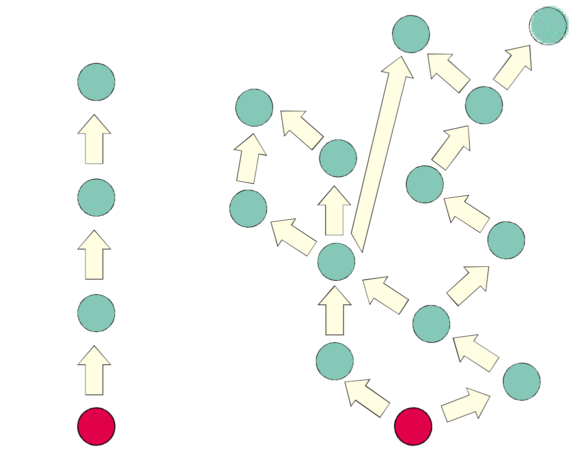
All organisms on Earth—including human beings—survive by participating in a **food chain** and a **food web**. Food chains and food webs show the *transfer of energy* from the sun to **producers**, such as plants, which transfer their own food to **consumers**, such as people. For example, the first-order consumer may be a plant eater, or **herbivore**, such as a sheep or manatee. The second-order consumer may then be a meat-eater or **carnivore**, such as a dog or shark, or an animal that eats both plants and animals, an **omnivore**, such as a person or a killifish. The transfer of energy is really complete when both producers and consumers die and their remains are consumed by **scavengers**. Scavengers eat what is left of producers and consumers. Examples of marine scavengers include some snails and crabs. The end of a food chain or web occurs when **decomposers**, such as bacteria, break down dead plants and animals, as well as wastes.



food chain

A different food chain might begin with a tree dined on by a leaf-eating beetle. The beetle then walks into a trap and becomes supper for a spider. The spider is then gobbled up by a small bird. Then that bird is caught by a cat. The cat, if lucky, may be the final link in that particular food chain.

Some food chains are complex and may move through many steps before they reach their endpoint. Other food chains, particularly those in extreme or harsh environments, may be quite simple and have only a few links. Food webs, as shown in the diagram below, contain many interrelated food chains and allow consumers to have choices in their diet.

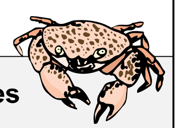


food chain
single-line system

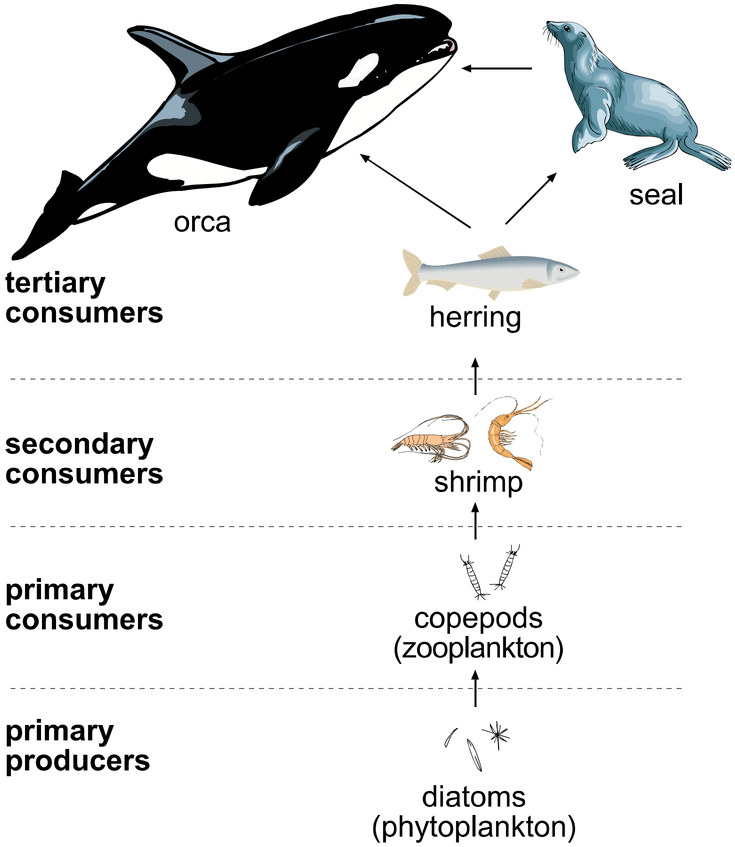
food web
many small food chains

Hierarchy in Food Chains: Who Eats Whom

In food chains and food webs, there is a hierarchy, or order, of "who eats whom." At the first level are plants, which are called *producers* because they produce the food necessary for themselves and all consumers and decomposers on the food chain. Although plants are at the bottom of the food chain or web, they are the most important part of the chain. Without plants, the chain would collapse, and all animals above would starve and perish.

	What Eats What in a Marine Ecosystem? 		
	Organism Type	**Method of Obtaining Food**	**Examples**
decomposers feed on dead organisms on all levels	producer	makes its own food	phytoplankton, sea grass, zooxanthellae
	consumer	obtains food by eating other organisms	sea star (starfish), sponge, shark
	herbivore	eats only producers	manatee, limpet
	carnivore	eats only consumers	shark, octopus, sea otter
	omnivore	eats both consumers and producers	basking shark, killifish sponge, coral, crab

The animals that eat the plants are called **primary consumers**. Those animals that consume primary consumers are called **secondary consumers**. **Tertiary consumers** are those animals that feed on secondary consumers. Some secondary and tertiary consumers may also eat producers or plants. For example, crabs feed on plants as well as fish. Typically, the highest level upon which a consumer feeds determines what it is called, even though it may feed on more than one level.



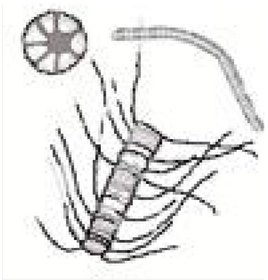
feeding levels in a marine food chain

The Ocean's Plants: Providing for the Sea's Carnivores and Herbivores

Biomass, the total amount of organisms per unit volume, of carnivores (meat-eaters) is much less than that of the herbivores (plant-eaters) they consume. Similarly, the biomass of herbivores will be much less than the total weight of the plants they consume. For example, a hundred tons of plants would produce only about 10 tons of herbivores, which would, in turn, feed and sustain only one ton of carnivores. As you move up levels on the food chain, biomass decreases.

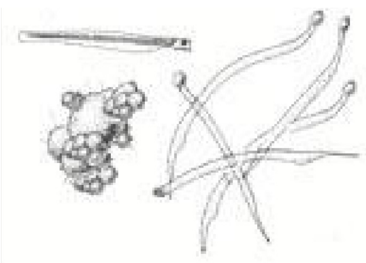
Phytoplankton: The First Level of the Ocean's Food Chain

On land and in the ocean, plants are the basis of all life and are the first level of food chains. **Phytoplankton**, the most plentiful plants in the ocean, are the most important plants in the ocean's food chain. Phytoplankton float in the ocean's currents and become food for the ocean's most numerous and greatest biomass of herbivores, the plant-eating **zooplankton**. Zooplankton also float in the ocean and depend on phytoplankton for survival.



phytoplankton

Zooplankton: Converting Plant Tissue to Animal Tissue



zooplankton

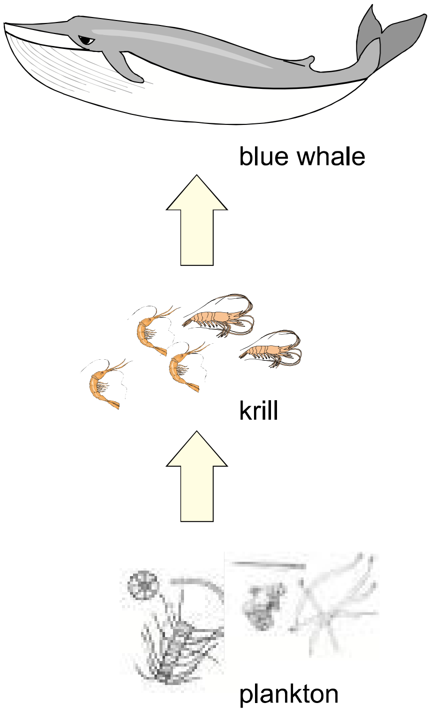
Zooplankton are the majority of the ocean's *primary consumers*: They convert plants (phytoplankton) into animal tissue (the zooplankton themselves). Zooplankton then become food for the next organisms higher up in the food chain: the zooplankton-eating animals. If we keep moving up the ocean's food chain, we finally reach organisms that are not food, or prey, for any other marine organisms; for example, sharks and killer whales.

Some zooplankton do not eat individuals one at a time but swallow large amounts of water and then trap phytoplankton while filtering out the water. By spending most of their feeding time in the photic zone—where plants grow—zooplankton can find and eat enough phytoplankton to sustain themselves.

Zooplankton are not as abundant as phytoplankton. When zooplankton eat phytoplankton, only some of the phytoplankton become part of the zooplankton. Most of the food energy consumed by the zooplankton is given off as either energy for survival or as waste.

A Simple Food Chain: From Phytoplankton to Krill to Baleen Whales

One of the simplest food chains in the ocean involves the whale. In the ocean off Antarctica, the sun remains in the sky for up to 24 hours during the summer. Because of this, many phytoplankton grow there at that time of the year. The phytoplankton are eaten by **krill**. *Krill* are shrimp-like zooplankton and form the second level in this food chain. Krill, then, are trapped and eaten by the carnivorous baleen whales. Baleen whales, the third level in this food chain, filter large amounts of krill out of the water with rows of whalebone plates in their mouths that act as sieves (see Unit 16).



food chain of the baleen whale

The picture to the left shows the basic food chain of a baleen whale. The food chain becomes complicated when other animals get into the picture and create a food web. A *food web* is a network of food chains that are linked together. For example, krill are not only eaten by whales but are also eaten by other fish, penguins, and seals. The baleen whale may also be eaten by the killer whale. In that case, the killer whale would be at the top of this food web.

A food web, even one as simple as the web described above, follows a *natural* order. Plants or animals at the lower levels are consumed by animals higher up in the chain. If a plant or animal at lower levels begins to die out or disappear, then animals higher up would also begin to die from lack of nourishment. There are a number of causes for a break in a food web.

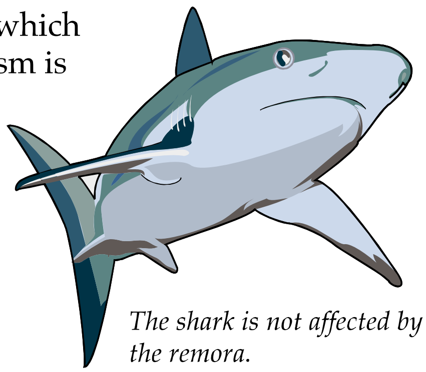
Disease or sudden weather changes can alter the biomass of particular plants, such as phytoplankton, or animals, such as zooplankton. Disease and harsh weather are natural phenomena. Over time, a food web will usually recover from such occurrences.

The world's fishing industry, however, is something that could destroy the ocean's food chain. If the fishing industry began wiping out lower levels of the food chain, they would upset the balance of marine life. Eventually, marine life at all levels would begin to disappear because of this break at a lower level of the food chain. To preserve ocean life, as well as make sure that there will be fish to be caught in the future, the fishing industry must monitor itself and not catch too many fish at any level in the ocean's food web.

Food Relationships in the Ocean

In the marine environment, there is a steady struggle for survival. Marine organisms must always be on the look out for hungry predators as well as hunt for food, search for mates, and stake out territories. To aid or benefit in their survival, many organisms have established relationships with organisms not within their species. A relationship that benefits an organism is called **symbiosis**. **Commensalism**, **mutualism**, and **parasitism** are examples of *symbiotic* relationships.

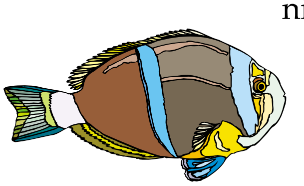
Commensalism is a symbiotic relationship in which one organism *benefits* while the other organism is *unaffected* by the relationship. Examples of marine organisms in commensalistic relationships with each other are several species of sharks and a small group of pilotfish, or a *remora*. The shark and the remora have a symbiotic relationship called *commensalism*.



The shark is not affected by the remora.

The remora is a small scavenger fish that attaches to the underside of many sharks. The remora feeds on the leftover particles of food that the shark does not eat. The shark is not affected by the remora, and the remora gains food by tagging along with the sharks. Another commensalistic relationship is found between some species of whales and barnacles. The barnacles live on the backs and around the mouths of some whales. Can you explain which of these organisms is benefiting and how?

Mutualism is a symbiotic relationship in which *both* organisms *benefit* from the relationship. Examples of marine organisms that are in a mutualistic relationship with each other are *coral polyps*, the basic structure of the coral animal, and algae known as *zooxanthellae*. The zooxanthellae live inside the coral polyps. The zooxanthellae benefit from the coral polyps in that they receive a place to live and food in the form of carbon dioxide, nitrates, and phosphate. The coral polyps receive food in the form of glucose and oxygen from the zooxanthellae. In this relationship both organisms receive something from the other. Another mutualistic relationship is found between the sea anemone and the clownfish. The clownfish lives



clownfish

among the stinging tentacles of the sea anemone. Can you explain how the relationship between the clownfish and sea anemone is mutualistic?

Parasitism is a symbiotic relationship in which one organism *benefits* and the other organism is *harmed*. An example of marine organisms that have a parasitic relationship with each other is isopods and fish. Isopods are very small crustaceans similar in appearance to a rolly polly insect. The isopods attach to the fish's skin and gills. They obtain nutrients from the fish's blood much as a tick obtains nutrients from a dog. Can you think of any other parasitic relationships that occur between marine organisms?

Summary

Food chains show the "transfer of energy" from the sun to *producers* (such as plants) and on to *consumers* (such as people) and finally to *decomposers*. Each consumer in a food chain has a smaller *biomass* than the links below it. *Simple food chains* are those with fewer links. Simple food chains usually exist where the environment is vulnerable to extreme change or where plants have a short growth season. A *food web* describes interrelated food chains within an ecosystem. Species within a food web may interact with each other through *predation*, *commensalism*, *mutualism*, and *parasitism*. We must protect natural food webs to preserve the food supply for all marine life.