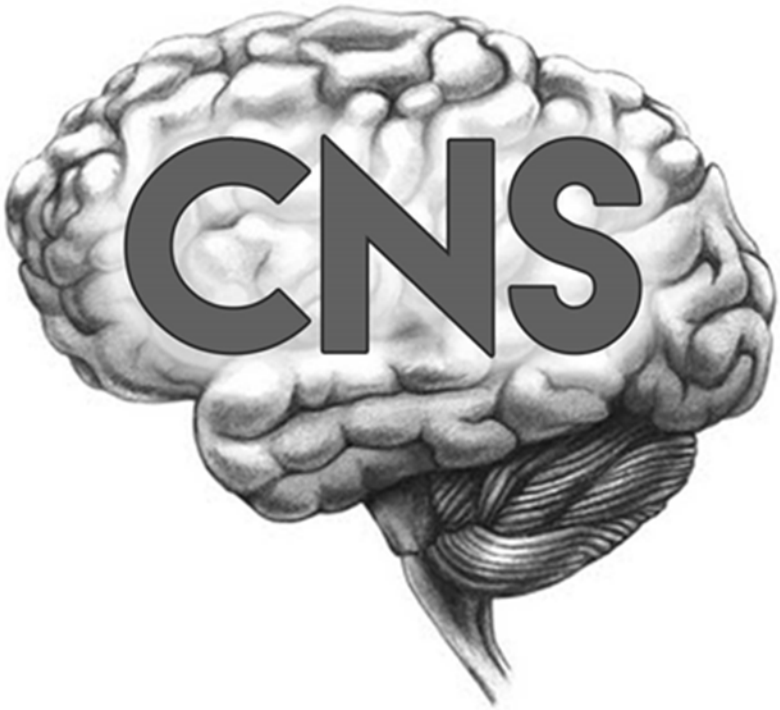


PHYSIOLOGY

○ Sheet ✓ Slide ○ Handout

Number

15

Subject

Cerebral Cortex; Intellectual Functions of the Brain; Learning and Memory

Prof.

Faisal Mohammed

Date: **00/00/2016**

Price:

Cerebral Cortex; Intellectual Functions of the Brain; Learning and Memory

Faisal I. Mohammed, MD, PhD

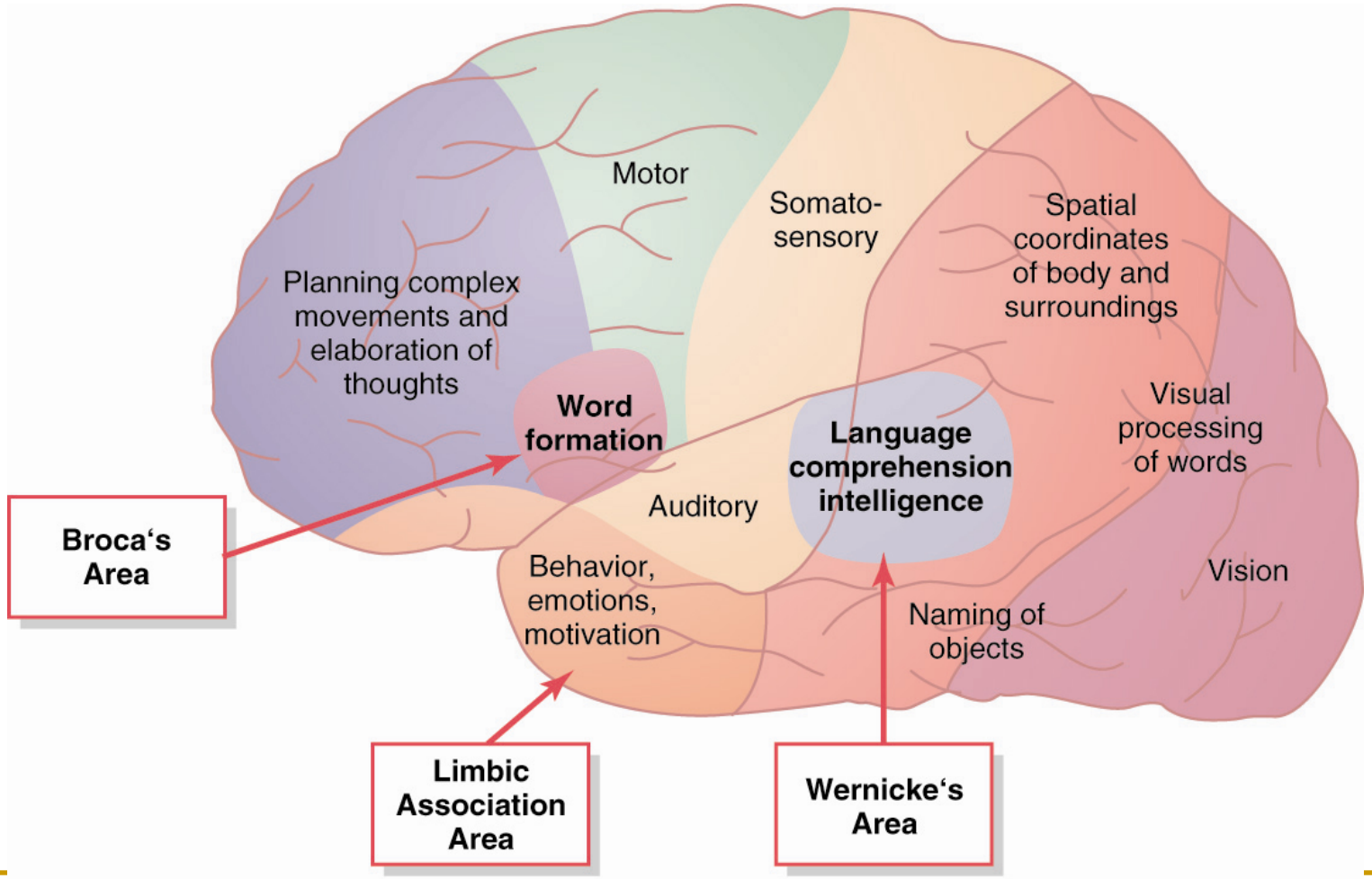
Objectives

- Describe intellectual functions of the cerebral cortical areas
- Explain memory and learning
- Outline the dominant and non-dominant hemispheres
- Delineate language areas of speech

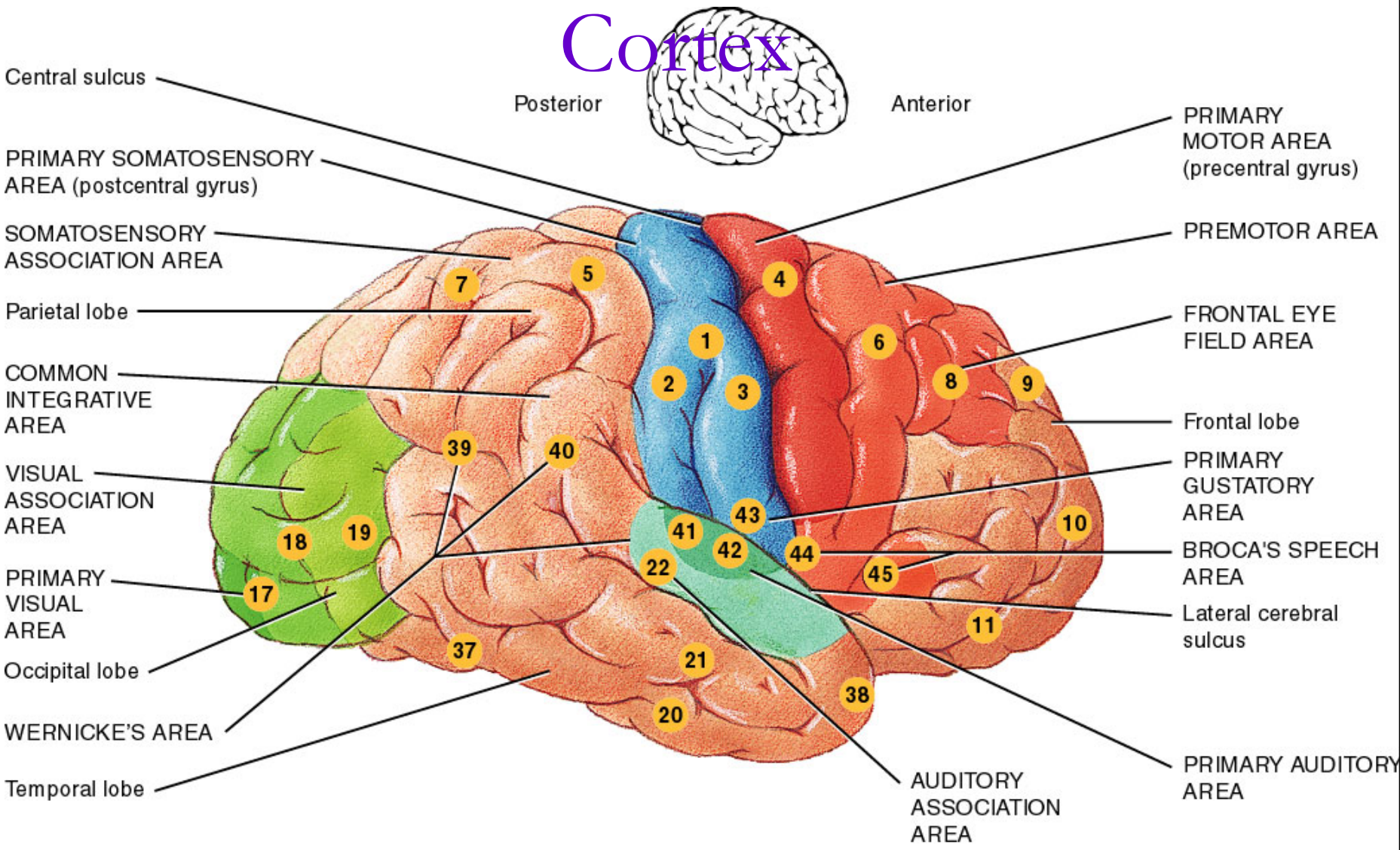
Physiologic Anatomy of Cerebral Cortex

- Each area of the cortex is connected to a specific part of the thalamus.
- When thalamic connection is lost cortical function stops.
- All sensory pathways pass through the thalamus with the exception of some olfactory signals.

Physiological Anatomy of the Cerebral Cortex



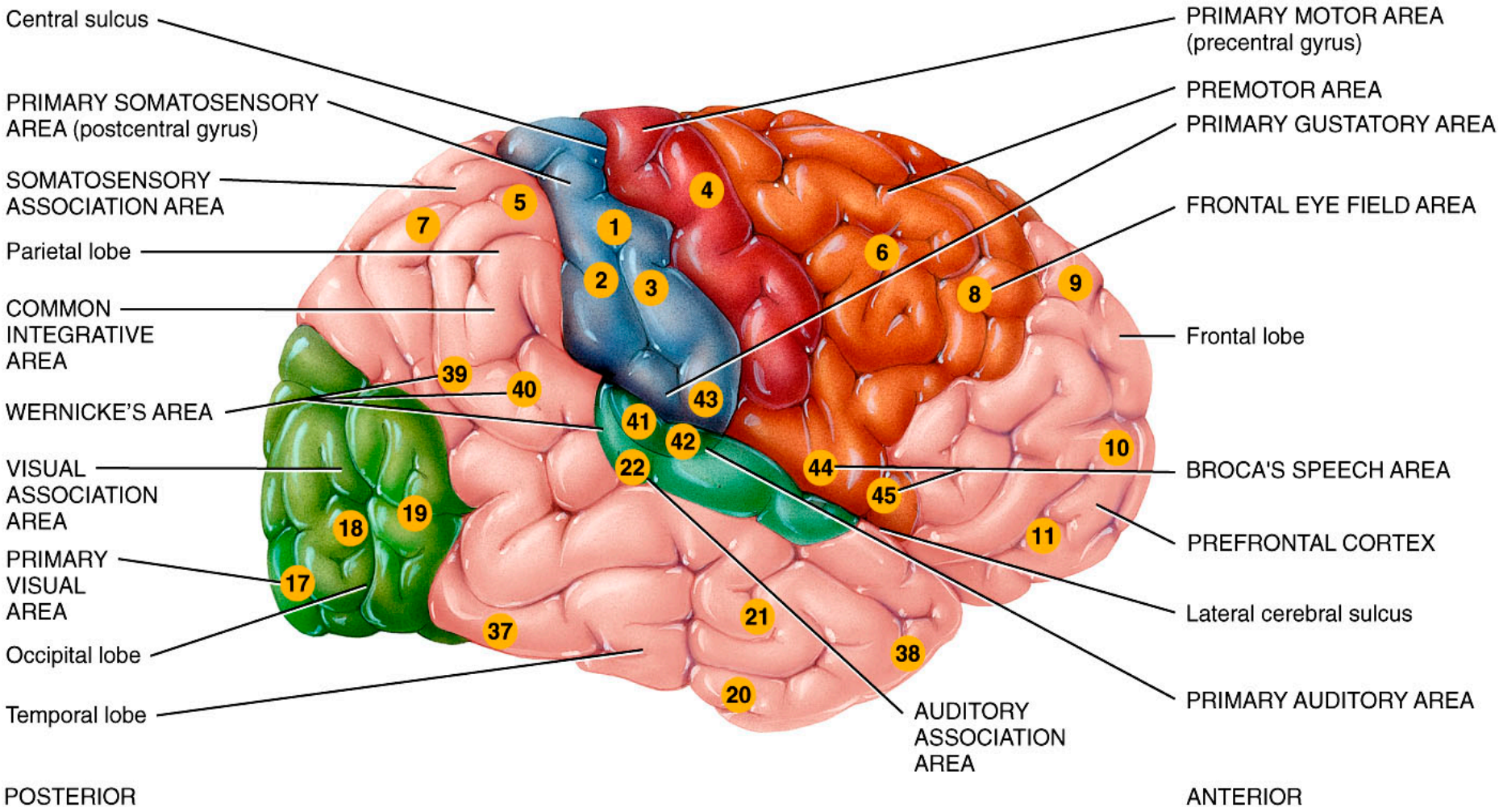
Functional Organization of the Cerebral Cortex



Lateral view of right cerebral hemisphere

14.15

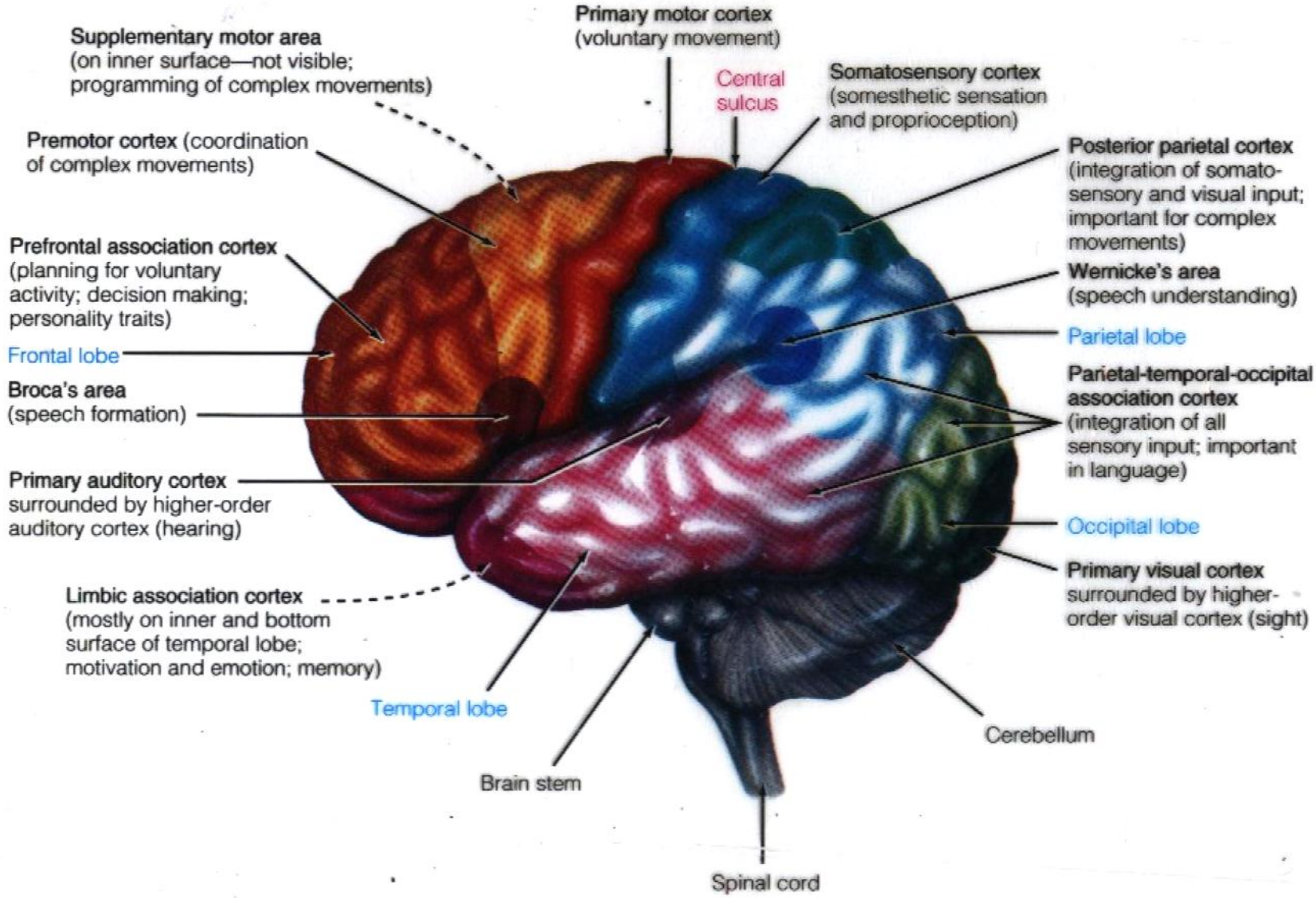
Functional Organization of the Cerebral Cortex

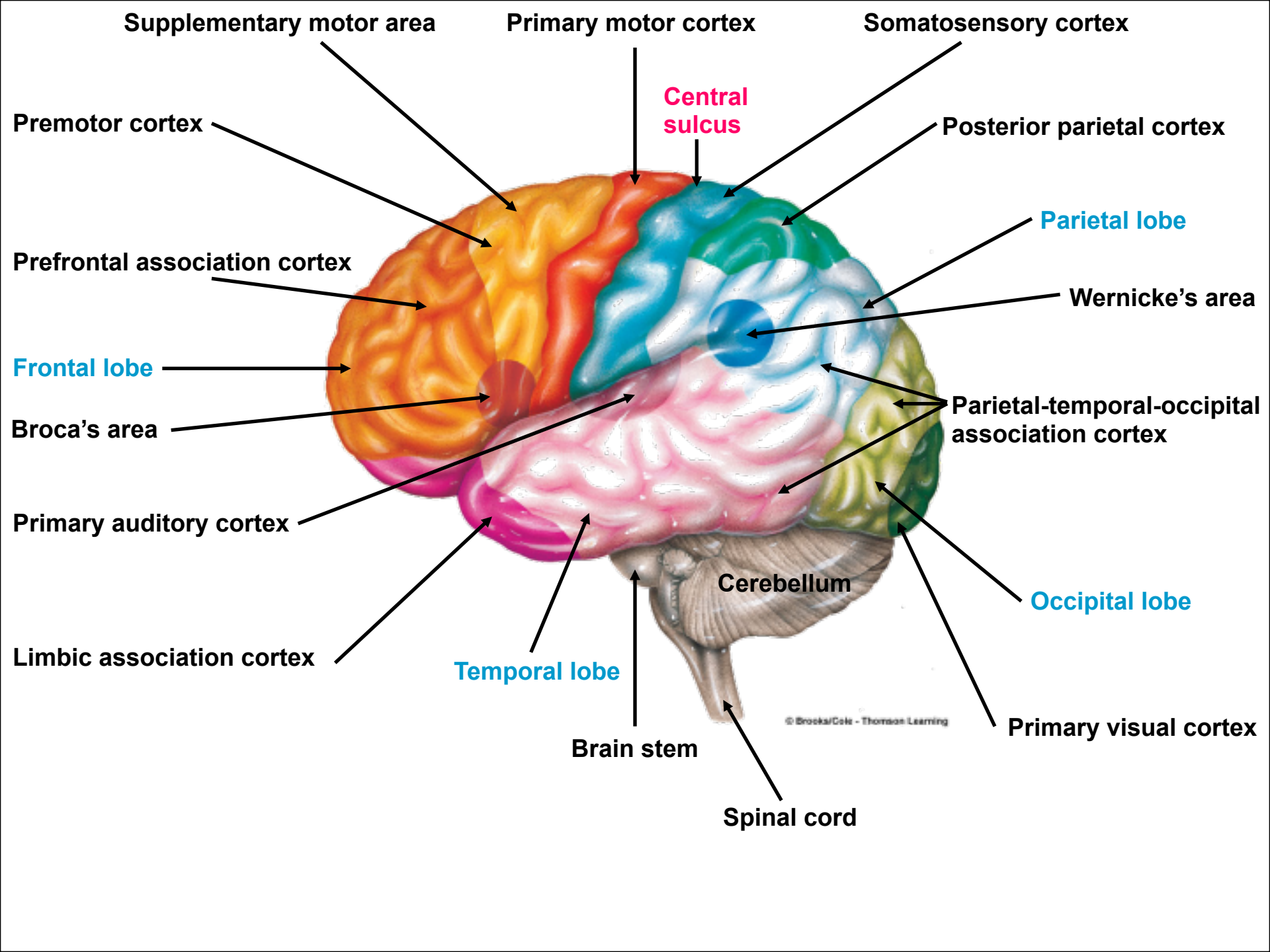


Lateral view of right cerebral hemisphere

Figure 14.15 Tortora - PAP 12/e

Functional Areas of the Cerebral Cortex




Supplementary motor area
Primary motor cortex
Somatosensory cortex
Central sulcus
Premotor cortex
Posterior parietal cortex
Parietal lobe
Prefrontal association cortex
Wernicke's area
Frontal lobe
Parietal-temporal-occipital association cortex
Broca's area
Primary auditory cortex
Cerebellum
Occipital lobe
Limbic association cortex
Temporal lobe
Brain stem
Primary visual cortex
Spinal cord
© Brooks/Cole - Thomson Learning

Dominant and Non-Dominant Hemisphere

- Wernicke's area more developed in one hemisphere, responsible for verbal symbolism and related intelligence. *Dominance is related to Language*
- 95% of population has a left dominant hemisphere.
- Wernicke's area can be as much as 50% larger in the dominant hemisphere.

Dominant and Non-Dominant Hemisphere (Cont'd)

- Damage to dominant Wernicke's area leads to dementia.
- Non-dominant side related to other forms of sensory intelligence (music, sensory feelings).

Hemispheric Lateralization

TABLE 14.3

Functional Differences Between the Two Cerebral Hemispheres

LEFT HEMISPHERE FUNCTIONS	RIGHT HEMISPHERE FUNCTIONS
Receives somatic sensory signals from and controls muscles on right side of body.	Receives somatic sensory signals from and controls muscles on left side of body.
Reasoning.	Musical and artistic awareness.
Numerical and scientific skills.	Space and pattern perception.
Ability to use and understand sign language.	Recognition of faces and emotional content of facial expressions.
Spoken and written language.	Generating emotional content of language.
	Generating mental images to compare spatial relationships.
	Identifying and discriminating among odors.

Table 14.03 Tortora - PAP 12/e

Language Areas

- Located in a large area surrounding the left (or language-dominant) lateral sulcus
- Major parts and functions:
  - Wernicke's area – involved in sounding out unfamiliar words – sensory aspect of speech- damage ⟶ sensory aphasia (Receptive aphasia)
  - Broca's area – speech preparation and production- motor aspect of speech – damage ⟶ motor aphasia (expressive aphasia0
  - Both Wernicke's and Broca's area damage ⟶ global aphasia
  - Lateral prefrontal cortex – language comprehension and word analysis
  - Lateral and ventral temporal lobe – coordinate auditory and visual aspects of language

Brain Organization and Handedness

- Close to 90% of people are right-handed and close to 10% are left-handed and a small number are ambidextrous (use both hands)
- 95% of right-handers process speech primarily in the left hemisphere
  - left-handers: around 65% in left hemisphere, 15-20% in right hemisphere, 15-20% in both
- More than 90% of people are born with the left hemisphere area that controls the movement of the right hand is bigger
  - They tend to use the right hand, this area grows and become dominant

Brain Organization and Handedness …cont

- Left handed people have their right cerebral hemisphere area that controls the movement of the left hand bigger
  - If they use the left hand then this area grow and become dominant
  - They still can convert and the younger the more easier if they start to use their right hand instead and then they become right handed
  - Same applies for using the legs

Intellectual Functions of the Prefrontal Association Area

- responsible for calling forth stored information and using it to obtain a goal
- responsible for concerted thinking in a logical sequence
  - damage causes an inability to keep tract of simultaneous bits of information, easily distracted

Intellectual Functions of the Prefrontal Association Area (Cont'd)

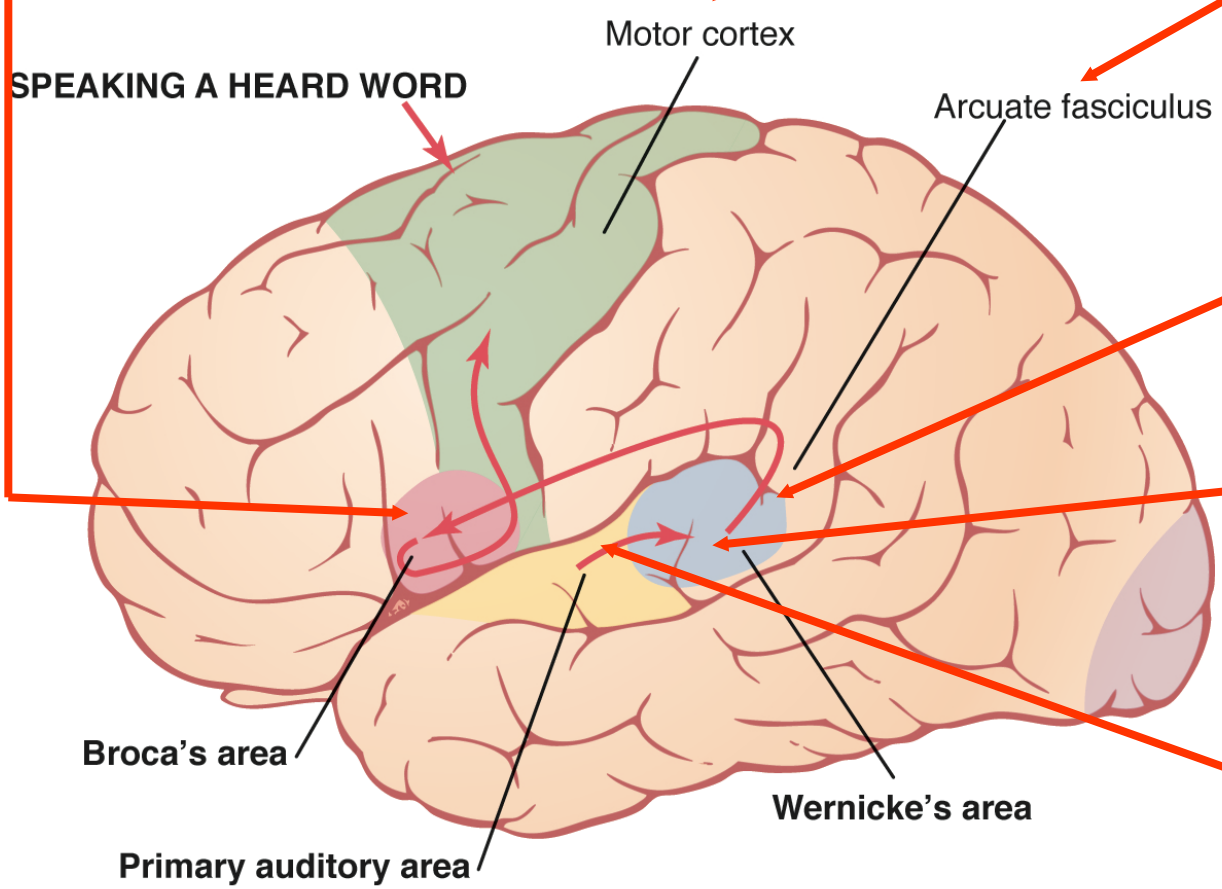
- elaboration of thought
  - prognosticate, plan, consider consequences of motor actions before they are performed
  - correlate widely divergent information, control one's activities
  - Personality trait and behavior that confines to values and manners of the culture

Pathways for Auditory Communication

5. activation of motor programs in Broca's area for control of word formation

6. transmission of signals to motor cortex to control speech muscles

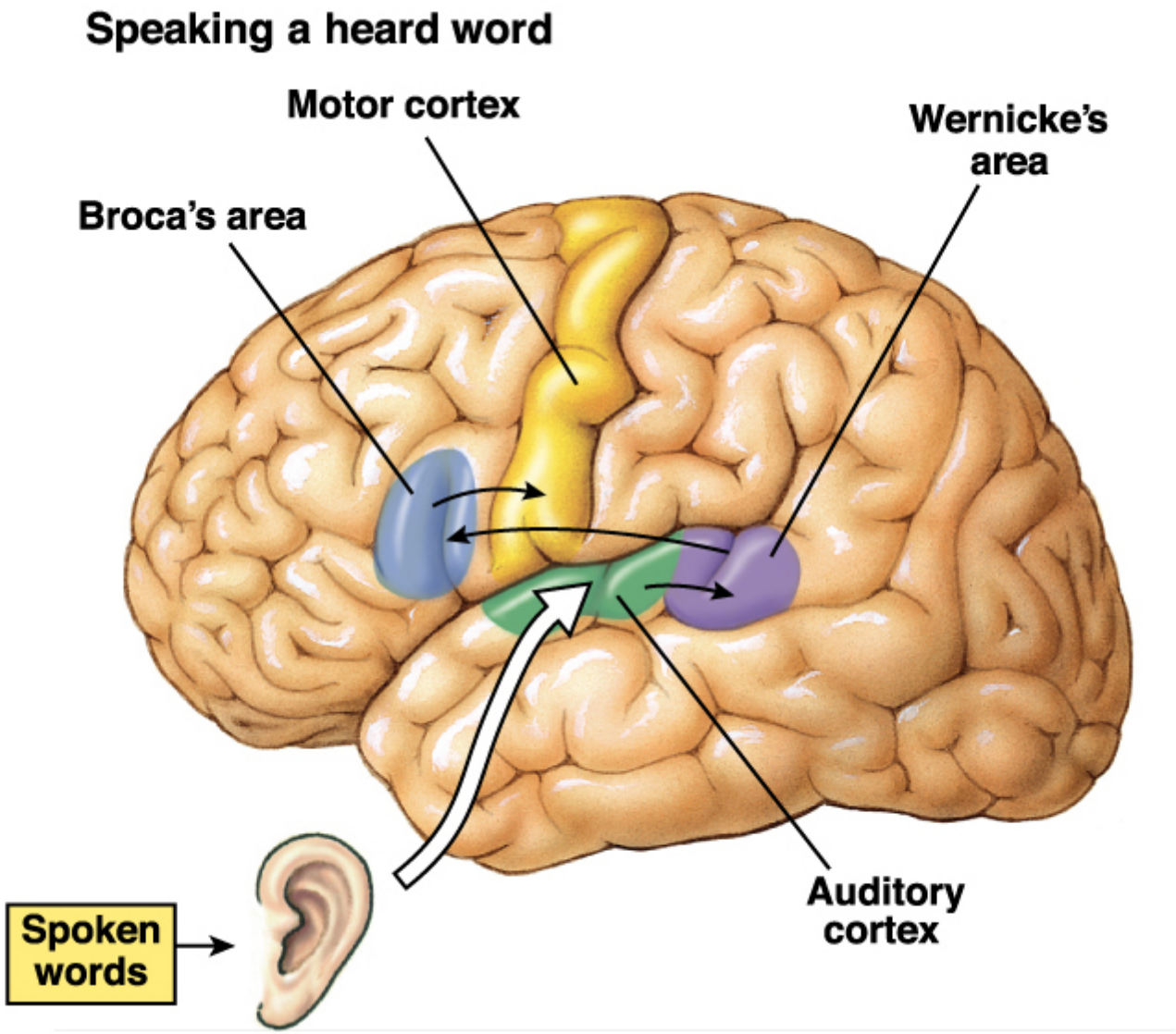
4. transmission via the arcuate fasciculus to Broca's area



3. formation of the word that expresses a particular thought

2. interpretation of the word and the thought that the word expresses in Wernicke's area

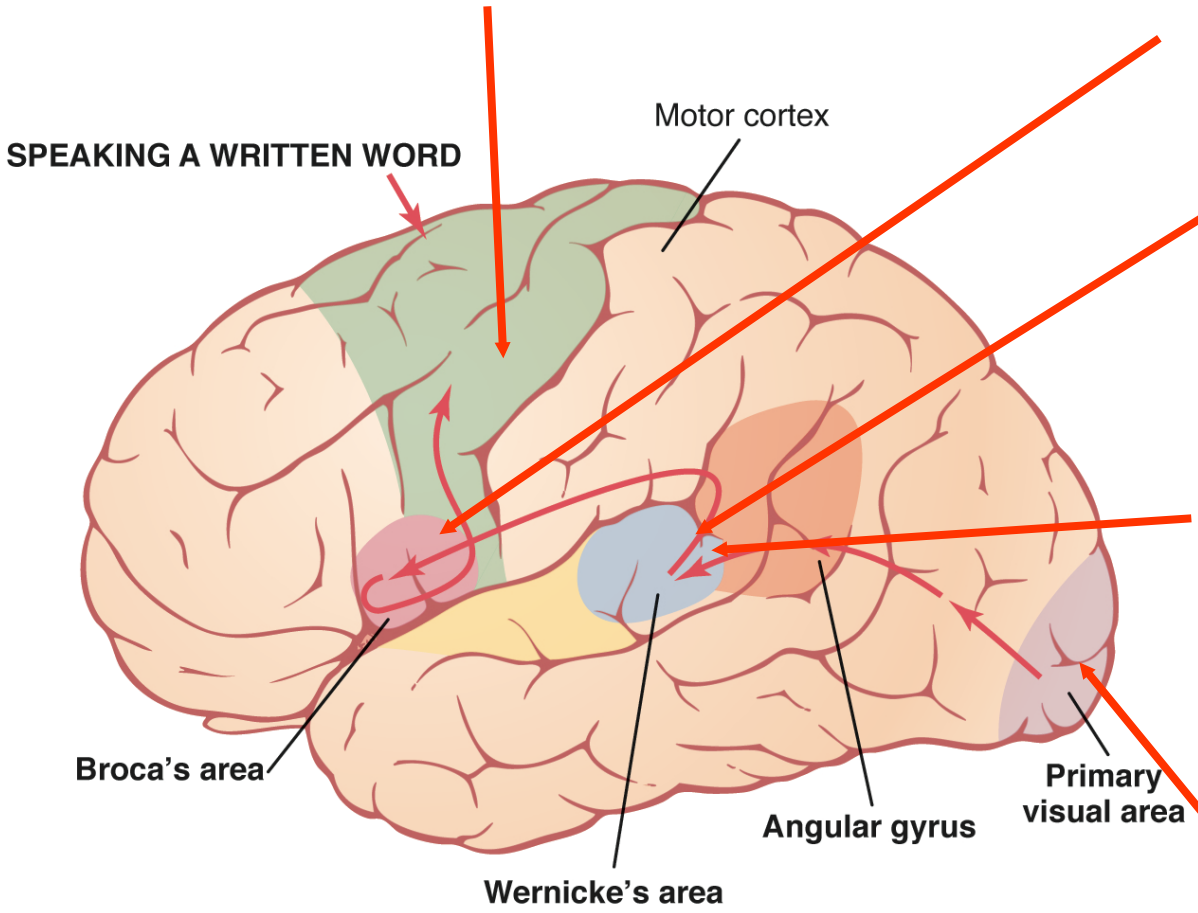
1. primary auditory area recognition of the sound as a word


Speaking a heard word
Motor cortex
Wernicke's area
Broca's area
Auditory cortex
Spoken words

Pathways for Visual Communication

5. transmission of signals to motor cortex to control speech muscles

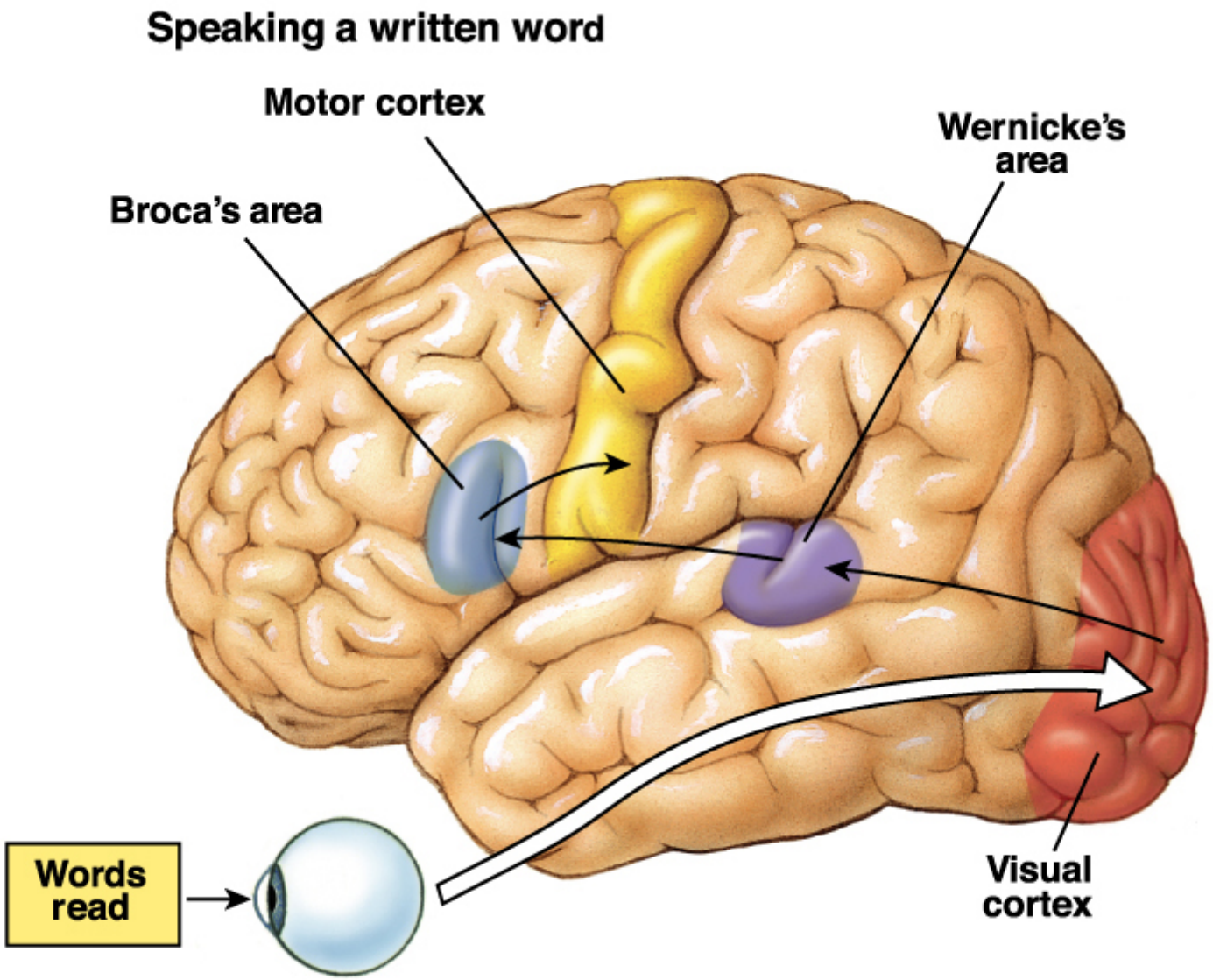
4. then to Broca's area for motor formation of the word



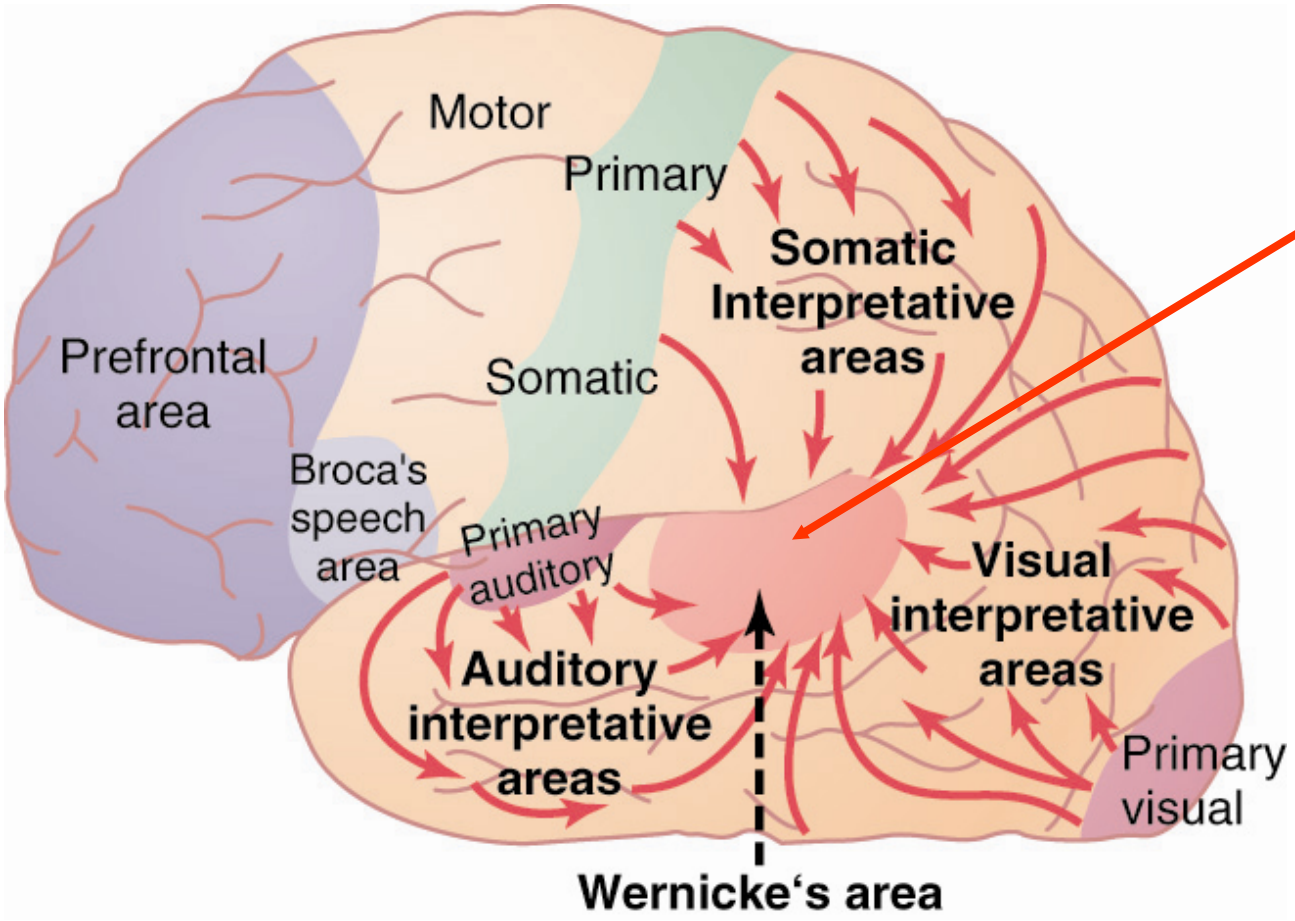
3. visual input reaches full level of interpretation in Wernicke's area

2. processing of the visual information in the parietal-temporal-occipital association cortex, the angular gyrus region

1. receive the visual input in primary visual area


Speaking a written word
Motor cortex
Wernicke's area
Broca's area
Words read
Visual cortex

Sensory Aspects of Communication



Wernicke's aphasia

Destruction of the visual and auditory association areas results in an inability to understand the written or spoken word.

Motor Aspects of Communication

- Speech involves two things
  - formation in the mind of thoughts to be expressed and the choice of words
  - motor control of vocalization and the act of vocalization
- Formation of word, thought and choice of words is function of Wernicke's area.
- Broca's area controls the motor coordination required for speech.

Function of the Corpus Callosum

- connects the two hemispheres and allows transfer of information
- interruption of these fibers can lead to bizarre types of anomalies
  - dominant hemisphere understands spoken word
  - non dominant hemisphere understands written word and can elicit motor response without dominant side knowing why response was performed

Thoughts and Memory

- Neural mechanism for thought is not known.
- Most likely a specific pattern of simultaneous neural activity in many brain areas.
- Destruction of cerebral cortex does not prevent one from thinking.
  - However, depth of thought and level of awareness may be less.

Memory and learning

- Learning is acquiring new sensory information or motor skills
- Change in the capability of synaptic transmission from neuron to neuron as a result of prior stimulation.
- Memory trace is a specific pattern or pathway of signal transmission.
- Once established they can be activated by the thinking mind to reproduce the pattern and thus the memory.

3 Types of Memory

- immediate memory
  - lasts for seconds or minutes (remembering 10 digit phone number)
- short-term memory
  - lasts for days to weeks
- long-term memory
  - lasts for years or for a lifetime

Mechanism of Memory

- Immediate memory may result from synaptic potentiation through the accumulation of calcium in the presynaptic membrane.
  - would promote neurotransmitter release
- Short-term memory may result from a temporary physical or chemical change in the pre- or postsynaptic membrane.

Cellular Basis for Memory

- repetitive stimulation causes a progressive decline in sensitivity called *habituation*
- results from progressive decline in the number of active calcium channels
- less calcium entry less transmitter released
- stimulation of facilitator terminal prevents habituation

Molecular Basis for Memory

Transmitter activates G protein which in turn activates adenylate cyclase resulting in an increase in cAMP.

cAMP activates a protein kinase that phosphorylates a component of the K+ channel blocking its activity.

This prolongs the action potential which increases transmitter release.

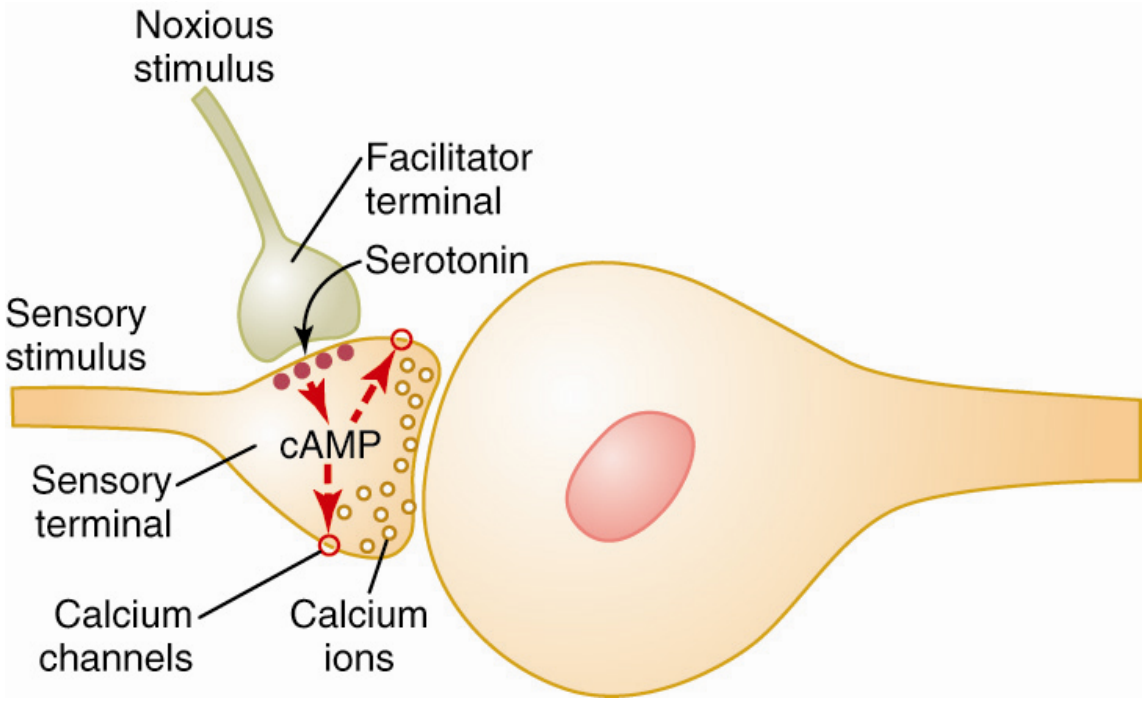


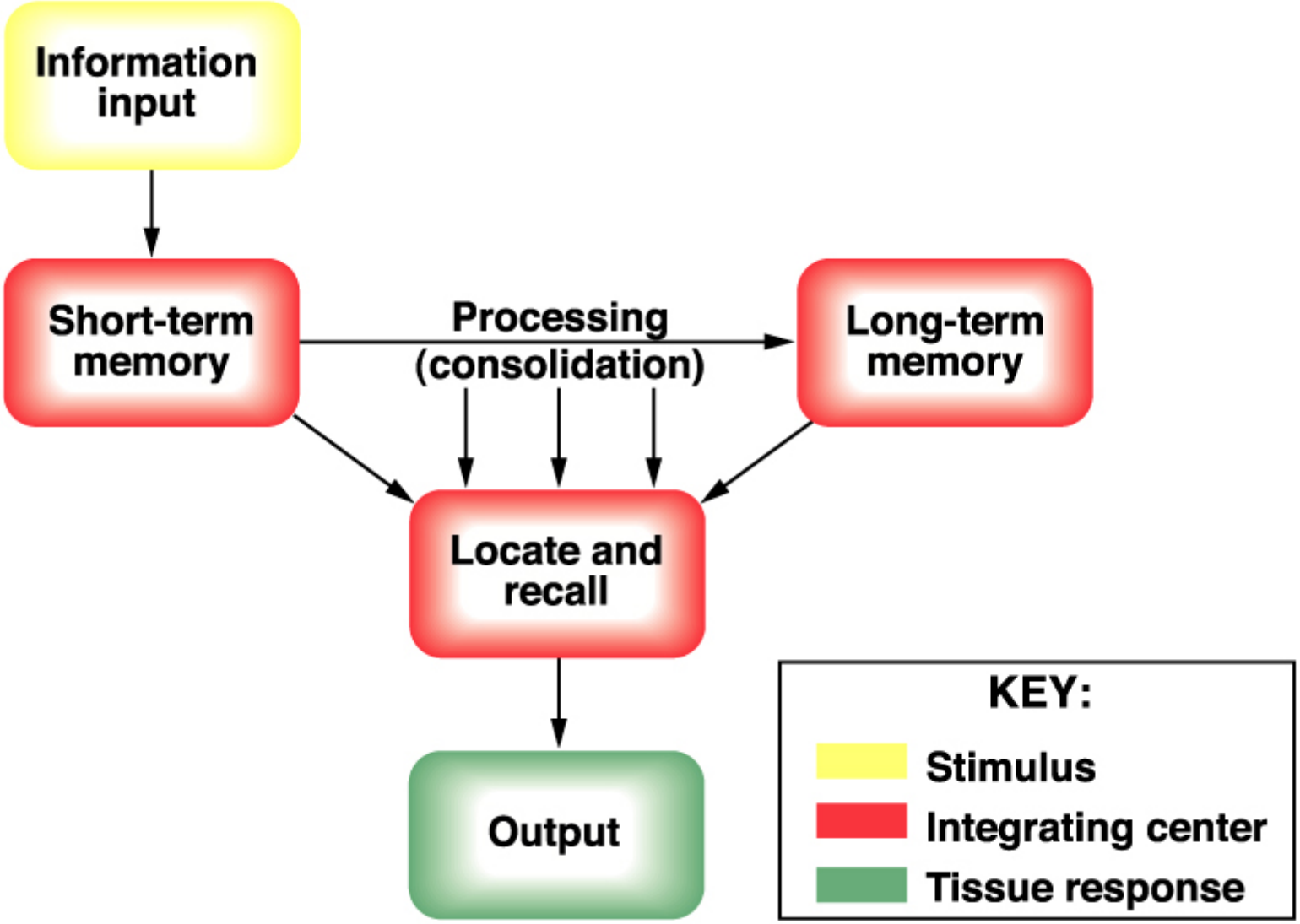
Figure 57-9; Guyton & Hall

Long-Term Memory

- results from a structural change in the synapse
- increase in the area for vesicular release therefore, more transmitter is released
- during periods of inactivity the area decreases in size
- enlargement of the release site area results from synthesis of release site proteins

Consolidation of Memory

- converting immediate into short and long-term memory
- results from chemical, physical and anatomical changes in the synapse
- requires time
- interruption of the process by electrical shock or by anesthesia will prevent memory development
- rehearsal enhances consolidation

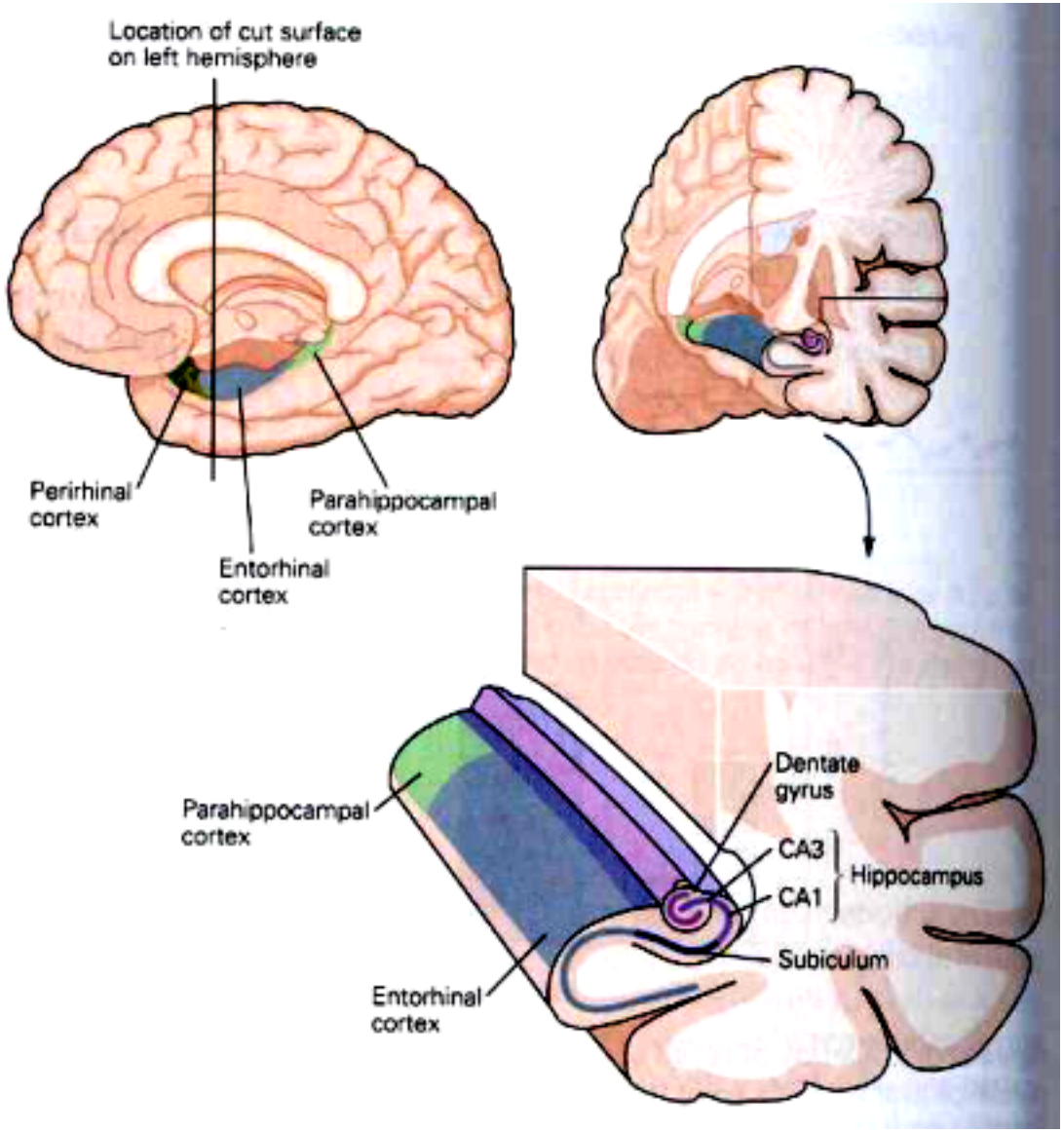

Information input
Short-term memory
Processing (consolidation)
Long-term memory
Locate and recall
Output
KEY:
Stimulus
Integrating center
Tissue response

Brain centers for memory

hippocampus is critical for long-term memory.

damage causes inability to form new verbal or symbolic long-term memory <u>anterograde amnesia</u>.

hippocampus is involved in determining which sensory experiences are important and which do not require attention.

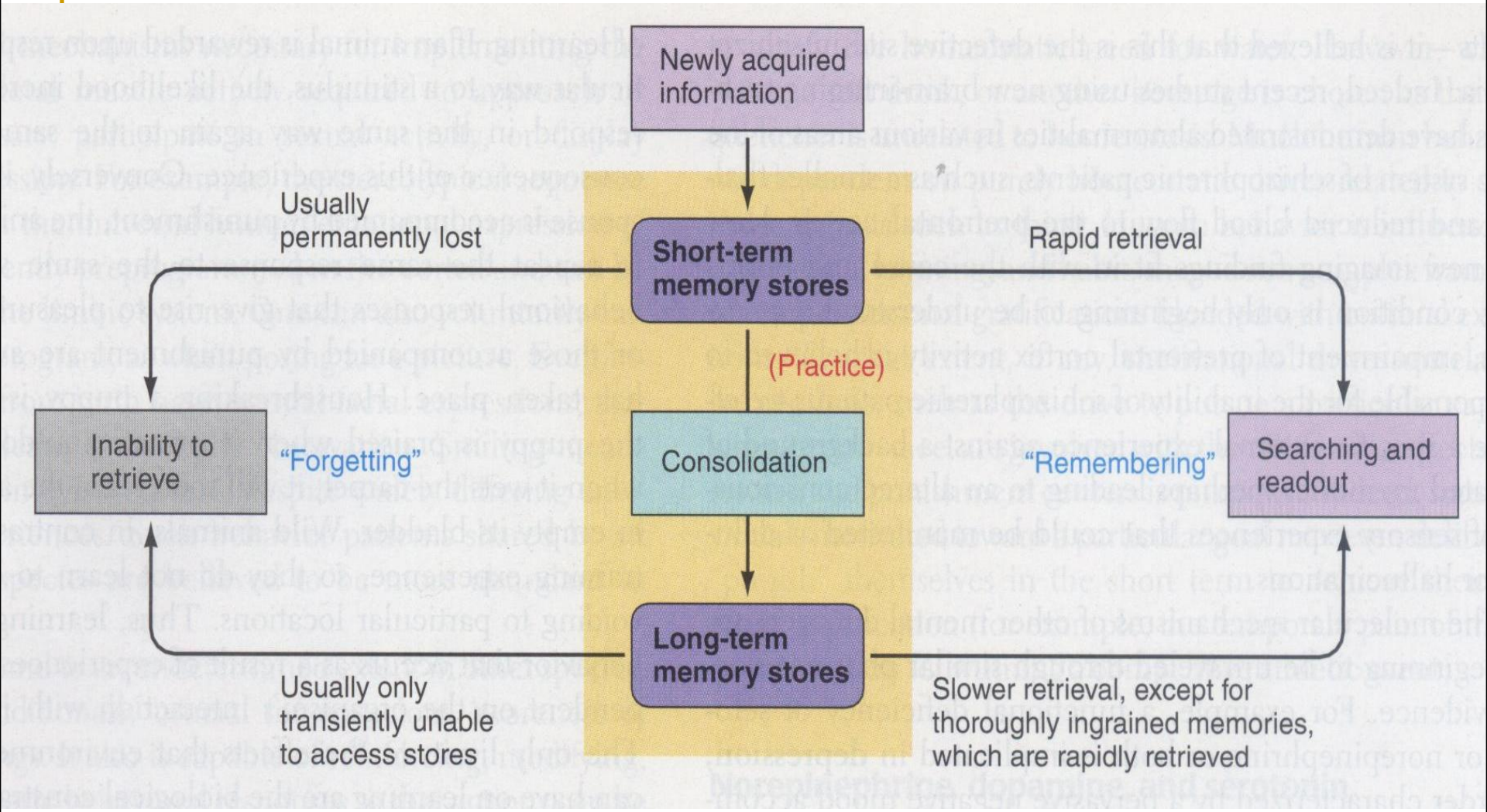


Brain Centers and Memory

- Thalamic structures are important for recalling memories.
- Damage to thalamus causes **retrograde amnesia** or the inability to recall stored experiences.
- Thalamus scans the cortex for the area and the circuit for the stored memory.

Comparison of Long-Term and Short-Term Memory

CHARACTERISTIC	SHORT-TERM MEMORY	LONG-TERM MEMORY
Time of Storage after Acquisition of New Information	Immediate	Later; must be transferred from short-term to long-term memory through consolidation; enhanced by practice or recycling of information through short-term mode
Duration	Lasts for seconds to hours	Retained for days to years
Capacity of Storage	Limited	Very large
Retrieval Time (remembering)	Rapid retrieval	Slower retrieval, except for thoroughly ingrained memories, which are rapidly retrieved
Inability to Retrieve (forgetting)	Permanently forgotten; memory fades quickly unless consolidated into long-term memory	Usually only transiently unable to access; relatively stable memory trace
Mechanism of Storage	Involves transient changes in functions of pre-existing synapses, such as altering amount of neurotransmitter released	Involves relatively permanent functional or structural changes between existing neurons, such as formation of new synapses; synthesis of new proteins plays key role


Newly acquired information
Usually permanently lost
Short-term memory stores
Rapid retrieval
(Practice)
Inability to retrieve
"Forgetting"
Consolidation
"Remembering"
Searching and readout
Long-term memory stores
Usually only transiently unable to access stores
Slower retrieval, except for thoroughly ingrained memories, which are rapidly retrieved

Thank You