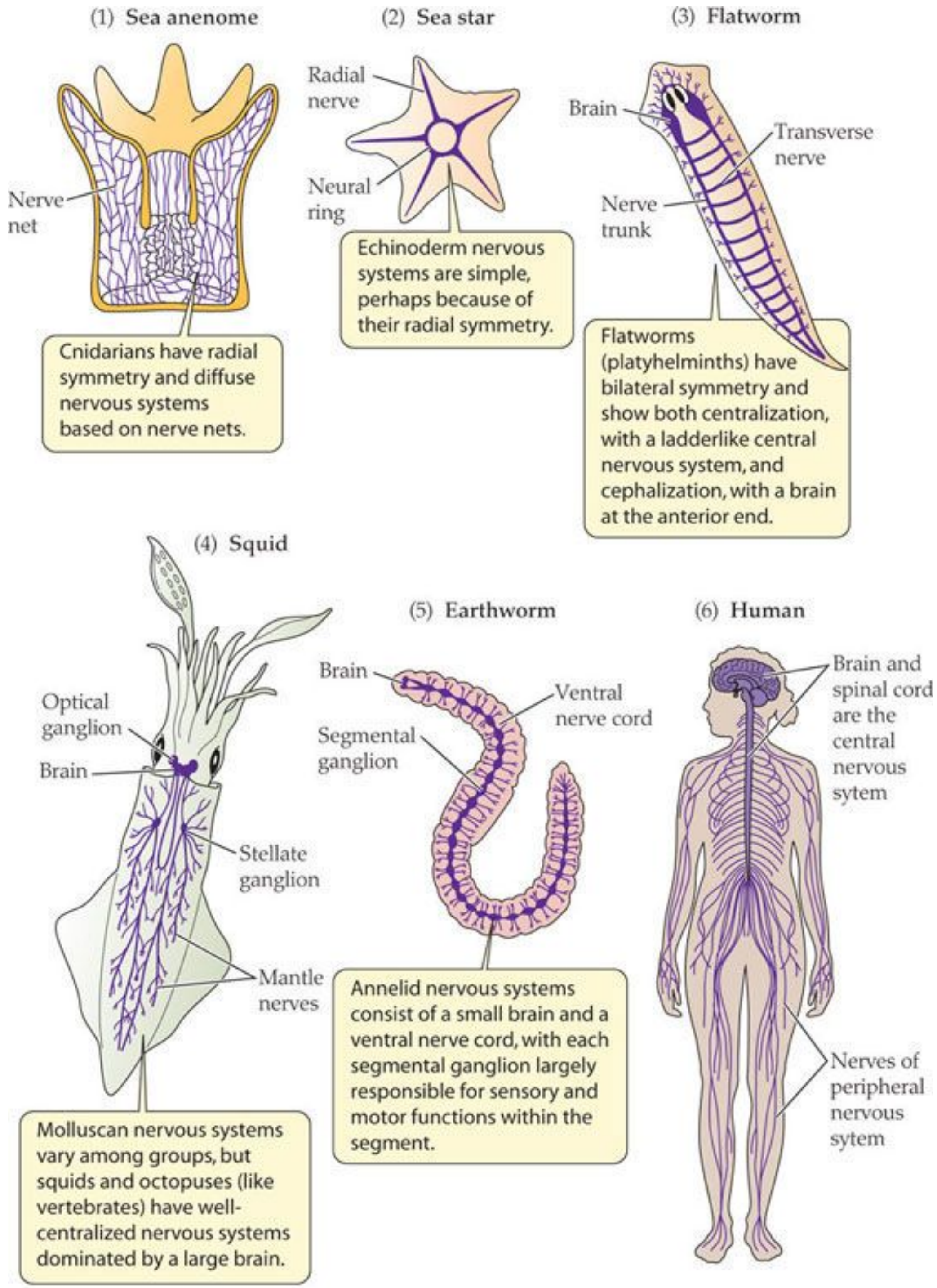
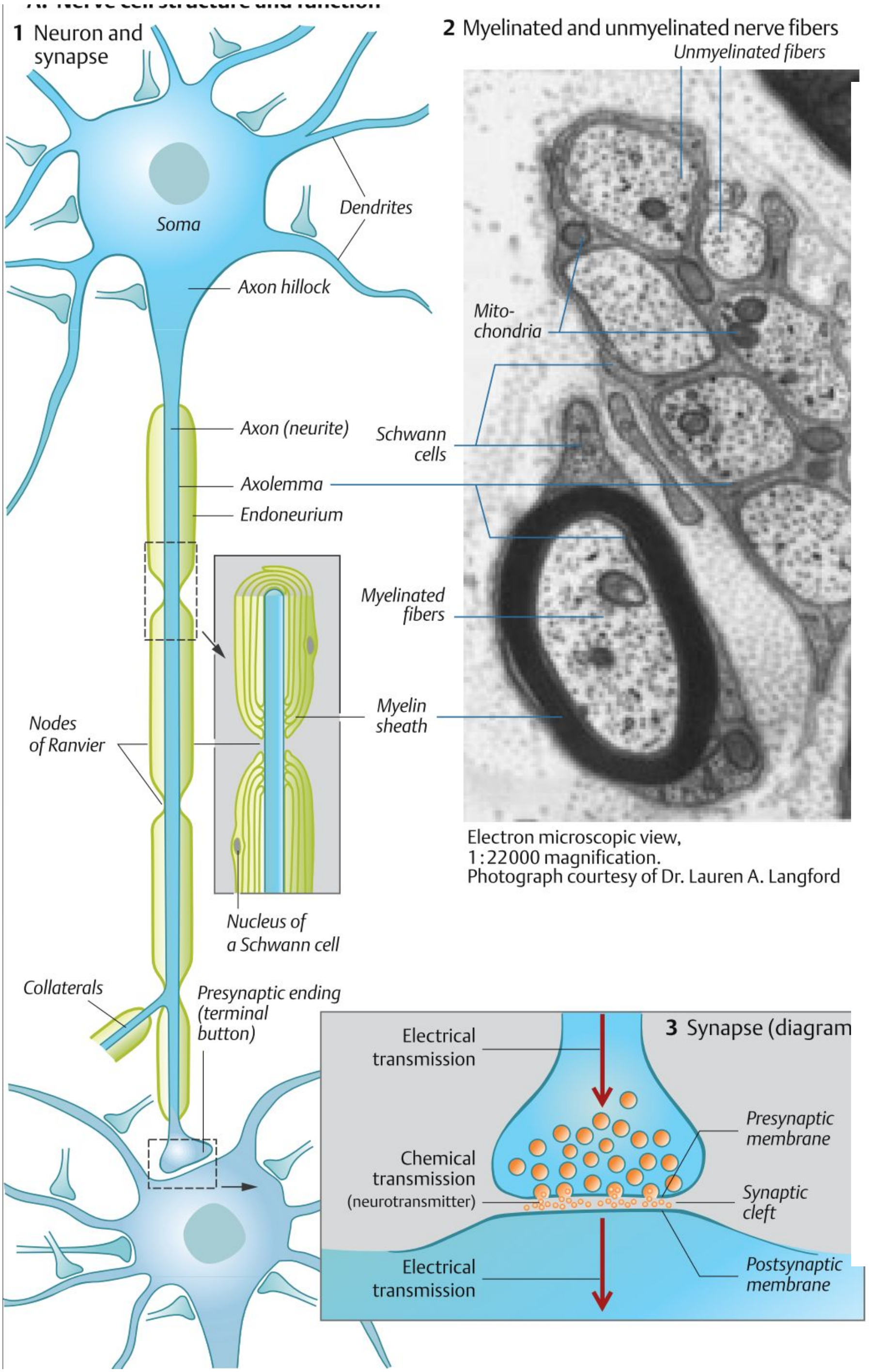
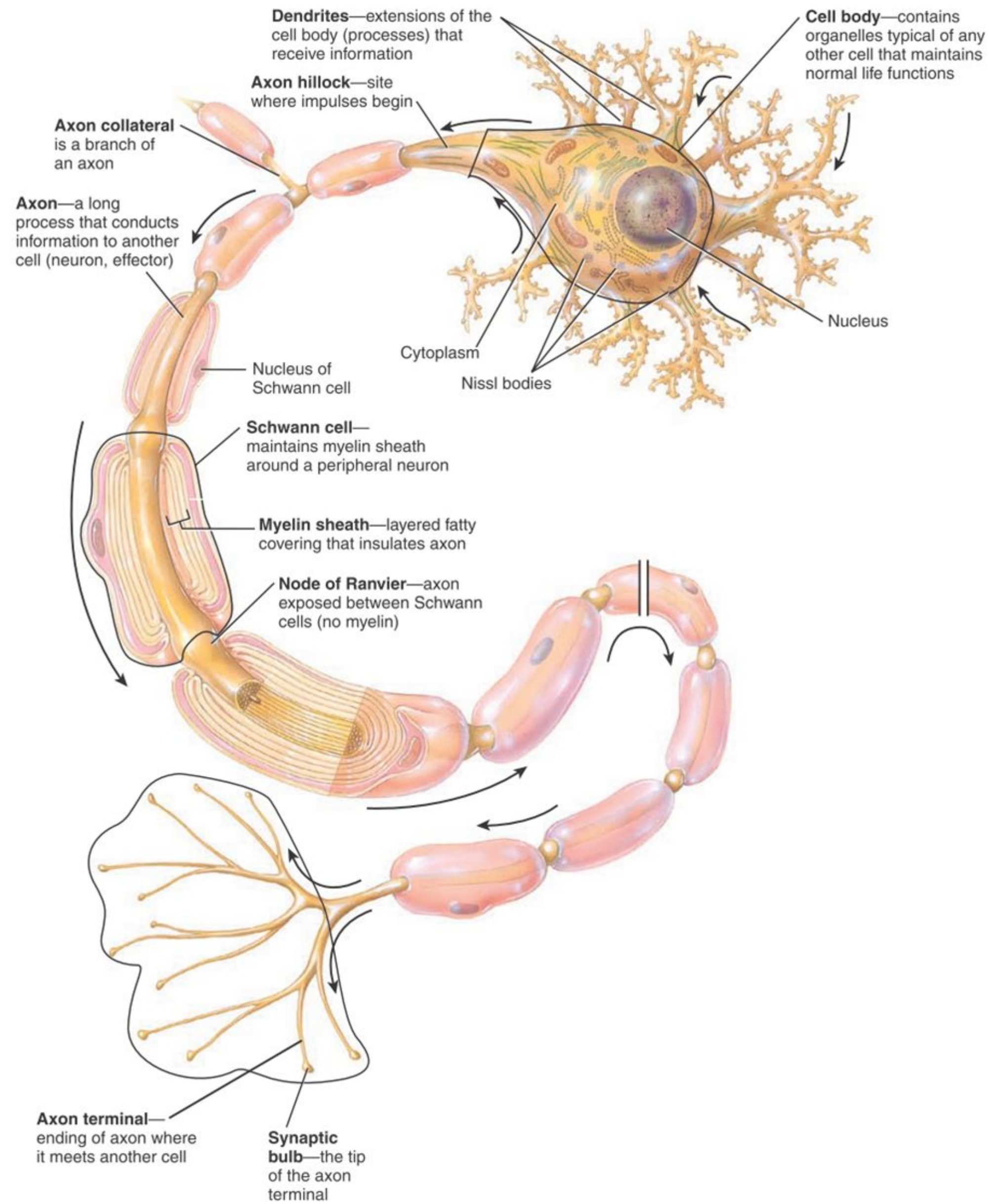
Общая физиология ЦНС

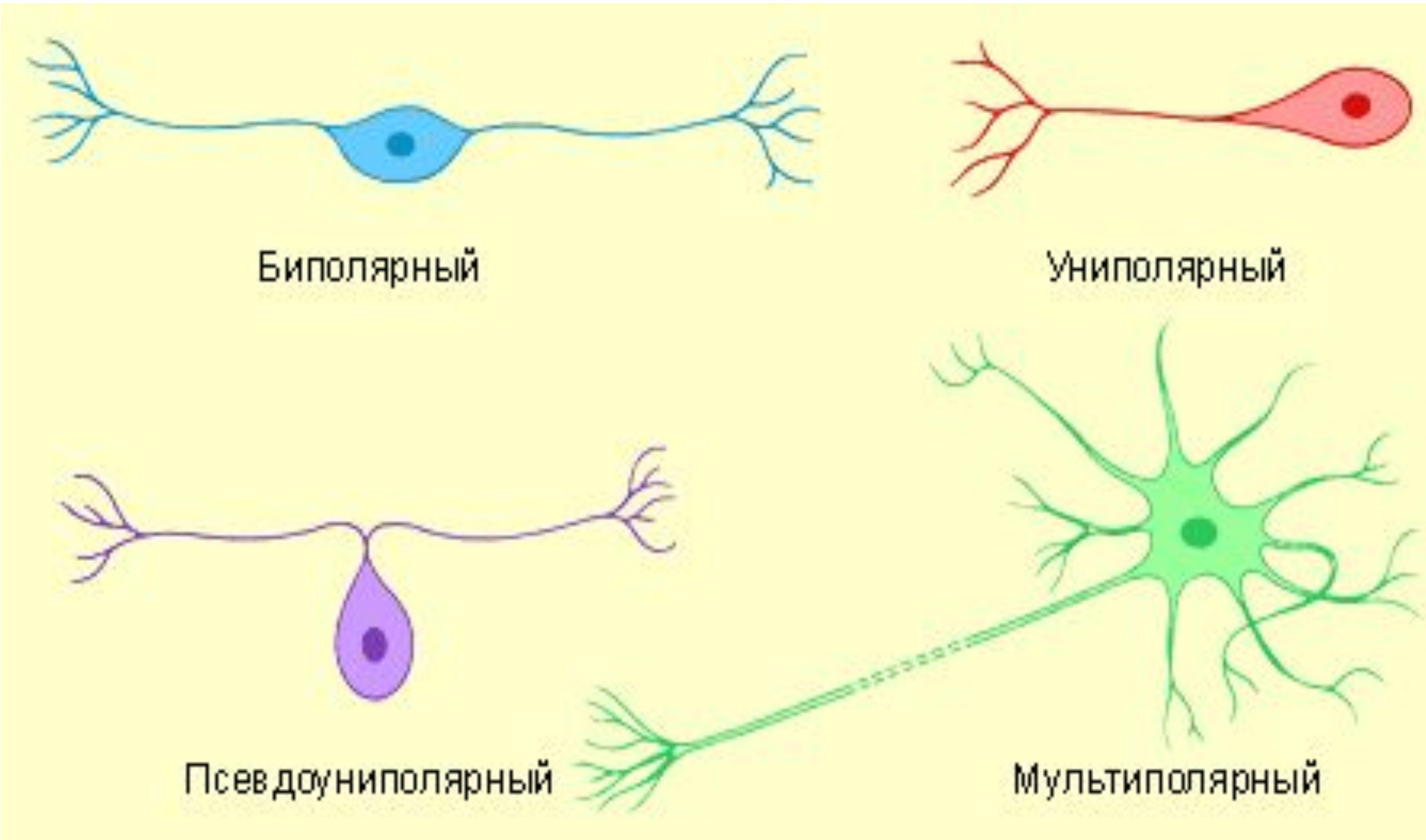


(1) Sea anenome
Nerve net
Cnidarians have radial symmetry and diffuse nervous systems based on nerve nets.
(2) Sea star
Radial nerve
Neural ring
Echinoderm nervous systems are simple, perhaps because of their radial symmetry.
(3) Flatworm
Brain
Transverse nerve
Nerve trunk
Flatworms (platyhelminths) have bilateral symmetry and show both centralization, with a ladderlike central nervous system, and cephalization, with a brain at the anterior end.
(4) Squid
Optical ganglion
Brain
Stellate ganglion
Mantle nerves
Molluscan nervous systems vary among groups, but squids and octopuses (like vertebrates) have well-centralized nervous systems dominated by a large brain.
(5) Earthworm
Brain
Ventral nerve cord
Segmental ganglion
Annelid nervous systems consist of a small brain and a ventral nerve cord, with each segmental ganglion largely responsible for sensory and motor functions within the segment.
(6) Human
Brain and spinal cord are the central nervous sytem
Nerves of peripheral nervous sytem

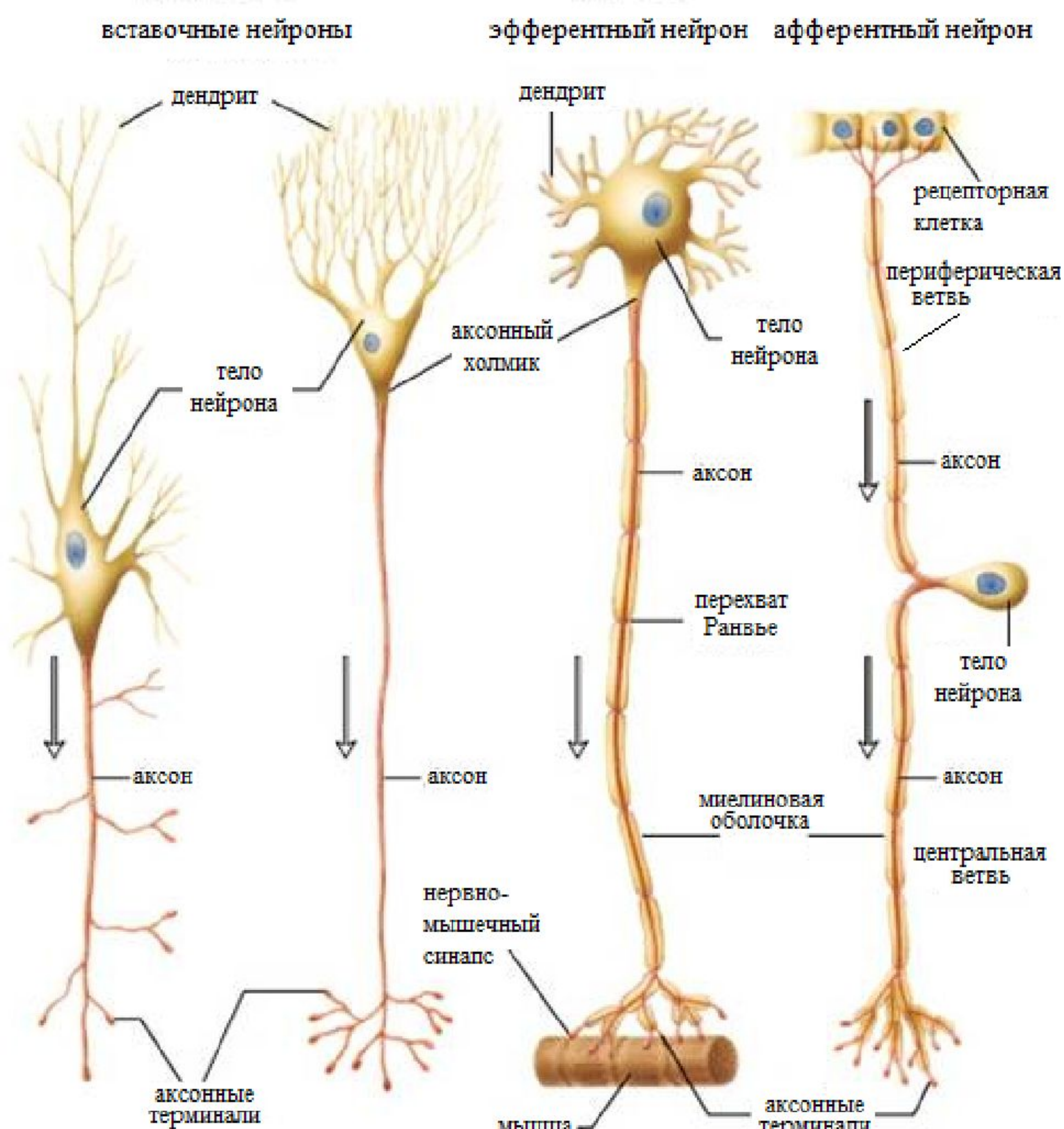

1 Neuron and synapse
Soma
Dendrites
Axon hillock
Axon (neurite)
Axolemma
Endoneurium
Nodes of Ranvier
Nucleus of a Schwann cell
Collaterals
Presynaptic ending (terminal button)
2 Myelinated and unmyelinated nerve fibers
Unmyelinated fibers
Mito-chondria
Schwann cells
Myelinated fibers
Myelin sheath
Electron microscopic view,
1:22000 magnification.
Photograph courtesy of Dr. Lauren A. Langford
3 Synapse (diagram
Electrical transmission
Chemical transmission
(neurotransmitter)
Presynaptic membrane
Synaptic cleft
Electrical transmission
Postsynaptic membrane

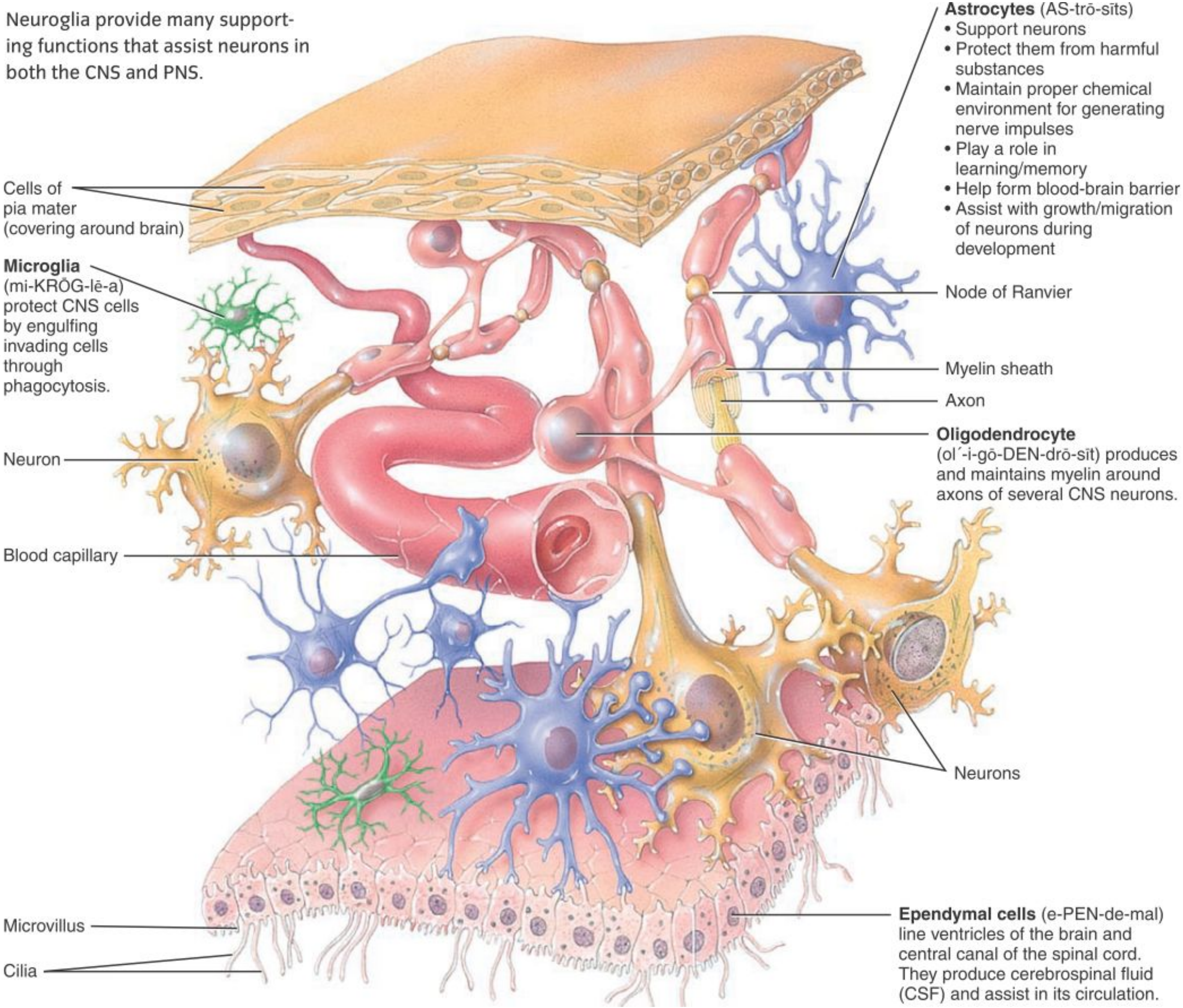

Dendrites—extensions of the cell body (processes) that receive information
Cell body—contains organelles typical of any other cell that maintains normal life functions
Axon hillock—site where impulses begin
Axon collateral is a branch of an axon
Axon—a long process that conducts information to another cell (neuron, effector)
Nucleus
Cytoplasm
Nissl bodies
Nucleus of Schwann cell
Schwann cell—maintains myelin sheath around a peripheral neuron
Myelin sheath—layered fatty covering that insulates axon
Node of Ranvier—axon exposed between Schwann cells (no myelin)
Axon terminal—ending of axon where it meets another cell
Synaptic bulb—the tip of the axon terminal

Виды нейронов

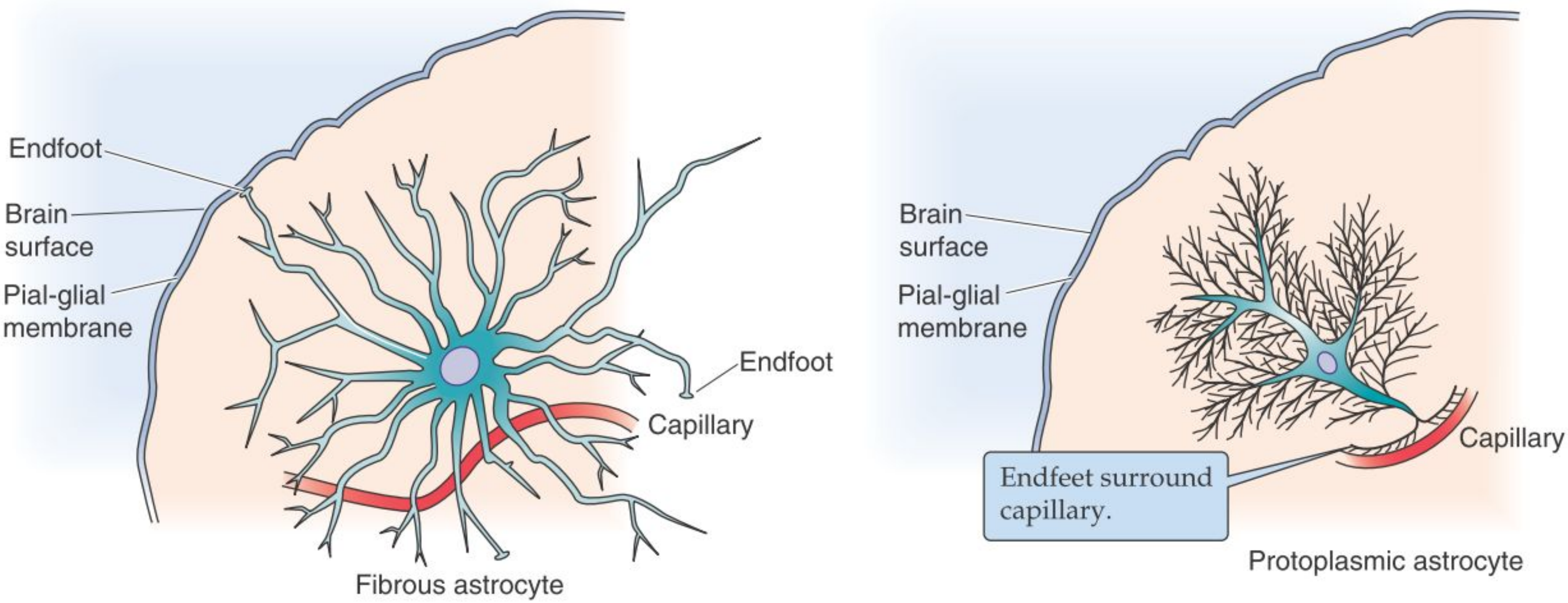


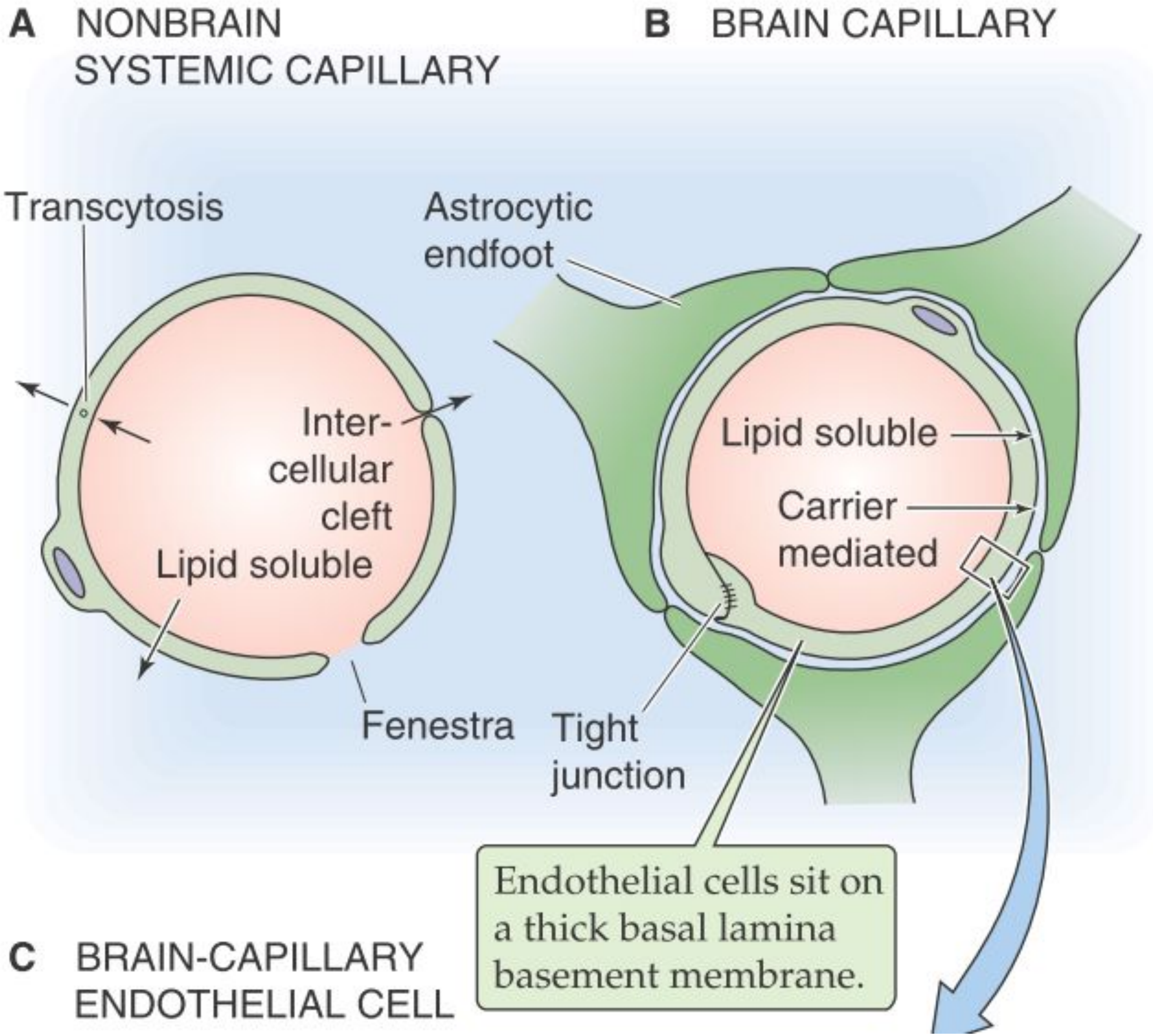
Виды нейронов

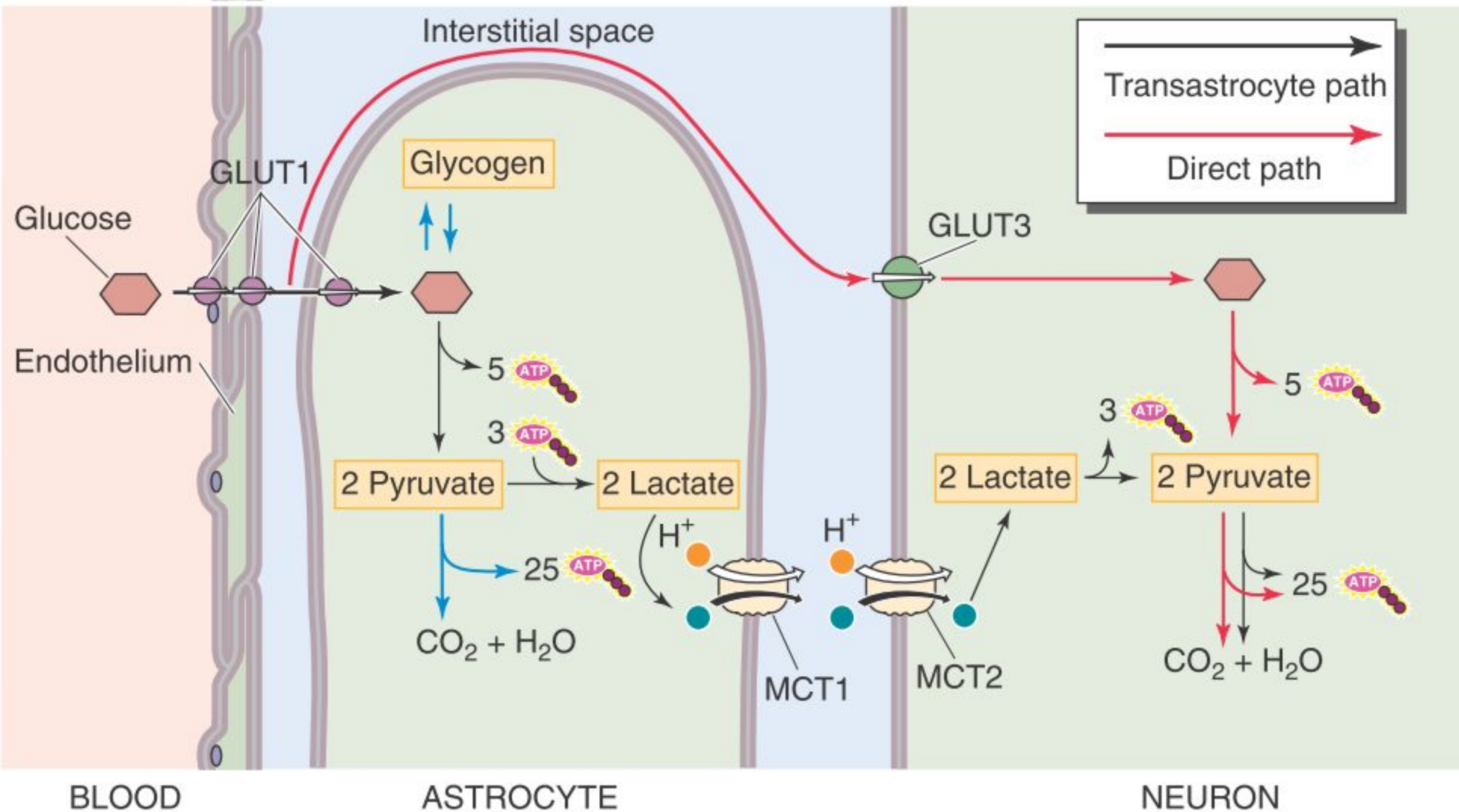




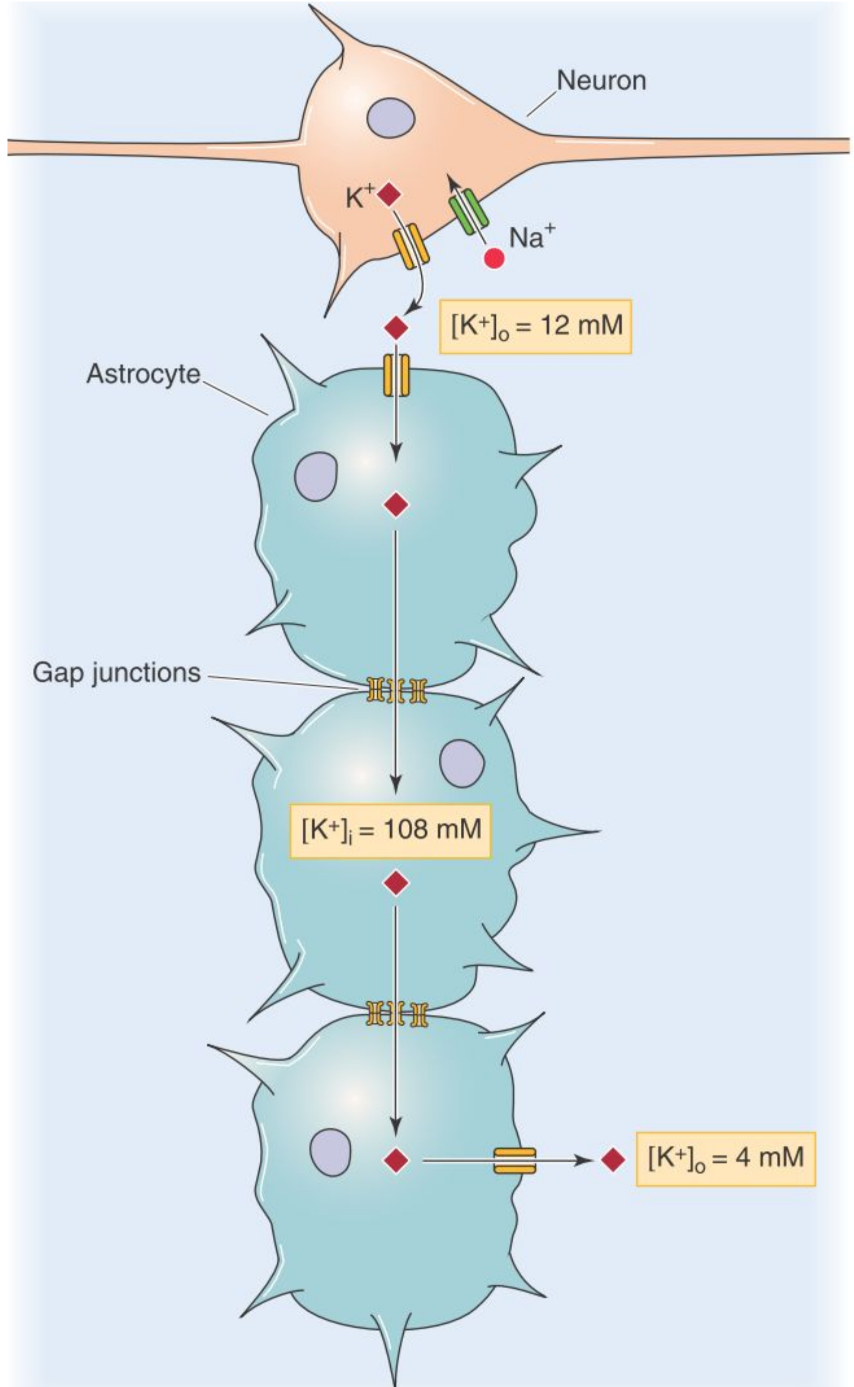
Neuroglia provide many supporting functions that assist neurons in both the CNS and PNS.
Cells of pia mater (covering around brain)
Microglia (mi-KRŌG-lē-a) protect CNS cells by engulfing invading cells through phagocytosis.
Neuron
Blood capillary
Microvillus
Cilia
Astrocytes (AS-trō-sīts)
• Support neurons
• Protect them from harmful substances
• Maintain proper chemical environment for generating nerve impulses
• Play a role in learning/memory
• Help form blood-brain barrier
• Assist with growth/migration of neurons during development
Node of Ranvier
Myelin sheath
Axon
Oligodendrocyte (ol´-i-gō-DEN-drō-sīt) produces and maintains myelin around axons of several CNS neurons.
Neurons
Ependymal cells (e-PEN-de-mal) line ventricles of the brain and central canal of the spinal cord. They produce cerebrospinal fluid (CSF) and assist in its circulation.


Endfoot
Brain surface
Pial-glial membrane
Endfoot
Capillary
Fibrous astrocyte
Brain surface
Pial-glial membrane
Capillary
Endfeet surround capillary.
Protoplasmic astrocyte

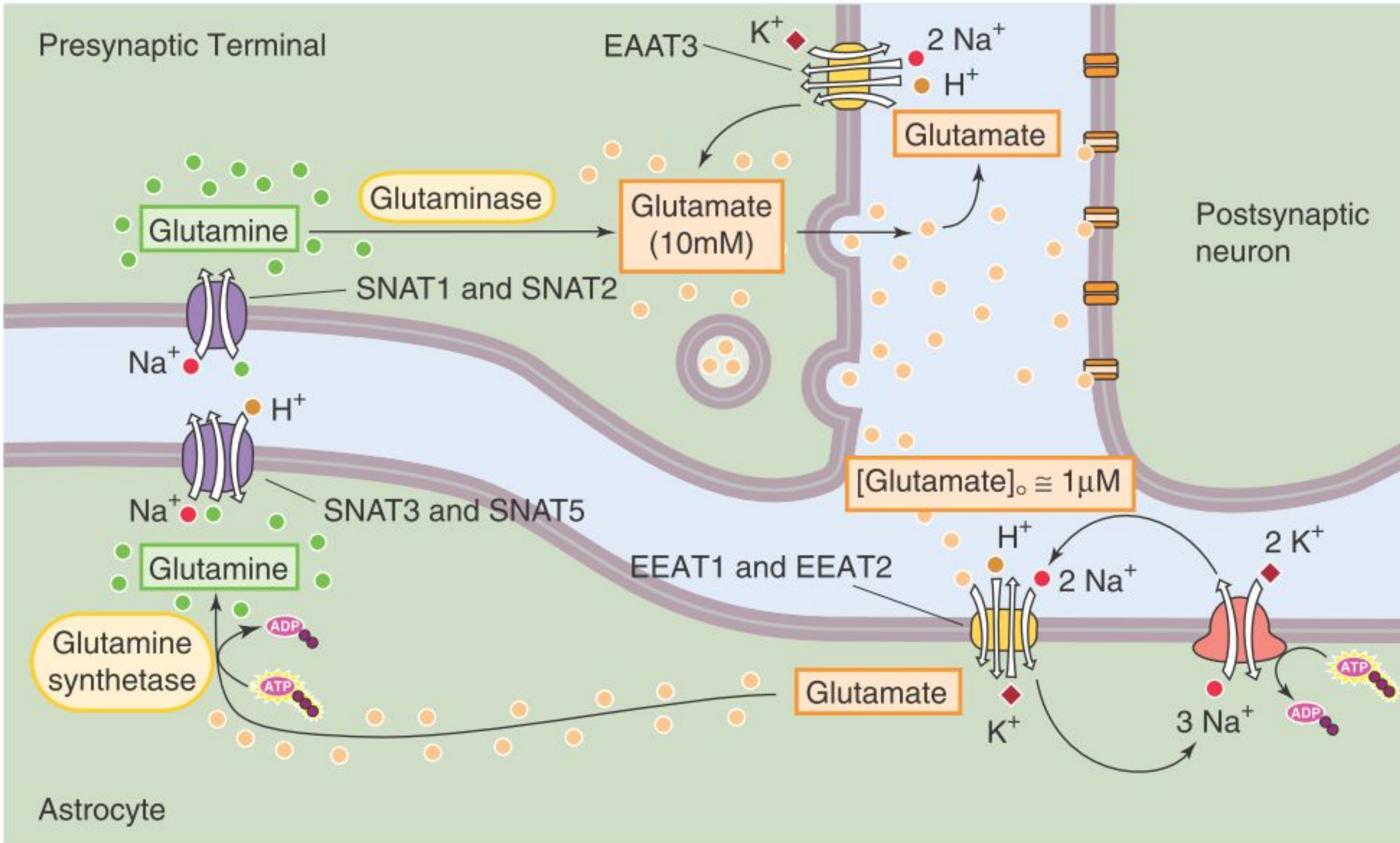

A NONBRAIN
SYSTEMIC CAPILLARY
B BRAIN CAPILLARY
Transcytosis
Inter-
cellular
cleft
Lipid soluble
Fenestra
Astrocytic
endfoot
Lipid soluble
Carrier
mediated
Tight
junction
Endothelial cells sit on
a thick basal lamina
basement membrane.
C BRAIN-CAPILLARY
ENDOTHELIAL CELL



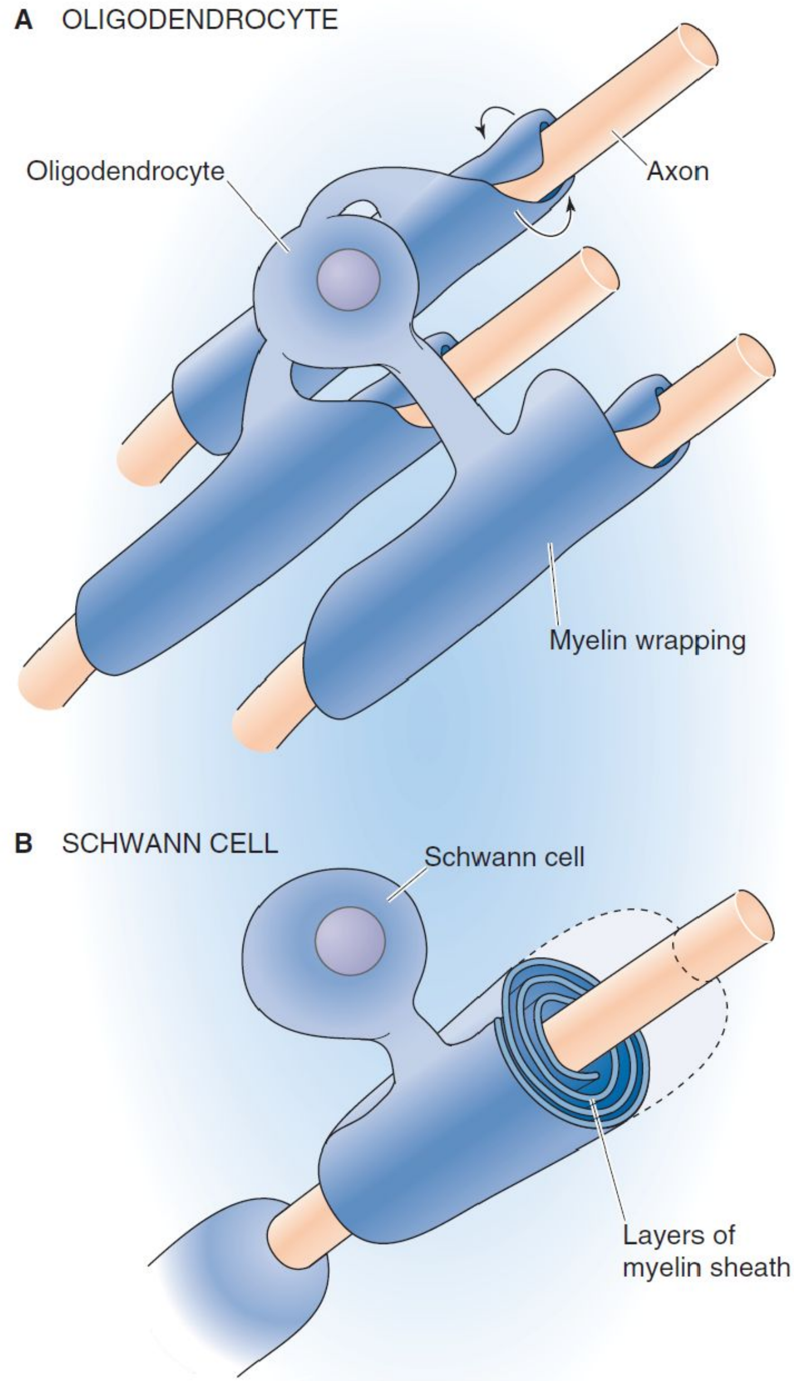
Interstitial space
Transastrocyte path
Direct path
Glycogen
GLUT1
Glucose
GLUT3
Endothelium
5 ATP
3 ATP
2 Pyruvate
2 Lactate
25 ATP
$CO_2 + H_2O$
H^+
MCT1
MCT2
5 ATP
3 ATP
2 Lactate
2 Pyruvate
25 ATP
$CO_2 + H_2O$
BLOOD
ASTROCYTE
NEURON

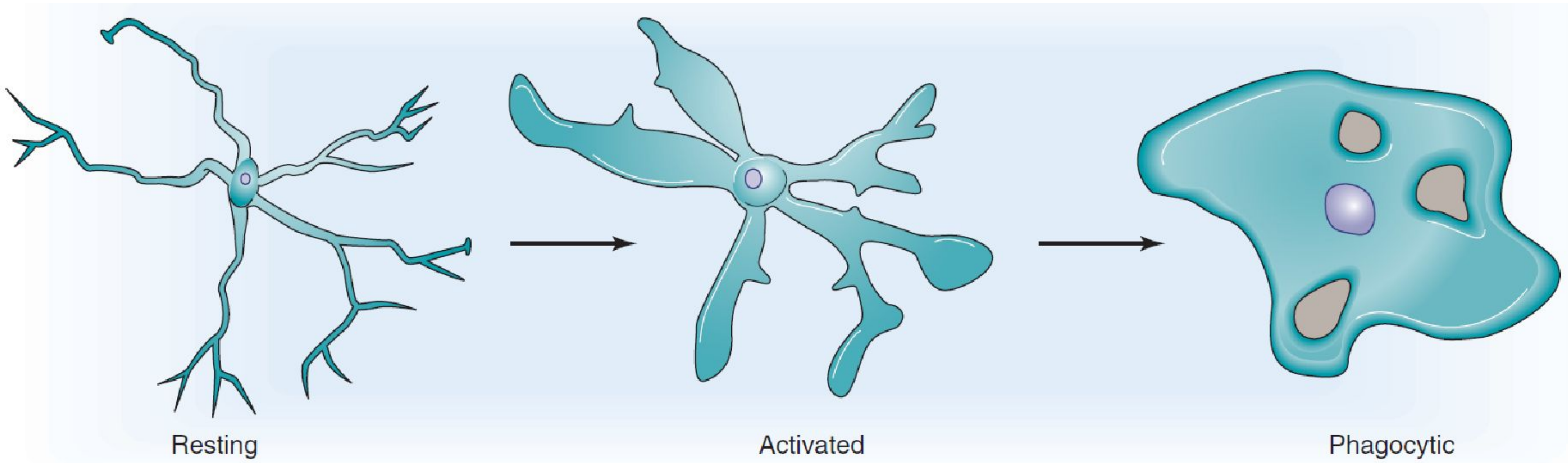


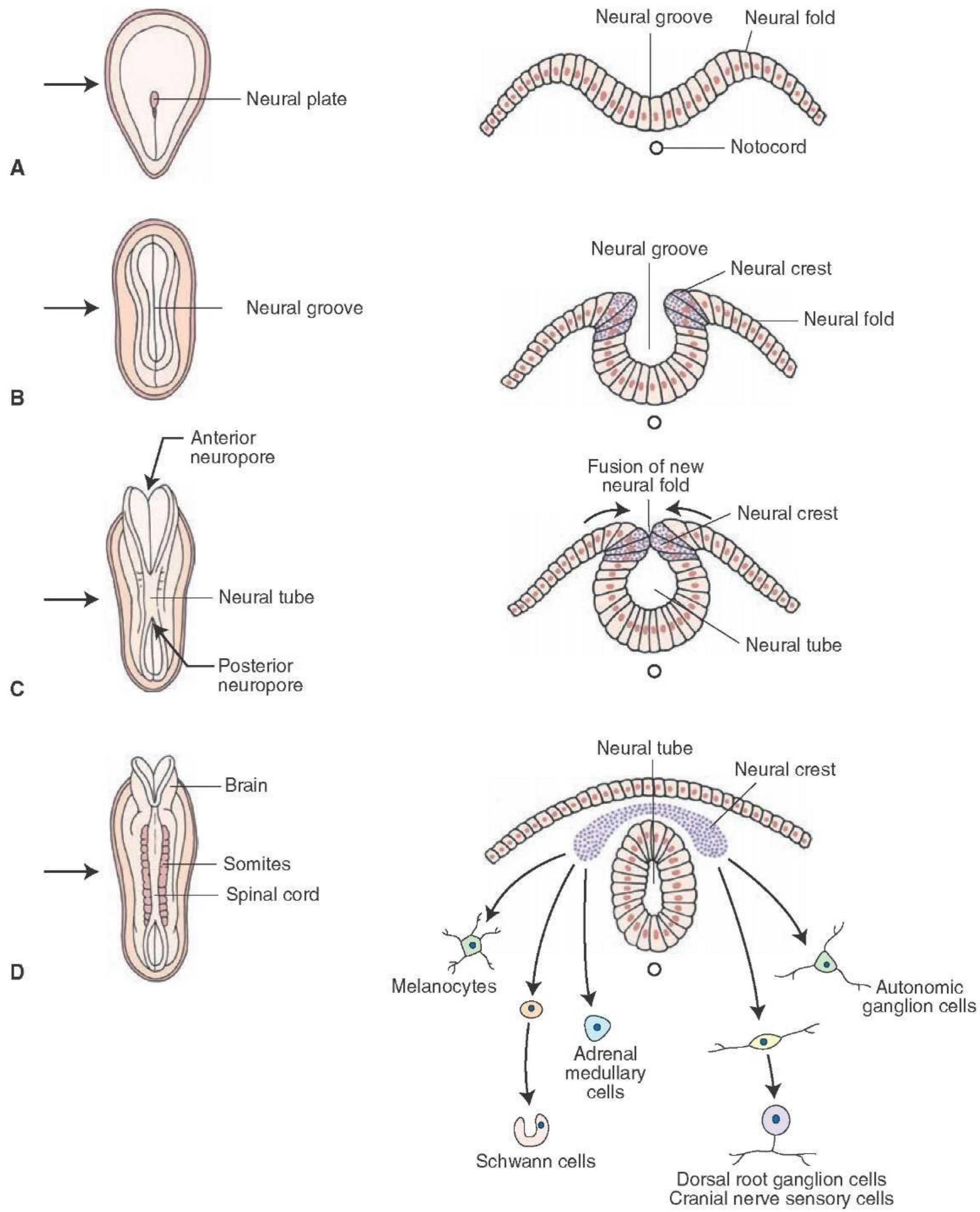
Neuron
K+
Na+
[K+]o = 12 mM
Astrocyte
Gap junctions
[K+]i = 108 mM
[K+]o = 4 mM



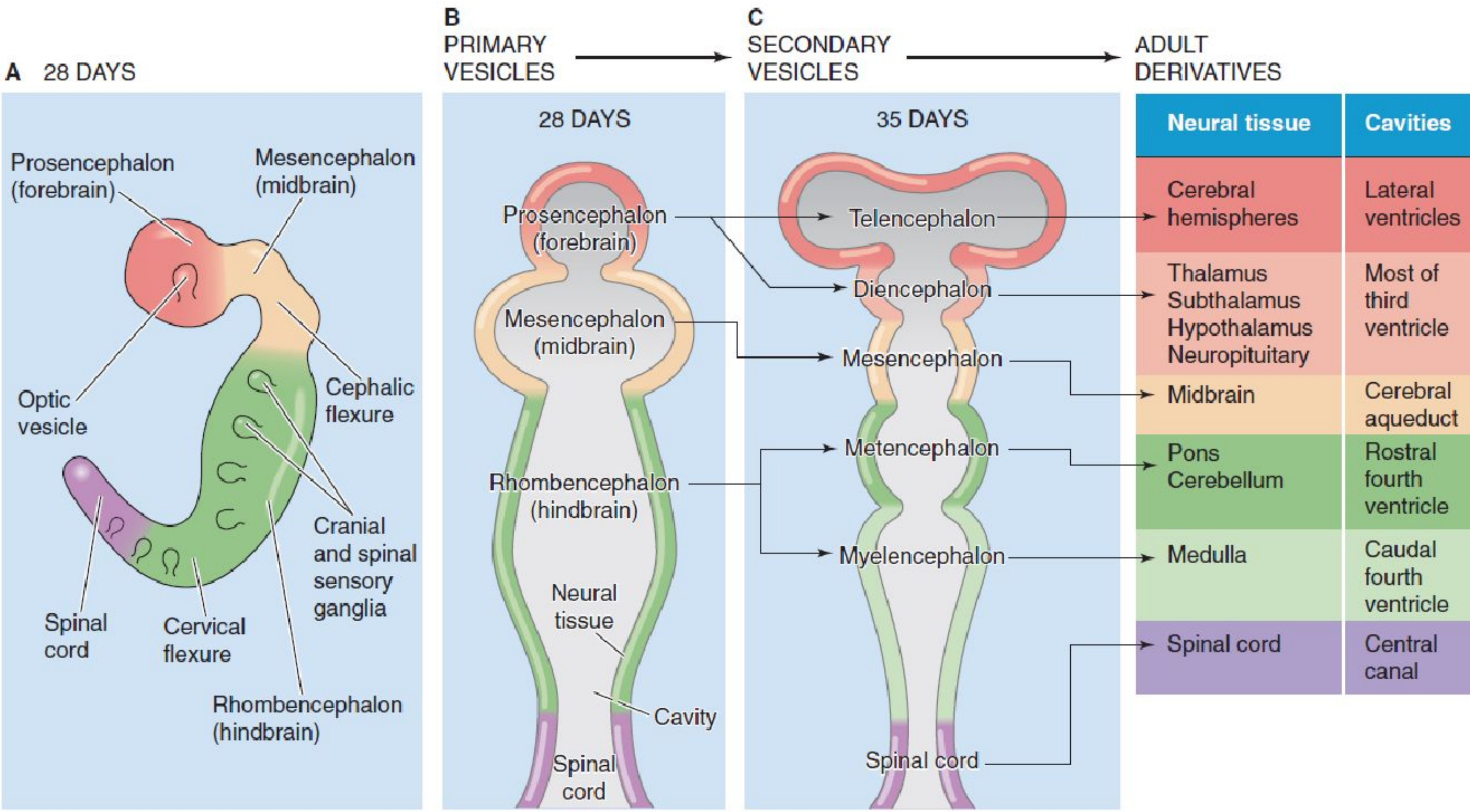
Presynaptic Terminal
EAAT3
K+
2 Na+
H+
Glutamate
Glutaminase
Glutamine
Glutamate (10mM)
Postsynaptic neuron
SNAT1 and SNAT2
Na+
H+
Na+
SNAT3 and SNAT5
[Glutamate]o ≅ 1µM
H+
2 K+
EEAT1 and EEAT2
2 Na+
Glutamine
ADP
Glutamine synthetase
ATP
Glutamate
K+
3 Na+
ATP
ADP
Astrocyte

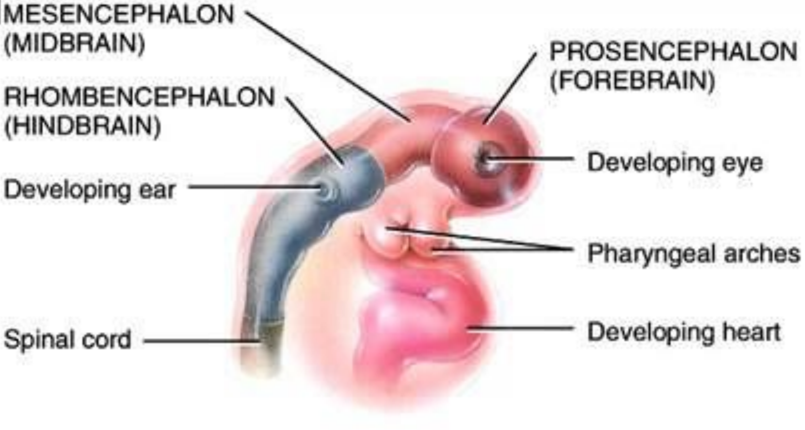

A OLIGODENDROCYTE
Oligodendrocyte
Axon
Myelin wrapping
B SCHWANN CELL
Schwann cell
Layers of
myelin sheath


Resting
Activated
Phagocytic



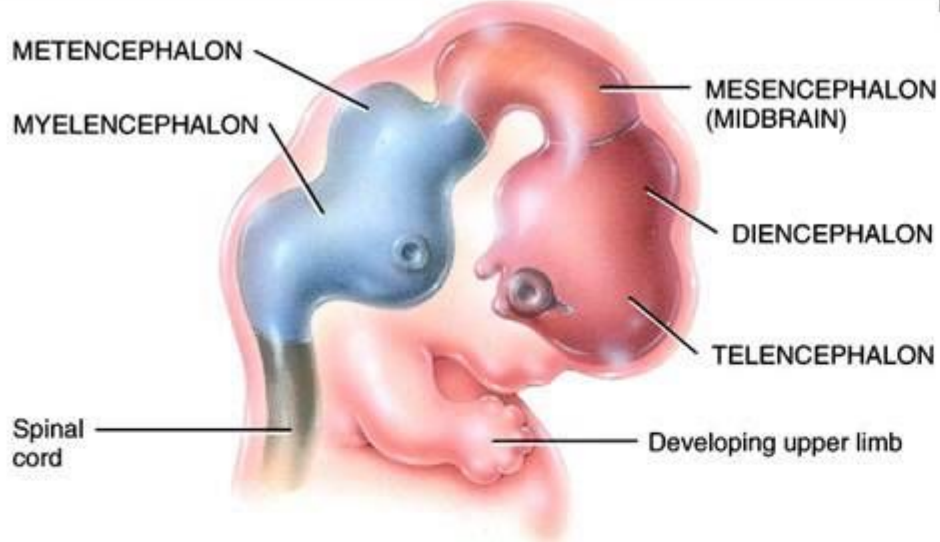
A
Neural plate
Neural groove
Neural fold
Notocord
B
Neural groove
Neural groove
Neural crest
Neural fold
C
Anterior neuropore
Neural tube
Posterior neuropore
Fusion of new neural fold
Neural crest
Neural tube
D
Brain
Somites
Spinal cord
Neural tube
Neural crest
Melanocytes
Schwann cells
Adrenal medullary cells
Dorsal root ganglion cells
Cranial nerve sensory cells
Autonomic ganglion cells


A 28 DAYS
B
PRIMARY VESICLES
C
SECONDARY VESICLES
ADULT DERIVATIVES
Prosencephalon (forebrain)
Mesencephalon (midbrain)
Optic vesicle
Cephalic flexure
Cranial and spinal sensory ganglia
Spinal cord
Cervical flexure
Rhombencephalon (hindbrain)
28 DAYS
Prosencephalon (forebrain)
Mesencephalon (midbrain)
Rhombencephalon (hindbrain)
Neural tissue
Cavity
Spinal cord
35 DAYS
Telencephalon
Diencephalon
Mesencephalon
Metencephalon
Myelencephalon
Spinal cord
Neural tissue
Cavities
Cerebral hemispheres
Lateral ventricles
Thalamus
Subthalamus
Hypothalamus
Neuropituitary
Most of third ventricle
Midbrain
Cerebral aqueduct
Pons
Cerebellum
Rostral fourth ventricle
Medulla
Caudal fourth ventricle
Spinal cord
Central canal

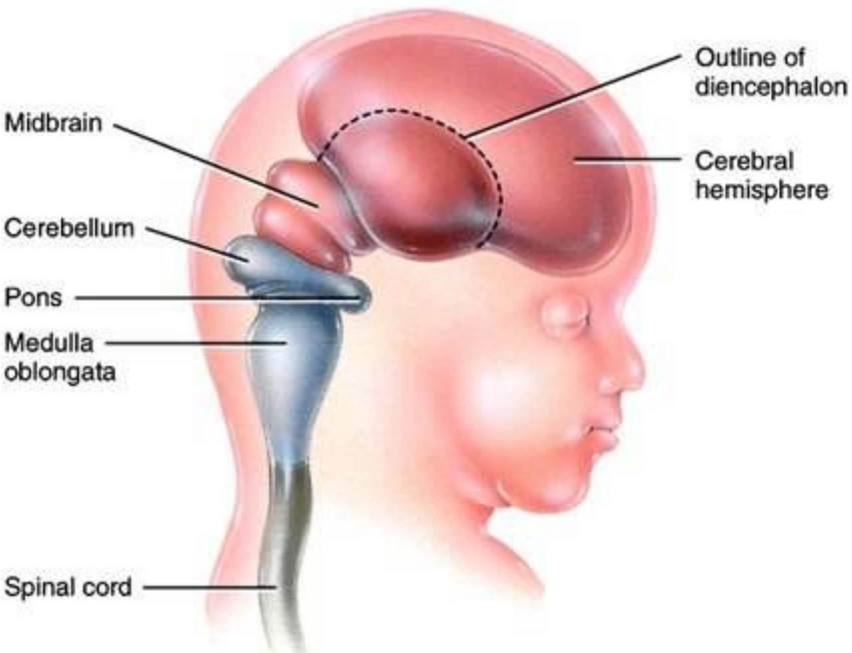


Lateral view of right side

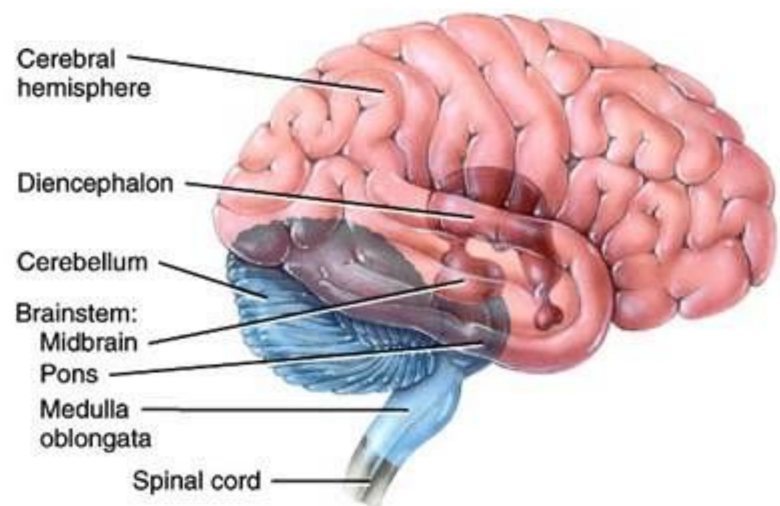
(a) Three-four week embryo showing primary brain vesicles



(b) Seven-week embryo showing secondary brain vesicles

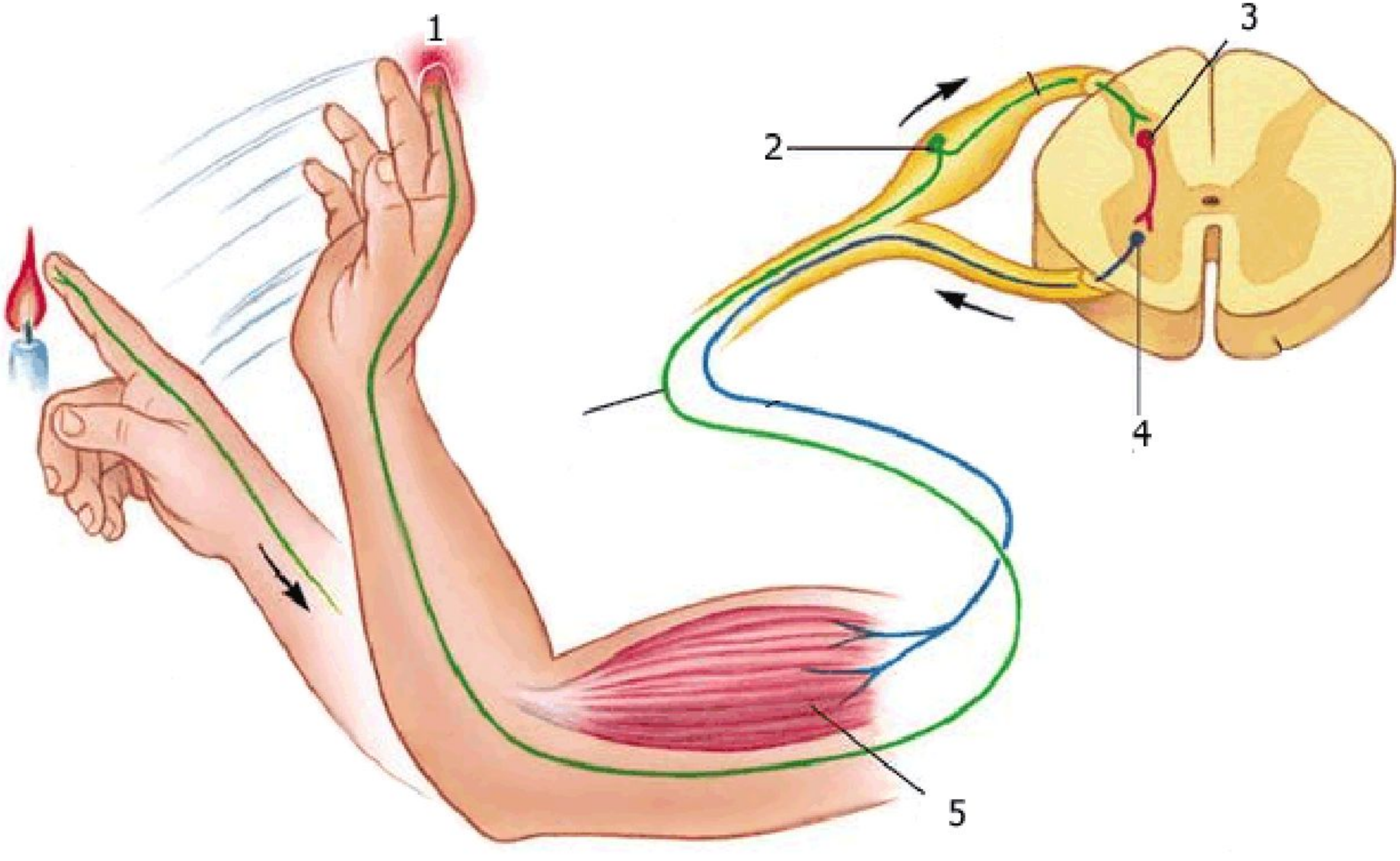


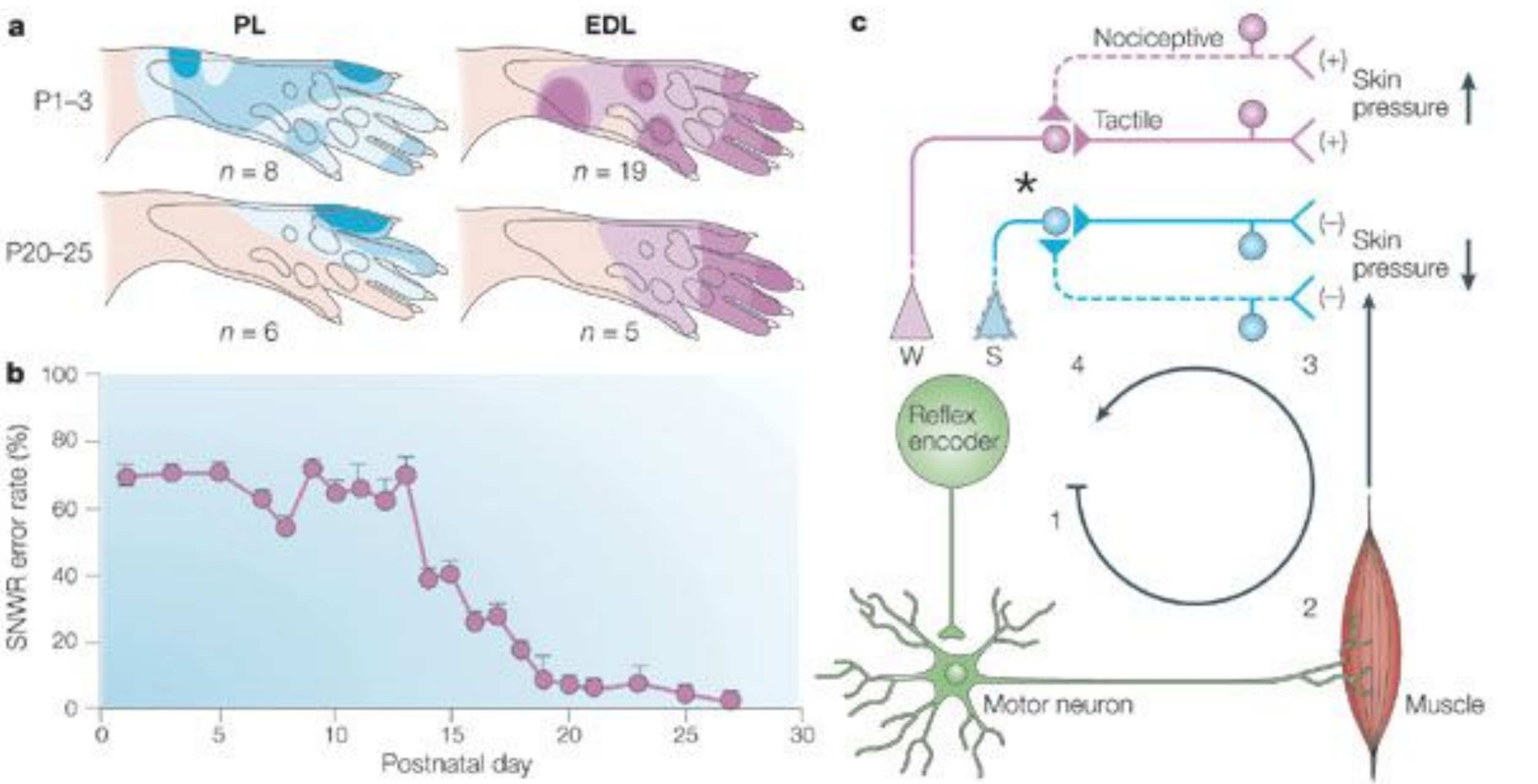
(c) Eleven-week fetus showing expanding cerebral hemispheres overgrowing the diencephalon



(d) Brain at birth (the diencephalon and superior portion of the brain stem have been projected to the surface)

1-рецептор
2-афферентный нейрон
3-вставочный нейрон
4-эффернетный нейрон
5-исполнительный орган





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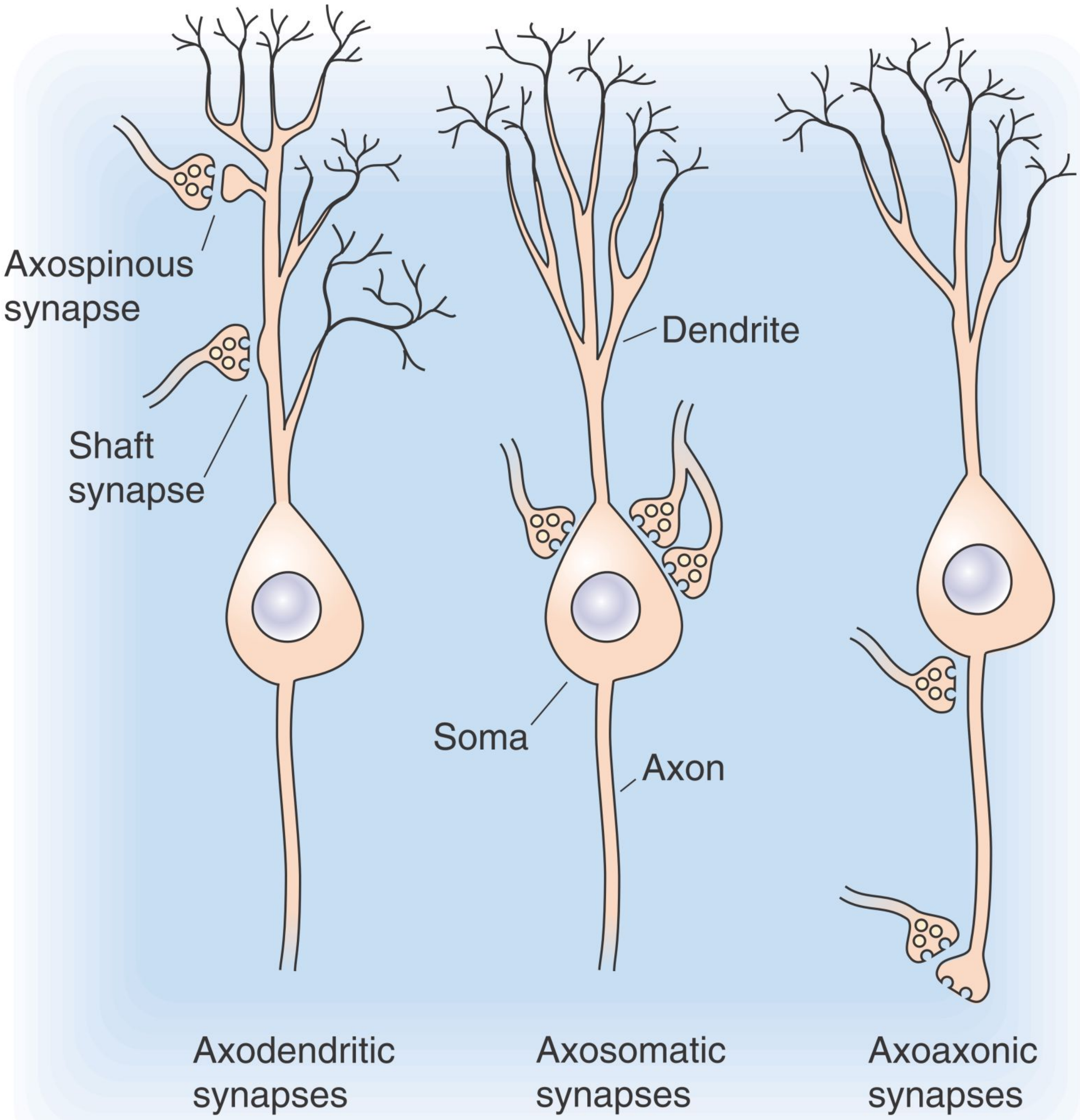
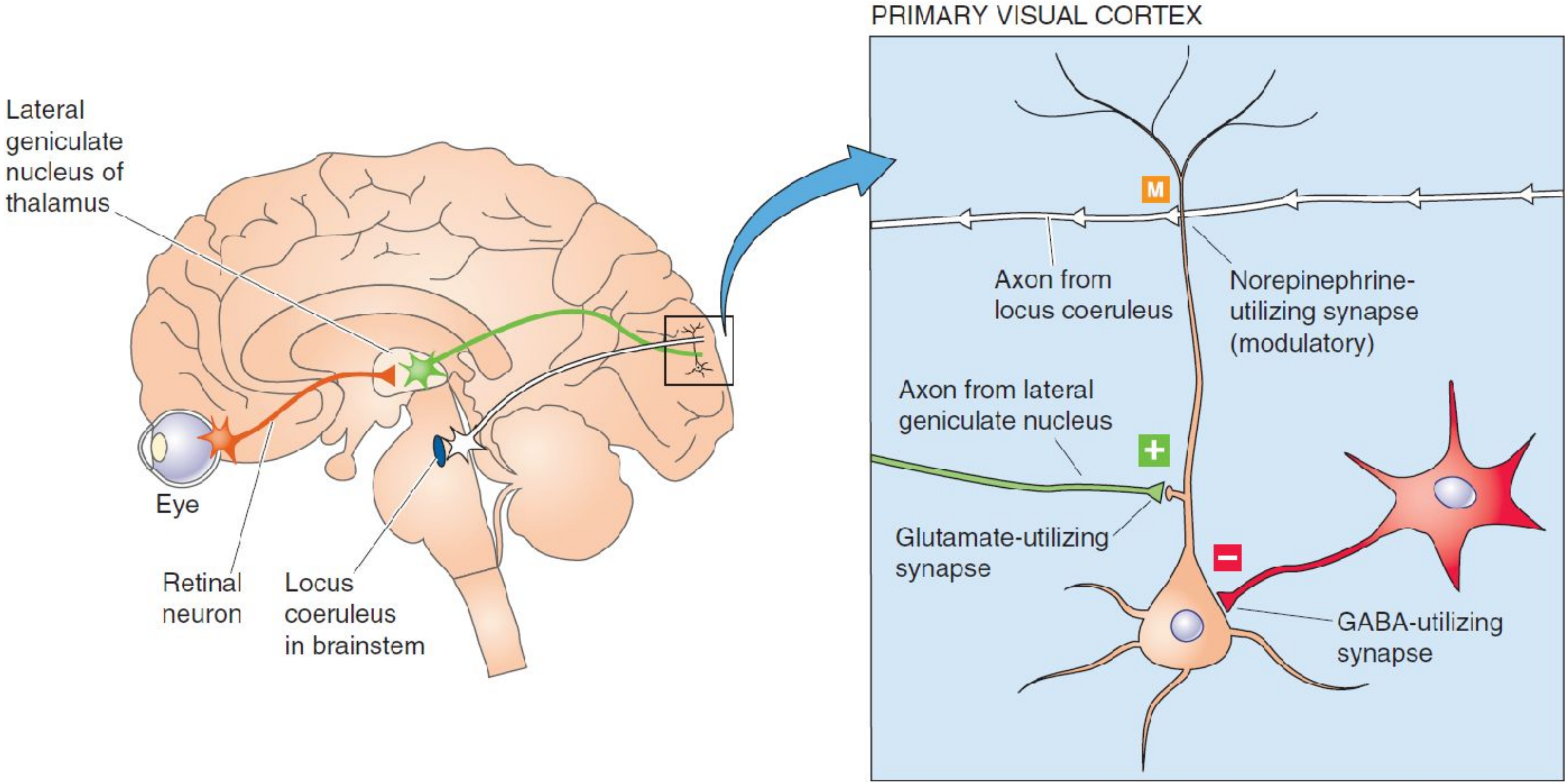
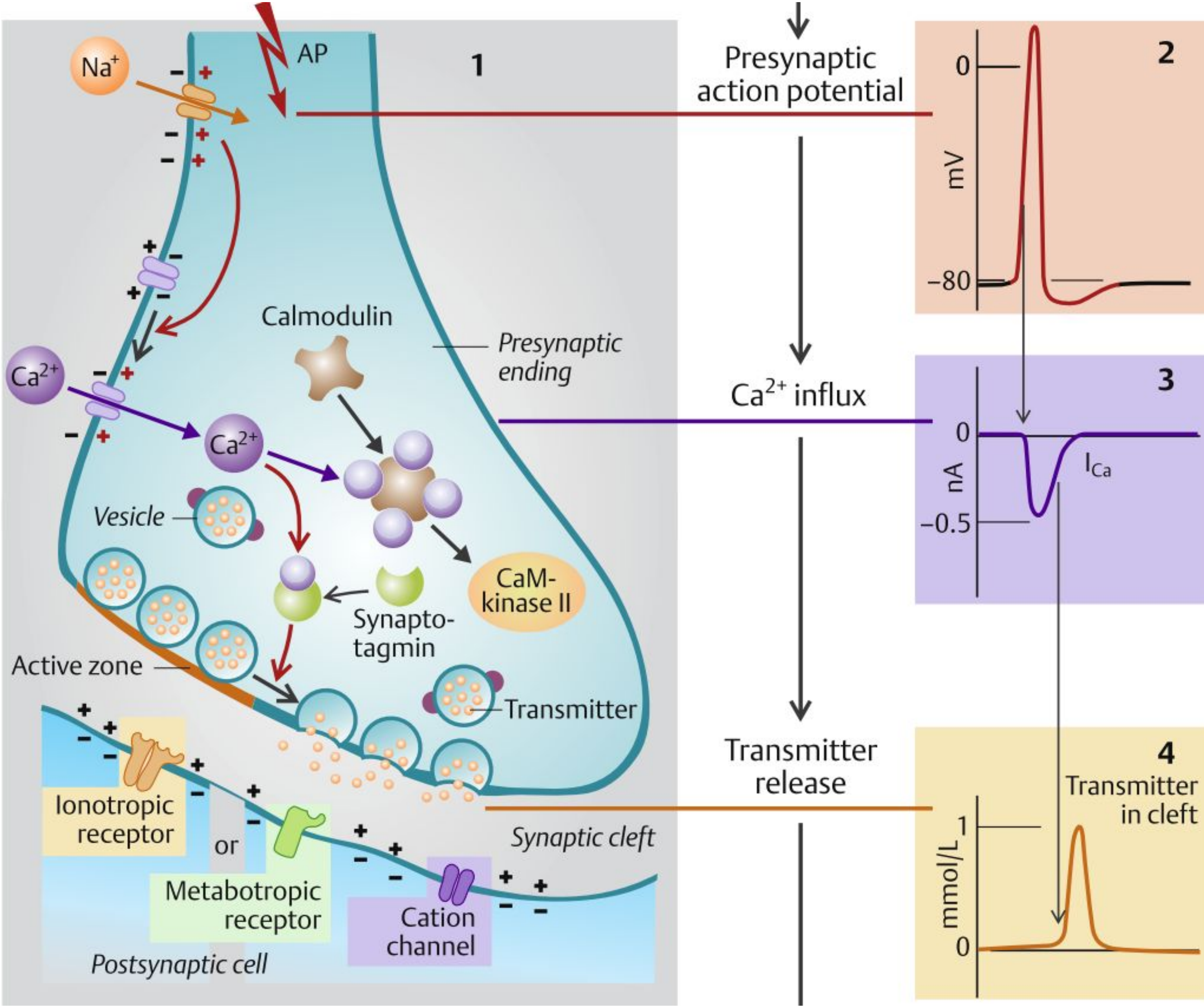
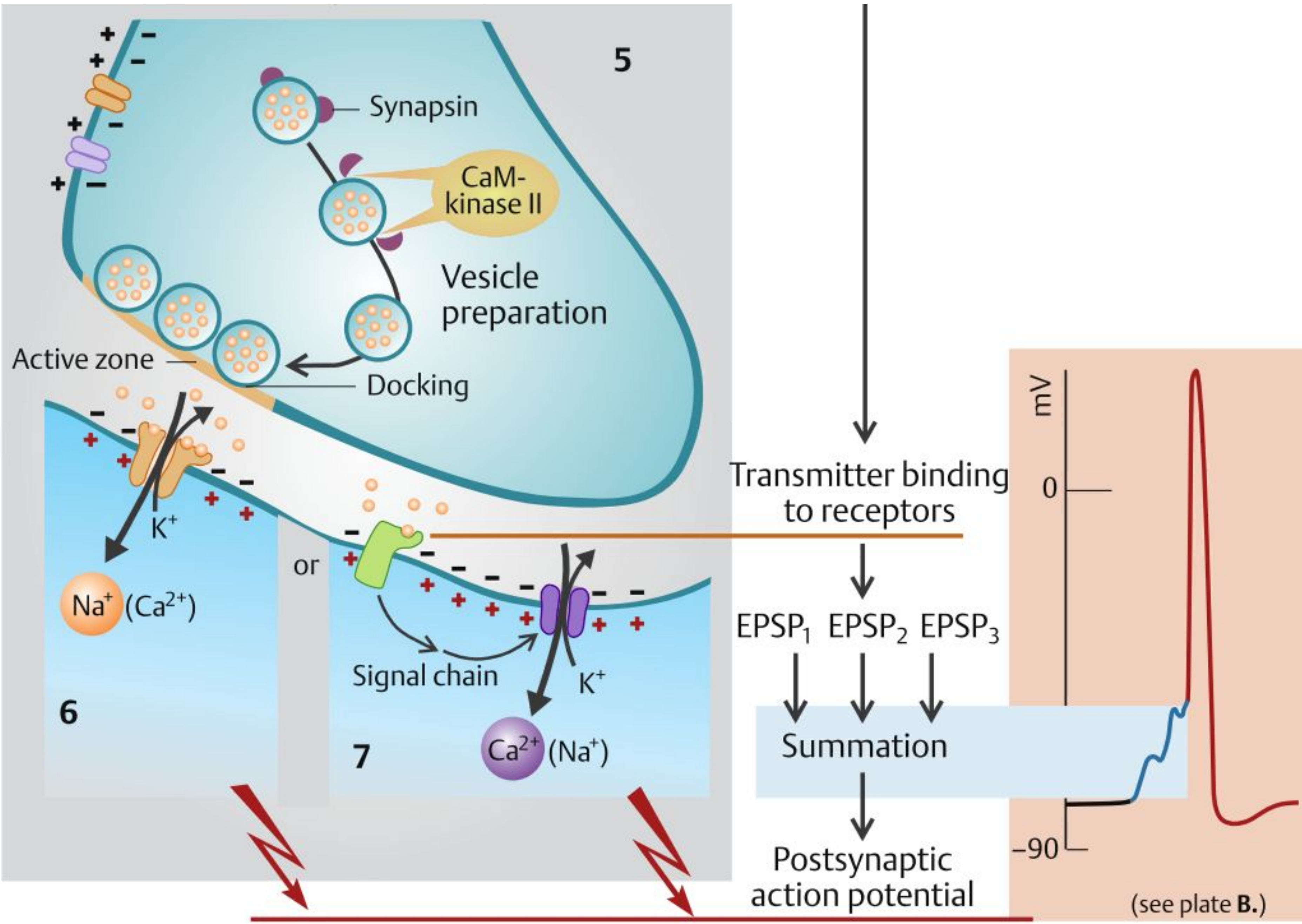

Axospinous synapse
Shaft synapse
Dendrite
Soma
Axon
Axodendritic synapses
Axosomatic synapses
Axoaxonic synapses

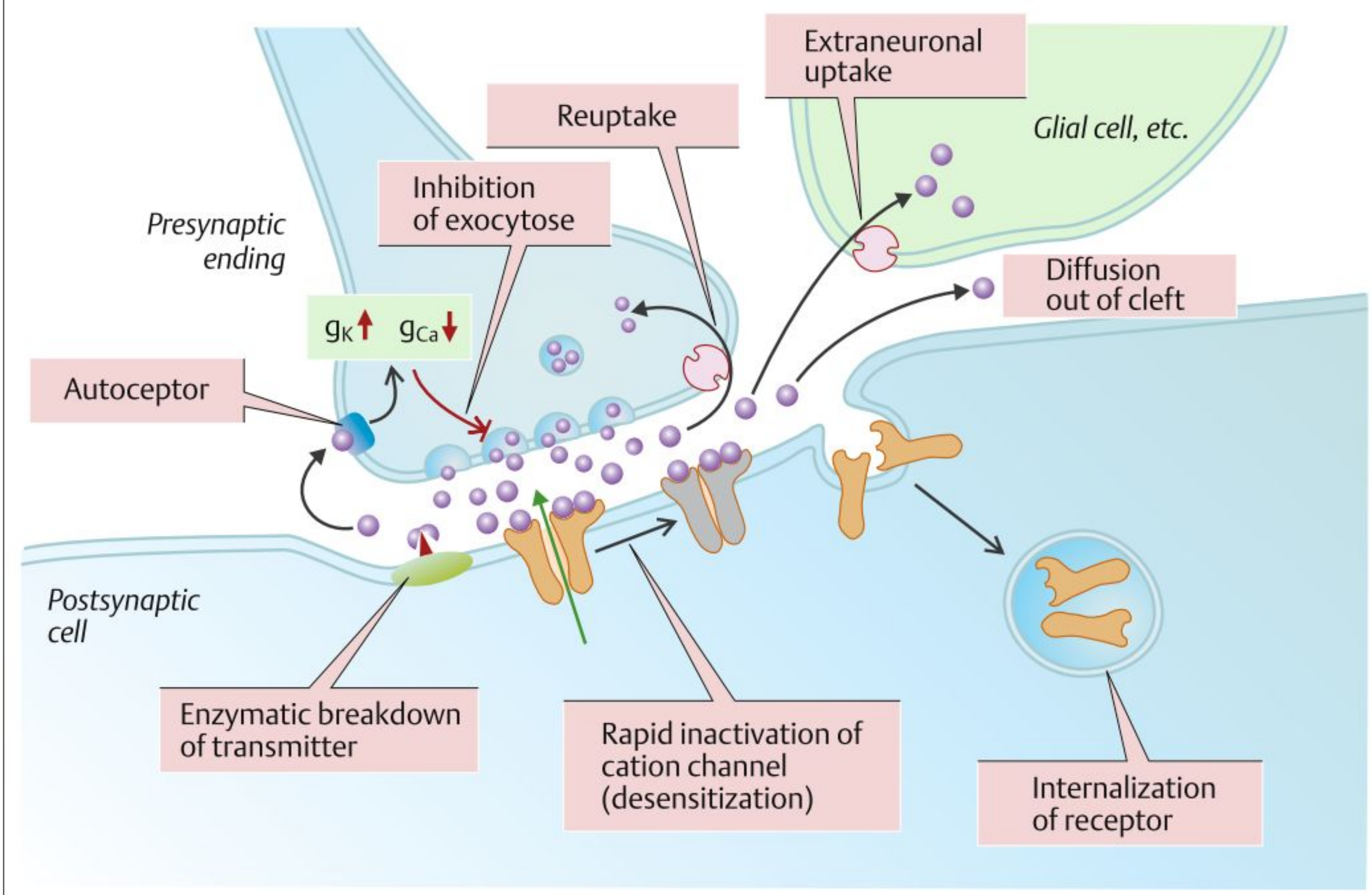

PRIMARY VISUAL CORTEX
Lateral geniculate nucleus of thalamus
Eye
Retinal neuron
Locus coeruleus in brainstem
M
Axon from locus coeruleus
Norepinephrine-utilizing synapse (modulatory)
Axon from lateral geniculate nucleus
+
Glutamate-utilizing synapse
−
GABA-utilizing synapse



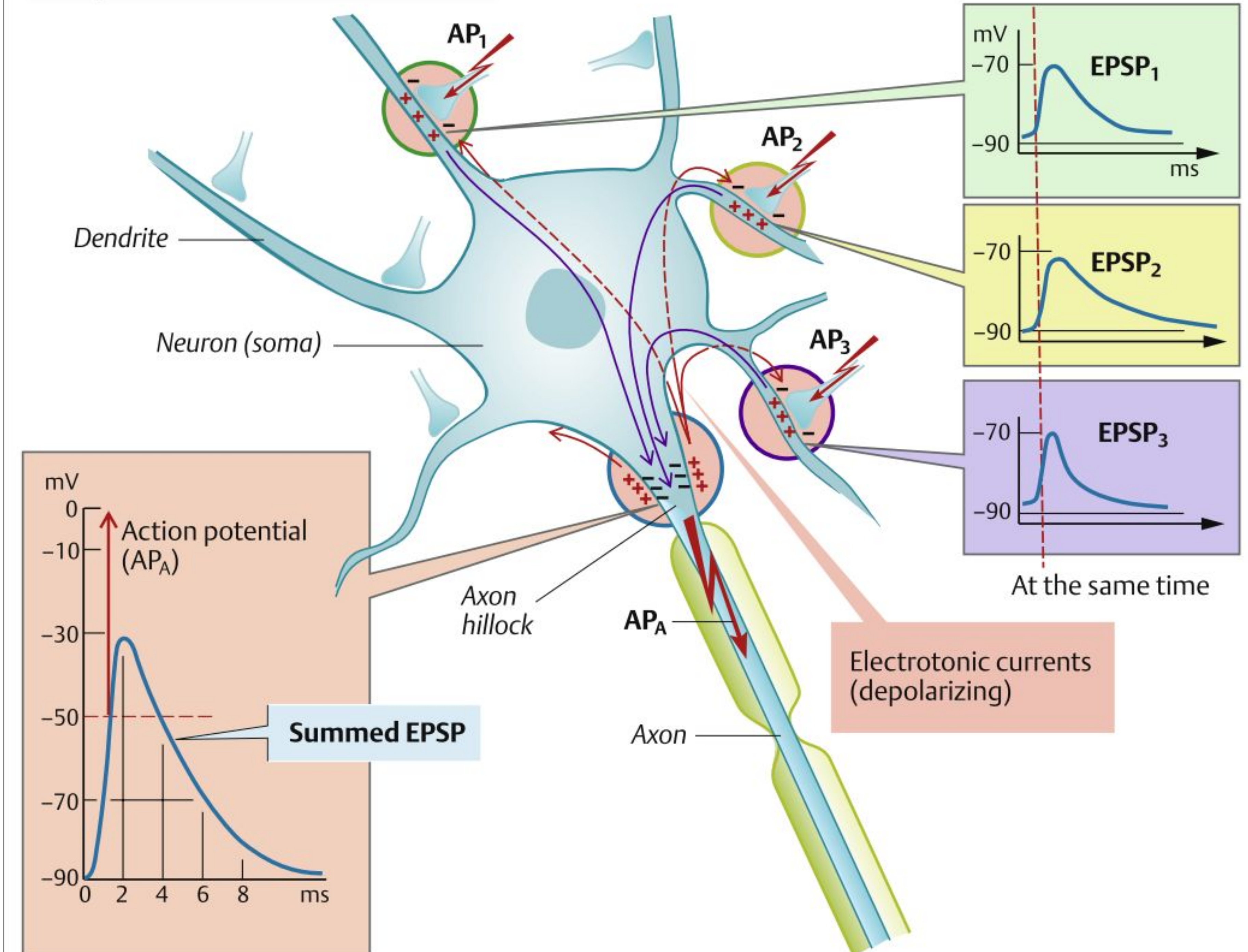
AP
1
Na+
Calmodulin
Presynaptic ending
Ca2+
Ca2+
Vesicle
CaM-kinase II
Synapto-tagmin
Active zone
Transmitter
Ionotropic receptor
or
Metabotropic receptor
Cation channel
Synaptic cleft
Postsynaptic cell
Presynaptic action potential
Ca2+ influx
Transmitter release
2
0
mV
−80
3
0
nA
ICa
−0.5
4
Transmitter in cleft
1
mmol/L
0


5
Synapsin
CaM-kinase II
Vesicle preparation
Active zone
Docking
K^+
Na^+ (Ca^{2+})
6
or
Signal chain
K^+
Ca^{2+} (Na^+)
7
Transmitter binding to receptors
$EPSP_1$ $EPSP_2$ $EPSP_3$
Summation
Postsynaptic action potential
mV
0
–90
(see plate **B.**)

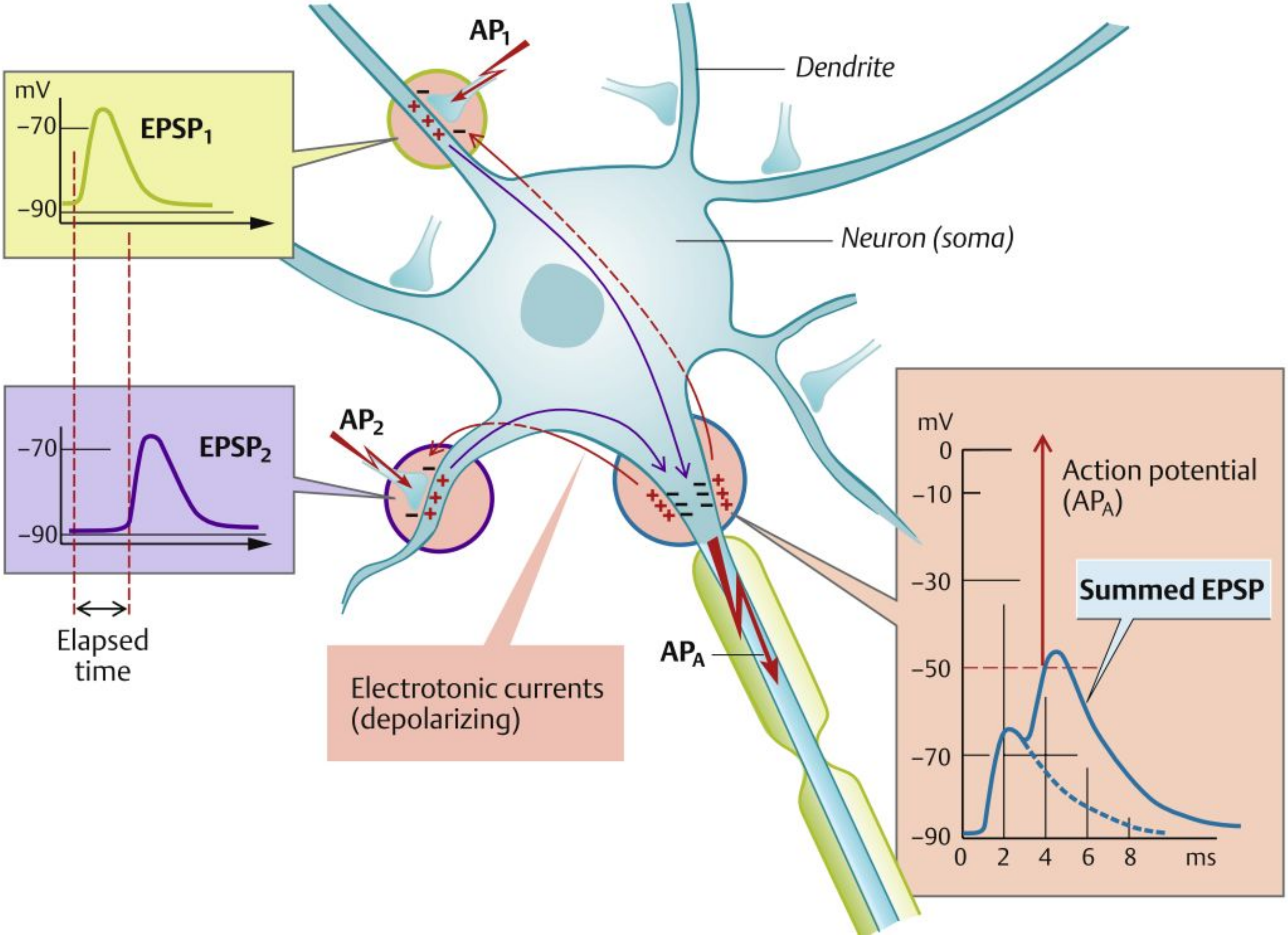
E. Termination of transmitter action

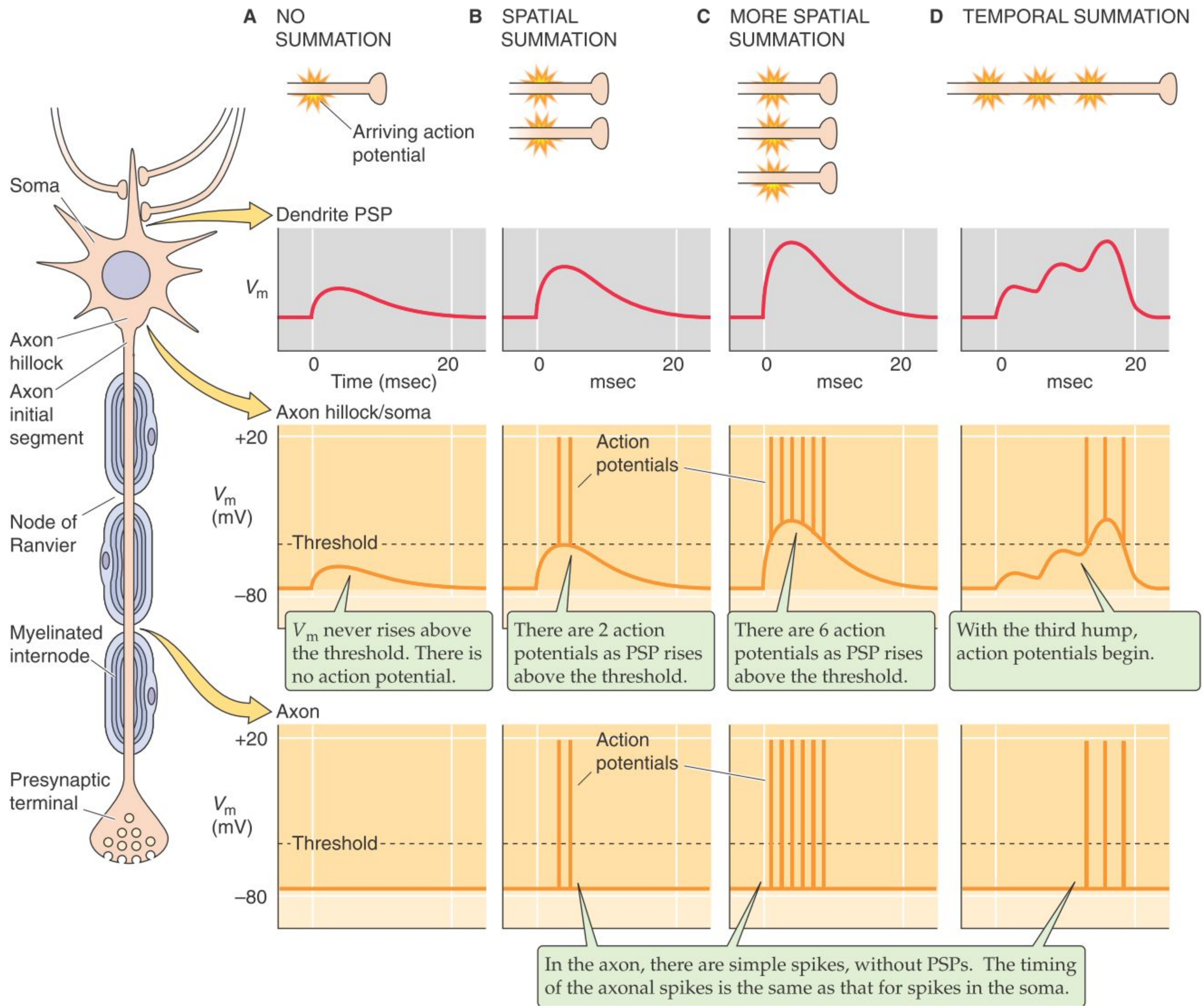


B. Spatial summation of stimuli

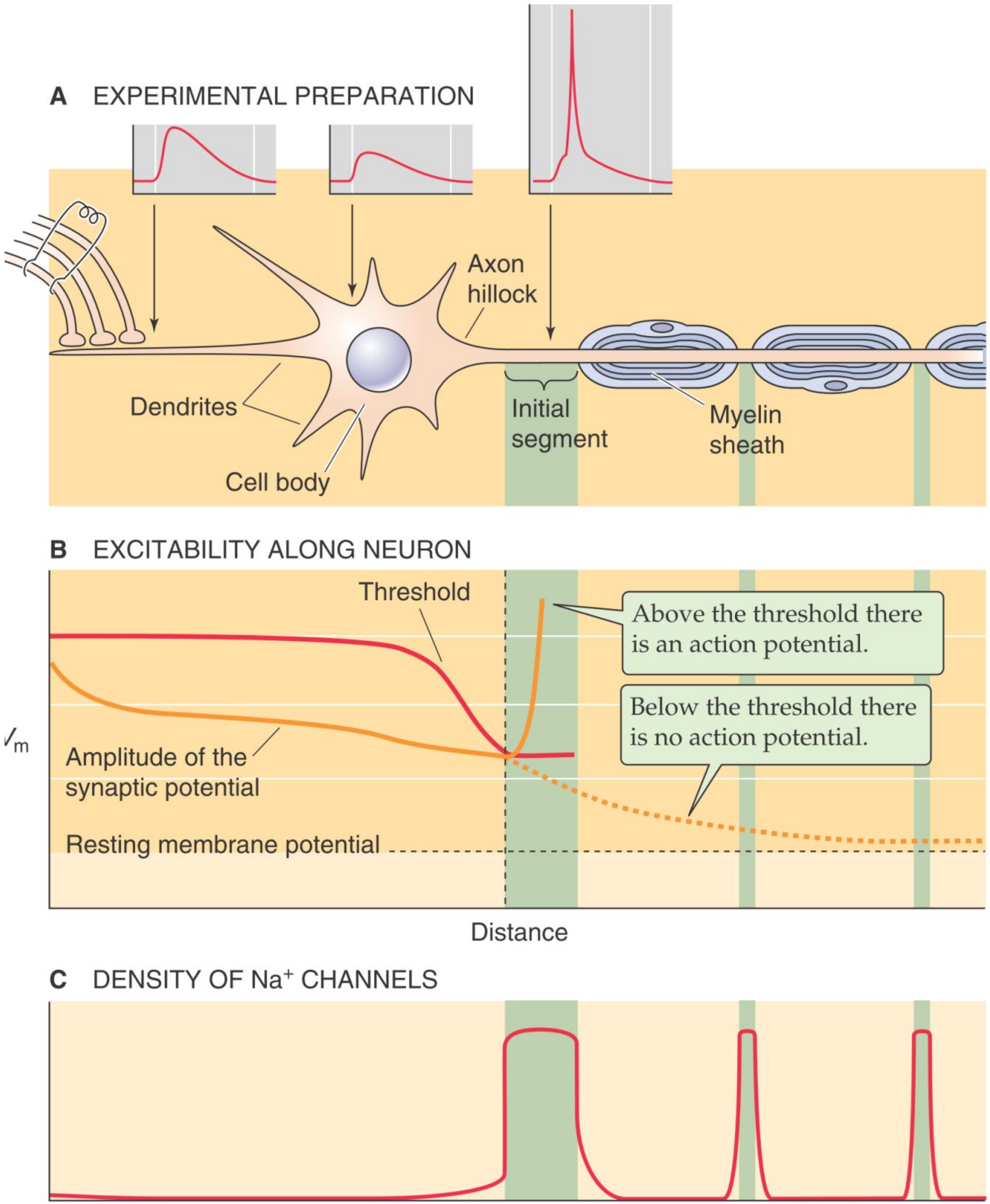


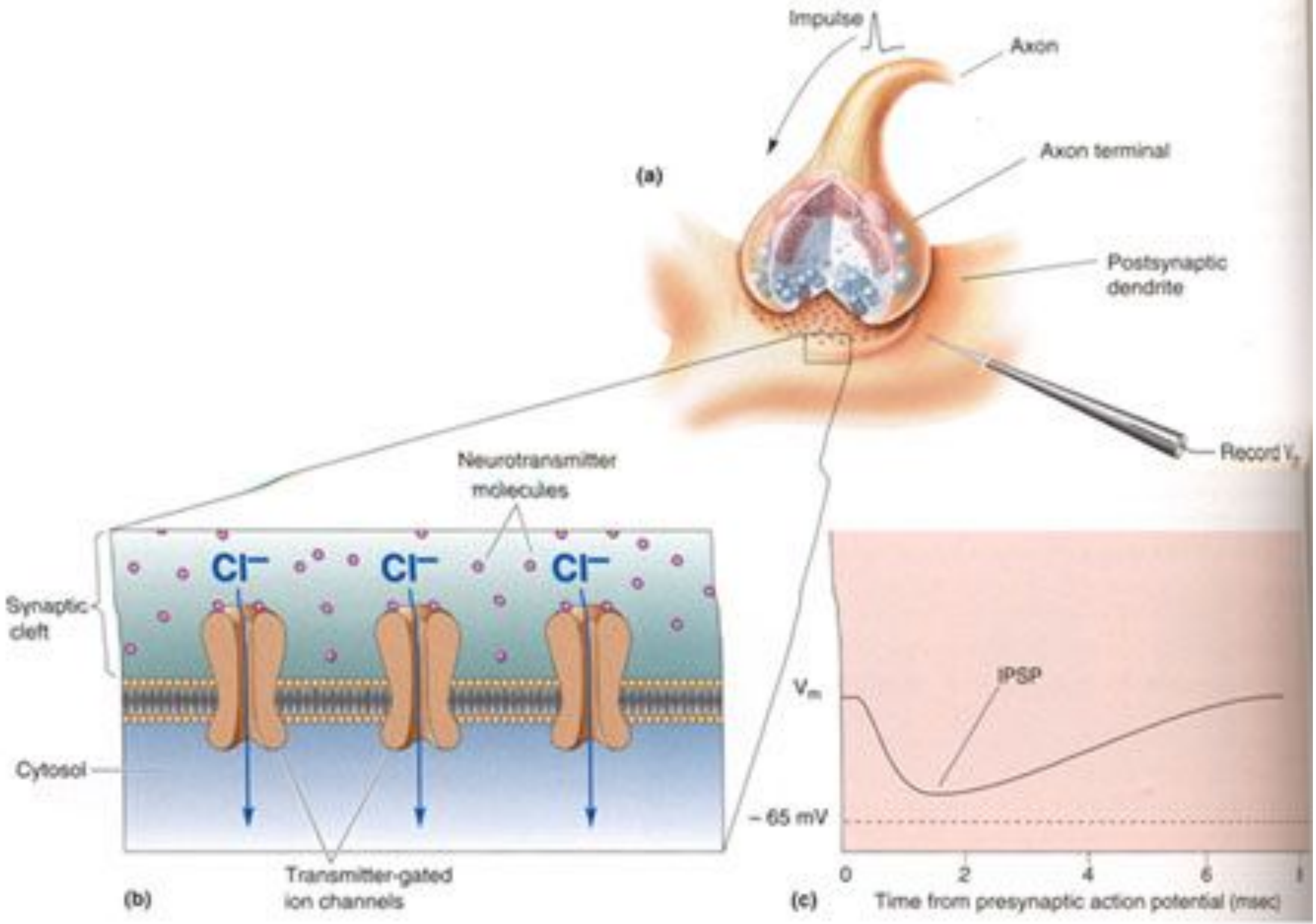
C. Temporal summation of stimuli





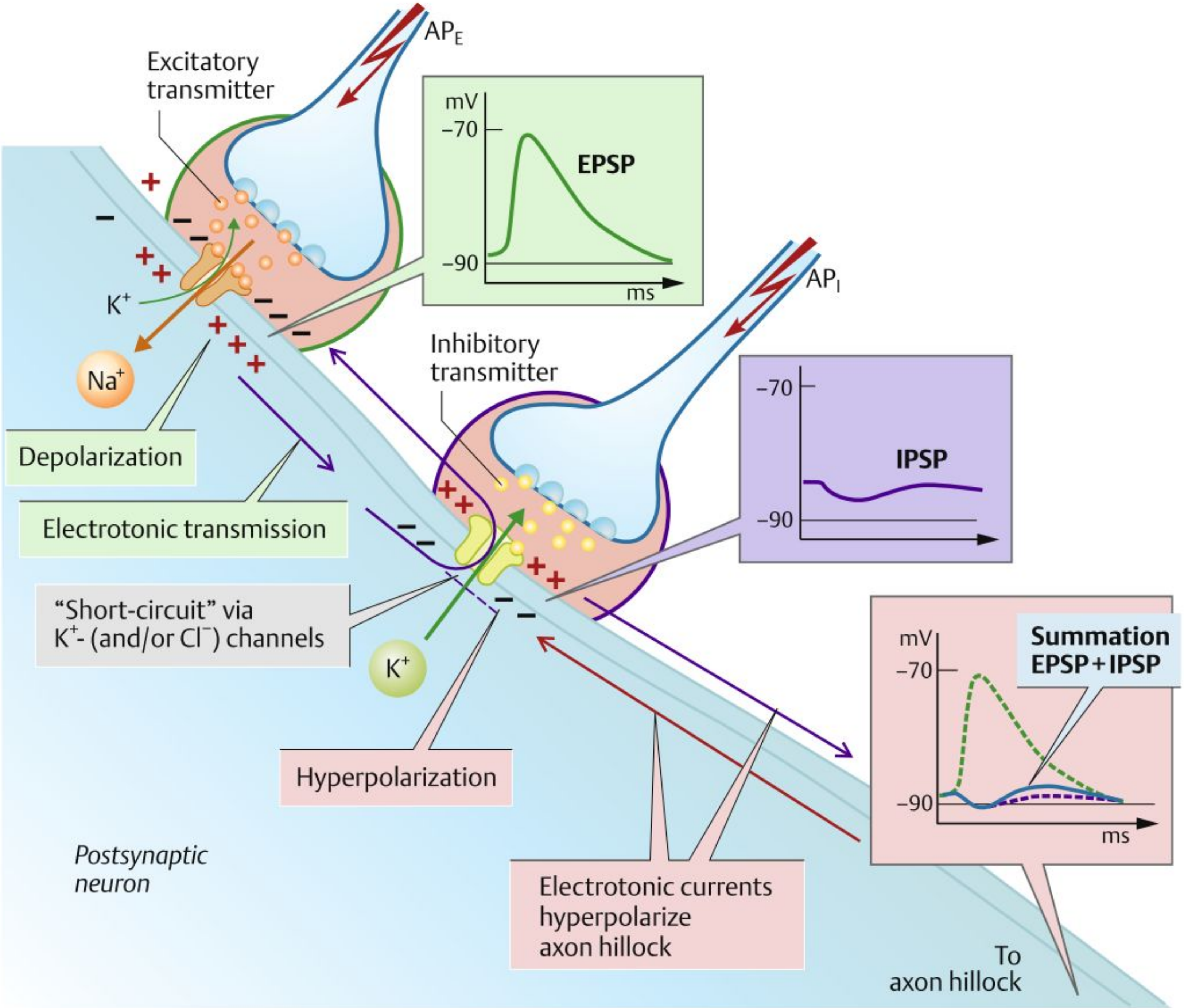
A NO SUMMATION
B SPATIAL SUMMATION
C MORE SPATIAL SUMMATION
D TEMPORAL SUMMATION
Arriving action potential
Soma
Axon hillock
Axon initial segment
Node of Ranvier
Myelinated internode
Presynaptic terminal
Dendrite PSP
Vm
0
20
Time (msec)
msec
Axon hillock/soma
+20
Vm (mV)
Threshold
–80
Action potentials
Vm never rises above the threshold. There is no action potential.
There are 2 action potentials as PSP rises above the threshold.
There are 6 action potentials as PSP rises above the threshold.
With the third hump, action potentials begin.
Axon
In the axon, there are simple spikes, without PSPs. The timing of the axonal spikes is the same as that for spikes in the soma.

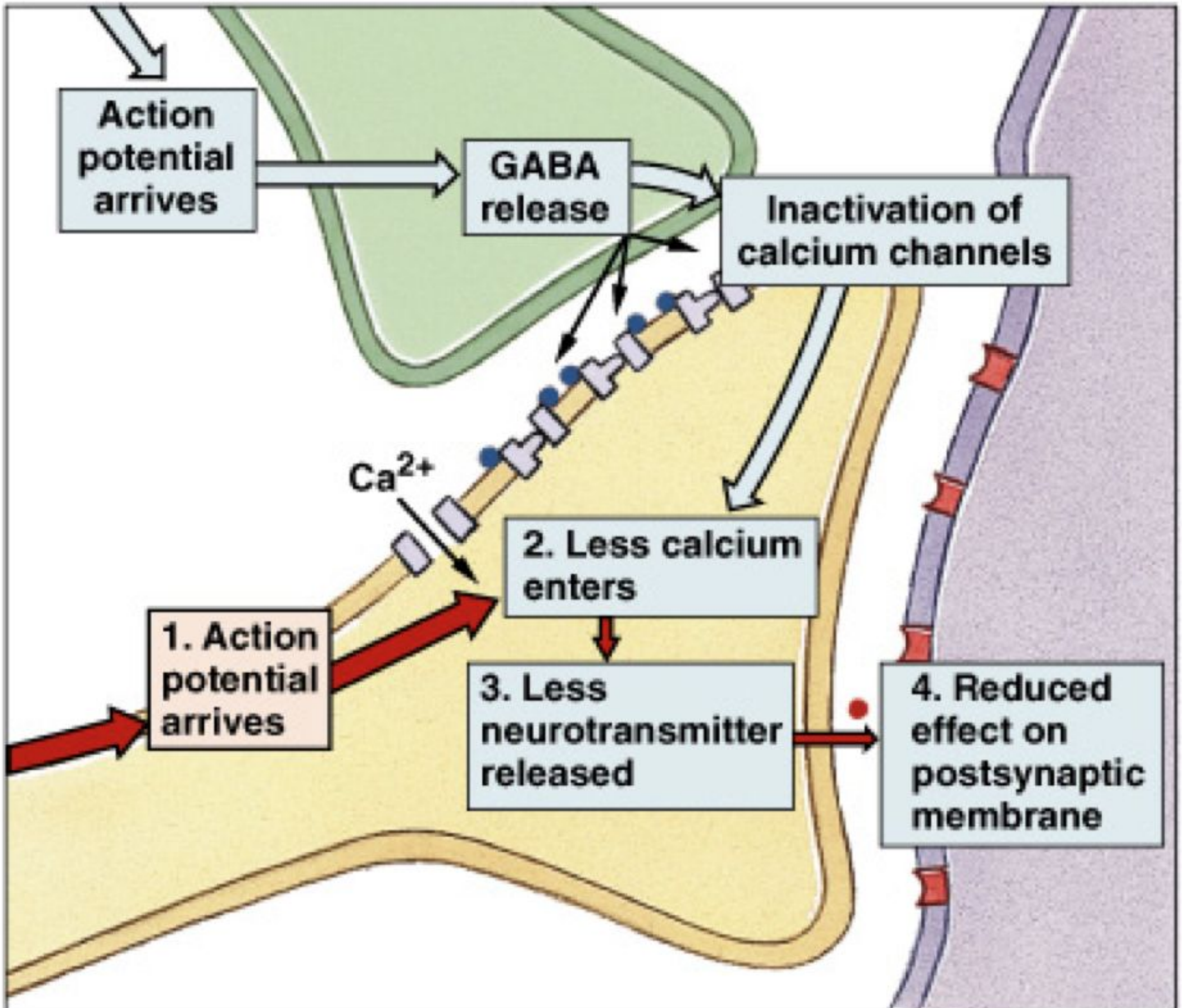

A EXPERIMENTAL PREPARATION
Axon hillock
Dendrites
Cell body
Initial segment
Myelin sheath
B EXCITABILITY ALONG NEURON
Threshold
Above the threshold there is an action potential.
Below the threshold there is no action potential.
Amplitude of the synaptic potential
Resting membrane potential
Distance
C DENSITY OF Na+ CHANNELS



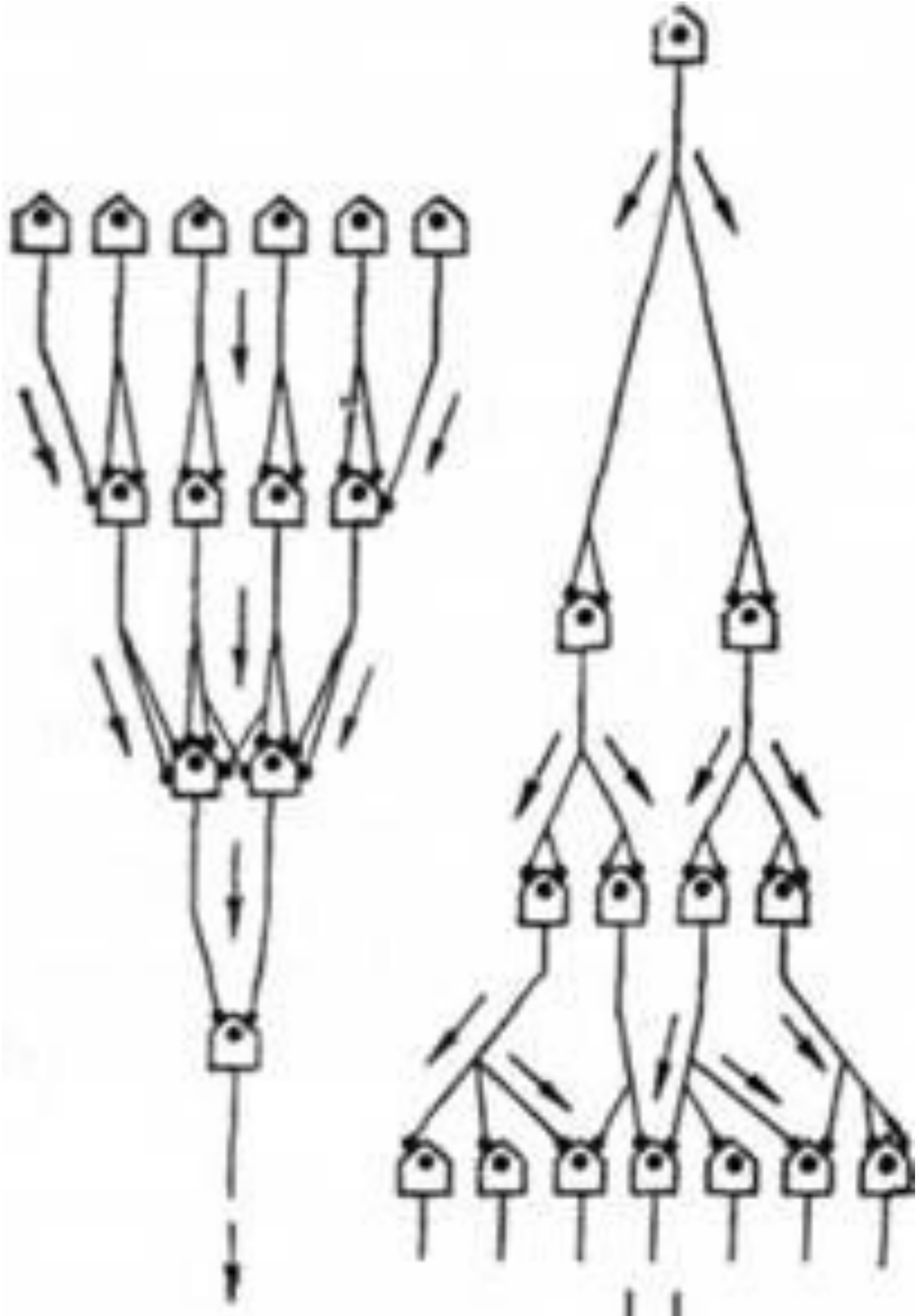
Impulse
Axon
(a)
Axon terminal
Postsynaptic
dendrite
Record V_m
Neurotransmitter
molecules
Synaptic
cleft
Cl^-
Cl^-
Cl^-
Cytosol
Transmitter-gated
ion channels
(b)
IPSP
V_m
– 65 mV
0
2
4
6
(c)
Time from presynaptic action potential (msec)

D. Effect of IPSP on postsynaptic stimulation

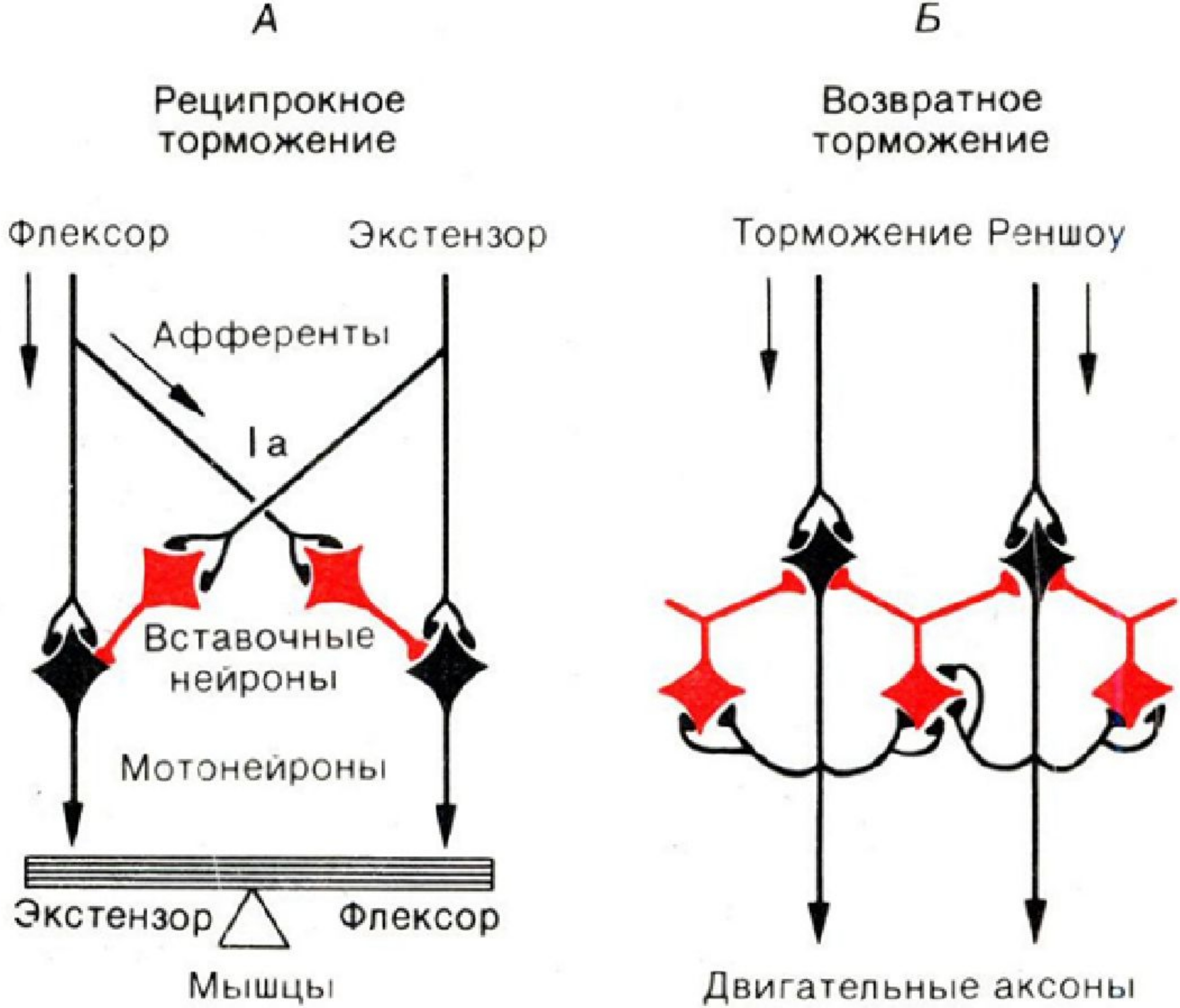


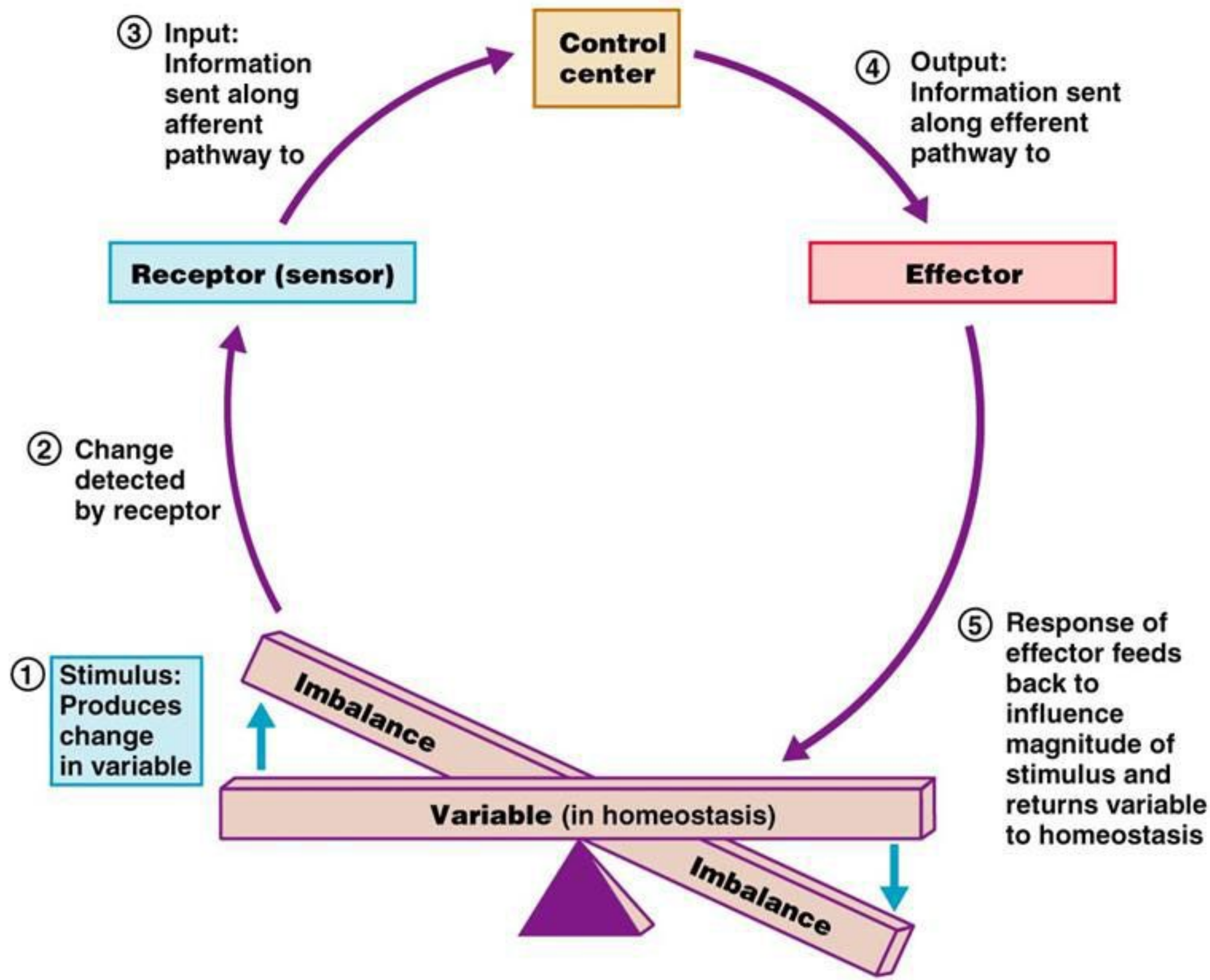


(a) Presynaptic inhibition

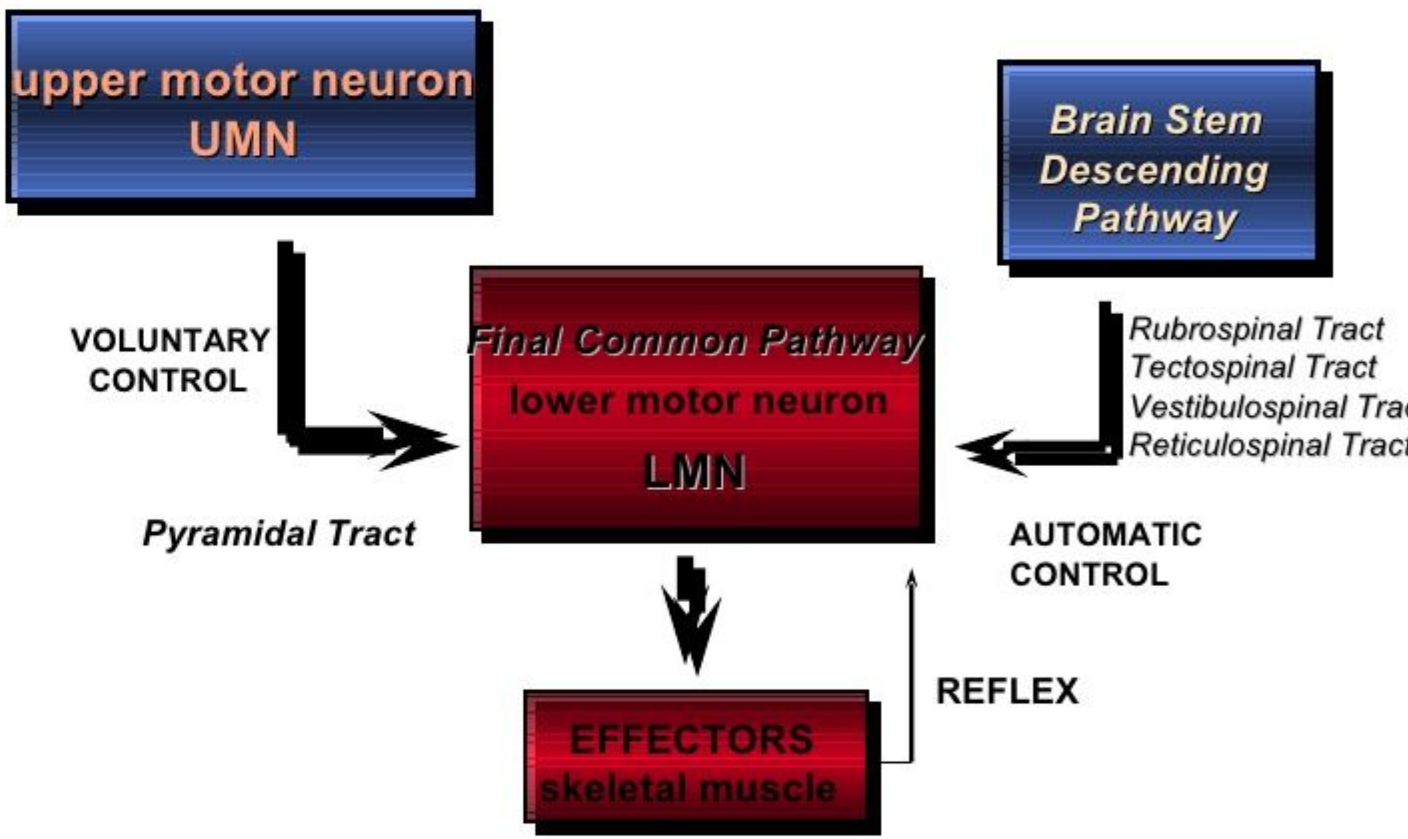


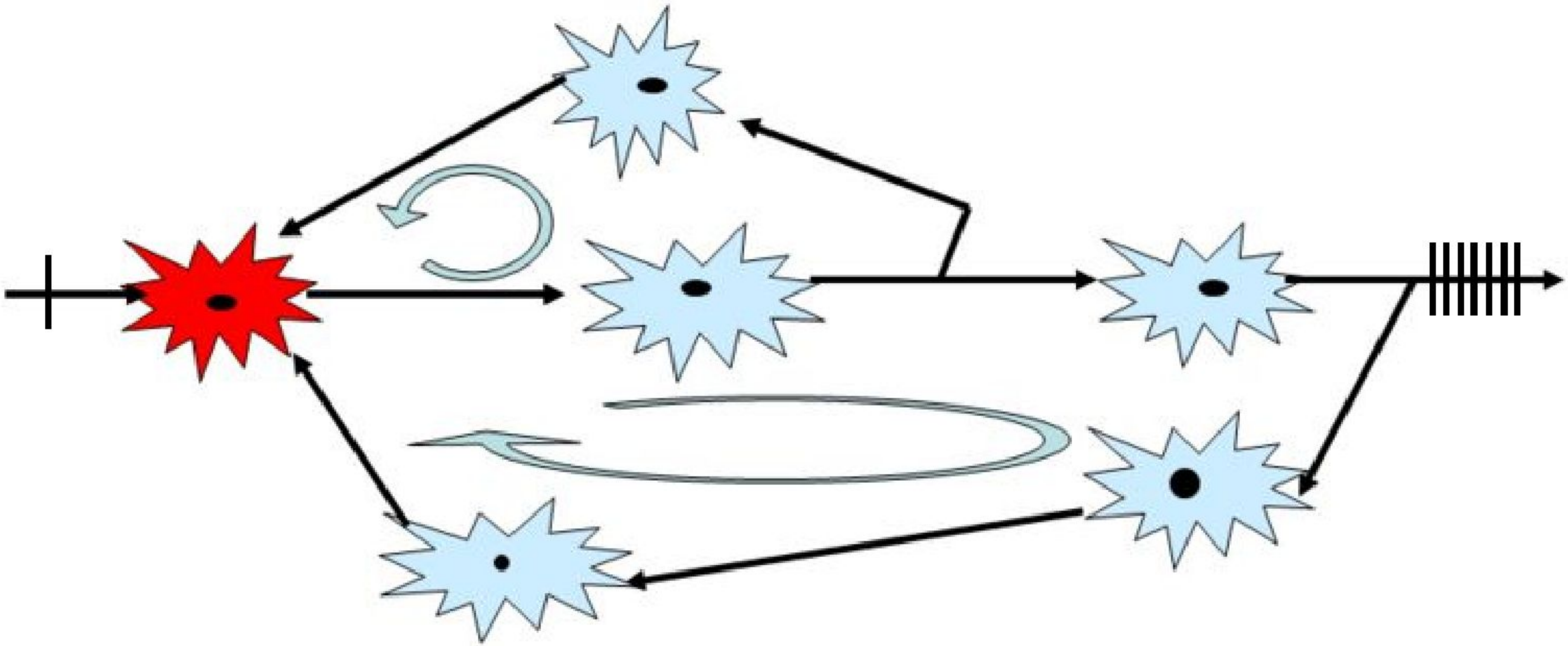
а *б*

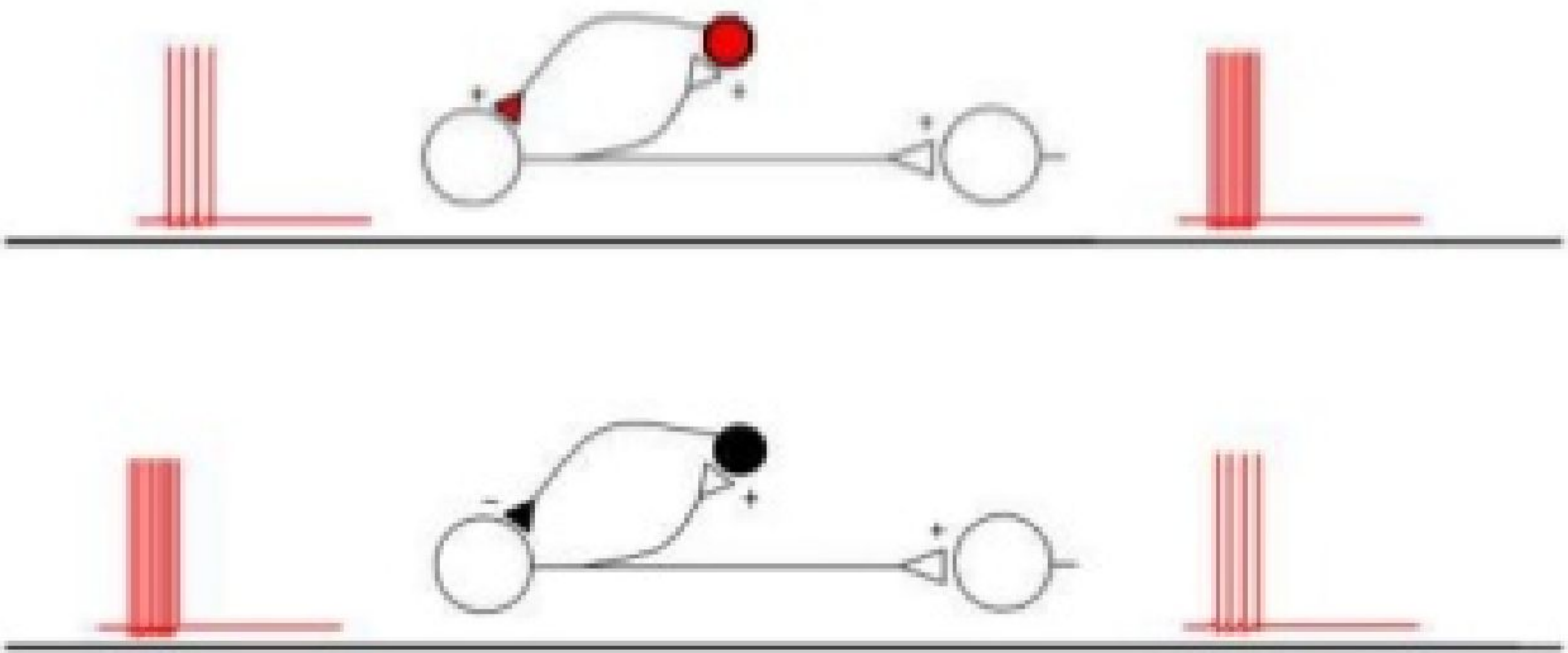

А
Реципрокное торможение
Флексор
Экстензор
Афференты
Ia
Вставочные нейроны
Мотонейроны
Экстензор
Флексор
Мышцы
Б
Возвратное торможение
Торможение Реншоу
Двигательные аксоны

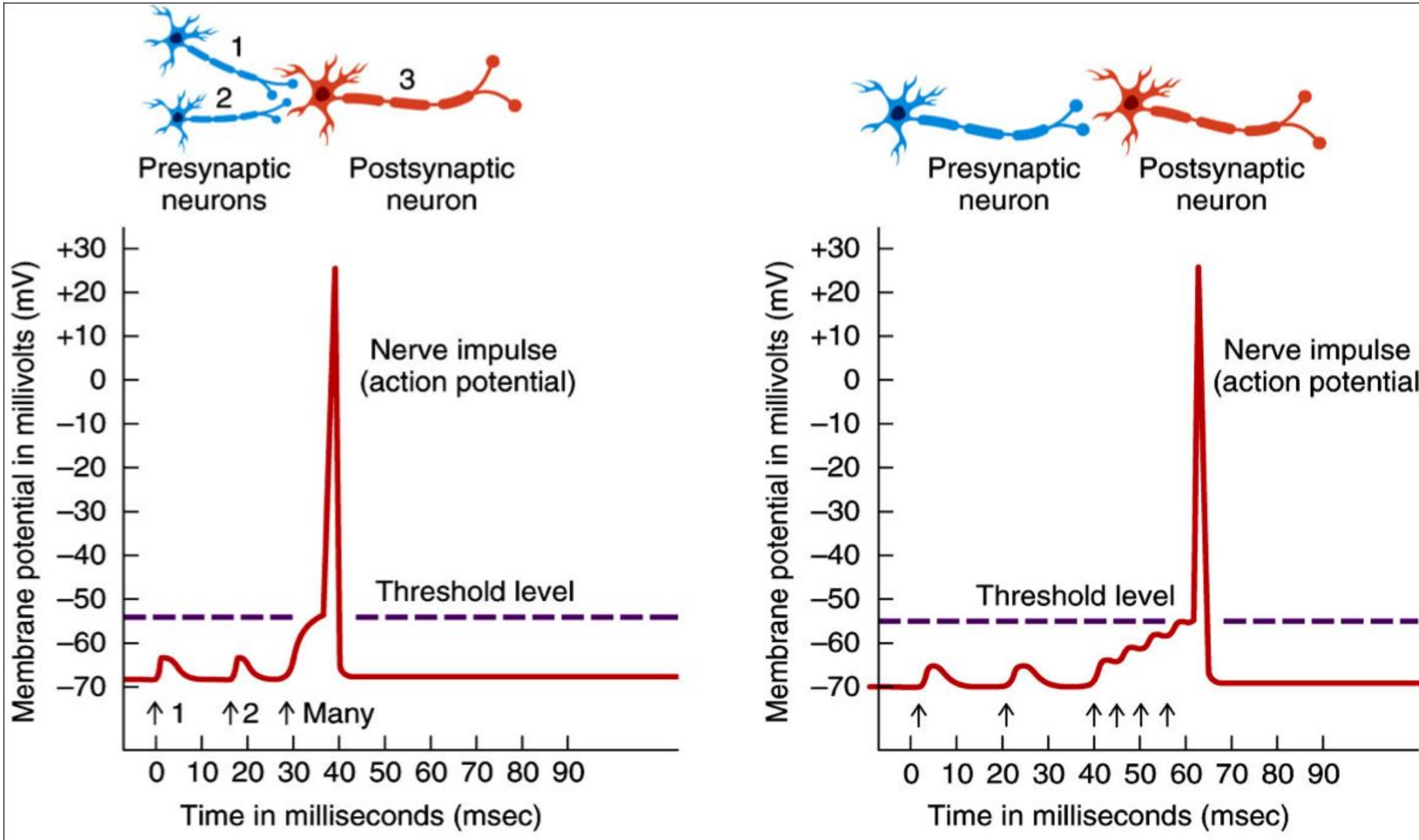

Control center
③ Input: Information sent along afferent pathway to
④ Output: Information sent along efferent pathway to
Receptor (sensor)
Effector
② Change detected by receptor
① Stimulus: Produces change in variable
Imbalance
Variable (in homeostasis)
Imbalance
⑤ Response of effector feeds back to influence magnitude of stimulus and returns variable to homeostasis

SOMATIC MOTOR SYSTEM





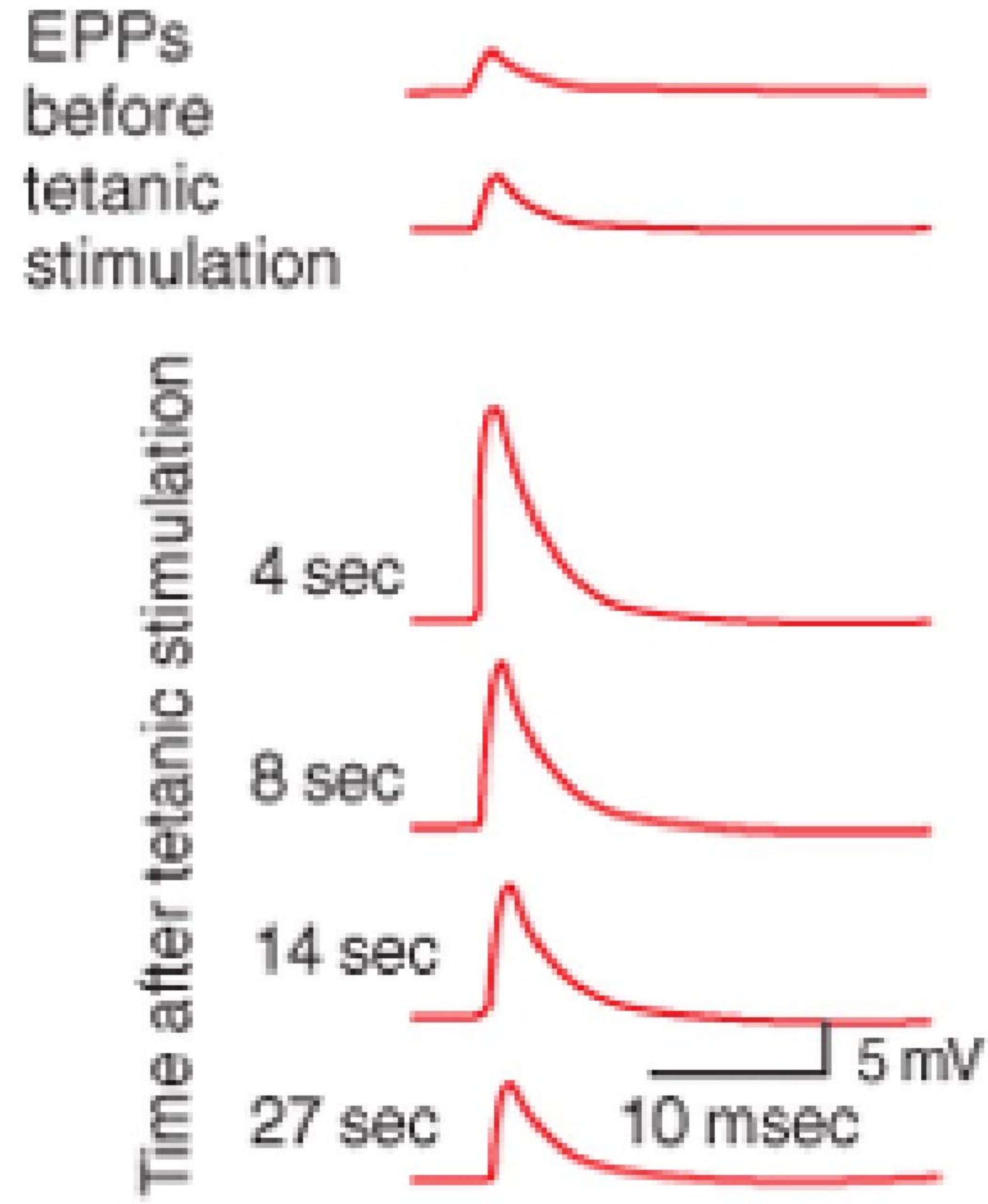


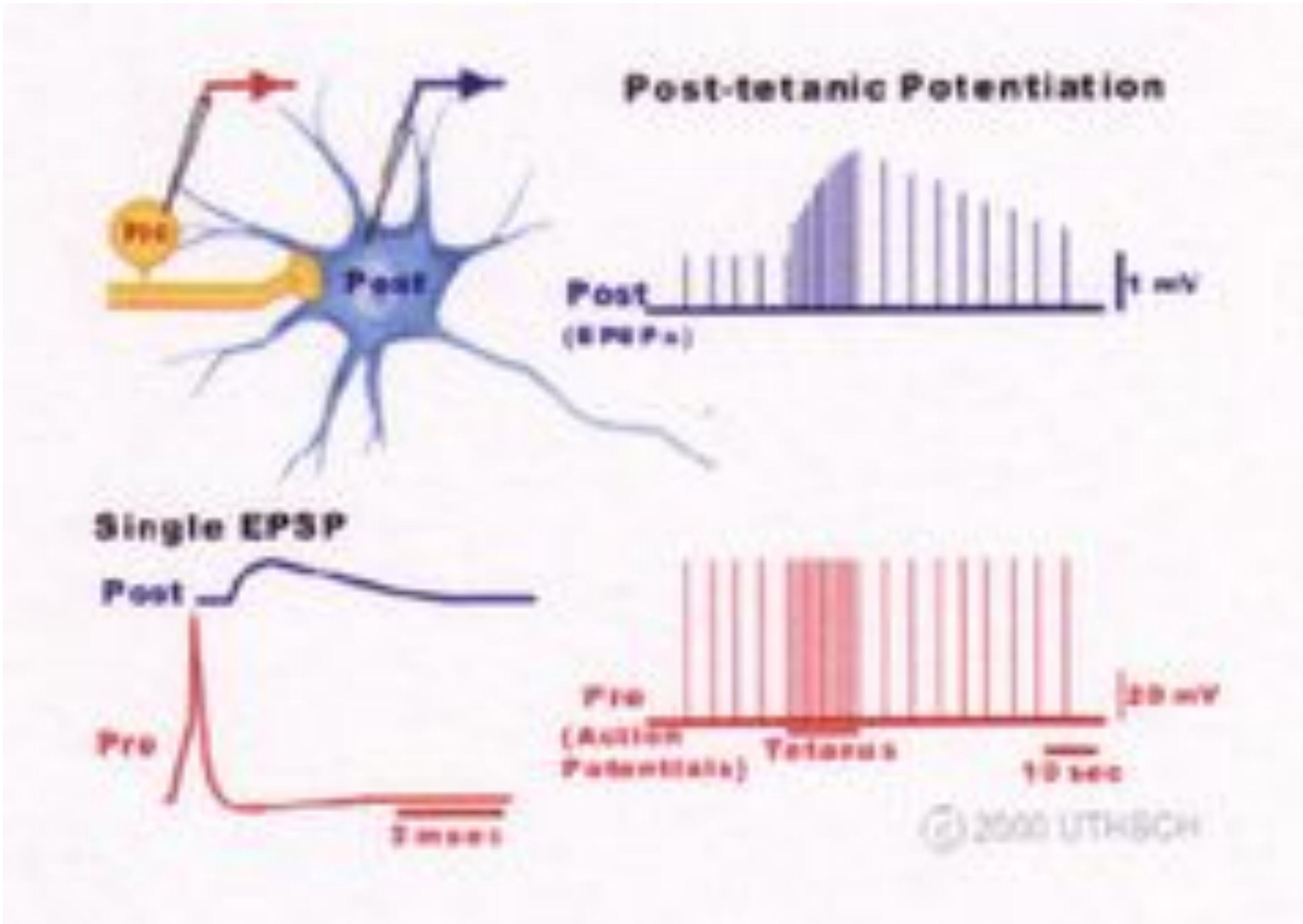


(a) Spatial summation

(b) Temporal summation

Figure 12.25 Tortora - PAP 12/e


EPPs before tetanic stimulation
Time after tetanic stimulation
4 sec
8 sec
14 sec
27 sec
5 mV
10 msec


Post-tetanic Potentiation
Post
Post
1 mV
Single EPSP
Post
Pre
20 mV
(Action
Potentials)
10 sec
Pre
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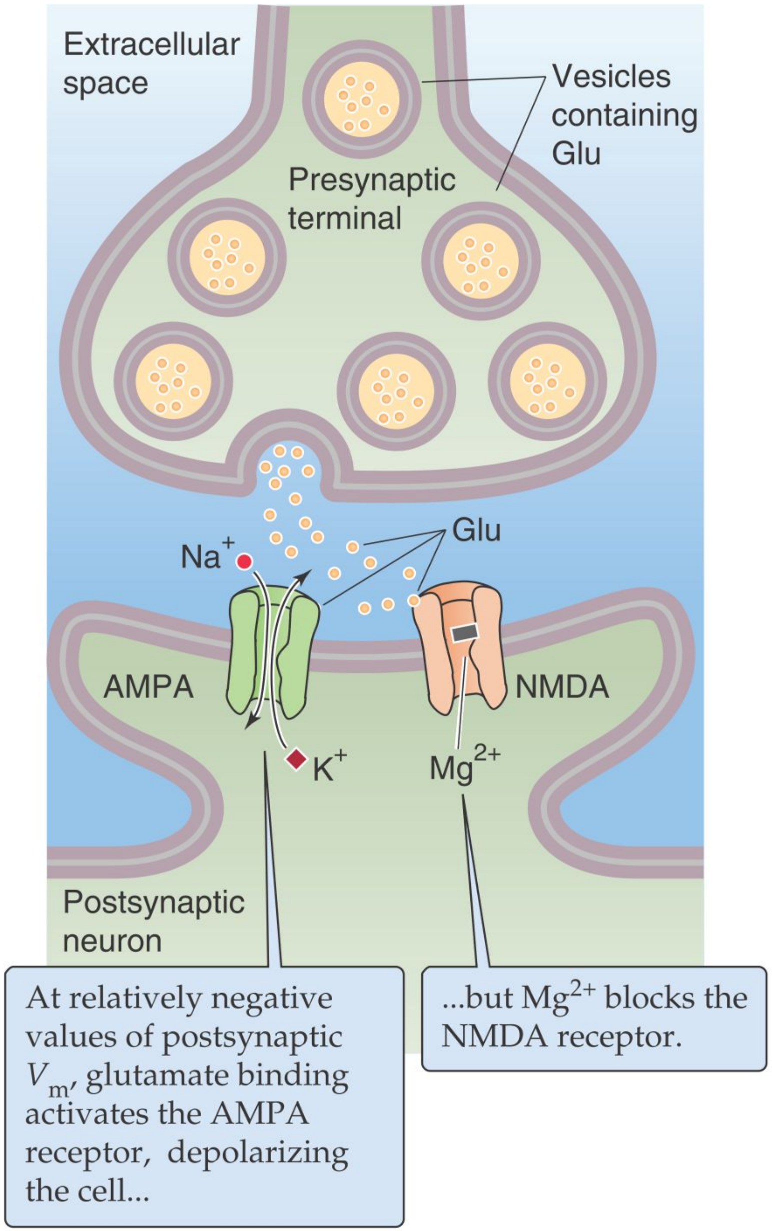
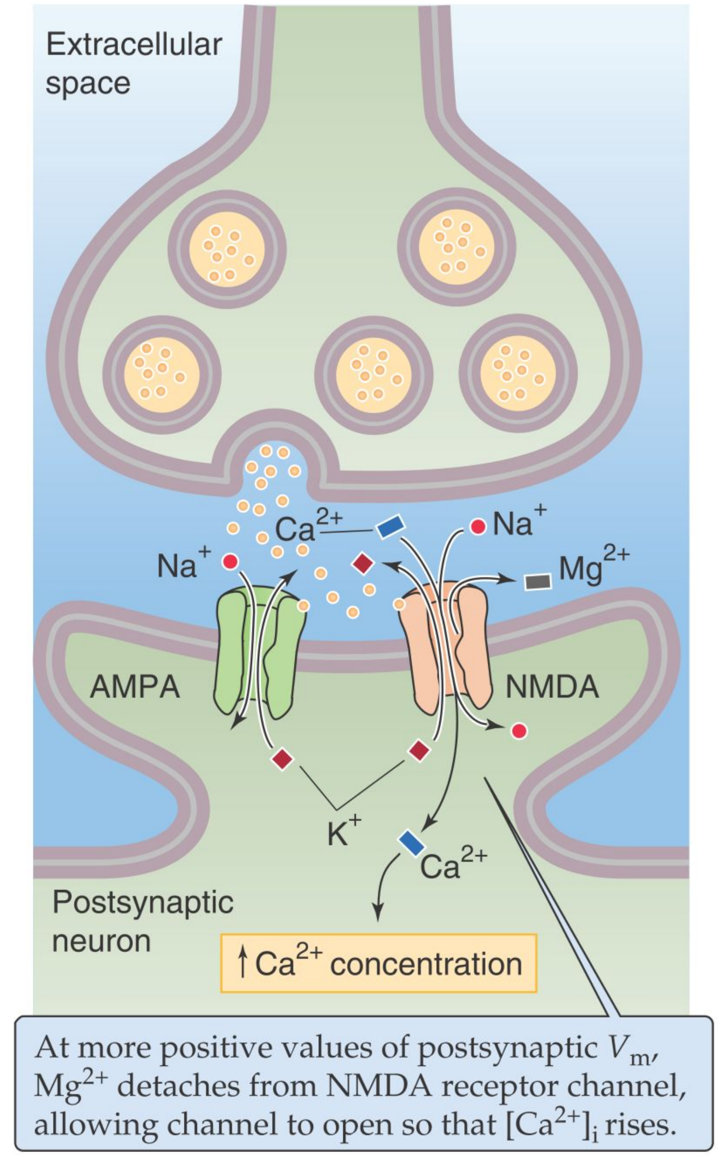
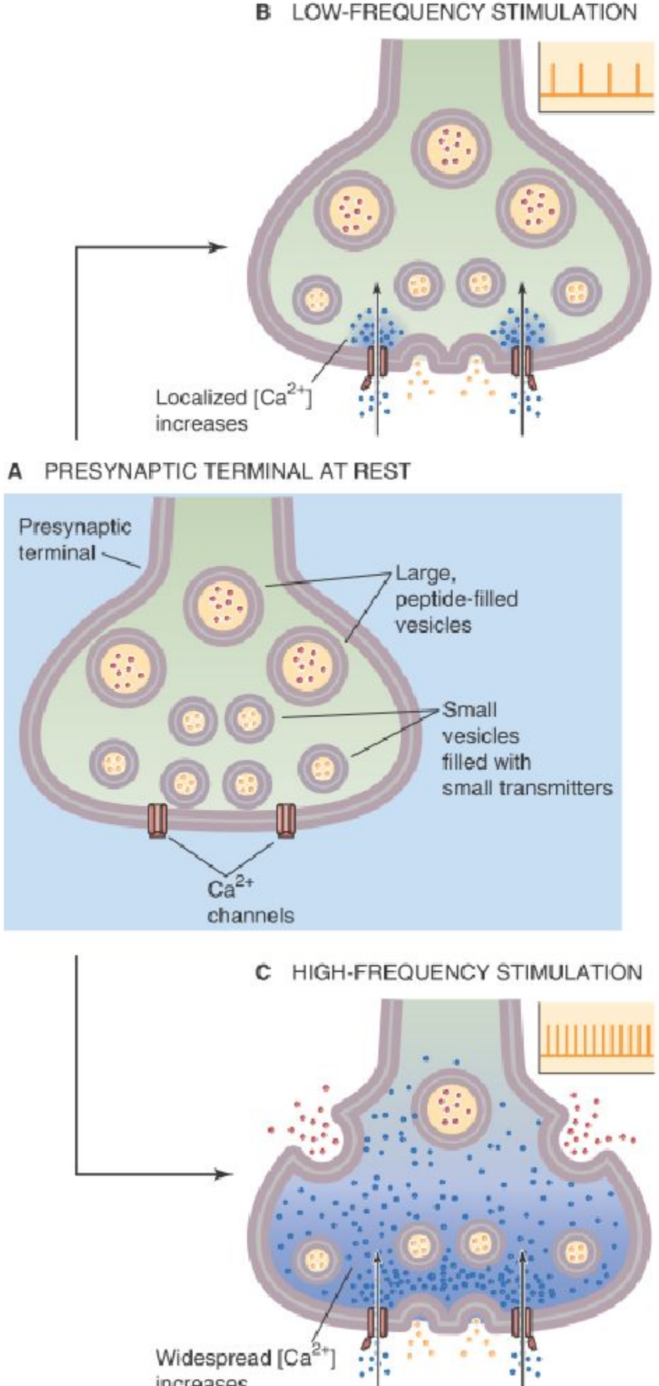
B ONLY AMPA RECEPTOR CHANNEL OPEN

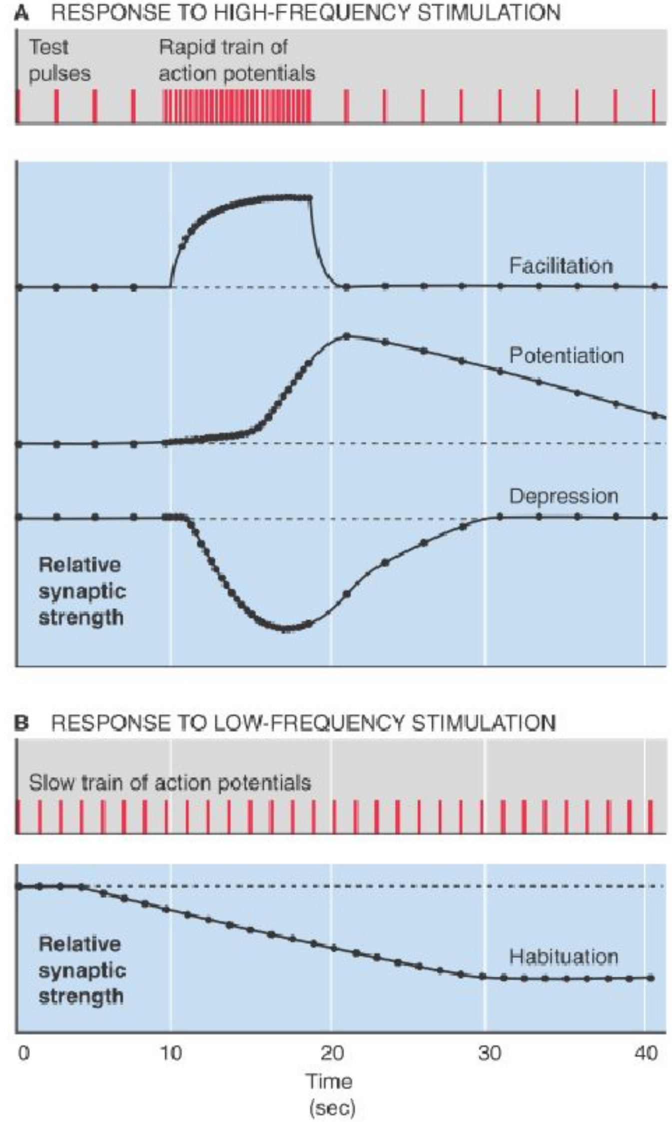


D AMPA AND NMDA RECEPTOR CHANNELS OPEN

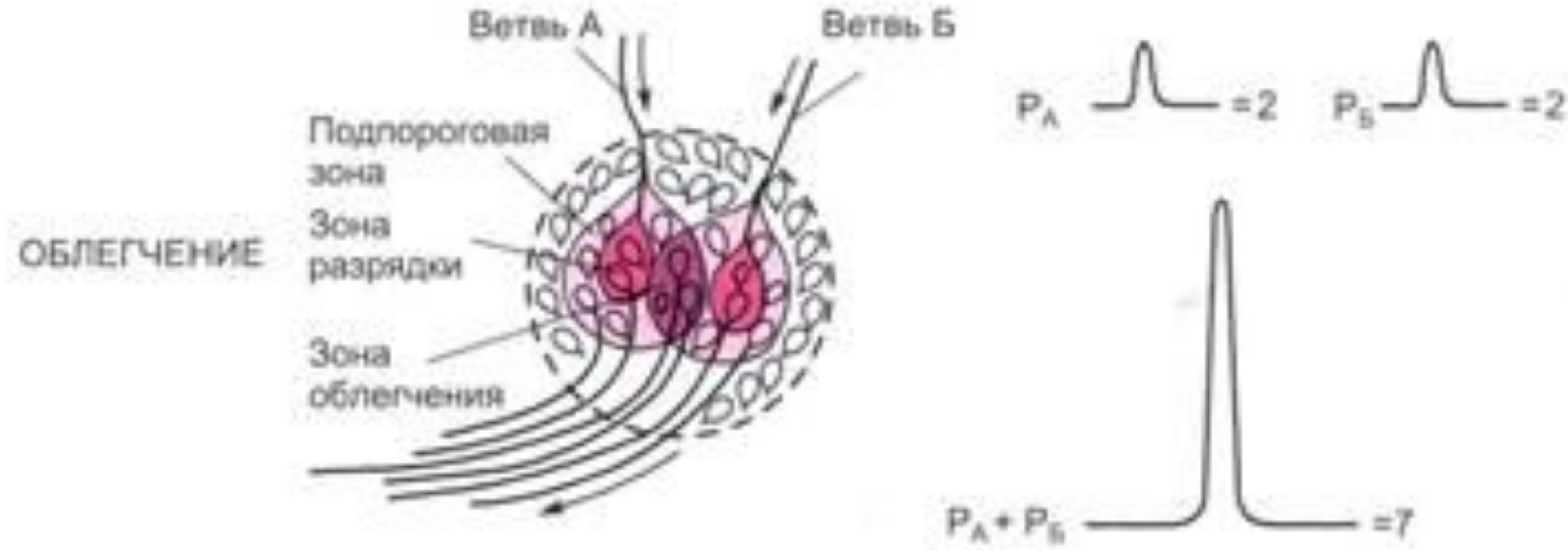




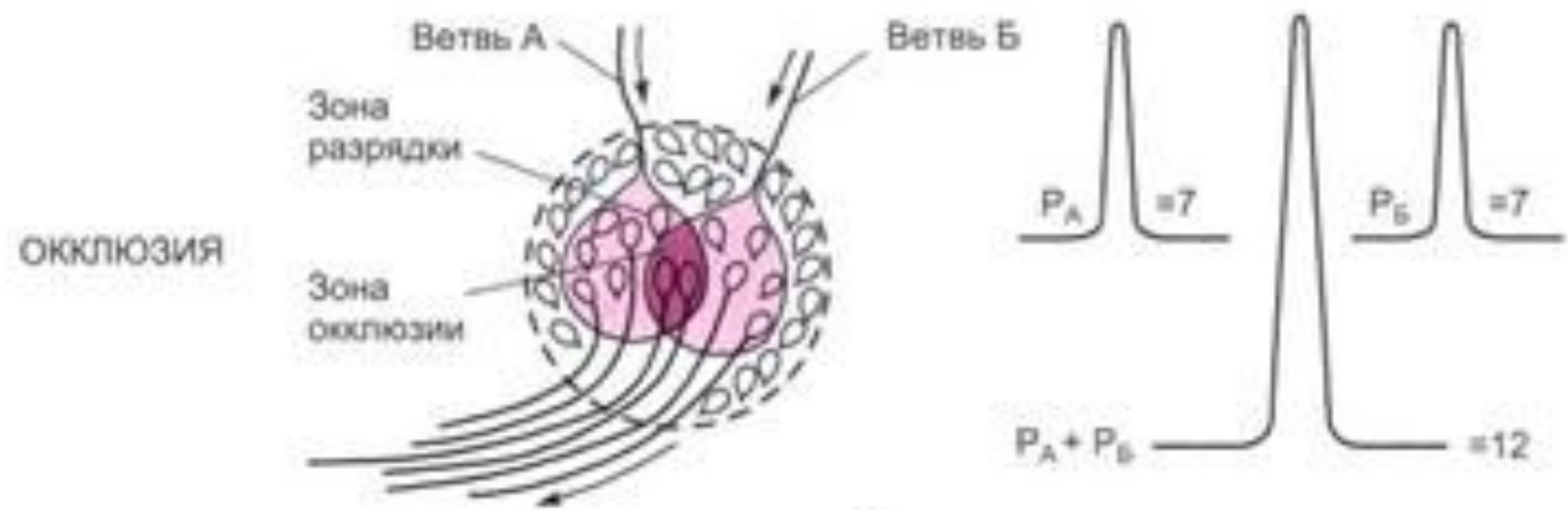
B LOW-FREQUENCY STIMULATION
Localized [Ca2+] increases
A PRESYNAPTIC TERMINAL AT REST
Presynaptic terminal
Large, peptide-filled vesicles
Small vesicles filled with small transmitters
Ca2+ channels
C HIGH-FREQUENCY STIMULATION
Widespread [Ca2+] increases



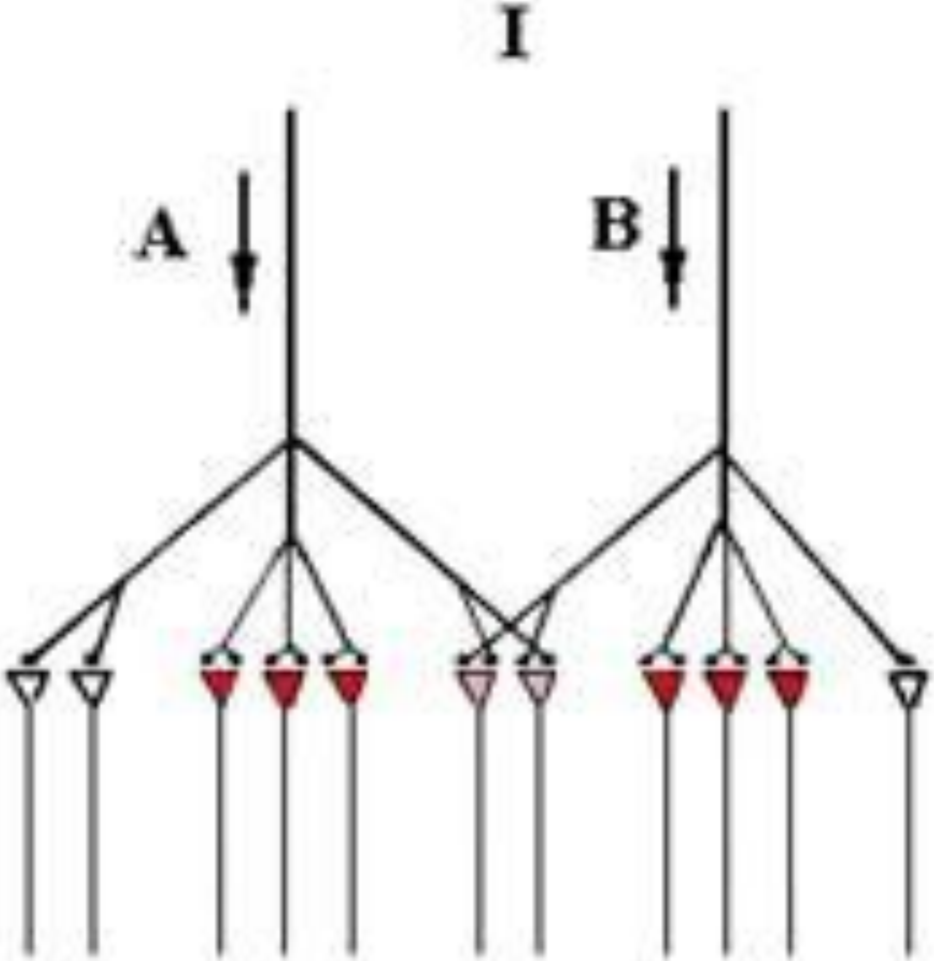
A RESPONSE TO HIGH-FREQUENCY STIMULATION
Test pulses
Rapid train of action potentials
Facilitation
Potentiation
Depression
Relative synaptic strength
B RESPONSE TO LOW-FREQUENCY STIMULATION
Slow train of action potentials
Relative synaptic strength
Habituation
0
10
20
30
40
Time (sec)


Ветвь А
Ветвь Б
Подпороговая зона
ОБЛЕГЧЕНИЕ
Зона разрядки
Зона облегчения
$P_А$
=2
$P_Б$
=2
$P_А + P_Б$
=7

б

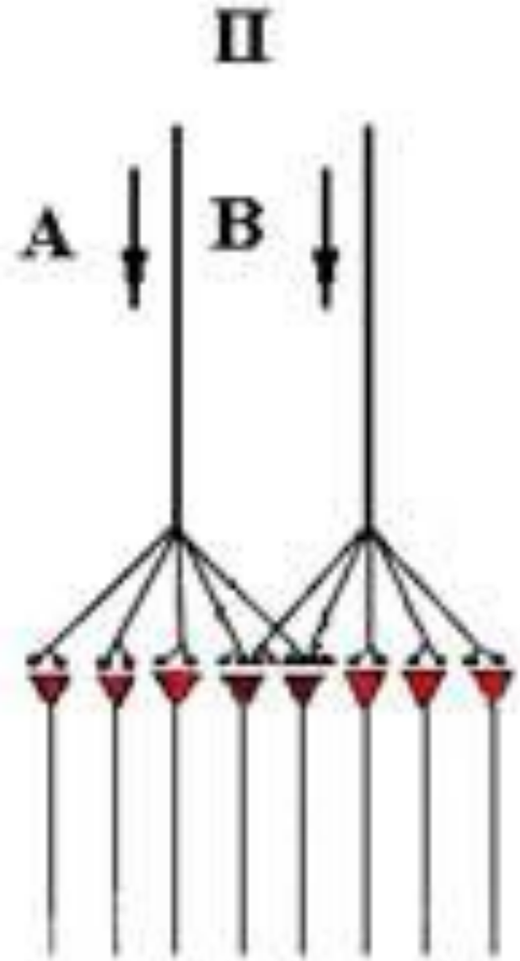

Ветвь А
Ветвь Б
Зона разрядки
ОККЛЮЗИЯ
Зона окклюзии
$P_А$
=7
$P_Б$
=7
$P_А + P_Б$
=12

в



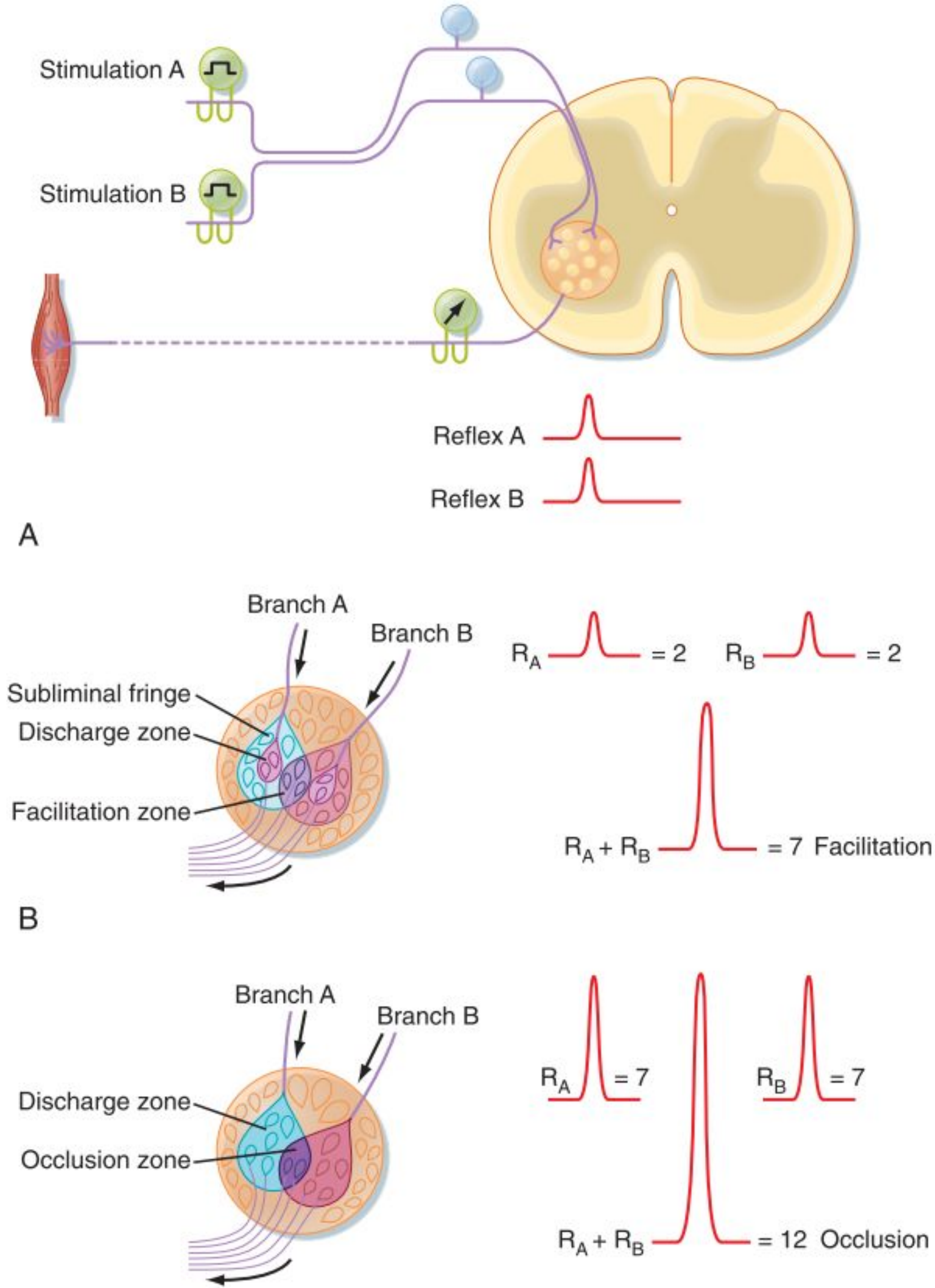
I - Облегчение:

A = 3, B = 3, A + B = 8



II - Окклюзия:

A = 5, B = 5, A + B = 8



Stimulation A
Stimulation B
Reflex A
Reflex B
A
Branch A
Branch B
Subliminal fringe
Discharge zone
Facilitation zone
R_A = 2
R_B = 2
$R_A + R_B$ = 7 Facilitation
B
Branch A
Branch B
Discharge zone
Occlusion zone
R_A = 7
R_B = 7
$R_A + R_B$ = 12 Occlusion