Issues with Pesticides

Pesticides have helped farmers reduce crop damage from pests and increase food production. Pesticides have also helped control populations of biting insects, such as mosquitoes, that spread diseases (Figure 1). While such benefits can result in more food and better health for some, pesticide use has a number of environmental costs.

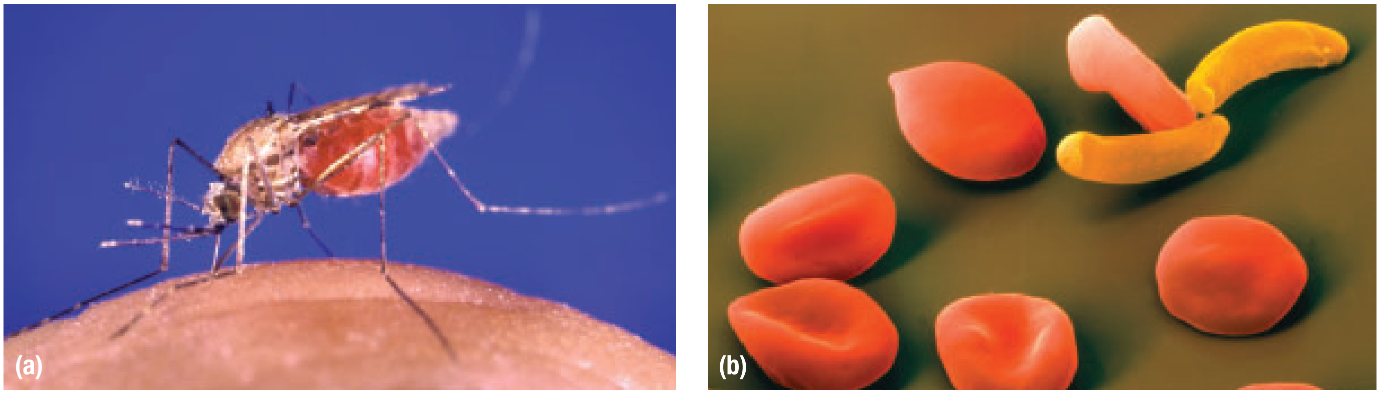

Figure 1 Pesticides have helped control the spread of disease-carrying insects such as (a) this mosquito, which transmits (b) the protozoan parasite that causes malaria.

Pesticides are often applied through aerosols or sprays onto fields, forests, and gardens. A serious drawback of this mode of delivery is that some of the pesticide never reaches the target species because it is carried away by the air or lands on the soil. These pesticides then become potential sources of soil, air, and water pollution. They can also harm other non-target species.

Non-Target Species

Pesticides often kill species they were not intended to kill. Because broad-spectrum pesticides control many different pests, they may kill non-damaging and potentially beneficial organisms. For example, a broad-spectrum insecticide may kill species of predatory insects that might normally feed on pests.

Killing beneficial organisms creates a situation in which farmers become more dependent on pesticides. When natural pest controls, such as predatory insects, are killed, farmers must replace them by using more pesticides.

Improper use of pesticides can also kill non-target species. For example, spraying an insecticide at the wrong time of year may kill honeybees, which are essential for pollinating fruit crops. As a result, less fruit will be produced.

The consequences of non-target killing can be surprising and serious. Consider the dramatic set of events that took place on the island of Borneo. In 1955, the World Health Organization began a DDT spraying program to control mosquitoes that were responsible for spreading malaria. The spraying initially reduced the spread of malaria, but it also caused an unexpected chain reaction on the island. In addition to killing mosquitoes, DDT killed wasps that preyed on thatch-eating caterpillars. Without the wasps, the caterpillars ravaged the thatched homes of the villagers (Figure 2).

Figure 2 A thatch roof, constructed of palm leaves, can be destroyed by caterpillars. These caterpillars are normally preyed on and controlled by wasps.

DDT also killed cockroaches that were then consumed by lizards. The DDT in the cockroaches damaged the nervous systems of the lizards, making them easy prey for cats. Many cats died from consuming the poisoned lizards.

In a final twist, the villagers were threatened by a new disease. When the cats disappeared, the rat population in the villages increased dramatically. The fleas on the rats carried the plague—a potentially devastating disease. To prevent an epidemic, large numbers of healthy replacement cats had to be brought to Borneo to control the rats.

Bioamplification

One of the most serious side effects of pesticide use is their tendency to accumulate in individual organisms. This happens because some pesticides are not broken down or eliminated with other body wastes. If an individual continues to eat food contaminated with the pesticide, it will accumulate in the body. If the pesticide is long-lived, then the concentration of pesticide in the individuals will increase to levels much higher than in the environment. Pesticides that bioaccumulate do so because they cannot easily be excreted from the body. This is because they are not soluble in water but are soluble in fats and oils. This process is called **bioaccumulation.**

bioaccumulation the concentration of a substance, such as a pesticide, in the body of an organism

TRY THIS POLLUTANTS FOLLOW THE FAT

SKILLS: Controlling Variables, Performing, Observing, Analyzing, Evaluating

SKILLS HANDBOOK 3.B.

In this activity, you will model the bioaccumulation of toxins in the body. Iodine will represent a persistent pesticide. Water (in the iodine solution) will represent body fluids. Mineral oil will represent body fat.

Equipment and Materials: **3 15-mL screw-top vials; pipette; pipette suction bulb; 6 mL mineral oil; 18 mL 0.1 % Lugol's iodine solution**

Never suck on the pipette with your mouth. Iodine solution is toxic and stains skin and clothing.

1. Record the appearance of the iodine solution and the mineral oil.
2. Using the pipette bulb, pipette 6 mL of iodine solution into each of the three vials.
3. Add 6 mL of mineral oil to a vial. Seal the vial. Shake it vigorously for 1 min while pressing on the vial cover. Let the contents settle for 2 min. Record your observations.
4. Open the first vial and, using a pipette, transfer 4 mL of the oil to the second vial.
5. Repeat step 3 using the second vial.
6. Use a pipette to transfer approximately 2 mL of the oil from the second vial to the third vial. Repeat step 3.

A. What property of iodine allowed you to detect its presence in the water? T/I

B. Was there evidence that iodine moved from the water to the oil? T/I

C. Explain how this process models the accumulation of pesticides in an organism. T/I

D. Describe what happened to the mineral oil as it was transferred to vials 2 and 3 and exposed to more iodine. T/I

E. Was there evidence that the iodine was bioaccumulating in the mineral oil? Explain. T/I

F. Many of your body's waste products are eliminated through your urine. Urine contains no fat or oils. What do your observations suggest about your body's ability to eliminate pesticides that have poor solubility in water? A

G. What does this activity suggest about the risks of eating fatty foods that were produced in contaminated environments? A

All individuals are part of a food chain. As a result, toxins stored in the fats and oils of organisms at one trophic level are passed on to the organisms at the next trophic level. The higher up the food chain, the more concentrated the pesticides become. This process is called **bioamplification**.

bioamplification the increase in concentration of a substance, such as a pesticide, as it moves higher up the food web

If a pesticide bioamplifies in a food chain, it may reach toxic concentrations. As illustrated in Figure 3, the concentration of DDT has increased more than 600 times. At these high levels, the organisms are likely to suffer toxic effects.

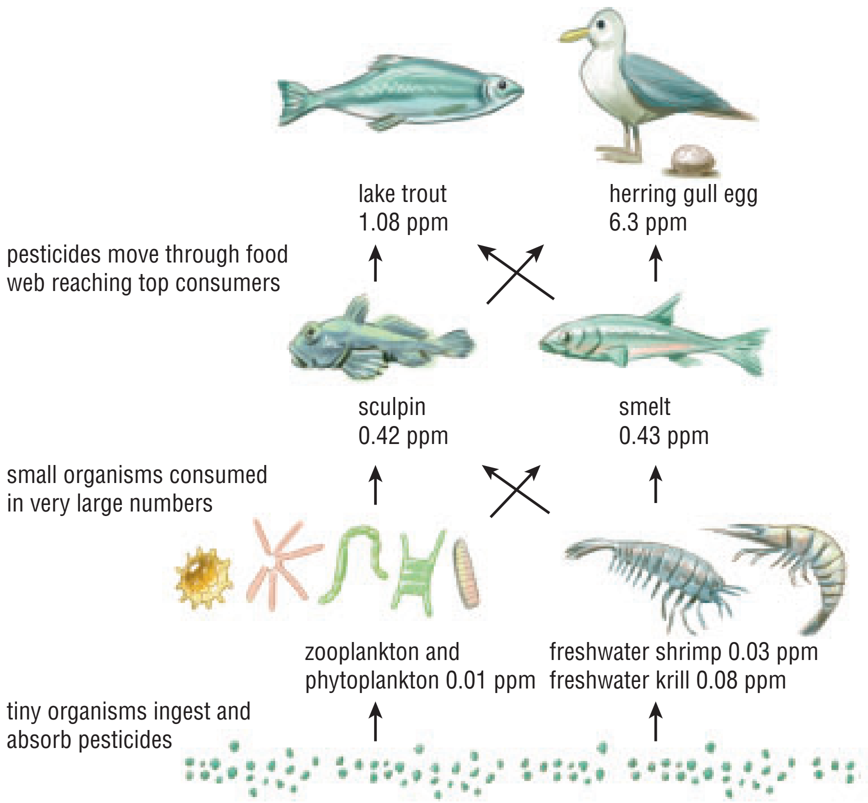

Figure 3 DDT bioaccumulates up the food chain. Gulls require more food because they are warm-blooded and must maintain their body temperature; therefore, they accumulate more DDT.

Many species of predatory birds, including osprey, bald eagles, and peregrine falcons, declined in numbers because DDT bioaccumulated in their bodies (Figure 4). DDT interfered with calcium metabolism and the female bird's ability to produce strong egg shells.

Figure 4 Eggshells of many species of birds, such as this peregrine falcon, were softened by DDT.

MATH TIP

Understanding ppm and ppb
Small concentrations are often measured using units of ppm (parts per million) or ppb (parts per billion). A concentration of 10 ppm is approximately equal to 10 mL of a substance dissolved in 1000 L of water.

To learn more about bioaccumulation of DDT in herring gulls,
GO TO NELSON SCIENCE

DID YOU KNOW?

Consuming Oils Can Be a Fishy Dilemma
Fish oils, especially from salmon and herring, are high in omega-3 fatty acids, which are considered to be beneficial in the diet. Unfortunately, salmon are near the top of food chains. Therefore, they are more likely to accumulate toxins within the very oils that are beneficial.

Other fat-soluble toxins, such as mercury and polychlorinated biphenyl (PCB), also bioamplify in the food web (Figure 5).

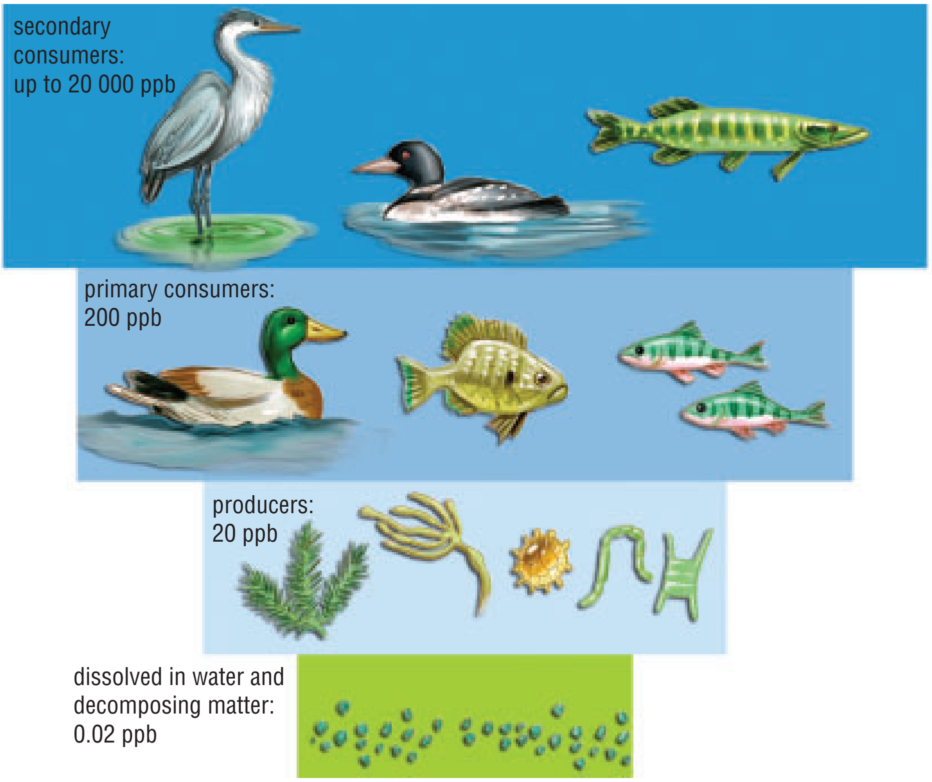

Figure 5 Populations of large predatory birds suffered due to the bioamplification of mercury in aquatic ecosystems.

Arctic ecosystems are particularly vulnerable to biomagnification of toxic substances. Many long-lived top consumers such as whales, polar bears, walrus, and fish live in the Arctic (Figure 6). In addition, Inuit that live in these environments rely on these same species as their traditional food supply—resulting in a potentially dangerous exposure of humans to toxins in their food. This is one danger associated with consuming food from the top of the food web.

Figure 6 Pesticides and mercury have biomagnified in the fatty tissues of the walrus.

Pesticide Resistance

When pesticides are used for long periods of time, some pest species may become resistant to the pesticide. This means that the pesticide is no longer able to control the pest. Individuals that exhibit the greatest resistance are more likely to survive an application of pesticide than those with little or no resistance. The individuals that survive will reproduce and pass on their resistance to their offspring. After many generations, the population can become highly resistant to a particular pesticide.

Weeds and insect pests are likely to develop resistance because they reproduce frequently and produce many seeds or offspring (Figure 7). When resistance develops in a pest, the farmer needs to apply a greater concentration of pesticide to have the same effect or switch to a different pesticide.

On a global scale, pesticide resistance is a serious concern. Figure 8 illustrates the numbers of species that have become resistant to various types of pesticides over a 50-year period.

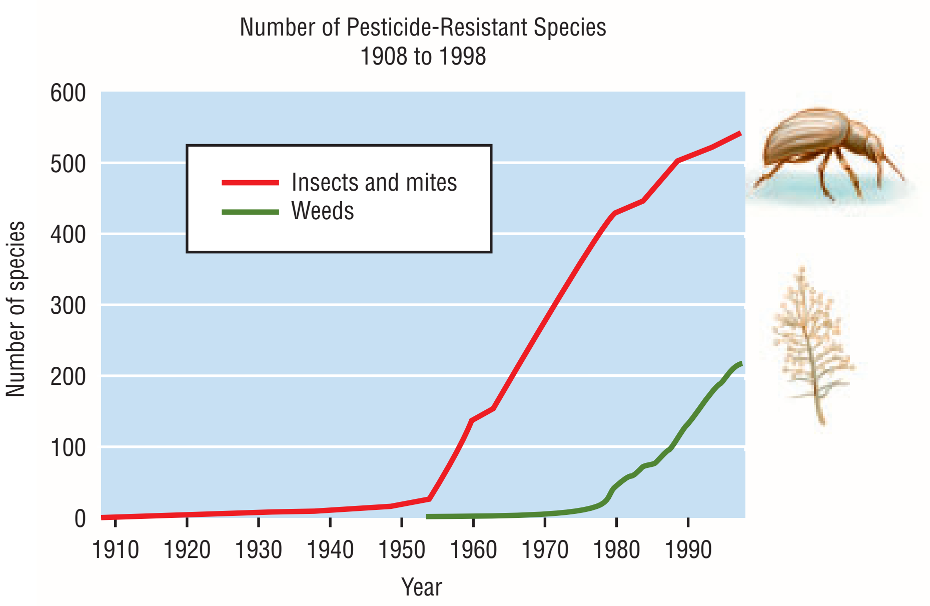

Figure 8 Pesticide resistance is increasing worldwide.

DID YOU KNOW?

Herbicides Clear the Way
Herbicides are used to maintain right-of-ways along the edges of highways and under power transmission lines. Using herbicides saves on labour costs but may also leave toxic residues. Before going berry picking along the side of a road, you might want to consider whether pesticides have been used.

Figure 7 Populations of green pigweed are resistant to some herbicides.

Reducing Our Dependence on Pesticides

There is little doubt that pesticides have dramatically increased global food production. By reducing competition and other pests, crops grow faster and have higher yields. The benefits of using pesticides must, however, be weighed against the risks of pollution, harm to non-target species, bioamplification, and pesticide-resistant species.

One alternative type of agriculture, **organic farming**, uses no synthetic pesticides or fertilizers. Organic farmers sometimes have to accept crop losses to naturally occurring pests. These losses, however, may be offset by the higher price growers get for their organic products, as well as savings from not purchasing synthetic chemicals.

organic farming the system of agriculture that relies on non-synthetic pesticides and fertilizers

To learn more about being an organic farmer,
GO TO NELSON SCIENCE

To learn more about organic farming in Canada,
GO TO NELSON SCIENCE

DID YOU KNOW?

Pest Baiting

The female apple codling moth releases a pheromone, or sex attractant, which attracts mates. When growers place pheromone baits in an orchard, the males become confused and have difficulty finding females. This reduces the population size of the next generation, which means fewer larvae will infest the crop.

integrated pest management a strategy to control pests that uses a combination of physical, chemical, and biological controls

Organic farmers rely on a range of ecologically sustainable techniques. These techniques are summarized in Table 1.

Table 1 Techniques Used by Organic Farmers

Method	Description
biological control	• Predatory insects, mites, and disease-causing micro-organisms prey on and infect prey species. • Examples include parasitic wasps and ladybird beetles (ladybugs).
altered timing	• Better timing of planting and harvesting can avoid peak pest populations.
crop rotation and mixed planting	• When farmers do not grow monocultures in the same location year after year, pest populations do not have the same opportunities to establish and prosper.
baiting pest	• Pheromone baits can be used to confuse some mating insects.

While organic farming minimizes environmental impacts, it could result in lower crop yields. This may not be acceptable. In such cases, an intermediate approach called **integrated pest management** (IPM) is often employed. IPM takes advantage of all types of management methods. The goal is to maximize efficiency, keep costs low, and reduce harm to the environment. IPM farmers use many of the techniques employed by organic farmers but use synthetic pesticides and fertilizers when necessary.

IN SUMMARY

- Non-target organisms may be harmed when pesticides are released into the air or water.
- Some pesticides and toxins bioaccumulate in the bodies of organisms and bioamplify up the food web.
- Many plant and insect pests are becoming increasingly resistant to pesticides.
- We can reduce our dependence on pesticides by using organic farming or integrated pest management (IPM) methods.

CHECK YOUR LEARNING

1. Outline three key benefits of using pesticides. K/U
2. What is a non-target organism? K/U
3. Describe how the loss of non-target organisms leads to even greater pesticide use. K/U
4. Explain why some pesticides bioaccumulate whereas others do not. K/U C
5. Use the example of DDT to explain how a pesticide can bioamplify and damage entire ecosystems. K/U
6. Define pesticide resistance. K/U
7. Explain why pesticide resistance is a major concern. K/U
8. Describe three alternatives to the widespread use of pesticides. K/U
9. Briefly explain the concept of “integrated pest management.” K/U C
10. Describe how organic farming methods are similar to natural ecosystem processes. K/U A
11. Use a graphic organizer to explain what happened on the island of Borneo when DDT was used to control the spread of malaria. K/U C