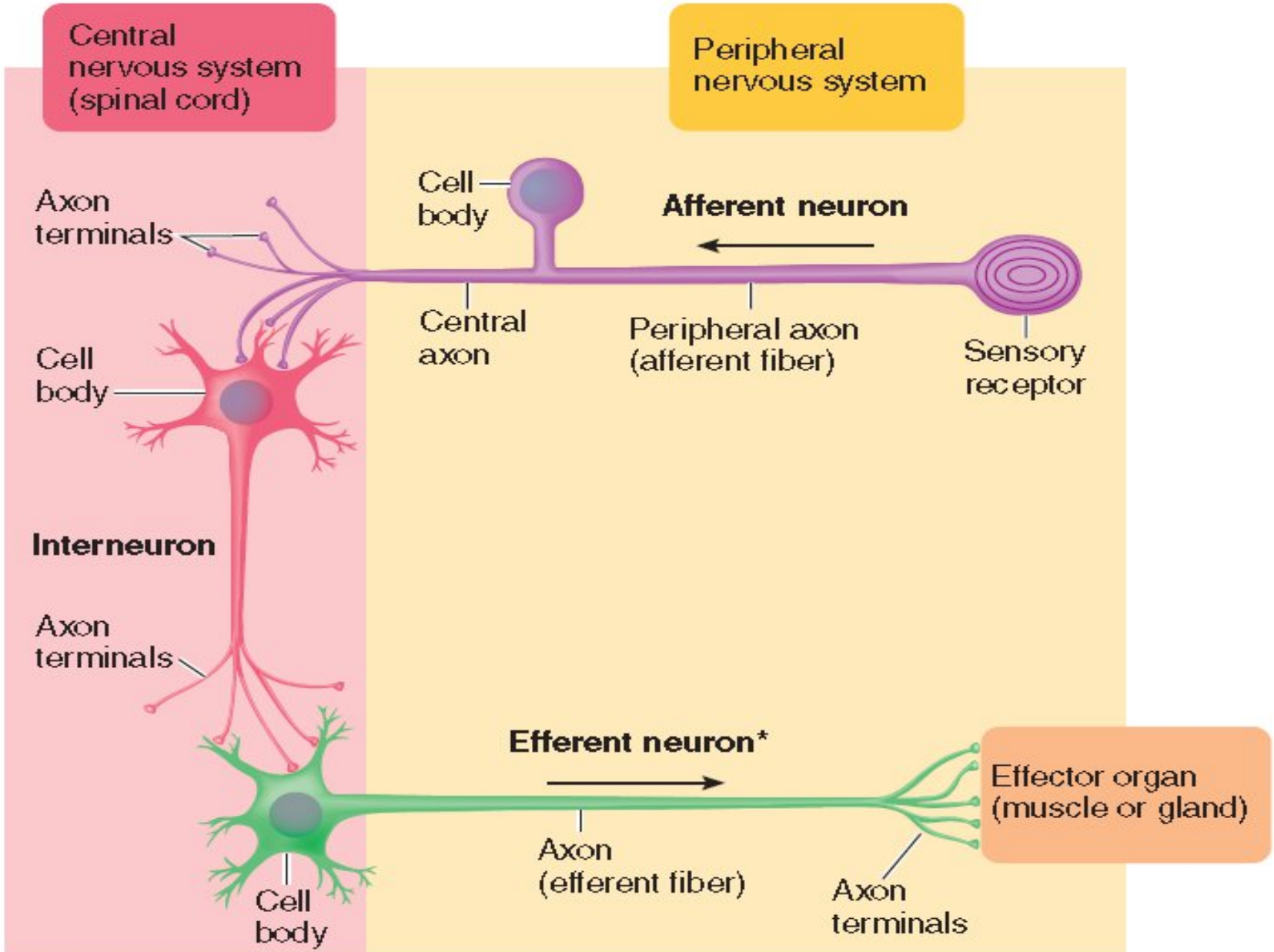
FISIOLOGI OTAK

Astri Handayani

TUJUAN PEMBELAJARAN

STRUKTUR DAN FUNGSI SEL PENYUSUN SISTEM SARAF

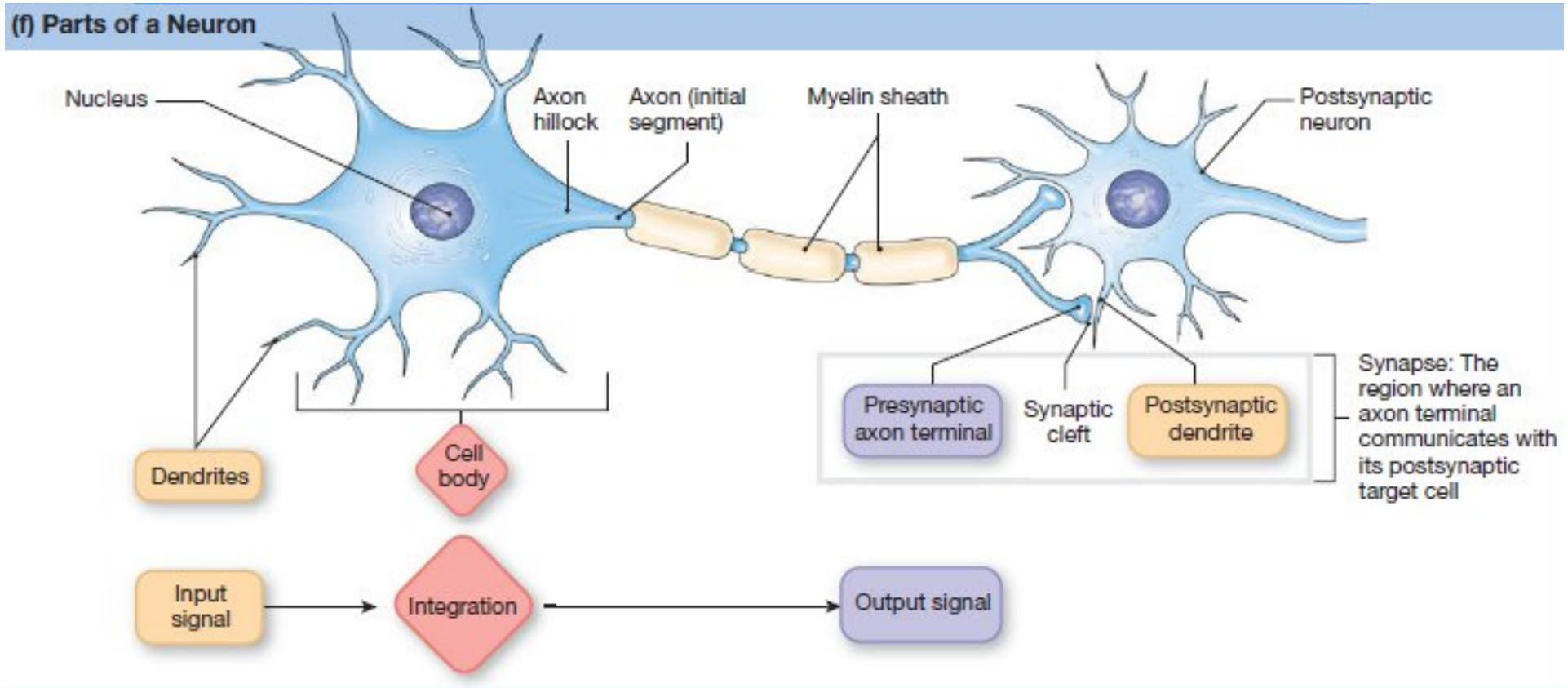


* Efferent autonomic nerve pathways consist of a two-neuron chain between the CNS and the effector organ.

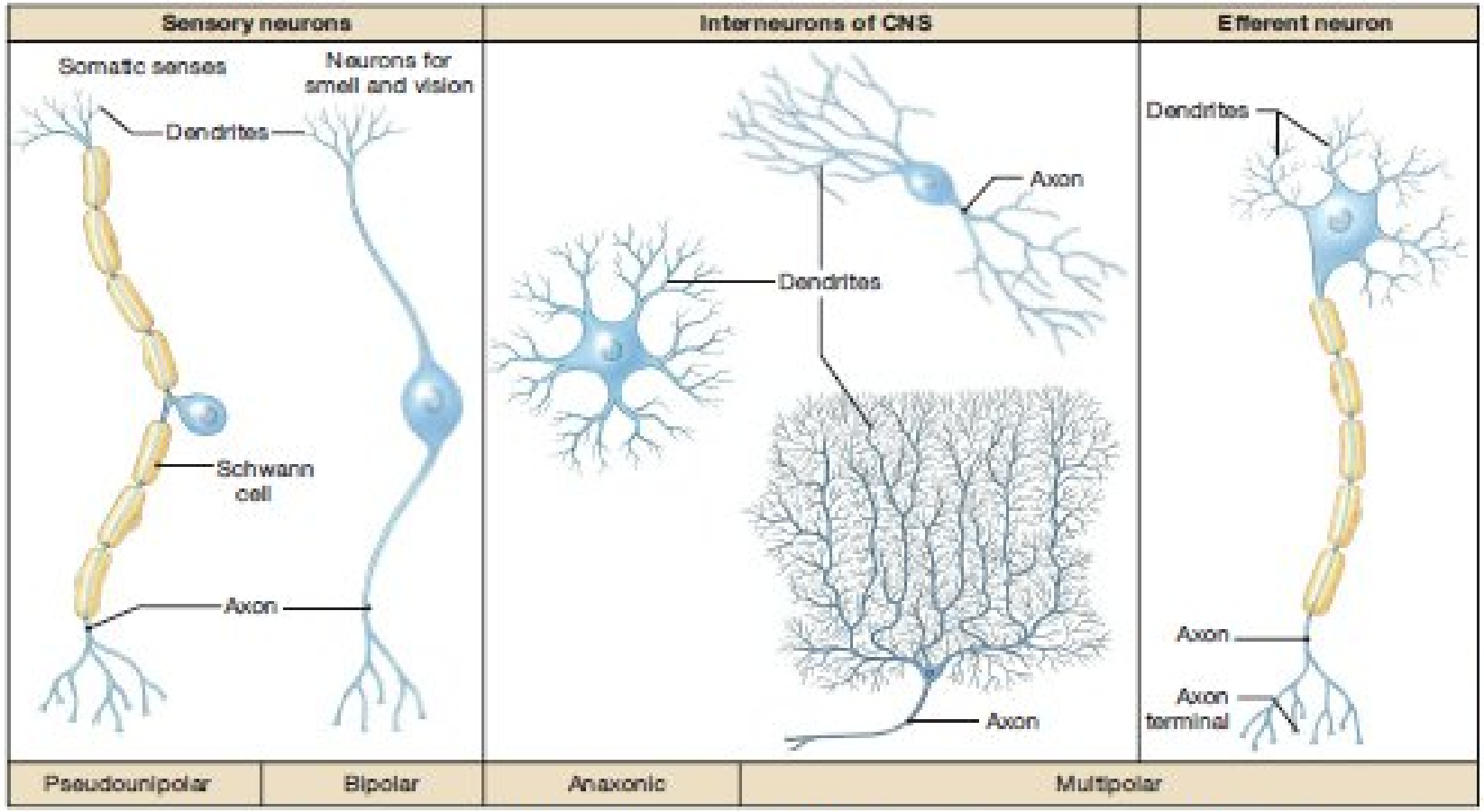
Figure 5-2 Structure and location of the three functional classes of neurons.

Sherwood, 9th ed,2016

NEURON


(f) Parts of a Neuron
Nucleus
Axon hillock
Axon (initial segment)
Myelin sheath
Postsynaptic neuron
Presynaptic axon terminal
Synaptic cleft
Postsynaptic dendrite
Synapse: The region where an axon terminal communicates with its postsynaptic target cell
Dendrites
Cell body
Input signal
Integration
Output signal

NEURON



(a) Pseudounipolar neurons have a single process called the axon. During development, the dendrite fused with the axon.

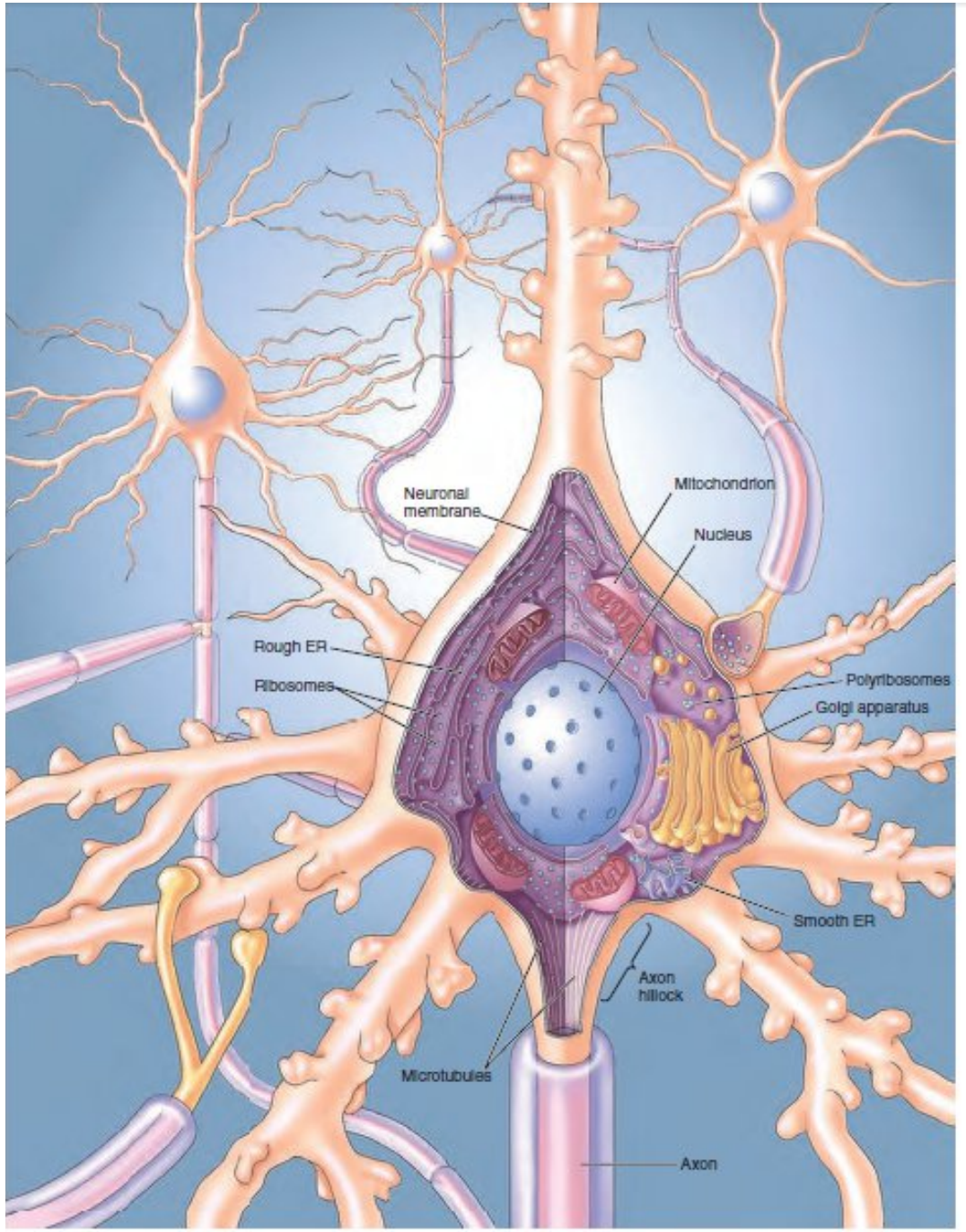
(b) Bipolar neurons have two relatively equal fibers extending off the central cell body.

(c) Anaxonic CNS interneurons have no apparent axon.

(d) Multipolar CNS interneurons are highly branched but lack long extensions.

(e) A typical multipolar efferent neuron has five to seven dendrites, each branching four to six times. A single long axon may branch several times and end at enlarged axon terminals.

STRUKTUR INTERNAL NEURON

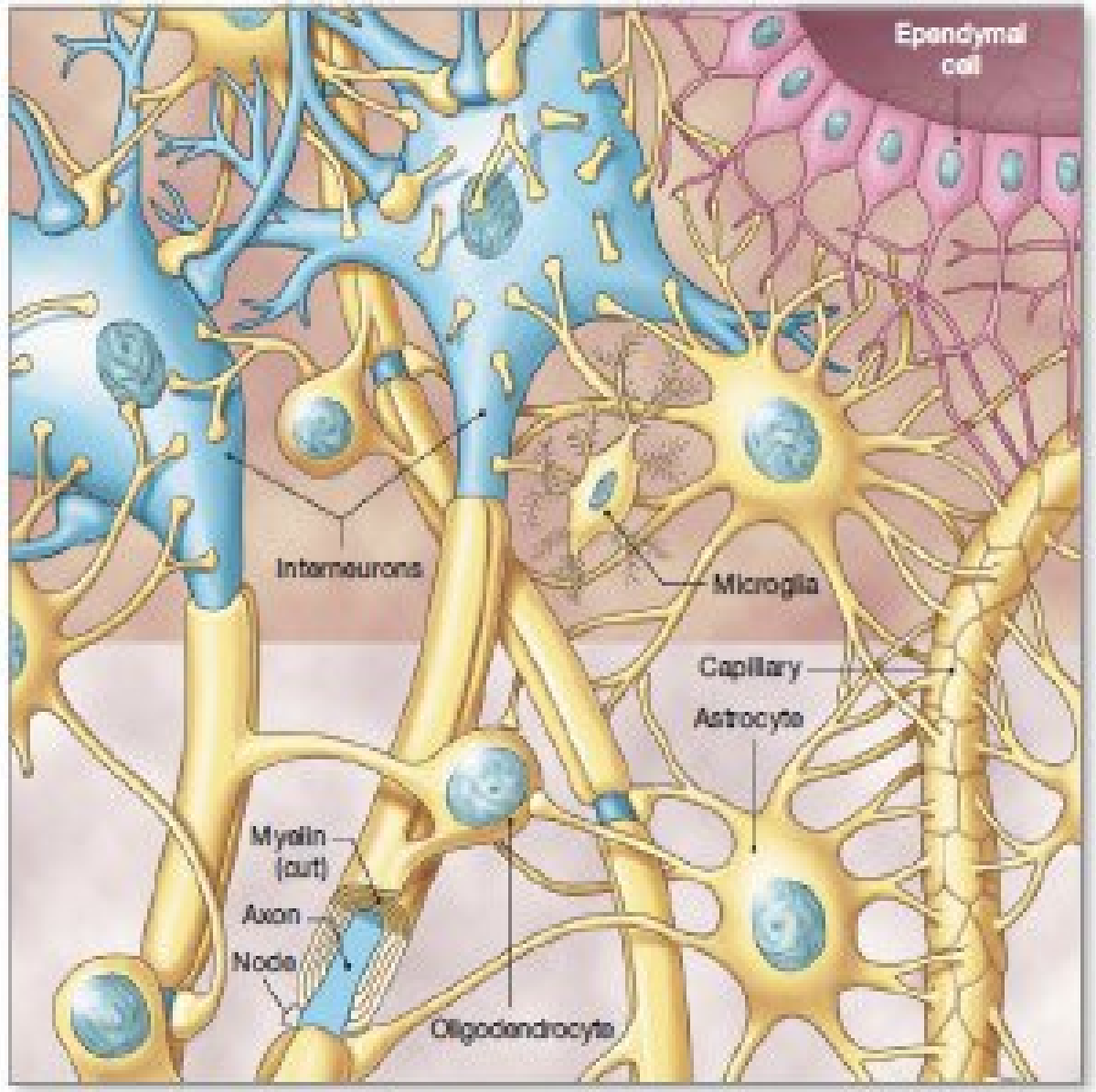


SEL GLIA

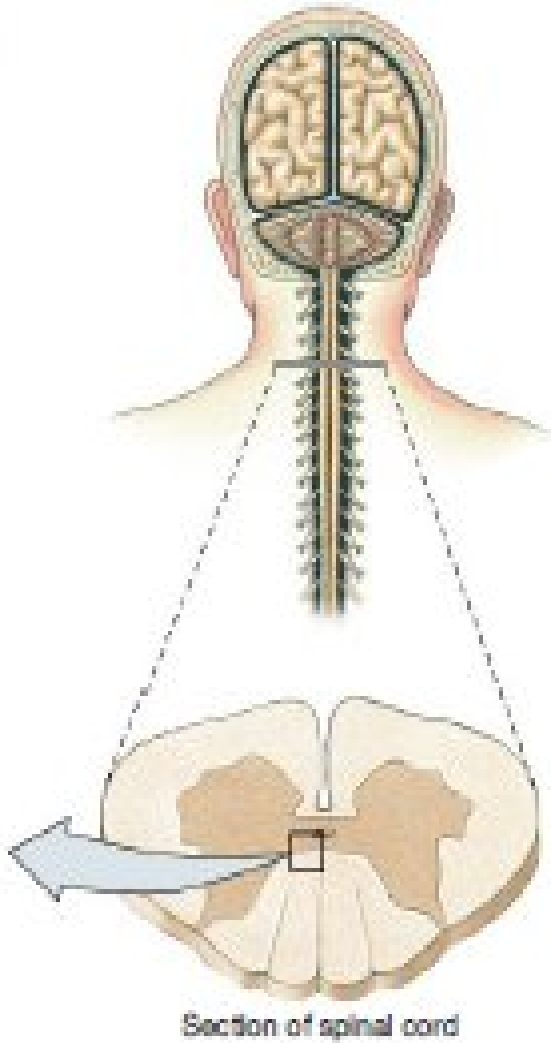
10 – 50 kali neuron

Fungsi: -

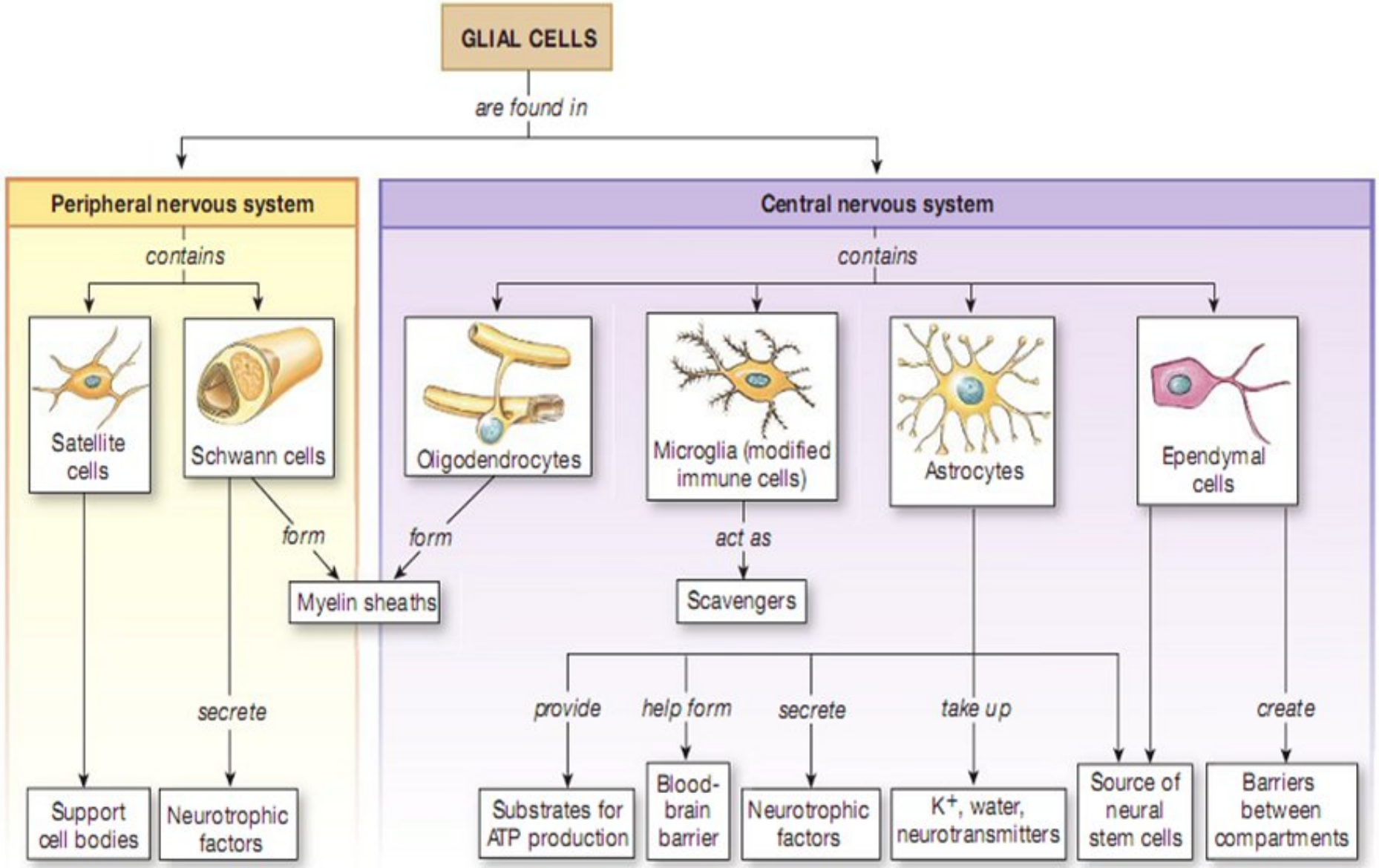
- komunikasi dengan neuron
- Dukungan biokimia untuk neuron



(a) Glial cells of the central nervous system



Section of spinal cord



(b) Glial cells and their functions

● FIGURE 8-5 *Glial cells provide physical and biochemical support for neurons.*

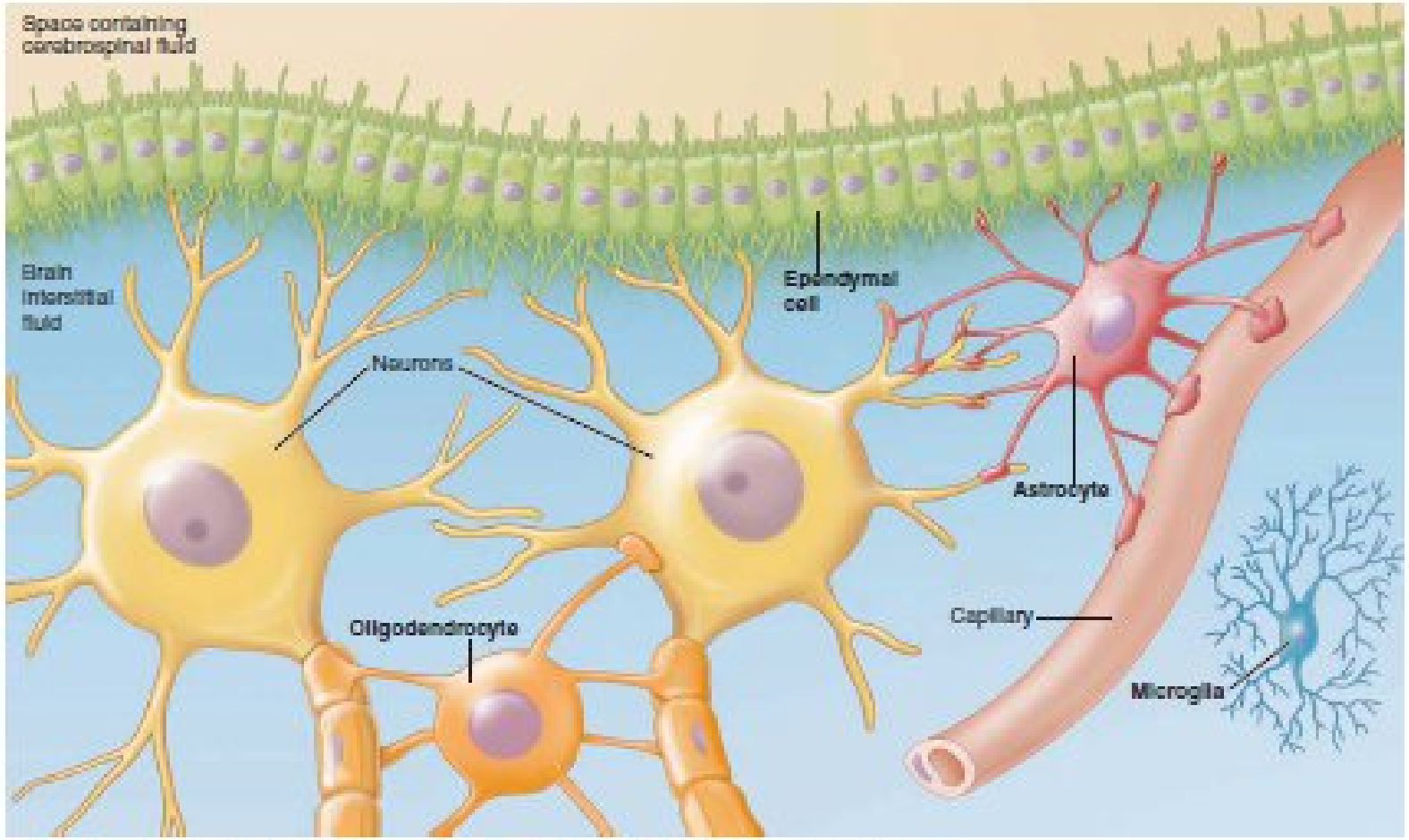
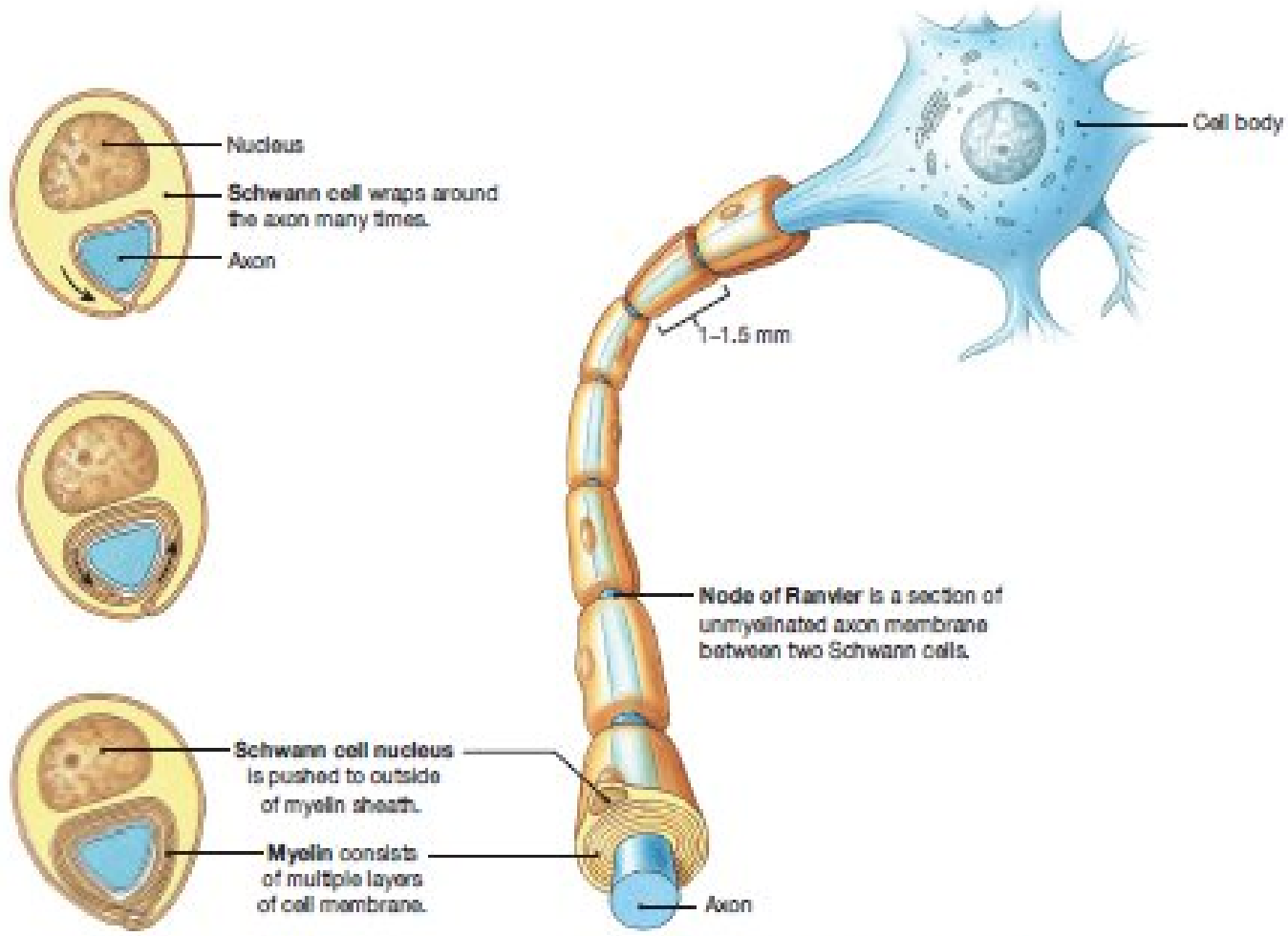
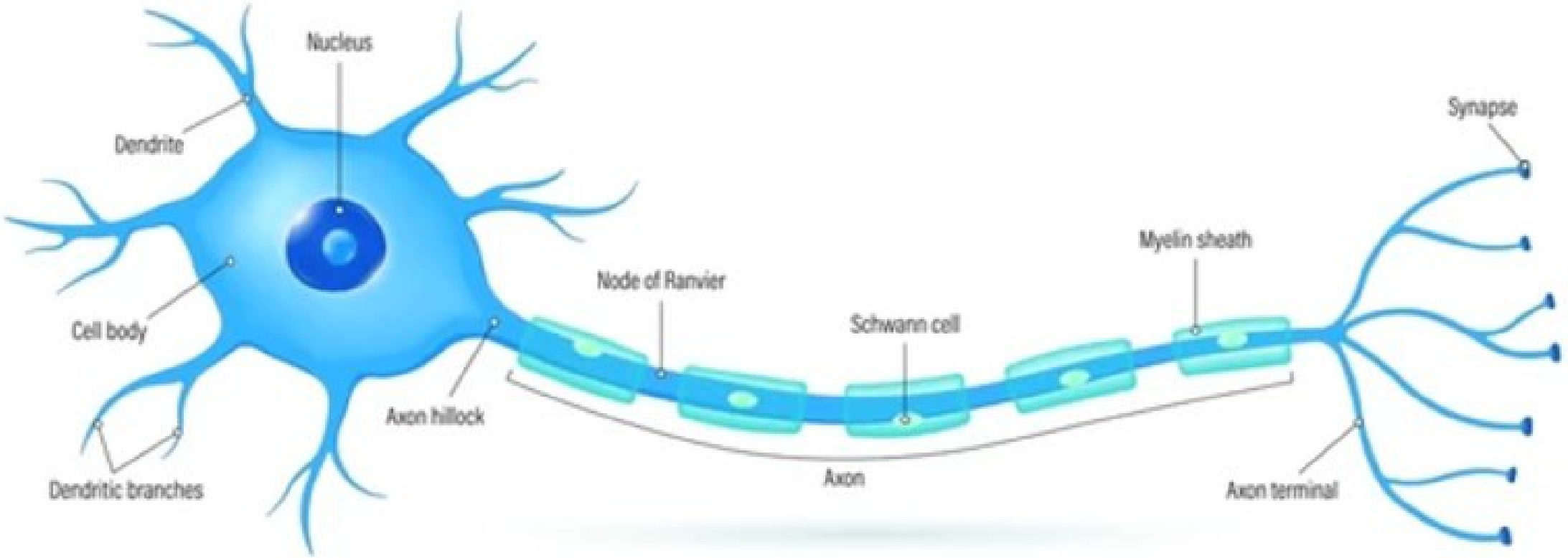


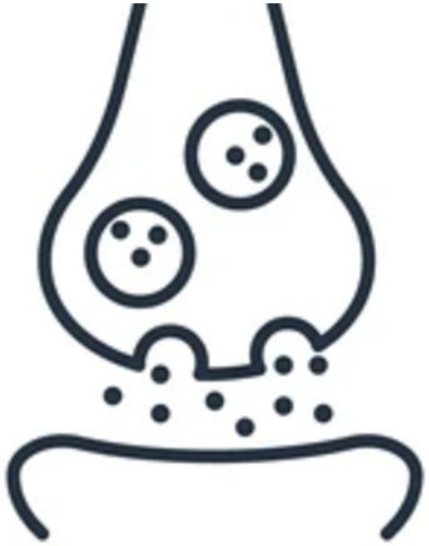
FIGURE 5-3 Glial cells of the central nervous system. The glial cells include the astrocytes, oligodendrocytes, microglia, and ependymal cells.



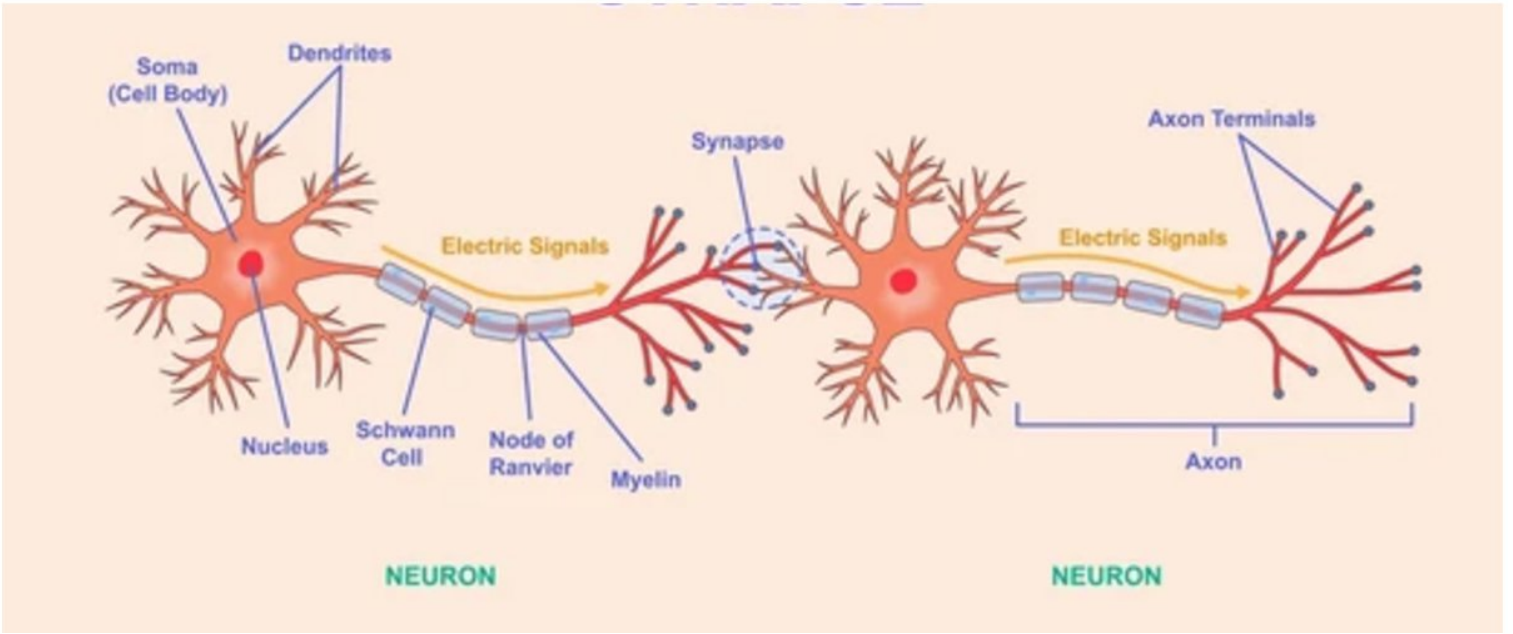
● FIGURE 8-6 *Schwann cells form myelin around peripheral neurons.*

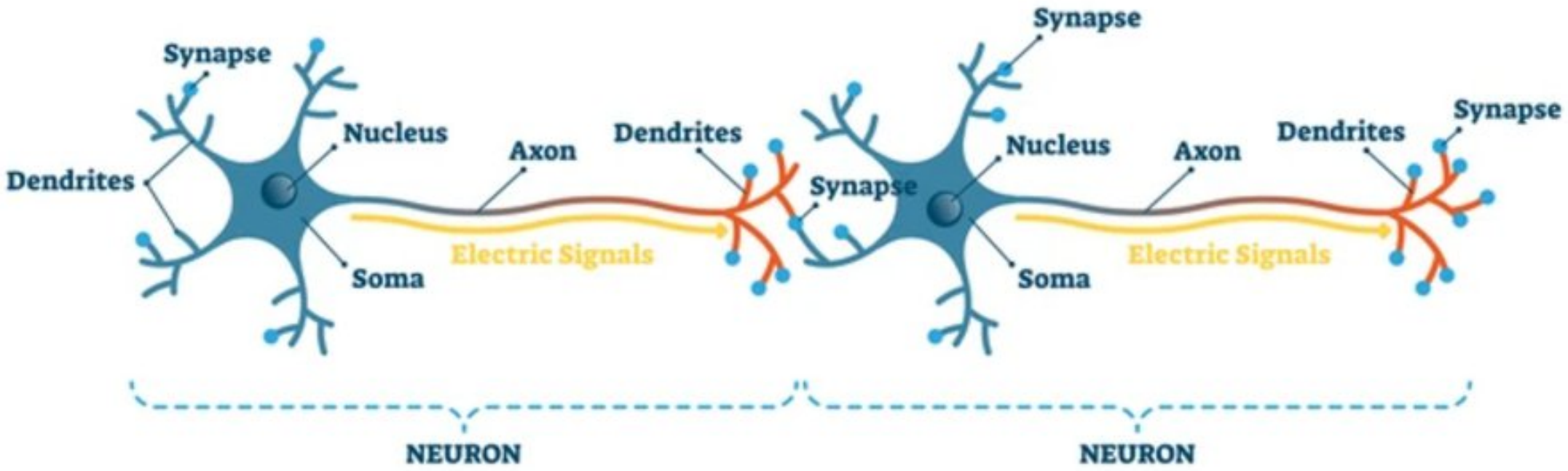
NEURON


Nucleus
Dendrite
Cell body
Dendritic branches
Axon hillock
Node of Ranvier
Schwann cell
Myelin sheath
Axon
Synapse
Axon terminal



synapse

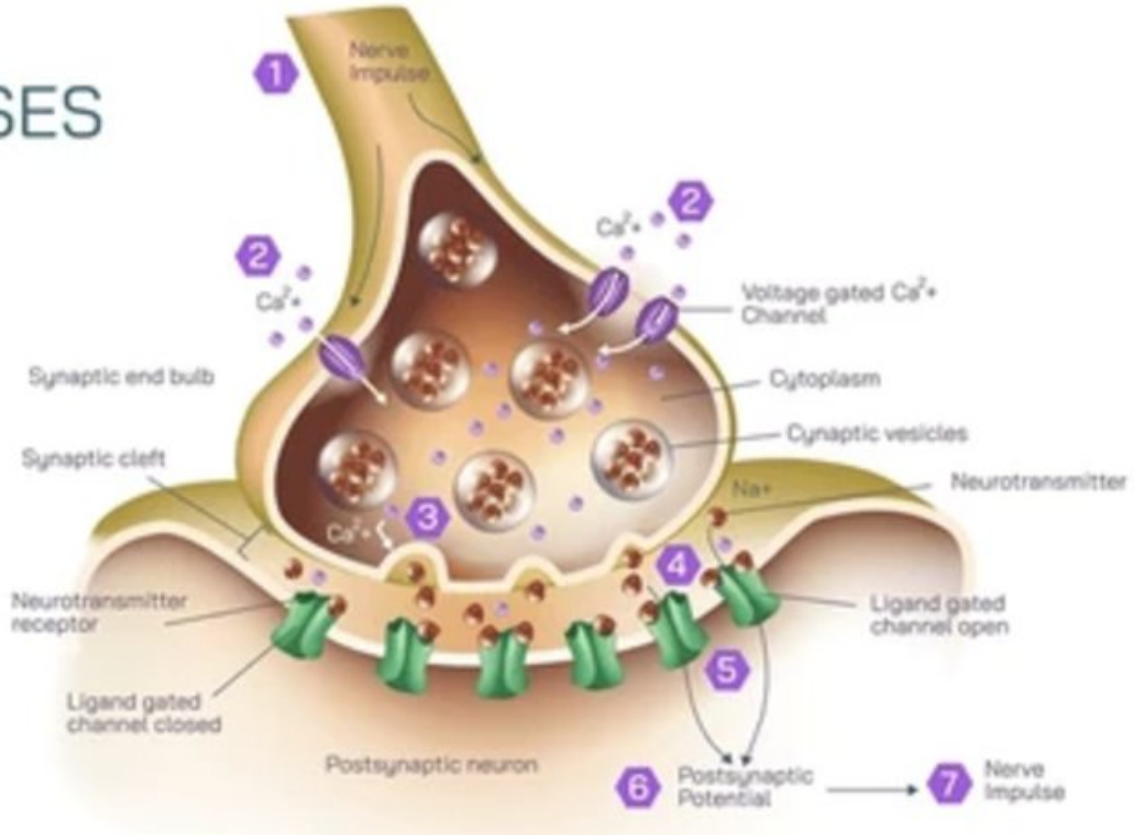

Soma
(Cell Body)
Dendrites
Nucleus
Schwann
Cell
Node of
Ranvier
Myelin
Electric Signals
Synapse
Axon Terminals
Electric Signals
Axon
NEURON
NEURON


Synapse
Nucleus
Dendrites
Axon
Dendrites
Synapse
Electric Signals
Soma
Synapse
Nucleus
Axon
Dendrites
Synapse
Synapse
Electric Signals
Soma
NEURON
NEURON

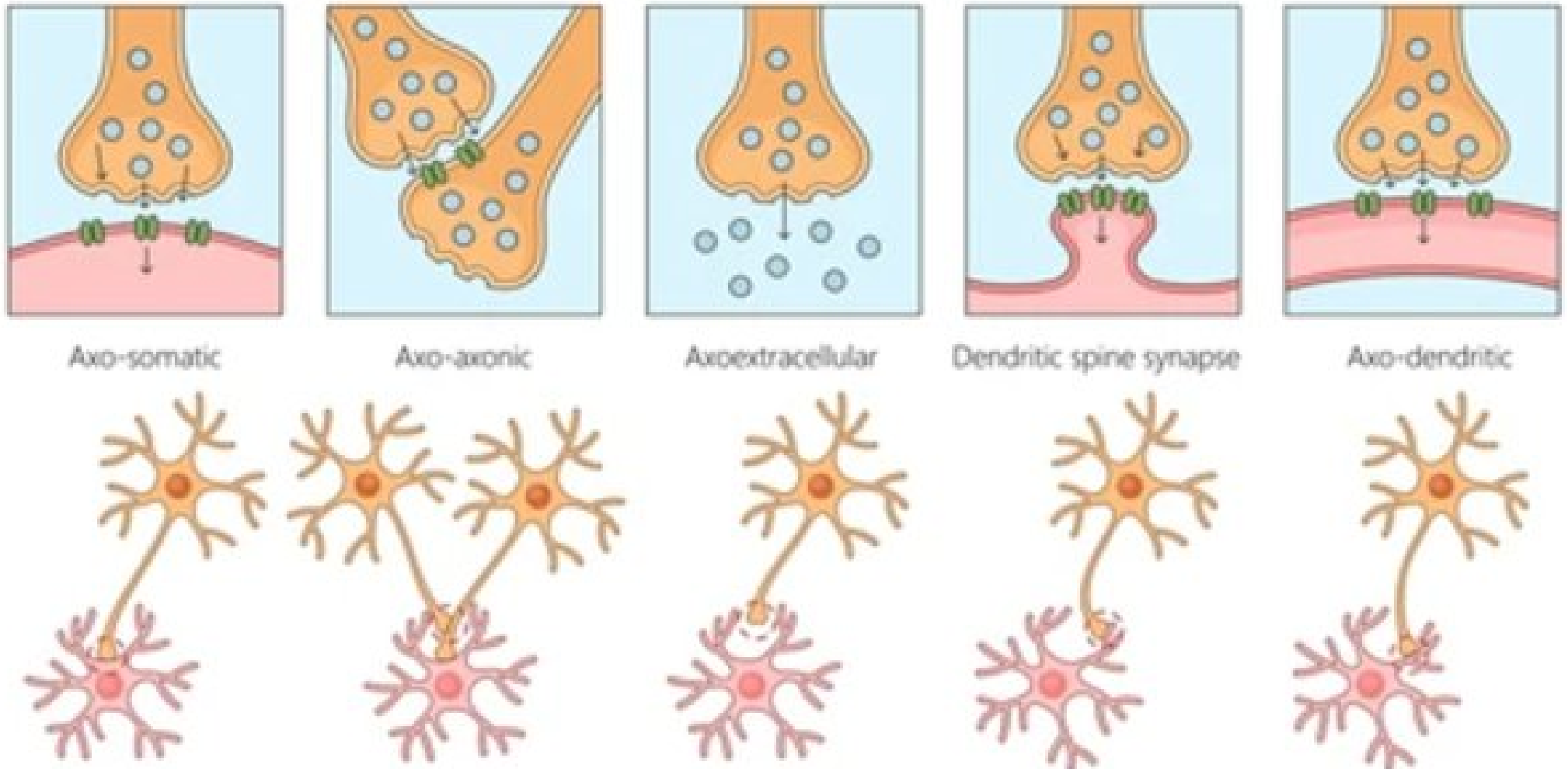
ACTION POTENTIALS & SYNAPSES

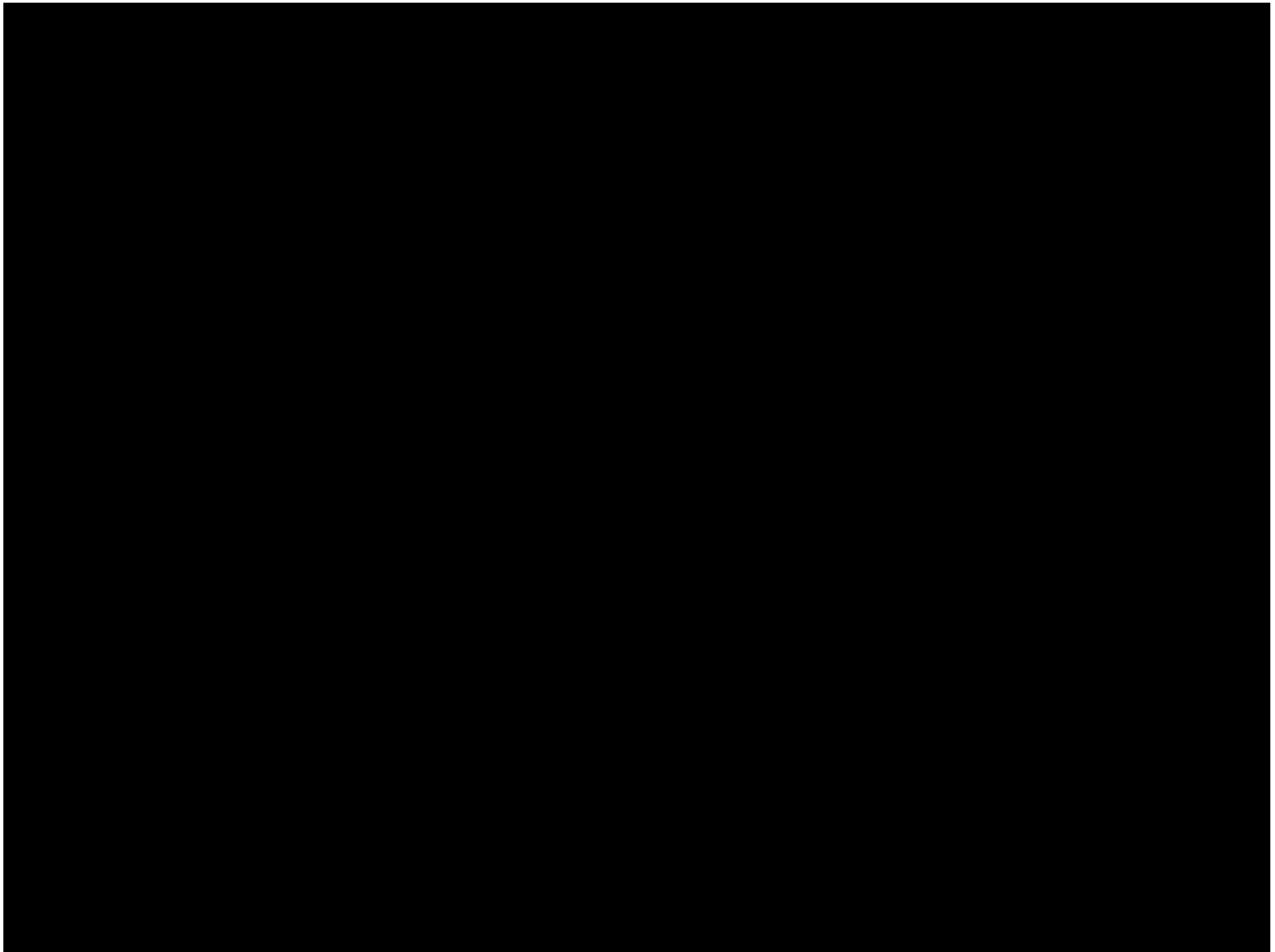
HOW NEURONS WORK?

Action potential reaches axon terminal and depolarizes membrane.

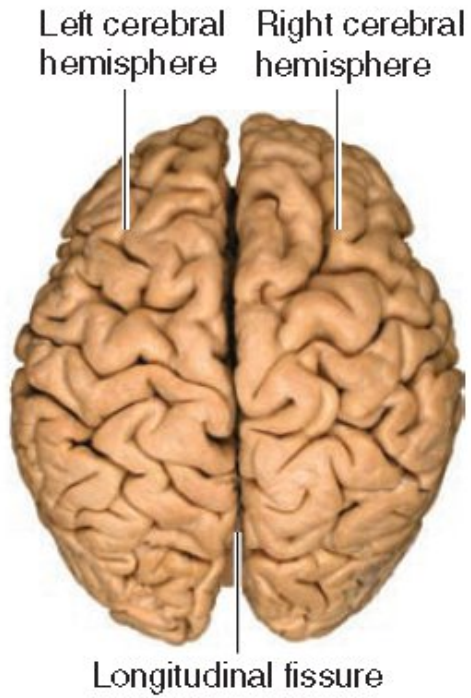


Synapse Types



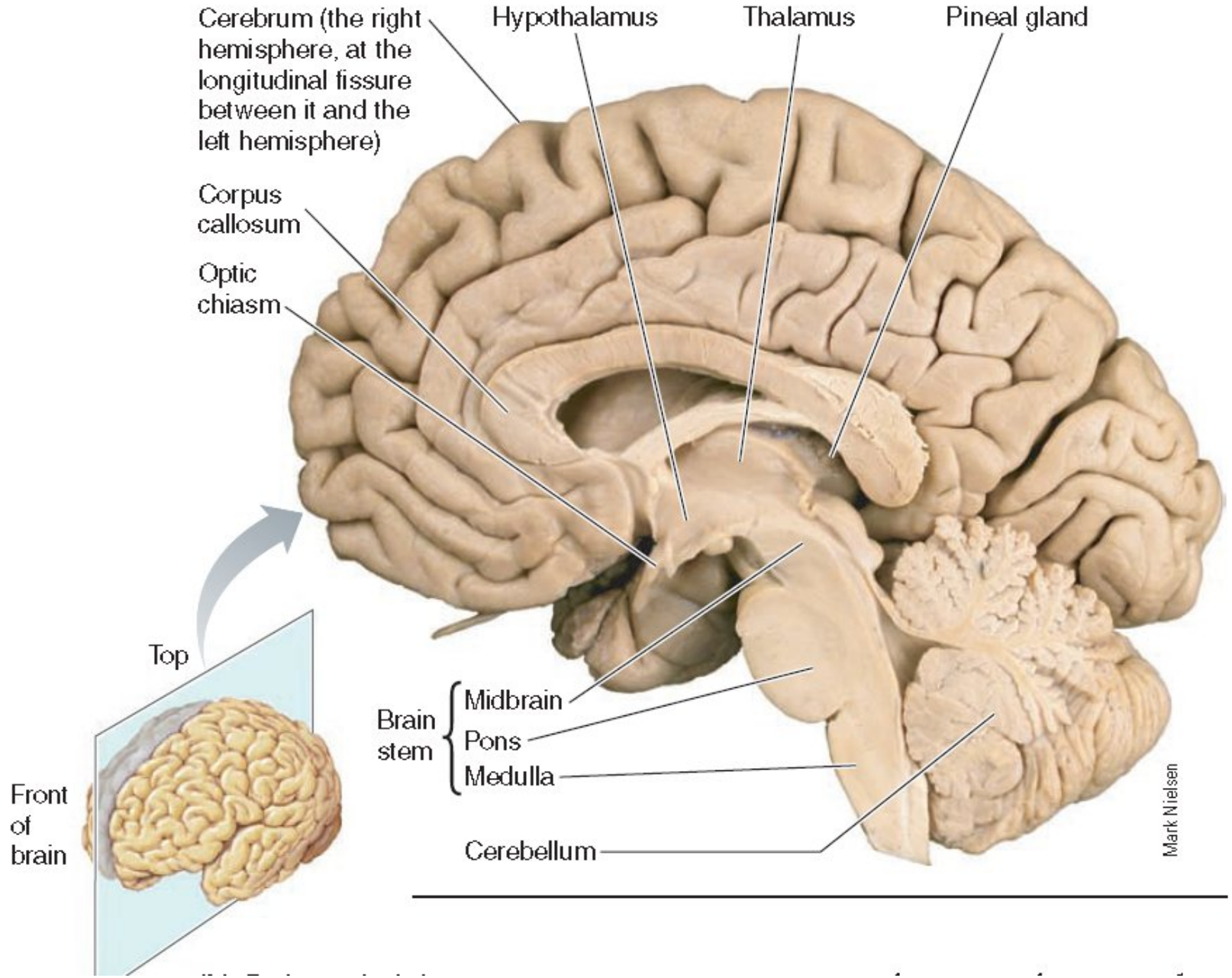


STRUKTUR OTAK SECARA ANATOMI



(a) Brain, superior (top) view

Figure 5-7 Brain of a human cadaver.
(a) Superior view looking down on the top of the brain. Note that the deep longitudinal fissure divides the cerebrum into the right and left cerebral hemispheres. (b) Sagittal view of the right half of the brain. All major brain regions are visible from this midline interior view. The corpus callosum serves as a neural bridge between the two cerebral hemispheres.



Sherwood, 9th ed,2016

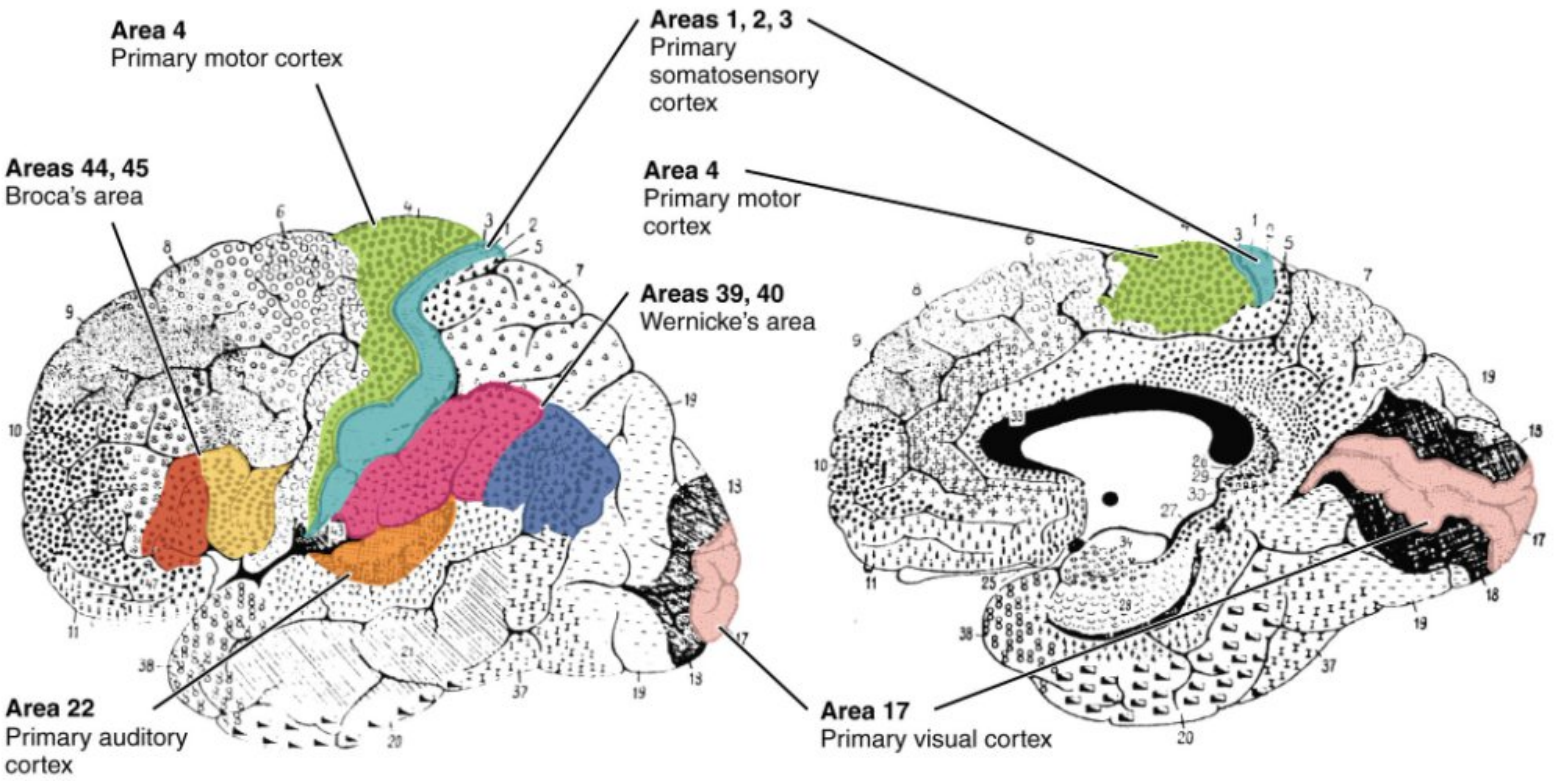
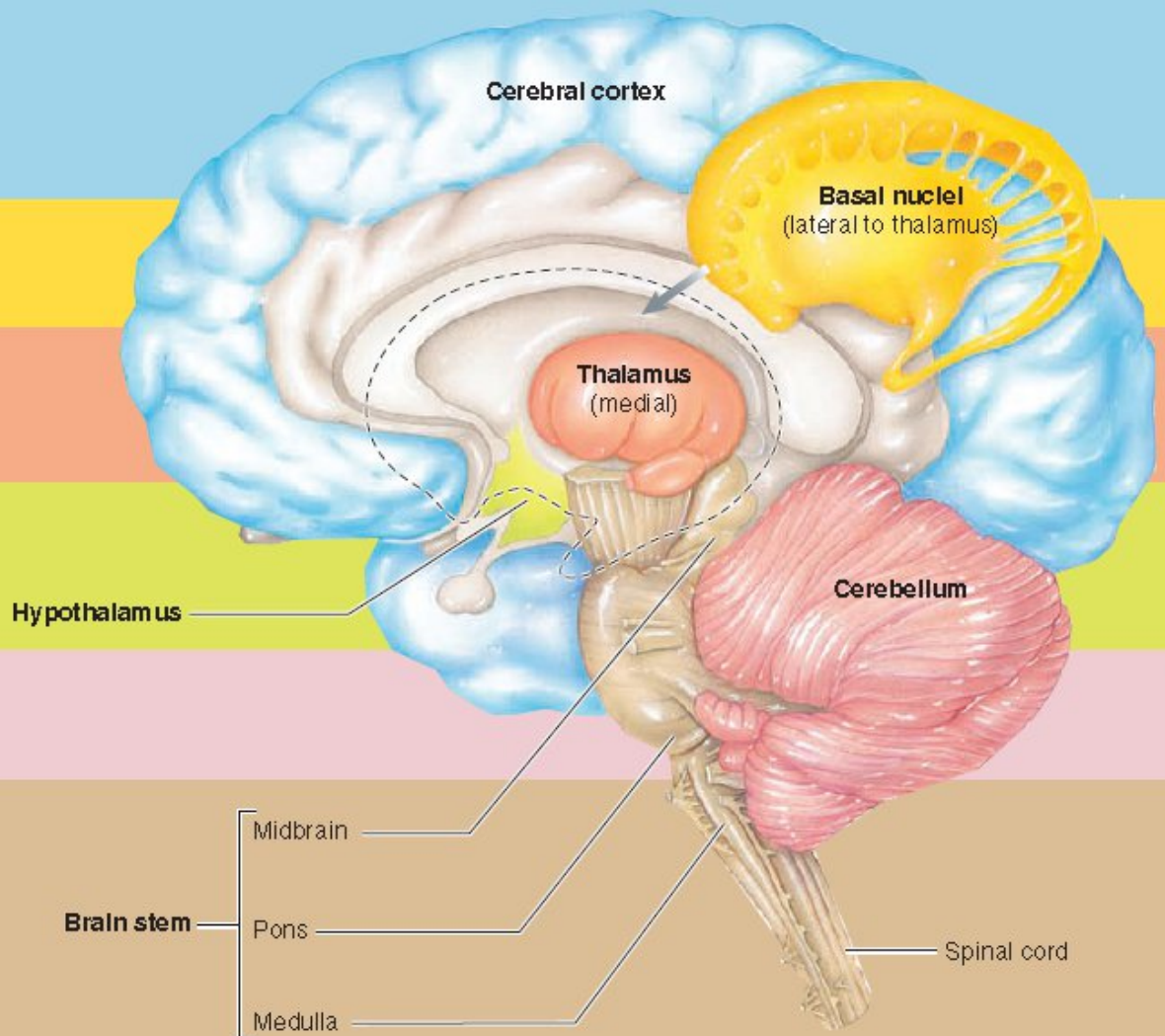


Figure 14.3.3 – Brodmann's Areas of the Cerebral Cortex: *Brodmann mapping of functionally distinct regions of the cortex was based on its cytoarchitecture at a microscopic level.*

BRODMANN'S AREAS

- Different regions of the cerebral cortex can be associated with particular functions, a concept known as localization of function.
- Areas 17 and 18 in the occipital lobe are responsible for primary visual perception.
- The temporal lobe is associated with primary auditory sensation, known as Brodmann's areas 41 and 42 in the superior temporal lobe.
- The primary somatosensory cortex Ⓟ identified as Brodmann's areas 1, 2, and 3.
- Area 17, as Brodmann described it, is also known as the primary visual cortex. Adjacent to that are areas 18 and 19, which constitute subsequent regions of visual processing.
- Area 22 is the primary auditory cortex, and it is followed by area 23, which further processes auditory information.
- Area 4 is the primary motor cortex in the precentral gyrus, whereas area 6 is the premotor cortex.
- Areas 1, 2, 3, 4, 17, and 22 are each described as primary cortical areas. The adjoining regions are each referred to as association areas

TABLE 5-1 Overview of Structures and Functions of the Major Components of the Brain



Cerebral cortex	1. Sensory perception 2. Voluntary control of movement 3. Language 4. Personality traits 5. Sophisticated mental events, such as thinking, memory, decision making, creativity, and self-consciousness
Basal nuclei	1. Inhibition of muscle tone 2. Coordination of slow, sustained movements 3. Suppression of useless patterns of movement
Thalamus	1. Relay station for all synaptic input 2. Crude awareness of sensation 3. Some degree of consciousness 4. Role in motor control
Hypothalamus	1. Regulation of many homeostatic functions, such as temperature control, thirst, urine output, and food intake 2. Important link between nervous and endocrine systems 3. Extensive involvement with emotion and basic behavioral patterns 4. Role in sleep–wake cycle
Cerebellum	1. Maintenance of balance 2. Enhancement of muscle tone 3. Coordination and planning of skilled voluntary muscle activity
Brain stem	1. Origin of majority of peripheral cranial nerves 2. Cardiovascular, respiratory, and digestive control centers 3. Regulation of muscle reflexes involved with equilibrium and posture 4. Reception and integration of all synaptic input from spinal cord; arousal and activation of cerebral cortex 5. Role in sleep–wake cycle

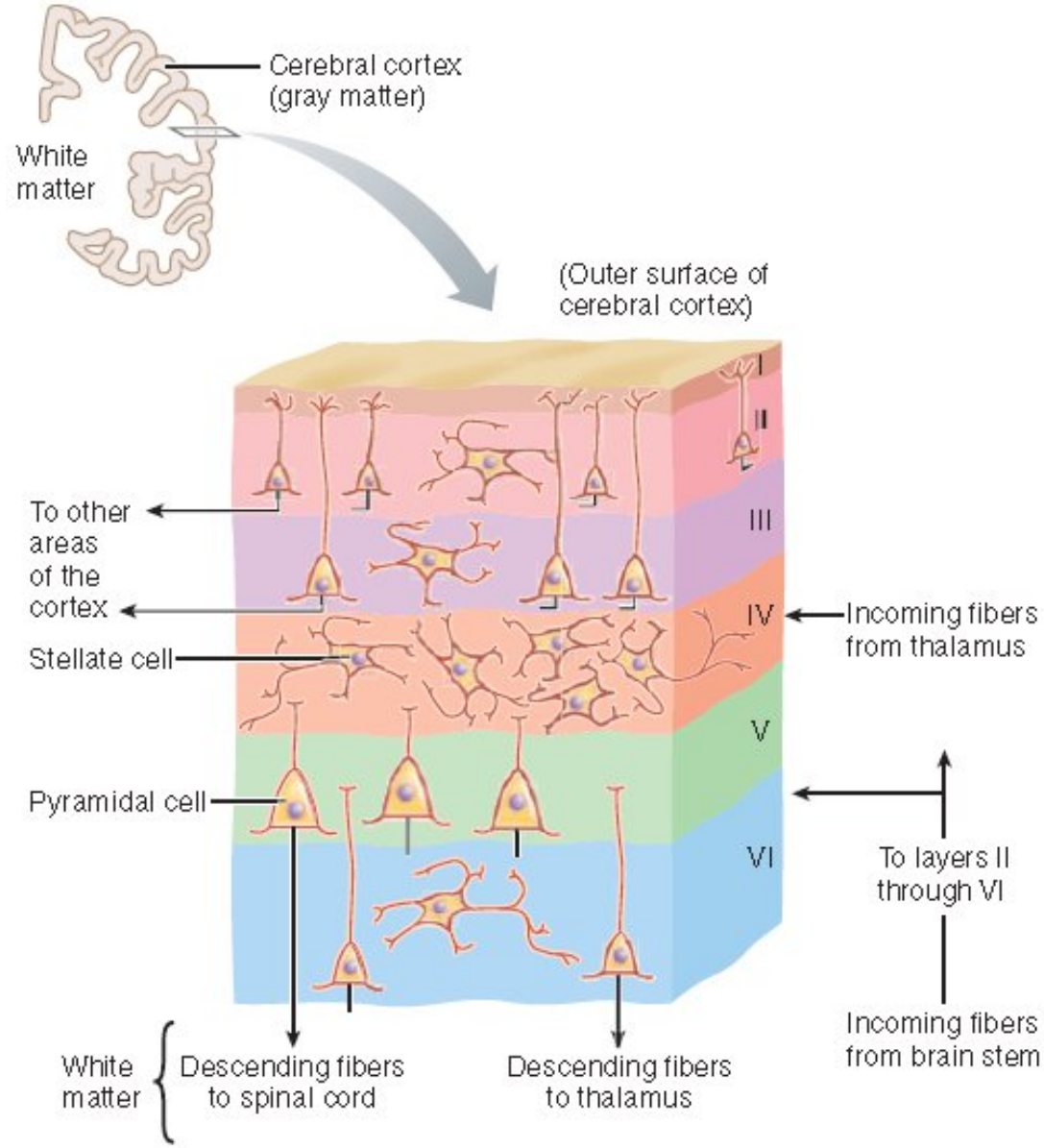


Figure 5-9 Layers of the cerebral cortex. Layer I is mostly glial cells and axons that run laterally. Layers II through VI contain different proportions of two main classes of cortical neurons: *pyramidal cells*, which are shaped like upside down pyramids and are the major output neurons, and *stellate cells*, which are shaped like stars. Stellate cells primarily receive input to the cortex and process local information.

Sherwood, 9th ed,2016

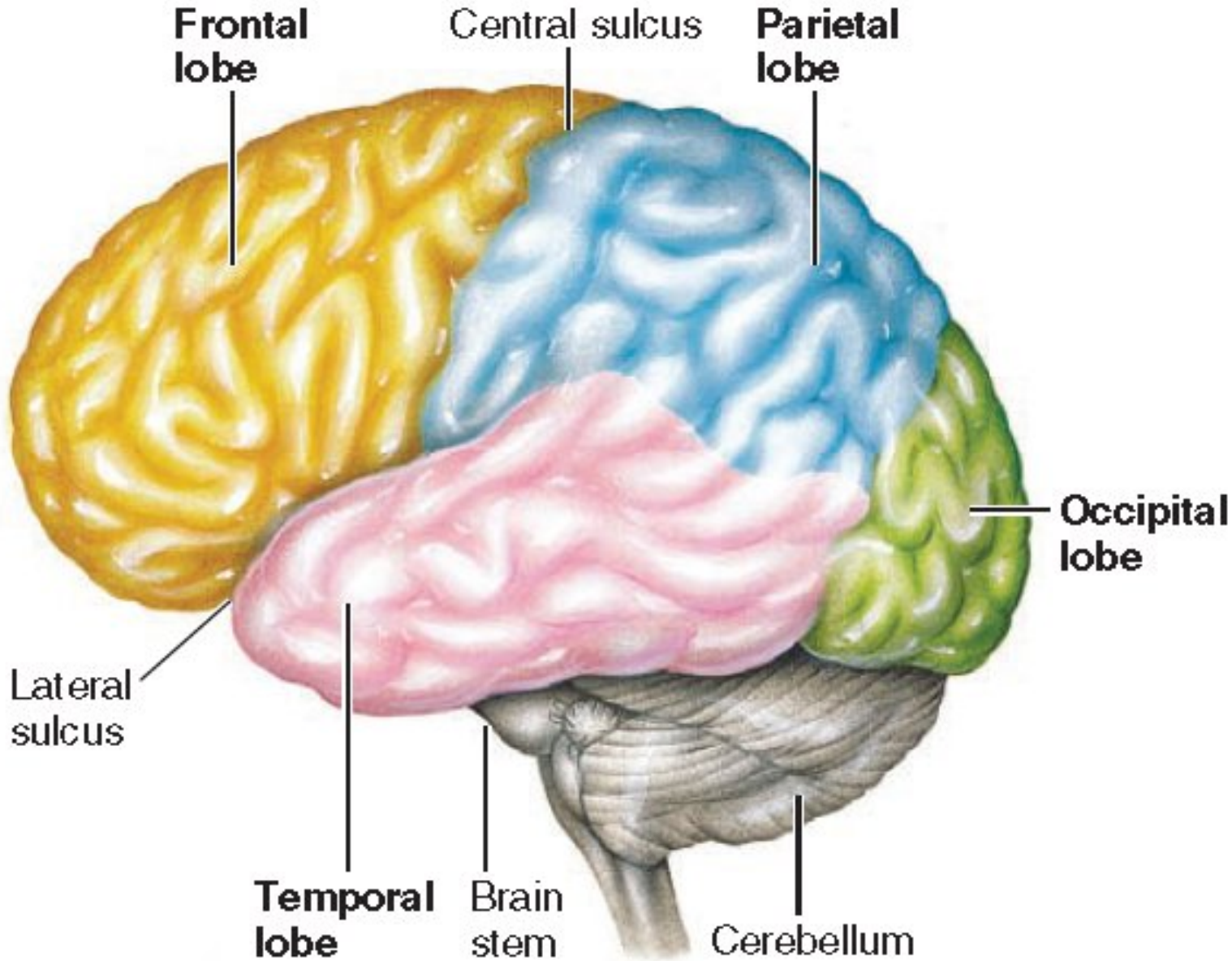


Figure 5-10 Cortical lobes. Each half of the cerebral cortex is divided into the occipital, temporal, parietal, and frontal lobes, as depicted in this lateral view of the left side of the brain.

Sherwood, 9th ed,2016

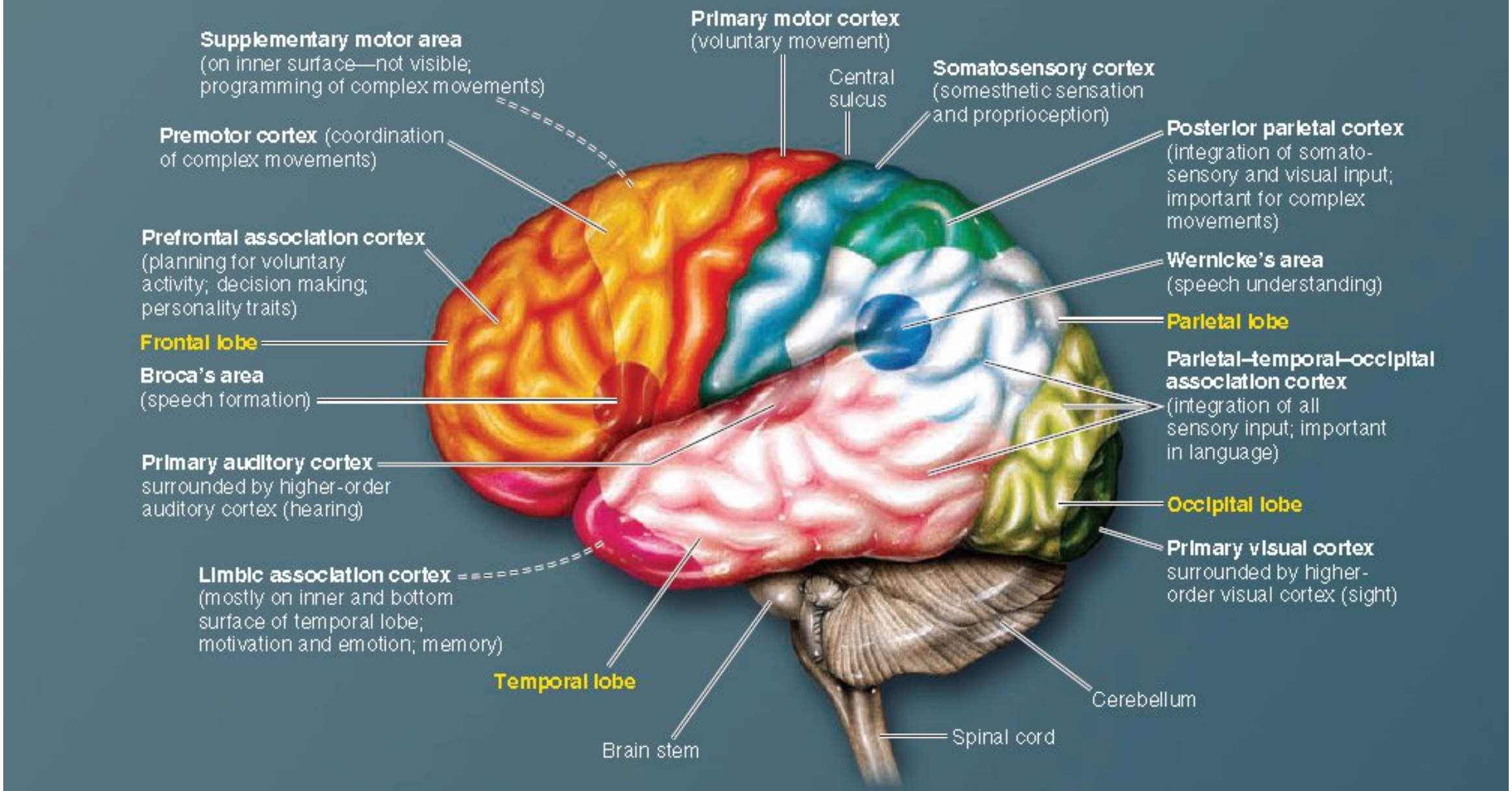


Figure 5-11 Functional areas of the cerebral cortex. Various regions of the cerebral cortex are primarily responsible for various aspects of neural processing, as indicated in this lateral view of the left side of the brain.

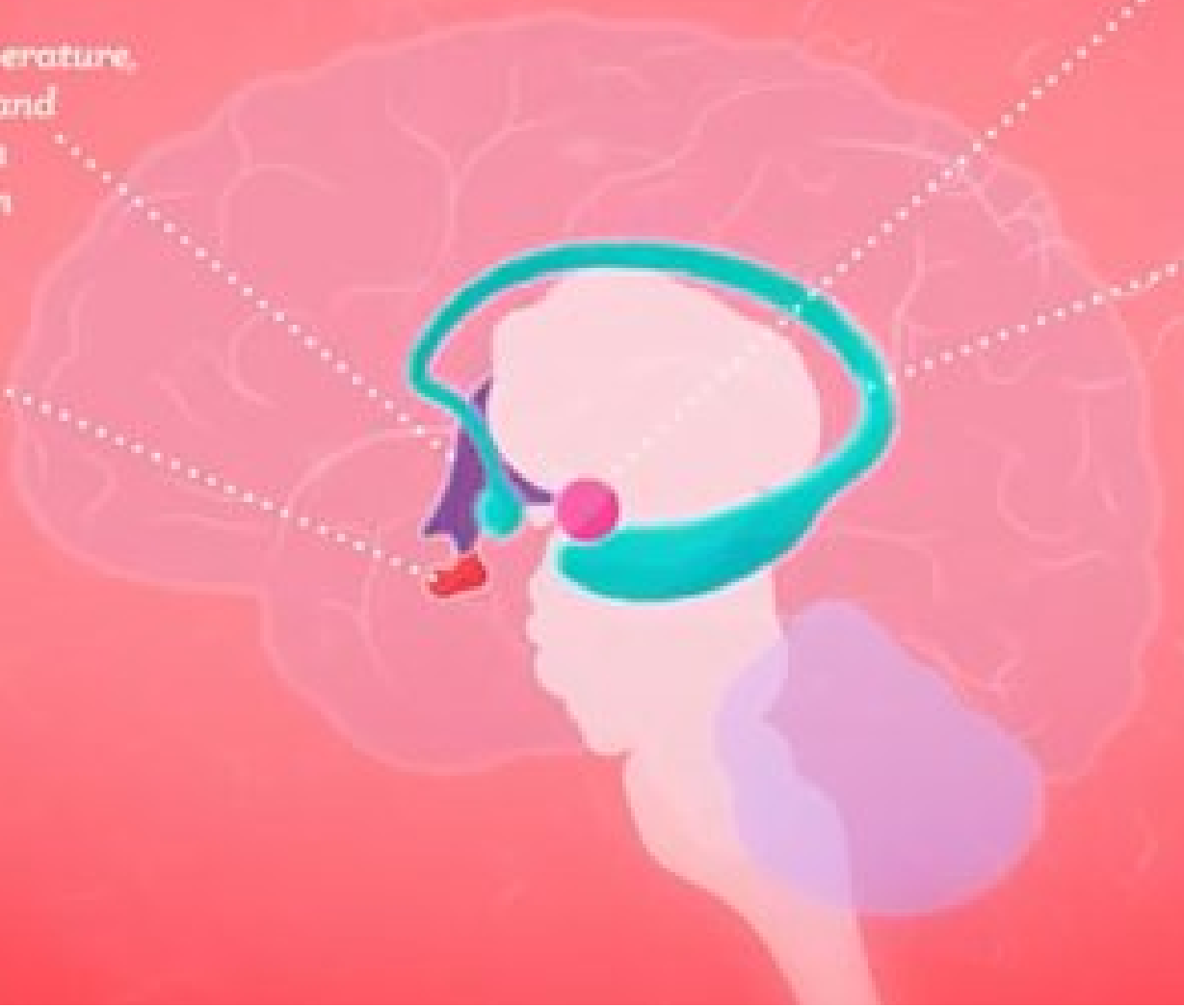
LIMBIC SYSTEM

HYPOTHALAMUS

regulates body temperature, circadian rhythms, and hunger, helps govern the endocrine system

PITUITARY GLAND

secretes many different hormones, some of which affect other glands

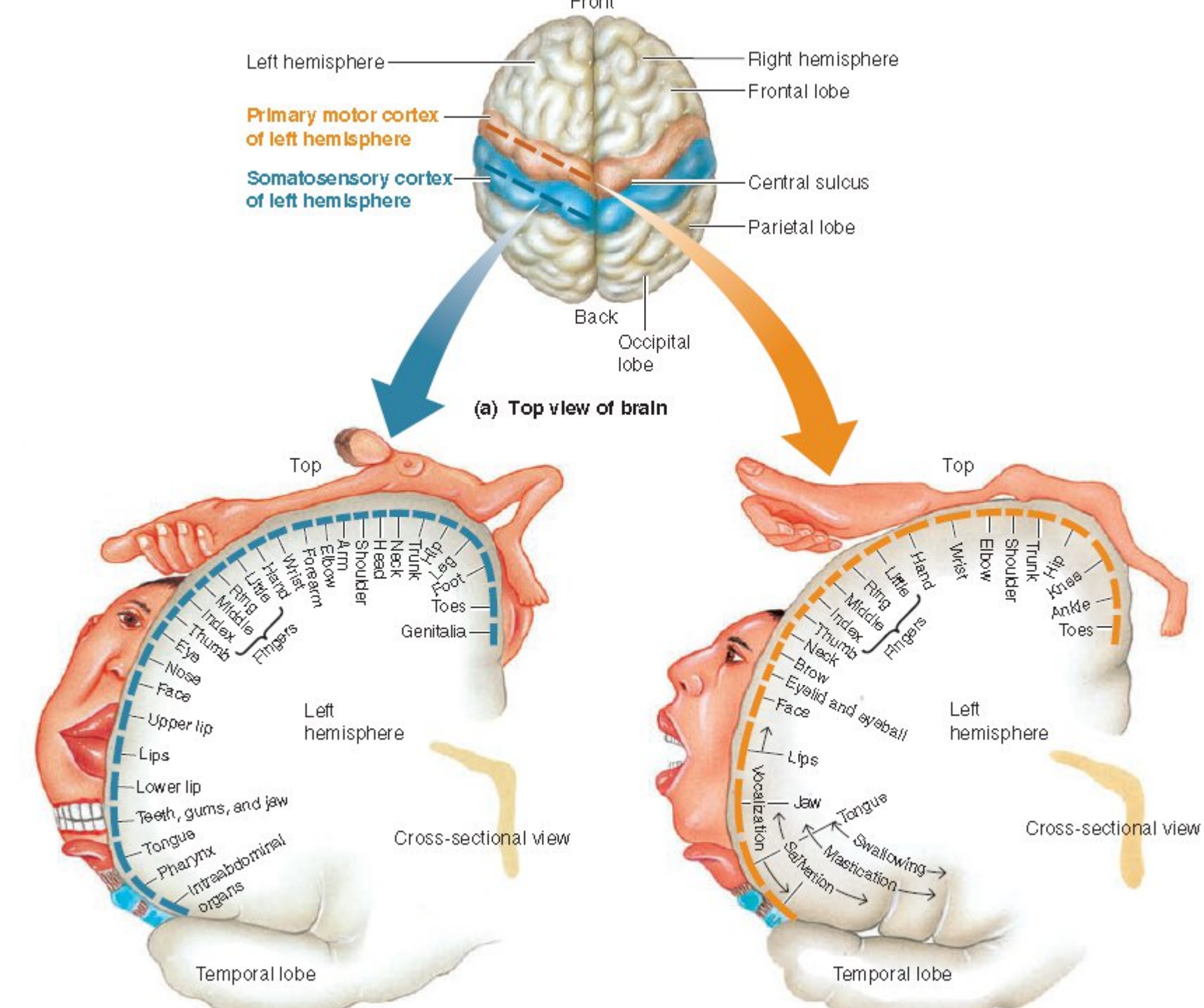


AMYGDALA

two lima-bean-sized clusters of neurons, involved in memory consolidation and emotion

HIPPOCAMPUS

central to learning and memory


Front
Left hemisphere
Right hemisphere
Frontal lobe
Primary motor cortex of left hemisphere
Somatosensory cortex of left hemisphere
Central sulcus
Parietal lobe
Back
Occipital lobe
(a) Top view of brain
Top
Toes
Genitalia
Leg
Foot
Trunk
Neck
Head
Shoulder
Arm
Elbow
Forearm
Wrist
Hand
Little
Ring
Middle
Index
Thumb
Fingers
Eye
Nose
Face
Upper lip
Lips
Lower lip
Teeth, gums, and jaw
Tongue
Pharynx
Intraabdominal organs
Left hemisphere
Cross-sectional view
Temporal lobe
Top
Hip
Knee
Ankle
Toes
Trunk
Shoulder
Elbow
Wrist
Hand
Little
Ring
Middle
Index
Thumb
Fingers
Neck
Brow
Eyelid and eyeball
Face
Lips
Jaw
Tongue
Vocalization
Salivation
Swallowing
Mastication
Left hemisphere
Cross-sectional view
Temporal lobe

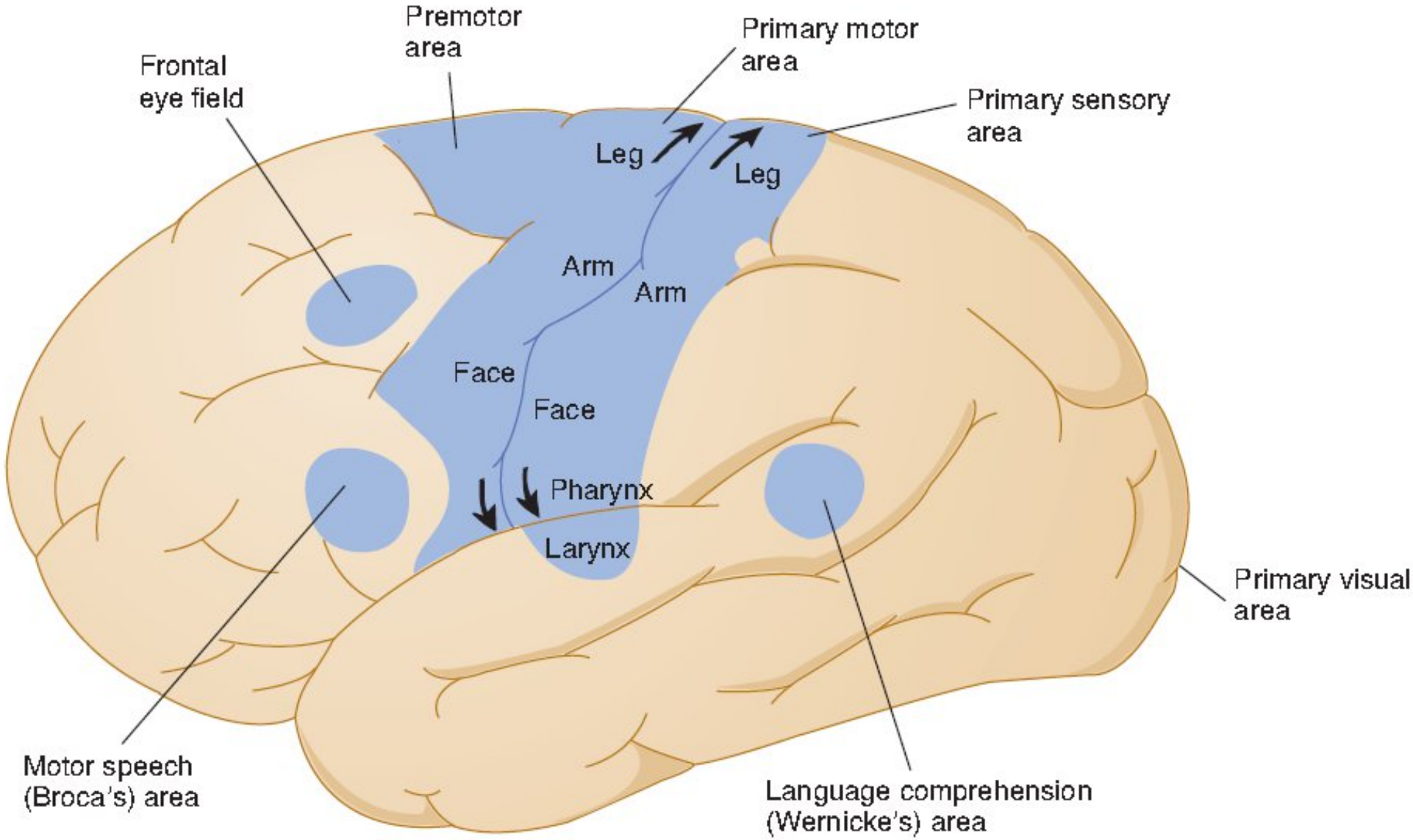
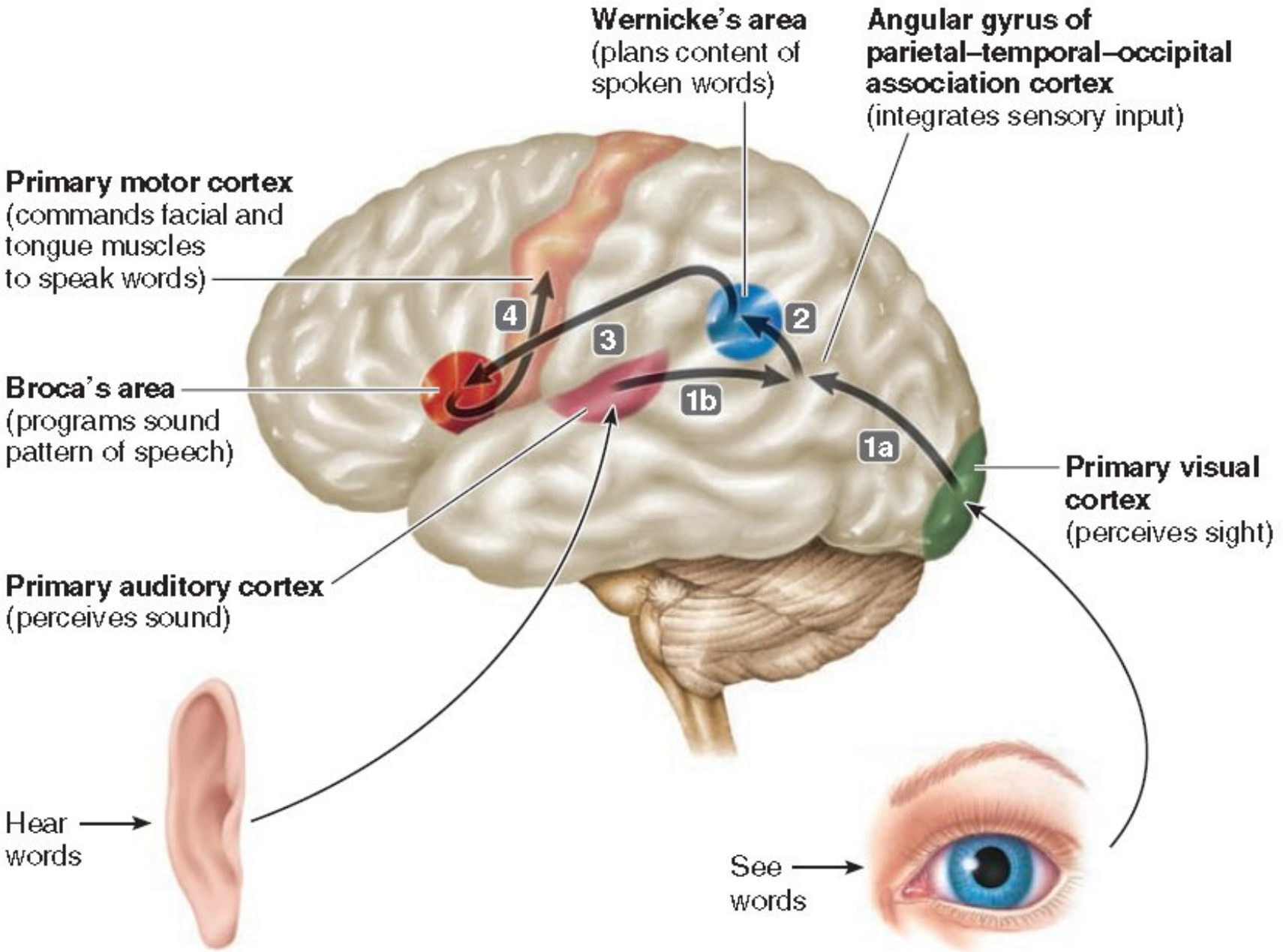


FIGURE 8–8 A lateral view of the left hemisphere showing some principal cortical areas and their functional correlates in the human brain. The primary somatosensory area is in the postcentral gyrus of the parietal lobe, and the primary motor cortex is in the precentral gyrus. (From Waxman SG: *Clinical Neuroanatomy*, 26th ed. McGraw-Hill, 2010.)



1a To speak about something seen, the brain transfers the visual information from the primary visual cortex to the angular gyrus of the parietal–temporal–occipital association cortex, which integrates inputs such as sight, sound, and touch.

1b To speak about something heard, the brain transfers the auditory information from the primary auditory cortex to the angular gyrus.

2 The information is transferred to Wernicke's area, where the choice and sequence of words to be spoken are formulated.

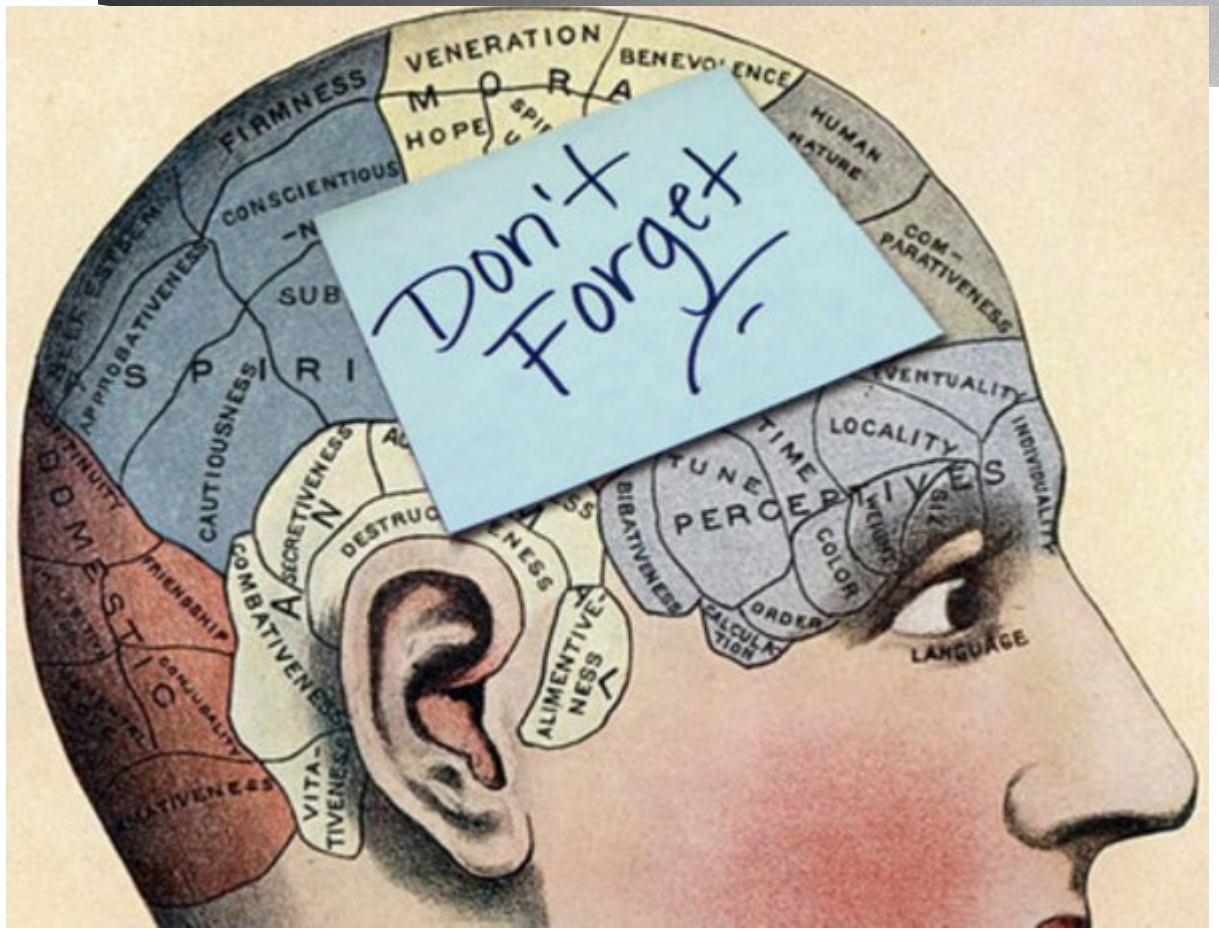
3 This language command is then transmitted to Broca's area, which translates the message into a programmed sound pattern.

4 This sound program is conveyed to the precise areas of the primary motor cortex that activate the appropriate facial and tongue muscles for causing the desired words to be spoken.

Figure 5-13 Cortical pathway for speaking a word seen or heard. The arrows and numbered steps describe the pathway used to speak about something seen or heard. Similarly, appropriate muscles of the hand can be commanded to write the desired words.

Definisi MEMORI & Pembelajaran

DEFINISI Memori



Kandell, 2015

Proses saat pengetahuan mengenai dunia dikode, disimpan dan diambil kembali

Bear, 2015

Retensi atau pengulangan dari informasi yang telah dipelajari

Ganong, 2015

Retensi dan penyimpanan dari informasi yang diperoleh

Penyimpanan pengetahuan ☾ jejak memori

DEFINISI PEMBELAJARAN

Bear, 2015

Akuisisi dari pengetahuan atau keterampilan yang baru

Sherwood, 2013

Akuisisi pengetahuan atau keterampilan sebagai konsekuensi pengalaman, instruksi, atau keduanya

Belajar : Stimulus ☾ Respon

Stimulus hadiah ☾ Merespon dengan cara yang sama terhadap stimulus yang sama

Stimulus hukuman ☾ Kemungkinan mengulang respon yang sama pada stimulus yang sama sangat kecil

Belajar : Perubahan perilaku yang terjadi akibat pengalaman

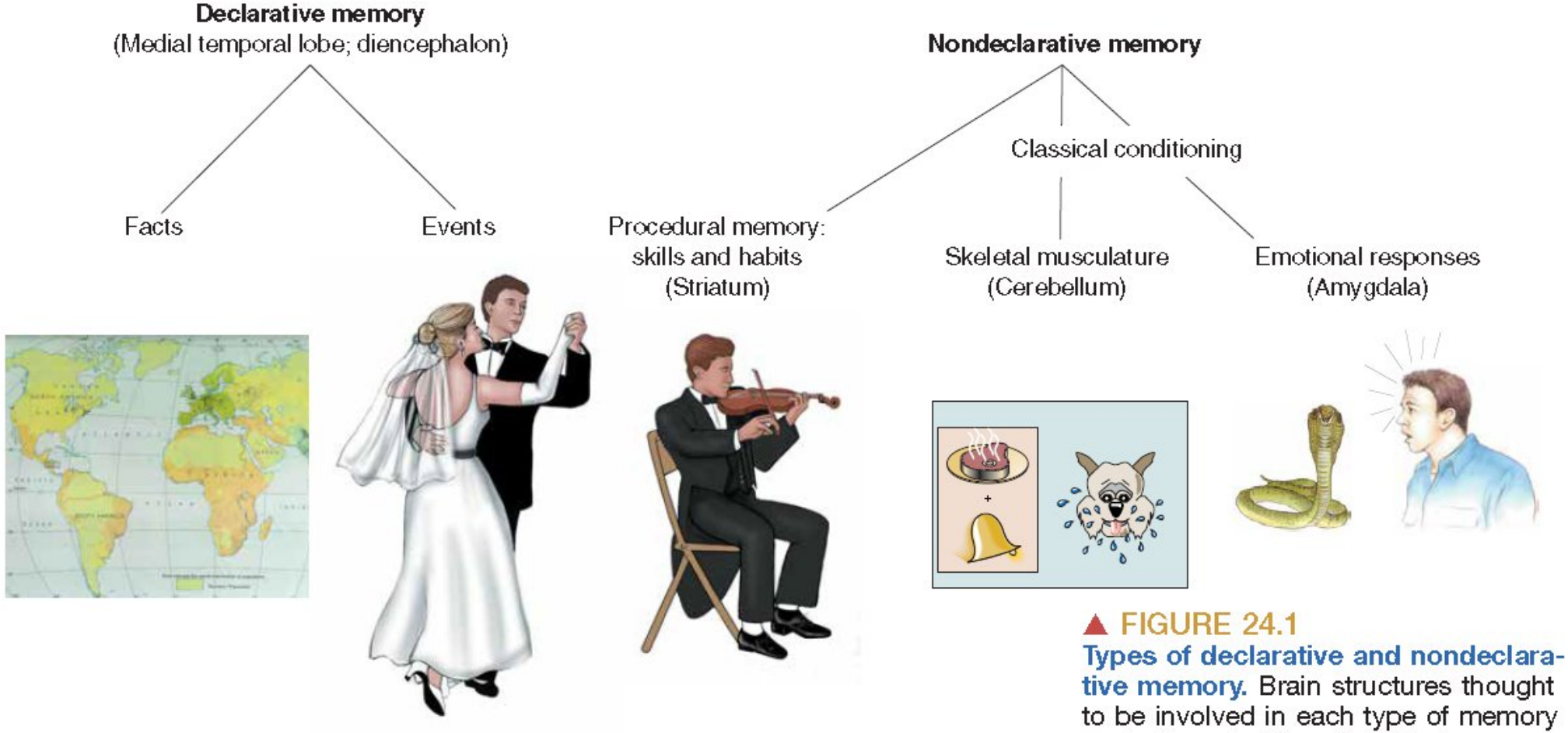
Belajar & Memori

Dasar untuk mengadaptasikan perilaku ke lingkungan tertentu

Survival

JENIS MEMORI DAN PEMBELAJARAN

JENIS MEMORI



▲ FIGURE 24.1
Types of declarative and nondeclarative memory. Brain structures thought to be involved in each type of memory are indicated. (Note that this is not a complete representation of all types of memory.)

Bear MF, Connors BW, Paradiso, MA. Neurotransmitter system. 4th ed. Neuroscience: Exploring the Brain.

TYPES OF PROCEDURAL MEMORIES

Involves learning a motor response (procedure) in reaction to a sensory input.

Formation of procedural memories occurs through 2 catagories of learning :

1. Non associative learning
2. Assiciative learning

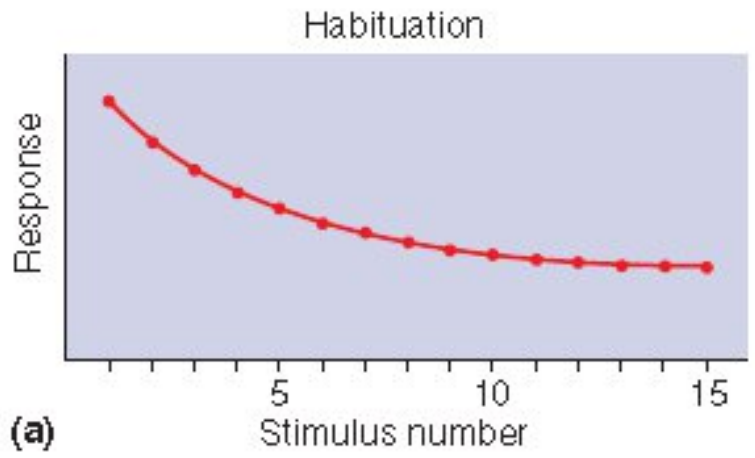
Bear MF, Connors BW, Paradiso, MA. Neurotransmitter system. 4th ed. Neuroscience: Exploring the Brain.

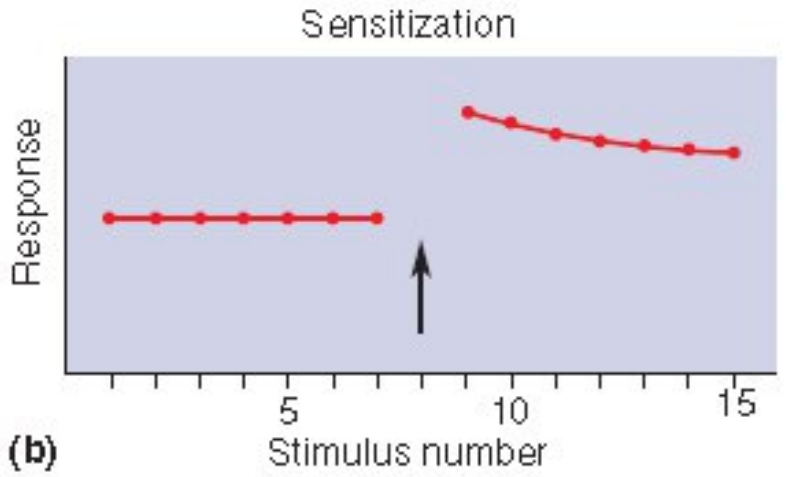
NONASSOCIATIVE LEARNING

Describe a change in behavioral response that occurs over time in response to a single type of stimulus.

Two types :

1. Habituation
2. sensitization





Bear MF, Connors BW, Paradiso, MA. Neurotransmitter system. 4th ed. Neuroscience: Exploring the Brain.

ASSOCIATIVE LEARNING

Behavior is altered by the formation of association between events

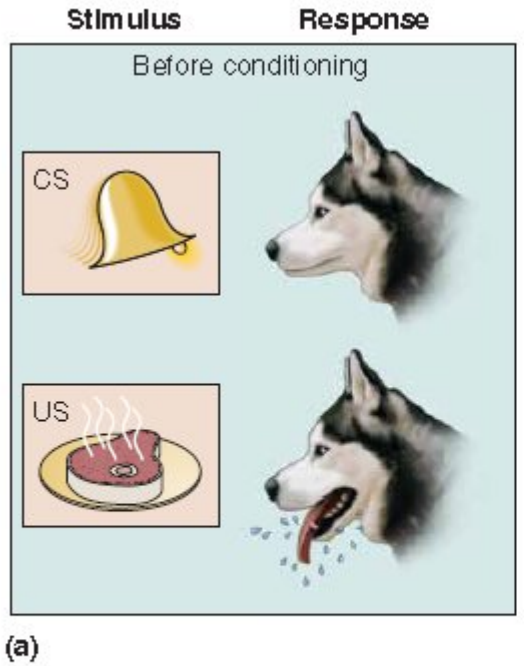
Two types :

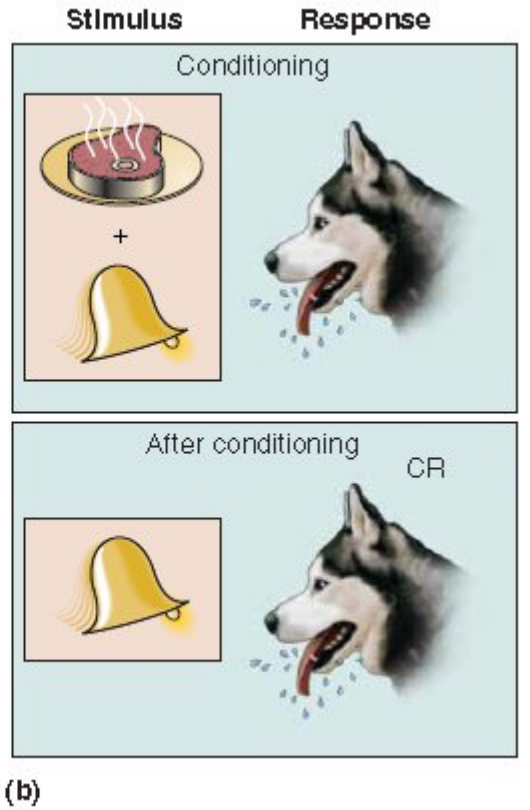
- Classical conditioning
- Instrumental conditioning

Classical conditioning (pavlov)
Involves associating stimulus that evokes a measurable response with a second stimulus that normally doesn't evoke this response.

Unconditional stimulus Ⓟ normally evoke the response
Ⓟin pavlov experiments : sign of a piece of meat Ⓟ salivation

Conditional stimulus Ⓟ doesn't evoke the response, require training
Ⓟ in pavlov experiments : auditory stimulus





Bear MF, Connors BW, Paradiso MA. Neuroscience: Exploring the Brain. 4th ed.

Instrumental conditioning

- Individual learn to associate a response, a motor act, with a meaningful stimulus, typically a rewards such as food

- Example :
  Hungry rats placed in a box with a lever that dispenses food Ⓟ when exploring the box, the rats bump the lever and pop out a piece of food Ⓟ after happen few times, rat learns that pressing the lever lead to a food rewards

- Subject learns that a particular behavior is associate with a particular consequences.

- Motivation plays a large part in instrumental conditioning Ⓟ neural cir
  involved in classical condition

Bear MF, Connors BW, Paradiso, MA. Neurotransmitter system. 4th ed.
Neuroscience: Exploring the Brain.

TABLE 5-3 Comparison of Short-Term and Long-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 modifications in functions of preexisting 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 a key role

Sherwood, Principles of human physiology, 7th ed

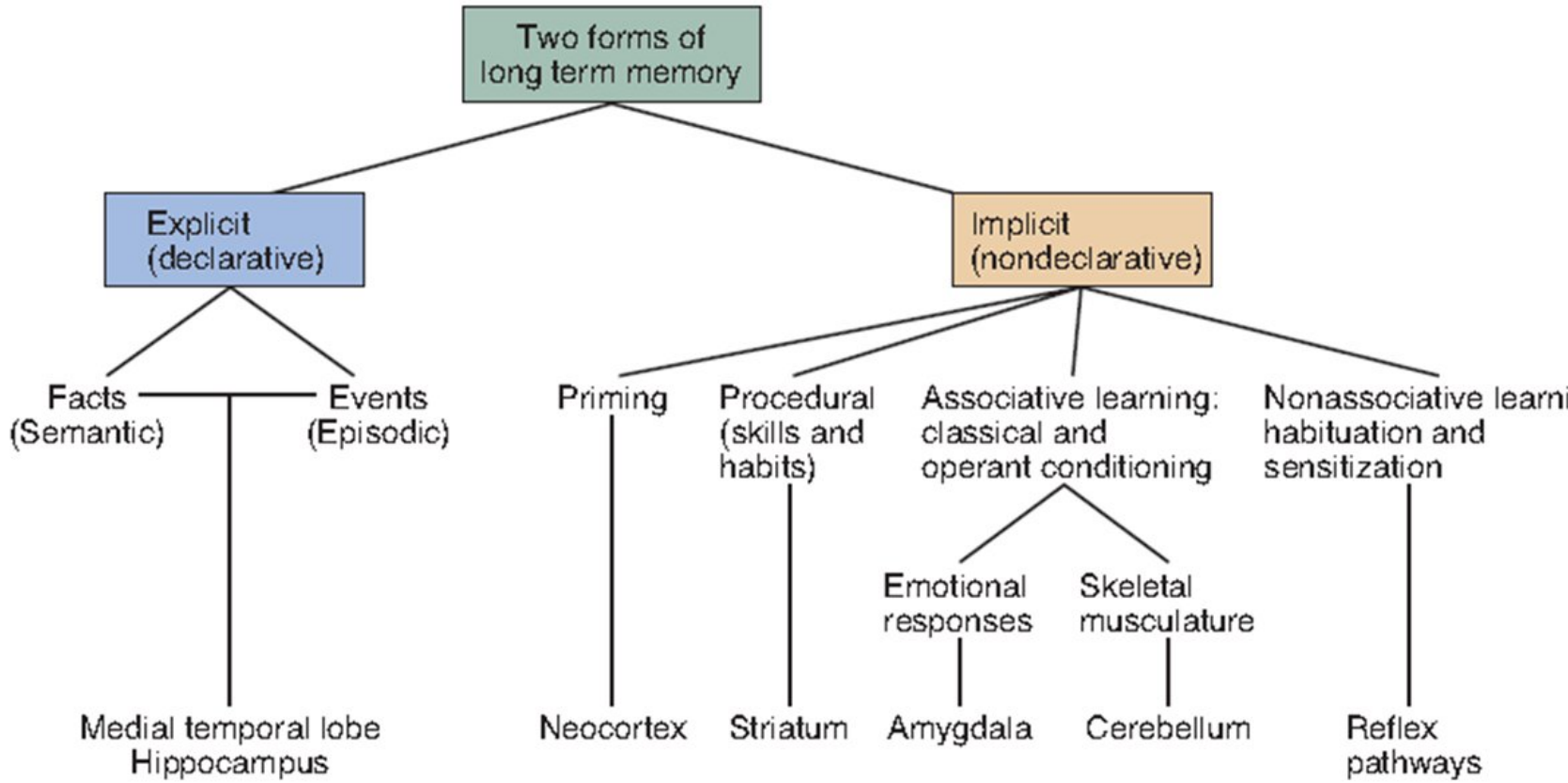


FIGURE 19–2 **Forms of long-term memory.** (Modified from Kandel ER, Schwartz JH, Jessell TM [editors]: *Principles of Neural Science*, 4th ed. McGraw-Hill, 2000.)

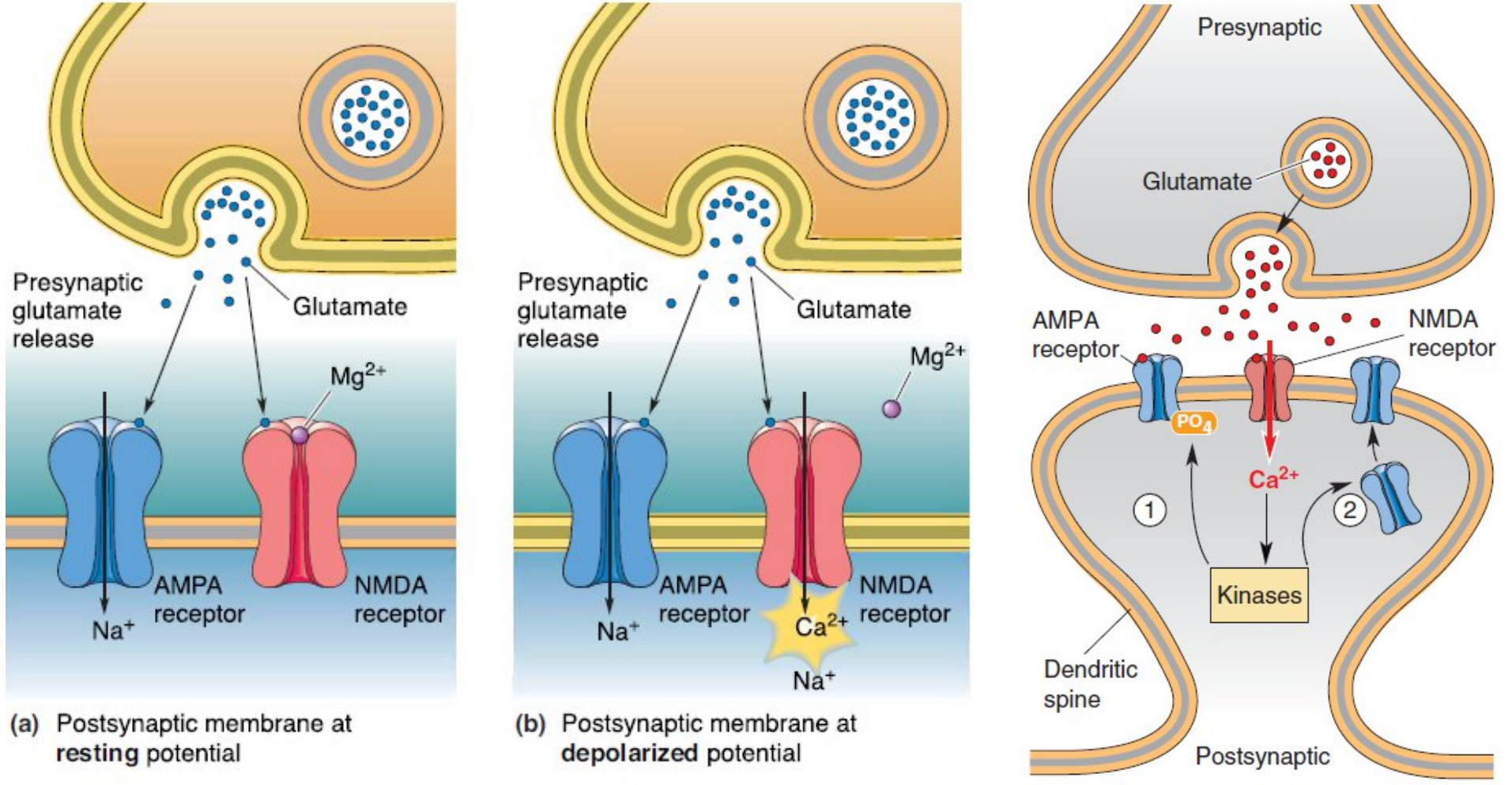
PLASTISITAS SINAPS

Mekanisme molekular pembelajaran dan memori

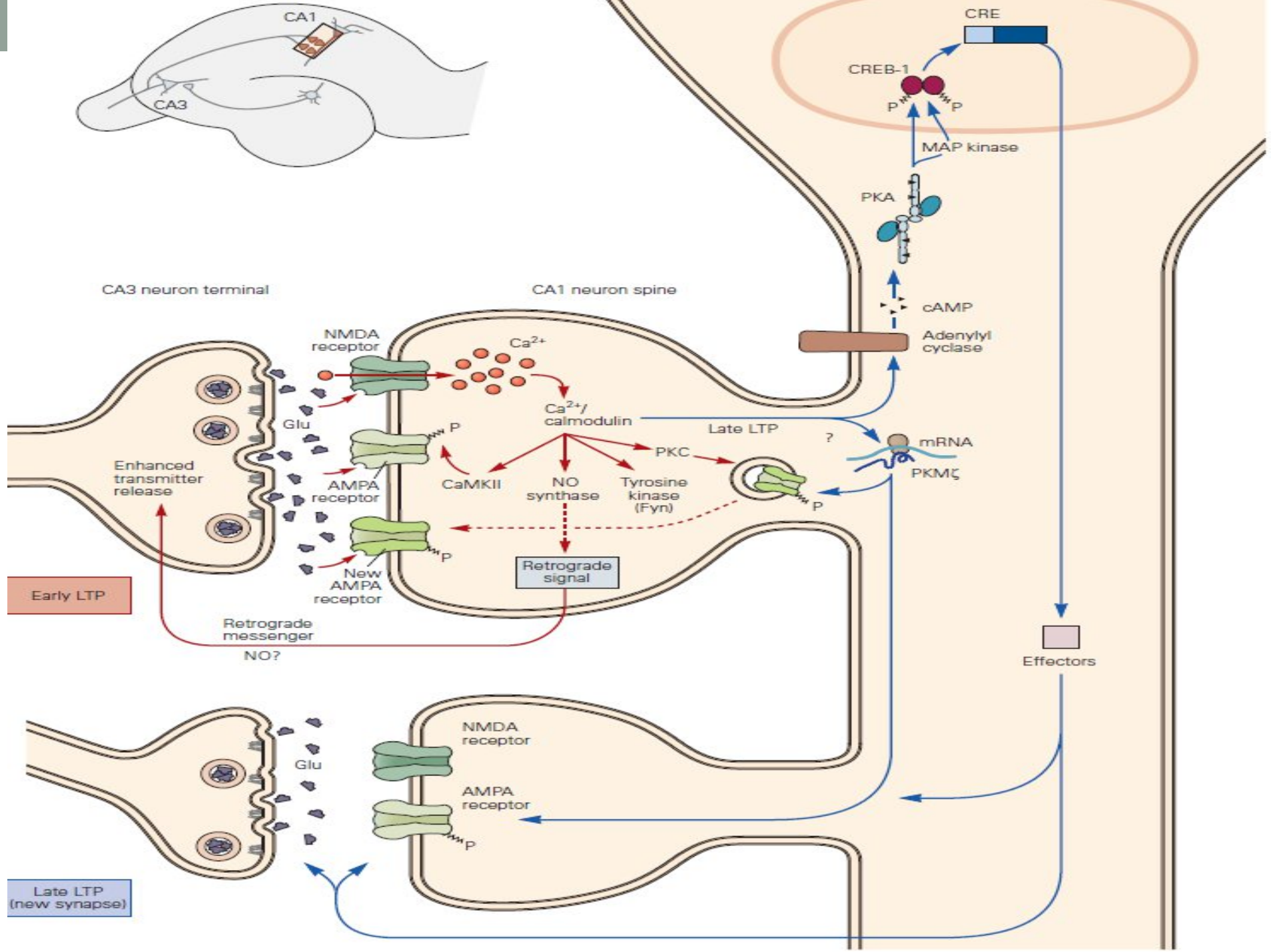
Plastisitas sinaps

- Merupakan proses dimana terjadi perubahan kekuatan sinaps yang dipengaruhi oleh aktivitas neuron
- Merupakan mekanisme seluler untuk pembelajaran dan memori
- Dipengaruhi oleh berbagai interaksi molekul dan protein seperti synaptophysin di presinaps dan PSD-95 di pasca sinaps.

Long term potentiation (LTP)



Bear, Neuroscience exploring the brain 4th ed, 2016


CA1
CA3
CRE
CREB-1
P
P
MAP kinase
PKA
cAMP
Adenylyl cyclase
CA3 neuron terminal
CA1 neuron spine
NMDA receptor
Ca^{2+}
Ca^{2+}/ calmodulin
Glu
P
Late LTP
?
mRNA
PKMζ
PKC
Enhanced transmitter release
AMPA receptor
CaMKII
NO synthase
Tyrosine kinase (Fyn)
P
P
New AMPA receptor
Retrograde signal
Early LTP
Retrograde messenger
NO?
Effectors
NMDA receptor
Glu
AMPA receptor
P
Late LTP (new synapse)

Perubahan struktur pada pembentukan memory jangka panjang :

- dihambat oleh obat blokade replikasi protein DNA di neuron presinaps

Perubahan yang terjadi :

- peningkatan situs sekresi neurotransmitter
- peningkatan jumlah vesikel transmitter yang dilepaskan
- peningkatan jumlah terminal presinaps
- perubahan struktur dendritic spine ☾ transmisi sinyal yang lebih kuat

Jumlah neuron dan koneksinya

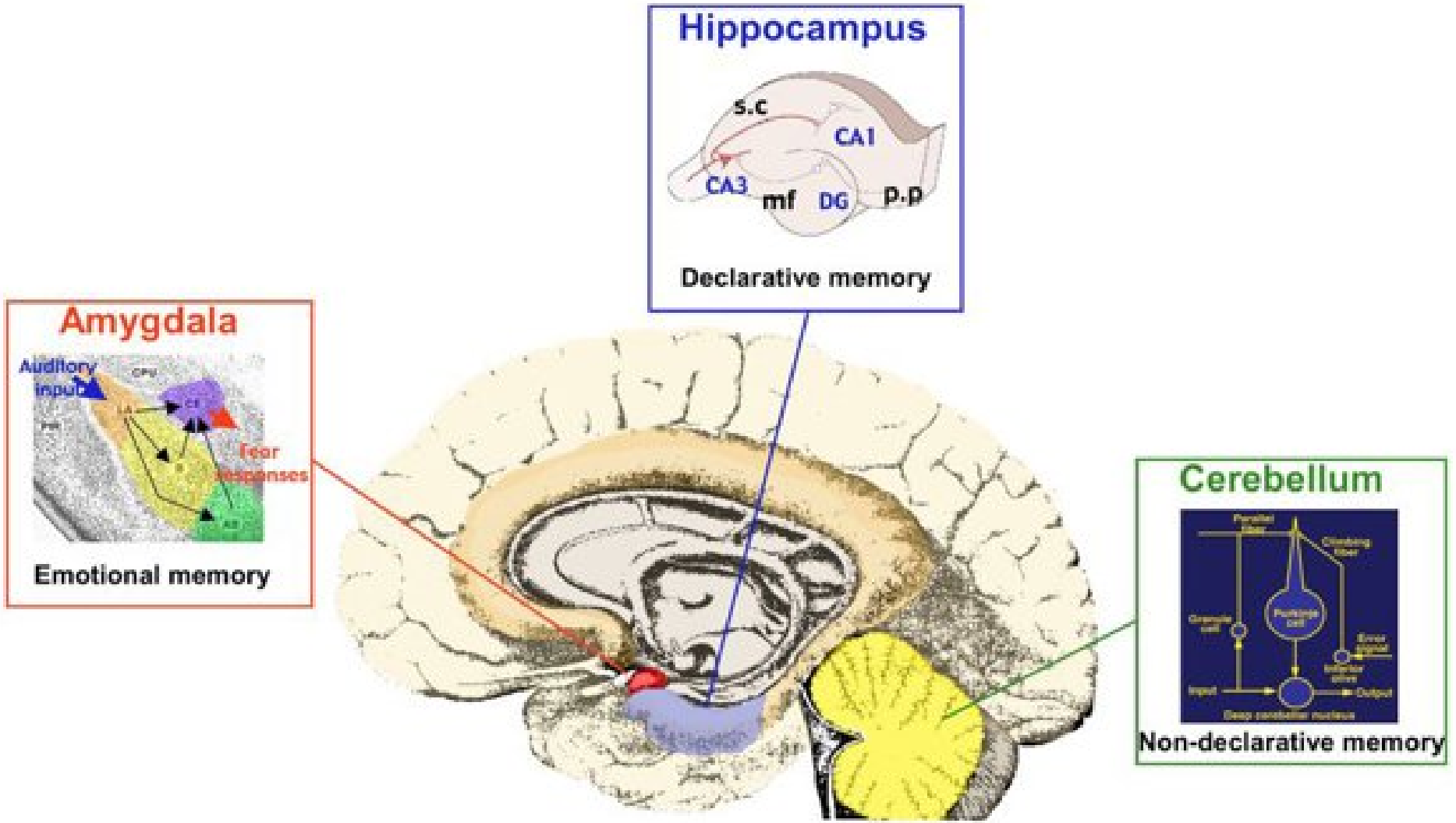
- dipengaruhi proses belajar
- use it or lose it

Konsolidasi memory

- perubahan memory jangka pendek ☾ panjang
- 5 – 10 menit (atau 1 jam konsolidasi kuat)
- memory baru akan dikode dan disimpan sesuai kemiripan dan perbedaan dengan simpanan memory.

Bagian otak yang paling berkaitan dengan memory

- hippocampus
  - peran penting ☾ short term memory yang melibatkan integrasi beberapa stimulus, tempat terjadinya LTP, penting untuk konsolidasi long term memory
  - peranan pada declarative memory
  - merupakan output pathway paling penting untuk reward dan punishment area dari sistem limbic ☾ mood dan motivasi
  - gangguan pembelajaran yang berkaitan dengan verbal dan symbol, namun skill baik


Hippocampus
s.c
CA1
CA3
mf
DG
p.p
Declarative memory
Amygdala
Auditory input
Fear responses
Emotional memory
Cerebellum
Non-declarative memory

amigdala

- nucleus kecil di bawah kutub anterior media cortex cerebral
- stimulasi amigdala
  - peningkatan atau penurunan tekanan arteri
  - peningkatan atau penurunan heart rate
  - peningkatan atau penurunan motilitas dan sekresi gastrointestinal
  - defekasi
  - dilatasi pupil
  - piloerection
- sekresi hormon pituitari anterior (gonadotropin dan adrenokortikotropik)

lobus temporal medial

sistem limbic

cerebellum

- peran penting ☾ procedural memory (motor skill yang didapat dari pelatihan)
- area cortical yang terlibat ☾ sesuai sistem yang terlibat
- recall tanpa disadari

- cortex prefrontal
  - penting untuk reasoning skill, berkaitan working memory
  - tempat penyimpanan sementara data
  - untuk fungsi eksekutif ☾ manipulasi, integrasi planning, problem solving, organizing activity
  - dibantu oleh regio sensoris melalui jaringan saraf