

SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

This project was funded in part by the National Science Foundation. Opinions expressed are those of the authors and not necessarily those of the Foundation. The SS&C Project encourages reproduction of these materials for distribution in the classroom. For permission for any other use, please contact SS&C, National Science Teachers Association, 1840 Wilson Blvd., Arlington, VA 22201-3000.

Copyright 1996 National Science Teachers Association.





SCOPE, SEQUENCE, and COORDINATION

SS&C Research and Development Center

Bill G. Aldridge, *Principal Investigator
and Project Director**
Dorothy L. Gabel, *Co-Principal Investigator*
Erma M. Anderson, *Associate Project Director*
Stephen Druger, *Project Associate for
Micro-Unit Development*
Nancy Erwin, *Project Editor*
Rick McGolerick, *Project Coordinator*

Evaluation Center

Frances Lawrenz, *Center Director*
Doug Huffman, *Associate Director*
Wayne Welch, *Consultant*
University of Minnesota, 612.625.2046

Houston SS&C Materials Development and Coordination Center

Linda W. Crow, *Center Director*
Godrej H. Sethna, *School Coordinator*
Martha S. Young, *Senior Production Editor*
Yerga Keflemariam, *Administrative Assistant*
Baylor College of Medicine, 713.798.6880

Houston School Sites and Lead Teachers

Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Goldsbury
Jack Yates H.S., Diane Schranck

California Coordination Center

Tom Hinojosa, *Center Coordinator*
Santa Clara, Calif., 408.244.3080

California School Sites and Lead Teachers

Sherman Indian H.S., Mary Yarger
Sacramento H.S., Brian Jacobs

Iowa Coordination Center

Robert Yager, *Center Director*
Keith Lippincott, *School Coordinator*
University of Iowa, 319.335.1189

Iowa School Sites and Lead Teachers

Pleasant Valley H.S., William Roberts
North Scott H.S., Mike Brown

North Carolina Coordination Center

Charles Coble, *Center Co-Director*
Jessie Jones, *School Coordinator*
East Carolina University, 919.328.6172

North Carolina School Sites and Lead Teachers

Tarboro H.S., Ernestine Smith
Northside H.S., Glenda Burrus

Puerto Rico Coordination Center**

Manuel Gomez, *Center Co-Director*
Acenet Bernacet, *Center Co-Director*
University of Puerto Rico, 809.765.5170

Puerto Rico School Site

UPR Lab H.S.

* * * * *

Pilot Sites

Site Coordinator and Lead Teacher
Fox Lane H.S., New York, Arthur Eisenkraft
Georgetown Day School, Washington, D.C.,
William George
Flathead H.S., Montana, Gary Freebury
Clinton H.S., New York, John Laffan**

Advisory Board

Dr. Rodney L. Doran (Chairperson),
University of Buffalo

Dr. Albert V. Baez, Vivamos Mejor/USA

Dr. Shirley M. Malcom, American Association
for the Advancement of Science

Dr. Shirley M. McBay, Quality Education for Minorities

Dr. Paul Saltman, University of California, San Diego

Dr. Kendall N. Starkweather, International
Technology Education Association

Dr. Kathryn Sullivan, Ohio Center of
Science and Industry

* Western NSTA Office, 894 Discovery Court, Henderson, Nevada 89014, 702.436.6685

** Not part of the NSF-funded SS&C project.

National Science Education Standard—Life Science The Nervous System and the Behavior of Organisms

Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses can be either innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

Multicellular animals have nervous systems to generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.

Like other aspects of an organism's biology, behaviors have evolved through natural selection. Behaviors often have an adaptive logic when viewed in terms of evolutionary principles.

Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology.

Teacher Materials

Learning Sequence Item:

912

Animal Behavior

September 1996

Adapted by: Lucy Daniel

Organisms, Stimuli, Receptors, Nervous Systems, Responses, and Behavior. Students should examine types of behavioral responses found in the animal world and common behavioral responses that occur in humans. They can measure the strength of various stimuli needed to perceive changes (pressure, light intensity, sound intensity, concentration of lemon juice in water solution) (*Biology, A Framework for High School Science Education, p. 125*).

Contents

Matrix

Suggested Sequence of Events

Lab Activities

1. Acting on Impulse
2. To Squirm Like a Worm
3. Let Me Enlighten You
4. Fast Fingers

Assessments

1. Planaria Training
2. Stimulus-Response One
3. Stimulus-Response Two

912

Learning Sequence

Organisms, Stimuli, Receptors, Nervous Systems, Responses, and Behavior. Students should examine types of behavioral responses found in the animal world and common behavioral responses that occur in humans. They can measure the strength of various stimuli needed to perceive changes (pressure, light intensity, sound intensity, concentration of lemon juice in water solution) (*Biology, A Framework for High School Science Education, p. 125*).

| Science as Inquiry | Science and Technology | Science in Personal and Social Perspectives | History and Nature of Science |
|---|--|--|--|
| <p>Acting on Impulse Activity 1</p> <p>To Squirm Like a Worm Activity 2</p> <p>Let Me Enlighten You Activity 3</p> <p>Fast Fingers Activity 4</p> <p>Stimulus-Response One Assessment 2</p> <p>Stimulus-Response Two Assessment 3</p> | <p>Find That Sound! Reading 2</p> | <p>Seeing in the Dark Reading 1</p> | <p>Planaria Training Assessment 1</p> <p>Stimulus-Response One Assessment 2</p> <p>Stimulus-Response Two Assessment 3</p> |

Suggested Sequence of Events

Event #1

Lab Activity

1. Acting on Impulse (40 minutes)

Alternative or Additional Activity

2. To Squirm Like a Worm (30 minutes)

Event #2

Lab Activity

3. Let Me Enlighten You (30 minutes)

Additional Activity

4. Fast Fingers (30 minutes)

Event #3

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

The following readings are included in the student version of the unit:

Reading 1 Seeing in the Dark

Reading 2 Find That Sound!

Suggested additional readings:

Miller, M.K., "Animal Voices." *Exploring Magazine*, Vol. 18, No. 1, Spring 1994, pp. 8–9.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.
2. Open-ended questions asking for essay responses.
3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

Acting on Impulse**How does a planarian respond to environmental stimuli?****Overview:**

Planaria can actually be trained to move through a maze, and their natural behaviors help in this training process. In this activity students investigate these behaviors. Planarian behaviors serve as an introduction to simple behavioral responses to specific stimuli (gravity and light) commonly found in many animals.

Materials:**Per lab group:**

planarian
water from aquarium, ~50 mL
test tube with stopper (13 × 100 mm)
test tube rack
aluminum foil (12 cm × 12 cm)
dropper
marking crayon
white paper
clock

Procedure:

Have students use the dropper to remove one planarian from the culture and place it in a test tube. They then add aquarium water to the test tube until it is nearly full and insert the stopper. Have them draw a line at the middle of the test tube and hold the test tube horizontally until the planarian has moved to the center of the tube. They then place the test tube “stopper-end up” in the test tube rack and observe the planarian for 10 minutes, recording how much time the planarian spends in each half of the test tube.

Students should then hold the test tube horizontally until the planarian has again moved to the center of the tube. They then place the test tube “stopper-end down” in the rack, observing the planarian for another 10 minutes and recording how much time it spends at each end of the tube.

After the planarian has again been allowed to return to the middle of the tube, students lay the tube on a sheet of white paper and make the same observations for another 10 minutes.

Finally, after the planarian has returned to the middle of the test tube, students place an aluminum foil square over the rounded end of the tube and again observe the planarian for 10 minutes.

Background:

Planarians are common, free-living flatworms that live in fresh water and are representative of the phylum Platyhelminths. They are not parasitic and are well-suited to laboratory study by students. Living specimens may be either purchased from supply houses or collected in freshwater streams, ponds, and lakes. Several varieties may be found in clear running water, but the usual forms are the small (from several millimeters up to half an inch), blackish *Planaria maculata* and the more frequent laboratory form, the brown *Dugesia tigrina*. A third form is *Planaria dorotocephalia*.

You can look for planaria on the underside of logs and under stones in ponds and lakes. If you find some in a submerged log, wrap the whole log in wet newspaper and bring it back to the lab. While submerged in fresh water, peel off sections of wood to reveal the planaria, which will usually float to the surface. An alternate method of collection is to use bait, such as pieces of raw beef liver or hard-boiled egg yolk, tied in cheesecloth. Attach the bait to a string and place it in a cold stream or lake. Brush off the gathered forms into collecting jars. Planarians in collecting jars may be gathered by picking them off the sides of the jars or plant material with a pipette.

Planarians in the lab should be maintained in black or opaque containers because they are photonegative, i.e., they move away from a light source. They thrive best when kept in shallow, darkened jars of pond water containing some small stones under which they can hide. Water should be changed frequently. Keep the temperature about 18 °C (64 °F). Feed them once a week. They will eat finely chopped raw beef liver, bits of worms, or bits of hard-boiled egg yolks. Remove excess food with a pipette after several hours to avoid fouling the water.

Figure 1. Size range of planarians: 3–12 mm.

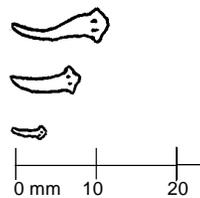


Figure 2. Diagram of the nervous system of planaria.

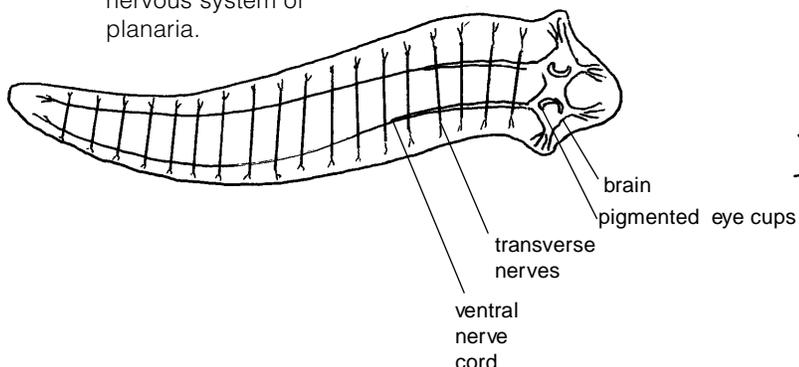
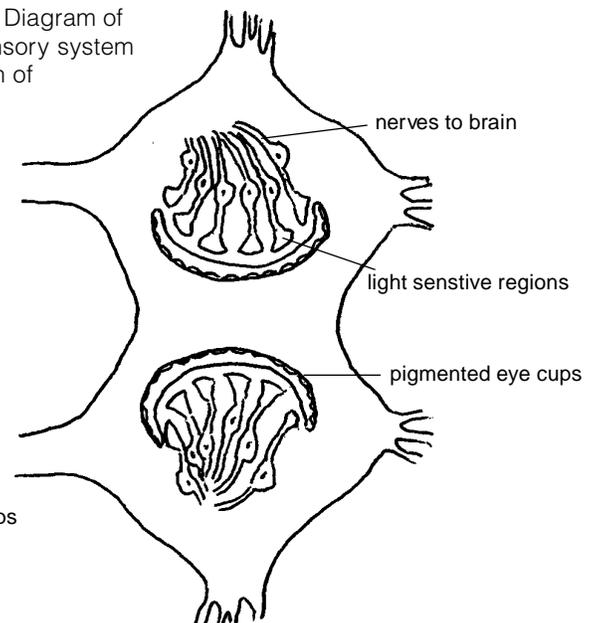


Figure 3. Diagram of photosensory system and brain of planaria.



When you study planaria, you will note how they glide smoothly through the water due to the action of cilia on their ventral surface. They can also crawl by means of strong body-muscle contractions. Darkly pigmented eyespots that allow planarians to react to light are easily found on the dorsal surface of the head. Also note the two ear-like regions that are tactile receptors. Two masses of nerve cell ganglia are located in the head and continue as two strands of nerve fibers posteriorly along the body.

Planarians do not “see” as most students understand it. They obtain directional information about light from photosensitive cells organized into eye cups. The eye cups are bilateral structures, and each is partially shielded from light by a layer of pigmented cells lining the cup. Since the openings of the eye cups face in opposite directions, the photoreceptors on the two side of the animal are unequally stimulated unless the animal is facing directly toward or away from a light source. The planarian uses directional information about light sources to move away from light. In addition, it shows a positive response to gravity—geotropism—and moves toward the bottom when its container is turned upside down. The advantage of these behaviors in planaria is that they will keep them on the rocks or plants at the bottom of a stream where it will be more difficult for predators to find them.

Variations:

Planarians can be taught to move through a maze. Have students design a small water maze and see if they can train their own planarian to negotiate the turns.

You may wish to challenge students to design an experiment to investigate planarian responses to various intensities of light. They could try to determine a minimum intensity that will elicit a negative response.

Adapted from:

Morholt, E., and P. Brandewein, *A Sourcebook for the Biological Sciences*, San Diego, Calif.: Harcourt Brace Jovanovich, 1986.

Purves, W.K., G.H. Orians, and H.C. Heller, *Life, The Science of Biology*. Sunderland, Mass.: Sinauer Associates, Inc., 1992.

alternative/extension activity for Event 1

Teacher Sheet

Science as Inquiry

To Squirm Like a Worm

How do earthworms respond to stimuli?

Overview:

This activity can be done as an alternative to Activity 1, as an introduction to simple behavioral responses to specific stimuli. Students observe, time, and record the behavior of earthworms. Instruct students to keep their hands wet while working with the earthworms and to wash their hands when they have finished.

Materials:

Per lab group:

earthworms (live), 3
cotton swabs, 2
aluminum pie pan, 8–10 inches in diameter
cardboard, 8" × 11" (to cover 1/2 of pie pan)
scissors
sand (moistened), ~750–1000 mL
flashlight
lamp (100-watt bulb)
clock or stopwatch
lemon juice, 25 mL
lemon juice and water solution (equal parts), 25 mL
water to moisten hands, 1 beaker (~250 mL)

Procedure:

Have students add moist sand to the pie pan until it is about 2/3 full, then cut a piece of cardboard to cover half of the pan. They should position three earthworms on top of the sand, with the anterior (front) ends of the worms facing in the same direction. They then cover the pan, placing the cardboard over the posterior (back) ends of the earthworms and leaving the anterior ends exposed. Have them record their observations.

Students then remove the cover and reposition the earthworms in the pan as before. However, this time they should cover the anterior (front) ends, leaving the posterior ends exposed. They again record their observations.

Have students repeat this process of positioning and covering the worms (first the posterior, then anterior), except this time they should shine a flashlight on the pan once the pan has been covered. They again observe, time, and record the behavior of the worms. Have students repeat the process once more, this time replacing the flashlight with the 100-watt lamp and recording their observations.

Finally, have students remove the cover from the pan and return two of the earthworms to the instructor's storage area. They then place their remaining earthworm in the center of the pan. Using the

cotton swab, they draw a line with the lemon juice and water solution in front of the anterior end of the earthworm and observe and record its behavior. Next they draw a line with the solution in front of the posterior end of the earthworm and record its behavior.

Have students repeat the process using the straight lemon juice. Remind them to wash their hands when they have finished the activity.

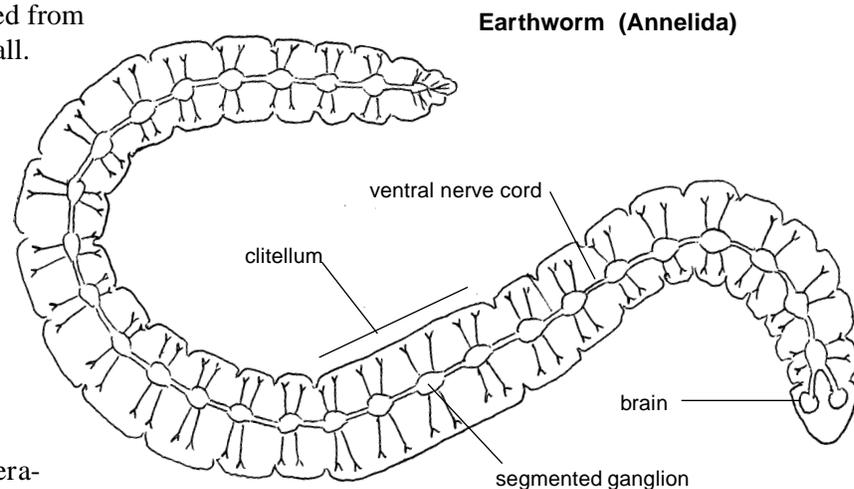
Background:

The earthworm (*Lumbricus*) is of the phylum Annelida, or segmented worm, of the class Oligochaeta. Earthworms have no eyes and relatively few setae (pairs of bristles that aid in locomotion). They are scavengers and ingestors of soil, from which they extract food particles.

The front (or anterior) end of the earthworm is pointed. This helps it move through the soil. The surface of the earthworm must remain moist to allow for the diffusion of oxygen and carbon dioxide during respiration. This is why students must keep their hand wet when handling the worms.

Earthworms react to the stimuli of light and chemicals and usually will move away from strong stimuli more quickly. The anterior and posterior ends respond differently to light. The anterior part is light sensitive and moves toward darkness, while the posterior end usually does not respond to light. This response to light and chemicals is helpful in preserving the species. Earthworms remain in the ground during the day to avoid the light. They come to the surface at night when there are fewer predators to see them—and when they also will not dehydrate. Sensitivity to chemicals helps earthworms avoid chemicals in the soil.

Earthworms are readily collected from the soil from late spring to early fall. Night is the best time, or after a good rain when they come to the surface. Collected worms can be kept in wooden containers, such as cigar boxes, or in specially designed plastic enclosures. Place two to six inches of moist rich soil or peat moss (sphagnum moss) in the boxes and lightly dampen the soil. Keep the animals covered and in a cool place (temperature about 15 °C [59 °F]). Feed them lettuce and bread soaked in milk, buried in the soil, about twice a week.



Variations:

As a variation students could test the reaction of earthworms to differences in temperature. Have them place the earthworms on moist paper towels in the pan and cover the pan with clear plastic wrap. They then place some ice cubes at one end of the pan and observe the reactions of the earthworms.

Adapted from:

Morholt, E., and P. Brandewein, *A Sourcebook for the Biological Sciences*. San Diego, Calif.: Harcourt Brace Jovanovich, 1986.

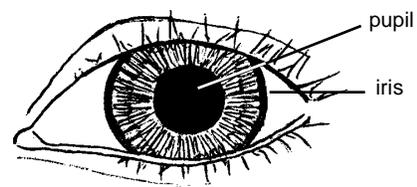
Purves, W.K., G.H. Orians, and H.C. Heller, *Life, The Science of Biology*. Sunderland, Mass.: Sinauer Associates, Inc., 1992.

Science as Inquiry

Let Me Enlighten You**How does light intensity affect the eye?****Overview:**

In this activity students investigate the pupils of their eyes and their pupils' reaction to light. The pupil is the dark opening in the center of the colored part of the eye (the iris).

At this point, students have observed behavioral responses to specific stimuli (i.e., light) in simple organisms. This activity introduces them to a human example, also based on light but with some differences. Planarians and earthworms respond to light with gross movements that result in locomotion away from the light source. In terms of an explanation, these broad patterns of behavior exhibited by animals ensure survival and reproductive success. The human response to a light stimulus may appear to be a much simpler situation without such significant consequences at stake. However, it should be pointed out to students that at this level of study, we are interested in noting and describing a variety of behavioral responses, the connection being that they are all neurally based. The simple point remains that all organisms have behavioral responses to internal and external stimuli.

**Materials:****Per lab group:**

flashlight (small)

clock with second hand

Procedure:

Students work in pairs. The first student closes his eyes for 10 seconds. As soon as he opens his eyes, the second student carefully observes what happens to the size of his pupils and records her observations.

The first student again closes both eyes for 10 seconds, at the same time holding his hand (or a card) vertically along the side of his nose, so that a light striking the left eye will not strike the right eye. After he opens his eyes, the second student shines the flashlight into his left eye and records her observations. They repeat this procedure with the right eye.

The two students now repeat the above procedures, but this time the first student concentrates on trying to control the reaction of his pupils. The second student records her observations.

The partners should now switch roles and repeat the entire process, so that the first student observes what happens to the second person's pupils and records this information.

Background:

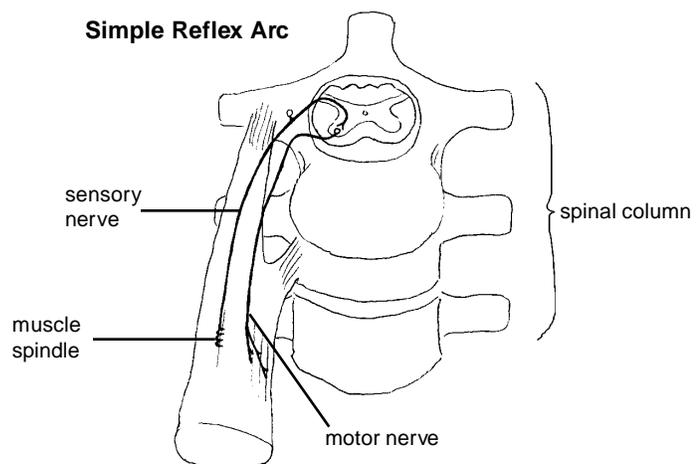
A full explanation of the mechanism involved in this phenomenon is beyond the scope of the ninth-grade sequence, but it is important that an initial explanation be considered. One possible explanation might be that in animals with binocular vision a single brain center is responding to light stimuli from both eyes. Apparently the light stimulus from the uncovered eye results in a single motor stimulus to both eyes.

In the tenth-grade sequence, students will learn that this is an example of a reflex arc. The reflex arc is an example of extremely rapid response to change—a response that does not need the conscious participation of the brain. Through a sensory nerve, the nervous impulse reaches the spinal cord and/or lower brain and is switched to a motor nerve. The proper motor response results before the conscious brain has had time to react to the message. When the conscious brain is involved, the reaction may be noticeably slower.

Prior to or following Activity 3 students may begin to question the difference between a behavior and a reflex. Behavior can be defined in one sense as the way in which something reacts to the environment. A reflex is defined as an automatic or involuntary response to a stimulus, as described above. Another common example of a reflex arc mechanism is the case of a hand touching a hot iron and subsequently pulling away. The conscious brain senses the pain but is not the instigator of the movement. These "reflex behaviors" are common to all humans and, although not under conscious control, like all other behavior they are generated by the nervous system, formed from specialized cells that conduct signals rapidly through long cell extensions that make up nerves. The questions and issues about instinct, inherited behaviors, fixed action patterns, etc., will be considered later. There should be no evidence in this activity that pupil response can be consciously controlled. The response is to an external change—the change in light intensity.

Variations:

Students may test the knee jerk response of their fellow classmates, an example of another reflex arc. Using a rubber hammer or a straight-edge covered with padding, one student carefully taps the knee cap of another student's crossed leg. Caution them not to hit hard.



Science as Inquiry

Fast Hands**Can reaction time be measured?****Overview:**

This is an optional activity to follow Activity 3. It provides students with a simple way to observe and measure the functioning of their own nervous systems, involving both sensory and motor nerve pathways. It is a good example of how behavior patterns can be modified through practice.

Reaction time is the amount of time that passes between awareness of a stimulus and response to it. Students will measure reaction time by trying to grasp a falling ruler.

Materials:**Per lab group:**

metric ruler

Procedure:

Students work in groups of three. Have the first student hold the ruler between her thumb and index finger while the second student holds the ruler at the 1-cm end. The first student *must keep her eyes on the bottom of the ruler (her end)* as her partner releases the ruler. She then tries to catch the ruler. They should repeat this process, dropping the ruler nine times for a total of 10 trials. The third student records the distance the ruler has fallen for each trial.

Students should repeat the procedure (switching places) for the two other members of the group.

Background:

Reaction time varies according to age and sometimes gender. You probably will not be able to beat your students' reaction time. With practice, reaction time can be improved, unlike more automated responses such as pupil response. Certain careers require that individuals have quick reaction time. Pilots, for example, practice using simulations so they will react quickly to certain situations.

Variations:

Have students create other reaction time tasks and test other students.

History and Nature
of Science

Planaria Training

Item:

Several years ago, a scientist conducted an experiment in which planaria were trained to do certain tasks. The “trained” planaria were then ground up and fed to other planaria. A claim was made that the planaria that fed on “trained” planaria were able to learn to do assigned “tasks” in much less time, thus implying memory transfer.

Discuss what would be needed to find out, with certainty, if this claim is valid. See if you can find out about other claims regarding unusual influence on animal behavior, such as transfer of information via transplants of brain cells.

Answer:

Students should begin to realize that “certainty” means different things to scientists than to the general public. A scientist may be satisfied with just “not quite random” in terms of animal behavior. The focus on what it means to be “trained” may also be important in this regard.

Science as Inquiry/
History and Nature of Science

Stimulus-Response One

Item:

Design an investigation using an invertebrate organism like an isopod, protozoan, annelid, or snail to test one of the following behavior responses: chemotaxis, rheotaxis, heliotaxis, thigmotaxis. When your proposal has been approved, carry out the investigation and prepare a report on your findings. Include charts and graphs.

Answer:

The proposal should have controls, safety measures, and a method of collecting data, including a hypothesis of what behavior would be considered to be evidence of a response to the stimulus. Some rationale for using the organism chosen for investigation should also be given.

Provide the following definitions:

Chemotaxis: directional locomotion in response to a chemical stimulus.

Rheotaxis: directional locomotion in response to a current, usually water.

Heliotaxis: directional locomotion in response to sunlight.

Thigmotaxis: directional locomotion in response to a solid object stimulus coming into contact with the organism.

Science as Inquiry/
History and Nature of Science

Stimulus-Response Two

Item:

Design a plan to teach your pet to perform a new “trick.” Be careful to identify your expectations in a scientific way so that they can be measured as to whether they have been achieved (e.g., in what percentage of trials will the animal respond according to what criterion of “success”). Explain why you think your method will succeed.

Answer:

The response should include a way to ensure that the animal did not know how to perform the “trick” before training. The “trick” should be humane and within the realm of reality. Also included should be thorough data collection over a period of time to show development of the new behavior.

Students may conclude (correctly) that "tricks" based on natural behaviors are more easily learned.

| Consumables | | |
|--|-------------------------------|-----------------|
| Item | Quantity per lab group | Activity |
| aluminum foil (12 cm × 12 cm) | 1 piece | 1 |
| cardboard (~8" × 11") | 1 piece | 2* |
| cotton swabs | 2 | 2* |
| earthworms (live) | 3 | 2* |
| lemon juice | 25 mL | 2* |
| lemon juice/water solution (equal parts) | 25 mL | 2* |
| paper (white) | 1 piece | 1 |
| planarian | 1 | 1 |
| sand, moistened | — | 2* |
| water (to moisten hands) | 1 beaker (~250 mL) | 2* |
| water from aquarium | ~50 mL | 1 |

| Nonconsumables | | |
|--------------------------------------|-------------------------------|-----------------|
| Item | Quantity per lab group | Activity |
| aluminum pie pan (8–10" in diameter) | 1 | 2* |
| clock | 1 | 1, 3 |
| clock or stopwatch | 1 | 2* |
| dropper | 1 | 1 |
| flashlight | 1 | 2* |
| flashlight (small) | 1 | 3 |
| lamp (100-watt bulb) | 1 | 2* |
| marking crayon | 1 | 1 |
| metric ruler | 1 | 4* |
| scissors | 1 | 2* |
| test tube with stopper (13 × 100 mm) | 1 | 1 |
| test tube rack | 1 | 1 |

*denotes alternative or additional activity

Key to activities:

1. Acting on Impulse
2. To Squirm Like a Worm
3. Let Me Enlighten You
4. Fast Fingers

Activity Sources

- Morholt, E., and P. Brandewein, *A Sourcebook for the Biological Sciences*. San Diego, Calif.: Harcourt Brace Jovanovich, 1986.
- Purves, W.K., G.H. Orians, and H.C. Heller, *Life, The Science of Biology*. Sunderland, Mass.: Sinauer Associates, Inc., 1992.

Student Readings

- Garb, M., "Find That Sound!" *Exploring Magazine*, Vol. 17, No. 4, Winter 1993, pp. 16–18.
- Murphy, P., "Seeing in the Dark." *Exploring Magazine*, Vol. 17, No. 3, Fall 1993, pp. 8–13.