CHAPTER 7

The Nervous System

The nervous system is the master coordinating system of the body. Every thought, action, and sensation reflects its activity. Because of its complexity, the structures of the nervous system are described in terms of two principal divisions—the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS, consisting of the brain and spinal cord, interprets incoming sensory information and issues instructions based on past experience. The PNS, consisting of cranial and spinal nerves and ganglia, provides the communication lines between the CNS and the body's muscles, glands, and sensory receptors. The nervous system is also divided functionally in terms of motor activities into the somatic and autonomic divisions. It is important, however, to recognize that these classifications are made for the sake of convenience and that the nervous system acts in an integrated manner both structurally and functionally.

Student activities provided in this chapter review neuron anatomy and physiology, identify the various structures of the central and peripheral nervous system, consider reflex and sensory physiology, and summarize autonomic nervous system anatomy and physiology. Because every body system is controlled, at least in part, by the nervous system, these understandings are extremely important to comprehending how the body functions as a whole.

1. List the three major functions of the nervous system.

1. _____

_____

2. _____

_____

3. _____

_____

ORGANIZATION OF THE NERVOUS SYSTEM

2. Choose the key responses that best correspond to the descriptions provided in the following statements. Insert the appropriate letter or term in the answer blanks.

Key Choices

A. Autonomic nervous system
B. Central nervous system (CNS)
C. Peripheral nervous system (PNS)
D. Somatic nervous system

_____ 1. Nervous system subdivision that is composed of the brain and spinal cord

_____ 2. Subdivision of the PNS that controls voluntary activities such as the activation of skeletal muscles

_____ 3. Nervous system subdivision that is composed of the cranial and spinal nerves and ganglia

_____ 4. Subdivision of the PNS that regulates the activity of the heart and smooth muscle, and of glands; it is also called the involuntary nervous system

_____ 5. A major subdivision of the nervous system that interprets incoming information and issues orders

_____ 6. A major subdivision of the nervous system that serves as communication lines, linking all parts of the body to the CNS

NERVOUS TISSUE—STRUCTURE AND FUNCTION

3. This exercise emphasizes the difference between neurons and neuroglia. Indicate which cell type is identified by the following descriptions. Insert the appropriate letter or term in the answer blanks.

Key Choices

A. Neurons
B. Neuroglia

_____ 1. Support, insulate, and protect cells

_____ 2. Demonstrate irritability and conductivity, and thus transmit electrical messages from one area of the body to another area

_____ 3. Release neurotransmitters

_____ 4. Are amitotic

_____ 5. Able to divide; therefore are responsible for most brain neoplasms

4. Relative to neuron anatomy, match the anatomical terms given in Column B with the appropriate descriptions of function provided in Column A. Place the correct term or letter response in the answer blanks.

	Column A	**Column B**
_____	1. Releases neurotransmitters	A. Axon
_____	2. Conducts electrical currents toward the cell body	B. Axonal terminal
_____	3. Increases the speed of impulse transmission	C. Dendrite
_____	4. Location of the nucleus	D. Myelin sheath
_____	5. Generally conducts impulses away from the cell body	E. Cell body

5. Certain activities or sensations are listed below. Using key choices, select the specific receptor type that would be activated by the activity or sensation described. Insert the correct term(s) or letter response(s) in the answer blanks. Note that more than one receptor type may be activated in some cases.

Key Choices

A. Bare nerve endings (pain)
B. Golgi tendon organ
C. Meissner's corpuscle
D. Muscle spindle
E. Pacinian corpuscle

Activity or Sensation	**Receptor Type**
Walking on hot pavement	1. (Identify two) _____ and _____
Feeling a pinch	2. (Identify two) _____ and _____
Leaning on a shovel	3. _____
Muscle sensations when rowing a boat	4. (Identify two) _____ and _____
Feeling a caress	5. _____

6. Using key choices, select the terms identified in the following descriptions by inserting the appropriate letter or term in the spaces provided.

Key Choices

A. Afferent neuron	F. Neuroglia	K. Proprioceptors
B. Association neuron	G. Neurotransmitters	L. Schwann cells
C. Cutaneous sense organs	H. Nerve	M. Synapse
D. Efferent neuron	I. Nodes of Ranvier	N. Stimuli
E. Ganglion	J. Nuclei	O. Tract

_____ 1. Sensory receptors found in the skin, which are specialized to detect temperature, pressure changes, and pain

_____ 2. Specialized cells that myelinate the fibers of neurons found in the PNS

_____ 3. Junction or point of close contact between neurons

_____ 4. Bundle of nerve processes inside the CNS

_____ 5. Neuron, serving as part of the conduction pathway between sensory and motor neurons

_____ 6. Gaps in a myelin sheath

_____ 7. Collection of nerve cell bodies found outside the CNS

_____ 8. Neuron that conducts impulses away from the CNS to muscles and glands

_____ 9. Sensory receptors found in muscle and tendons that detect their degree of stretch

_____ 10. Changes, occurring within or outside the body, that affect nervous system functioning

_____ 11. Neuron that conducts impulses toward the CNS from the body periphery

_____ 12. Chemicals released by neurons that stimulate other neurons, muscles, or glands

7. Figure 7–1 is a diagram of a neuron. First, label the parts indicated on the illustration by leader lines. Then choose different colors for each of the structures listed below and use them to color in the coding circles and corresponding structures in the illustration. Next, circle the term in the list of three terms to the left of the diagram that best describes this neuron's structural class. Finally, draw arrows on the figure to indicate the direction of impulse transmission along the neuron's membrane.

- ◯ Axon
- ◯ Dendrites
- ◯ Cell body
- ◯ Myelin sheath

Unipolar

Bipolar

Multipolar

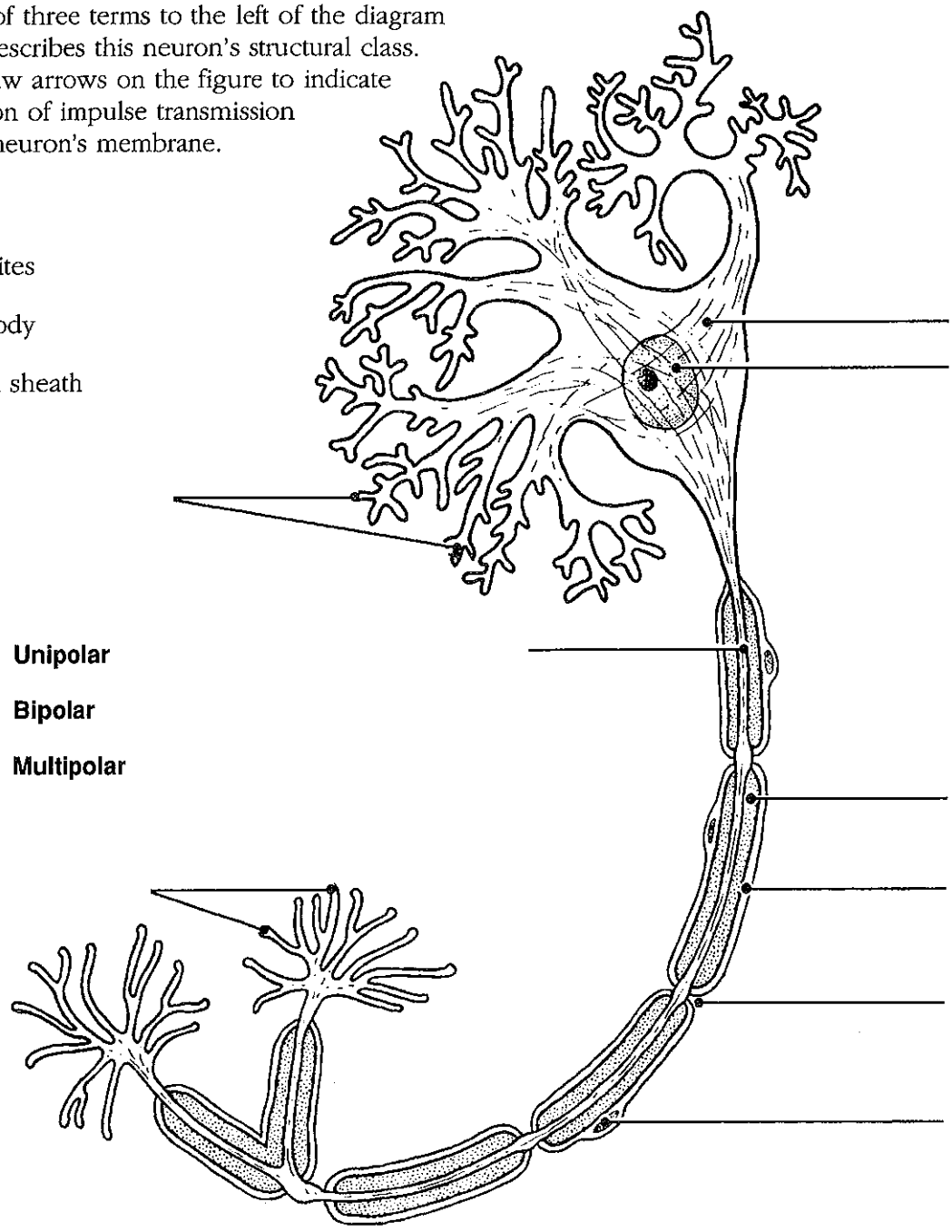


Figure 7–1

8. List in order the *minimum* elements in a reflex arc from the stimulus to the activity of the effector. Place your responses in the answer blanks.

1. Stimulus
2. _____
3. _____
4. _____
5. Effector organ

9. Using the key choices, identify the terms defined in the following statements. Place the correct term or letter response in the answer blanks.

Key Choices

A. Action potential
B. Depolarization
C. Polarized
D. Potassium ions
E. Refractory period
F. Repolarization
G. Sodium ions
H. Sodium-potassium pump

_____ 1. Period of repolarization of the neuron during which it cannot respond to a second stimulus

_____ 2. State in which the resting potential is reversed as sodium ions rush into the neuron

_____ 3. Electrical condition of the plasma membrane of a resting neuron

_____ 4. Period during which potassium ions diffuse out of the neuron

_____ 5. Transmission of the depolarization wave along the neuron's membrane

_____ 6. The chief positive intracellular ion in a resting neuron

_____ 7. Process by which ATP is used to move sodium ions out of the cell and potassium ions back into the cell; completely restores the resting conditions of the neuron

10. Using the key choices, identify the types of reflexes involved in each of the following situations.

Key Choices

A. Somatic reflex(es)
B. Autonomic reflex(es)

_____ 1. Patellar (knee-jerk) reflex

_____ 2. Pupillary light reflex

_____ 3. Effectors are skeletal muscles

_____ 4. Effectors are smooth muscle and glands

_____ 5. Flexor reflex

_____ 6. Regulation of blood pressure

_____ 7. Salivary reflex

11. Refer to Figure 7–2, showing a reflex arc, as you complete this exercise. First, briefly answer the following questions by inserting your responses in the spaces provided.

1. What is the stimulus? _____

2. What tissue is the effector? _____

3. How many synapses occur in this reflex arc? _____

Next, select different colors for each of the following structures and use them to color in the coding circles and corresponding structures in the diagram. Finally, draw arrows on the figure indicating the direction of impulse transmission through this reflex pathway.

◯ Receptor region ◯ Association neuron

◯ Afferent neuron ◯ Efferent neuron

◯ Effector

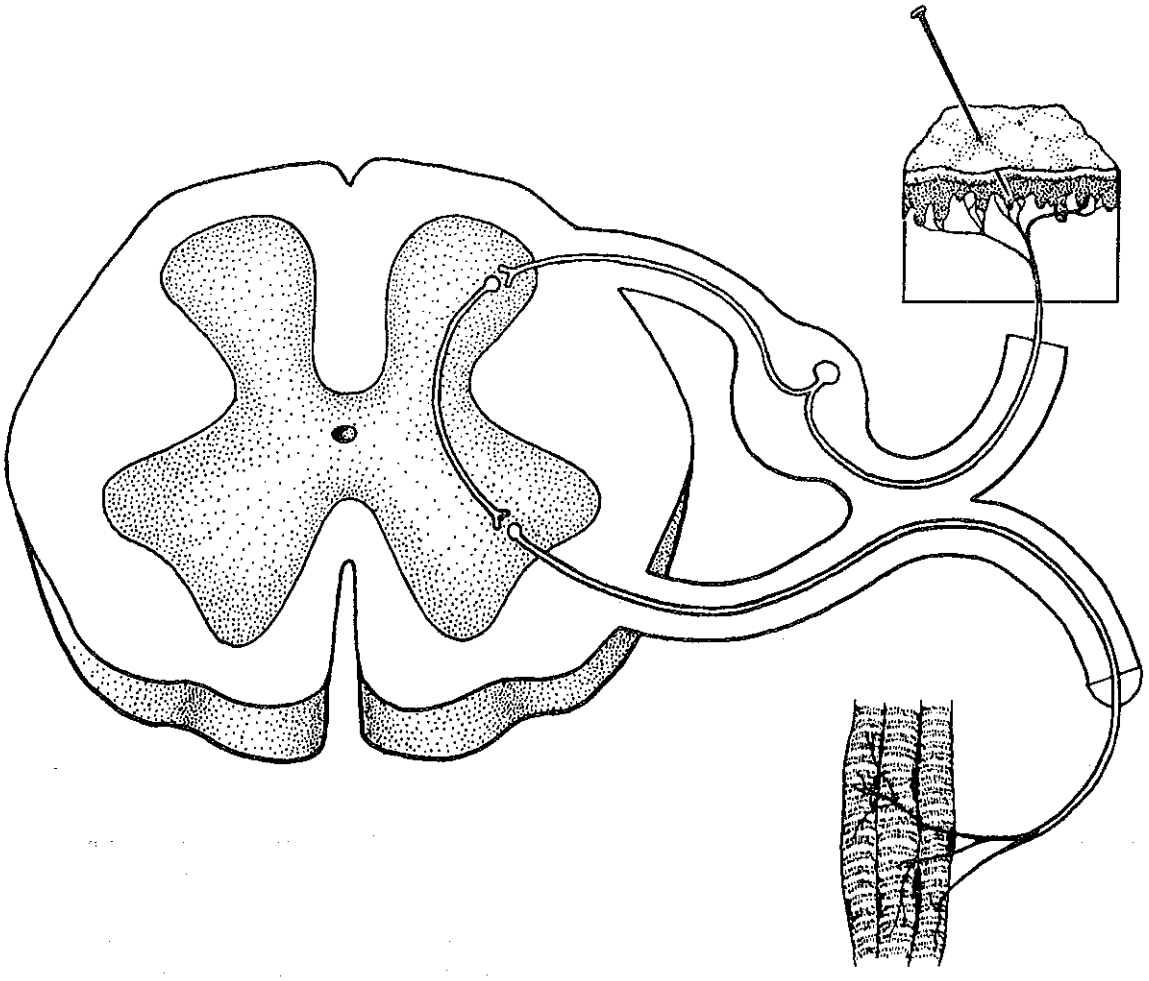


Figure 7–2

12. Circle the term that does not belong in each of the following groupings.

1. Astrocytes Neurons Oligodendrocytes Microglia
2. K+ enters the cell K+ leaves the cell Repolarization Refractory period
3. Nodes of Ranvier Myelin sheath Unmyelinated Saltatory conduction
4. Predictable response Voluntary act Involuntary act Reflex
5. Oligodendrocytes Schwann cells Myelin Microglia
6. Cutaneous receptors Free dendritic endings Stretch Pain and touch
7. Cell interior High Na+ Low Na+ High K+

CENTRAL NERVOUS SYSTEM

Brain

13. Complete the following statements by inserting your answers in the answer blanks.

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.

The largest part of the human brain is the (paired) __(1)__. The other major subdivisions of the brain are the __(2)__ and the __(3)__. The cavities found in the brain are called __(4)__. They contain __(5)__.

14. Circle the terms indicating structures that are *not* part of the brain stem.

Cerebral hemispheres Midbrain Medulla

Pons Cerebellum Diencephalon

15. Complete the following statements by inserting your answers in the answer blanks.

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.

A __(1)__ is an elevated ridge of cerebral cortex tissue. The convolutions seen in the cerebrum are important because they increase the __(2)__. Gray matter is composed of __(3)__. White matter is composed of __(4)__, which provide for communication between different parts of the brain as well as with lower CNS centers. The lentiform nucleus, the caudate, and other nuclei are collectively called the __(5)__.

16. Figure 7–3 is a diagram of the right lateral view of the human brain. First, match the letters on the diagram with the following list of terms and insert the appropriate letters in the answer blanks. Then, select different colors for each of the areas of the brain provided with a color-coding circle and use them to color in the coding circles and corresponding structures in the diagram. If an identified area is part of a lobe, use the color you selected for the lobe but use *stripes* for that area.

_____ 1. ◯ Frontal lobe

_____ 2. ◯ Parietal lobe

_____ 3. ◯ Temporal lobe

_____ 4. ◯ Precentral gyrus

_____ 5. Parieto-occipital fissure

_____ 6. ◯ Postcentral gyrus

_____ 7. Lateral sulcus

_____ 8. Central sulcus

_____ 9. ◯ Cerebellum

_____ 10. ◯ Medulla

_____ 11. ◯ Occipital lobe

_____ 12. ◯ Pons

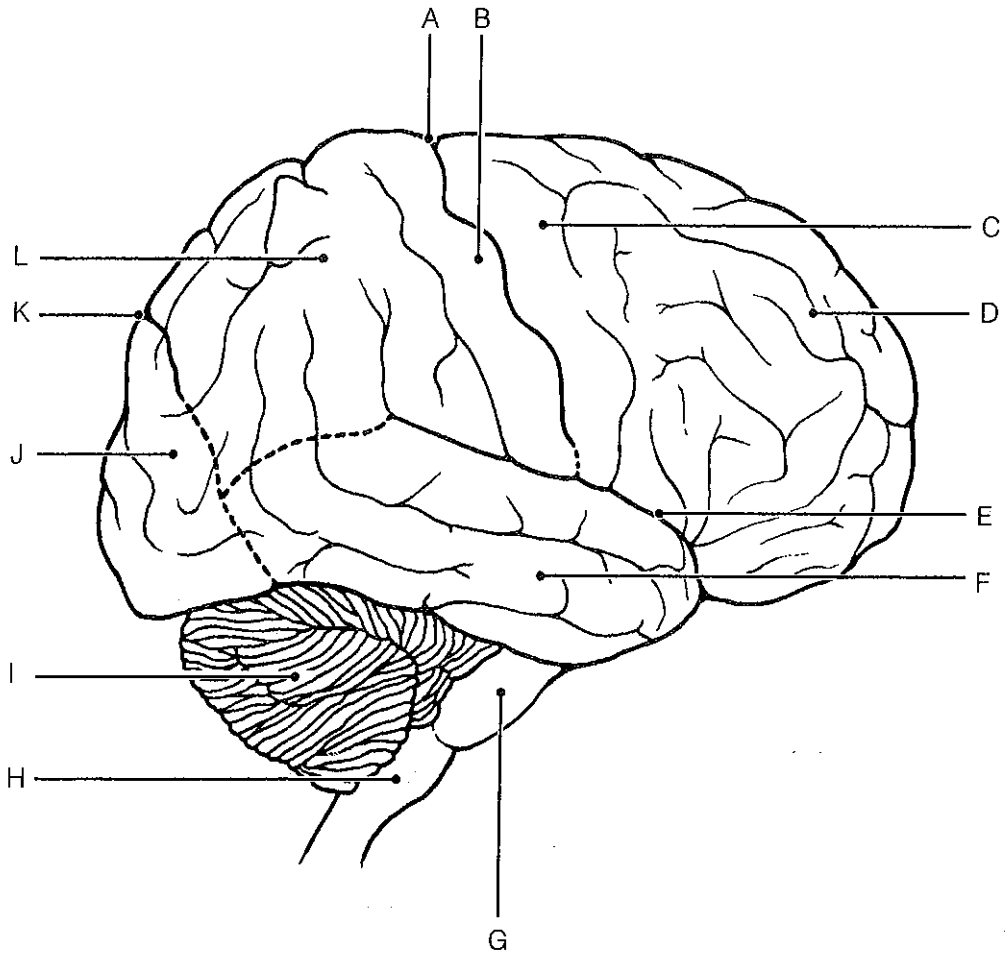


Figure 7–3

17. Figure 7–4 is a diagram of the sagittal view of the human brain. First, match the letters on the diagram with the following list of terms and insert the appropriate letter in each answer blank. Then, color the brain-stem areas blue and the areas where cerebrospinal fluid is found yellow.

_____ 1. Cerebellum
_____ 2. Cerebral aqueduct
_____ 3. Cerebral hemisphere
_____ 4. Cerebral peduncle
_____ 5. Choroid plexus
_____ 6. Corpora quadrigemina
_____ 7. Corpus callosum
_____ 8. Fourth ventricle
_____ 9. Hypothalamus
_____ 10. Medulla oblongata
_____ 11. Optic chiasma
_____ 12. Pineal body
_____ 13. Pituitary gland
_____ 14. Pons
_____ 15. Thalamus

18. Referring to the brain areas listed in Exercise 17, match the appropriate brain structures with the following descriptions. Insert the correct terms in the answer blanks.

_____ 1. Site of regulation of water balance and body temperature

_____ 2. Contains reflex centers involved in regulating respiratory rhythm in conjunction with lower brain stem centers

_____ 3. Responsible for the regulation of posture and coordination of skeletal muscle movements

_____ 4. Important relay station for afferent fibers traveling to the sensory cortex for interpretation

_____ 5. Contains autonomic centers, which regulate blood pressure and respiratory rhythm, as well as coughing and sneezing centers

_____ 6. Large fiber tract connecting the cerebral hemispheres

_____ 7. Connects the third and fourth ventricles

_____ 8. Encloses the third ventricle

_____ 9. Forms the cerebrospinal fluid

_____ 10. Midbrain area that is largely fiber tracts; bulges anteriorly

_____ 11. Part of the limbic system; contains centers for many drives (rage, pleasure, hunger, sex, etc.)

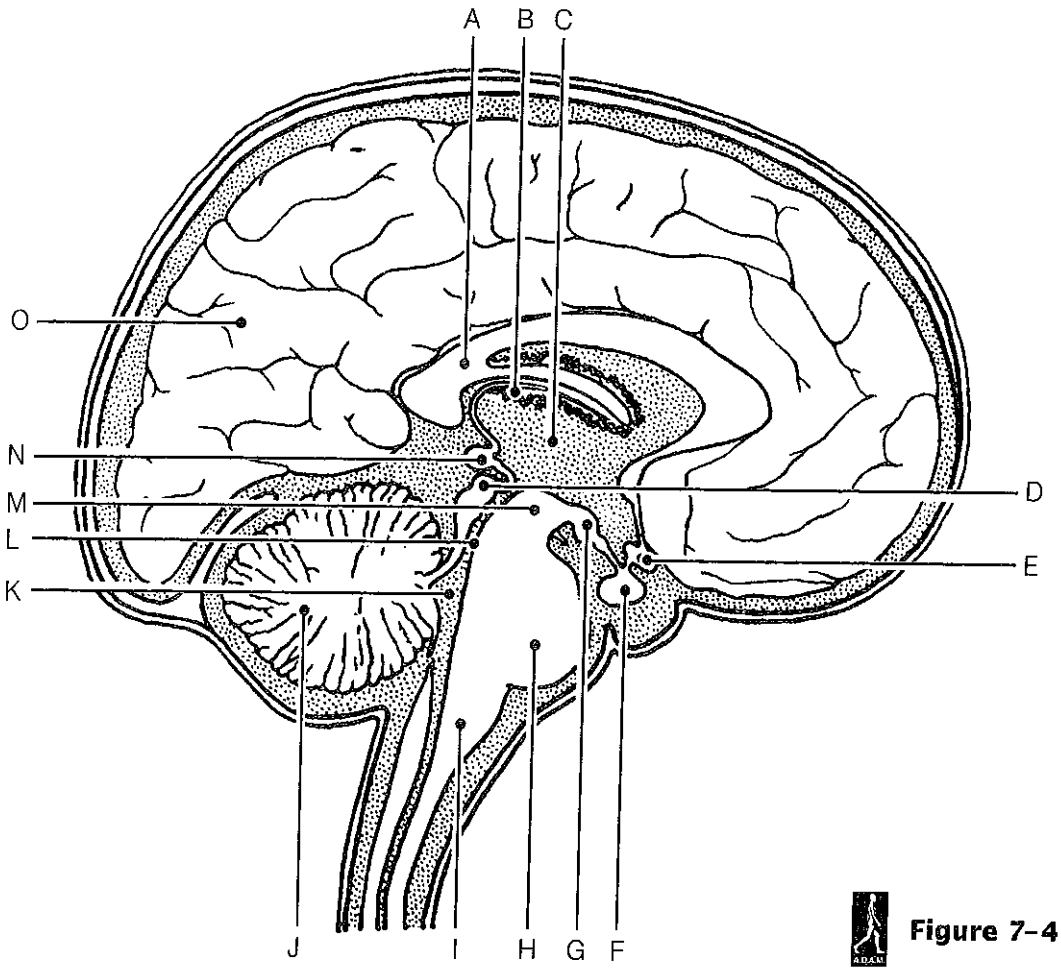


Figure 7–4

19. For each of the following statements that is true, insert *T* in the answer blank. If any of the statements are false, correct the underlined term by inserting the correct term in the answer blank.

_____ 1. The primary sensory area of the cerebral hemisphere(s) is found in the precentral gyrus.

_____ 2. Cortical areas involved in audition are found in the occipital lobe.

_____ 3. The primary motor area in the temporal lobe is involved in the initiation of voluntary movements.

_____ 4. A specialized motor speech area located at the base of the precentral gyrus is called Wernicke's area.

_____ 5. The right cerebral hemisphere receives sensory input from the right side of the body.

_____ 6. The pyramidal tract is the major descending voluntary motor tract.

_____ 7. Damage to the thalamus impairs consciousness and the awake/sleep cycles.

→

_____ 8. A flat EEG is evidence of clinical death.

_____ 9. Beta waves are recorded when an individual is awake and relaxed.

Protection of the CNS—Meninges and Cerebrospinal Fluid

20. Identify the meningeal (or associated) structures described here.

_____ 1. Outermost covering of the brain, composed of tough fibrous connective tissue

_____ 2. Innermost covering of the brain; delicate and vascular

_____ 3. Structures that return cerebrospinal fluid to the venous blood in the dural sinuses

_____ 4. Middle meningeal layer; like a cobweb in structure

_____ 5. Its outer layer forms the periosteum of the skull

21. Figure 7–5 shows a frontal view of the meninges of the brain at the level of the superior sagittal (dural) sinus. First, label the *arachnoid villi* on the figure. Then, select different colors for each of the following structures and use them to color the coding circles and corresponding structures in the diagram.

◯ Dura mater

◯ Pia mater

◯ Arachnoid membrane

◯ Subarachnoid space

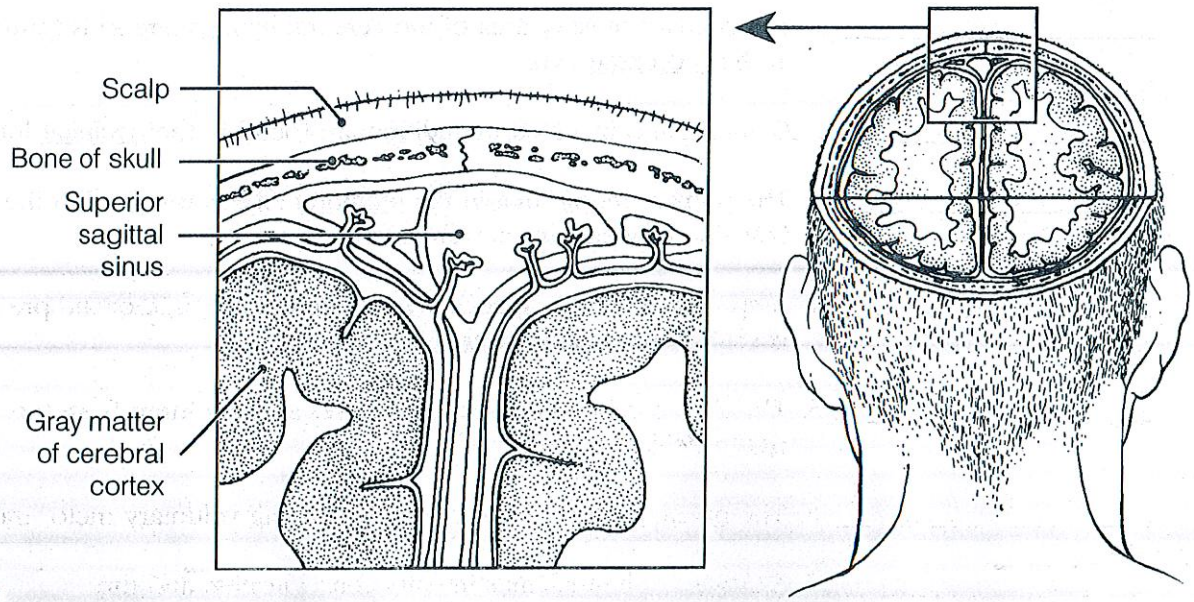
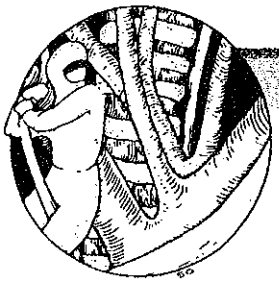


Figure 7–5

DEVELOPMENTAL ASPECTS OF THE NERVOUS SYSTEM

38. Complete the following statements by inserting your responses in the answer blanks.

Body temperature regulation is a problem in premature infants because the __(1)__ is not yet fully functional. Cerebral palsy involves crippling neuromuscular problems. It usually is a result of a lack of __(2)__ to the infant's brain during delivery. Normal maturation of the nervous system occurs in a __(3)__ direction, and fine control occurs much later than __(4)__ muscle control. The sympathetic nervous system becomes less efficient as aging occurs, resulting in an inability to prevent sudden changes in __(5)__ when abrupt changes in position are made. The usual cause of decreasing efficiency of the nervous system as a whole is __(6)__. A change in intellect due to a gradual decrease in oxygen delivery to brain cells is called __(7)__. Death of brain neurons, which results from a sudden cessation of oxygen delivery, is called a __(8)__.



INCREDIBLE JOURNEY

A Visualization Exercise for the Nervous System

You climb on the first cranial nerve you see . . .

39. Where necessary, complete statements by inserting the missing words in the answer blanks.

Nervous tissue is quite densely packed, and it is difficult to envision strolling through its various regions. Imagine instead that each of the various functional regions of the brain has a computerized room where you can observe what occurs in that particular area. Your assignment is to determine where you are at any given time during your journey through the nervous system.

You begin your journey after being miniaturized and injected into the warm pool of cerebrospinal fluid in your host's fourth ventricle. As you begin your stroll through the nervous tissue, you notice a huge area of branching white matter overhead. As you enter the first computer room you hear an announcement through the loudspeaker, "The pelvis is tipping too far posteriorly. Please correct. We are beginning to fall backward and will soon lose our balance." The computer responds immediately, decreasing impulses to the posterior hip muscles and increasing impulses to the anterior thigh muscles. "How is that, proprioceptor 1?" From this information, you determine that your first stop is __(1)__.

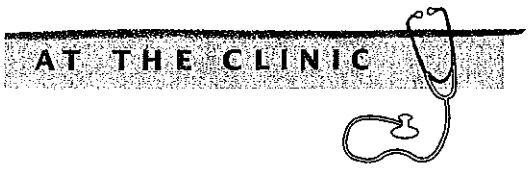
_____ 2.
_____ 3.
_____ 4.
_____ 5.
_____ 6.
_____ 7.
_____ 8.
_____ 9.
_____ 10.
_____ 11.
_____ 12.

At the next computer room, you hear, "Blood pressure to head is falling; increase sympathetic nervous system stimulation of the blood vessels." Then, as it becomes apparent that your host has not only stood up but is going to run, you hear, "Increase rate of impulses to the heart and respiratory muscles. We are going to need more oxygen and a faster blood flow to the skeletal muscles of the legs." You recognize that this second stop must be the __(2)__.

Computer room 3 presents a problem. There is no loudspeaker here. Instead, incoming messages keep flashing across the wall, giving only bits and pieces of information. "Four hours since last meal: stimulate appetite center. Slight decrease in body temperature: initiate skin vasoconstriction. Mouth dry: stimulate thirst center. Oh, a stroke on the arm: stimulate pleasure center." Looking at what has been recorded here—appetite, temperature, thirst, and pleasure—you conclude that this has to be the __(3)__.

Continuing your journey upward toward the higher brain centers, finally you are certain that you have reached the cerebral cortex. The first center you visit is quiet, like a library with millions of "encyclopedias" of facts and recordings of past input. You conclude that this must be the area where __(4)__ are stored, and that you are in the __(5)__ lobe. The next stop is close by. As you enter the computer center, you once again hear a loudspeaker: "Let's have the motor instructions to say tintinnabulation. Hurry, we don't want them to think we're tongue-tied." This area is obviously __(6)__. Your final stop in the cerebral cortex is a very hectic center. Electrical impulses are traveling back and forth between giant neurons, sometimes in different directions and sometimes back and forth between a small number of neurons. Watching intently, you try to make some sense out of these interactions, and suddenly realize that this *is* what is happening here. The neurons *are* trying to make some sense out of something, and this helps you decide that this must be the brain area where __(7)__ occurs in the __(8)__ lobe.

You hurry out of this center and retrace your steps back to the cerebrospinal fluid, deciding en route to observe a cranial nerve. You decide to pick one randomly and follow it to the organ it serves. You climb on to the first cranial nerve you see and slide down past the throat. Picking up speed, you quickly pass the heart and lungs and see the stomach and small intestine coming up fast. A moment later you land on the stomach and now you know that this wandering nerve has to be the __(9)__. As you look upward, you see that the nerve is traveling almost straight up and that you'll have to find an alternative route back to the cerebrospinal fluid. You begin to walk posteriorly until you find a spinal nerve, which you follow until you reach the vertebral column. You squeeze between two adjacent vertebrae to follow the nerve to the spinal cord. With your pocket knife you cut away the tough connective tissue covering the cord. Thinking that the __(10)__ covering deserves its name, you finally manage to cut an opening large enough to get through and you return to the warm bath of cerebrospinal fluid that it encloses. At this point you are in the __(11)__, and from here you swim upward until you get to the lower brain stem. Once there, it should be an easy task to find the holes leading into the __(12)__ ventricle, where your journey began.



40. After surgery, patients are often temporarily unable to urinate, and bowel sounds are absent. Identify the division of the autonomic nervous system that is affected by anesthesia.

41. A brain tumor is found in a CT scan of Mr. Childs's head. The physician is assuming that it is not a secondary tumor (i.e., it did not spread from another part of the body) because an exhaustive workup has revealed no signs of cancer elsewhere in Mr. Childs's body. Is the brain tumor more likely to have developed from nerve tissue or from neuroglia? Why?

42. Amy, a high-strung teenager, was suddenly startled by a loud bang that sounded like a gunshot. Her heartbeat accelerated rapidly. When she realized that the noise was only a car backfiring, she felt greatly relieved but her heart kept beating heavily for several minutes more. Why does it take a long time to calm down after we are scared?

43. While working in the emergency room, you admit two patients who were in an auto collision. One is dead on arrival, having sustained a severed spinal cord at the level of C_2. The other patient suffered a similar injury but at the level of C_6 and is still alive. Explain briefly, in terms of the origin and function of the phrenic nerves, why one injury was fatal and the other was not.

44. You have been told that the superior and medial part of the right precentral gyrus of your patient's brain has been destroyed by a stroke. What part of the body is the patient unable to move? On which side, right or left?

45. *Application of knowledge:* You have been given all of the information needed to identify the brain regions involved in the following situations. See how well your nervous system has integrated this information, and name the brain region (or condition) most likely to be involved in each situation. Place your responses in the answer blanks.

1. Following a train accident, a man with an obvious head injury was observed stumbling about the scene. An inability to walk properly and a loss of balance were quite obvious. What brain region was injured?

_____

2. An elderly woman is admitted to the hospital to have a gallbladder operation. While she is being cared for, the nurse notices that she has trouble initiating movement and has a strange "pill-rolling" tremor of her hands. What cerebral area is most likely involved?

_____

3. A child is brought to the hospital with a high temperature. The doctor states that the child's meninges are inflamed. What name is given to this condition?

_____

4. A young woman is brought into the emergency room with extremely dilated pupils. Her friends state that she has overdosed on cocaine. What cranial nerve is stimulated by the drug?

_____

5. A young man has just received serious burns, resulting from standing with his back too close to a bonfire. He is muttering that he never felt the pain. Otherwise, he would have smothered the flames by rolling on the ground. What part of his CNS might be malfunctional?

_____

6. An elderly gentleman has just suffered a stroke. He is able to understand verbal and written language, but when he tries to respond, his words are garbled. What cortical region has been damaged by the stroke?

_____

7. A 12-year-old boy suddenly falls to the ground, having an epileptic seizure. He is rushed to the emergency room of the local hospital for medication. His follow-up care includes a recording of his brain waves to try to determine the area of the lesion. What is this procedure called?

_____

46. Marie Nolin exhibits slow, tentative movements and a very unstable gait. Examination reveals she cannot touch her finger to her nose with eyes closed. What is the name of this condition and what part of her brain is damaged?

47. Which would be the more likely result of injury to the posterior side of the spinal cord only—paralysis or paresthesia (loss of sensory input)? Explain your answer.