SECTION IV
LIGHT IN WATER

TEACHER'S INFORMATION
Water absorbs light. Since light is essential to plant growth and almost all living things depend on plants either directly or indirectly for their food, light is very important in aquatic habitats. As water gets deeper, it gets darker. Even in very clear water that does not have sediment or phytoplankton to block light penetration, it looks dark at 150 m although a few photons penetrate to 600 m. This lack of light in deeper water has two consequences. The first is that plants in the ocean or in lakes can grow well only within 100200 m of the surface in very clear water. In water that is murky, they must be much closer to the surface. Second, rooted plants or seaweed that must grow from the bottom up do not live in very deep water.

Light is also necessary for vision, an important sense for many animals. Animals that depend on vision as a sense are restricted to relatively shallow water when one considers that ocean depths are measured in thousands of meters. Animals that are bioluminescent, making their own light, have one interesting solution to this lack of light in deep water. Many animals that must search for prey or that need to find others of their own species in shallow murky water or in deeper dark water make use of senses other than vision. These include senses that pick up sound (vibrations), chemical information, or electrical fields.

In addition to the general lack of light, there is a differential absorption of different colors (wavelengths) of light by water. Red and orange are absorbed most effectively while blue penetrates best. Underwater movies or photographs which are made with natural light look blue while those that show bright colors are made with artificial lights carried by the photographer. The brilliant colors we associate with some kinds of marine animals like sponges are invisible in their natural habitat! Other marine organisms like the colorful coral reef fish live in shallow water where their colors show. Color vision is common in some fish that live in shallow water, but not in those that live in deeper water or way out at sea.

With the exception of some very unique aquatic habitats such as the deep ocean vents, organisms that use light for PHOTOSYNTHESIS produce the food that sustains all other living things, either directly or indirectly. Things that do photosynthesis may be lumped into the category "plants," but include organisms that range from the familiar higher green plants to mosses to single-celled ALGAE (phytoplankton) to multi-celled algae (seaweeds) to many kinds of bacteria. All of these things produce FOOD (stored energy) from inorganic elements and are lumped into a group called PRODUCERS. Plants use sunlight to provide the energy for the chemical process that takes place within their cells called PHOTOSYNTHESIS. As the name implies, light (photo) energy is used to make (synthesize) some of the compounds the plant needs. The raw materials for this process are carbon dioxide and water. The oxygen that is produced is a waste product. The food energy they produce is stored in themselves their bodies, stems, leaves or seeds.

The producers form the base or bottom of the FOOD CHAIN, also called a FOOD WEB because it is not as simple as a straight chain. Animals that eat the producers or other animals are called CONSUMERS. Consumers that eat plants are called HERBIVORES which comes from Latin roots meaning "grass eating." Animals that eat other animals are called CARNIVORES from Latin for "meat eating." Some kinds of animals eat both plants and animals and are called OMNIVORES from the Latin for "all." The general term PREDATOR applies to an animal that eats another. The word PREY refers to the animal that is eaten. A given animal might be a predator on one species and the prey of another.

At each stage of the transfer of food energy, it is used for many different things. Some is used for growth or as stored food (fat or oil). Some is used for reproduction. Some is wasted as undigested material lost in feces or the bodies of dead organisms. Much of the food that an animal eats is broken down in a process called RESPIRATION that takes place inside cells. In this process, oxygen combines with the carbon and hydrogen atoms in the food to make carbon dioxide(CO_2) and water(H_2O). Energy is released which the cells capture and use to do work such as movement, making new molecules or moving molecules around. Since no energy transfer is perfect, some energy is also lost as heat. Food that is broken down is said to be "burnt" since the end products, carbon dioxide and water, are the same as those of combustion. Food energy is measured in calories, so animals are referred to as burning calories when they do cellular respiration.

Food that is burnt or broken down is gone from the food chain and not available to the animals at the next level. Consequently, each level of the food chain above the level of the producers has less available food than the level below it. The food available to the next level of the food chain is in the bodies of the plants or animals at the lower level and is called the STANDING CROP. The amount of food available at each level may be expressed as total weight or as calories.

What determines the length of a food chain? Why do some habitats have longer chains than others? First, the amount and quality of food stored in the producers has an effect. Since energy is lost at each stage, if you start with a great deal or with very high quality food that has lots of nutrition, there will be some left at the higher levels. Second, efficient use and transfer of energy makes for longer food chains. If the animals at one level are very inefficient and burn most of the energy they consume, they will not be making much of themselves for the next level to eat. In general, food chains in aquatic habitats are often rather long when compared with those on land.

Human activities may affect food chains in many ways. Pollution and habitat destruction cause obvious changes that are easy to see. Dead fish are hard to ignore. It is also easy to understand the consequences of filling a pond or marsh in order to build a shopping center or to add another field to a farm. The whole habitat goes away. Much more subtle changes may result from the extensive harvesting or removal of specific levels of the food chain.

When we selectively remove or add some fish, we are making changes that may have a significant impact on the other animals and on the plants in the pond, lake or ocean. Very careful planning of fishery regulations are necessary to be able to remove animals from a system on a long term basis without destroying the ECOLOGICAL BALANCE of the entire system. The result of this careful planning is a calculation of how many fish can be taken year after year without upsetting this balance and is called the SUSTAINED YIELD. The people who study these problems are in a field called FISHERIES MANAGEMENT. They set fishing limits for both sportfishing and commercial fishing and enforce them. Adding species can also have a profound and unexpected outcome. Sometimes the additions are accidental such as the zebra mussels which are spreading all over the United States. Sometimes the additions are done on purpose.

The concepts of food webs can be communicated to students by letting them be the animals in a simple food chain and playing a game to see who survives. The rules of the game are the rules that govern the survival of plants and animals in the wild. When they have mastered the basic rules that govern food chains, then the students can experiment with the system by changing one rule at a time (remind them only one variable per experiment). They can ask "what if" questions, predict the answers and then run an experiment to see what happens. This kind of SIMULATION of natural systems is a form of MODELING. Sophisticated modeling can be done with computers. Educational computer software that will allow students to continue to ask "what if" questions about food chains are available (see Recipes and Resources). Because the computer runs the simulation much faster, students can collect a great deal of "data" using a computer simulation. Such experiments might make a very nice science fair project.