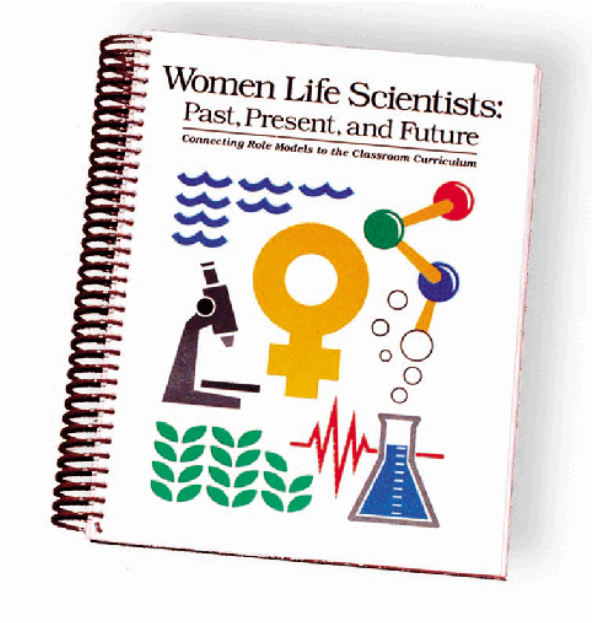

Rachel Carson

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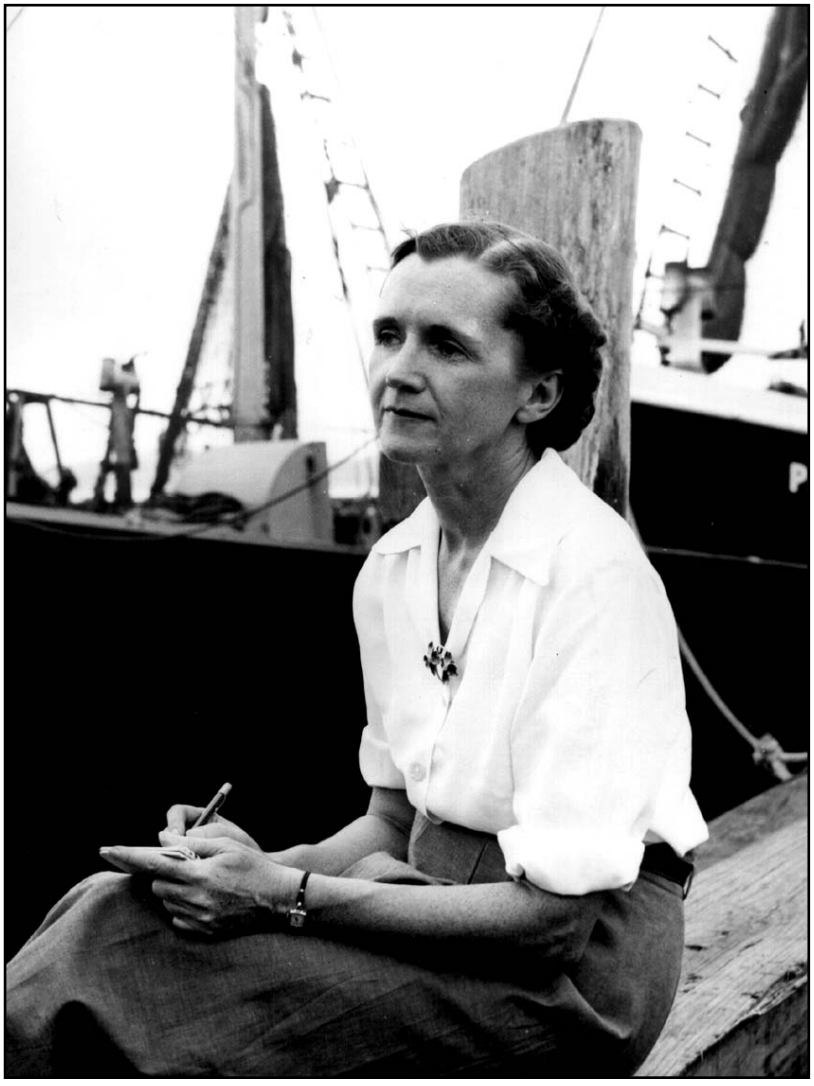
Copies of the activities from *Women Life Scientists: Past, Present, and Future* can be found at http://www.the-aps.org/education/k12curric/index.asp. To purchase bound copies, visit the APS store at http://www.the-aps.org/cgi-bin/ecom/productcatalog/Product_catalog.htm.

Visit the APS Education Online Website for more resources:
http://www.the-aps.org/education/

Rachel Carson
Ecologist & Science Writer
1907-1964



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Rachel Carson's childhood

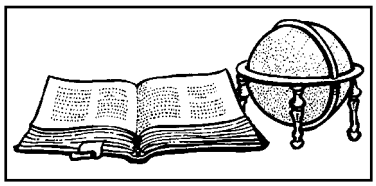
Rachel Carson was born on May 27, 1907, in a rural area not far from Pittsburgh, Pennsylvania. Because her sister and brother were so much older than she was (Marian was 10 years older and Robert was 8 years older), Rachel spent much of her time during childhood roaming through the woods near her home alone or with her mother, Maria. Rachel later said about her mother, "Her love of life and all living things was her outstanding quality." With her mother, Rachel explored the wonders of plant and animal life in their woods.

Because her mother worried about the many serious diseases that often infected people in the small town where Rachel went to school, she kept her home from school at the slightest sign of a sniffle or word of disease in the town. Fortunately, Mrs. Carson was a former school teacher who made sure that Rachel kept up with her studies. Rachel's teachers were concerned about the amount of school that Rachel missed, but they had to admit that she was bright and prepared when she came to class.

There was no television when Rachel was young, so the family spent their evenings singing around the piano or listening to Mrs. Carson read stories. Rachel enjoyed the stories so much that she thought it would be fun to write her own stories for other people to read. By the time she was seven or eight years old, she had decided to be a writer. Rachel was also fascinated by the ocean, even though she had never seen one. Her family had a large conch shell on the mantle. Rachel liked to hold it to her ear and pretend that she was standing on the shore, listening to all the sounds of the sea. Her love of the sea and of writing were characteristics that remained throughout her life.

Rachel's favorite magazine when she was a child was *St. Nicholas Magazine* because it included a section of stories written by children. When Rachel was 10, World War I had begun and her brother Robert joined the Army Aviation. One of his letters home told of a Canadian aviator who saved his plane after part of the wing had been shot off. This inspired Rachel to write the story and submit it to *St. Nicholas Magazine*. She was delighted to learn that her story, "A Battle in the Clouds," won a silver badge and a payment of 10 dollars! Three more of Rachel's stories were published in the magazine, including one that won a gold badge.

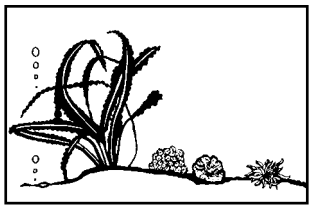
Rachel's experiences in college



After Rachel graduated from high school, both she and her parents wanted her to go to college. She won a scholarship to the Pennsylvania College for Women, not far from her home. Nevertheless, her parents had to sell some of their land and work extra jobs to help pay her tuition. Rachel began college as an English major. She was a quiet and studious young woman who, though she was not disliked, did not have many close friends. Most of the other young women at the school came from wealthier families and could afford to buy new clothes and go to parties after classes. Because of the sacrifices her family was making for her to attend college, Rachel devoted herself to her studies. She liked sports and played on the school's field hockey team. She also became a reporter for the school newspaper.

When Rachel was a sophomore, she took a required course in biology. This course and its teacher, Mary Scott Skinker, would change the direction of Rachel's life. Rachel had always enjoyed exploring wildlife; now she found that she could do this as a profession! After much soul-searching, she changed her major to biology in her junior year of college. Many of her friends and teachers were appalled! But Rachel was determined and worked extra hard to make up the courses she needed for a degree in biology.

How did her career get started?



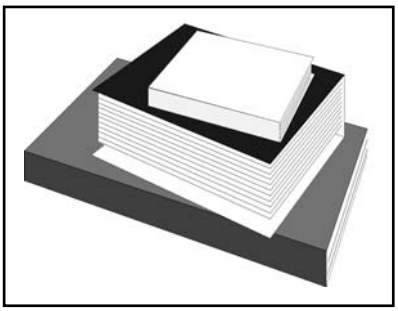
After she graduated from college, Rachel won a summer scholarship to study at the Woods Hole Marine Biological Laboratory in Massachusetts. At last she would see the ocean! She thoroughly enjoyed her work and studies at Woods Hole, and the following fall she enrolled at The Johns Hopkins University to study for her Master's degree in zoology. Rachel earned her degree in 1932; however, it was the time of the Depression, so jobs were very scarce. She taught part-time at both Johns Hopkins University and the University of Maryland. Since it was less costly for a family to live together than apart, Rachel invited her parents to move into a small house in Maryland with her. Rachel's father helped support the family working odd jobs and her mother did the cooking and cleaning.

When her father died in 1935, Rachel became the sole support for her mother. This was a time of great sorrow for the family, but it was also the time when Rachel got her first job as a biologist. She went to see her friend and mentor, Elmer Higgins, at the Bureau of Fisheries (now the Fish and Wildlife Service). He needed someone to write radio stories about marine life — professional writers did not know enough science to write the stories, and scientists did not know how to write in ways that would make the stories interesting to nonscientists. Mr. Higgins hired Rachel part-time to write these stories. He was so pleased with her work that he encouraged her to apply for a position as junior aquatic biologist at the Bureau. Before she could apply, Rachel had to take the government's civil service exam. She was the only woman who took the exam at that time, and she earned the highest score. She got the job!

When Rachel was 30, her older sister, Marian, who had two daughters in elementary school, died. Rachel and her mother took the girls in and raised them. With more people to feed and clothe, money was even tighter for the family. Mr. Higgins encouraged Rachel to send an article she wrote to the magazine, *Atlantic Monthly*. The article not only earned extra money, but it also attracted the attention of a book publisher and a famous author. These two men urged Rachel to expand her article into a book. Writing late at night after her work at the Bureau, Rachel finished her first book, *Under the Sea-Wind*, in 1941. While the scientific community had high praise for the book, it did not sell well. The United States entered World War II just a few weeks after it was published. People had more urgent matters on their minds.

Rachel continued to do well in her job at the Bureau and was promoted several times. Finally, in 1949, she became editor-in-chief. She had many close friends at the Bureau who said that Rachel had a great sense of humor and liked to play practical jokes. Although she had dated several nice young men in school and at work, she said she was too busy to marry. One friend said that was probably true; she had a very demanding job, as well as her mother and nieces to support.

An extensive writing career



Despite the fact that she enjoyed her job and her family, Rachel was becoming restless. She was anxious to write another book. She began reading thousands of books and articles and consulted many oceanographers about life in the oceans. She even made a deep sea dive to see for herself what life underwater is like! Just before her second book, *The Sea Around Us*, was published in 1951, *The New Yorker* magazine printed portions of it as a three-part series. They paid her the equivalent of one year's salary at the Fish and Wildlife Service! Rachel realized that she could earn a living with her writing. *The Sea Around Us* became a bestseller. When her first book, *Under the Sea-Wind*, was reprinted, it became a bestseller, too.

Rachel won many awards for her books. One was the National Book Award. Many people were surprised that a science book had become so popular. When she accepted the award, Rachel said, "...this notion, that 'science' is something that belongs in a separate compartment of its own, apart from everyday life, is one that I should like to challenge. We live in a scientific age.... Science is part of the reality of living: it is the what, the how, and the why of everything in our experience...."

In 1952, Rachel resigned from the Fish and Wildlife Service. She was already working on her next book, *The Edge of the Sea*, which was an ecological approach to the organisms that live along the shoreline. She had become a popular guest speaker and, with her earnings from her books and speaking engagements, she was able to build a summer cottage at the shore in West Southport, Maine. Her mother still lived with her and her nieces visited often. In 1957, one of Rachel's nieces died of pneumonia, so Rachel adopted her five-year-old son, Roger.

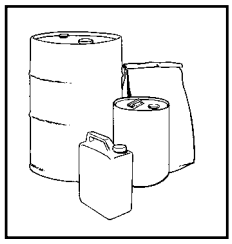
Concern about pesticides

At this time, Rachel and many other scientists were becoming concerned about the effects of pesticides, such as DDT. She could see that they were destroying the balance of animals in the food chain. Although scientists were talking about these hazards, most nonscientists were unaware of their concerns. Rachel decided she must research this issue and write a book for the public that would explain the dangers.

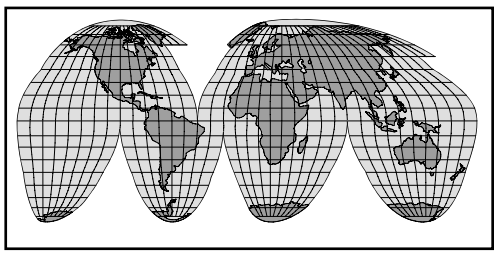
Rachel knew that chemical companies and agriculturalists would not like her to speak against pesticides. The chemicals protected farmers' crops from destruction by insects, and chemical companies made a lot of money producing and selling them. Rachel did not think that all uses of pesticides were bad, but years of studying the sea told her that all life forms are connected to one another. What affects one life form may have unforeseen consequences for another. Rachel knew that she had to be very certain that her information was absolutely correct or those who disagreed with her would discredit her work.

This was a very difficult time for Rachel. Not only was her research exhausting and depressing but also her mother became seriously ill. In 1958, Maria Carson died. Rachel had lived with her mother all her life, except for the years when she was in college and graduate school. It was many months before she felt able to begin writing again. Then, in 1960, her doctor discovered that Rachel had a breast tumor. She had surgery and her doctor assured her that the

tumor was not cancerous. However, he was not telling her the truth. Several months later Rachel learned this and began radiation therapy. She worked on her book when she felt well enough. She began it by describing what spring would be like if pesticides were used without regard for their consequences. She imagined that there would be no birds singing, no crickets chirping, and no bees buzzing. She named her book *Silent Spring*.



Silent Spring was published in 1962. Immediately, it was attacked by many people. However, many others were shocked to learn of the effects of pesticides. When she was well, Rachel spoke to various groups, including the U.S. Congress, and entered into debates with those who disagreed with her. She spent her final summer in Maine in 1963. One September afternoon she and a friend watched the butterflies that were migrating south. Because of their short life span, Rachel and her friend knew that very few of the butterflies would return. Yet, Rachel explained that she was happy knowing that "it is a natural and not unhappy thing that a life comes to its end." Rachel died the following spring, on April 14, 1964.



Because of *Silent Spring*, many people were introduced to ideas that have become common today: pollution, conservation, and ecology. The use of the pesticide, DDT, is banned in the United States and many other countries today, and the government has restricted the use of other toxic substances. Today, there are still many concerns about our environment and what we must do to protect it. Because of her central role in environmental issues and her ability to explain these issues clearly and accurately to nonscientists, Rachel Carson, a pioneer of ecology, made a profound and lasting impact on our society.

SUGGESTIONS FOR TEACHERS

ACTIVITY #1: The Deadly Links Game
ACTIVITY #2: What Is Biological Magnification?
ACTIVITY #3: DDT in Real Life

Purpose

To learn about Rachel Carson and her work in ecology, to learn how toxic chemicals move through the organisms in an ecosystem, to illustrate biological magnification in various organisms within an ecosystem graphically and/or pictorially, and to practice pipetting skills.

Objectives

1) To be able to define biological magnification.
2) To understand how food (energy) moves through an ecosystem
3) To explain how toxic chemicals concentrate in organisms at the higher trophic levels of an ecosystem.
4) To illustrate the proportion of a toxic chemical in various organisms within an ecosystem.

Materials

Activity #1

- white pipe cleaners, paper dots, wooden craft sticks, or other materials that can be picked up by students easily; 20 per student
- colored pipe cleaners, paper dots, etc.; 10 per student
- 8-20 small paper bags
- arm bands or handkerchiefs in 3 colors to represent the different animals; for 30 students: 18-20 for grasshoppers, 6-9 for shrews, and 2-3 for hawks

Activity #2

- 7 test tubes and a test tube rack for each team of 3 or 4 students; 1-3 additional test tubes for you
- cooking oil and water
- Sudan III stain (see directions below)
- one 5-ml pipette and pipette bulb or pump for each team

Activity #3

- tables provided in activity pages

Before You Begin

Activity #1

1) Collect the materials indicated.
2) Locate an area outside for food collection or push the desks and chairs to the edge of the room.

Activity #2

1) Collect the materials indicated.
2) Set up five test tubes for each team as follows. Place 3 ml of water into each test tube. Carefully layer 1 ml of cooking oil on top of the water in each test tube. Label the test tubes "grasshopper."
3) Student teams will need two additional empty test tubes to represent the shrews and one or two test tubes to represent the hawks. The numbers of grasshoppers, shrews, and hawks in the class as a whole represent the decrease in numbers of individuals as you progress from primary consumers to top carnivores in an environment.
4) To prepare the Sudan III stain, dissolve 0.3 g of Sudan III in 100 ml of 70% ethanol, while stirring. Allow the stain to sit overnight, and then dispense it into dropper bottles for each team. Sudan III is a stain for fats.
   NOTE: the Sudan III stain is optional for this activity, since the difference in color between water and cooking oil is apparent. However, the red color makes the results appear more dramatic.
5) Students should have some background about producers and consumers and about food chains and food webs.

Activity #3

1) Provide white and colored paper, poster board, markers, etc.
2) Prepare space on the boards or walls for student groups to hang their posters.

Safety Considerations

- Students should know and practice proper

pipetting procedures for *Activity #2* — no mouth pipetting!
- Warn students that the Sudan III stain will permanently stain clothing.

Questions to Ask

Activity #1
- Are any of the grasshoppers, shrews, or hawks producers? Why/why not?
- Which organism(s) is (are) primary consumers? secondary consumers?
- Why are there are so many more grasshoppers than shrews and hawks?
- Was the pesticide effective for killing the grasshoppers?
- Did the farmers want to kill shrews and hawks? Would the farmers want these animals to live?
- The pesticide was intended to kill grasshoppers. Why did shrews also die?
- What would you expect to happen to the size of the hawk population in this environment? Why?

Activity #2
- See the questions at the end of the student activity pages.

Activity #3
- Are the organisms listed in the table producers or consumers? Which are the primary consumers and which are the top carnivores?
- Which component of the ecosystem has the lowest concentration of DDT? Which has the highest?
- Why does the concentration of DDT in the organisms increase as you go up in the food chain?
- See the questions in the student activity pages.

Where to Go From Here
- Assign students to write a brochure explaining the hazards of some pollutant. It should be written for the nonscientist but be scientifically complete and accurate, as was Rachel Carson's book, *Silent Spring*.
- As a class, prepare a series of radio shows on specific animals. Each team of three or four students should write a 5-minute script on an animal of interest to them. The scripts should be entertaining, but factual. Once a week, have one team read its script to the class as if it were a radio show.
- Assign students to write a book report on one of Rachel Carson's books (see "References and Resources" below).
- Set up a debate on the pros and cons of pesticides or another substance that has both benefits and dangers for humans and other animals. Students assigned to each side of the issue should research their position and attempt to convince the others of their argument. Be sure to write to chemical companies for information on how their products are tested.

Ideas for Assessment
- Have teams write a group lab report on *Activity #2*.
- Use *Activity #3* as an assessment activity.
- Have students develop a brochure explaining biological magnification to a layperson.

References and Resources

✓*By Rachel Carson:*

The Sea Around Us. (1951). New York: Oxford University Press.

Under the Sea-Wind. (1952). New York: Oxford University Press.

The Edge of the Sea. (1955). Boston: Houghton Mifflin.

Silent Spring. (1962). Boston: Houghton Mifflin.

The Sense of Wonder. (1965). New York: Harper & Row.

✓*About Rachel Carson:*

Foster, L. M. (1990). *The Story of Rachel Carson and the Environmental Movement.* Chicago: Childrens Press.

Harlan, J. (1989). *Sounding the Alarm: A Biography of Rachel Carson*. Minneapolis, MN: Dillon Press.

Kudlinski, K. V. (1988). *Rachel Carson: Pioneer of Ecology*. New York: Viking Kestrel.

Ransom, C. F. (1993). *Listening to Crickets: A Story About Rachel Carson*. Minneapolis, MN: Carolrhoda Books. (appropriate reading for upper elementary/lower middle school students)

✓*About the activities:*

Adapted with permission from Deadly Links,

(1983, 1985, 1992). *Project WILD K-12 Activity Guide*, Western Regional Environmental Education Council. To locate the Project WILD Coordinator in your state, contact the headquarters at 5430 Grosvenor Lane, Bethesda, MD 20814, (301) 493-5447, fax (301) 493-5627.

✓*For science supplies:*

Carolina Biological Supply Company, 2700 York Road, Burlington, NC 27215, (800) 334-5551.

Fisher Scientific, Educational Division, 485 South Frontage Road, Burr Ridge, IL 60521, (800) 955-1177.

Flinn Scientific, P.O. Box 219, Batavia, IL 60510, (630) 761-8518.

WARD'S, 5100 West Henrietta Road, P.O. Box 92912, Rochester, NY 14692-9012, (800) 962-2660.

✓*Other resources:*

Contact the following organizations for more information about Rachel Carson and about protecting the environment:

Rachel Carson Council, Inc., 8940 Jones Mill Road, Chevy Chase, MD 20815, (301) 652-1877, fax (301) 951-7179, email rccouncil@aol.com.

The Rachel Carson Homestead, 613 Marion Avenue, Springdale, PA 15144-1242, (412) 274-5459, fax (412) 820-8935, email rachel@envirolink.org.

Free subscriptions to *ChemEcology* are available by contacting the Chemical Manufacturers Association, 2501 M Street NW, Washington, DC 20037, (202) 887-1236, fax (202) 887-5422, email uscmancn@ibmmail.com.

✓*Photo credit:*

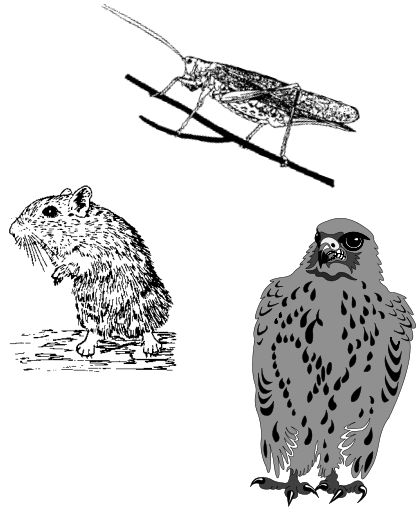
Photo on page 175 by Edwin Gray, (1951). Courtesy of the Rachel Carson History Project, Bethesda, MD.

ACTIVITY #1: The Deadly Links Game

Get Started

Each student will be assigned a role to play in a simulation of a food chain: you will be either a **grasshopper**, a **shrew**, or a **hawk**.

Arm bands of different colors will indicate which organism you are. There will be approximately three times as many grasshoppers as shrews, and three times as many shrews as hawks.



The Deadly Links Game

1. Each grasshopper collects a small paper bag or container from the instructor. Write your initials on it. This container will represent your "stomach." Turn your back to the "food area" in which the simulation will take place while your teacher distributes the "food" for the grasshoppers: pipe cleaners, paper dots, or other materials.

2. At your teacher's signal, grasshoppers move into the "food area" and begin gathering the food and placing it in their stomach bags one piece at a time. (The shrews and hawks are predators who watch their prey from the sidelines!) When your teacher tells you, stop collecting food.

3. Next, your teacher will tell the shrews that it is their time to hunt for food. When a shrew tags a grasshopper, the shrew should take the bag of food and the grasshopper should go sit on the sidelines. When your teacher indicates, the shrews should stop hunting.

4. At your teacher's signal, the hawks may begin hunting for shrews. Shrews may hunt again for any grasshoppers who are still "alive," following the same rules above. When a shrew is tagged by a hawk, the hawk takes the food bag(s) and the shrew goes to sit on the sidelines. Stop hunting when your teacher indicates.

5. Animals who are still living at the end of the simulation should empty their food bags and count the number of food pieces they have, then fill out the table on the following page accordingly. Animals that were consumed should find out which animal has the bag with their initials on it and help to complete its tables.

TABLE: Count Your Deadly Links Food Pieces			
Animal	**Total No. of food pieces**	**Total No. of white food pieces**	**Total No. of colored food pieces**

What Happened to Your Animal?

In the environment in which these animals live, a pesticide was sprayed onto the crops to prevent damage by the grasshoppers. **The colored food pieces represent plants that contained the pesticide**.

- Grasshoppers still alive at the end of the simulation should check their food pieces. **If any grasshoppers have colored food pieces, they are now dead.**
- Shrews still alive at the end should check their food pieces. **If half or more of the shrews' food pieces are colored, they are now dead.**
- **The hawk with the highest number of food pieces lives at this time.** However, because it has consumed pesticide, it will not have any baby hawks, because the egg shells it produces will be so thin that the eggs will not hatch successfully.

ACTIVITY #2: What Is Biological Magnification?

Get Started

You will observe in this activity a simulation of what actually occurs in nature when pesticides are common. Because animals' bodies cannot break down many pesticides, they are not excreted and instead remain stored in the animal. When that animal is eaten by a predator, the predator gets a concentrated dose of the pesticide. This phenomenon is called *biological magnification*.

You will work in teams and as a whole class for this activity. Team members should be selected for roles as: **organizer**, **materials-gatherer**, **team pipetter**, and **class volunteer pipetter**.

Procedure

1. The **materials gatherer** should collect a test tube rack, five test tubes labeled "grasshopper," two empty test tubes, a pipette, and a dropper bottle of Sudan III stain.

2. The **organizer** should label the empty test tubes "shrew."

3. Without shaking the test tube, the **team pipetter** should remove 2 ml of the solution in one of the grasshopper test tubes from the top down (i.e., do not place the pipette all the way to the bottom of the test tube). Place the 2 ml into one of the shrew test tubes. *This represents the shrews consuming the grasshoppers.*

4. The **team pipetter** should repeat *step 3* with a second grasshopper test tube and the same shrew test tube. The **organizer** should set the shrew test tube aside to let the solution settle.

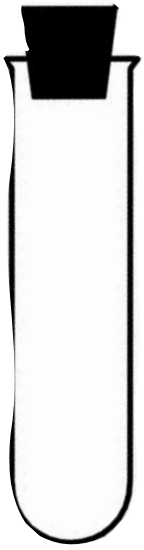
5. The **team pipetter** and the **organizer** should repeat *steps 3* and *4* with two more grasshopper test tubes and the other shrew test tube. Leave the fifth grasshopper test tube in your rack.

6. Your teacher will select one shrew test tube from two teams. The **volunteer pipetter** from each of those two teams should use a pipette to remove 3 ml of the solution in the shrew test tube from the top down and place it into your teacher's test tube, which is labeled "hawk." The second team will do the same. *This represents the hawk consuming the shrews.*

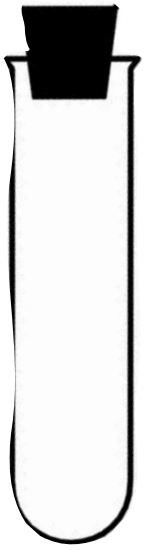
7. The **organizer** should add two or three drops of Sudan III stain to the fifth grasshopper test tube and the shrew test tube(s). Shake the tubes gently and allow them to sit in the test tube rack for a few minutes. ***Use the illustration on the following page to draw a picture of your results so far.***

8. Your teacher will add Sudan III to the hawk test tube. ***Draw that result on the following page, too.***

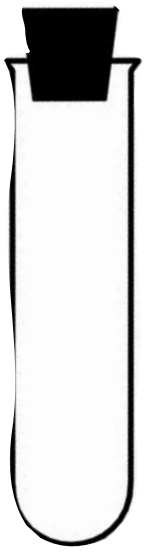
Draw Your Results



Grasshopper test tube



Shrew test tube



Hawk test tube

Questions to Answer
(with your team members and/or the whole class)

1. How do the test tubes compare?

2. Suppose the part of the solution stained red represents the amount of pesticide found in the bodies of the animals. How does the total amount of pesticide in the various animals compare?

3. How does the proportion of pesticide in the various animals compare?

ACTIVITY #3: DDT in Real Life

Get Started

You will work in pairs or teams on this activity.

1. Examine the table below. This table shows the amounts of DDT found in various components of an ecosystem on Long Island.

2. Make three observations about this ecosystem, based on the table and the information in it.

_____

_____

_____

Table:
Concentration of DDT in
Components of Long Island Ecosystem

DDT in parts per million:	Found in:
0.00005	Water
0.04	Plankton
0.94	Sheepshead minnow
1.33	Pickerel
2.07	Needlefish
22.8	Merganser duck
26.4	Cormorant

(Data from Audesirk, G., & Audesirk, T. (1993). *Biology: Life on Earth.* New York: Macmillan, p. 998.)

Procedure (work as a team or with partners)

1. Does the table on page 188 show biological magnification? Explain your reasoning.

_____

_____

_____

2. Discuss how you could show this information in a graph or picture. Check your ideas with your teacher.

3. Use the materials available (colored paper, poster board, markers, etc.) to present the information in the table with a graph or picture.

4. Put your graph or picture up on the wall.

5. Examine the graphs/pictures prepared by the other teams/partners, then answer the following questions:

- Which one(s) present the most information?
- Which are easiest to understand? Why?
- What changes could you make to your graph/picture to make it more complete or understandable?