

SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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

National Science Education Standard—Life Science

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 organisms'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:

911

Neurons and the Nervous System

September 1996

Adapted by: Tom Hinojosa

Stimuli, Receptors, Nervous Systems, Responses, and Behavior. Students should observe the specialized structures of neurons and the nervous system of a simple animal (*Biology, A Framework for High School Science Education*, p. 124).

Contents

Matrix

Suggested Sequence of Events

Lab Activities

1. You're Making Me Nervous
2. You're Making Me Nervous, Again
3. Common Carriers
4. Cell Phones

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2. The Parts of the Whole
3. Getting Down to Basics
4. Consider an Alternate Plan

911

Learning Sequence

Stimuli, Receptors, Nervous Systems, Responses, and Behavior. Students should observe the specialized structures of neurons and the nervous system of a simple animal (*Biology, A Framework for High School Science Education, p. 124*).

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
<p>You're Making Me Nervous Activity 1</p> <p>You're Making Me Nervous, Again Activity 2</p> <p>Common Carriers Activity 3</p> <p>Cell Phones Activity 4</p> <p>Surveying the System Assessment 1</p> <p>The Parts of the Whole Assessment 2</p> <p>Getting Down to Basics Assessment 3</p> <p>Consider an Alternate Plan Assessment 4</p>			

Suggested Sequence of Events

Event #1

Lab Activity

1. You're Making Me Nervous (40 minutes)

Alternate or Additional Activities

2. You're Making Me Nervous, Again (40 minutes)
3. Common Carriers (30 minutes)

Event #2

Lab Activity

4. Cell Phones (30–40 minutes)

Event #3

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

Suggested readings:

Barinaga, M., "New Clue to Brain Wiring Mystery." *Science*, Vol. 270, October 27, 1995, p. 581.

Richardson, S., "A Nematode Like Us" (Biology Watch). *Discover Magazine*, December 1993, p. 43.

Thomas, J.H., "The Mind of a Worm." *Science*, Vol. 264, June 17, 1994, pp. 1698–1699.

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

You're Making Me Nervous**How do organisms move and respond to external stimuli?****Overview:**

Students begin with a basic study of the nervous system of a simple animal, the earthworm. The goal is familiarize them with the basic components of the nervous system and their anatomical locations through direct observation. They should be encouraged to consider the location and extent of the nervous system in relation to its key physiological functions, which will provide a basis for learning about the specialized structures of individual neurons in a later activity (Activity 4).

Remind students of the need to be careful with sharp objects and of what to do if they happen to cut themselves. All students should wash their hands after a dissection activity and give all dissection materials to you for proper disposal.

Materials:**Per lab group (two students):**

- dissecting needle or probe
- dissecting pan
- dissecting pins
- dissecting scissors
- earthworm (preserved)
- hand lens

Procedure:

Working in pairs, students perform a simple dissection of a preserved earthworm in order to find and expose as many aspects of the nervous system as possible. The quality of dissection work will vary widely depending upon the skill of the student and the quality and condition of the earthworm. You should visit each student group often to check on their progress. Use a laboratory assistant or another teacher if possible. By focusing on the nervous system, with minimal attention to other internal organs, most students should be successful in this activity.

Have students draw and label their findings, noting the location of the nervous system tissue in relation to other structures and tissues.

Background:

The earthworm is an invertebrate that has a segmented body and specialized body parts (Figure 1). Oxygen from the air moves directly into its body through its skin, while carbon dioxide, in like fashion, moves out of its body through its skin. The earthworm has a series of enlarged contractile tubes that serve as hearts, pumping blood through the blood vessels of the worm's body. Earthworms have well-developed nervous systems centered around a main nerve cord that extends along the ventral (bottom) side of the body (Figure 2). Many ganglia (clusters of nerve cell bodies) occur along the nerve cord. A

large ganglion, which may be referred to as the brain, is attached to the nerve cord at the front or anterior end of the body. Although earthworms have no obvious sense organs, they can detect many stimuli.

Students should be able to locate the ventral nerve cord. Extending the length of the body, it appears as a thin white line on the ventral body wall. They may note that this is quite different from the case in humans, in whom the spinal cord is located in the spinal column along the back, or dorsal, side of the body. The double nerve ganglion, or brain, is located near segment two at the anterior end of the worm's body.

Figure 1. Earthworm external appearance:

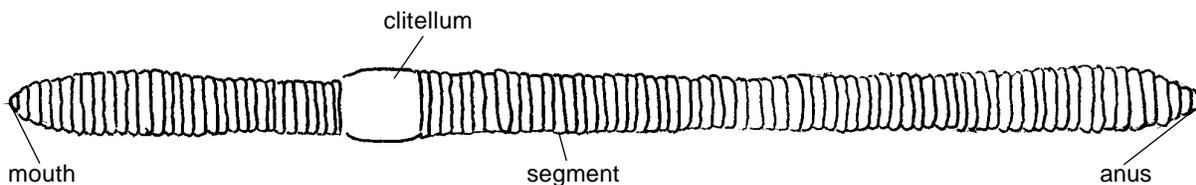
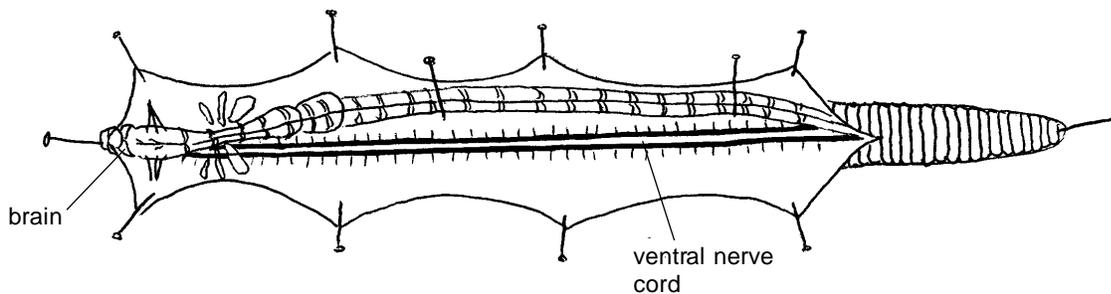


Figure 2. Illustration of pinned dissection procedure:



Variations:

None suggested.

References/Adapted from:

Biological Science: An Ecological Approach, 5th Edition, BSCS, Boston, Mass.: Houghton Mifflin Company, 1982.

Daniel, L., *Life Science, Laboratory Manual*. Westerville, Ohio.: Glencoe Division Macmillan/McGraw-Hill School Publishing Company, 1993.

Illustrations by Lisa Carisio, California SS&C Coordination Center, Santa Clara, 1996.

Science as Inquiry

You're Making Me Nervous, Again**How do organisms sense and respond to external stimuli?****Overview:**

In this alternate activity for Event 1, students dissect and study the nervous system of the grasshopper. As in Activity 1, they should be encouraged to consider the location and extent of the nervous system in relation to its key physiological functions, which will provide a basis for learning about the specialized structures of individual neurons in a later activity (Activity 4).

Remind students of the need to be careful with sharp objects and of what to do if they happen to cut themselves. All students should wash their hands after a dissection activity and give all dissection materials to you for proper disposal.

Materials:**Per lab group (two students):**

- dissecting needle and/or probe
- dissecting pan
- dissecting scissors
- forceps
- grasshopper (preserved)
- hand lens

Procedure:

Have students work in pairs, one student performing the dissection and the other recording observations. Their task is to find and expose as many aspects of the nervous system as they can. They should draw and label their findings in a lab notebook, noting the location of nervous system tissue in relation to other tissues.

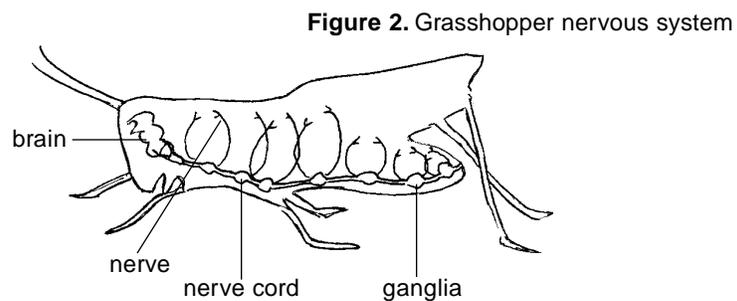
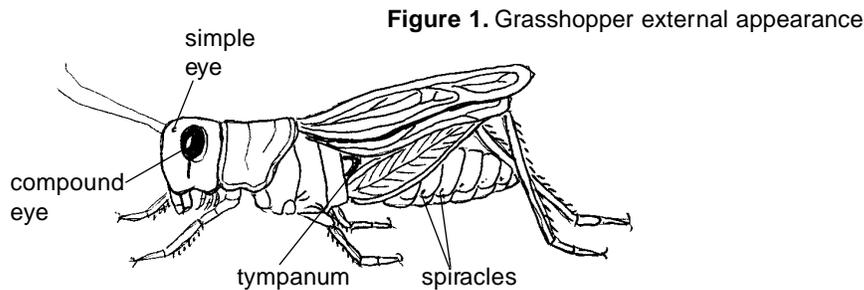
In their lab sheets, students are given basic instructions on how to expose the internal organs of the grasshopper through dissection. Caution them to be careful not to cut the organs underneath the external surface when dissecting. They should use a hand lens to study the internal anatomy and a blunt probe or dissecting needle to help separate and locate various structures. First they find the central nerve cord and observe how far it extends through the body. They then attempt to locate the brain and as many other aspects of the nervous system as they can, noting any other interesting observations as they go. Encourage them to consider how the nervous system seems to relate to the other structures of the body and whether it is located where they expected.

Background:

The grasshopper has two compound eyes and three simple eyes (Figure 1). Other sensory parts located on the head are the antennae, which have highly sensitive receptors for smell. A drum-shaped eardrum (or tympanum) is located on either side of the thorax, approximately between the legs and the wings. The

grasshopper breathes through spiracles, tiny pores along the ventral part of the abdomen. Like all insects, the grasshopper has three main body parts—head, thorax, and abdomen—and six legs specialized either for jumping, walking, climbing, and/or holding food. Note that the female grasshopper has a much longer abdomen than the male in order to accommodate an ovipositor through which eggs are laid.

Grasshoppers, like all arthropods, have a brain that consists of two ganglia (clusters of nerve cell bodies) located in the head (Figure 2). Two nerve cords extend along the bottom (ventral) side of the body, connecting pairs of ganglia in every segment of the body. Nerve branches run from these ganglia throughout the body. These branches can be quite small and difficult for students to find through dissection. Interestingly, because grasshoppers have ganglia in every segment they can continue functioning for some time even if decapitated.



Variations:

None suggested.

Adapted from:

Daniel, L., *Life Science, Laboratory Manual*. Westerville, Ohio.: Glencoe Division Macmillan/McGraw-Hill School Publishing Company, 1993.

Goodman, H.D., L.E. Graham, T.C. Emmel, and Y. Shechter, *Biology Today*. Orlando, Fla.: Holt, Rinehart and Winston, Inc., 1991.

Illustrations by Lisa Carisio, California SS&C Coordination Center, Santa Clara, 1996.

alternative/extension activity for Event 1

Teacher Sheet

Science as Inquiry

Common Carriers

**How extensive is the nervous system in various organisms?
How is this related to how the body functions?**

Overview:

Students who do not perform the dissections recommended in Activities 1 and 2 may substitute this activity. Here students study and compare the nervous systems of several different species using only drawings. Like Activities 1 and 2, the goal is to familiarize students with the nervous system as a whole, providing a basis for learning about the specialized structures of individual neurons in a later activity.

Materials:

Per student:

colored pencils, at least 3

Lab Sheet A: outline drawings of worm, crawfish, and rabbit
(included with Student Materials)

Lab Sheet B: outline drawings of grasshopper and human
(included with Student Materials)

Procedure:

Students may work alone on this activity. They should first study Lab Sheet A, which depicts a worm, a crawfish, and a rabbit. All of these organisms have certain common components in their nervous systems—nerve cord (spinal cord), brain, ganglia (plural of ganglion), and peripheral nerves extending from the nerve cord. The nerves shown include both sensory and motor components, but this should not be made explicit at this time.

Have students copy into their notebooks the outline drawings of the three organisms and label each of the nervous system components listed above. The worm is already labeled as an example. They should color code the structures common to each organism and record exactly where each structure is located in each organism, noting both similarities and differences.

Turning to Lab Sheet B, students should copy or trace the illustrations of the human and grasshopper into their notebooks in outline form only. Based on the illustrations and examples on Lab Sheet A, they then draw in the same structures as before (nerve cord, brain, ganglia, nerves) where they would expect to find them in the actual organisms. They should note that the nerve cord on the invertebrate species of this activity is located on the ventral side of the body, while the spinal or nerve cord of the vertebrates is located on the dorsal side (you may need to help them with this observation). Accordingly, students should draw in the nerve cord of the grasshopper on the ventral side and the nerve cord of the human on the dorsal side. Again, they should color code the structures common to all of the organisms in the activity.

Background:

The nervous system of multicellular organisms comprises a group of organs that monitor the environment and control and coordinate body activities. It can be described as having two main subdivisions: the *central nervous system* (CNS) and the *peripheral nervous system*. The central nervous system includes the brain and the spinal cord (nerve cord). Its primary function is to receive stimuli from inside and outside the body and to then coordinate the body's response. The peripheral nervous system consists of nerves that vary in size but which all provide pathways to and from the central nervous system, thus achieving (electrochemical) communication between the brain and all other parts of the body.

The basic unit of the nervous system is the neuron or nerve cell. Neurons that receive stimuli and transmit that information to the central nervous system are called *sensory neurons*. Those which carry electrochemical impulses away from the central nervous system to the muscles, glands, or other organs in order to effect a response are called *motor neurons*. A third type of neuron—an *interneuron*—links sensory and motor neurons.

Every nerve cell consists of a nerve body and two types of nerve fibers. The nerve body contains the nucleus and cytoplasm of the cell and is found in the ganglia of the organisms of this activity. The rest of the nerve cord consists primarily of threadlike extensions from the cell body called dendrites and axons. Dendrites carry impulses from other neurons toward the cell body and are generally short and highly branched. The axon carries impulses away from the cell body to other neurons or muscles. Axons are usually longer than dendrites and have branches only at the end of the fiber.

To function sensory neurons must first be activated by various specific sensory receptors throughout the body. For example, the ear acts as a sensory receptor to detect sound and then initiates impulses that travel along sensory pathways to the brain. Once the impulse reaches the brain, the organism can analyze and interpret the information, which then may or may not require a motor response. In certain cases, special direct sensory-to-motor pathways—reflex arcs—exist. A reflex arc allows a very fast response to a painful or aversive stimulus, sending information directly to a motor unit even before sending it on to the brain. This allows the organism to react quickly, as when a person touches a hot stove.

A large segment of the nervous system, the *autonomic system*, operates at the subconscious level and controls many functions of the internal organs, including the heart, gastrointestinal tract, and various glands.

Variations:

Students could do mini-research projects to learn more about the brain structures of the organisms depicted in this activity. They will find that brain structures vary quite a bit in shape and size although they share some common features. They might consider how their findings can be explained in terms of the organisms' natural behaviors and what role the brain plays in terms of survival and day-to-day functioning. They would be interested to learn which animal in the world has the largest brain relative to its total body mass. (Hint: It's not humans!)

Adapted from: none

References:

Goodman, H.D., L.E.Graham, T.C. Emmel, and Y. Shechter, *Biology Today*. Orlando, Fla.: Holt, Rinehart and Winston, Inc., 1991.

Illustrations by Lisa Carisio, California SS&C Coordination Center, Santa Clara, 1996.

Science as Inquiry

Cell Phones**How does the nervous system provide a communication system for the body?****Overview:**

In the preceding activities students studied the nervous systems of simple organisms as a whole. They should have observed that components of the nervous system extend throughout the interior of an organism and connect to some form of a brain. They should have concluded that the nervous system is well situated to provide a communications network inside the body, conveying information about external and internal stimuli and initiating appropriate physiological responses. At this point it is appropriate to study the specialized structures of neurons that help the nervous system carry out its function as a communications tool inside the body.

Materials:**Per lab group:**

microscope, compound light

prepared slides (any set of 3 or 4 that includes 1 nerve cell slide):

nerve cell

epithelium

onion root tip

blood smear

Procedure:

Students should work in groups of two if enough microscopes and slides are available. Make sure that the labels on the prepared slides are hidden. Have students examine each of the slides, looking for the one that seems best suited to carry out the functions of a nerve cell. Since they may not have studied general cell structure and organelles at this point (see micro-units 9.32 and 9.33), they will make their choice based on the overall gross structural features of the cells that you use. Therefore, it is very important that you use slides with clear and distinct cell images.

Begin with a quick review of the basic nervous system, focusing on its ability to provide a communications network throughout the body. Ask students to consider what shape, structures, or features would be advantageous for such a function, reminding them that nerve cells must receive impulses as well as transmit impulses to other cells. A quick demonstration and discussion of the components of the familiar wire-between-two-cans “telephone” apparatus may be useful for some students. Do not discuss the electrochemical transmission of impulses at this time; it will be taken up at a higher grade level once an empirical basis for understanding such a system has been established.

Have students observe each of the candidate cells under the microscope. They should draw the cells in their notebooks with descriptive notes about whether a particular cell seems structurally suited to be a

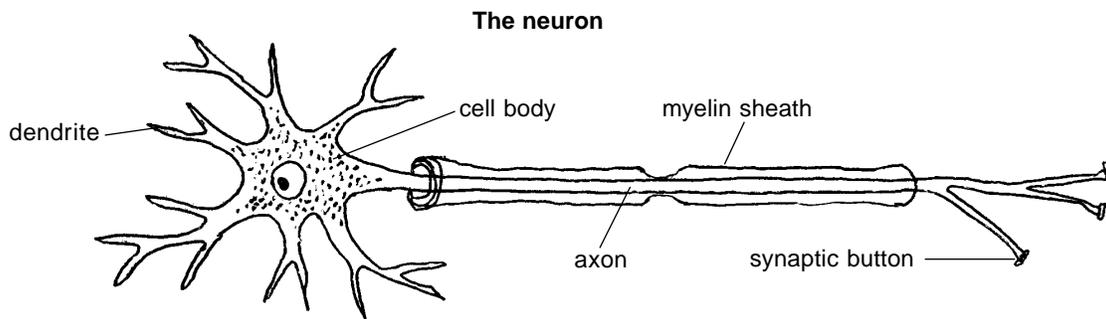
nerve cell. Each lab group should come to a consensus as to which cell is a true nerve cell, with a written justification for their choice.

A post-lab discussion during which you would show the class a representative nerve cell would be appropriate here. This would be a good time to introduce the terms *dendrite* and *axon*.

Background:

The basic unit of the nervous system is the neuron or nerve cell. Neurons that receive stimuli and transmit that information to the central nervous system are called *sensory neurons*. Those that carry electrochemical impulses away from the central nervous system to the muscles, glands, or other organs in order to effect a response are called *motor neurons*. A third type of neuron—an *interneuron*—links sensory and motor neurons.

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To function sensory neurons must first be activated by various specific sensory receptors throughout the body. For example, the ear acts as a sensory receptor to detect sound and then initiates impulses that travel along sensory pathways to the brain. Once the impulse reaches the brain, the organism can analyze and interpret the information, which then may or may not require a motor response. In certain cases, special direct sensory-to-motor pathways—reflex arcs—exist. A reflex arc allows a very fast response to a painful or aversive stimulus, sending information directly to a motor unit even before sending it on to

the brain. This allows the organism to react quickly, as when a person touches a hot stove.

A large segment of the nervous system, the *autonomic system*, operates at the subconscious level and controls many functions of the internal organs, including the heart, gastrointestinal tract, and various glands.

Variations:

This lab could be done with a limited number of microscopes by setting up “stations” for each type of prepared slide and circulating two students through each station at a time. During this time other students could go over appropriate readings or work on Lab Activity 3.

If no prepared slides of nerve cells are available, you could have students attempt to draw a picture of a typical nerve cell as you read one or two detailed descriptions of a neuron from a reference or neuroanatomy textbook. Follow this up by showing the entire class a good illustration of a typical neuron (with structural labels) so that they can make corrections and modifications to their preliminary drawings.

Adapted from: none.

Nerve cell illustration by Lisa Carisio, California SS&C Coordination Center, Santa Clara, 1996.

Science As Inquiry

Surveying the System**Item:**

A partner missed the lab activity involving the dissection of a worm and wants to make it up. In the space below, give your friend some help by naming the major components of the nervous system he can expect to find and describing where in the body he can expect to find them.

Answer:

Brain—head or anterior (front) portion of the body.

Nerve cord —runs nearly the length of the body as a narrow white cord on the ventral (bottom) side of the interior of the body (connected to the brain).

Ganglia—several bumps or nodes found along the nerve cord.

Nerves (peripheral)—extend out from the nerve cord at all levels, to all areas of the body.

Science As Inquiry

The Parts of the Whole**Item:**

The nervous system works with other systems in the body to sense and respond to external stimuli. Which of the following terms describes a component of the nervous system of most simple animals?

- A. blood vessels
- B. ganglia
- C. bones
- D. skin

Justification:

Other than the component you chose above, name at least two other components of the nervous system found in the earthworm.

Answer:

The best choice is B. The other components that students who have completed this micro-unit should be familiar with are the brain, nerve cord, and (peripheral) nerves.

Science As Inquiry

Getting Down to Basics**Item:**

While the nervous system of multicellular organisms is quite extensive and covers virtually the entire body, its basic part, the individual nerve cell, is quite small. However, the nerve cell's structure and shape is well suited for its function.

Draw a basic nerve cell. Label as many parts as you can. Explain how its structure is related to its function.

Answer:

Refer to the illustration provided earlier in the Teacher Materials for Activity 4. Students' ability to label parts will depend on how much emphasis was placed on such knowledge when Activity 4 was completed in class.

The explanation should clearly indicate an understanding of the communication and sensing functions of the nerve cell. The student may point out that multiple dendritic structures are helpful in receiving as much input from other cells and sensors as possible, while the long extended portion (axon) allows the cell to project toward other cells, establishing an unbroken system of communication that extends the length of the body.

Science As Inquiry

Consider An Alternate Plan**Item:**

A rabbit has a backbone for structural support and is, therefore, classified as a *vertebrate*. A crawfish has an exoskeleton (hard outer surface) for structural support and is classified as an *invertebrate*. Describe the similarities and differences of the nervous systems of these two organisms.

Answer:

Both have the same basic components—brain, nerve cord, ganglia, and (peripheral) nerves. Vertebrates have a spinal column that encases the nerve cord and runs along the dorsal part of the interior of the body. Invertebrates do not have a spinal column and, in the case of crawfish (see Activity 3), the nerve cord runs along the ventral interior wall of the body.

Note: If students did not complete Activity 3, they may still be able to describe features of the nervous system common to both organisms and speculate that since the crawfish does not have a backbone, its nerve cord is likely to be in an anatomical location different from that of the rabbit or other vertebrates.

Consumables		
Item	Quantity per lab group	Activity
earthworm (preserved)	1	1
grasshopper (preserved)	1	2*
outline drawings of worm, crawfish, and rabbit (included with Student Materials)	1 set per student	3*
outline drawings of grasshopper and human (included with Student Materials)	1 set per student	3*
pencils, at least 3 colors	1 of each color per student	3*

Nonconsumables		
Item	Quantity per lab group	Activity
dissecting needle or probe	1	1, 2*
dissecting pan	1	1, 2*
dissecting pins	—	1
dissecting scissors	1	1, 2*
forceps	1	2*
hand lens	1	1, 2*
microscope, compound light	1	4
prepared slides: nerve cell, epithelium, onion root tip, and blood smear (any set of 3–4 that includes 1 nerve cell slide)	1 each	4

*denotes alternative/additional activities

Key to activities:

1. You're Making Me Nervous
2. You're Making Me Nervous, Again
3. Common Carriers
4. Cell Phones

Activity Sources/References

- Barr, M.L. and J.A. Kiernan, *The Human Nervous System, An Anatomical Approach*, 4th Edition. Philadelphia: Harper & Row Publishers, 1983.
- Biological Science: An Ecological Approach*, 5th Edition, BSCS, Boston: Houghton Mifflin Co., 1982.
- Daniel, L., *Life Science Laboratory Manual*. Westerville, Ohio: Glencoe Div., Macmillan/McGraw-Hill School Publishing Co., 1993.
- Goodman, H.D., L.E. Graham, T.C. Emmel, and Y. Schechter, *Biology Today*. Orlando: Holt, Rinehart and Winston, Inc., 1991
- Kandel, E.R. and J.H. Schwartz, *Principles of Neural Science*. New York: Elsevier North Holland, Inc., 1982.

Illustrations by Lisa Carisio, California SS&C Coordination Center, Santa Clara