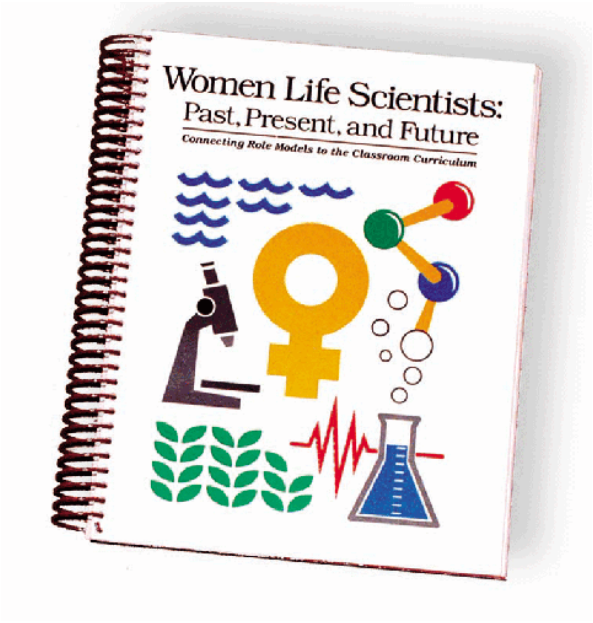

Jennifer Clarke

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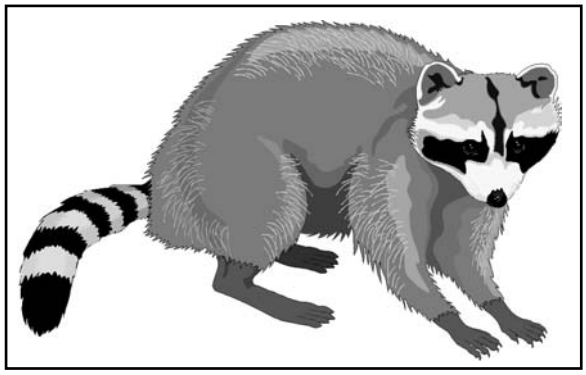
Jennifer Clarke
Behavioral Ecologist
1956-

Unit developed by
April L. Gardner
University of Northern Colorado, Greeley, Colorado

An early interest in animals



Jennifer Clarke was born on February 3, 1956, in Gallipolis, Ohio. Growing up in this rural area with two older sisters, she recalls always being around animals and being fascinated by their behavior. Raccoons got into the garbage cans at night, deer passed by their house, and birds twittered and preened at the bird feeders. The whole family enjoyed spending time outdoors, and Jennifer's parents took the girls on many trips to the mountains in the western and eastern United States. Jennifer particularly enjoyed being around animals in their natural environment.

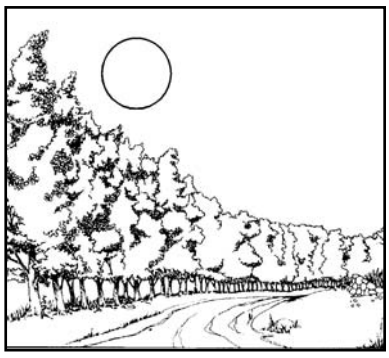
As she grew up, Jennifer talked about her interest in working with animals. Several people suggested that she consider being a veterinarian. While this sounded interesting to Jennifer, she was not sure she wanted to work inside in an office most of the time. She most enjoyed being outdoors and observing animals in that environment. When she was 15, she first heard the term *zoologist* and learned that a zoologist is a person who studies animals. From that time on, Jennifer knew she would become a zoologist.

She began reading all the books she could find on animals and nature. She was especially intrigued by Jane Goodall's work on the behaviors of chimpanzees. Ms. Goodall worked in Africa, watching the interactions of families of chimpanzees with each other. Jennifer was excited to discover a woman doing the type of work she hoped to do someday. Jennifer also credits her parents for encouraging her career plans. Her father is a physician — a scientist — and her mother is an artist — an observer. She explains that her career today requires being a keen observer and applying scientific methods to her observations.

Asking questions about animal behavior

After graduating from high school, Jennifer went to Miami University in Oxford, Ohio, where she majored in zoology. She especially loved learning about animal behavior and ecology. After she received her bachelor's degree in 1978, she took a very special trip to the Galapagos Islands. She says visiting each island was like "turning the pages of an animal behavior text!"

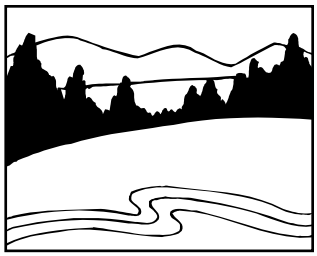
That fall Jennifer moved to Missoula, Montana, to begin work on her master's degree at the University of Montana. Her area of study again was zoology, with an emphasis in the behavioral ecology of animals. As she took courses and began reading research studies in animal behavior, she learned that several zoologists had noticed that nocturnal animals appeared to be less active on nights when there was a full moon. However, no one had studied this closely to determine whether or not this was really true, or to consider why this might be the case. Are predators more successful at catching prey on nights when there is a full moon? Could it be that prey decreased their activity on full-moon nights to minimize their chances of being caught by a predator? Jennifer decided to make these questions the basis of her master's research project. She found that, indeed, predators are better at catching prey when the moon is full. This study led to her continuing research on the



effect of moonlight on a variety of behavioral interactions, including predator-prey interactions, among nocturnal animals.

After she completed her master's degree in 1981, Jennifer decided that she needed to take some time to find out whether or not she wanted to continue a career as a zoologist. She worked a variety of jobs, including one in a veterinarian's office. She found that she really did prefer working with animals in the field to being an animal doctor. She decided to continue her education by getting her doctorate. While she was at the University of Montana, Jennifer had the opportunity to teach some classes in zoology. She found that she enjoyed sharing her understanding about things she loved with students. Now, she was happy to discover that she could pursue a career at a university where she would combine two things that she loved: research on animal behavior and teaching zoology classes.

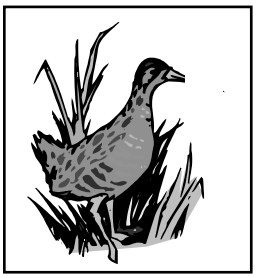
Observing animals in a natural environment



Jennifer enrolled in a Ph.D. program at Washington State University at Pullman, studying zoology with an emphasis in population ecology and behavioral ecology. She had already decided that, for her dissertation research, she wanted to observe animals in their natural environment, not in a laboratory setting as she had for her master's degree study. Her research advisor at Washington State was interested in territoriality among ptarmigan, which had been introduced into the California Sierra Nevada Mountains near the University, and he needed a graduate student to pursue this project. Jennifer happily accepted the challenge.

What is a ptarmigan?

Ptarmigan are birds that live in alpine (that is, mountainous) environments. One reason that Jennifer likes studying ptarmigan is that they accept having observers around them. This makes them good "study animals." As Jennifer began studying the ptarmigan in the Sierras, she discovered that they were so spread out that they really did not exhibit any territorial behaviors. At first she was disappointed — it seemed she did not have a project after all. Then she decided, "I'm a trained observer. So I'll observe these birds and see what they do."



Jennifer found that the ptarmigan did two things: They ate and they slept. She decided that watching them eat would be more interesting than watching them sleep, so that's what she did. As Jennifer watched, she made an interesting observation: The ptarmigan in the Sierras ate only two different kinds of plants. Jennifer went back to the research literature on ptarmigan *foraging* (eating) behavior. According to the literature, ptarmigan ate many different kinds of plants. Why were the ptarmigan in the Sierras eating only two kinds of plants? This led to the two major questions of Jennifer's doctoral research: were the ptarmigan native to the Sierra Nevadas, that is, had they lived there at some time in the past and died out before being reintroduced? If they were not native to the area, were they having a detrimental effect on the environment? She eventually determined that the ptarmigan were not native to the Sierra Nevadas, but they were also not having a negative impact on that environment because they ate only the most abundant plants in the area. Jennifer is still interested in ptarmigan behavior and continues to study them in Rocky Mountain National Park near

her home in Colorado.

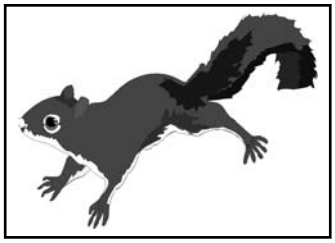
While Jennifer was in graduate school in Washington, she met her future husband, Steve Mackessy. Not surprisingly, it was an animal that brought them together! Steve was also a graduate student at the University. His dog Wasser would come into Jennifer's office down the hall to beg for cookies. After Jennifer got to know Wasser, she got to know Steve. They discovered that they both loved studying animals and being outdoors. Steve's special interest is poisonous snakes and their venoms. Jennifer and Steve were married shortly after they received their Ph.D. degrees in 1989.

While she was completing her dissertation, Jennifer applied for and was offered a faculty position at the University of Northern Colorado (UNC) in Greeley. She began teaching and doing research at UNC as an assistant professor of zoology. Steve took a postdoctoral research position at Colorado State University in Fort Collins, near Greeley. In 1993, Jennifer was promoted to associate professor of zoology and, in 1994, Steve also joined the faculty at UNC as assistant professor of zoology. Today, Jennifer and Steve live in Greeley with their two dogs, Nicky and Holmes; their two cats, B.G. and Angus; and several snakes.

Career barriers

Jennifer says that she has encountered some barriers in her career. She was one of only four women in her Ph.D. program, and none of the professors in the program at that time were women. Because of this, she felt somewhat discouraged and isolated while working on her degree. As a result of that experience, she is especially happy that she can serve as a role model for the undergraduate and graduate women that she teaches at UNC.

A new area of research



Jennifer continues doing research with her graduate students on the effects of moonlight on the behaviors of nocturnal animals and on the behaviors of ptarmigan in Rocky Mountain National Park. She has also begun a new area of research: How do animals communicate with each other without letting predators know where they are? She and several of her graduate students have discovered that prey animals, such as the *coati* (similar to a raccoon; with a longer body and tail, and a long, flexible snout) and the flying squirrel, communicate with each other using ultrasound. Jennifer looks forward to asking many more questions about animal behavior, and discovering their answers, as her career continues!

SUGGESTIONS FOR TEACHERS

ACTIVITY #1: Observing Fruit Flies
ACTIVITY #2: Observing Siamese Fighting Fish

Purpose

To learn about two types of behavior in animals, *agonistic behavior* and *reproductive behavior,* and to design and carry out an experiment to determine the sign stimulus for a particular behavior.

Objectives

1) To define and give examples of ethology, ethnogram, agonistic behavior, reproductive behavior, and sign stimulus.
2) To interpret the results of experiments on animal behaviors.
3) To explain the adaptive advantage of animal behaviors.
4) To design and critique an experiment to determine the sign stimulus of an animal behavior.

Materials

Activity #1 — for each pair of students

- dissecting microscope
- vials with 2-3 virgin female *Drosophila melanogaster* flies (wild type)
- vials with 2-3 male *Drosophila melanogaster* flies (wild type)

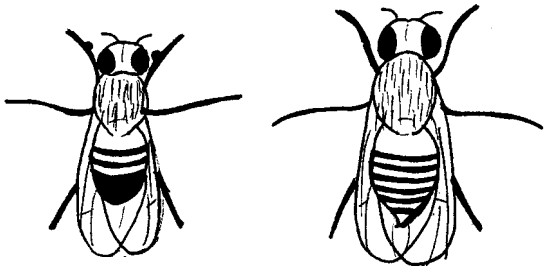
Activity #2 — for each team

- 1 male Siamese fighting fish (*Betta splendens*) in a flat-sided fish bowl
- mirror
- paper
- scissors
- colored markers

Before You Begin

Activity #1

1) Collect virgin female fruit flies, and separate male and female flies. The easiest way to do this is to remove all the adult flies from a vial with larvae and pupae. Male fruit flies are not sexually mature until about 10-12 hours after emerging from the pupal case. Females that hatch and are collected during this period should be virgin.
   NOTE: Male and female fruit flies can be distinguished by the shape and coloration of their abdomens, as well as by the presence or absence of sex combs on the front legs. Males have rounded, solid black abdomens, while females have pointed abdomens with alternating light and dark bands. However, newly emerged flies of both sexes tend to have elongated abdomens and light coloration. Males have sex combs, a thick tuft of dark hairs about one-third of the way up the front legs. This is the most reliable way to sex young flies.



MALE FEMALE

2) Place two or three virgin female flies and two or three male flies in separate, labeled vials for each student pair.
3) Students will also need access to a dissecting microscope.
4) The behaviors your students may observe include the following:
   - From males: wing vibrations (rapid movements up and down); waving (wings extended and slowly relaxed), forelegs extended to tap female; licking female's genitalia; circling female; stamping forelegs without touching female.
   - From females: extruding a tubelike structure from abdomen; nonreceptive females may run, jump, or fly from male, depress wings and curl the tip of the abdomen down, or ignore the male.

Activity #2

1) Male Siamese fighting fish, or *Bettas*, are available at most pet stores for $3.00 to $5.00 each. Many stores will buy the fish

back from you when you are finished with them; check with your pet store. You will need one fish for each student team.
2) Fish should be placed in separate fish bowls or aquaria, since their behaviors toward other males are so aggressive that they will fight until only one fish remains.
3) The fish bowls must be flat-sided so that the *Bettas*' reflections are not distorted.
4) Follow the advice of the pet store for feeding the fish and for transferring them to your aquaria after purchasing them.
5) Each student team also needs a mirror, paper, colored markers, and a pair of scissors.
6) After the students determine that their *Betta* will exhibit agonistic behaviors to the paper model, encourage them to try to elicit those behaviors using just a portion of the paper model by cutting off certain fins, etc. They may also want to try different shapes of the same color or different colors.

Safety Considerations

Activity #1

- Ensure that students know the appropriate use of the microscope.

Activity #2

- Stress that the *Bettas* are to be kept in separate fish bowls!

Questions to Ask

Activity #1

- What behaviors did you observe that you think are mating behaviors? Why do you think they are mating behaviors rather than eating or other behaviors?
- What are the adaptive advantages of the fruit flies' mating behaviors?
- Do you think the males would be able to mate successfully if they didn't exhibit the mating behaviors? Why/why not?
- Do you think the fruit flies' behaviors are affected by their genotypes, that is, by their genetic makeup? Why/why not?

Activity #2

- What might be the advantage of agonistic (combative) behaviors for *Bettas*? In what way(s) do they make the fish better adapted to their environment?
- If you repeated this experiment with the same fish, do you think you would see the same behaviors?
- If you did this experiment with another male *Betta* fish, do you think it would exhibit exactly the same agonistic behaviors you observed with your fish? Why/why not?
- What is the overall effect of the agonistic behaviors on the *Betta's* appearance?
- Do *Bettas* react to color or to shape (or both) with agonistic behaviors?
- What is the advantage of recognizing and quickly reacting to the sign stimulus (rather than an actual fish)?

Where to Go From Here

- Ask students to design additional experiments using fruit flies, Siamese fighting fish, or other organisms to test their hypotheses about animal behavior.
- Assign students to observe robins as they forage for food in their yards or in a park. Have them keep a record of the path traveled by the robins: How often/when do they turn? How often/when do they continue on a straight path? Ask students to prepare a written report of their findings.
- Assign students to read and write a report about ethologist Jane Goodall (see "References and Resources" section).
- Assign students to read and report on the studies of Mark and Delia Owens, who wrote *The Cry of the Kalahari* and *The Eye of the Elephant* (see "References and Resources" section).
- Take a field trip to the zoo. Each student team should closely observe the behavior of one animal species and use their observation data to prepare an ethnogram. Later, have students prepare a poster to display their findings to the rest of the class.
- Invite a zoologist from a local university or zoo to class to describe his/her research. Make a special effort to invite a female and/or minority zoologist.

Ideas for Assessment

- Tell students that you will ask them to hand in a lab report for their experiments. Request that they give their questions and

hypothesis, experimental plan (in steps), recorded observations, and conclusion. Score or grade these based on completeness and soundness of interpretations.

- Ask students to define and give examples of the following: ethology, agonistic behavior, reproductive behavior, and signal stimuli.
- Give your students the research results on the following page, "Food Solicitation Response in Herring Chicks," to analyze.

References and Resources

✓*About animal behavior:*

Alcock, J. (1983). *Animal Behavior: An Evolutionary Approach* (3rd ed.). Stamford, CT: Sinauer.

Barash, D. P. (1982). *Sociobiology and Behavior* (2nd Ed.). New York: Elsevier.

Bond, C. E. (1979). *Biology of Fishes*. Philadelphia, PA: W. B. Saunders.

Clarke, J. A., & Johnson, R. E. (1990). Biogeography of white-tailed ptarmigan *(Lagopus leucurus)*: Implications from an introduced population in the Sierra Nevada. *Journal of Biogeography, 17*, p. 649-656.

Eibl-Eibesfeldt, I. (December, 1961). The fighting behavior of animals. *Scientific American*, p. 112.

Gould, J. L. (1982). *Ethology*. New York: W. W. Norton.

Hall, J. C. (1994). The mating of a fly. *Science, 264*, p. 1702-1714.

Lorenz, K. Z. (1942). *King Solomon's Ring.* London: Methuen.

MacNichol, E. F., & Levine, J. S. (February 1982). Color vision in fishes. *Scientific American*, p. 108.

Manning, A. (1979). *An Introduction to Animal Behavior.* New York: Addison-Wesley.

Marler, P., & Stokes, A. W. (eds.). (1968). Mating behavior of *Drosophila*. In *Animal Behavior in Laboratory and Field.* San Francisco, CA: Freeman.

Morris, D. (1967). *The Naked Ape.* New York: McGraw-Hill.

Pool, R. (1995). Putting game theory to the test. *Science, 267,* p.1591-1593.

Sheller, R. H., & Axel, R. (March, 1984). How genes control an innate behavior. *Scientific American,* p. 54.

Simpson, M. J. A. (1968). The threat display of the Siamese fighting fish, *Betta splendens*. *Animal Behavior Monograph, 1*, p. 1.

✓*About ethologists:*

Goodall, J. (1967). *My Friends, The Wild Chimpanzees.* Washington, DC: National Geographic Society.

Goodall, J. (1990). *Through a Window: My Thirty Years With the Chimpanzees of Gombe.* Boston, MA: Houghton Mifflin.

Montgomery, S. (1991) *Walking With the Great Apes: Jane Goodall, Dian Fossey, Birute Galdikos.* Boston, MA: Houghton Mifflin.

Owens, M., & Owens, D. (1984). *The Cry of the Kalahari.* Boston, MA: Houghton Mifflin.

Owens, M., & Owens, D. (1992). *The Eye of the Elephant: An Epic Adventure in the African Wilderness*. Boston, MA: Houghton Mifflin.

✓*For laboratory exercises in animal behavior:*

Morgan, J. G., & Carter, M. E. B. (1993). *Investigating Biology.* Redwood City, CA: Benjamin/Cummings Publishing.

Eberhard, C. (1987). *Biology Laboratory: A Manual to Accompany Biology.* Philadelphia, PA: W. B. Saunders College Publishing.

Kull, R. C., Jr. (1989). *Lab Manual to Accompany the Nature of Life.* New York: Random House.

Gunstream, S. E. (1993). *Explorations in Basic Biology*. New York: Macmillan Publishing.

✓*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.

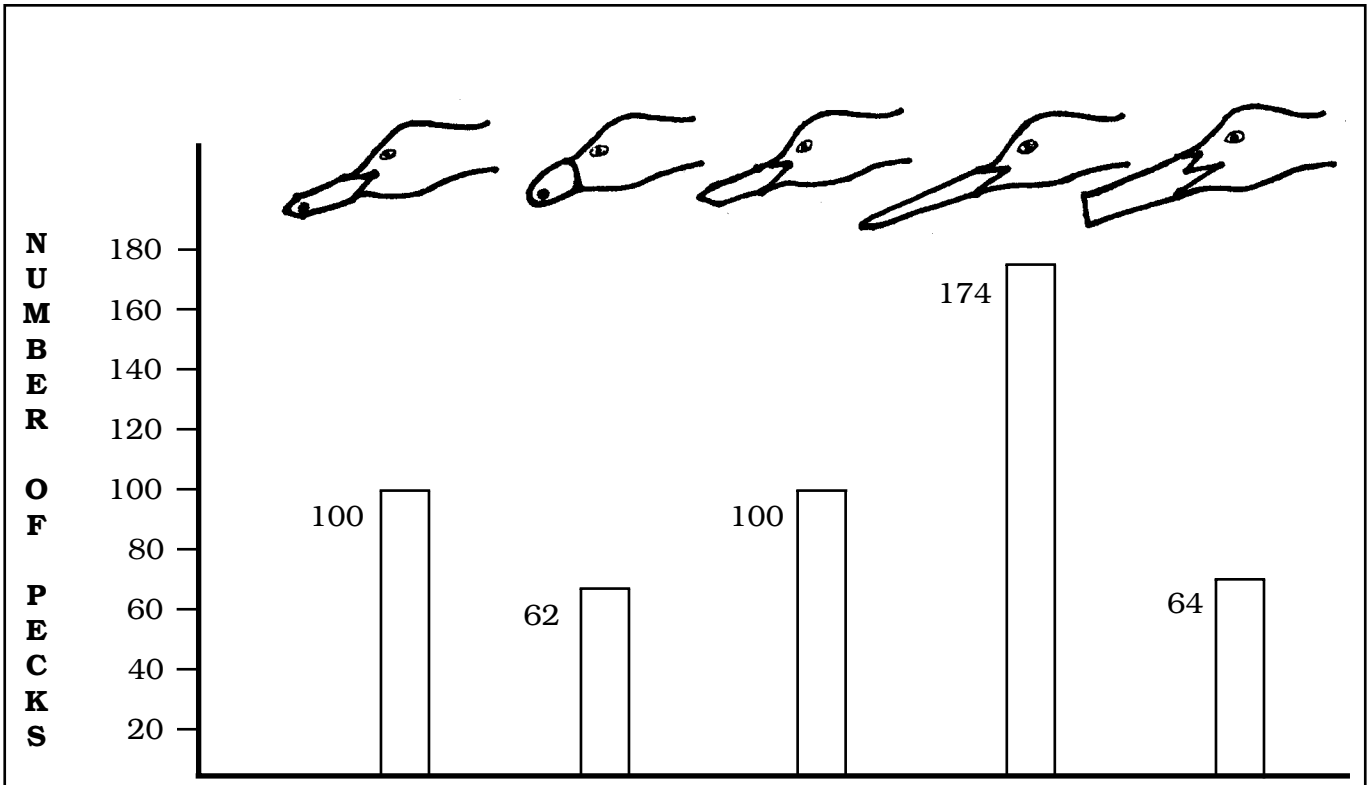
Flinn Scientific, P.O. Box 219, Batavia, IL 60510, (630) 761-8518.

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

✓*Photo credit:*

Photo on page 125 courtesy of Jennifer Clarke, University of Northern Colorado, Greeley, CO.

The Food Solicitation Response in Herring Chicks



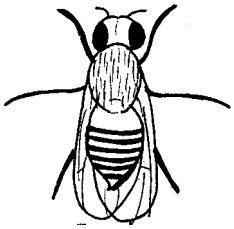
Niko Tinbergen and A. C. Perdeck studied interactions between herring gulls and their chicks during feeding. They noted that the adult gulls have a red dot at the end of their beaks. When gulls return to the nests, the chicks peck at this red dot and this stimulates the adults to regurgitate food for the chicks. Tinbergen and Perdeck wondered what the sign stimulus for this behavior was. They designed an experiment in which they constructed paper models of gull heads and bills of various shapes and colors, with and without red dots. They placed these paper models with the chicks and scored the number of pecks the chicks made at the models over a standard time period. The graph above shows some of their results.

On the basis of this data, what do you think is the sign stimulus (stimuli)? Justify your answer.

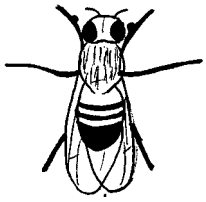
(Adapted from Purves, W. K., Orians, G. H., & Heller, H. C. (1992). *Life: The Science of Biology*. Salt Lake City, UT: W. H. Freeman, p. 986-987.)

Activity #1: Observing Fruit Flies

Part 1: Charting Behavior



Female



Male

Your Mission

Ethologists are biologists who study behaviors in animals and the evolution of those behaviors. For example, they study *mating* (reproductive) behaviors, *foraging* (eating) behaviors, or *agonistic* behaviors (behaviors animals exhibit when they are in conflict). They do this by making careful, detailed observations and designing experiments to test their hypotheses about animal behaviors. An *ethnogram* is a chart that lists all the behaviors observed in categories.

In this activity you will work in pairs (**Partner A** and **Partner B**) to study the behaviors of fruit flies.

The categories in your ethnogram on fruit flies may include "Feeding Behaviors," "Grooming Behaviors," and "Captive Behaviors." Based on your observations, you may have additional behavioral categories. Discuss your findings with each other and come to a consensus on the categories you will use for your ethnogram and the best assignment of behaviors to those categories.

Procedure

1. Set up a dissecting microscope and collect one vial each of female and male fruit flies from your teacher.

2. Place one of the vials of female flies underneath the microscope. **Partner A** will observe and describe closely the behaviors shown by the female flies. **Partner B** will write down the behaviors as **Partner A** observes and describes them. Be sure to write "Female Flies" at the top of the page.

3. After 5 minutes of observations, switch roles and repeat *step 2* with the vial of male flies.

4. Use your observation data to prepare an ethnogram for the fruit flies.

5. Turn in and/or compare your ethnograms with those of the other students in the class.





Part 2: How Many Different Mating Behaviors Do You See?

Your Mission

Fruit flies (*Drosophila melanogaster*) exhibit at least 14 different mating behaviors. There are different behaviors for male and female flies.

In this part of the activity, you will place male and female fruit flies together and see how many different mating behaviors you can observe.

Procedure

1. You will observe the flies twice, for 5 minutes each time. **Partner A** should observe the flies and report the behaviors. **Partner B** should record and time the behaviors (i.e., how long did the male fly circle the female fly, etc.). Sketches may help to describe the behavior (the observer may have to do this after the observation period). Switch roles for the second observation period.

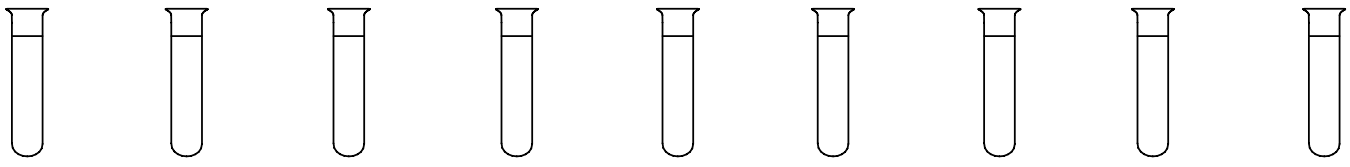
2. To place the virgin females in the vial with the males, gently tap the vial with the male flies to knock them to the bottom and uncap the vial. Then quickly uncap the vial with the female flies and place it over the mouth of the males' vial. Now, gently tap the female flies into the vial and recap it.

3. Place the vial under the microscope. Observe and record the behaviors for 5 minutes.

4. Switch roles and repeat *step 3*.

5. Write a detailed paragraph describing the overall mating behaviors exhibited by the fruit flies. Was there a particular sequence to the behaviors? Were the females receptive or nonreceptive to the males? What are examples of receptive and nonreceptive behaviors by the females?

6. Turn in and/or compare your findings with others in the class.



Activity #2: Observing Siamese Fighting Fish

Part 1: Aggressive vs. Submissive Behavior

Your Mission

When a male Siamese fighting fish (*Betta splendens*) sees another male *Betta*, he begins a ritual of responses toward the "intruder." In fact, even the sight of his own reflection in a mirror will stimulate those behaviors. These are called *agonistic behaviors*, and they may be aggressive or submissive. They are thought to help the dominant organism keep greater access to food, space, or mates.

Working in teams of two to four, in this experiment you will determine the specific agonistic behaviors exhibited by *Bettas* when they are placed in a (supposedly) threatening situation.

Note: The agonistic behaviors of *Bettas* are so aggressive that, if two males are placed in the same aquarium, they will fight until only one fish is left alive. For that reason, you must avoid placing more than one fish in the same fishbowl.

Procedure

1. Examine your *Betta* fish carefully. Be sure you can identify the *dorsal fin* (on the top of the fish), the *ventral fin* (on the underside of the fish), the *pectoral fin* (smaller fin nearest the head on the underside of the fish), the *gill cover*, and the *tail*.

2. Observe the behavior of the fish for 5 minutes. Note and record the position, size, and color of the various fins and the swimming behavior of the fish.

3. Predict the behavior(s) you expect to observe when your fish sees its reflection. Write your predictions down.

4. Have pencil and paper ready for each team member to record observations; when every team member is ready, place the mirror against the fishbowl.

5. As you observe, list, in order, the behaviors exhibited by your fish.

6. After 5 minutes of observation, remove the mirror and compare notes with your team members.

7. Use your data to complete the tables on the following page.

8. As a team, write a detailed paragraph describing the agonistic behaviors displayed by your *Betta*.

Prediction

Predict what your *Betta* will do when he sees his reflection:

Table 1 — Sequential Behaviors

List, in order, responses
that occurred one after the other:

Table 2 — Simultaneous Behaviors

List responses that
occurred at the same time:





Part 2: What Will Cause a Response in Siamese Fighting Fish?

Your Mission

As you have already noted, male Siamese fighting fish do not require the presence of a real fish to respond with agonistic behaviors — they respond to simple reflections of themselves. Would they also respond to paper models of *Betta* fish? Do they need to see the whole fish to respond? In this part of the activity, you will design an experiment to answer these questions.

Note: The specific stimulus, or stimuli, needed to elicit a particular behavior is called the *sign stimulus*. Konrad Lorenz was one of the first to recognize that a stimulus quite different from the usual one could cause the same behavior pattern in animals. One day on a beach surrounded by jackdaw birds, Lorenz decided to go for a swim. When baby jackdaw birds are attacked by a predator, a flock of adults will mob the attacker. When Lorenz removed his black swim trunks from his pack and shook them out, the jackdaws mobbed him! He discovered that the sign stimulus for this behavior was anything black and flapping.

Procedure

1. First, draw a picture of your Siamese fighting fish and color it appropriately with the markers. Cut out the fish you have drawn.

2. Hold your model beside the fish bowl. Does your *Betta* fish respond with agonistic behaviors?

3. As a team, discuss what you think was the most important part of the paper model your *Betta* saw, in terms of causing it to exhibit agonistic behaviors. Based on your discussion, write down one or more hypotheses about the most important characteristic which causes those behaviors.

4. Next, design an experiment to test your hypothesis, using the paper model. Write out the steps of your experiment to hand in to your teacher.

5. Carry out your experiment. Make and record your observations as before.

6. What is the sign stimulus for Siamese fighting fish? What conclusions can you draw from the results of your experiment? Viewing what part(s) of the *Betta* elicits, or causes, agonistic behaviors?