2.3 Effects of Bioaccumulation on Ecosystems

Synthetic chemicals enter the environment in air, water, and soil. Plants take up some of these chemicals, and the chemicals bioaccumulate in the fat tissue of herbivores and carnivores. Synthetic chemicals become biomagnified in food pyramids and harm organisms. Heavy metals such as lead, cadmium, and mercury also bioaccumulate in the environment and negatively affect organisms. Scientists are working to find ways to remove harmful environmental chemicals. Methods include bioremediation in which organisms are used to help clean up chemical pollution.

Words to Know

bioaccumulation
bioremediation
heavy metals
keystone species
parts per million
PCBs

Figure 2.51 Malformations in frogs have greatly increased since 1980. This frog has three hind legs.

Did You Know?

A major cause of frog malformations is the flatworm *Ribeiroia*. This parasite can spend part of its life cycle in snails and then move into tadpoles, hindering their development. Epidemics of this parasite may be caused by fertilizer run-off and the presence of cattle manure near water habitats. These pollutants produce large algae blooms that feed the snail hosts, increasing their numbers.

Amphibians, such as frogs, are vertebrates that can live in two different environments. As larvae, they live in water and breathe by means of gills. As adults, they move onto land and breathe with lungs. Because amphibians live both in water and on land, they are useful to scientists as indicators of the health of an ecosystem.

In the water phase of their life cycle, amphibians are sensitive to the effects of chemical run-off and other pollutants in the environment. Their egg casings are permeable and can be penetrated by harmful chemicals. Their skin, which is a partial breathing organ, also makes them more sensitive to toxic substances. Scientists believe that factors harming amphibians today are also harming other species.

Since the 1980s, the number of amphibians in the world has fallen dramatically. Of the more than 5700 known species of amphibians, currently 43 percent are declining in number, 32 percent are threatened,

and 168 species are thought to be extinct. At the same time, scientists have found that malformations in frogs, such as missing or additional legs, have greatly increased (Figure 2.51 on the previous page). In some locations, up to 50 percent of the frogs are malformed. Similar deformities have been reported for salamanders and toads.

Scientists have confirmed several causes of the amphibian loss, such as prolonged drought and increased ultraviolet radiation due to depletion of the ozone layer. Other causes include habitat loss, pollution, overhunting, parasites, and diseases caused by viruses and fungi. Researchers have found that tadpoles exposed to increased doses of ultraviolet radiation die or develop incorrectly, gaining extra limbs or eyes. Exposure to certain pesticides also interferes with tadpole development. **Pesticides** are chemicals used to eliminate pests, such as insecticides that kill insects and herbicides that kill weeds.

2-3A Simulating Toxic Effects in an Ocean Ecosystem

Find Out ACTIVITY

Pesticides are one group of compounds that may harm many different organisms. The negative impact of an accidental spill of pesticides can be felt in ocean ecosystems. In this activity, you will simulate these effects.

Safety

- Do not eat any food in the laboratory.

Materials

- 0.5 kg of coloured candies
- 1 killer whale name tag
- 3 seal name tags
- 5 large fish name tags
- 6 small fish name tags
- 15 krill name tags
- 15 small bags or containers

What to Do

1. You will select or be assigned a role in an ocean ecosystem as a killer whale, seal, big fish, small fish, or krill. Determine your role in the food chain.
2. If you are a krill, you will simulate feeding on zooplankton and phytoplankton by gathering the candies distributed in the classroom. Put your collected candy in the container provided. You have 15 seconds to "feed" (do not eat the candy). At the end of 15 seconds, you must stay where you are.
3. Students representing the next members of the food chain continue the simulation by tapping the prey on the elbow and obtaining all the candy from the prey. At the end of 15 seconds, the eaten prey must stay where they are, as they are now dead. The simulation is complete when the killer whale has eaten.
4. Your teacher will tell you which candy colours represent food contaminated by pesticide. If red and orange candies contain the pesticide, determine the percentage of toxic candies "eaten" by each member of the food chain:

$$\frac{\text{red candies} + \text{orange candies}}{\text{total candies}} \times 100$$

5. If there are any krill still alive who consumed any red or orange candy, they are now dead. If there are any small fish still alive that consumed 20 percent or more red or orange candy, they are now dead. If any higher carnivores consumed 20 percent or more red or orange candy, they are now sick. If they consumed 30 percent or more, they are now dead.
6. Determine how many organisms are still alive.

What Did You Find Out?

1. What effect did the pesticide have on the ecosystem?
2. What effect would a pesticide have on an ecosystem if it remained in the ecosystem for 50 years instead of degrading rapidly?

Figure 2.52 Pollution entering a lake from a steel mill (A). Pollution entering a stream from an abandoned car (B)

Suggested Activity

Conduct an Investigation 2-3B on page 100

Figure 2.53 Organisms are frequently exposed to chemicals that can build up in their bodies.

How Pollutants Climb the Food Chain

Human activities can make natural disturbances such as forest fires and insect infestations much worse. Over the past century, human activity has resulted in many new disturbances. Rapid changes have been very stressful for many organisms. Some organisms have died, and in some cases complete extinction of a species has occurred. One of the biggest changes has been the introduction into the environment of synthetic (human-made) chemicals (Figure 2.52).

Bioaccumulation

Synthetic and organic chemicals build up in the environment when decomposers cannot break them down through the biodegradation process. **Bioaccumulation** is the gradual build-up of these chemicals in living organisms (Figure 2.53). A chemical will accumulate if it is taken up and stored faster than it is broken down and excreted. Chemicals enter organisms through food intake, skin contact, or respiration. If the accumulation of a substance is too high, it can be harmful. Some chemicals are temporarily stored in fat tissue but are released from storage when fat is burned for energy. These chemicals can be harmful to the animal if they are not metabolized (chemically changed) or are not excreted in the feces or urine.

Synthetic and organic chemicals can affect the nervous, immune, and reproductive systems of animals. Bioaccumulation of these chemicals can cause birth defects in offspring or a complete failure to reproduce. These chemicals affect not only individual organisms but also entire ecosystems when keystone species are affected. **Keystone species** are species that can greatly affect population numbers and the health of an ecosystem. Salmon are a keystone species in many British Columbia forest ecosystems. In fall, salmon are an important food source for bears, wolves, eagles, and otters. Salmon alter the ecosystem as their decaying bodies become a rich source of nutrients such as nitrogen for trees. Salmon can also retain harmful chemicals in their body fat and transfer these chemicals to other organisms.

Biomagnification is the process in which chemicals not only accumulate but become more concentrated at each trophic level. Chemicals bioaccumulate and become biomagnified when pollutants are stored in plant tissue and in the fat tissue of animals. Chemicals remain trapped in plants and animals until they are eaten and the tissues and fats are broken down for energy.

As you learned in section 2.1, herbivores eat large quantities of plants and carnivores eat many times their body weight of prey during their lifetimes. For this reason, even small concentrations of chemicals in producers and primary and secondary consumers can build up to cause problems at higher trophic levels. For example, a red tide is caused by an algae bloom in which the algae become so numerous that they can turn coastal seawaters red. Red tides produce toxic organic chemicals that can affect organisms such as clams, mussels, and oysters. As the shellfish eat the algae, the toxins bioaccumulate to a level that is poisonous to other organisms such as fish, humans, and other mammals. If eaten, these shellfish can cause paralytic shellfish poisoning, which can result in serious illness or death.