Activity 3

ANTS & CO.:
Tiny Farms

Can a farm be the size of a walnut? It can if the farmer is an ant. Some of the world's smallest farmers are leaf-cutter ants. Leaf-cutter ants farm in the tropical zones of the Western Hemisphere. Farming in the tropics is no easy achievement, whether you're an ant or a human, because the warm soils swarm with pests ready to attack your crop. These six-legged farmers have amazed scientists by growing crops successfully for millions of years. By comparison, humans have only been farming for a few thousand years. What is the secret of the ants' long-standing success? Cameron Currie, a biologist, discovered the answer by taking a close look at life on an ant farm.

Leaf-cutter ants harvest leaves from the tropical forest, but they can't eat these leaves. Most tropical leaves are poisonous to the ants. Instead, the ants feed the leaves to a fungus. The fungus eats the leaves and produces nourishing food that the ants can eat. The fungus is similar to mushrooms you buy in grocery stores.

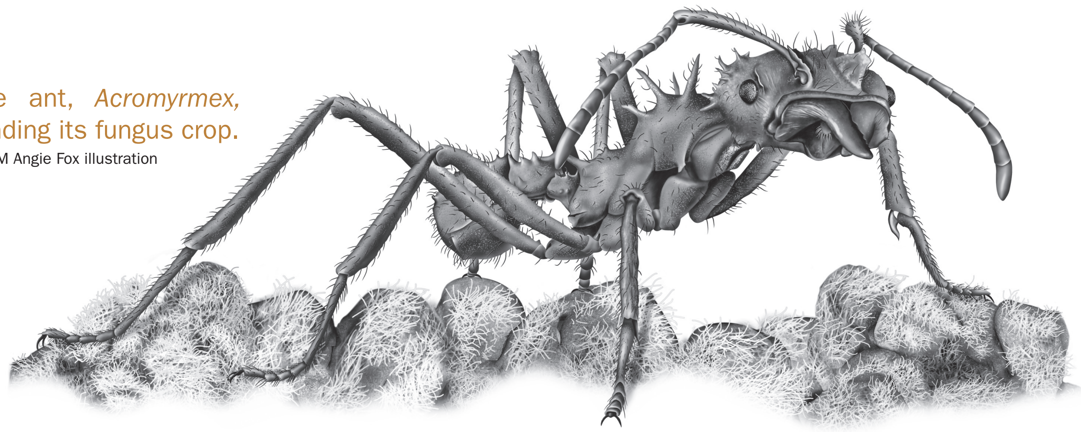
Every day the ants file out of their nests and into the forest. They cut down pieces of leaves, hoist them over their bodies, and haul them back to their nest. The ants chew the leaves into a pulp and spread the pulp deep in the underground nest. The fungus grows on the bed of leaves, and the ants weed and tend it carefully, eating only the fungus tips. When a queen ant establishes a new nest, she brings along a piece of fungus from the old nest to start a new crop.

The ants and the fungus have formed a lasting bond of mutual dependency. Without their fungus crop the ants would die. Without ants to cultivate the fungus, it would die. The lives of the partners are so intertwined that when a biological change happens in one of them, it is accompanied by a change in the other. This is called coevolution. Ants and their fungus crop have coevolved for millions of years. How do scientists know this? They

Cameron Currie and colleagues search tropical forests for ant farms, which they bring back to their laboratories to study.
Photo courtesy Anna Himler

recently discovered the long history of this relationship by tracing the ancestry of the ants and their fungus crop through their DNA. The fungal crops found on ant farms today descended from a single fungus that lived about 50 million years ago. As the ants branched into new species, the fungus also branched into new species.

Scientists once believed that the ants were successful for so long because they



The ant, *Acromyrmex*, tending its fungus crop.
UNSM Angie Fox illustration

kept their fungus crop free of disease. Ants are meticulous farmers. They lick the surfaces of their nest and each other with their tongues to keep everything spotless. They reduce the number of pests entering the farm by chewing the harvested leaves into mush. They weed the garden carefully, removing weeds to special dump chambers or to garbage heaps outside the nest. The research suggested that the ants were so good at keeping out pests that no disease could take hold.

Among the ants that Cameron Currie studies are two types of leaf-cutter ants, *Atta* and *Acromyrmex* (ack-crow-MUR-mex). As a young graduate student, Cameron had a hunch that these and other farming ants did have a pest problem; it just hadn't been discovered. He based his hunch on examples of human crop disasters. Anyone who farms knows that farmers are constantly battling a barrage of pests. And the battle gets tougher when farmers grow the same crop year in and year out. The crops usually do well for a while, but they are sitting ducks for diseases. Was life really any different on ant farms?

Cameron set off for the tropics to collect ant nests to study. He searched under rocks and in ravines for nests small enough to pack up and take back to his lab. In his first summer of research he collected between 50 and 60 walnut-sized nests from various fungus-growing ant species. In the lab, after the ants had time to settle down from their trip, he looked for evidence of infection by crop pests.

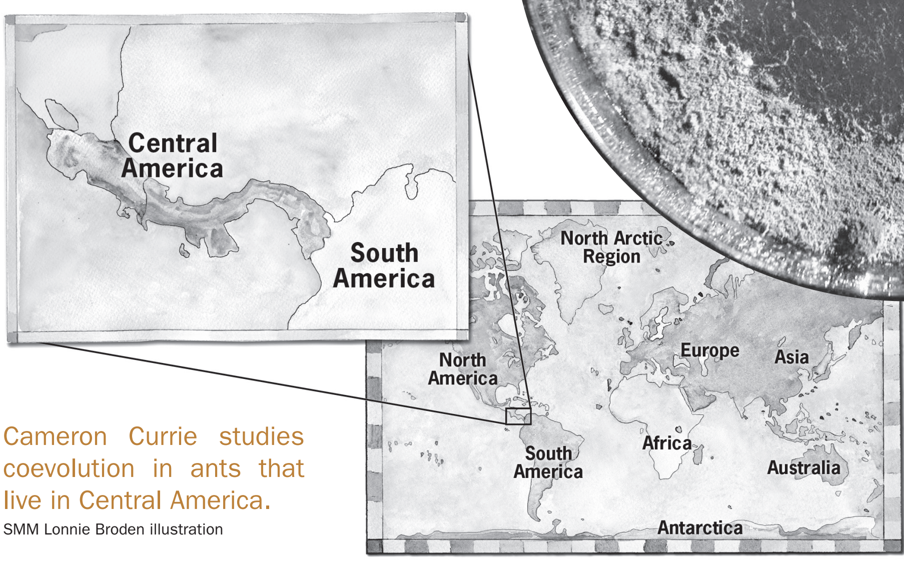
Cameron's hunch proved right. A crop pest called *Escovopsis* (es-co-VOP-sis) kept showing up in the ant farms. This pest is found only on the fungus crop of farming ants. This pest is found nowhere else in nature, yet is extremely common on the ant farms. And each ant species that Cameron looked at had its own specialized species of *Escovopsis*. All of this suggested to Cameron that the crops pest had coevolved with the ant and the fungus crop.

Cameron also discovered that the crop pest could be deadly. If he removed the ants from a farm infected with the pest, the crop died in just a few days. But if the ants were allowed to stay, the pest only slowed the growth of the crop but didn't wipe it out. What secret did the ants have that kept the deadly crop pest under control?

Cameron began to wonder about a white coating he noticed on many of the ants. The ants working deep in the nests were often covered with it. When he examined the substance under a powerful microscope, he discovered it was actually alive. The ants were wearing a coating of tiny bacteria. Were they harmless hangers-on—like fleas on an elephant—or was this news? Did the bacteria help the ants protect their fungus crop from the pest?

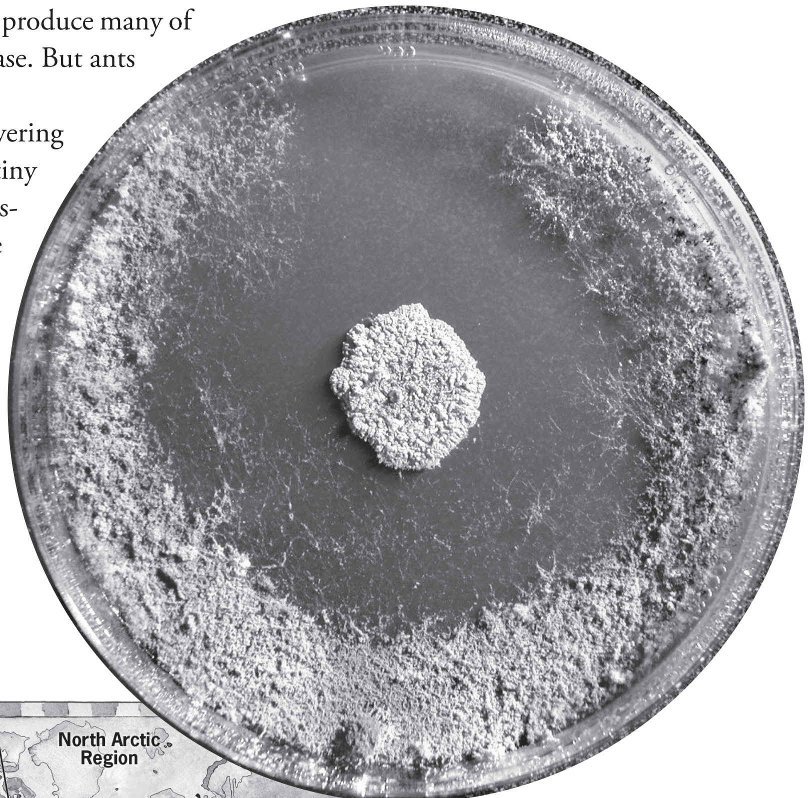
Through experiments, Cameron discovered the key to the smooth-running ant farms. The bacteria living on the ants produce antibiotics that kill the crop pest and keep the ant farms running well. The bacteria are known as actinomycetes (ak-TIN-oh-my-see-tees). They also produce many of the antibiotics that humans use to fight disease. But ants used them first!

Explore how Cameron set about discovering some of the fascinating interactions on a tiny farm cooperative. In this activity you'll investigate life on a walnut-sized farm, simulate petri dish experiments in which bacteria are introduced to killer pests, and decide whether the results of the experiments provide evidence for coevolution.



Cameron Currie studies coevolution in ants that live in Central America.

SMM Lonnie Broden illustration



On a petri dish, Cameron tests how well the crop pests grow in the presence of the bacteria.

Photo courtesy Cameron Currie

PART ONE

Three buddies & a menace

You're invited to investigate the underground world of the leaf-cutter ants and their partners, the fungus crop and bacteria . . . and their enemy, the crop pest *Escovopsis.* First, you will make a set of cards telling about each player among the leaf-cutter ants' partners. Then create a poster showing how they work together.

Work with a partner

Each team of two will need:

- Ant Fact Cards 1 and 2
- tape or glue stick
- large sheet of paper (about 11x17)
- scissors

1 Meet the Players

a Cut out the four cards along the broken lines. Fold each card on the solid line so you can read the writing. Paste or tape the cards closed.

b Now use the cards to create a poster showing the leaf-cutter partners. Read the information on each card to help you decide where to place the card. Tape the top of the cards to a sheet of paper in a pattern you think best shows the relationships connecting the players (who depends on who). Make sure you can flip the card over to read the other side.

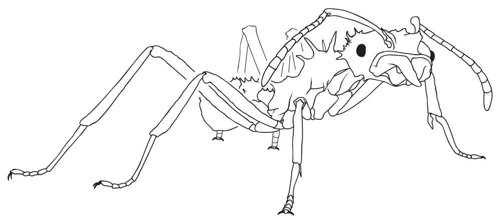
2 Chart Their Game

Draw arrows on the poster between the players showing the relationships. Title the poster.

Ant Fact Cards 1

Farming Ant
Acromyrmex

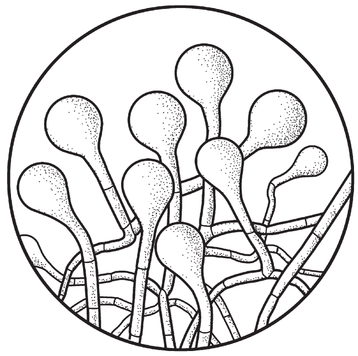
(ack crow MUR mex)



Size: 1-2 centimeters
length of a zipper pull

Fungus Crop
Lepiotaceae

(Lep ee oh TAY seeah)



Size: 30-50 microns
Two strands equals a human hair's width.

Role: Farming Ant
Name: *Acromyrmex*

Habitat: *Acromyrmex* ants live in nests about 50 centimeters deep. About 500 to 100,000 worker ants live in a single nest.

Habits: These ants can't eat the leaves in tropical forests because they contain poisons. They have evolved ways to use these toxic leaves to grow their own food. Big ants harvest the leaves, and smaller ants chew them into a paste. The smallest ants spread the paste in the nest chambers so the fungus will grow. Ants weed and prune their crop to keep it healthy. The fungus crop is the ant's only food.

Role: Fungus crop
Name: *Lepiotaceae*

Habitat: This fungus grows in *Acromyrmex* colonies. It lives off leaf mulch supplied by the ants.

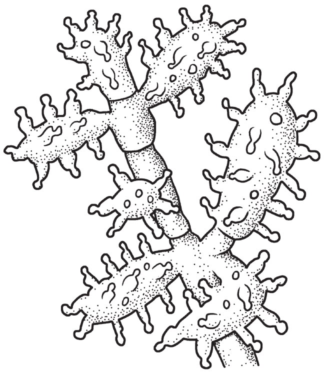
Habits: This fungus looks like tiny strands with swollen tips. The tips are highly nutritious and the ants digest them easily. This fungus cannot reproduce on its own. It depends on the ants to be cultivated and supplied with leaves.

UNSM Angie Fox ant illustration, Cara Gibson Escovopsis.

Ant Fact Cards 2

Crop Pest
Escovopsis

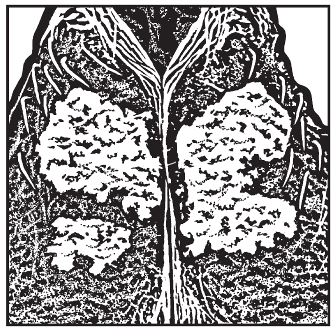
(es co VOP sis)



Size: 100 microns
width of a human hair

Bacteria
Actinomycetes

(ac TIN oh my see tees)



Size: 1 micron
2,000 fit across the head of a pin.

Role: Crop Pest
Name: *Escovopsis*

Habitat: This crop pest is a hair-like fungus that is found in nests of *Acromyrmex* ants. It is a parasite that lives off the ants' fungus crop. When it overwhelms the fungus crop, the ants starve and die.

Habits: The crop pest looks like a white cloud when it blooms. Ant nests often start off free of the crop pest, but within two years most of the ant nests become infected.

Role: Bacteria
Name: *Actinomycetes*

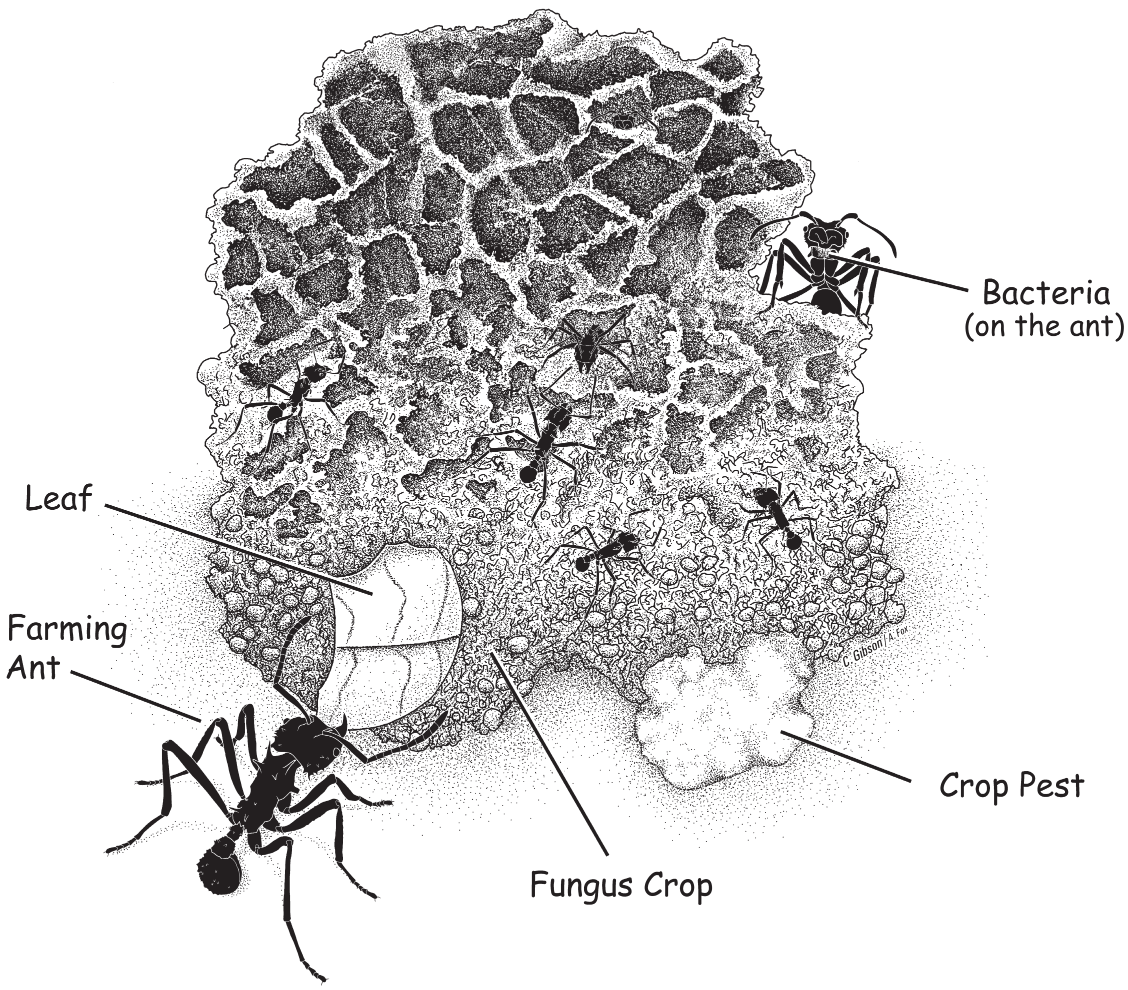
Habitat: These bacteria live on the surface of *Acromyrmex* ants. They appear on the underside of the ant like a white dust. Sometimes this dust completely covers an ant's body.

Habits: The bacteria produce an antibiotic that helps the ants protect their farm from the crop pest. Glands inside the ant's body appear to nourish these bacteria.

3 Consider This

a Make an award in the Leaf-Cutter Game of Life. Who is the most valuable player? Why?

b You're the ref: Which player can you remove without stopping the game?



Cara Gibson illustration, modified by Angie Fox

PART TWO

Killers vs. the bacteria

After investigating hundreds of ant nests, Cameron discovered the ants have a serious pest called *Escovopsis* that kills their fungus crops. When the ants were around, the crop pest seemed not to cause much damage to the fungus crop. But when the ants were taken from the nest, the pest could kill a fungus crop in just a few days.

The ants appeared to protect their crop from the crop pest, but how did they do it? Cameron discovered that there is a patch on the ant's body that supports a thick concentration of bacteria. Close inspection with a microscope showed that under this patch there is a gland that secretes substances that nourish the bacteria (called actinomycetes). So the ants appeared to be feeding the bacteria. But why? What do these bacteria do for the ants?

Cameron guessed that the bacteria help the ants protect their crop from the pest. To test his idea he began growing samples of the crop pest and testing the effects of the bacteria on the pest's survival. Check out Cameron's experiment, measure his results, and then come to your own conclusions about the effects of the bacteria.

Work with a partner

Each team will need:

- Crop Pest vs. Bacteria Experiment
- Crop Pest vs. Bacteria Data Chart
- cm ruler
- two colored pencils (red plus one other)

1 Set-Up: Control and Test Experiment

In the lab, Cameron grows the crop pest in petri dishes. Petri dishes are sterile round containers with tight-fitting lids. The lids prevent other micro-life from getting in and contaminating his experiments. They also keep the crop pest from getting out and contaminating his lab. To begin, Cameron pours a layer of food material in each petri dish so the crop pest has something to feed on.

To find out whether the bacteria prevent the crop pest from growing, Cameron sets up a control and test condition.

a A control is the part of the experiment that shows what happens when you don't change or add anything extra. For the control, what should be in the petri dish?

b In this test, the crop pest grows on a petri dish that is like the control, but with one difference: A spot of bacteria is added in the middle of the dish. What would you expect to find if the bacteria stop the pest?

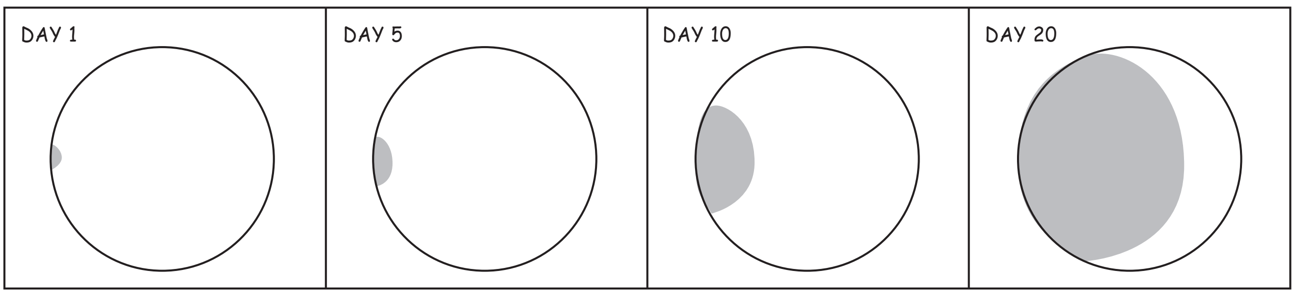
2 Running the Experiment

Cameron introduces a small amount of the crop pest at the edge of the dish. This is the control. Cameron places the dishes in a warm place and records the growth on day 1, 5, 10, and 20.

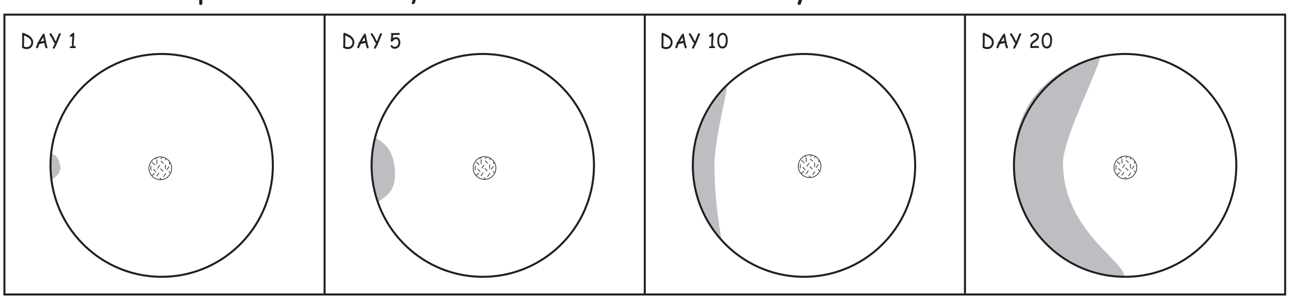
a Look at the Crop Pest vs. Bacteria Experiment sheet. On the section labeled "control," color the crop pest (the growing spot at the edge of each dish on days 1–20) one color (but **not** red). Notice how the crop pest changes from day 1 to day 20.

Crop Pest vs. Bacteria Experiment

CONTROL: Crop Pest *Escovopsis*



TEST: Crop Pest *Escovopsis* + Bacteria actinomycetes



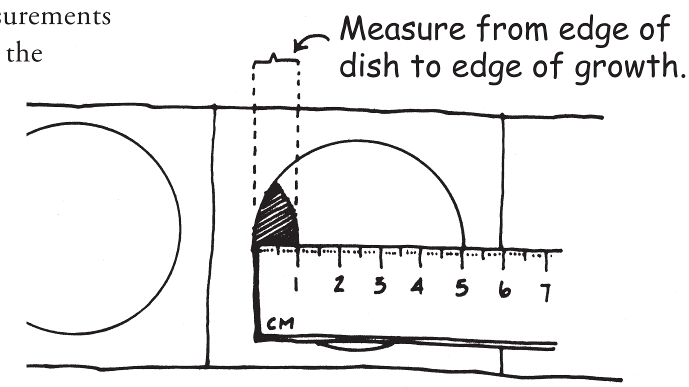
b On the same experiment sheet look at the section labeled “Test.” Here Cameron introduces the crop pest at the edge of dish and a spot of the bacteria in the center. Again, Cameron places the dishes in a warm place and records the growth on day 1, 5, 10, and 20.

c On the experiment sheet, color the bacteria red. Color the crop pest the same as in the control. Notice how the pest changes from day 1 to day 20.

3 Measure and Chart the Results

a Measure the growth of the crop pest in each dish in millimeters. Start from the round edge of the petri dish and measure toward the center of the dish.

b Record the measurements for each dish on the Crop Pest vs. Bacteria Data Chart.



Crop Pest vs. Bacteria Data Chart

Measuring the effects of bacteria on the growth of a crop pest

	DAY 1	DAY 5	DAY 10	DAY 20
CONTROL Crop Pest alone *(Escovopsis)*				
TEST Crop Pest + Bacteria (*Escovopsis* + actinomycetes)				

4 Consider This

Review your data. What can you conclude about the effect of the actinomycetes bacteria on the crop pest *Escovopsis?*

PART THREE

Evidence for coevolution

In coevolution, changes in one species are accompanied by changes in another. Many scientists have established that the ants and their fungus crop are a good example of coevolution, because the two are completely dependent on each other for their survival.

Cameron Currie began to wonder if the bacteria and the crop pest might also have coevolved with the ant and the fungus crop. This would mean a four-partner coevolution—not just two partners. But how could this coevolution be determined?

Cameron decided to test whether the bacteria affected the growth of only the pest *Escovopsis*, or whether it affected other fungus species as well. If the bacteria developed a substance that would kill only one kind of crop pest, then that would support the idea that the two organisms had coevolved.

Work with a partner

Each team will need:

- Crop Pest vs. Bacteria vs. New Pest Experiment
- Crop Pest vs. Bacteria vs. New Pest Data Chart
- cm ruler
- three different colored pencils (red plus two other colors)

1 Controls and Tests

As in the first experiment, the microorganisms Cameron tests grow in petri dishes. To begin, Cameron pours a layer of food material in the 1, 2, and 3 petri dishes so the microorganisms in each dish have something to feed on.

a To test whether the bacteria can kill other kinds of crop pests, Cameron repeats the previous experiment with some additions. The new test condition is added to see whether the new kind of crop pest will be stopped by the bacteria.

b For this test to be convincing, three controls are needed. Look at the Crop Pest vs. Bacteria vs. New Pest Experiment sheet to see the controls. Name them here:

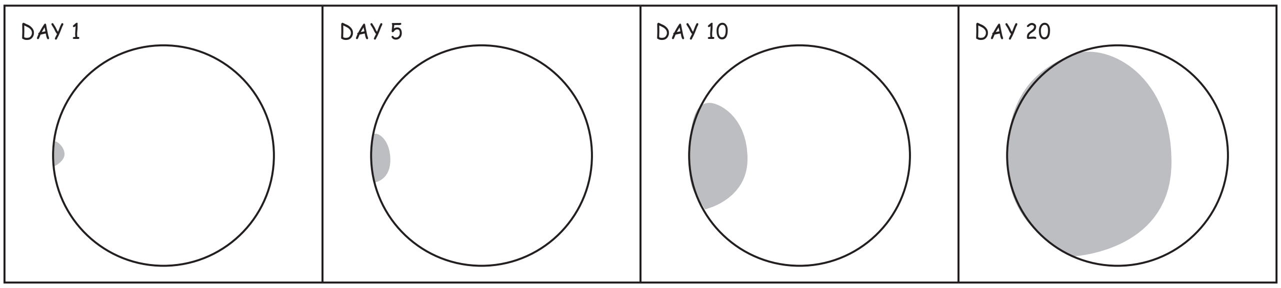
Control 1:

Control 2:

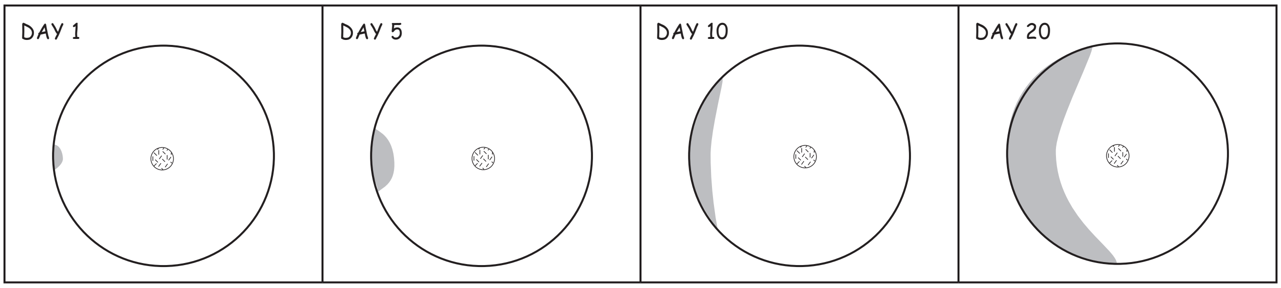
Control 3:

Crop Pest vs. Bacteria vs. New Pest Experiment

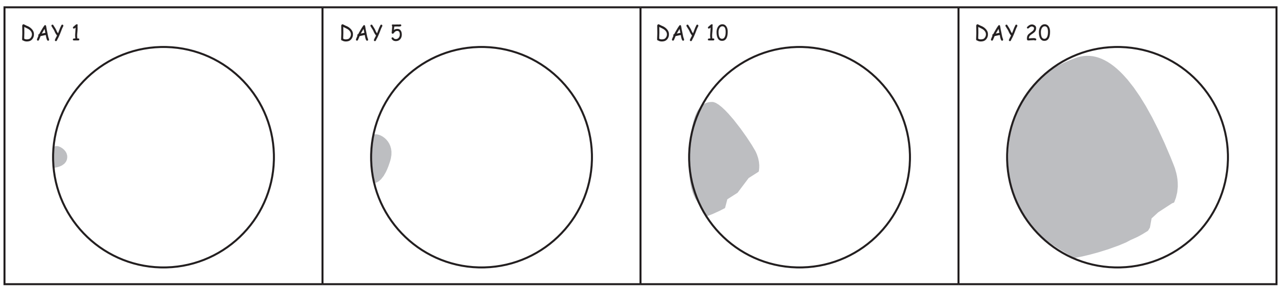
CONTROL ONE: Crop Pest *Escovopsis*



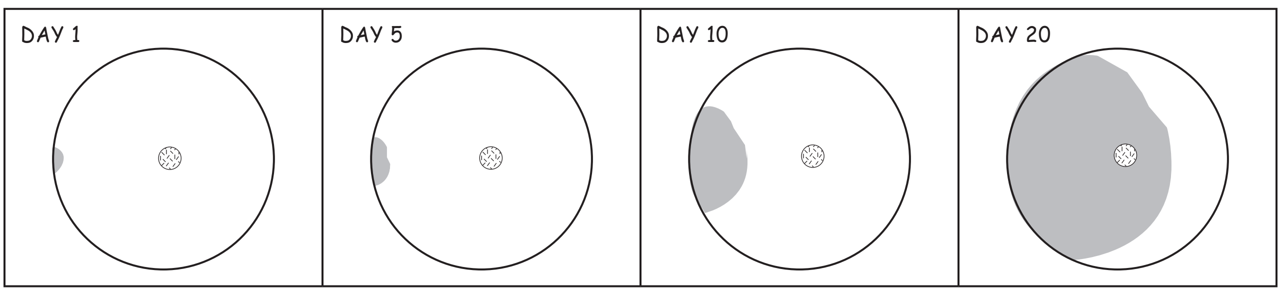
CONTROL TWO: Crop Pest *Escovopsis* + Bacteria actinomycetes



CONTROL THREE: New Pest *Trichoderma*



TEST: New Pest *Trichoderma* + Bacteria actinomycetes



Linda Allison illustration.

c Why are these conditions considered controls for the test condition?

2 Running the Data

Repeat the procedures as in the previous experiment. On the Experiment Sheet dishes where bacteria are added, color the bacteria red. Color the crop pest *Escovopsis* a different color. Color the new pest *Trichoderma* a third color.

3 Measure and Chart the Growth

Measure the growth of the crop pest in each dish in millimeters. Start from the round edge of the petri dish and measure toward the center of the dish. Record the measurements for each dish on the Crop Pest vs. Bacteria vs. New Pest Data Chart.

Crop Pest vs. Bacteria vs. New Pest Data Chart

Measuring the effects of bacteria on two different kinds of crop pests

	DAY 1	DAY 5	DAY 10	DAY 20
CONTROL ONE Crop Pest alone (*Escovopsis*)				
CONTROL TWO Crop Pest + Bacteria (*Escovopsis* + actinomycetes)				
CONTROL THREE New Pest alone (*Trichoderma*)				
TEST New Pest +Bacteria (*Trichoderma* + actinomycetes)				

4 Consider This

Why did Cameron test the bacteria with the new pest?

Hint: A defender that kills one and only one kind of pest may have coevolved with it.

Do you think this experiment suggests that the bacteria and the crop pest may be coevolved partners? Why or why not?

PART FOUR
Be a science reporter

Write a short news story about ants and their partners. Tell your readers about how leaf-cutter ants, their fungus crop, the crop pest, and the bacteria have lived together in an association for millions of years. Based on what you have learned, explain how you think this association came about. What evidence supports your explanation?

P.S. Don't forget the headline.