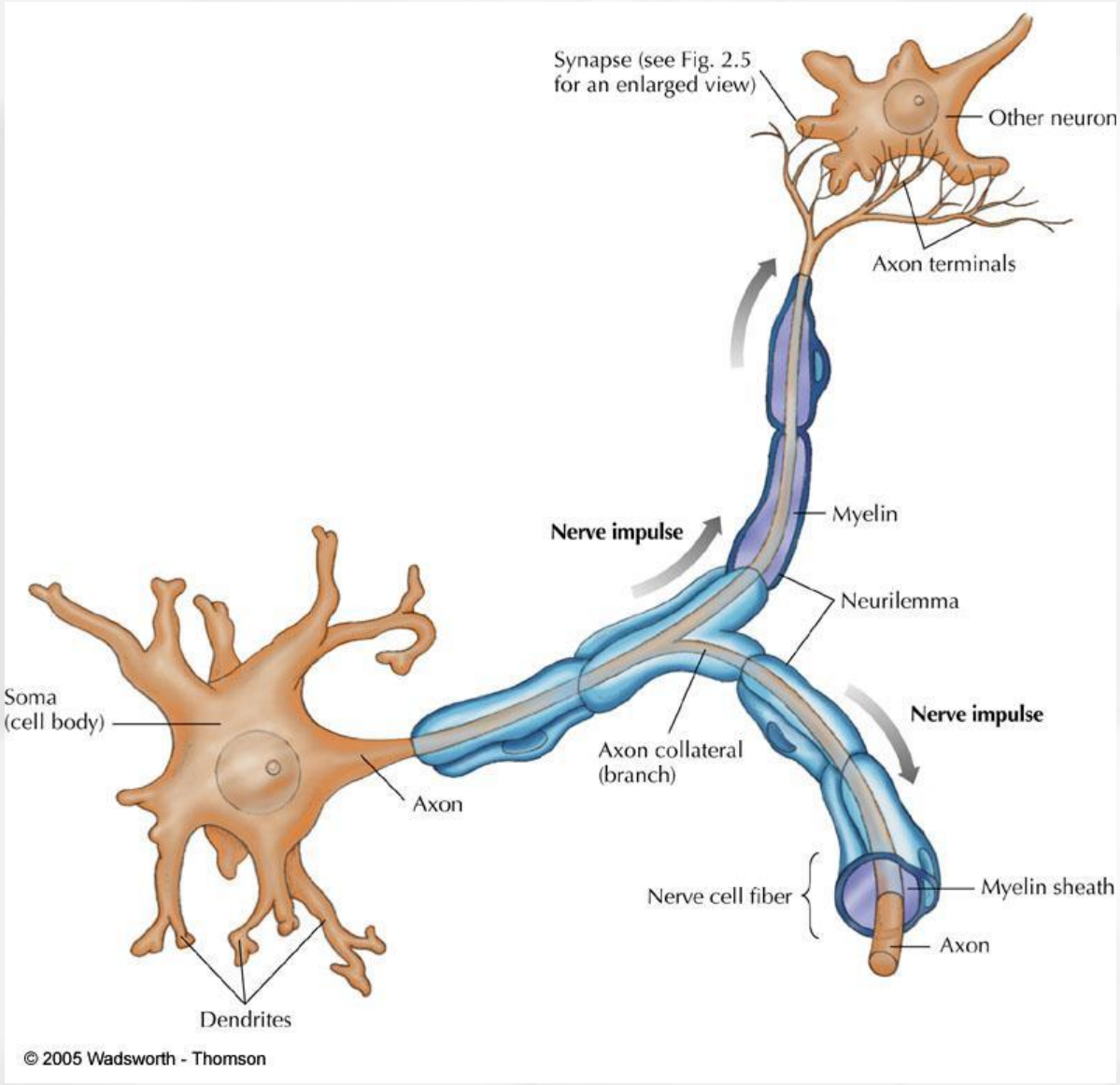
Chapter 2
Brain and Behavior

Neuron and Its Parts

- Neuron: Individual nerve cell
  - Dendrites: Receive messages from other neurons
  - Soma: Cell body; body of the neuron
  - Axon: Fiber that carries information away from the cell body
  - Axon Terminals: Branches that link the dendrites and somas of other neurons


Synapse (see Fig. 2.5 for an enlarged view)
Other neuron
Axon terminals
Myelin
Nerve impulse
Neurilemma
Soma (cell body)
Nerve impulse
Axon collateral (branch)
Axon
Nerve cell fiber
Myelin sheath
Axon
Dendrites
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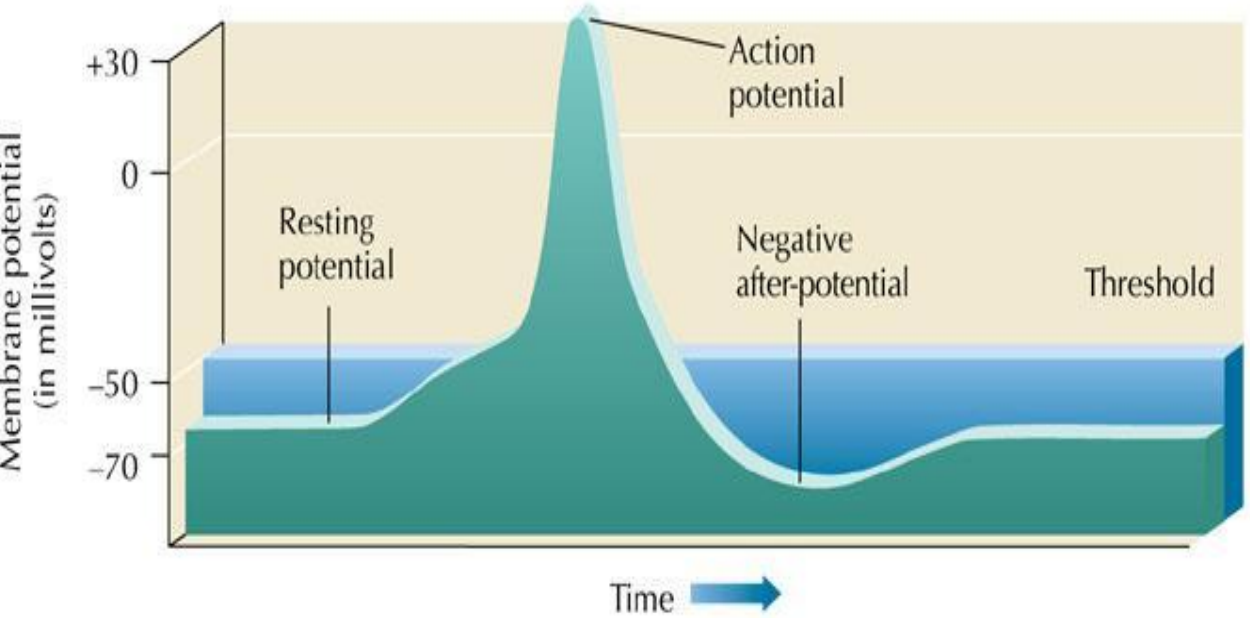
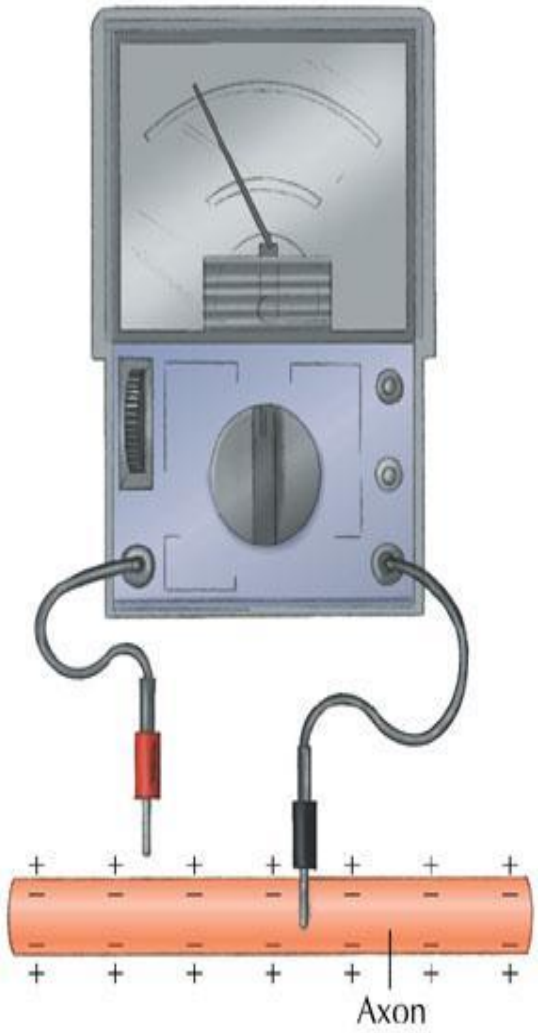
The Nerve Impulse

- Resting Potential: Electrical charge of an inactive neuron
- Threshold: Trigger point for a neuron's firing
- Action Potential: Nerve impulse
- Negative After-Potential: When a neuron is less willing to fire





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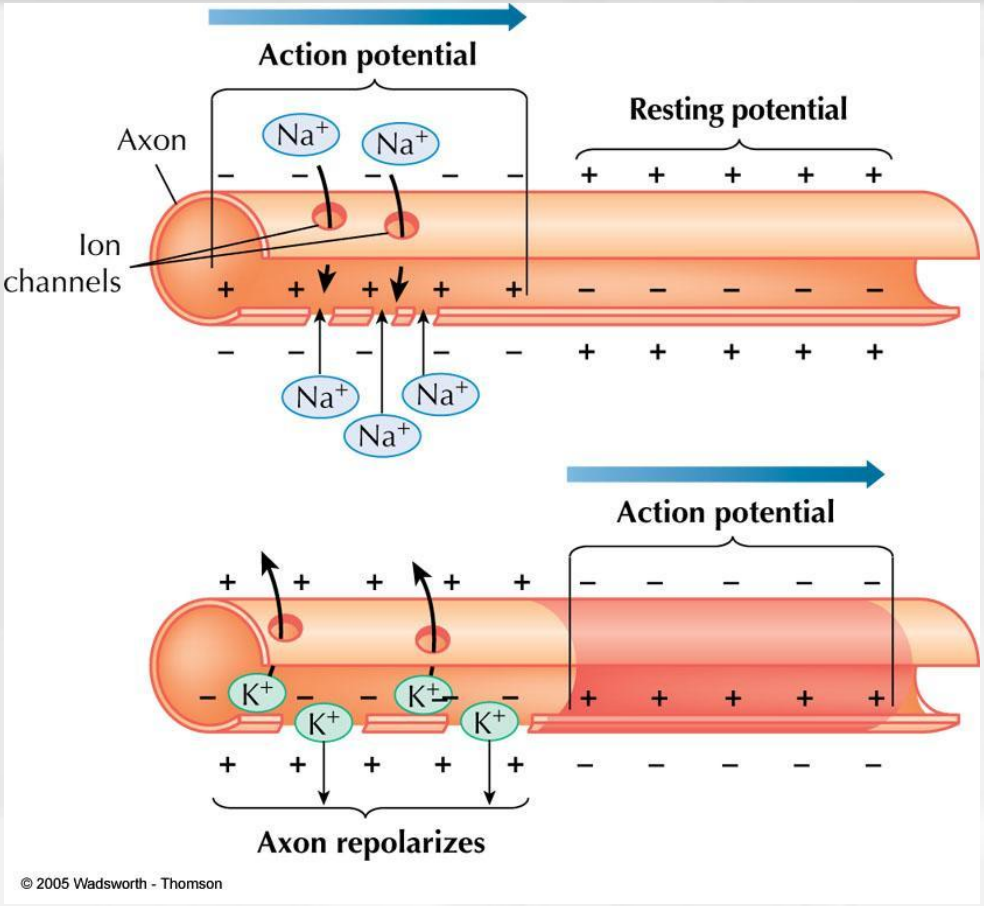


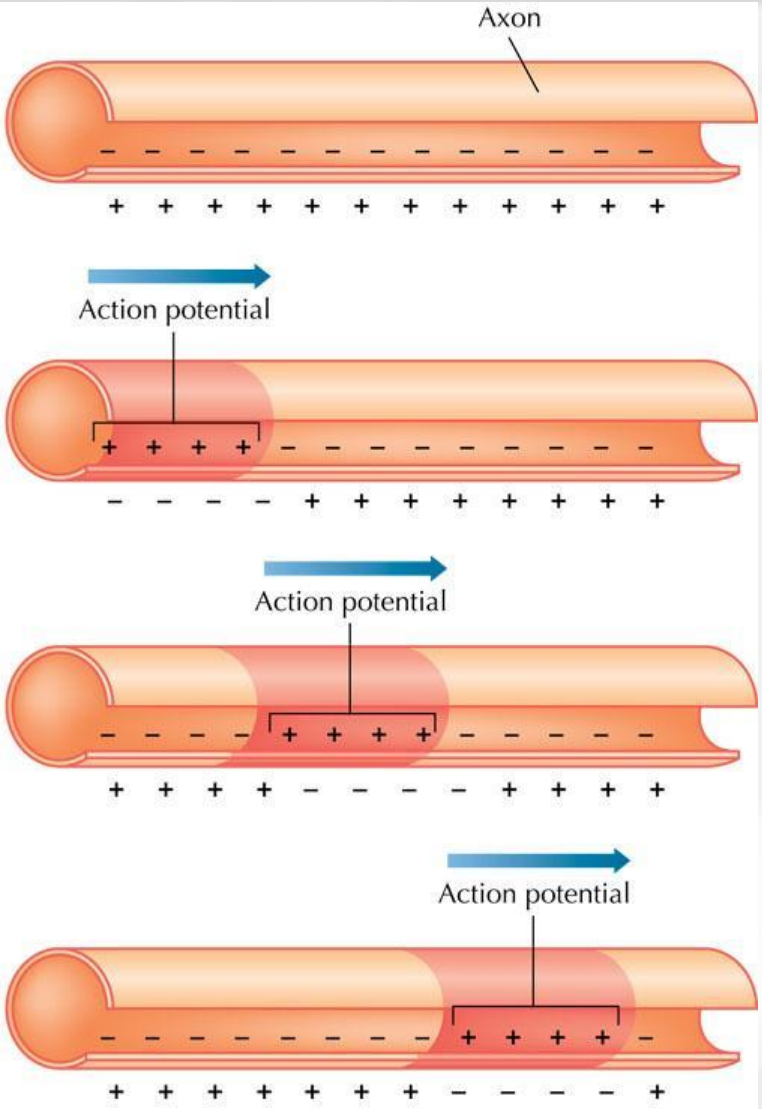
FIGURE 2.4 The interior of an axon. The right end of the top axon is at rest. Thus, it has a negative charge inside. An action potential begins when ion channels open and sodium ions (Na+) rush into the axon. In this drawing, the action potential would travel from left to right along the axon. In the lower axon, the action potential has moved to the right. After it passes, potassium ions (K+) flow out of the axon. This quickly renews the negative charge inside the axon, so it can fire again. Sodium ions that enter the axon during an action potential are pumped out more slowly. Removing them restores the original resting potential.

1. In its resting state, the axon has a negatively charged interior.

2. During an action potential, positively charged atoms (ions) rush into the axon. This briefly changes the electrical charge inside the axon from negative to positive. Simultaneously, the charge outside the axon becomes negative.

3. The action potential advances as positive and negative charges reverse in a moving zone of electrical activity that sweeps down the axon.

4. After an action potential passes, positive ions rapidly flow out of the axon to quickly restore its negative charge. An outward flow of additional positive ions returns the axon to its resting state.



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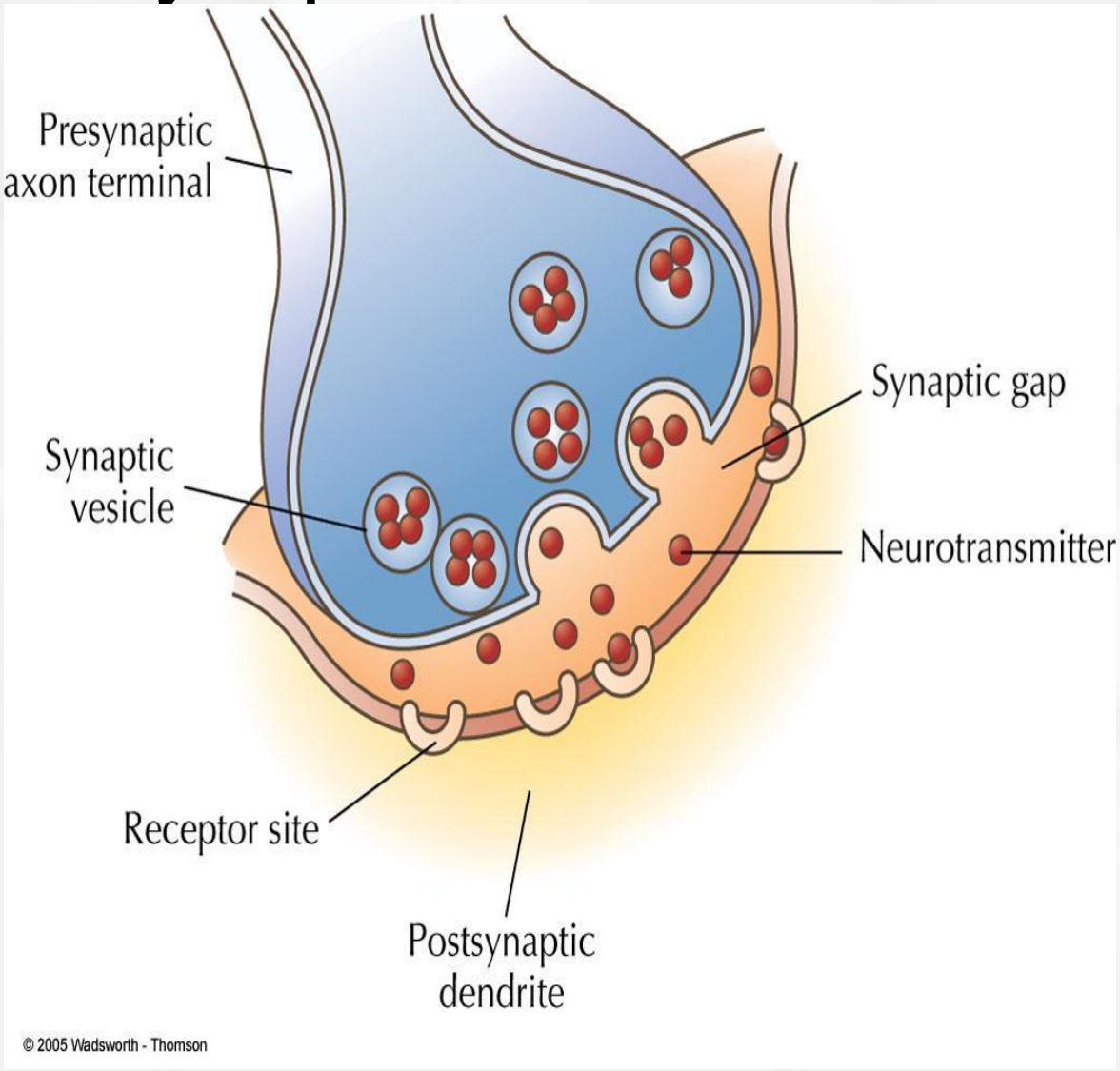
Synapses

- Messages from one neuron to another pass over a microscopic gap between neurons called a *synapse*



Neurotransmitters

- Chemicals in the brain that alter activity in neurons
- Receptor Site: Areas on the surface of neurons and other cells that are sensitive to neurotransmitters
- Our knowledge of these chemicals is incomplete. Suspected effects of 6 of them are displayed on the following table.

TABLE 5.1 HOW NEUROTRANSMITTERS AFFECT US

Neurotransmitter	Known or Suspected Effects
Serotonin	Affects mood, sleep, appetite, sensory perception, temperature regulation, pain suppression, impulsivity, and aggression; may play a role in some psychological disorders, such as depression
Acetylcholine (ACh)	Affects muscle action, cognitive functioning, memory, REM (rapid-eye-movement) sleep, emotion. Suspected role in Alzheimer's disease
Dopamine (DA)	Affects movement, attention, memory, learning, and emotion. Plays a role in both schizophrenia and Parkinson's disease.
Norepinephrine (NE) (or noradrenaline)	Affects learning, memory, dreaming, emotion, waking from sleep, eating, alertness, wakefulness, reactions to stress
Epinephrine (or adrenaline)	Affects emotional arousal, memory storage, and metabolism of glucose necessary for energy release
GABA (gamma aminobutyric acid)	Neural inhibition in the central nervous system; Tranquilizing drugs act on GABA to decrease anxiety

Neurotransmitters and Behavior

- *Parkinson's Disease*
  - Parkinson's Disease is a condition in which the individual has trouble executing voluntary movements, and has tremors, rigidity and a depressed mood.
  - This condition has been linked to a gradual decay in a system of axons that release the neurotransmitter **dopamine**.

Why study neurotransmitters? Actor Michael J. Fox suffers from Parkinson's disease, which involves a decrease in cells that produce dopamine. In this photo, he is testifying before a U.S. subcommittee to urge increased funding for research on Parkinson's and other medical conditions.

Neural Regulators

- Neuropeptides: Regulate activity of other neurons
  - Enkephalins: Relieve pain and stress; similar to endorphins
  - Endorphins: Released by pituitary gland; also help to relieve pain
- These chemicals work together to reduce pain/stress so that it is not disabling

- Why does the communication between neurons have to be both an electrical and chemical process? Why not just electrical?

Nerves and Neurons

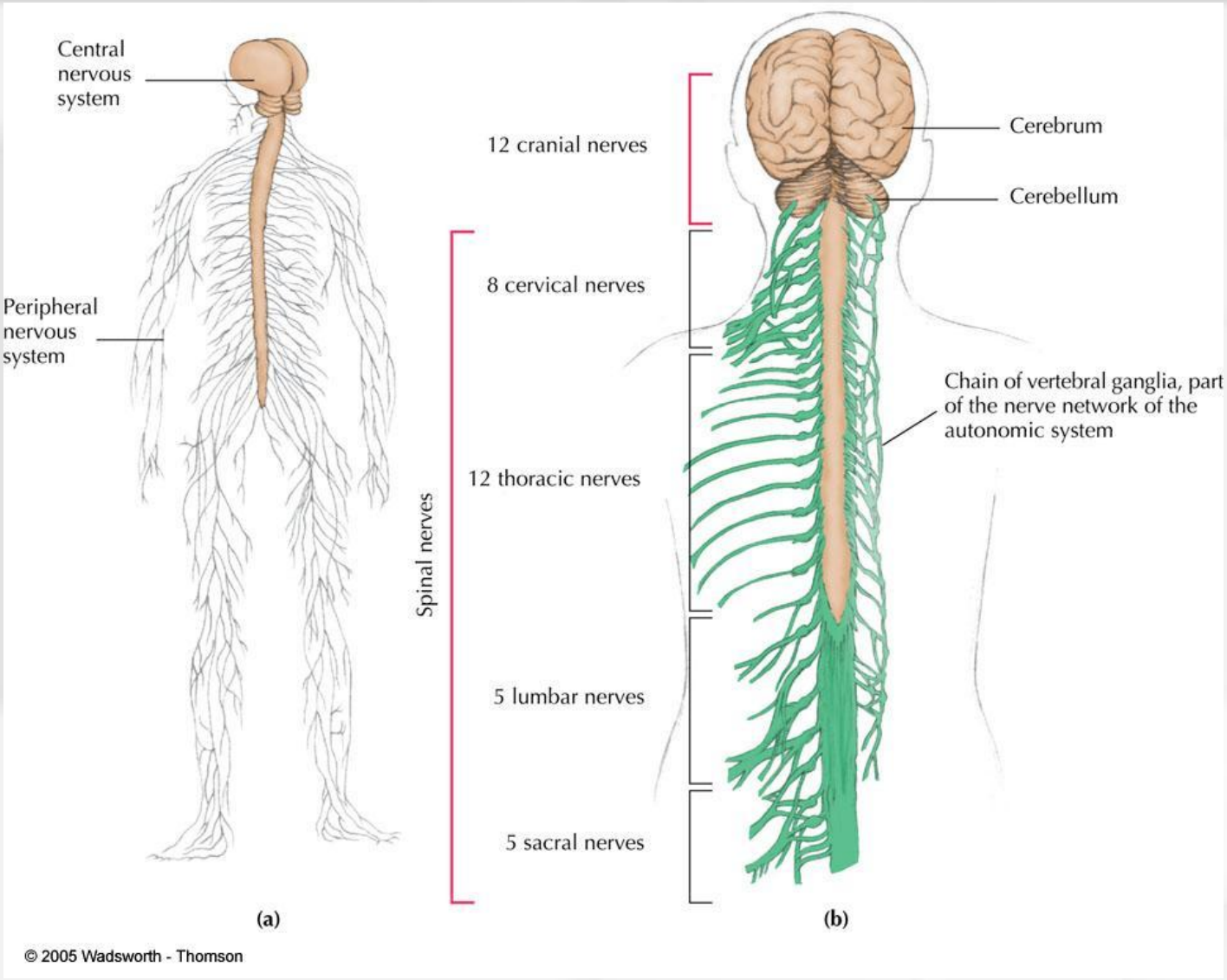
- Nerves: Large bundles of axons and dendrites
- Myelin: Fatty layer of tissue that coats axons
- Saltatory conduction: nerve impulses traveling down an axon coated with myelin jump from gap to gap in the myelin layer.
- What condition results when one's immune system destroys the myelin layer of axons?

Neural Networks

- Central Nervous System (CNS): Brain and spinal cord

- Peripheral Nervous System: All parts of the nervous system **outside** of the brain and spinal cord

  - Somatic System: Links spinal cord with body and sense organs; controls voluntary behavior via sensory neurons and motor neurons
  - Autonomic System: Serves internal organs and glands; controls automatic functions such as heart rate and blood pressure



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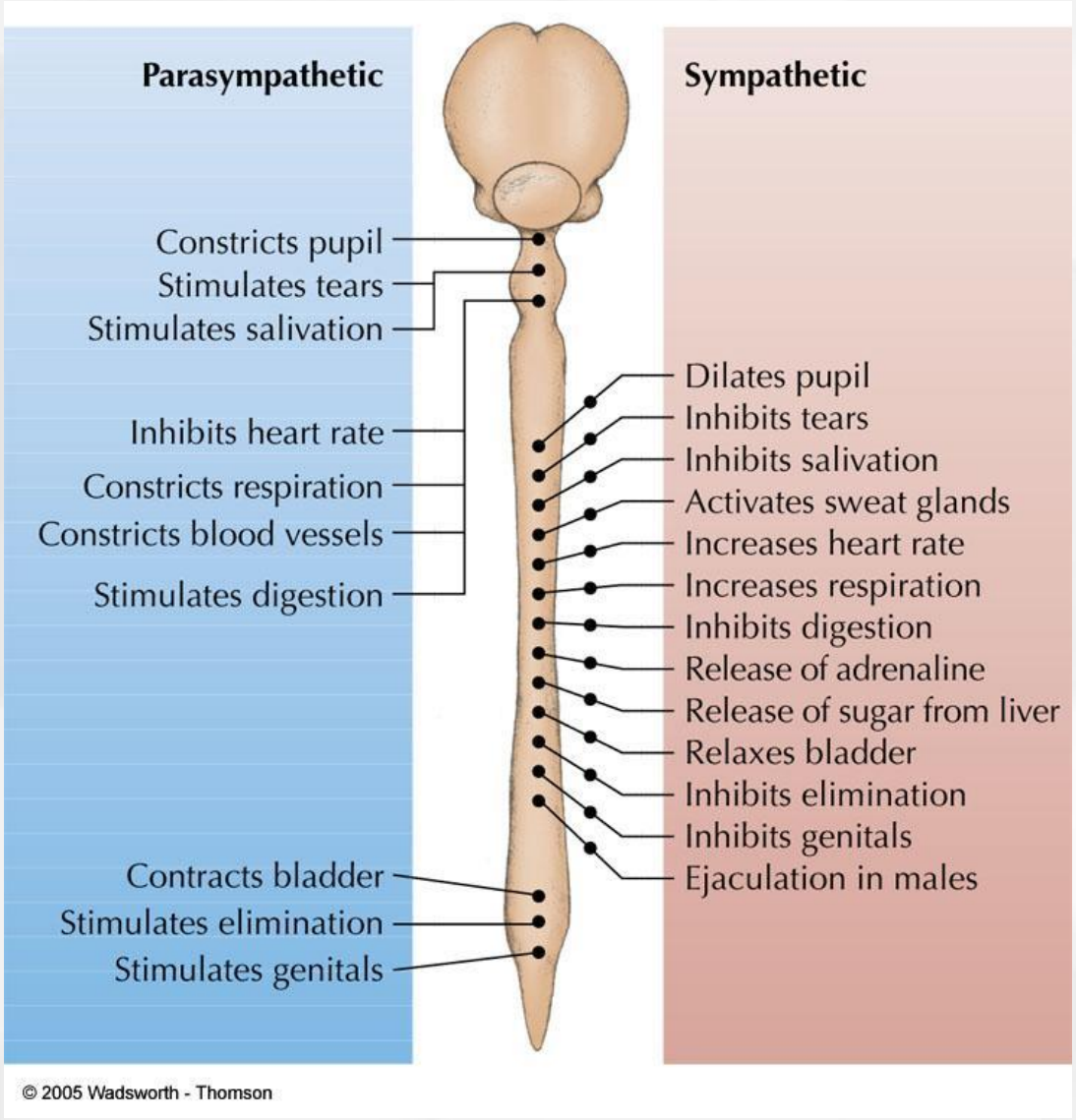
Two Divisions of the Autonomic System

- Sympathetic: Arouses body; emergency system
- Parasympathetic: Quiets body; most active after an emotional event

Two Divisions of the Autonomic System



The Spinal Cord

- Spinal Nerves: 31 of them; carry sensory and motor messages to and from the spinal cord
- Cranial Nerves: 12 pairs that leave the brain directly; also work to communicate messages

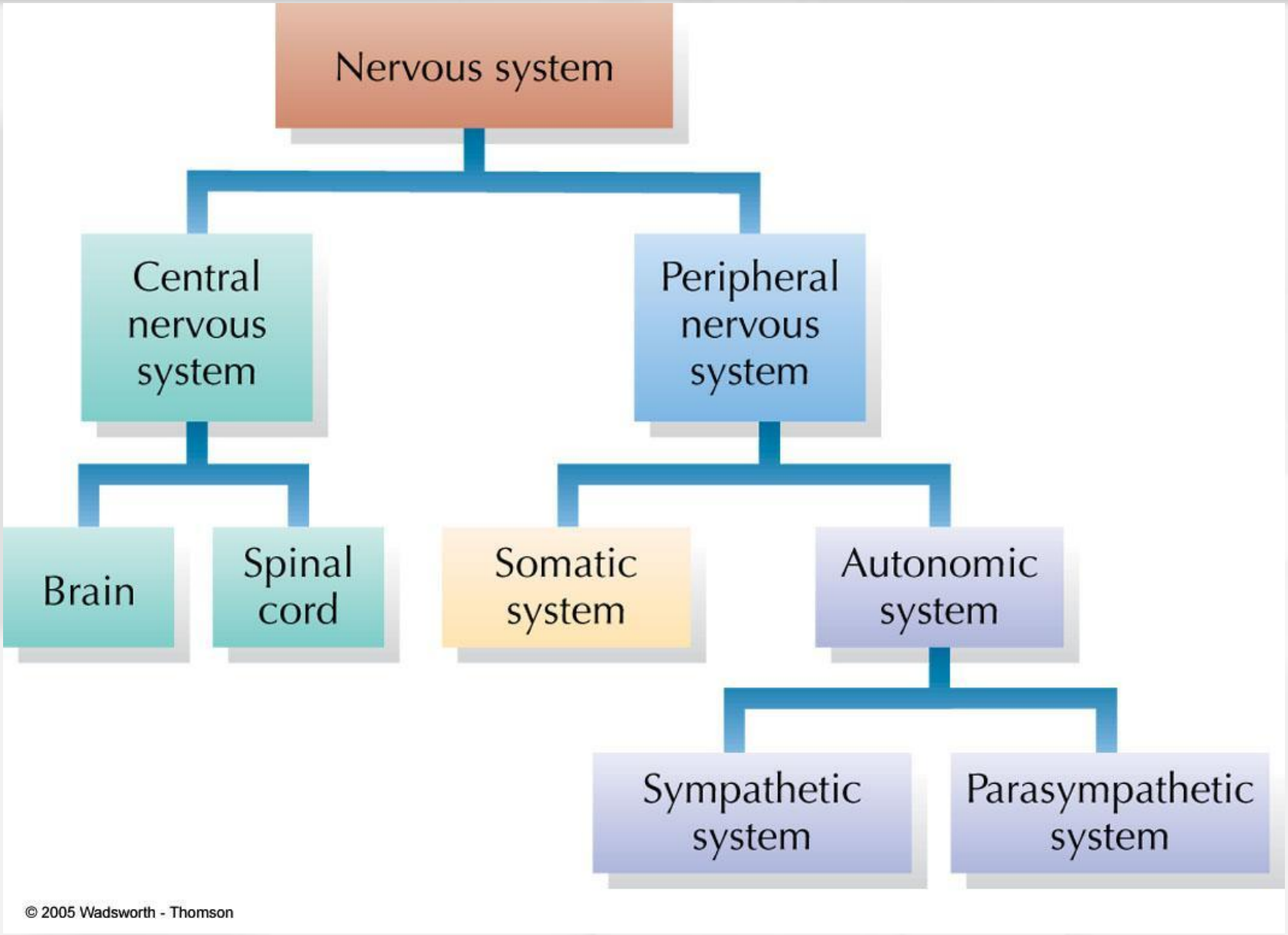
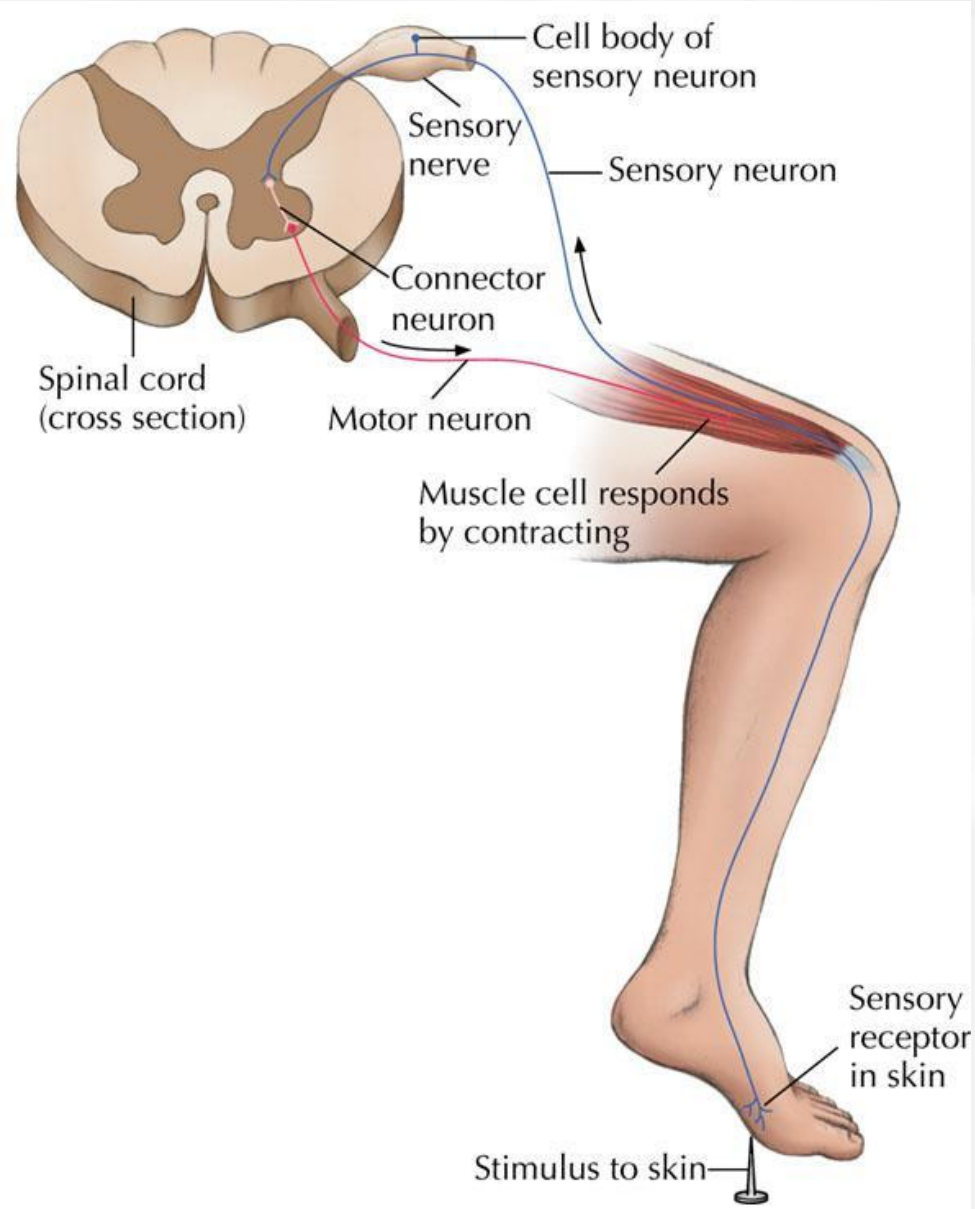


FIGURE 2.7 Subparts of the nervous system.


Cell body of sensory neuron
Sensory nerve
Sensory neuron
Connector neuron
Spinal cord (cross section)
Motor neuron
Muscle cell responds by contracting
Sensory receptor in skin
Stimulus to skin
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Researching the Brain

- Ablation: Surgical removal of parts of the brain.
- Deep Lesioning: A thin wire electrode is lowered into a specific area inside the brain. Electrical current is then used to destroy a small amount of brain tissue.
- Electrical Stimulation of the Brain (ESB): When an electrode is used to activate target areas in the brain.
- Electroencephalograph (EEG): Detects, amplifies, and records electrical activity in the brain.

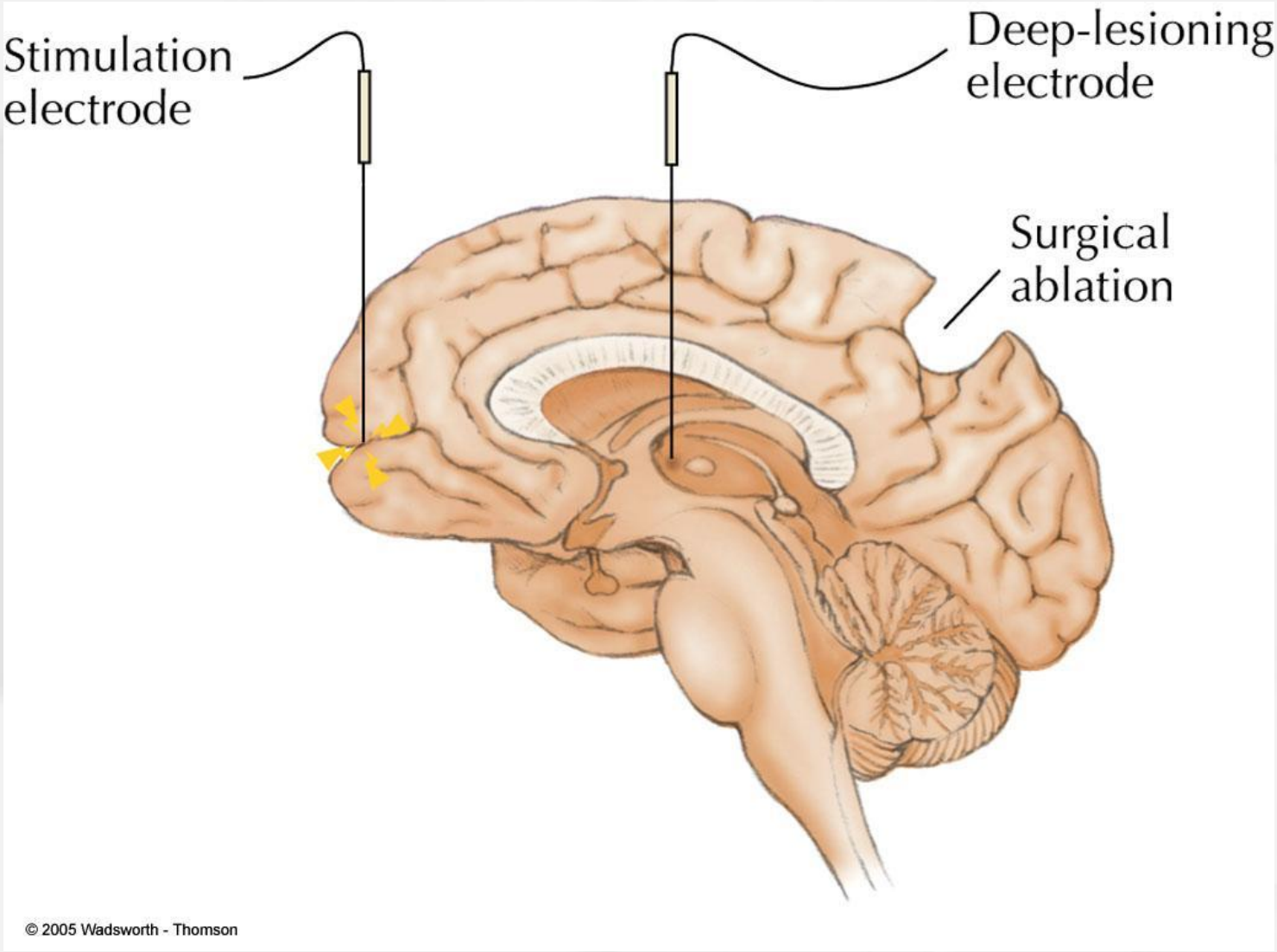


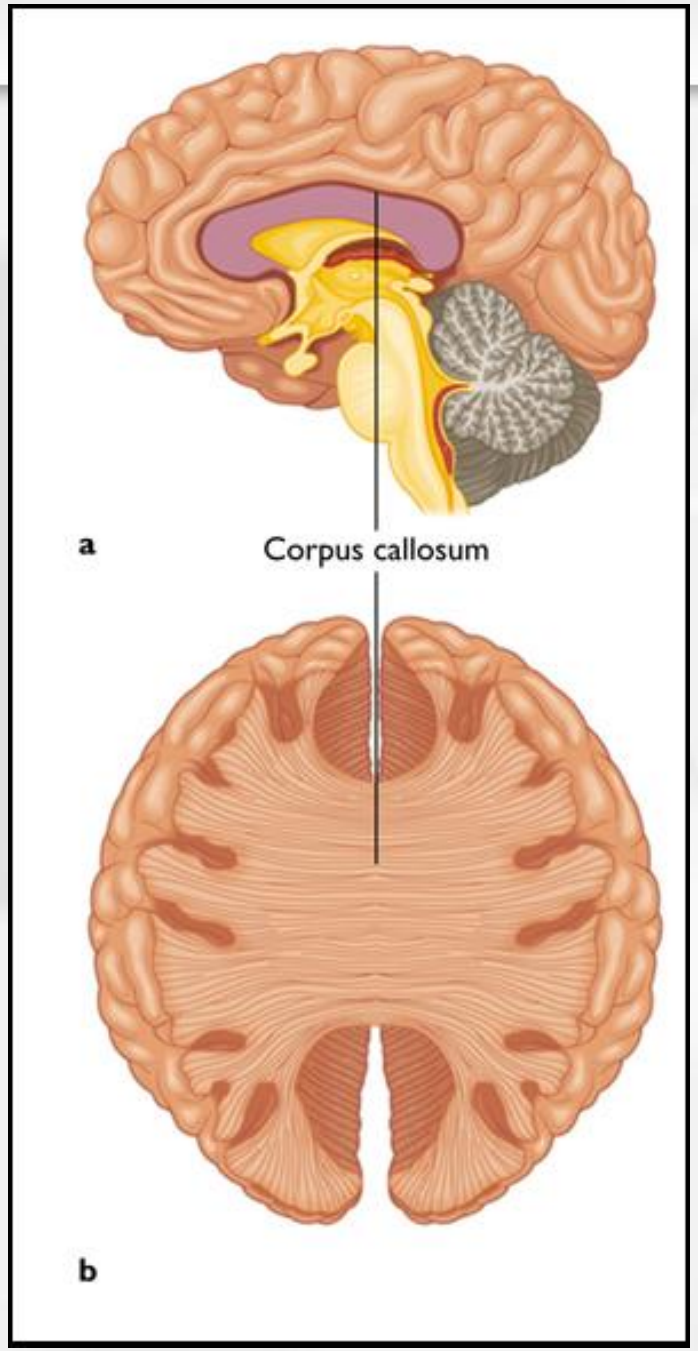
FIGURE 2.10 The functions of brain structures are explored by selectively activating or removing them. Brain research is often based on electrical stimulation, but chemical stimulation is also used at times.

Researching the Brain (cont'd)

- Computed Tomographic Scanning (CT): Computer-enhanced X-ray image of the brain or body
- Magnetic Resonance Imaging (MRI): Uses a strong magnetic field, *not an X-ray*, to produce an image
- Functional MRI (fMRI): MRI that also records brain activity
- Positron Emission Tomography (PET): Computer-generated color image of brain activity, based on glucose consumption in the brain

Cerebral Cortex

- Definition: Outer layer of the cerebrum
- Cerebrum: Two large hemispheres that cover upper part of the brain
- Cerebral Hemispheres: Right and left halves of the cortex
- Corpus Callosum: Bundle of fibers connecting cerebral hemispheres

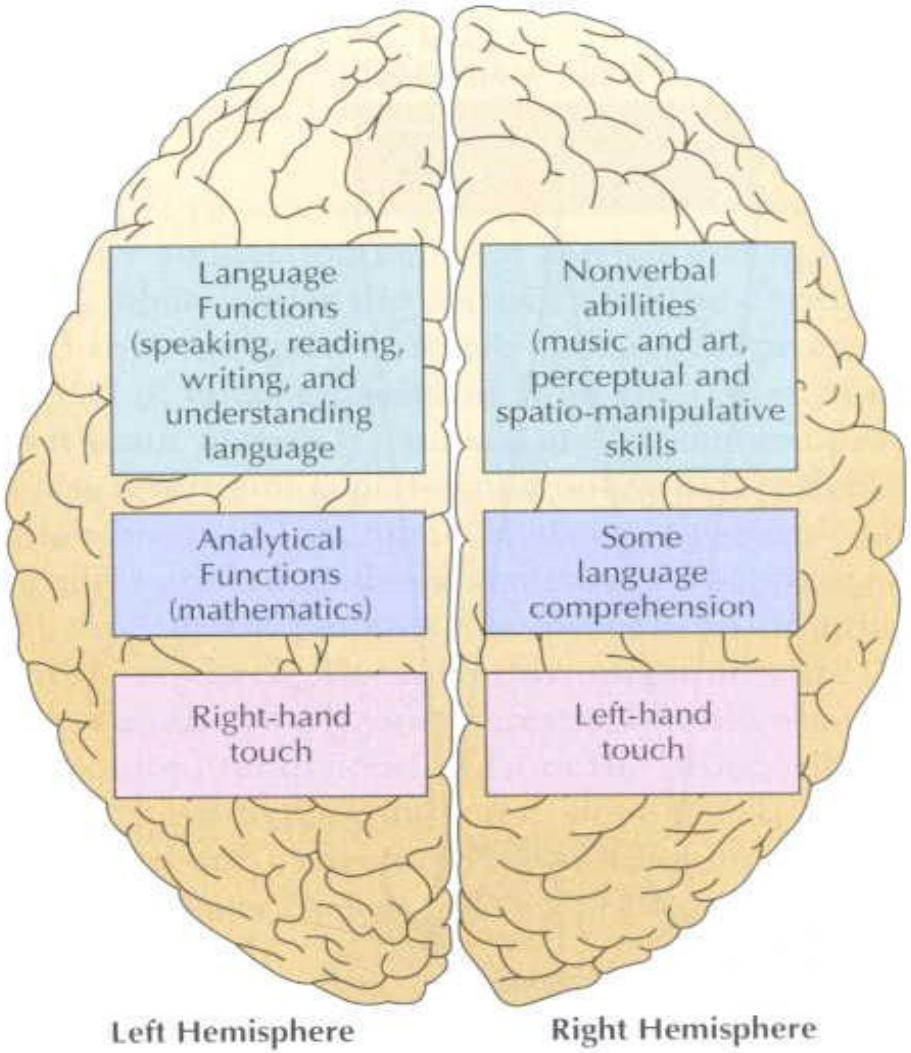


Hemispheric specialization

Some cortical functions are localized to a particular hemisphere of the brain.

Hemispheric Specialization

Figure 6.8 *Functions of the left and right hemispheres.* The left hemisphere specializes in verbal and analytical functions, whereas the right hemisphere focuses on nonverbal abilities, such as spatiomanipulative skills, art and musical abilities, and visual recognition tasks.




Left hemisphere
DETAILS
"A bunch of Ds"
"It's about sewing."
D
D
D
D
D
DDDDD
A stitch in time saves nine.
Right hemisphere
OVERALL PATTERN
"The letter L"
"A small effort now saves time later."
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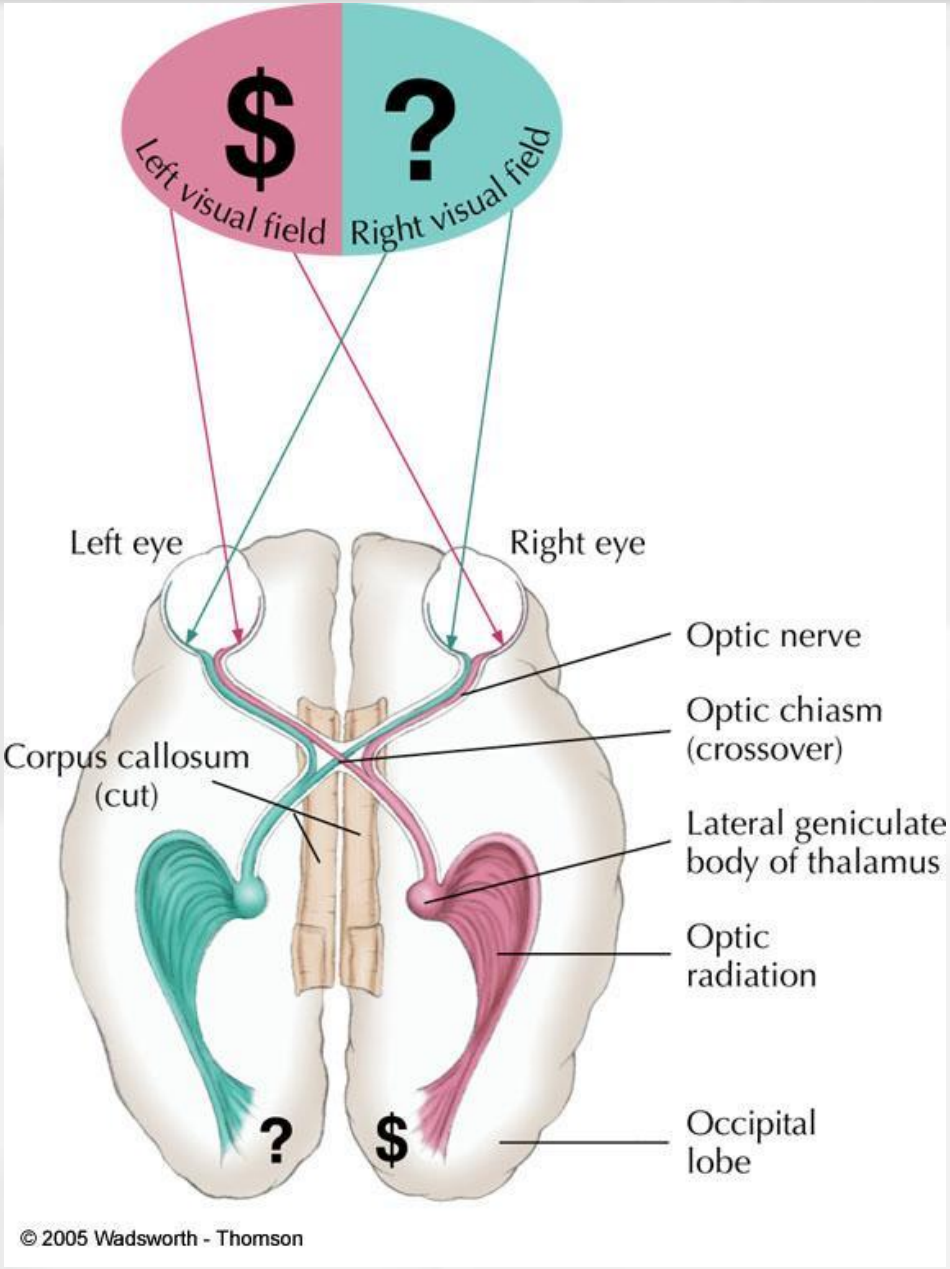
Split Brains

- How do we test only one side of the brain?
- Corpus Callosum is cut; done to control severe epilepsy (seizure disorder).

- Result: The person now has “two brains” in one body.
- This operation is rare and is often used as a last resort.


$
?
Left visual field
Right visual field
Left eye
Right eye
Optic nerve
Optic chiasm
(crossover)
Corpus callosum
(cut)
Lateral geniculate
body of thalamus
Optic
radiation
Occipital
lobe
?
$
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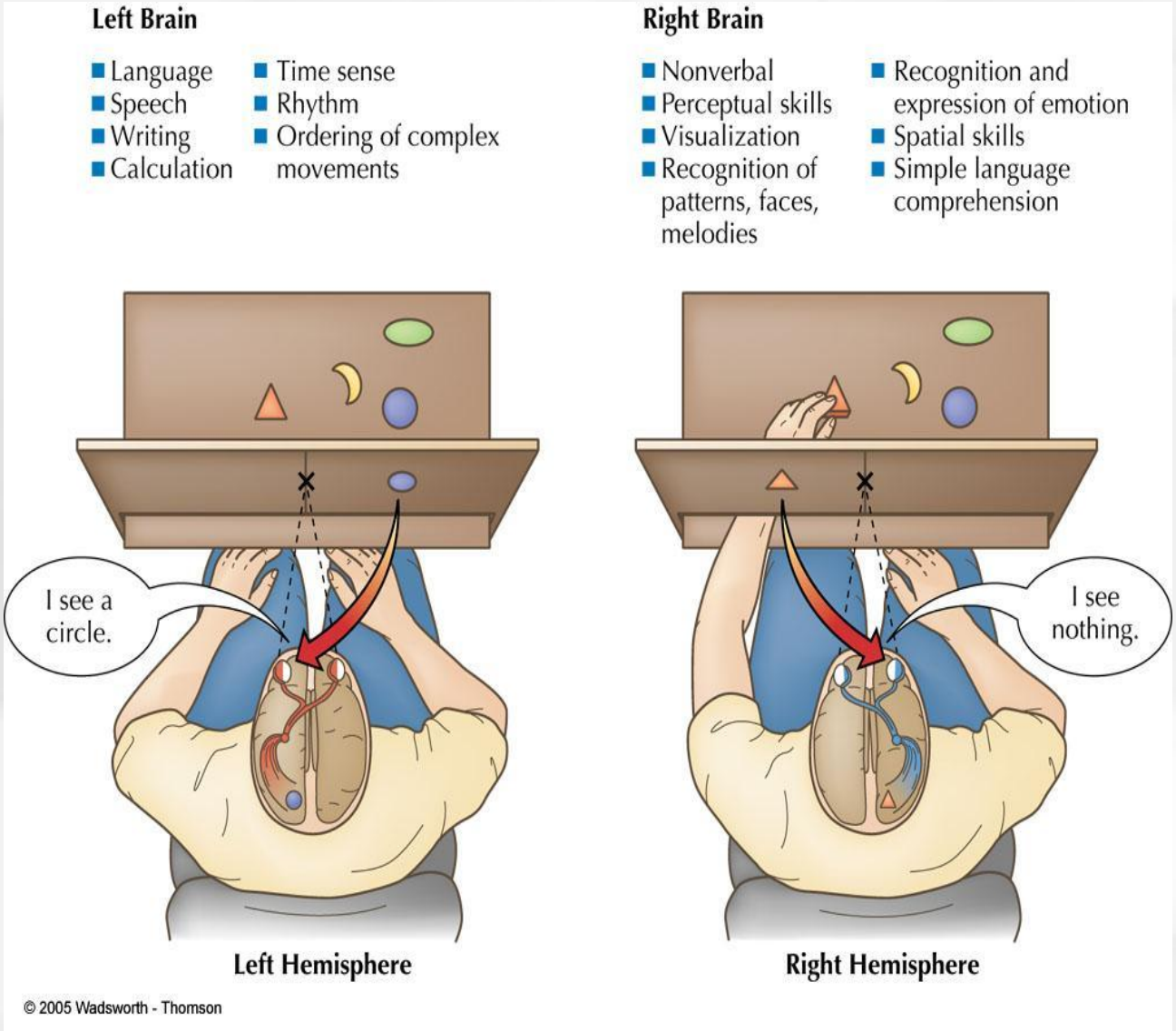
Left Brain
Language
Speech
Writing
Calculation
Time sense
Rhythm
Ordering of complex movements
Right Brain
Nonverbal
Perceptual skills
Visualization
Recognition of patterns, faces, melodies
Recognition and expression of emotion
Spatial skills
Simple language comprehension
I see a circle.
I see nothing.
Left Hemisphere
Right Hemisphere
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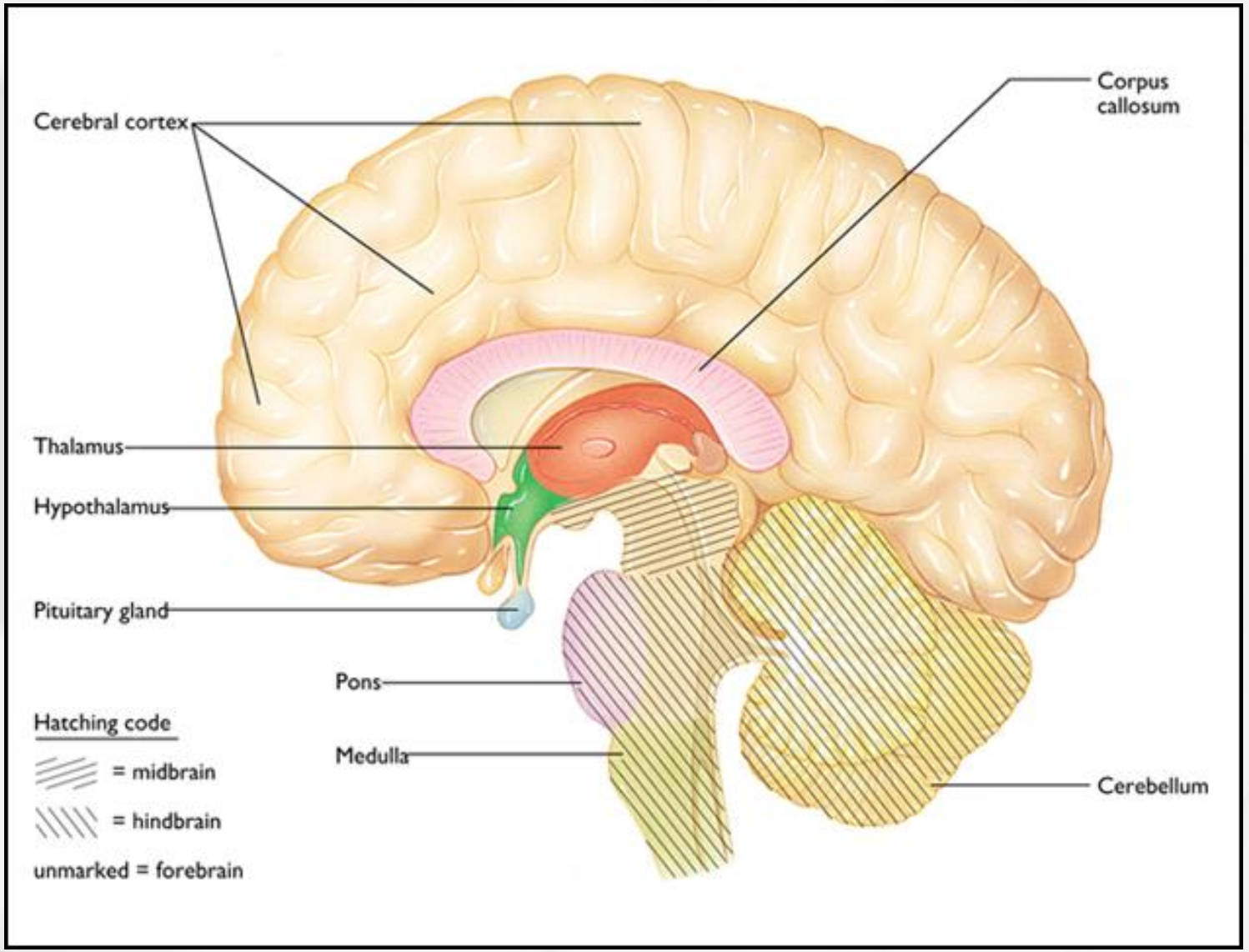
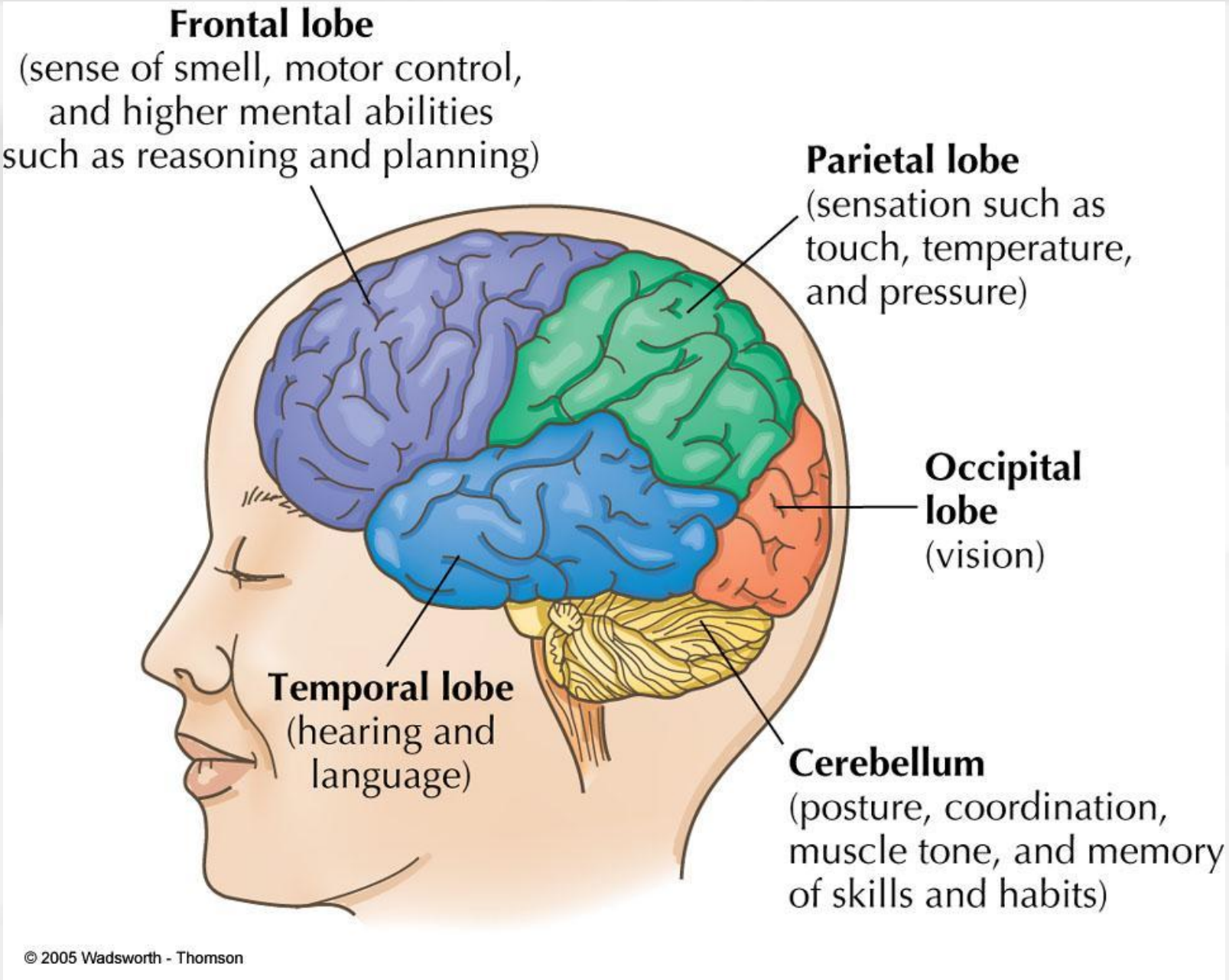
Central Cortex Lobes

- As discussed, the cerebral cortex can be divided into two hemispheres.
- We can further divide the cortex into several smaller areas called lobes.


Cerebral cortex
Corpus callosum
Thalamus
Hypothalamus
Pituitary gland
Pons
Medulla
Cerebellum
Hatching code
= midbrain
= hindbrain
unmarked = forebrain



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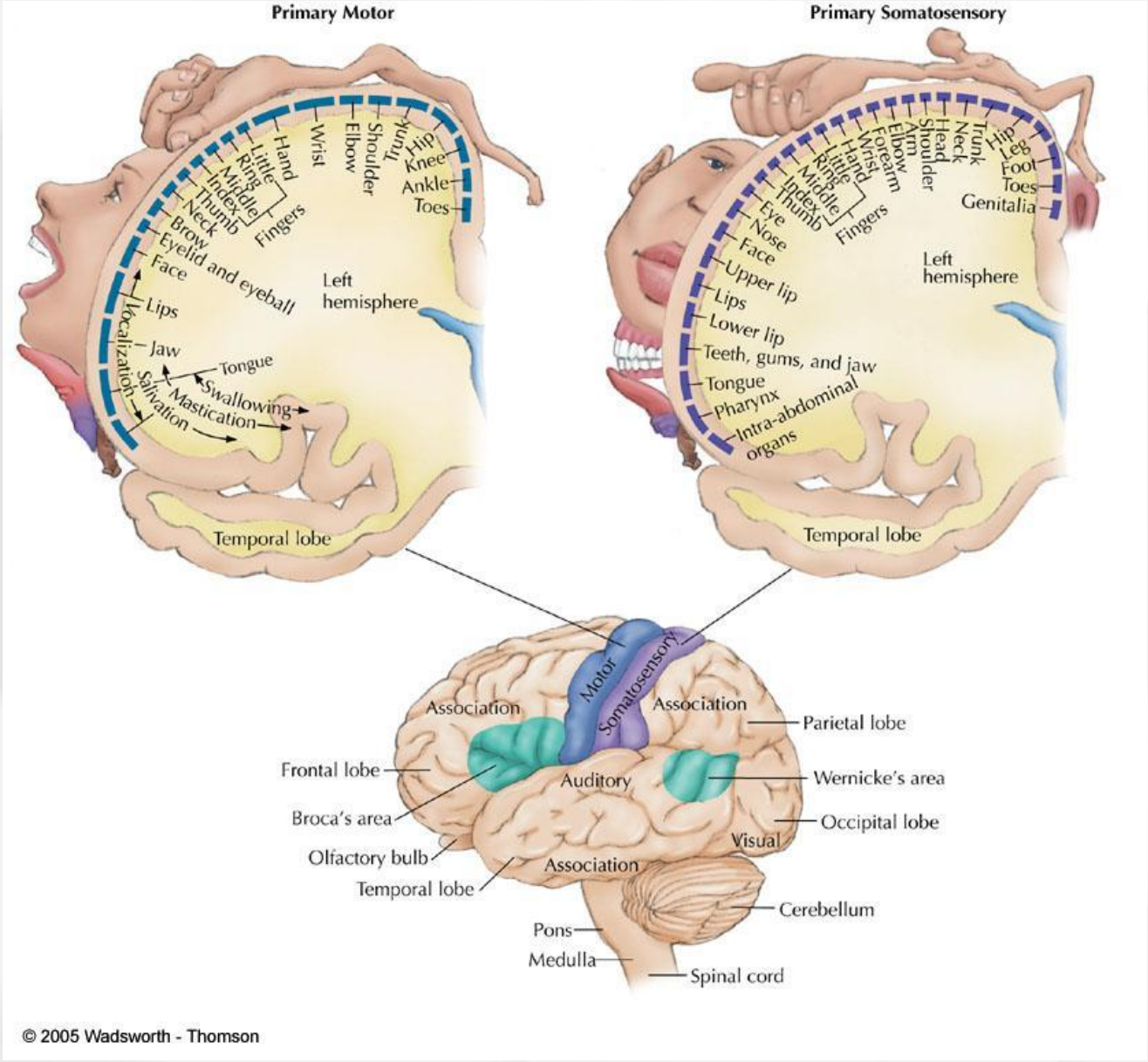
Which lobe is damaged if…..

- A person is unable to feel or locate the left side of his/her body?
- A person has difficulty with fine movement of the right hand?
- A person has loss of vision in the right visual field?
- A person has hearing loss in the left ear?



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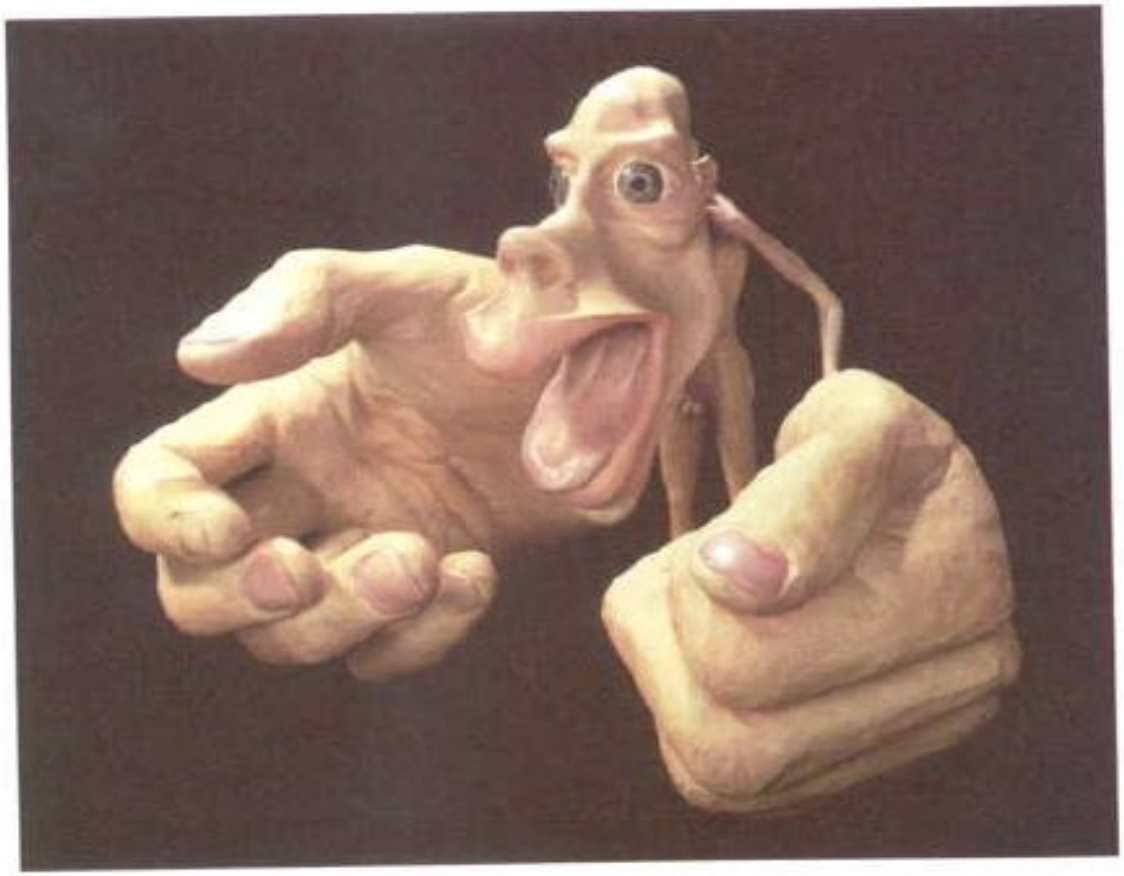
Space Allocation in the somatosensory cortex

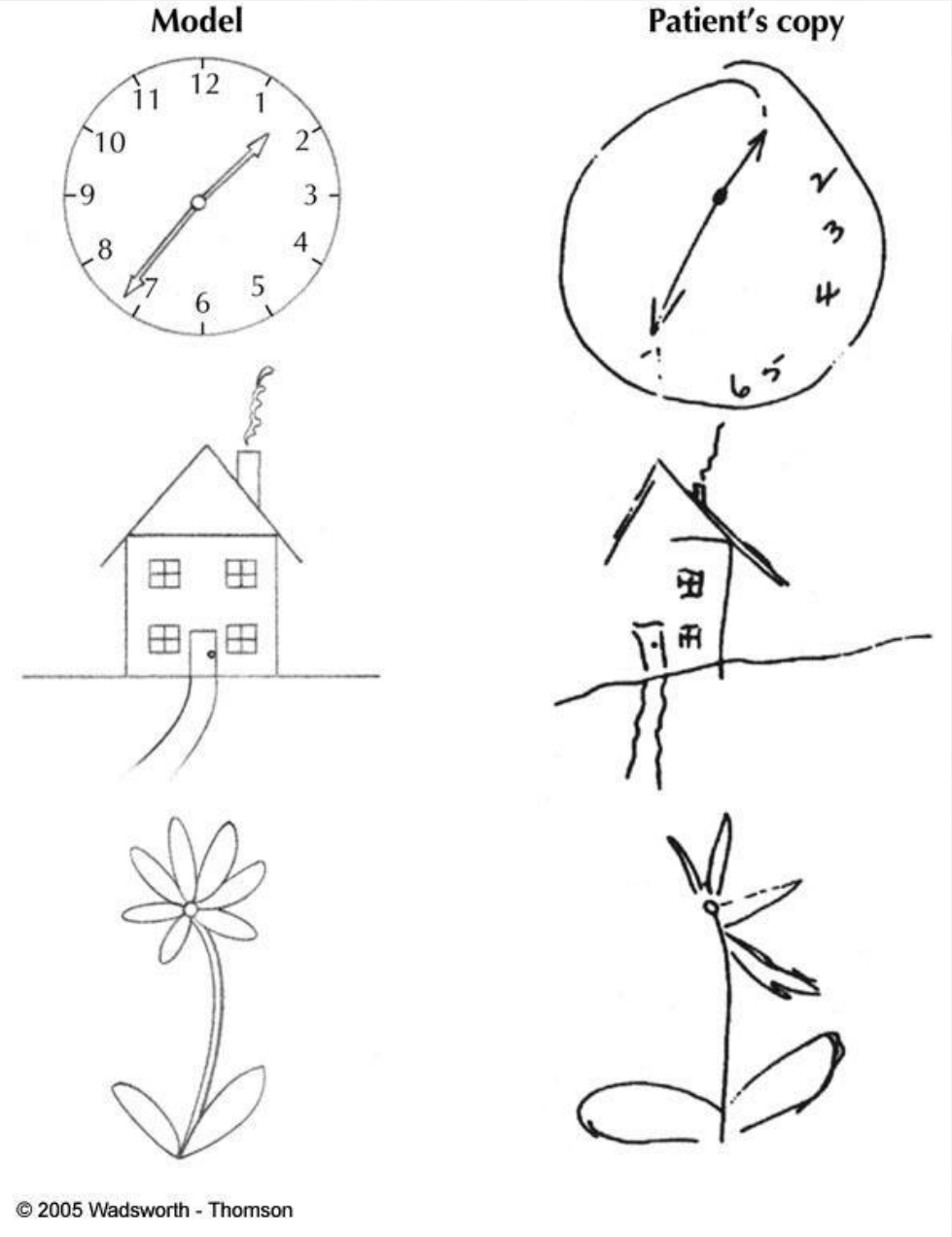


The motor and somatosensory cortex. This fanciful representation of a human suggests the overriding importance of the hands and the mouth by the amount of cortex that is dedicated to them.

When the Brain Fails to Function Properly

- Association Cortex: Combine and process information from the five senses

- Aphasia: Speech disturbance resulting from brain damage



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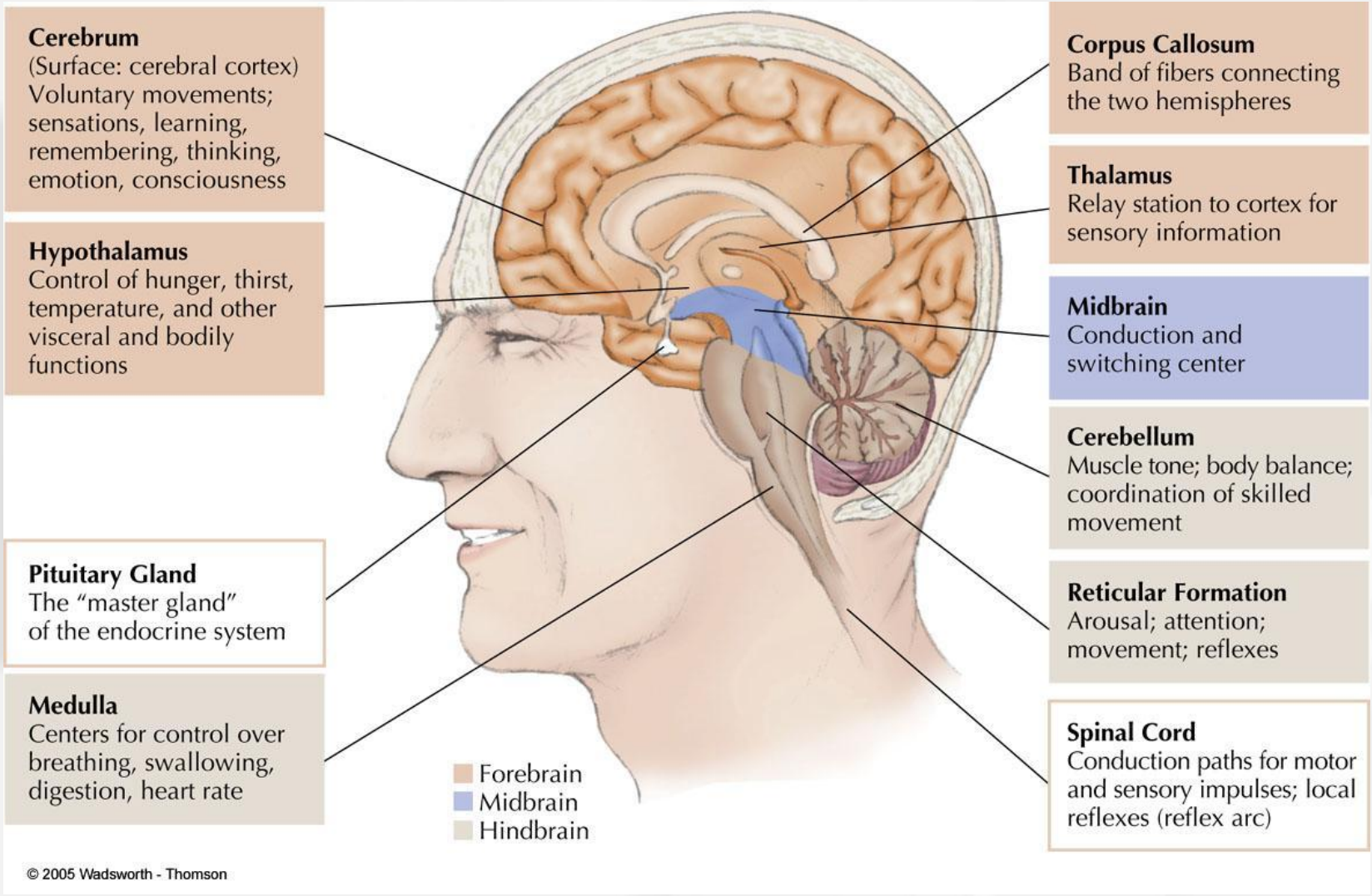
When the Brain Fails to Function Properly (cont'd)

- Broca's Area: Related to language and speech production
  - If damaged, person knows what s/he wants to say but can't say the words
- Wernicke's Area: Related to language comprehension
  - If damaged, person has problems with meanings of words, NOT pronunciation



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Subcortex

- Hindbrain (Brainstem)
  - Medulla: Connects brain with the spinal cord and controls vital life functions such as heart rate and breathing
  - Pons (Bridge): Acts as a bridge between medulla and other structures
    - Influences sleep and arousal
  - Cerebellum: Located at base of brain
    - Regulates posture, muscle tone, and muscular coordination

Subcortex: Reticular Formation (RF)

- Lies inside medulla and brainstem
  - Associated with alertness, attention and some reflexes (breathing, coughing, sneezing, vomiting)
- Reticular Activating System (RAS): Part of RF that keeps the cortex active and alert
    - Its alarm clock

Forebrain

- Structures are part of *Limbic System*: System within forebrain closely linked to emotional response
  - Thalamus: Relays sensory information to the cortex; switchboard
  - Hypothalamus: Regulates emotional behaviors and motives (e.g., sex, hunger, rage, hormone release)
  - Amygdala: Associated with fear responses
  - Hippocampus: Associated with storing memories; helps us navigate through space

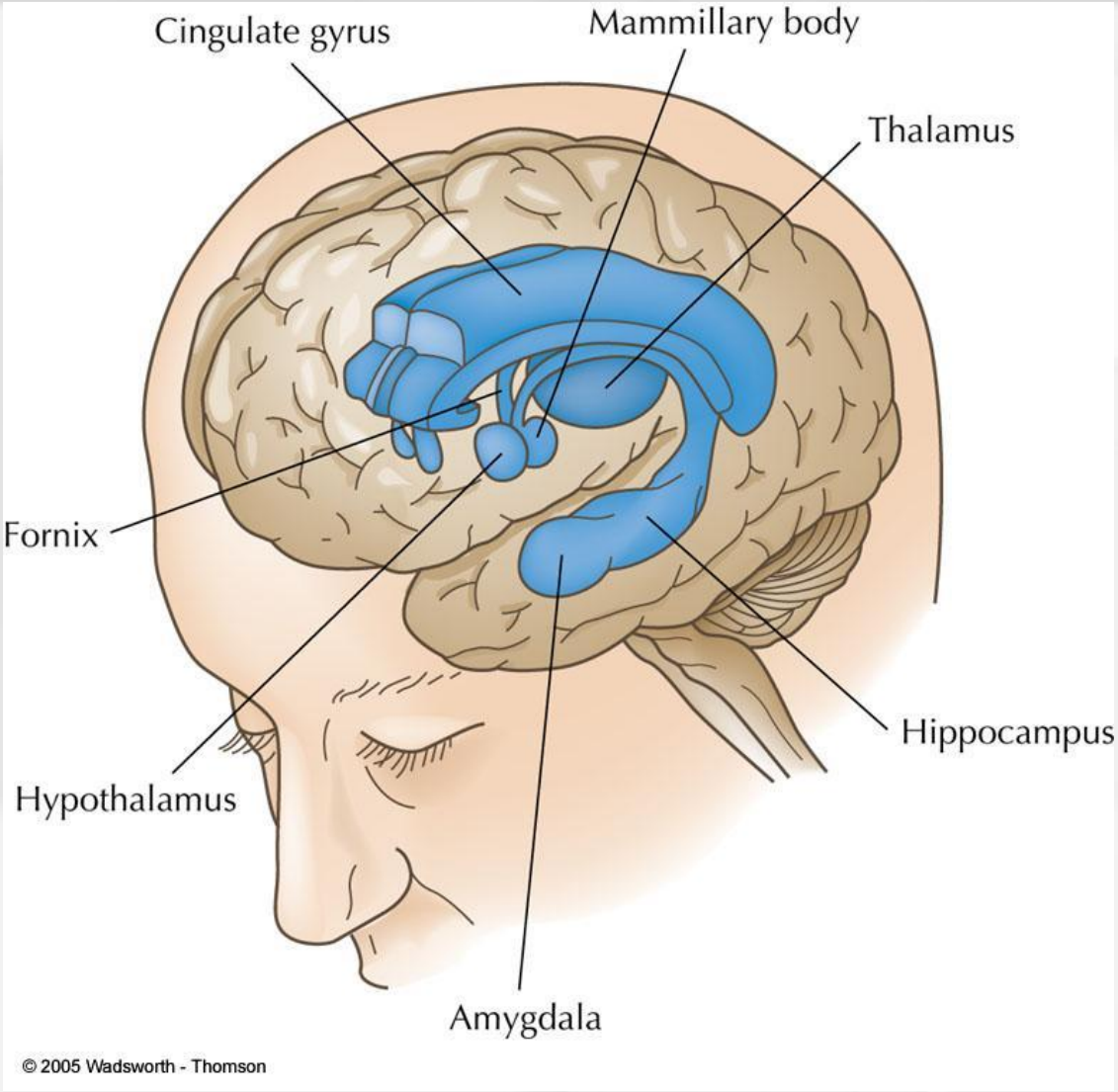


FIGURE 2.26 Parts of the limbic system. Although only one side is shown here, the hippocampus and the amygdala extend out into the temporal lobes at each side of the brain. The limbic system is a sort of "primitive core" of the brain strongly associated with emotion.

Endocrine System

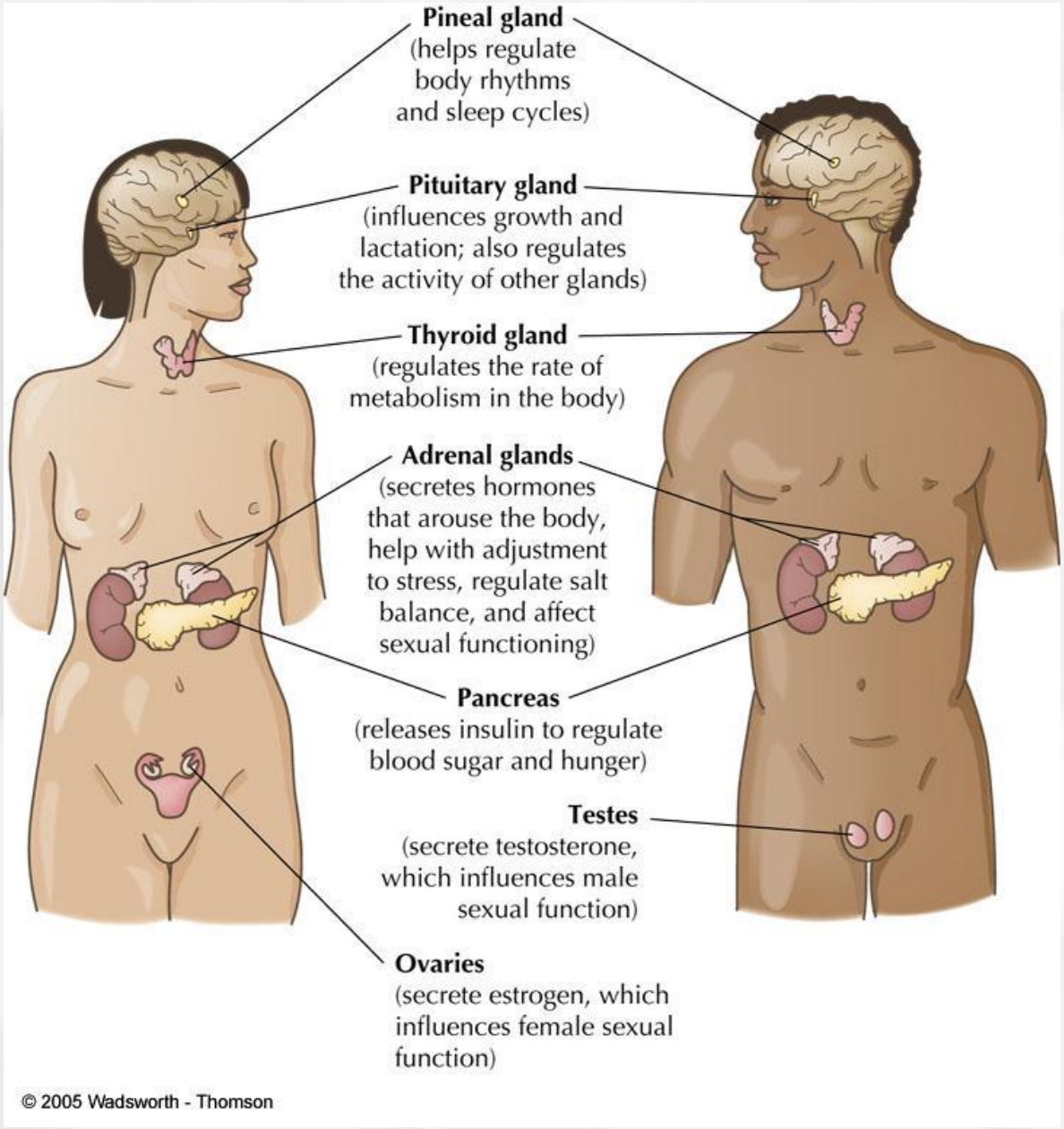
- Glands that pour chemicals (hormones) directly into the bloodstream or lymph system
  - Pituitary Gland: Regulates growth via growth hormone
    - Too little means person will be smaller than average
      - Hypopituitary Dwarfs: As adults, perfectly proportioned but tiny
    - Too much leads to *giantism*
      - Excessive body growth

Endocrine System (cont'd)

- Acromegaly: Enlargement of arms, hands, feet, and facial bones
  - Too much growth hormone released late in growth period
    - Andre the Giant

Endocrine System Concluded

- Pineal Gland: Regulates body rhythms and sleep cycles.
  - Releases hormone melatonin, which responds to daily variations in light.
- Thyroid: In neck; regulates metabolism.
  - Hyperthyroidism: Overactive thyroid; person tends to be thin, tense, excitable, nervous.
  - Hypothyroidism: Underactive thyroid; person tends to be inactive, sleepy, slow, obese.


Pineal gland
(helps regulate body rhythms and sleep cycles)
Pituitary gland
(influences growth and lactation; also regulates the activity of other glands)
Thyroid gland
(regulates the rate of metabolism in the body)
Adrenal glands
(secretes hormones that arouse the body, help with adjustment to stress, regulate salt balance, and affect sexual functioning)
Pancreas
(releases insulin to regulate blood sugar and hunger)
Testes
(secrete testosterone, which influences male sexual function)
Ovaries
(secrete estrogen, which influences female sexual function)
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The Adrenal Glands

- Adrenals: Arouse body, regulate salt balance, adjust body to stress, regulate sexual functioning; located on top of kidneys
  - Releases epinephrine and norepinephrine (also known as adrenaline and noradrenaline)
    - Epinephrine arouses body; is associated with fear
    - Norepinephrine arouses body; is linked with anger

The Adrenal Glands (cont'd)

- Adrenal Medulla: Source of epinephrine and norepinephrine
- Adrenal Cortex: Produces hormones known as corticoids
  - Regulate salt balance
  - Deficiency in some types will cause powerful salt cravings
  - Oversecretion of adrenal sex hormones can cause virilism: exaggerated male characteristics (Bearded woman)
  - May also cause premature puberty (full sexual development in childhood) if occurs early in life

Handedness

- Preference for right or left hand
- Dominant Hemisphere: Applies to side of person's brain that produces language
- Lateralization: Difference in the abilities of the brain's hemispheres

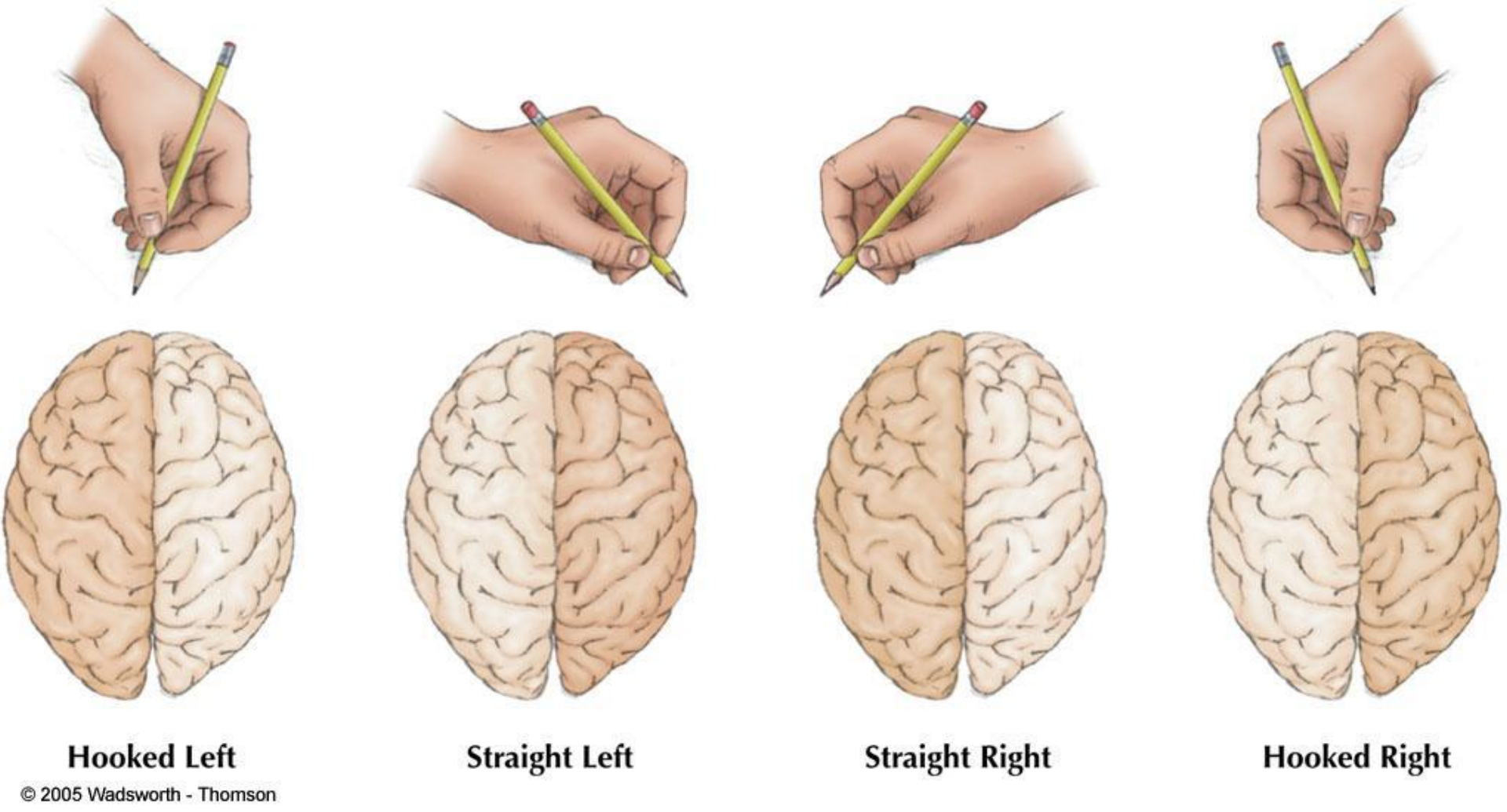

FIGURE 2.29 Research suggests that the hand position used in writing may indicate which brain hemisphere is used for language.