

# The Role of the Nervous System

11.1

## Vocabulary

neuron	glial cell	somatic system
neural signalling	myelin sheath	autonomic system
afferent neuron	node of Ranvier	sympathetic division
interneuron	central nervous system (CNS)	parasympathetic division
efferent neuron	peripheral nervous system (PNS)	neural circuit
dendrite	afferent system	reflex arc
axon	efferent system	

Textbook pp. 516–521

**MAIN IDEA:** The nervous system of an animal has four main functions: (1) it receives information about conditions in the internal and external environment; (2) it transmits messages along neurons; (3) it integrates the information to formulate an appropriate response; and (4) it sends signals to effector tissues or organs. Neurons are cells that are specialized for the reception and transmission of electrical signals.

1. What part of a neuron is involved in each activity? **K/U**
  - (a) synthesizing proteins, carbohydrates, and lipids for cell use
  - (b) receiving external stimuli
  - (c) bundling together to form nerves, which transmit signals over long distances
  - (d) passing signals to other cells

## STUDY TIP

### Make Connections

As you learn about the characteristics of various components of the nervous system, always consider how those characteristics help that component carry out one of these functions.

2. Label **Figure 1** to show the parts of a neuron. Add arrows to show the direction of the electrical impulses that travel across a neuron. **K/U C**

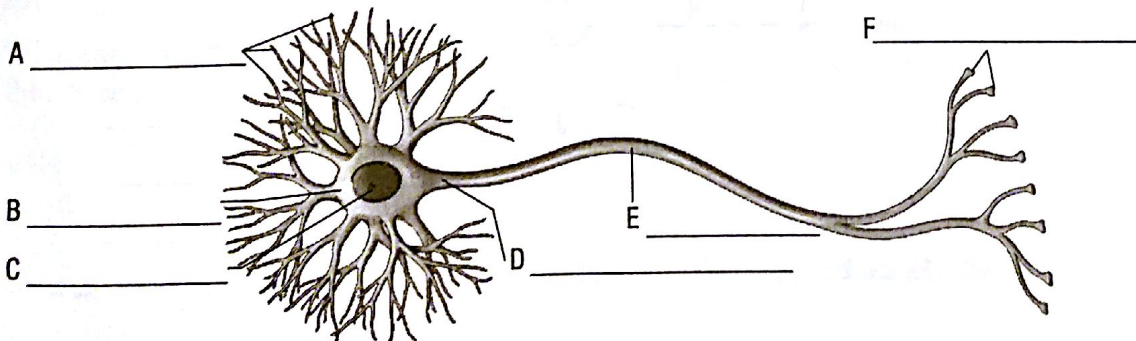


Figure 1

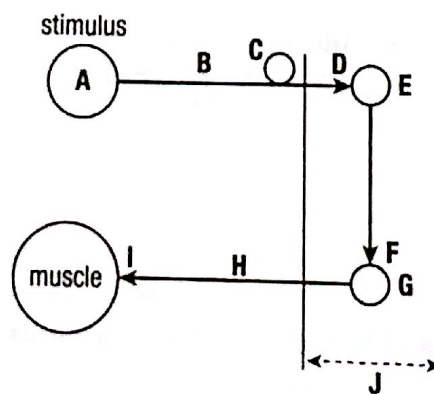
**MAIN IDEA:** Afferent neurons conduct information from sensory receptors to interneurons, which integrate the information into a response. The response signals are passed to efferent neurons, which activate the effectors that perform the response. A neural circuit consists of the receptor, the afferent neuron, the interneuron, the efferent neuron, and the effector. The simplest neural circuit is the reflex arc.

3. Complete **Table 1** to summarize how neurons process information in the nervous system. **K/U C**

**Table 1** Neural Signalling

Component	Type of nerve	Action of neural signal
reception		
transmission		
integration		
response		

4. Label the parts of a reflex arc shown in **Figure 2**. **K/U C**

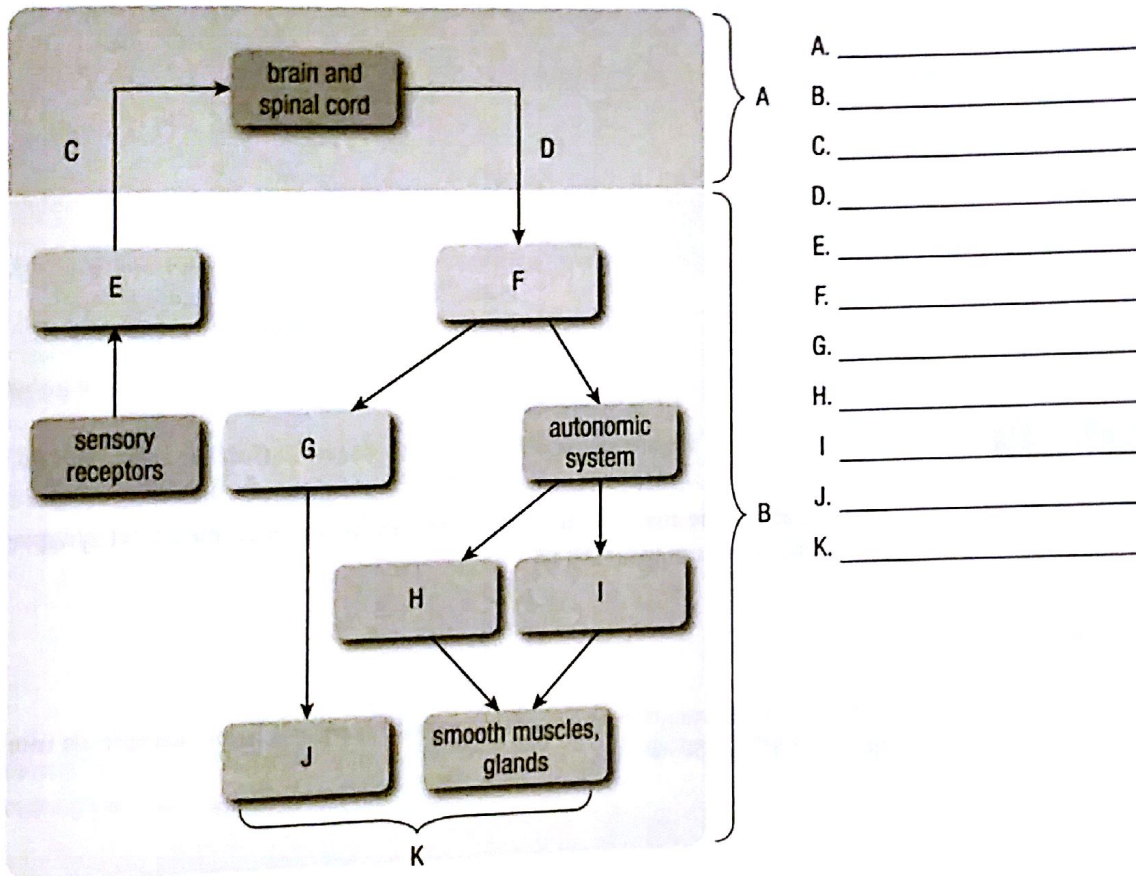


- A. \_\_\_\_\_
- B. \_\_\_\_\_
- C. \_\_\_\_\_
- D. \_\_\_\_\_
- E. \_\_\_\_\_
- F. \_\_\_\_\_
- G. \_\_\_\_\_
- H. \_\_\_\_\_
- I. \_\_\_\_\_
- J. \_\_\_\_\_

**Figure 2**

**MAIN IDEA:** The central nervous system (CNS) consists of the brain and spinal cord. It communicates with the peripheral nervous system (PNS), which is made up of the afferent and efferent systems.

- Which part of the nervous system is used to process information related to each area below? **KSU**
  - senses
  - voluntary actions
  - involuntary actions that speed up respiratory metabolism
  - involuntary actions that slow down respiratory metabolism
- Label the main parts of the nervous system shown in Figure 3. **KSU KS**



- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
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Figure 3

**MAIN IDEA:** Glial cells provide structural and functional support to neurons. They help to maintain the balance of ions surrounding the neurons and form insulating layers around the axons.

- What characteristics of neurons makes them vulnerable? In what ways would they benefit from structural and functional support? **KSU KS**
- What are the myelin sheath and nodes of Ranvier? How do they support neurons? **KSU**



Textbook pp. 522–529

**Vocabulary**

synapse

chemical synapse

neurotransmitter

synaptic cleft

electrical synapse

membrane  
potential

ion channel

resting potential

action potential

threshold potential

refractory period

**MAIN IDEA:** Neurons make connections using two types of synapses: electrical and chemical. In an electrical synapse, impulses pass directly from the sending cell to the receiving cell by ion flow through gap junctions. In chemical synapses, neurotransmitters released from the presynaptic cell bind to the postsynaptic cell.

1. (a) Draw and label a diagram of an electrical synapse and a chemical synapse.

(b) What are the main structural difference between an electrical synapse and a chemical synapse? **KU TO**

2. Which type of synapse do you think would transmit impulses signals more quickly? Why? **KU A**

**MAIN IDEA:** The unequal distribution of positive and negative charges on either side of a neuron's membrane establishes a potential difference, called the resting potential. An action potential is generated when a stimulus pushes the resting potential to the threshold value at which  $\text{Na}^+$  channels open in the plasma membrane. Action potentials move along an axon as the ion flows generated in one location on the axon depolarize the potential in an adjacent location.

3. What advantage does a chemical synapse have over an electrical synapse? **KU**



4. Number the steps below to show the correct sequence for signal transmission in a chemical synapse. **KU** **22**
- \_\_\_ neurotransmitter binds with receptor
  - \_\_\_ calcium ions rush into neuron's cytoplasm
  - \_\_\_ action potential depolarizes the presynaptic membrane
  - \_\_\_ ion gate opens to allow particular ion to enter cell
  - \_\_\_ synaptic vesicles release neurotransmitter into the synaptic cleft

Use Figure 1 to answer questions 5 to 7.

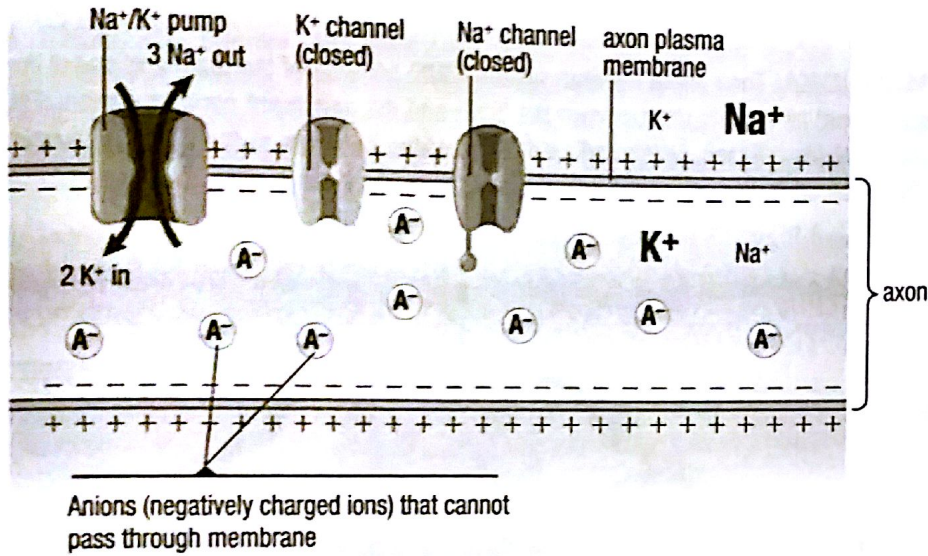


Figure 1

5. Describe the concentrations of the ions inside and outside the neural membrane during resting potential. **KU**
6. Describe the concentrations of the ions inside and outside the neural membrane during action potential. **KU**
7. Describe the concentrations of the ions inside and outside the neural membrane during the refractory period. **KU**

**STUDY TIP**

**Review Prior Knowledge**

To help you understand the role  $K^+$  and  $Na^+$  play in transmitting neural impulses, review how ions interact in Chapter 1.

# The Central Nervous System

Textbook pp. 530–536

### Vocabulary

meninges	medulla oblongata	cerebral cortex
cerebrospinal fluid	cerebellum	thalamus
grey matter	pons	blood–blood barrier
white matter	cerebrum	

**MAIN IDEA:** The central nervous system (CNS) consists of the brain and spinal cord. The spinal cord carries signals between the brain and the peripheral nervous system (PNS) and also controls reflexes. Cerebrospinal fluid provides nutrients to the CNS and cushions the CNS. A blood-brain barrier allows only selected substances to enter the cerebrospinal fluid.

### STUDY TIP

#### Afferent and Efferent

Remember that afferent neurons are **APPROACHING** the central nervous system and efferent neurons are **EXITING** the central nervous system.

1. Label Figure 1 to show the parts of the spinal cord. **MCU C**

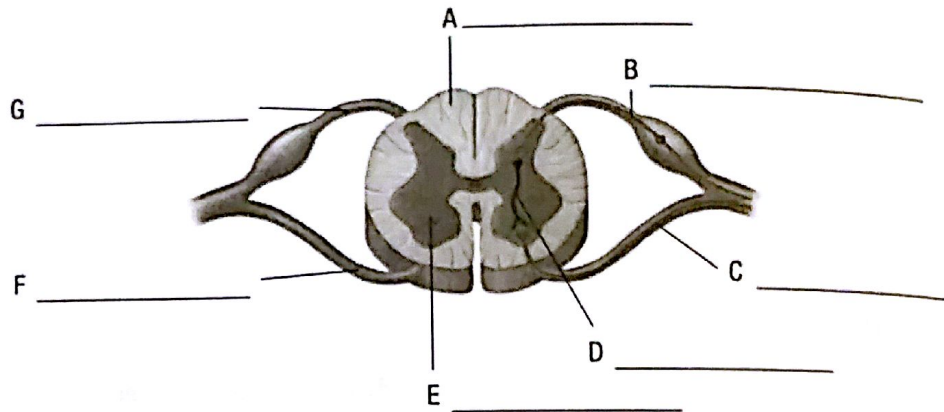


Figure 1

2. Label Figure 2 to show the parts of the brain. **MCU C**

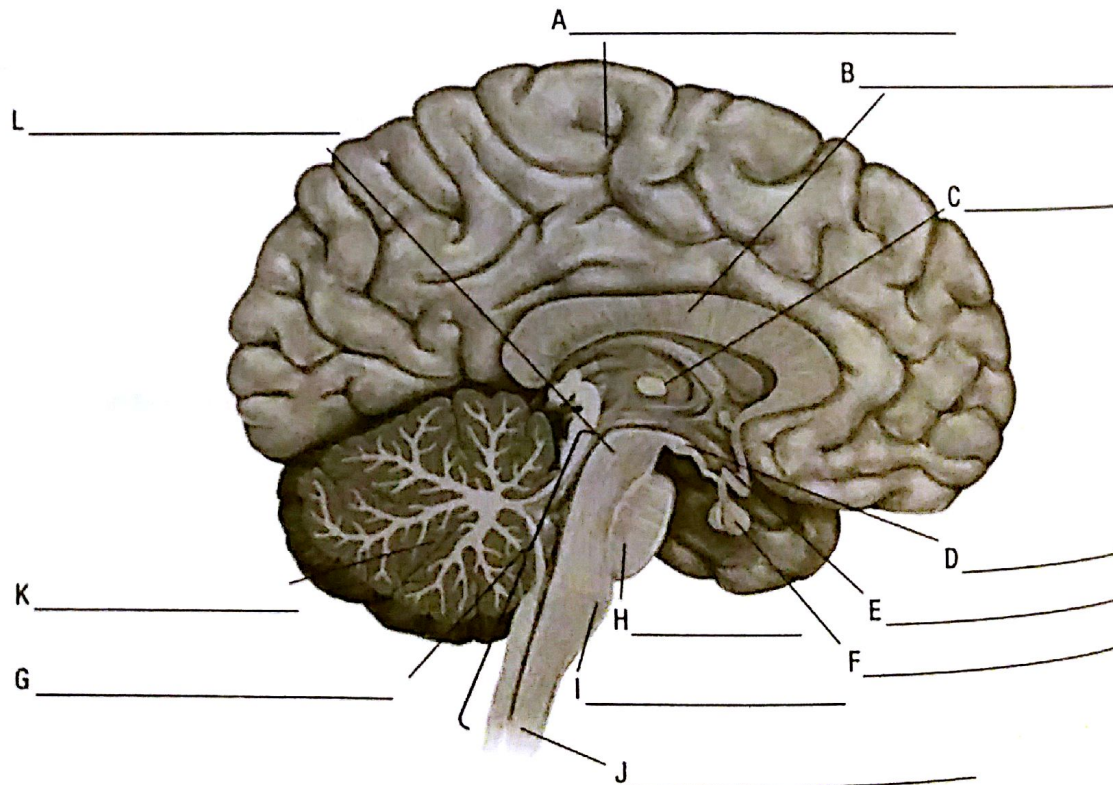


Figure 2



3. (a) Describe possible problems that could arise from the diffusion of blood contents into the cerebral fluids in the brain.

(b) How is the brain protected from this danger? **KU**

**MAIN IDEA:** The primary somatosensory areas of the cerebral cortex register incoming sensory information. The primary motor areas of the cerebrum control voluntary movements of skeletal muscles in the body. Some functions, including long-term memory and consciousness, are equally distributed between the two cerebral hemispheres. Other functions are concentrated in the left hemisphere or the right hemisphere.

4. In **Table 1** below, describe six different functions that would be processed in the cerebral cortex. Indicate in which area of the cortex each function would be processed. An example has been provided. **KU 77 C 1A**

**Table 1** Processing in the Cerebrum

Function	Processed in what part of cerebral cortex?
moving fingers to write with a pencil	primary somatosensory area

5. Complete the following description of the two cerebral hemispheres. **KU**

Each cerebral \_\_\_\_\_ can function separately. The right \_\_\_\_\_ responds primarily to \_\_\_\_\_ signals from, and controls \_\_\_\_\_ in, the \_\_\_\_\_ side of the body. It also specializes in \_\_\_\_\_ conceptualizing, including \_\_\_\_\_, and \_\_\_\_\_ recognition. The left \_\_\_\_\_ responds primarily to \_\_\_\_\_ signals from, and controls \_\_\_\_\_ in, the \_\_\_\_\_ side of the body and also specializes in spoken and written \_\_\_\_\_, \_\_\_\_\_ reasoning, and \_\_\_\_\_. \_\_\_\_\_ bundles called the \_\_\_\_\_ connect the two hemispheres.

6. The surface layer of the human cerebrum is intricately folded and contains many unmyelinated neurons. How might that be advantageous to the complex processing that goes on there? **KU 77**



**MAIN IDEA:** Grey-matter centres in the pons and medulla control involuntary functions, such as heart rate, blood pressure, respiration rate, and digestion. Centres in the midbrain coordinate responses to visual and auditory sensory input.

7. Complete **Table 2** to summarize the functions of the following structures in the midbrain and hindbrain. **K/U C**

**Table 2** Midbrain and Hindbrain

Brain area	Function
cerebellum	
thalamus	
hypothalamus	
pituitary gland	
basal nuclei	

8. In what ways do the structures of the midbrain and hindbrain work with the cerebrum to carry out their functions? **K/U TA**

9. The midbrain and hindbrain function together with the endocrine system to maintain homeostasis. Identify which part of the brain is most involved in this coordinated effort and describe the interaction. **K/U TF**

# The Peripheral Nervous System

## Vocabulary

spinal nerves

cranial nerves

substantia gelatinosa (SG)

Textbook pp. 537–541

**MAIN IDEA:** The somatic system of the peripheral nervous system (PNS) controls the skeletal muscles that produce voluntary body movements, as well as the involuntary muscle contractions that maintain balance, posture, and muscle tone.

1. The somatic system consists of 31 pairs of spinal nerves, controlling different parts of the body. Complete **Table 1** to identify the parts of the body controlled by each type of spinal nerve. **K/U C**

**Table 1** Spinal Nerves

Type of spinal nerve	Area of body controlled

2. Complete the following description of how the spinal nerves emanate from the spinal column. **K/U**

The \_\_\_\_\_ roots, which lay outside the spinal cord, form the beginning of the \_\_\_\_\_ nervous system. Each \_\_\_\_\_ nerve branches repeatedly. In mammals, \_\_\_\_\_ exit from the spinal cord in the \_\_\_\_\_ root to carry efferent signals to the \_\_\_\_\_ muscles. The \_\_\_\_\_ and \_\_\_\_\_ of the motor neurons are located \_\_\_\_\_ the spinal cord. Their \_\_\_\_\_ extend from the spinal cord to the \_\_\_\_\_ cells they control.

**MAIN IDEA:** The autonomic system of the PNS controls involuntary functions, such as heart rate, blood pressure, glandular secretions, and smooth muscle contractions. The autonomic system is organized into sympathetic and parasympathetic divisions, which balance and fine-tune involuntary body functions. The sympathetic system predominates in situations of stress, danger, or strenuous activities. The parasympathetic system predominates during quiet, low-stress situations.

3. On a separate sheet of paper, draw a Venn diagram to compare the structure of the autonomic nervous system with the structure of the somatic nervous system. **K/U C**

**STUDY TIP****Visualize**

To visualize the sympathetic and parasympathetic systems working in opposition, think of the accelerator and brakes on a car. They operate in opposition to control the car's speed precisely.

4. Complete **Table 2** to summarize the functions of each region in the autonomic peripheral nervous system. **K/U G**

**Table 2** Autonomic PNS

Region	Function
parasympathetic actions in the brain	
parasympathetic actions in the lower spinal cord	
sympathetic actions in the section of the spinal cord in the neck	
sympathetic actions in the section of the spinal cord in the region of the ribs	
sympathetic actions in the lower spinal cord	

**MAIN IDEA:** Naturally produced painkillers and synthetic painkillers work because they block or reduce the binding of pain neurotransmitters to substantia gelatinosa (SG) receptor cells.

5. Is the body's reaction to pain controlled by the somatic or the autonomic nervous system? Explain. **K/U T/I**
6. Think of the structure of a chemical synapse. Suggest two ways in which drugs could be used to influence the actions of the synapse. **K/U A**
7. Studies have suggested that exercise can be as effective in treating depression as antidepressant medications. Why does this make sense? **T/I K/U**



## Vocabulary

sensory adaptation

Textbook pp. 542–548

**MAIN IDEA:** In the visual system, photoreceptors detect light stimuli at particular wavelengths. They convert the stimuli to nerve impulses, which move the information via the optic nerve to the visual centres in the CNS. Hair cells in each ear sense sound and respond by triggering action potentials, sending signals via the auditory nerve to the thalamus and then to the brain's temporal lobe. Chemoreceptors for taste have receptors in taste buds that relay signals to the thalamus and then to gustatory (taste) centres, such as those in the cerebral cortex. Chemoreceptors for smell make direct connections with interneurons in the brain, rather than using afferent neurons as a conduit. Mechanoreceptors for touch and pressure are embedded in the skin and other surface tissues.

1. Indicate which type of receptor(s) will respond to each type of stimulus. **LO 11.5.1**
  - (a) you lean against a wall
  - (b) you look at a photograph
  - (c) you taste a fruit you like
  - (d) a bell rings
  - (e) you step outside to see if you need a coat
  - (f) you cut your finger
  - (g) you walk past a bakery

## STUDY TIP

### Make Connections

As you perform daily activities, such as walking from one class to another, or eating dinner, think about what types of receptors are working in your nervous system. Where are neurons carrying sensory input? Where are motor and autonomic neurons carrying instructions?

2. Label **Figure 1** to show the parts of the eye. **LO 11.5.2**

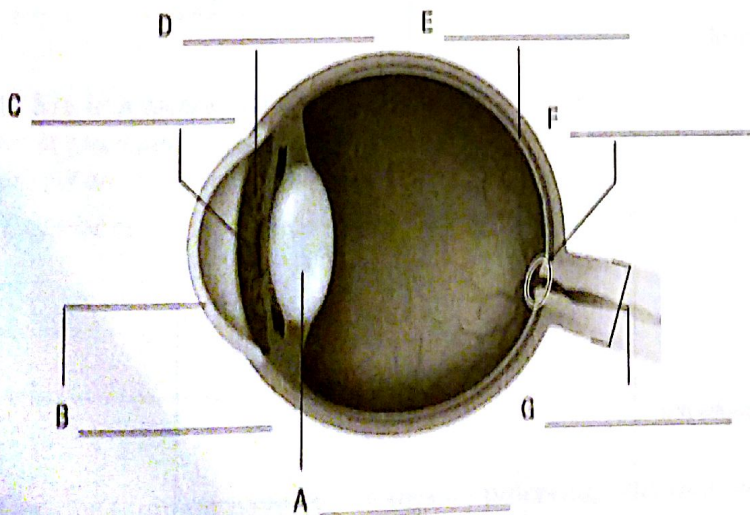
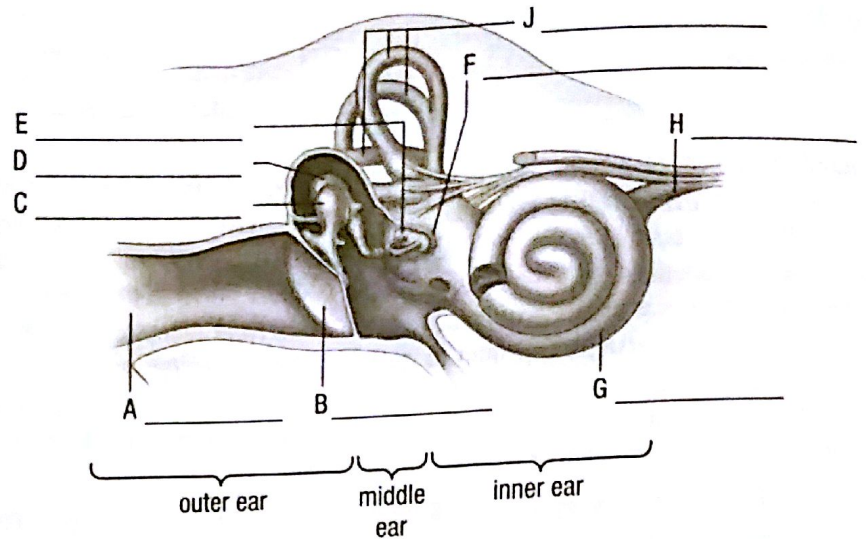


Figure 1

3. Label **Figure 2** to show the parts of Eustachian tube in the ear. Add the numbers 1 through 6 to show the order in which these parts become involved in processing sound. (Not every part will have a number, and some will share a number.)



**Figure 2**

4. Complete **Table 1** to compare how the body processes taste, smell, and touch.

**Table 1** Taste, Smell, and Touch Sensors

	Taste	Smell	Touch
Location of sensors			
Description of sensors			
How messages are conveyed			



5. (a) What sense do most animals have other than sight, hearing, taste, smell, and touch?

(b) Where are the sensors for this sense located? **K/U**

**MAIN IDEA:** Some sensory systems become less reactive to a stimulus if it continues at a constant level. This reduction is called sensory adaptation. When the body is subjected to potentially damaging internal and external conditions, nociceptors (pain receptor) detect these damaging stimuli and send a message to the brain that is interpreted as pain.

6. Describe an everyday example of a sensory system becoming less reactive to a continued stimulus. **A**

7. To what degree do pain receptors become less reactive to a continued stimulus. Why might this be? **K/U T/I**

**MAIN IDEA:** A sensory processing disorder is a neurological disorder that causes difficulties in processing information received from sensory receptors. Stimuli are received normally but are perceived or interpreted abnormally.

8. Describe an example of a sensory disorder with a physical cause. **K/U**

9. Describe common symptoms of sensory processing disorders. **K/U**



Textbook pp. 549–553

**Vocabulary**

renin-angiotensin-aldosterone pathway

**MAIN IDEA:** Stress is the body's response to stimuli, or stressors, that cause a disruption in homeostasis. The response is an attempt to restore homeostasis. Stress can be caused by a range of factors. Physical stress, such as exercising, can also cause a stress response. Different individuals may respond differently to the same stress.

1. (a) Define "stress".
  - (b) What are the risks of prolonged stress? **KU**
2. Describe an example of each type of stress. **KU** **TA**
  - (a) positive stress
  - (b) negative physical stress
  - (d) short-term emotional stress
  - (e) long-term psychological stress

**MAIN IDEA:** Symptoms of stress can include accelerated heart rate, sweaty hands, an upset stomach, and rapid breathing. Long-term exposure to stress has been associated with many diseases and negative health effects.

3. Describe a few ways you deal with the stress that you encounter in your life. **KU** **TA**
4. Describe an example of a severe allergic reaction and explain how it produces extreme stress, or shock, in the body. **KU**
5. (a) Prostaglandins are part of a stress response. What role do they play?
  - (b) How do pain relievers such as acetylsalicylic acid (ASA) work? **KU**

**STUDY TIP****Controlling Stress**

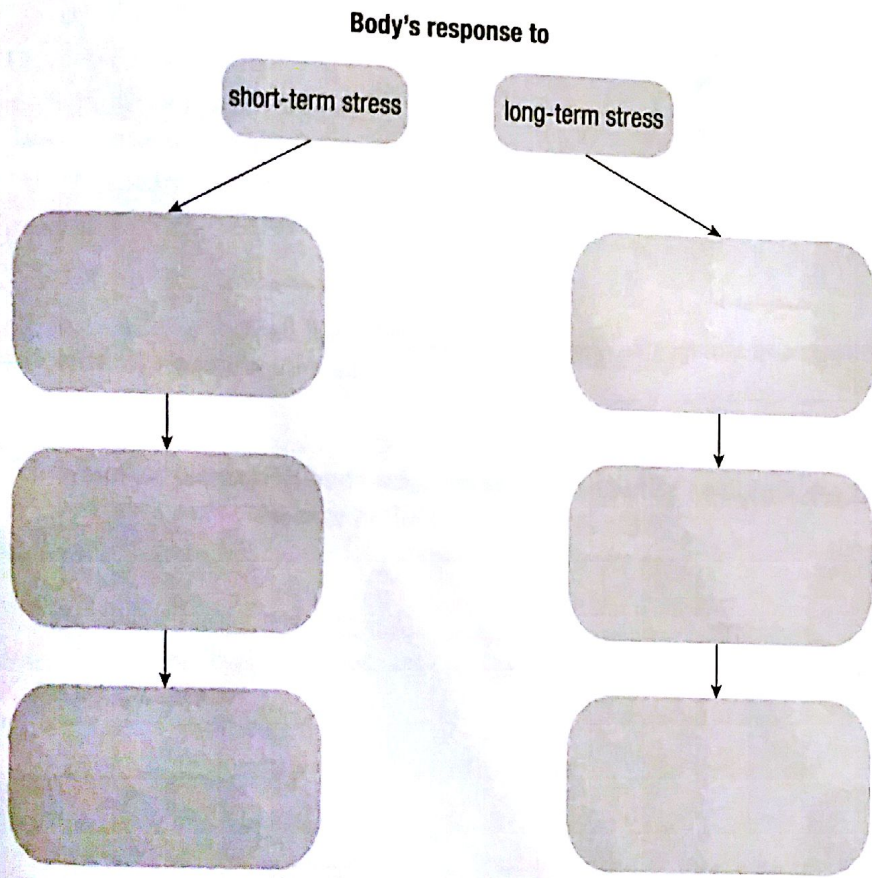
Writing a test or exam can be a cause of stress. However, making a conscious effort to reverse symptoms of stress, for example deliberately breathing slowly and keeping your mind from racing around, can help reduce stress and help you focus on the task at hand.

**MAIN IDEA:** The endocrine, nervous, and excretory systems are all involved in the stress response. The endocrine system secretes hormones, such as epinephrine and cortisol. The nervous system responds to brief stressors and also stimulates the endocrine system. The excretory system regulates the volume of fluid in the body and maintains or increases blood pressure during an emergency.

6. (a) How does stress affect hormones in the body?

(b) How does stress affect the nervous system? **K/U**

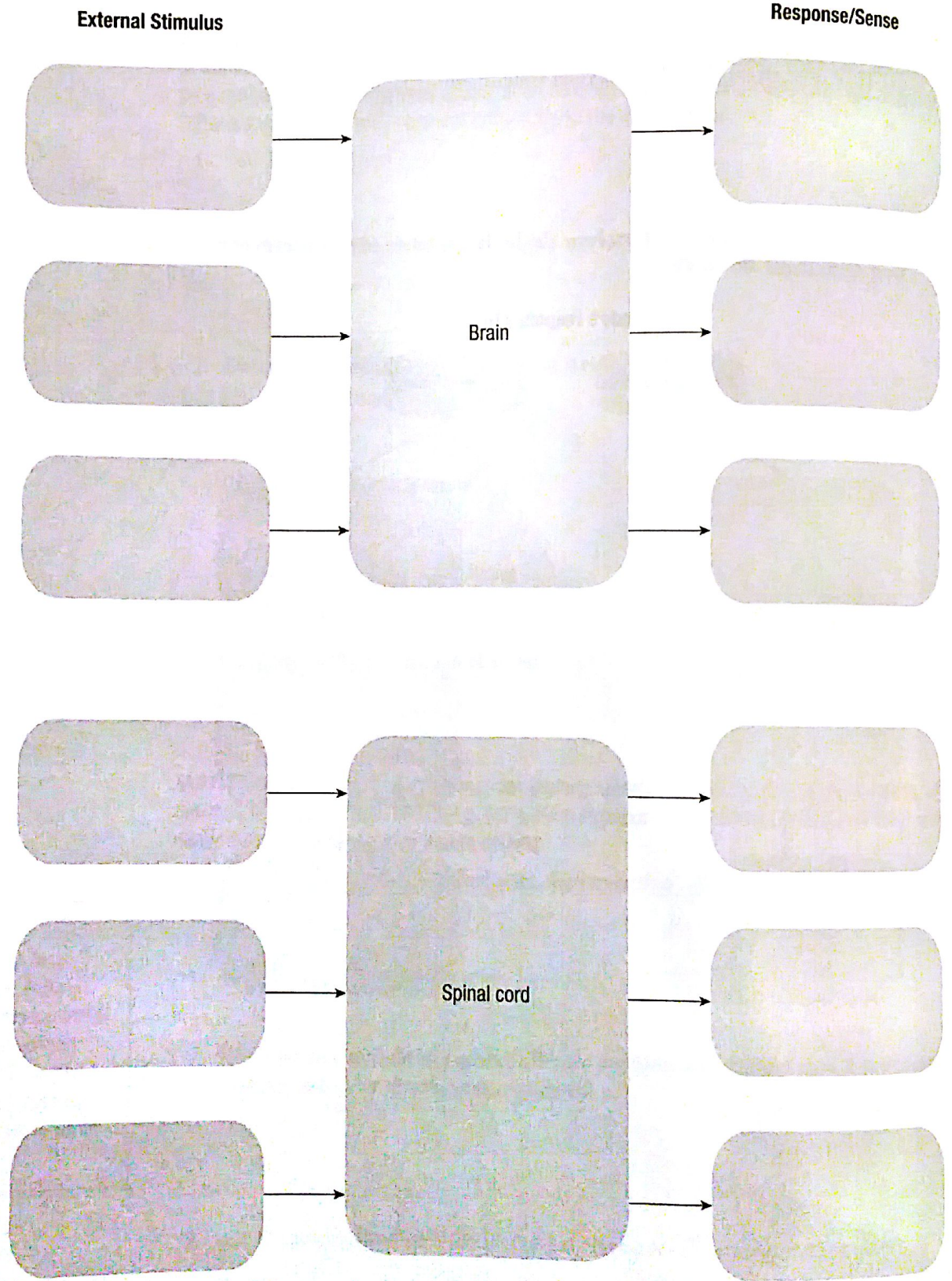
7. Complete the flow chart to show how the body responds to short-term and long-term stress. **K/U T/I IC**





### The Nervous System

Complete the flow chart to show the stimulus processed by the brain or the spinal cord and the response or sense that results from the stimulus.





- Integration of simple responses to certain stimuli, such as the knee-jerk response, is accomplished by which region? (11.1) **K/U**
  - cerebellum
  - hypothalamus
  - corpus callosum
  - spinal cord
- Exocytosis is used by the synaptic vesicles to remove their contents at which location? (11.2) **K/U**
  - presynaptic membrane
  - axon hillock
  - nodes of Ranvier
  - postsynaptic membrane
- The coordination of motor activities in mammals is carried out by which region in the brain? (11.3) **K/U**
  - pons
  - cerebellum
  - cerebrum
  - medulla
- Parasympathetic stimulation would result in which response? (11.4) **K/U**
  - decreased blood flow in skin
  - pupil dilation
  - increased heart rate
  - decreased activity of digestive tract
- Indicate whether each statement is true or false. If you think a statement is false, rewrite it to make it true. **K/U**
  - Electrochemical messages are carried by the movement of ions through the nerve membrane. (11.2)
  - When the nerve cell is excited, it becomes more permeable to potassium ions than sodium ions. (11.2)
  - When an increase in body temperature is detected by sensors in the brain, it sends a nerve message to the hypothalamus. (11.5)
- Compare and contrast the main functions of the autonomic division of the nervous system and the somatic division of the nervous system (11.4) **K/U T/I**
- List three factors that determine an action potential's rate of propagation. (11.2) **K/U**
- Which two areas of the brain control respiration? (11.3) **K/U**
- A neuron generates an action potential. Describe the concentration of  $K^+$ . (11.2) **K/U**

- K/U** Knowledge/Understanding
- T/I** Thinking/Investigation
- C** Communication
- A** Application

