SUBDIVISIONS OF THE NERVOUS SYSTEM

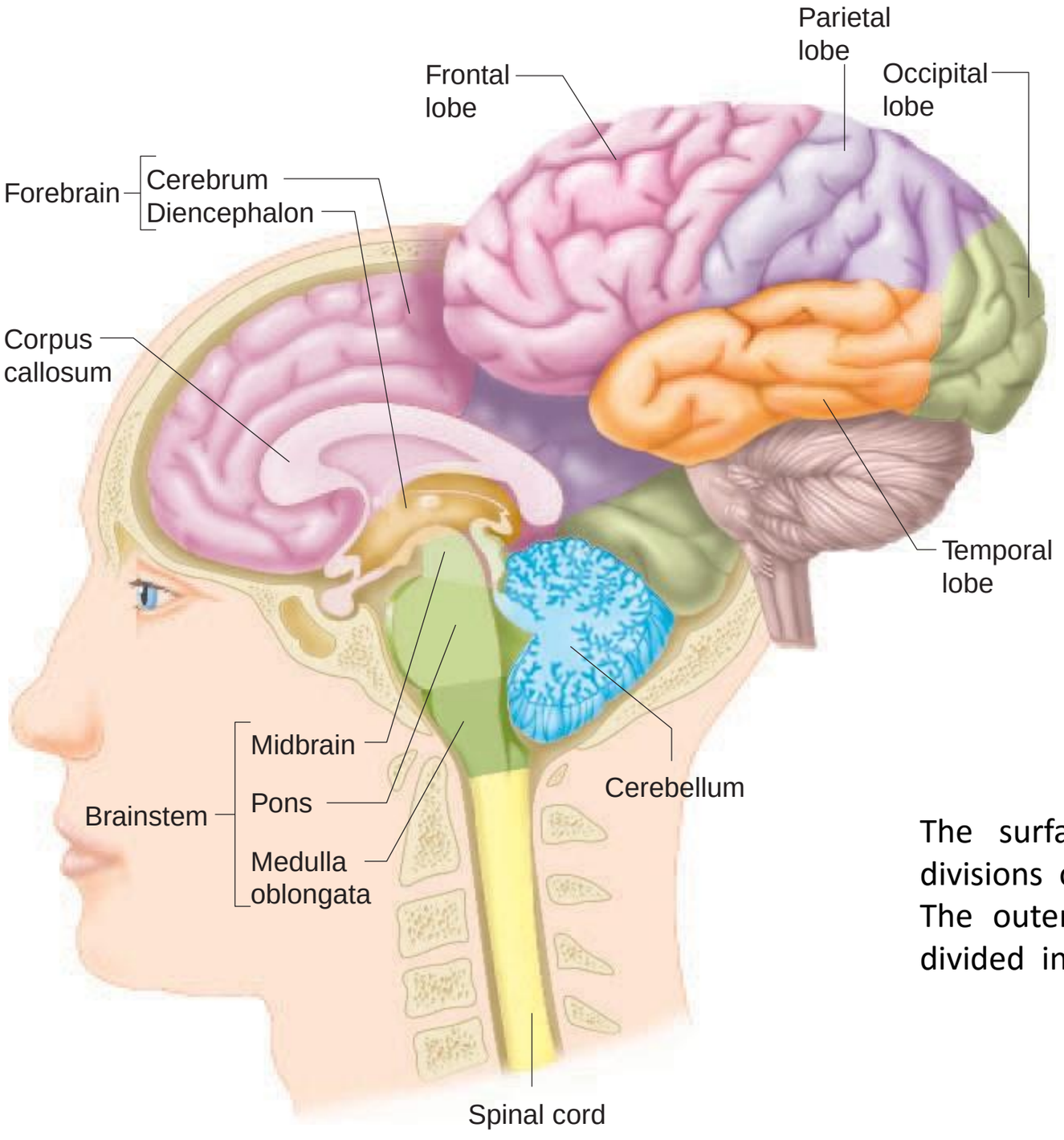
DIVISIONS OF THE CENTRAL NERVOUS SYSTEM

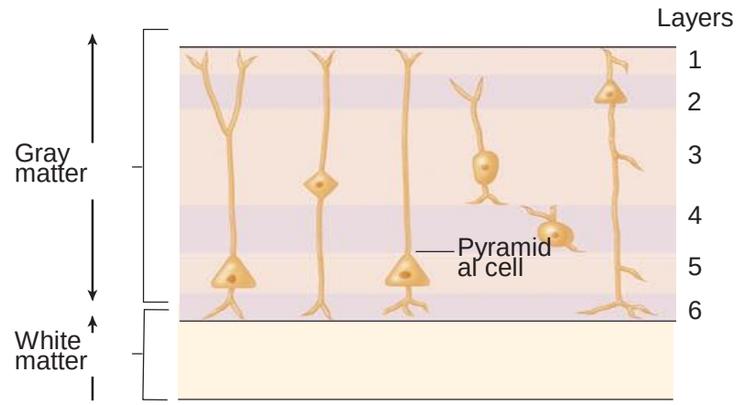
BRAIN:

- The brain is divided into six regions: **cerebrum, diencephalon, midbrain, pons, medulla oblongata**, and **cerebellum**.
- The **cerebrum**, made up of right and left cerebral hemispheres, and the **diencephalon** together form the **forebrain**.
- The **cerebral cortex** forms the outer shell of the cerebrum and is divided into parietal, frontal, occipital, and temporal lobes.
- The **diencephalon** contains the **thalamus** and **hypothalamus**.
- The **limbic system** is a set of deep forebrain structures associated with learning and emotions.
- The **cerebellum** plays a role in posture, movement, and some kinds of memory.
- The **midbrain, pons**, and **medulla** oblongata form the **brainstem**, which contains the **reticular formation**.

THE CEREBRAL CORTEX

DIVISIONS OF THE BRAIN

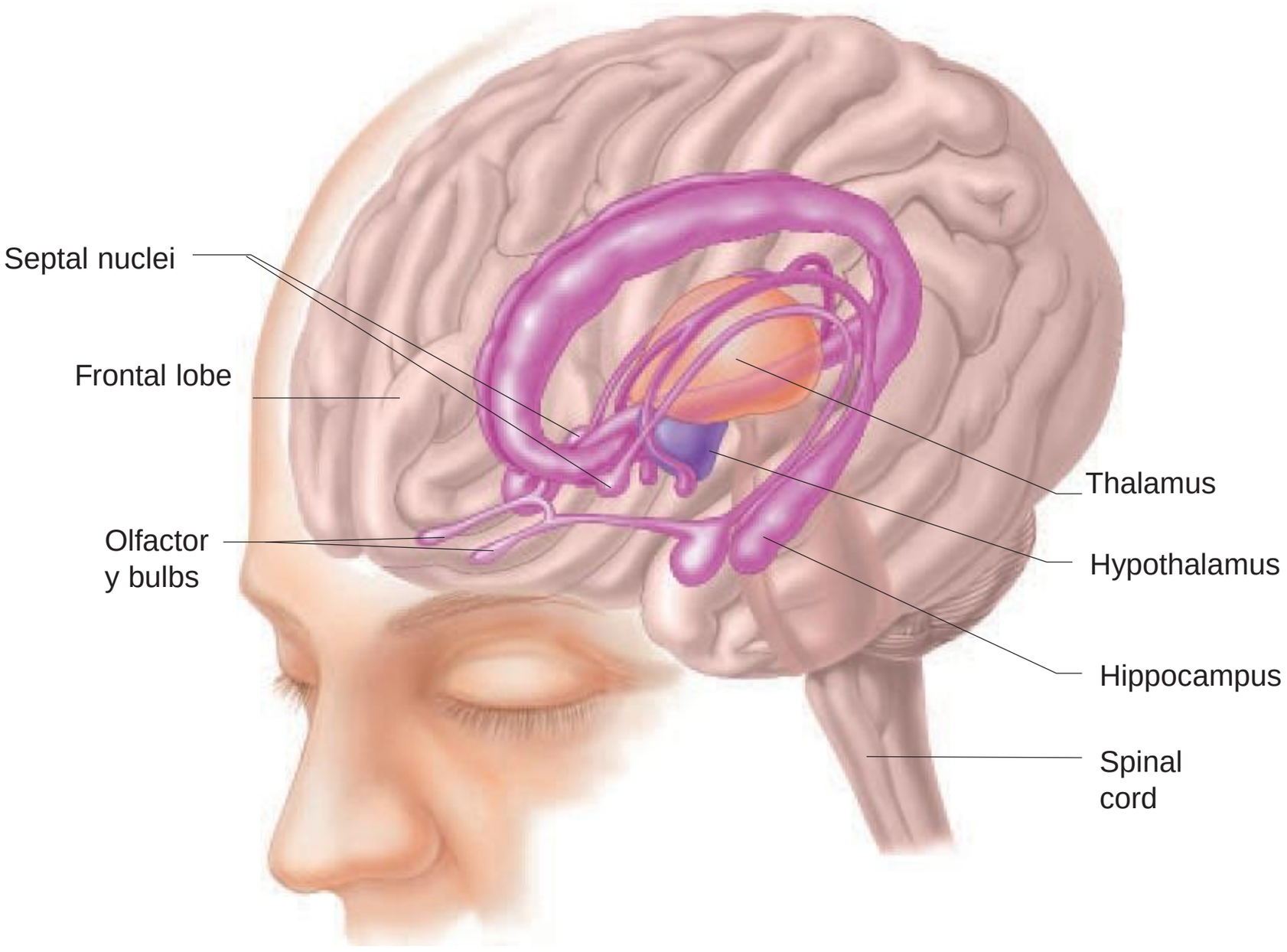




Organization of the cortex showing six cell layers overlying the white matter.

The surface of the cerebral cortex and the divisions of the brain shown in sagittal section. The outer surface of the cerebrum (cortex) is divided into four lobes as shown.

STRUCTURES OF THE LIMBIC SYSTEM AND THEIR ANATOMIC RELATION TO THE HYPOTHALAMUS



The **hypothalamus** lies below the **thalamus** and is on the undersurface of the brain. Although it is a tiny region that accounts for less than 1 percent of the brain's weight, it contains different cell groups and pathways that form the master command center for neural and endocrine coordination.

CEREBELLUM

The **cerebellum** consists of an outer layer of cells, the cerebellar cortex and several deeper cell clusters. Although the cerebellum does not initiate voluntary movements, *it is an important center for coordinating movements and for controlling posture and balance*. In order to carry out these functions, the cerebellum receives information from the muscles and joints, skin, eyes and ears, viscera, and the parts of the brain involved in control of movement. Although the cerebellum's function is almost exclusively motor, it is implicated in some forms of learning.

BRAINSTEM

All the nerve fibers that relay signals between the fore- brain, cerebellum, and spinal cord pass through the brainstem. Running through the core of the brainstem and consisting of loosely arranged neuron cell bodies intermingled with bundles of axons is the **reticular formation,** which is the one part of the brain absolutely essential for life. It receives and integrates input from all regions of the central nervous system and processes a great deal of neural information. The reticular formation is involved in motor functions, cardiovascular and respiratory control, and the mechanisms that regulate sleep and wakefulness and focus attention. Most of the biogenic amine neurotransmitters are released from the axons of cells in the reticular formation and, because of the far-reaching projections of these cells, affect all levels of the nervous system.

FUNCTIONS OF THE MAJOR PARTS OF THEE BRAIN

I. FOREBRAIN

A.Cerebral hemispheres

1.Contain the cerebral cortex, which participates in perception, the generation of skilled movements, reasoning, learning, and memory

2.Contain subcortical nuclei, including those that participate in coordination of skeletal muscle activity

3.Contain interconnecting fiber pathways

B.Thalamus

1.Is a synaptic relay station for sensory pathways on their way to the cerebral cortex

2.Participates in control of skeletal muscle coordination

3.Plays a key role in awareness

C.Hypothalamus

1.Regulates anterior pituitary gland function

2.Regulates water balance

3.Participates in regulation of autonomic nervous system

4.Regulates eating and drinking behavior

5.Regulates reproductive system

6.Reinforces certain behaviors

7.Generates and regulates circadian rhythms

8.Regulates body temperature

9.Participates in generation of emotional behavior

D.Limbic system

1.Participates in generation of emotions and emotional behavior

2.Plays essential role in most kinds of learning

II.CEREBELLUM

A.Coordinates movements, including those for posture and balance

B.Participates in some forms of learning

III.BRAINSTEM

A.Contains all the fibers passing between the spinal cord, forebrain, and cerebellum

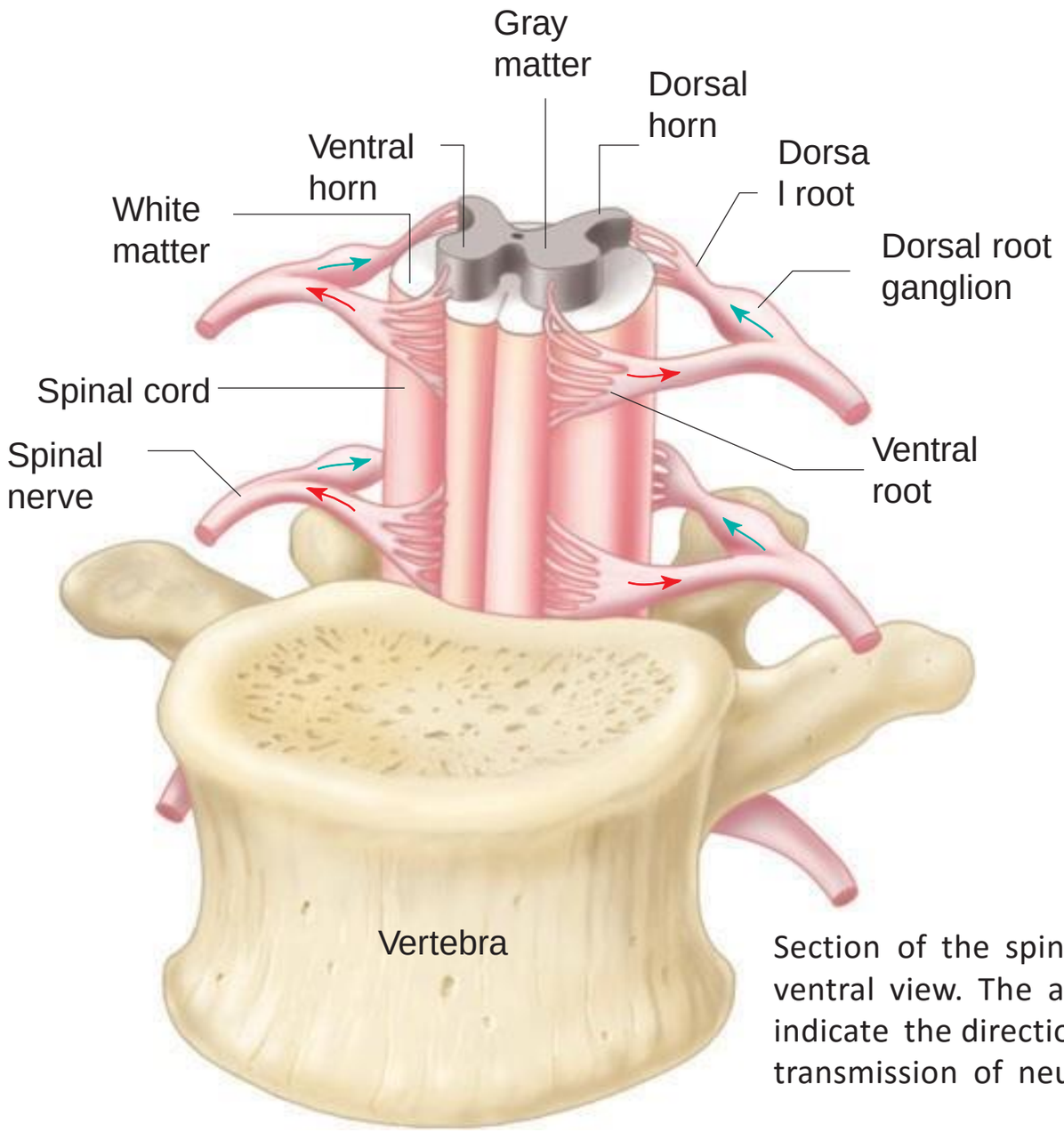
B.Contains the reticular formation and its various integrating centers, including those for cardiovascular and respiratory activity

C.Contains nuclei for cranial nerves III through XII

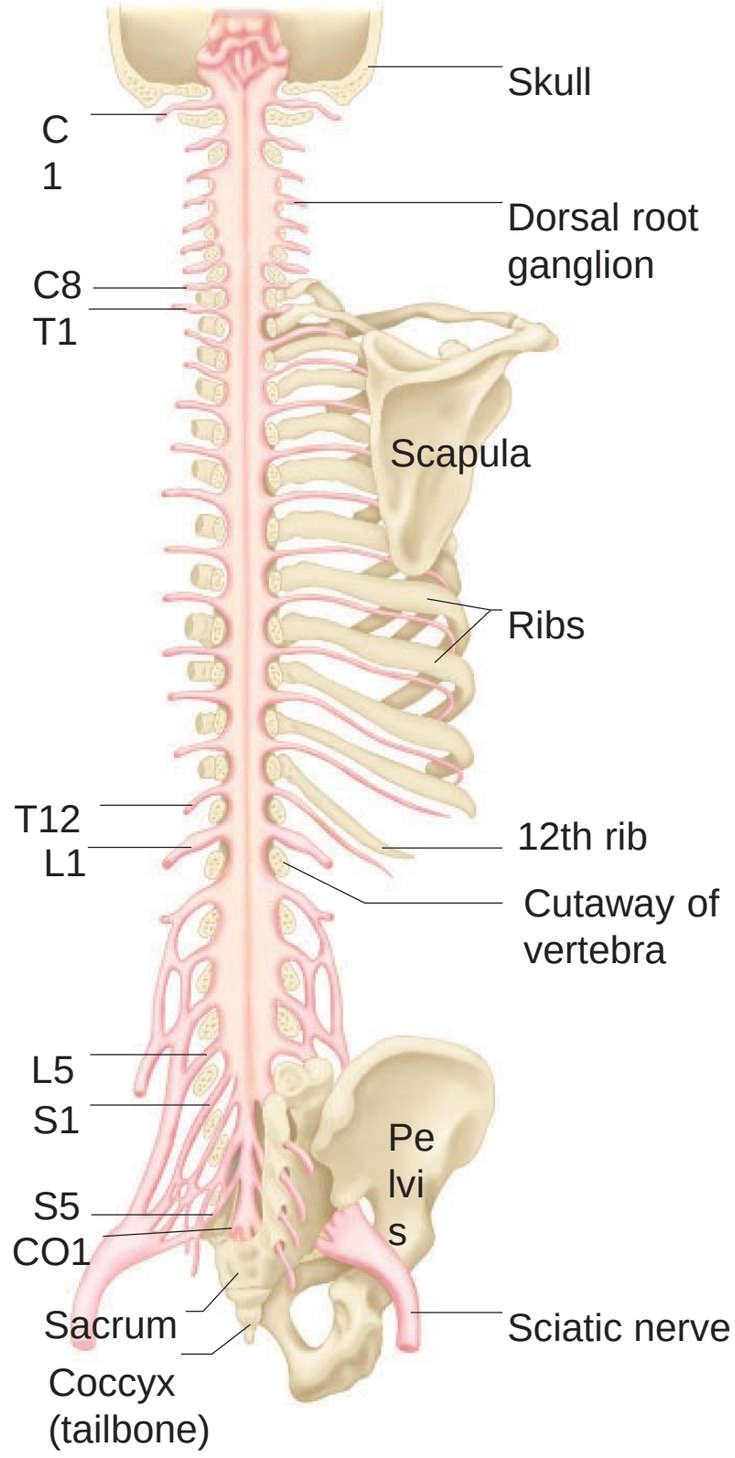
CENTRAL NERVOUS SYSTEM: SPINAL CORD

The spinal cord is divided into two areas: central gray matter, which contains nerve cell bodies and dendrites; and white matter, which surrounds the gray matter and contains myelinated axons organized into ascending or descending tracts. The axons of the afferent and efferent neurons form the spinal nerves.

SPINAL CORD



Section of the spinal cord, ventral view. The arrows indicate the direction of transmission of neural activity.



Dorsal view of the spinal cord. Parts of the skull and vertebrae have been cut away. In general, the eight cervical nerves (C) control the muscles and glands and receive sensory input from the neck, shoulder, arm, and hand. The 12 thoracic nerves (T) are associated with the chest and abdominal walls. The five lumbar nerves (L) are associated with the hip and leg, and the five sacral nerves (S) are associated with the genitals and lower digestive tract.

THE CRANIAL NERVES

NAME	FIBERS	COMMENTS
I. Olfactory	Afferent	Carries input from receptors in olfactory (smell) neuroepithelium. Not true nerve.
II. Optic	Afferent	Carries input from receptors in eye. Not true nerve.
III. Oculomotor	Efferent	Innervates skeletal muscles that move eyeball up, down, and medially and raise upper eyelid; innervates smooth muscles that constrict pupil and alter lens shape for near and far vision.
	Afferent	Transmits information from receptors in muscles.
IV. Trochlear	Efferent	Innervates skeletal muscles that move eyeball downward and laterally.
	Afferent	Transmits information from receptors in muscle.
V. Trigeminal	Efferent	Innervates skeletal chewing muscles.
	Afferent	Transmits information from receptors in skin; skeletal muscles of face, nose, and mouth; and teeth sockets.
VI. Abducens	Efferent	Innervates skeletal muscles that move eyeball laterally.
	Afferent	Transmits information from receptors in muscle.
VII. Facial	Efferent	Innervates skeletal muscles of facial expression and swallowing; innervates nose, palate, and lacrimal and salivary glands.
	Afferent	Transmits information from taste buds in front of tongue and mouth.
VIII. Vestibulocochlear	Afferent	Transmits information from receptors in ear.
IX. Glossopharyngeal	Efferent	Innervates skeletal muscles involved in swallowing and parotid salivary gland.
	Afferent	Transmits information from taste buds at back of tongue and receptors in auditory-tube skin.
X. Vagus	Efferent	Innervates skeletal muscles of pharynx and larynx and smooth muscle and glands of thorax and abdomen.
	Afferent	Transmits information from receptors in thorax and abdomen.
XI. Accessory	Efferent	Innervates neck skeletal muscles.
XII. Hypoglossal	Efferent	Innervates skeletal muscles of tongue.

AUTONOMIC NERVOUS SYSTEM

Divisions of the Peripheral Nervous system

I. Afferent division

II. Efferent division

A. Somatic nervous system

B. Autonomic nervous system

1. Sympathetic division
2. Parasympathetic division
3. Enteric division

Peripheral Nervous System: Somatic and Autonomic Divisions

Somatic

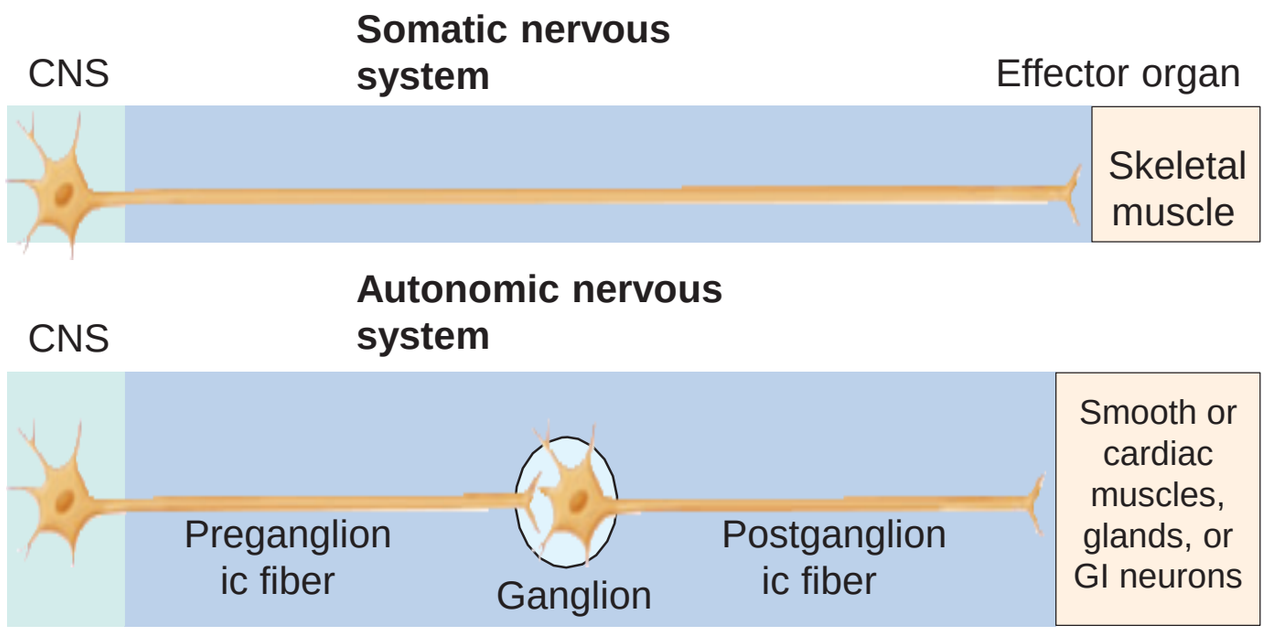
1. Consists of a single neuron between central nervous system and skeletal muscle cells
2. Innervates skeletal muscle
3. Can lead only to muscle excitation

Autonomic

1. Has two-neuron chain (connected by a synapse) between central nervous system and effector organ
2. Innervates smooth and cardiac muscle, glands, and GI neurons
3. Can be either excitatory or inhibitory

PERIPHERAL NERVOUS SYSTEM

- The peripheral nervous system consists of 43 paired nerves—12 pairs of cranial nerves and 31 pairs of spinal nerves.
- Most nerves contain axons of both afferent and efferent neurons.
- The efferent division of the peripheral nervous system is divided into somatic and autonomic parts.
- The somatic fibers innervate skeletal muscle cells and release the neurotransmitter acetylcholine.

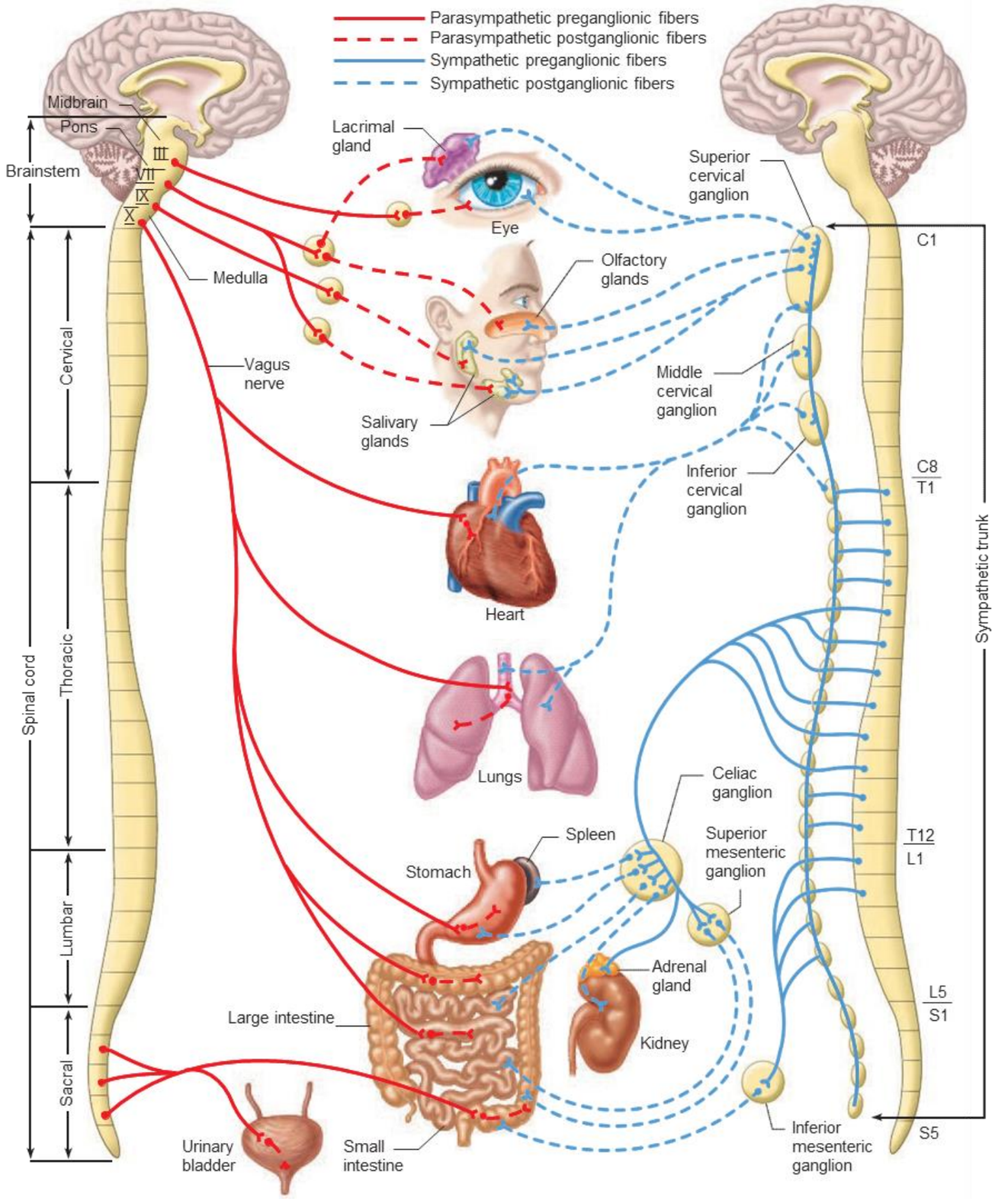


Efferent division of the peripheral nervous system.
Overall plan of the somatic and autonomic nervous systems.

AUTONOMIC NERVOUS SYSTEM

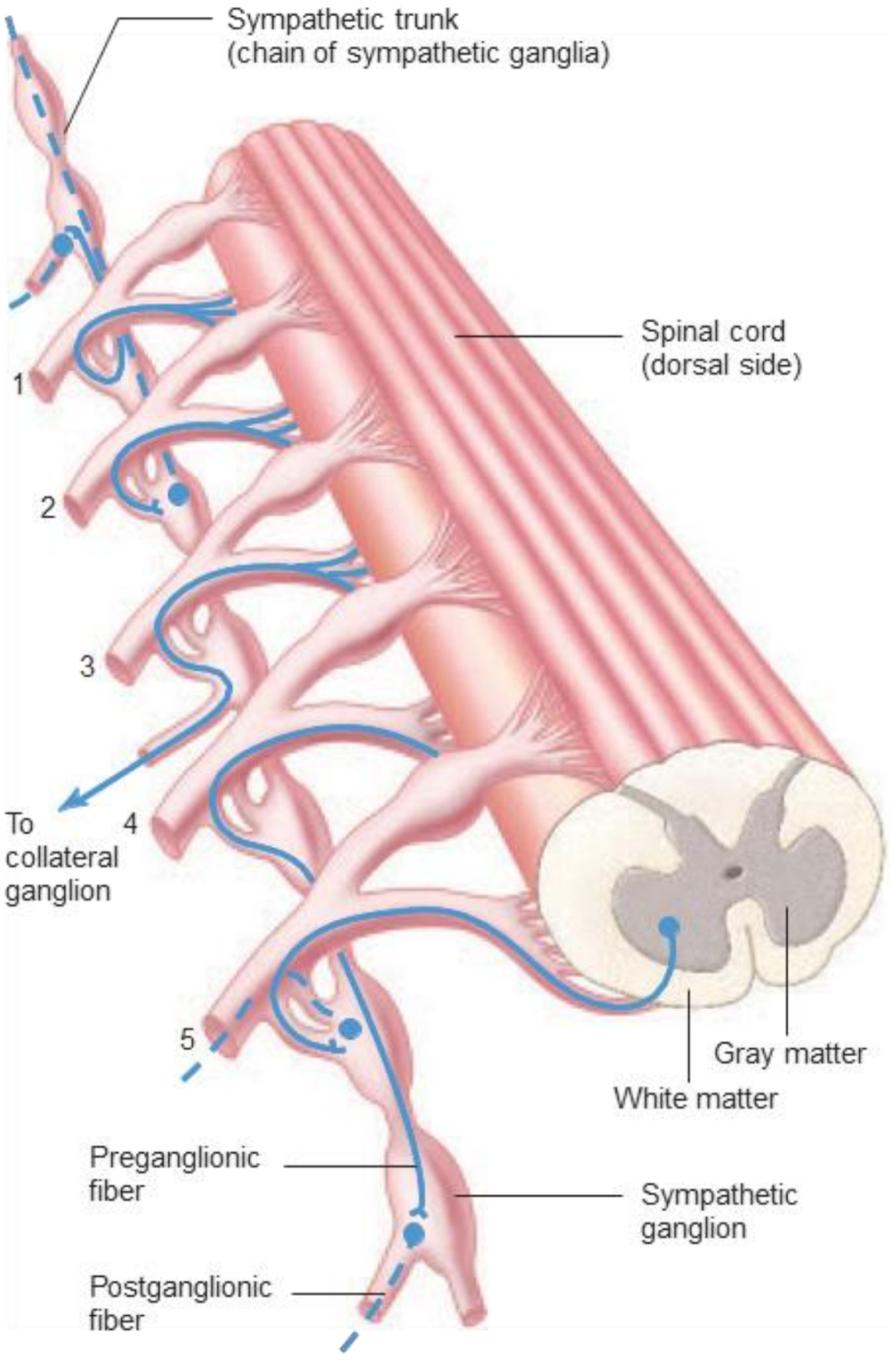
- The autonomic nervous system innervates cardiac and smooth muscle, glands, and gastrointestinal tract neurons. Each autonomic pathway consists of a preganglionic neuron with its cell body in the CNS and a postganglionic neuron with its cell body in an autonomic ganglion outside the CNS.
- The autonomic nervous system is divided into sympathetic and parasympathetic components. The preganglionic neurons in both sympathetic and parasympathetic divisions release acetylcholine; the postganglionic parasympathetic neurons release mainly acetylcholine; and the postganglionic sympathetic cells release mainly norepinephrine.
- The adrenal medulla is a hormone-secreting part of the sympathetic nervous system and secretes mainly epinephrine.
- Many effector organs innervated by the autonomic nervous system receive dual innervation from the sympathetic and parasympathetic division of the autonomic nervous system.

THE PARASYMPATHETIC AND SYMPATHETIC DIVISIONS OF THE AUTONOMIC NERVOUS SYSTEM



The celiac, superior mesenteric, and inferior mesenteric ganglia are collateral ganglia. Only one sympathetic trunk is indicated, although there are two, one on each side of the spinal cord. Not shown are the fibers passing to the liver, blood vessels, genitalia, and skin glands.

SYMPATHETIC NERVOUS SYSTEM



Relationship between a sympathetic trunk and spinal nerves (1 through 5) with the various courses that preganglionic sympathetic fibers (solid lines) take through the sympathetic trunk. Dashed lines represent postganglionic fibers.

LOCATIONS OF RECEPTORS FOR ACETYLCHOLINE, NOREPINEPHRINE, AND EPINEPHRINE

I.Receptors for acetylcholine

a.Nicotinic receptors

On postganglionic neurons in the autonomic ganglia At neuromuscular junctions of skeletal muscle

On some central nervous system neurons

b.Muscarinic receptors

On smooth muscle On cardiac muscle On gland cells

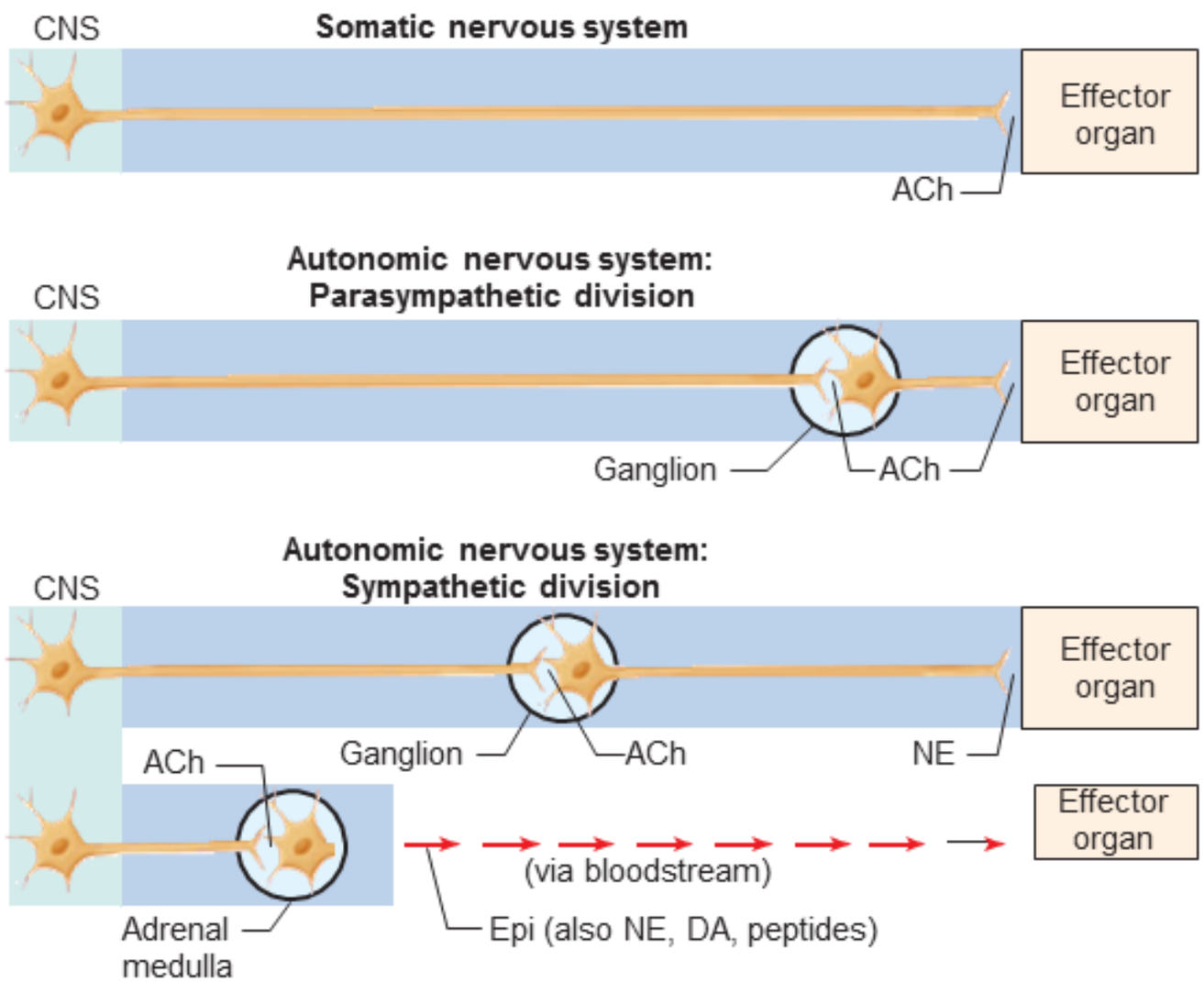
On some central nervous system neurons

On some neurons of autonomic ganglia (although the great majority of receptors at this site are nicotinic)

II. Receptors for norepinephrine and epinephrine

On smooth muscle On cardiac muscle On gland cells

On some central nervous system neurons



Transmitters used in the various components of the peripheral efferent nervous system. Notice that the first neuron exiting the central nervous system—whether in the somatic or the autonomic nervous system—releases acetylcholine. In a very few cases, postganglionic sympathetic neurons may release a transmitter other than norepinephrine. (ACh, acetylcholine; NE, norepinephrine; Epi, epinephrine; DA, dopamine.)

REVIEW QUESTIONS

- Make an organizational chart showing the central nervous system, peripheral nervous system, brain, spinal cord, spinal nerves, cranial nerves, forebrain, brainstem, cerebrum, diencephalon, midbrain, pons, medulla oblongata, and cerebellum.
- Draw a cross section of the spinal cord showing the gray and white matter, dorsal and ventral roots, dorsal root ganglion, and spinal nerve. Indicate the general location of pathways.
- List two functions of the thalamus.
- List the functions of the hypothalamus.
- Make a peripheral nervous system chart indicating the relationships among afferent and efferent divisions, somatic and autonomic nervous systems, and sympathetic and parasympathetic divisions.
- Contrast the somatic and autonomic divisions of the efferent nervous system; mention at least three characteristics of each.
- Name the neurotransmitter released at each synapse or neuroeffector junction in the somatic and autonomic systems.
- Contrast the sympathetic and parasympathetic components of the autonomic nervous system; mention at least four characteristics of each.