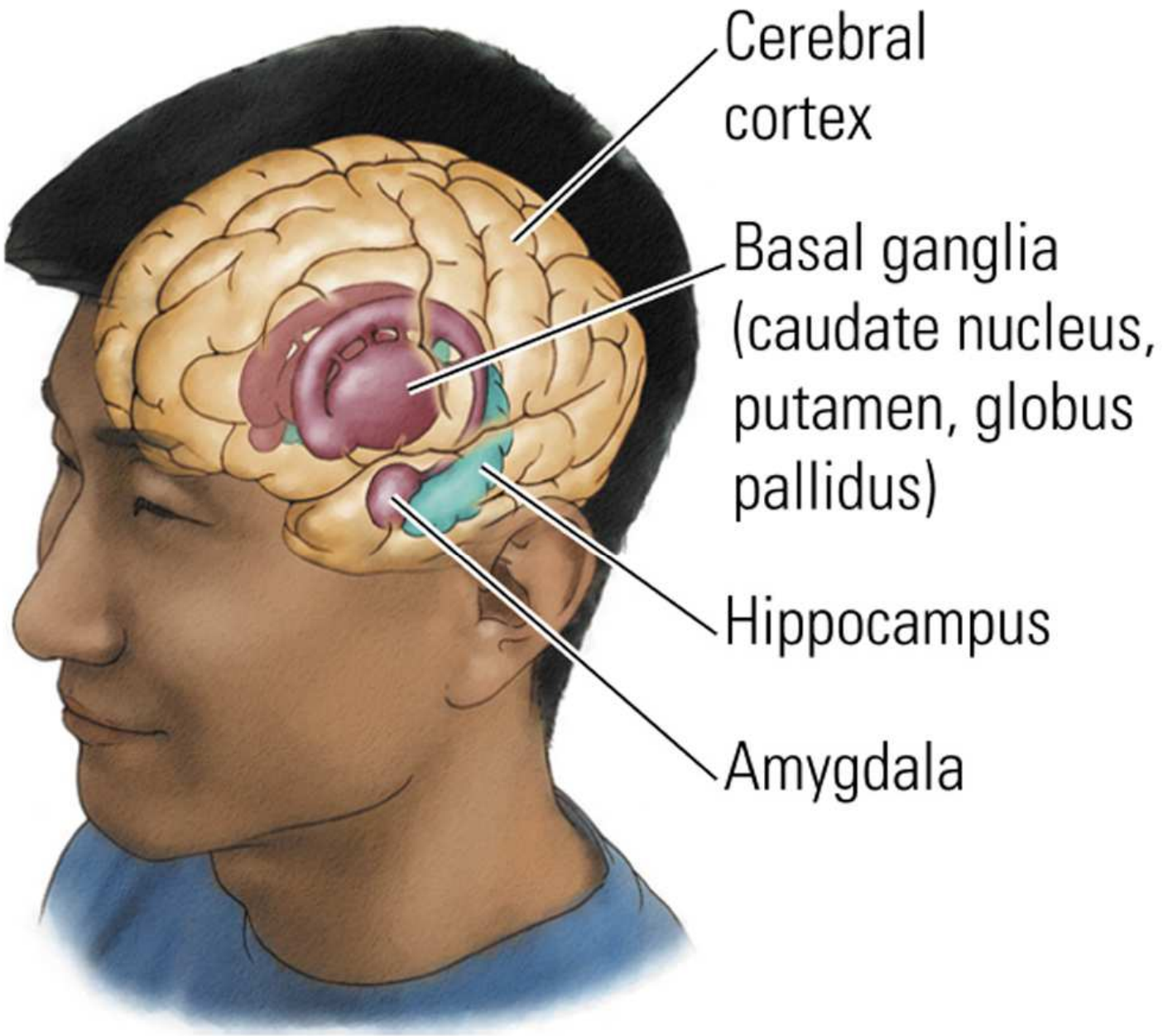
The CNS: Forebrain

- Three principle structures
  - Neocortex
    - Regulates various mental activities
  - Basal Ganglia
    - Control of movement
  - Limbic System
    - Regulates emotions and behaviors that create and require memory


Cerebral cortex
Basal ganglia (caudate nucleus, putamen, globus pallidus)
Hippocampus
Amygdala

Four Lobes

The Cortex: Four Lobes

- Occipital: Vision
- Parietal: Tactile, association
- Temporal: Visual, auditory, and language
- Frontal: Integrates sensory and motor functions; planning (executive function)

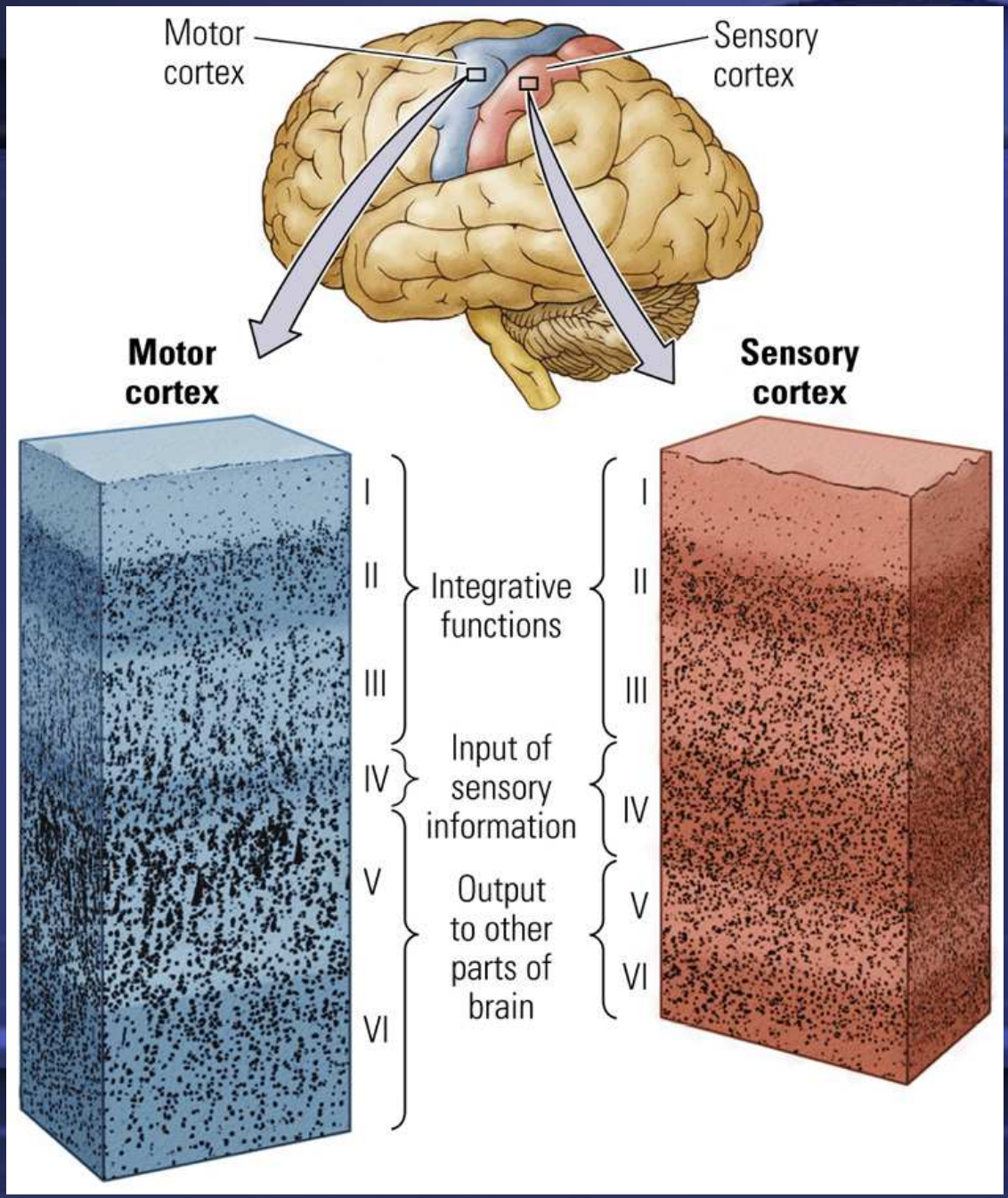
The Cortex

- Neocortex (“new bark”)
  - 6 layers of gray matter
  - Creates and responds to a perceptual world
- Limbic Cortex
  - 3 or 4 layers of gray matter
  - Controlling motivational states

Layers of the Cortex

- Different layers have different cell types
- Density of cells in each layer varies
- Differences in appearance relate to function

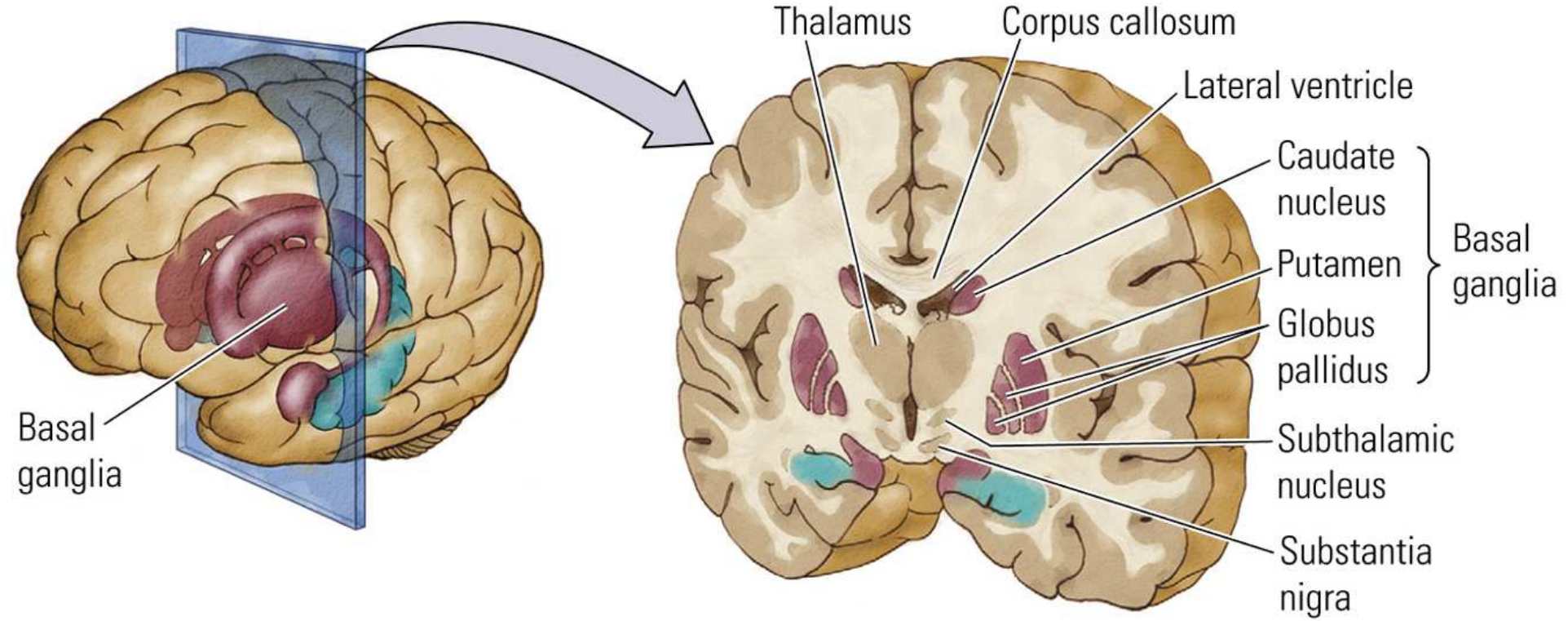
- Cytoarchitectonic Map (Broadman's)
  - Map of neocortex based on the organization, structure, and distribution of the cells


Motor cortex
Sensory cortex
Motor cortex
Sensory cortex
I
II
III
IV
V
VI
Integrative functions
Input of sensory information
Output to other parts of brain
I
II
III
IV
V
VI

Basal Ganglia

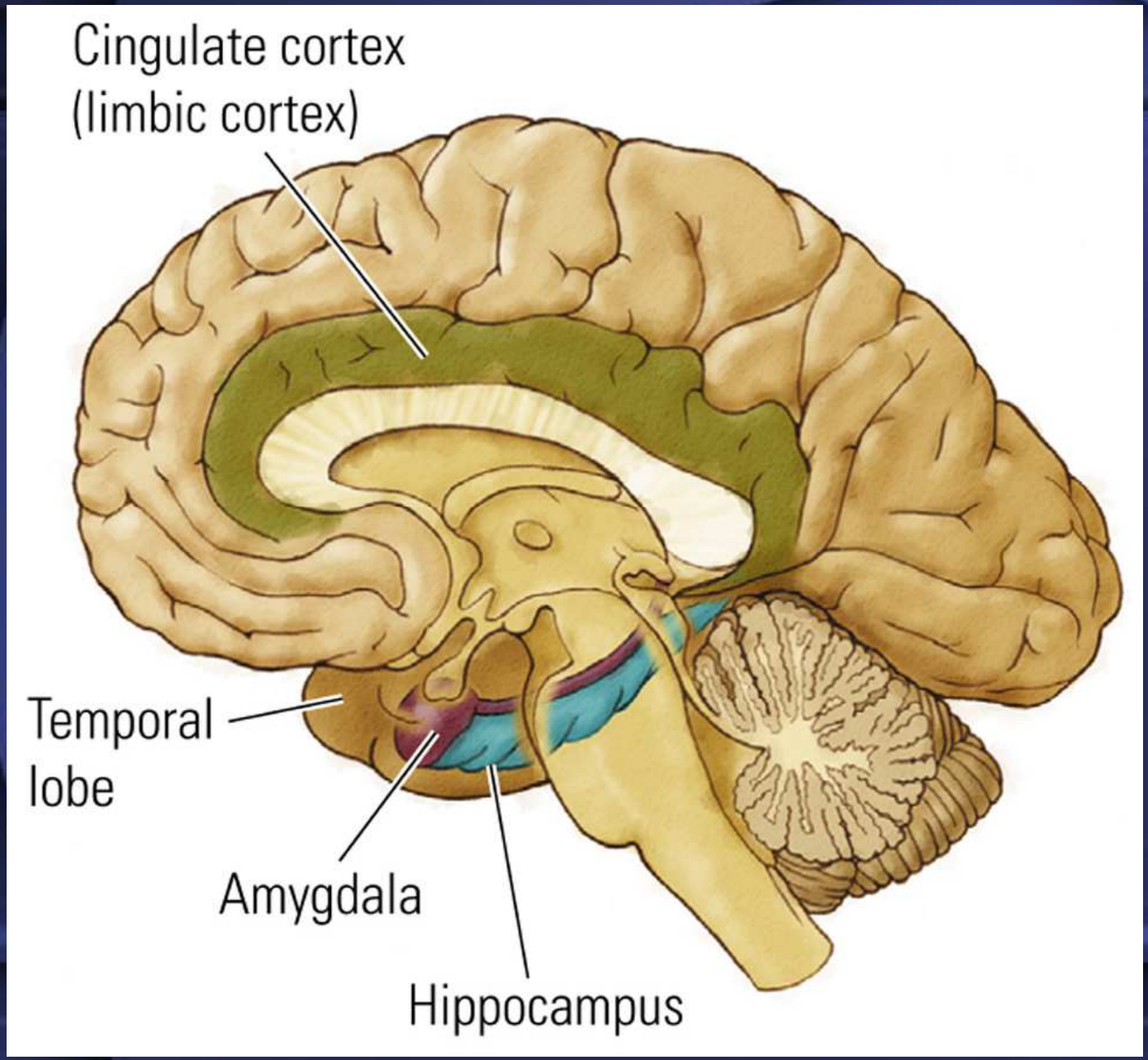
Basal Ganglia

- Collection of nuclei just below the white matter of the cortex
  - Caudate, putamen, globus pallidus, substantia nigra, nucleus accumbens, & subthalamic nucleus
- Controls voluntary movement
- Related disorders
  - Parkinson's disease and Tourette's syndrome


Thalamus
Corpus callosum
Lateral ventricle
Caudate nucleus
Putamen
Globus pallidus
Basal ganglia
Subthalamic nucleus
Substantia nigra
Basal ganglia

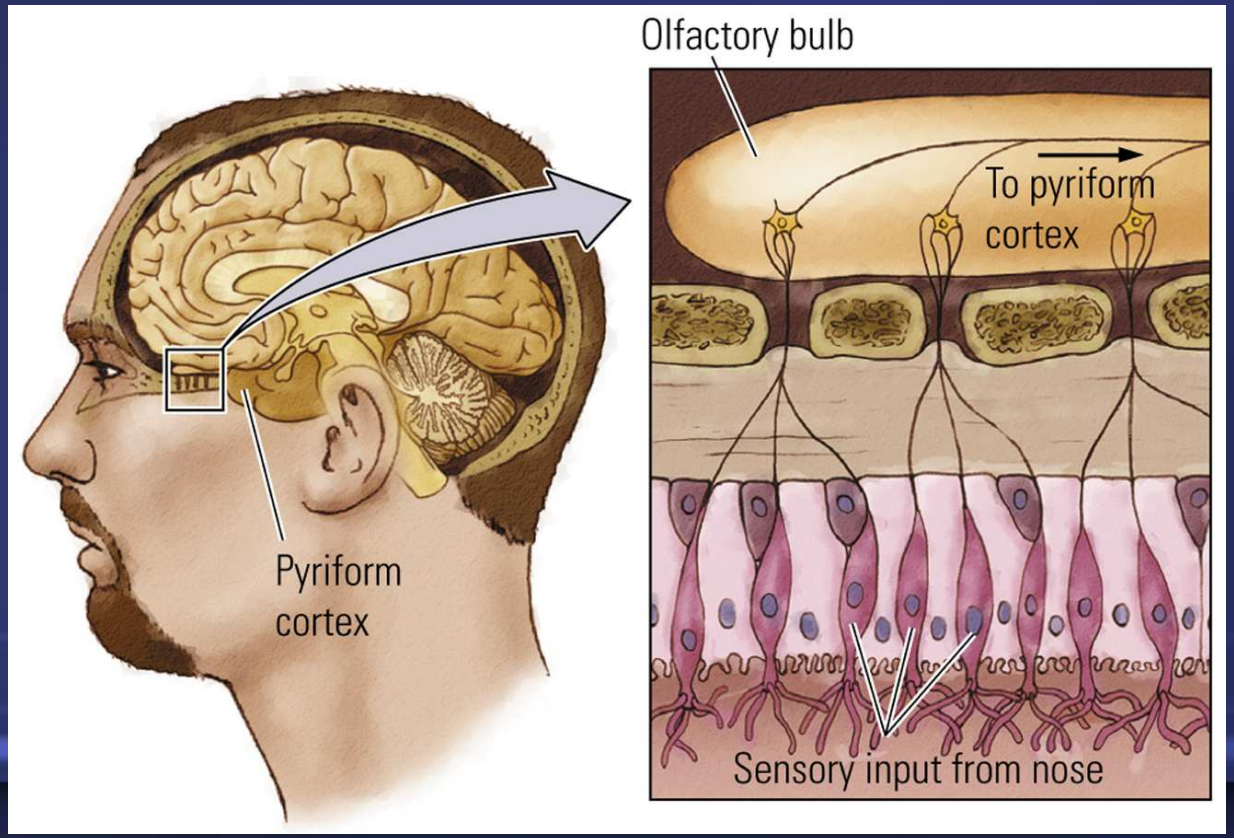
The Limbic System

- Group of structures between the neocortex and brain stem
  - Cingulate cortex, hippocampus, and amygdala
- Regulates
  - Emotional and sexual behaviors
  - Memory
  - Spatial navigation

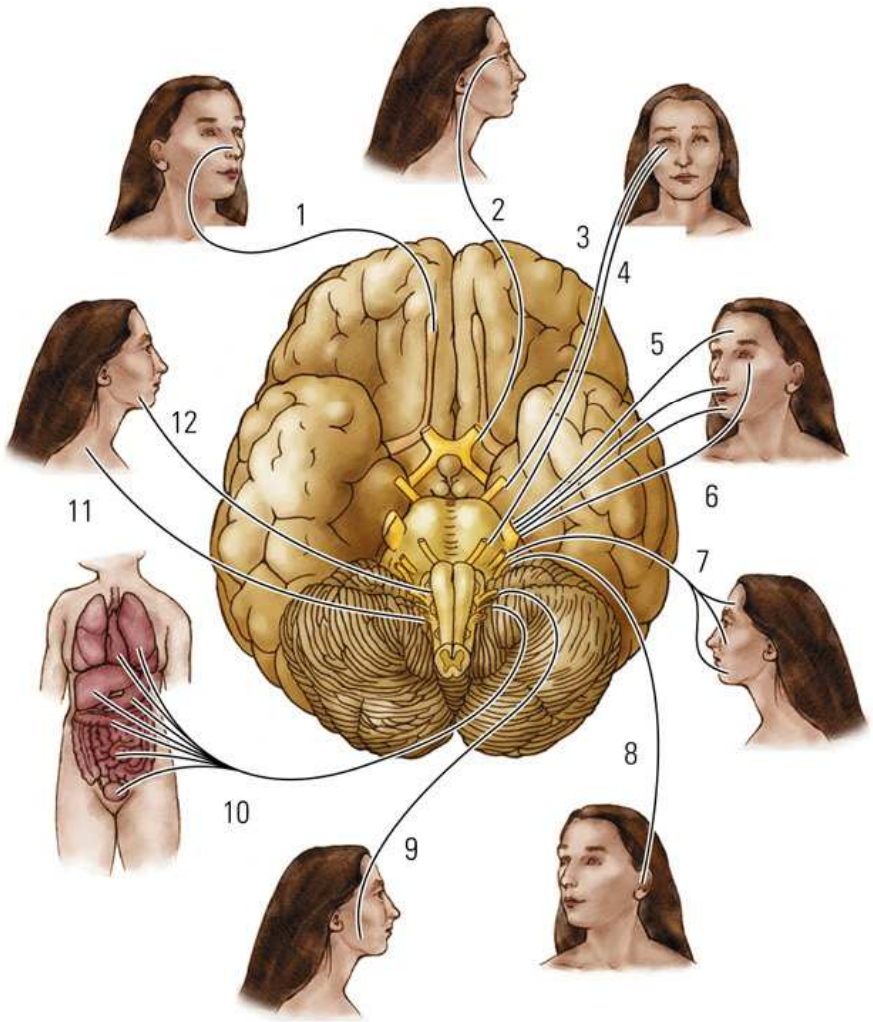

Cingulate cortex
(limbic cortex)
Temporal
lobe
Amygdala
Hippocampus

The Olfactory System

Olfactory bulbs → Pyriform Cortex → Thalamus → Neocortex

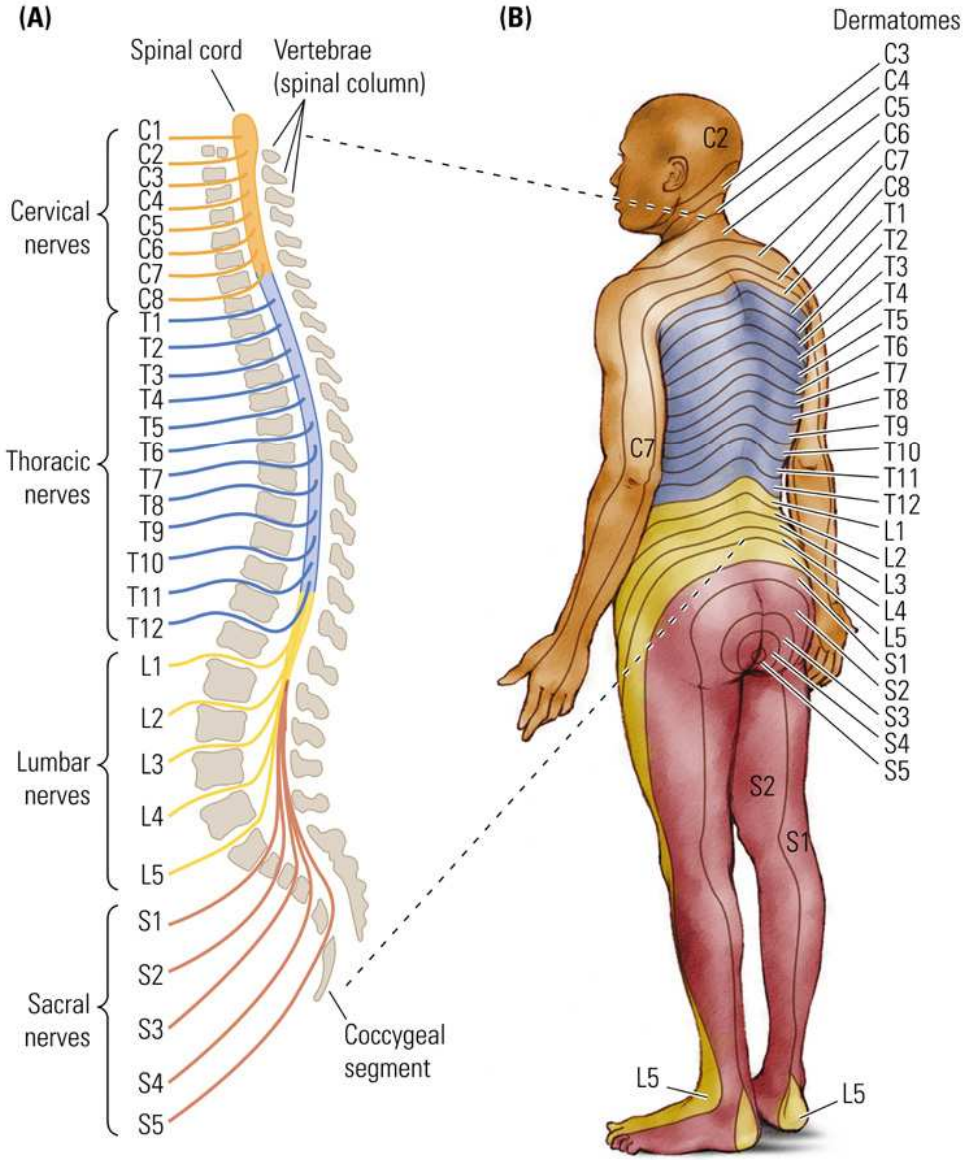


Cranial Nerves



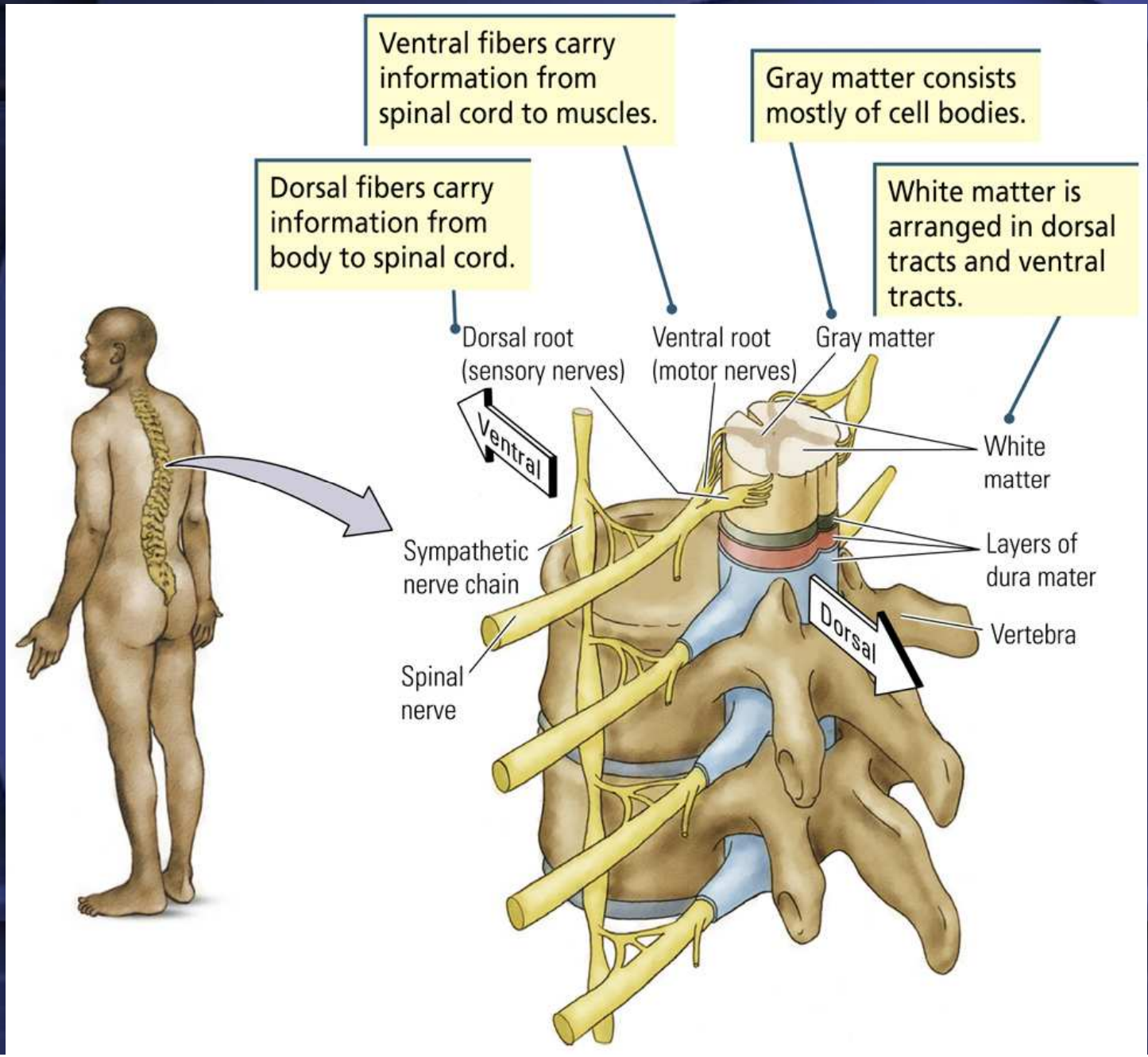
Cranial nerve	Name	Function
1	Olfactory	Smell
2	Optic	Vision
3	Oculomotor	Eye movement
4	Trochlear	Eye movement
5	Trigeminal	Masticatory movements and facial sensation
6	Abducens	Eye movement
7	Facial	Facial movement and sensation
8	Auditory vestibular	Hearing and balance
9	Glossopharyngeal	Tongue and pharynx movement and sensation
10	Vagus	Heart, blood vessels, viscera, movement of larynx and pharynx
11	Spinal accessory	Neck muscles
12	Hypoglossal	Tongue muscles

Somatic Nervous System: Spinal Nerves



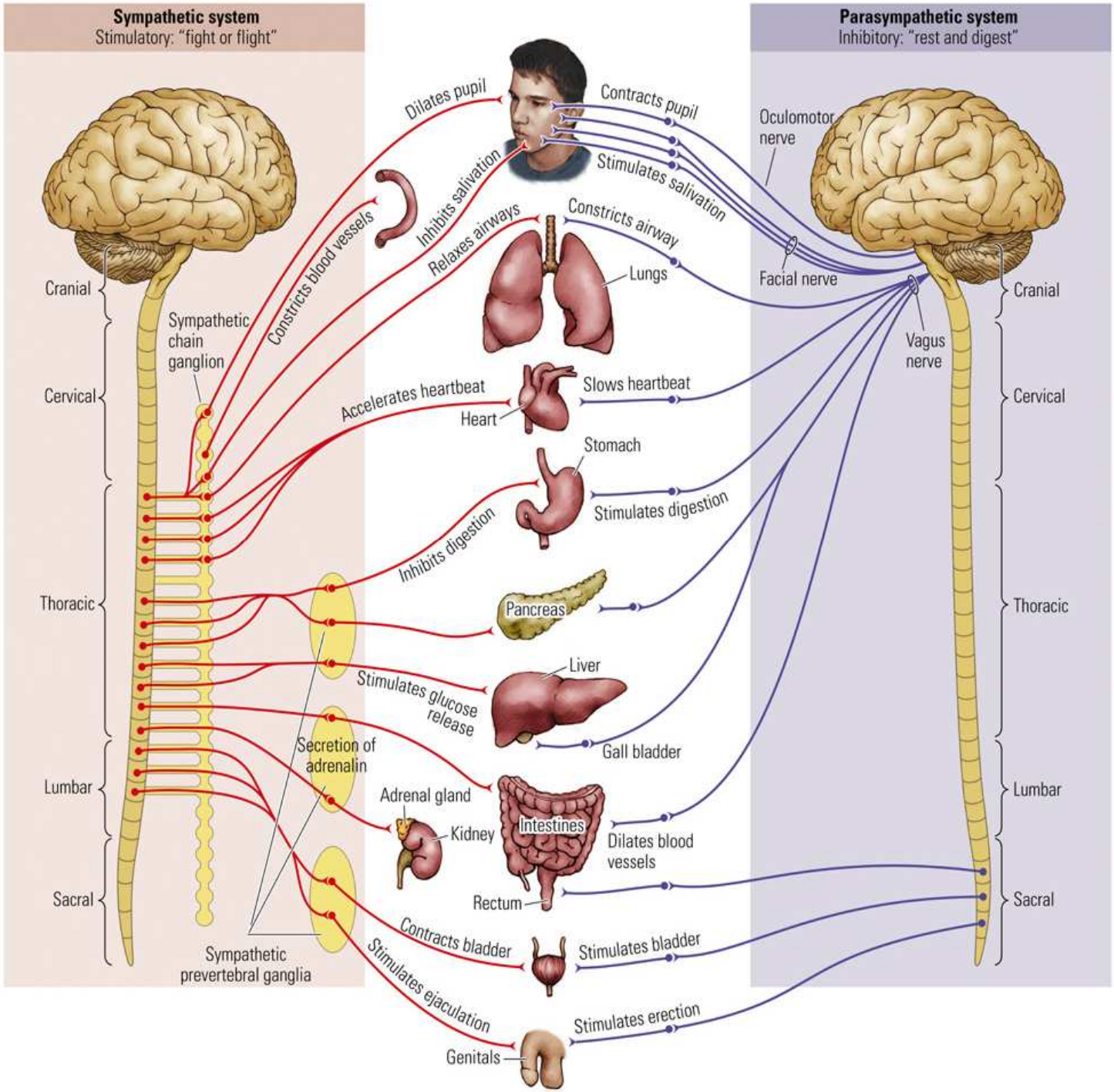
The Somatic Nervous System

- Dermatome
  - Area of the skin supplied with afferent nerve fibers by a single spinal-cord dorsal root
- Law of Bell and Magendie
  - The general principle that sensory fibers are located dorsally and motor fibers are located ventrally


Ventral fibers carry information from spinal cord to muscles.
Gray matter consists mostly of cell bodies.
Dorsal fibers carry information from body to spinal cord.
White matter is arranged in dorsal tracts and ventral tracts.
Dorsal root (sensory nerves)
Ventral root (motor nerves)
Gray matter
Ventral
White matter
Sympathetic nerve chain
Layers of dura mater
Dorsal
Vertebra
Spinal nerve

The Autonomic Nervous System

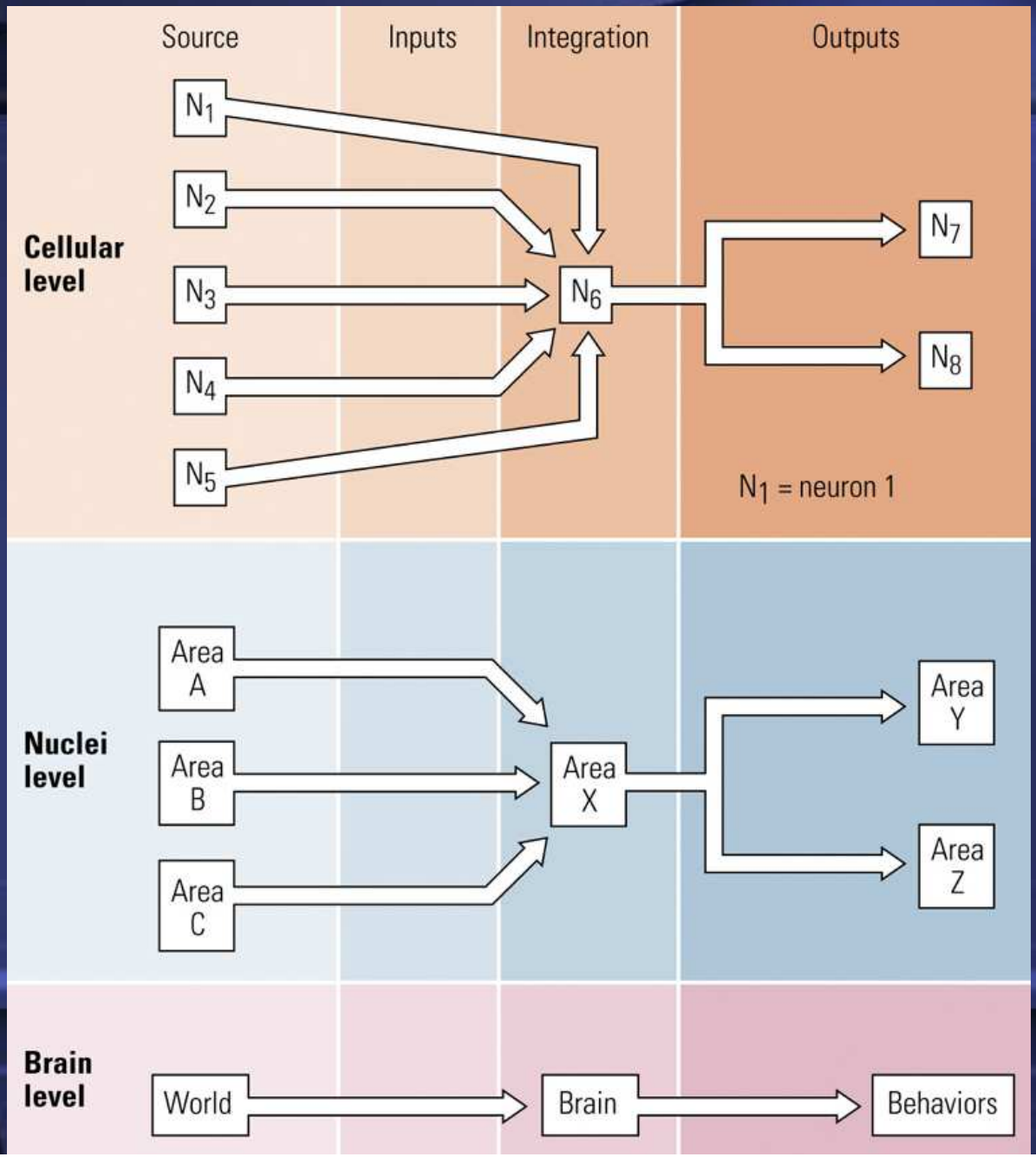
- Sympathetic System
  - Arouses the body for action (e.g., increase heart rate and blood pressure)
  - Mediates the “fight or flight” response
- Parasympathetic System
  - Opposite of sympathetic: prepares the body to “rest and digest”
  - Reverses the “fight or flight” responses


Sympathetic system
Stimulatory: "fight or flight"
Parasympathetic system
Inhibitory: "rest and digest"
Dilates pupil
Contracts pupil
Stimulates salivation
Inhibits salivation
Constricts blood vessels
Relaxes airways
Constricts airway
Lungs
Oculomotor nerve
Facial nerve
Vagus nerve
Cranial
Cervical
Thoracic
Lumbar
Sacral
Sympathetic chain ganglion
Accelerates heartbeat
Heart
Slows heartbeat
Stomach
Stimulates digestion
Inhibits digestion
Pancreas
Liver
Stimulates glucose release
Gall bladder
Secretion of adrenalin
Adrenal gland
Kidney
Intestines
Dilates blood vessels
Rectum
Contracts bladder
Stimulates bladder
Stimulates ejaculation
Stimulates erection
Genitals
Sympathetic prevertebral ganglia

Eight Principles of Nervous System Function

Principle 1

- The Sequence of Brain Processing Is:
  - " In → Integrate → Out"


Source
Inputs
Integration
Outputs
Cellular level
N1
N2
N3
N4
N5
N6
N7
N8
N1 = neuron 1
Nuclei level
Area A
Area B
Area C
Area X
Area Y
Area Z
Brain level
World
Brain
Behaviors

Eight Principles of Nervous System Function

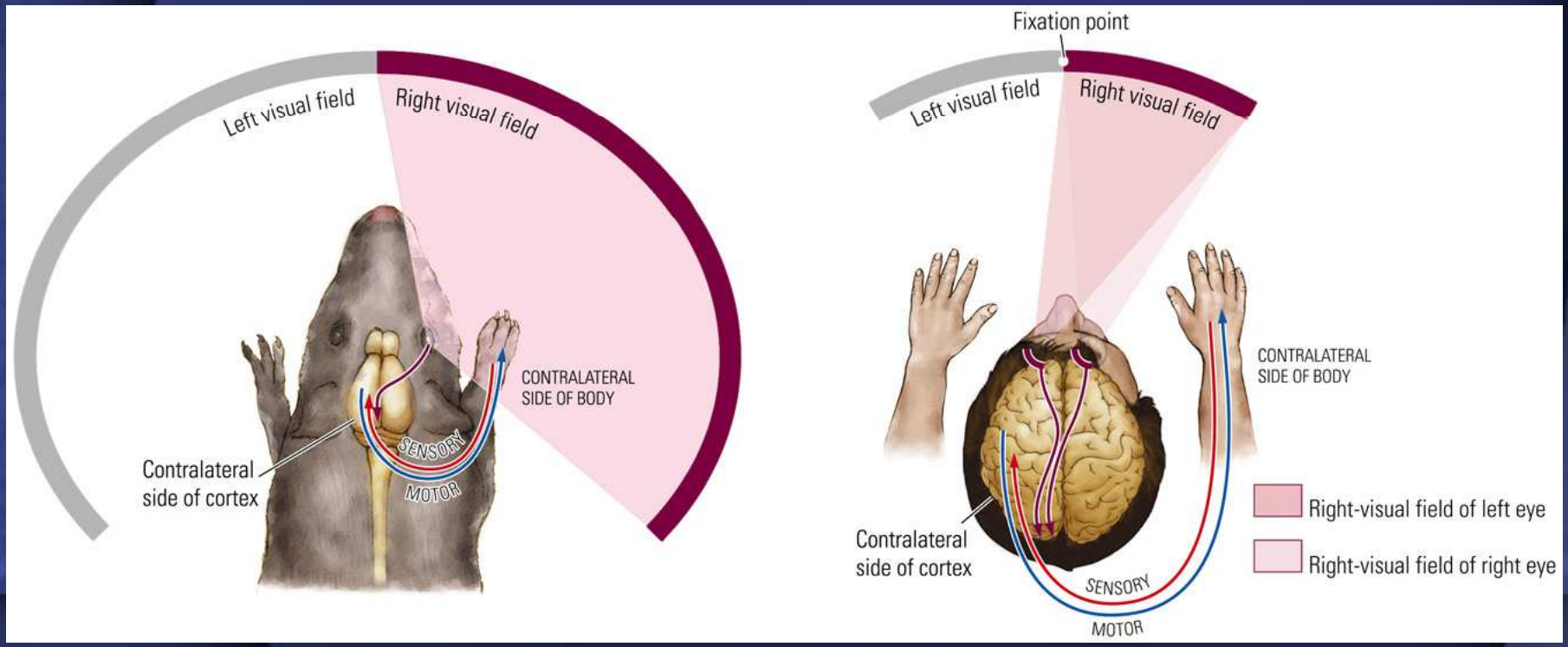
Principle 2

- Sensory and Motor Divisions Exist Throughout the Nervous System
  - Periphery
    - Cranial and spinal nerves
  - Brain
    - All the way up the cortex

Eight Principles of Nervous System Function

Principle 3

- Many of the Brain's Circuits Are Crossed



Eight Principles of Nervous System Function

Principle 4

- The Brain is Both Symmetrical and Asymmetrical
  - Asymmetry is essential for certain tasks
    - Language is usually on the left side
    - Spatial functions are usually on the right side

Eight Principles of Nervous System Function

Principle 5

- The Nervous System Works Through Excitation and Inhibition
  - Excitation: process by which the activity of a neuron is increased
  - Inhibition: process by which the activity of a neuron is decreased or stopped
  - Applies to individual neurons and to nuclei

Eight Principles of Nervous System Function

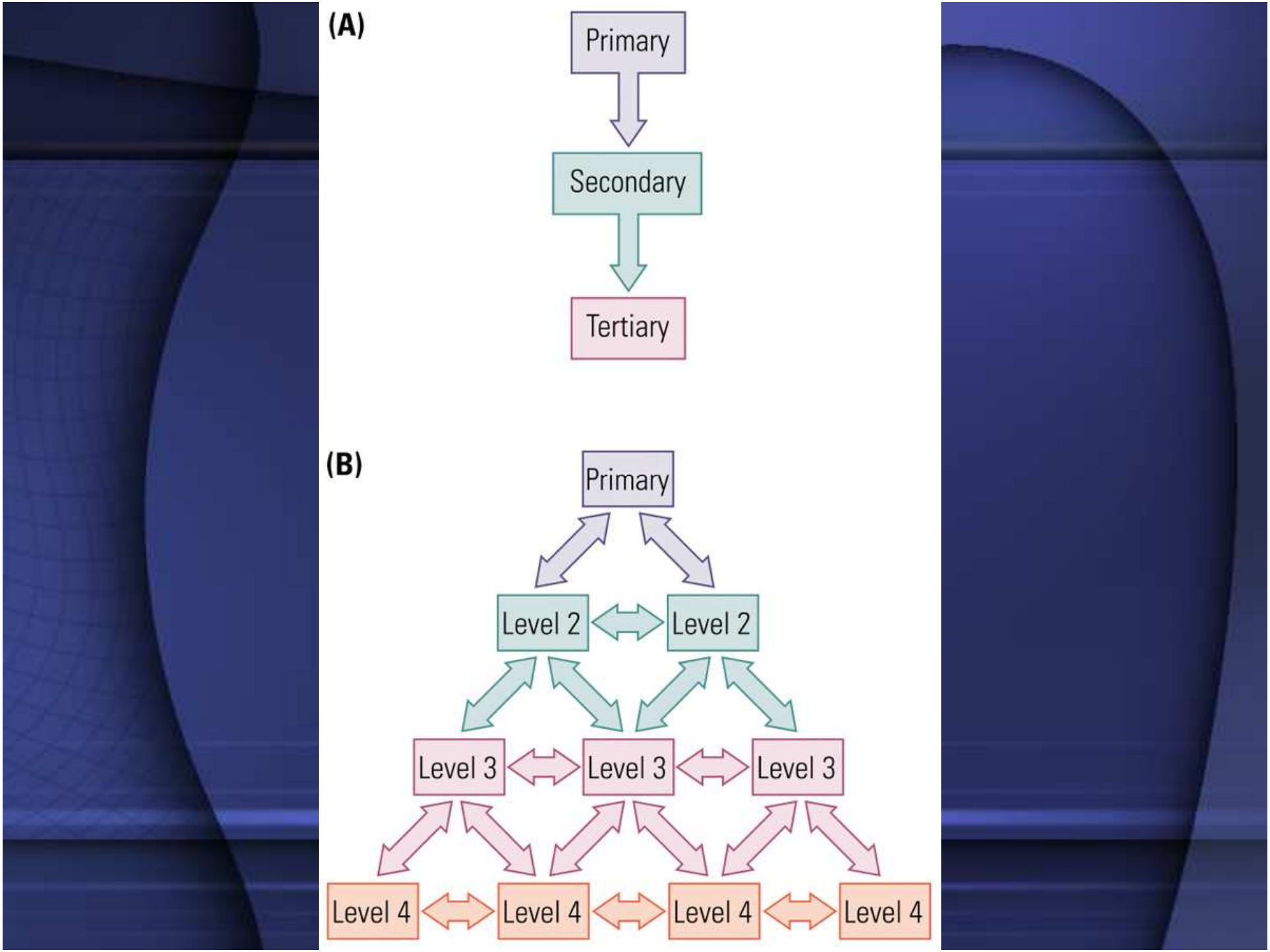
Principle 6

- The Central Nervous System Functions on Multiple Levels
  - "Descent with Modification"
    - During evolution, new brain areas were placed on top of older ones
  - Newer brain levels added increased control and processing
  - Levels work together to produce behavior

Eight Principles of Nervous System Function

Principle 7

- Brain Systems Are Organized Both Hierarchically and in Parallel
  - Binding Problem: Because a single sensory event is analyzed by multiple parallel channels that do not converge onto a single brain region, there is said to be a problem in binding together the segregated analyses into a single sensory experience


(A)
Primary
Secondary
Tertiary
(B)
Primary
Level 2
Level 2
Level 3
Level 3
Level 3
Level 4
Level 4
Level 4
Level 4

Eight Principles of Nervous System Function

Principle 8

- Functions in the Brain Are Both Localized and Distributed
  - Because functions (e.g., language) have many aspects, it is not surprising that these aspects reside in widely separated areas of the brain
  - Small area of damage = focal symptoms
  - Large area of damage = remove entire function