

04

**Synapse and integration of
information at the synaptic level**

Main Activity

The inside of the cell

- ✓ ...
- ✓ Synthesis
- ✓ Transport
- ✓ ...

Introduction

Information processing and transmission

The membrane

- ✓ Signal reception
- ✓ Signal integration
- ✓ AP generation
- ✓ AP propagation
- ✓ Signal transmission

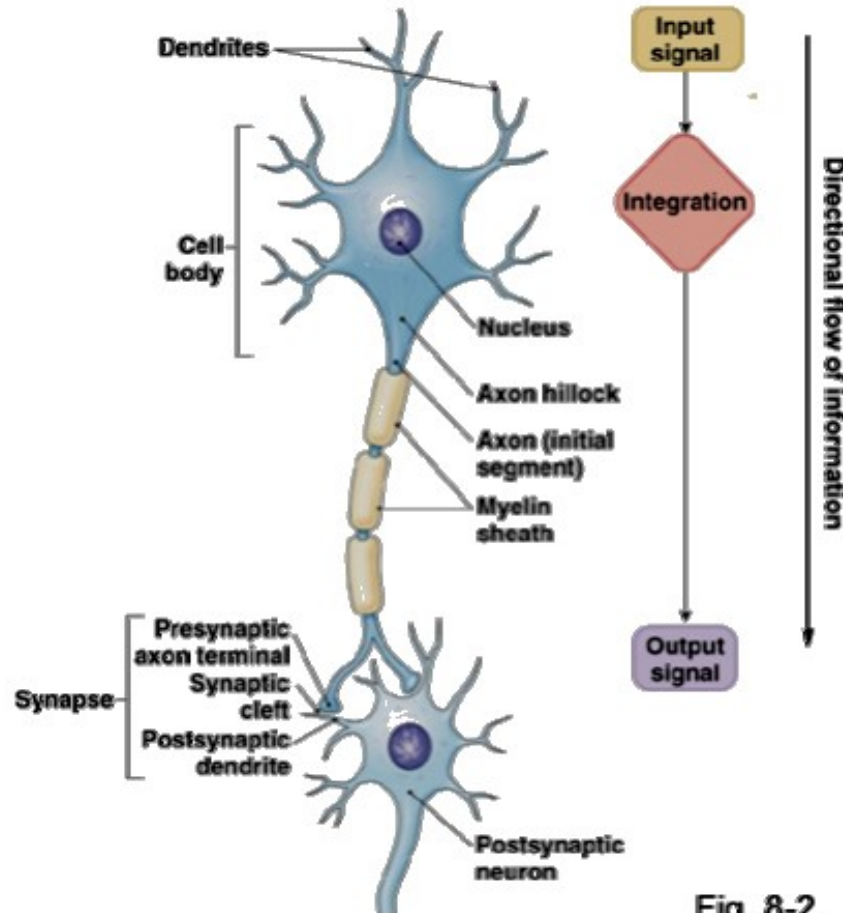


Fig. 8-2

Introduction

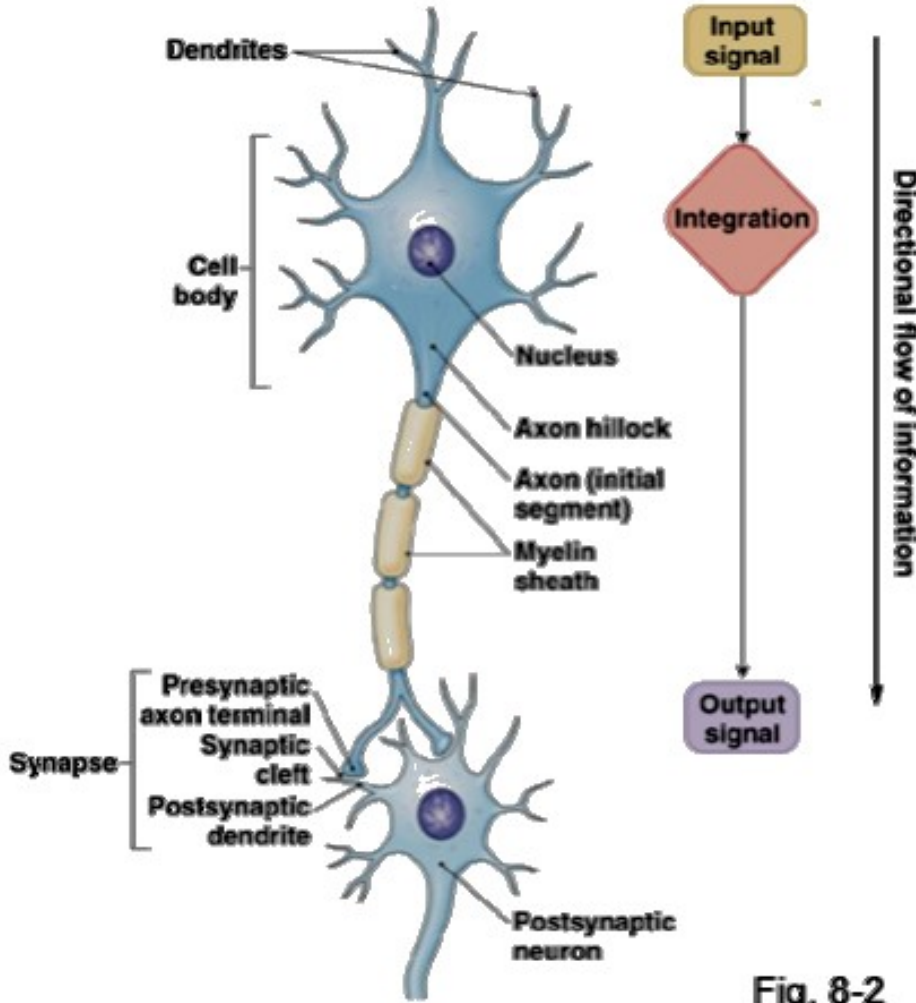
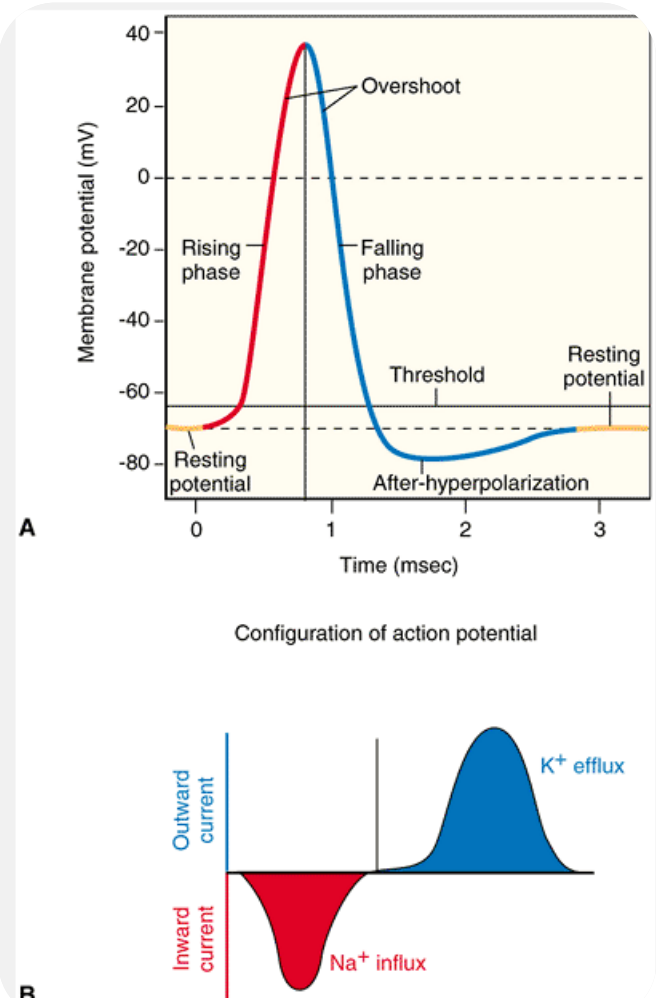


Fig. 8-2



Synapse

- Communication between neurons

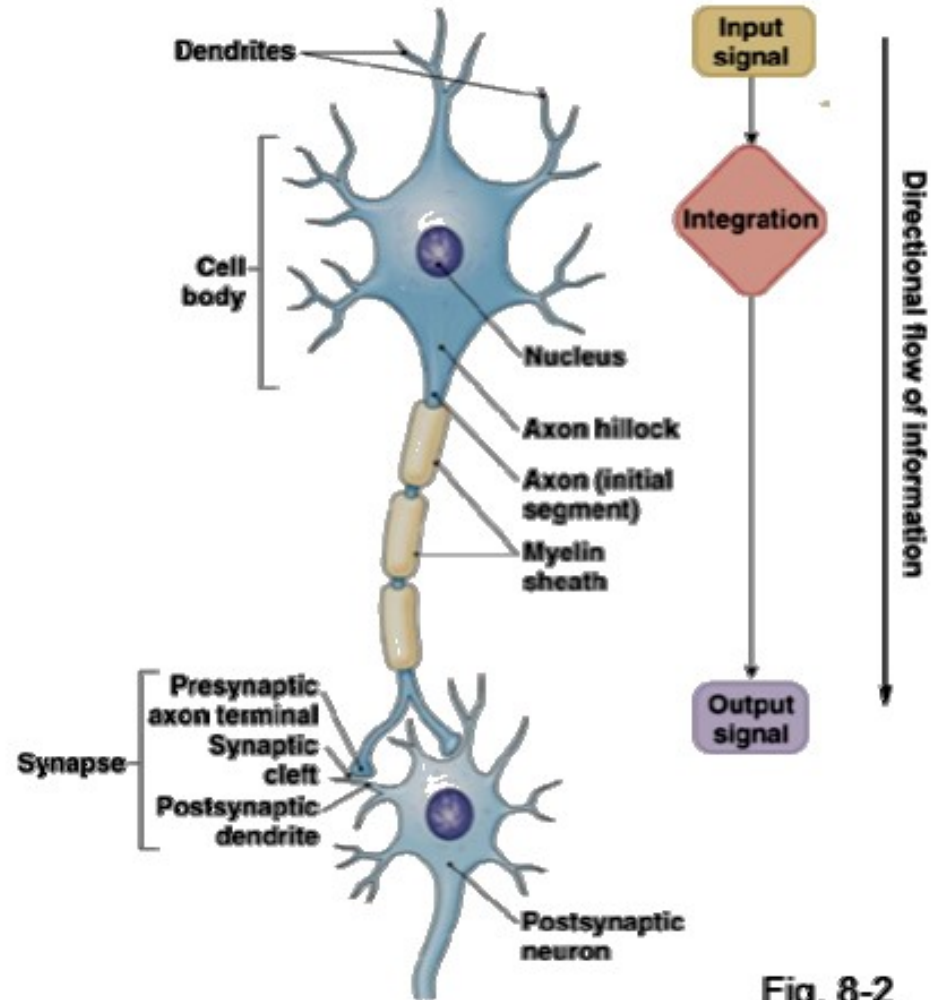


Fig. 8-2

Synapse

- Communication between neurons
- Electrical
- Chemical

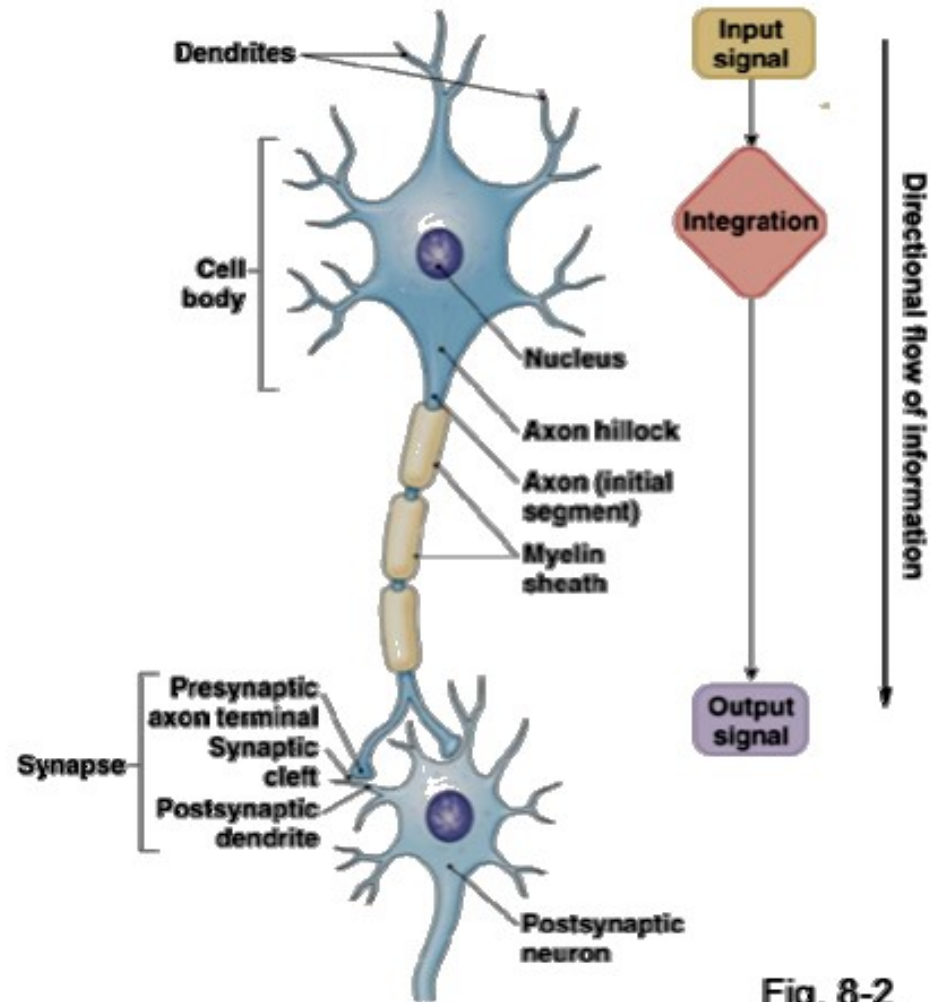
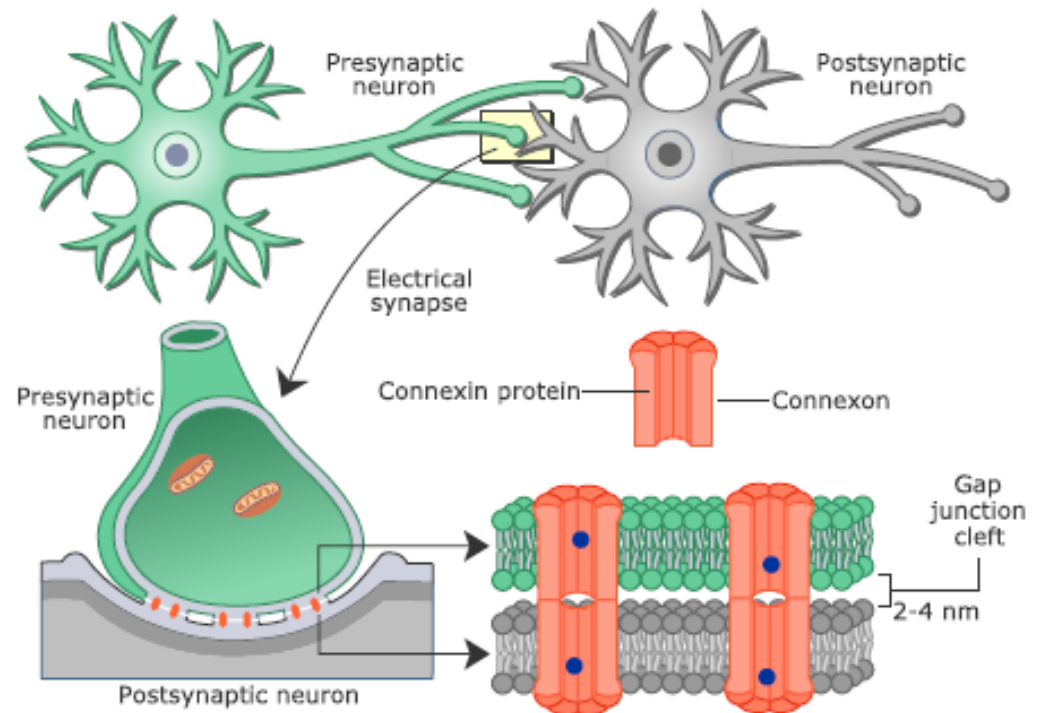


Fig. 8-2

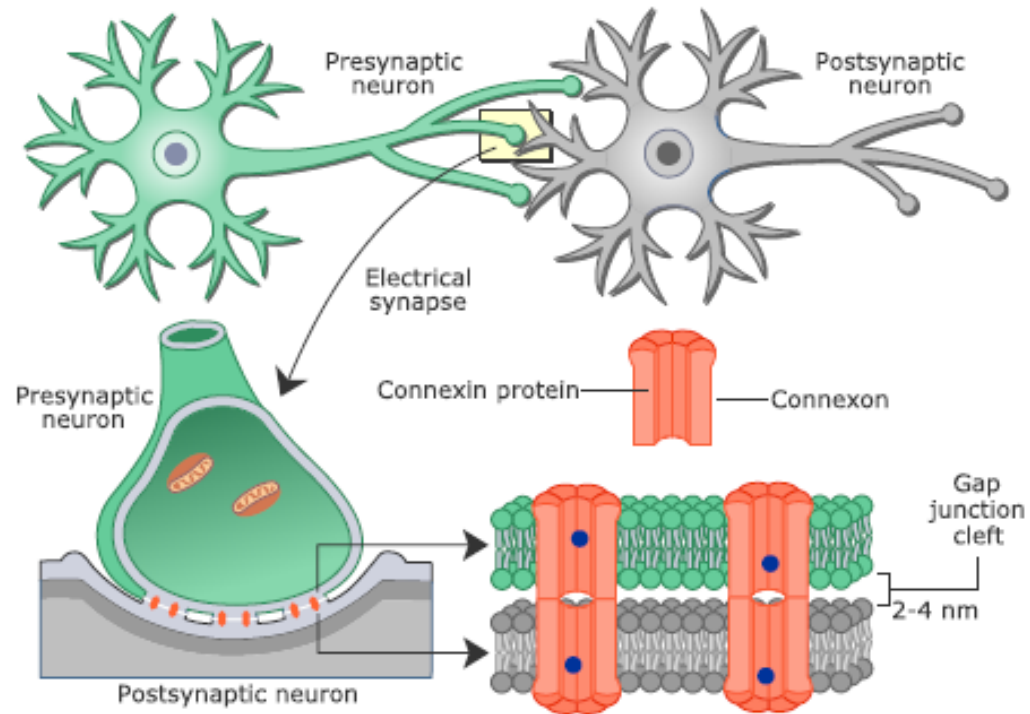
Electrical synapse

- Evolutionary old
- Less frequent than ch.
- Ubiquitous



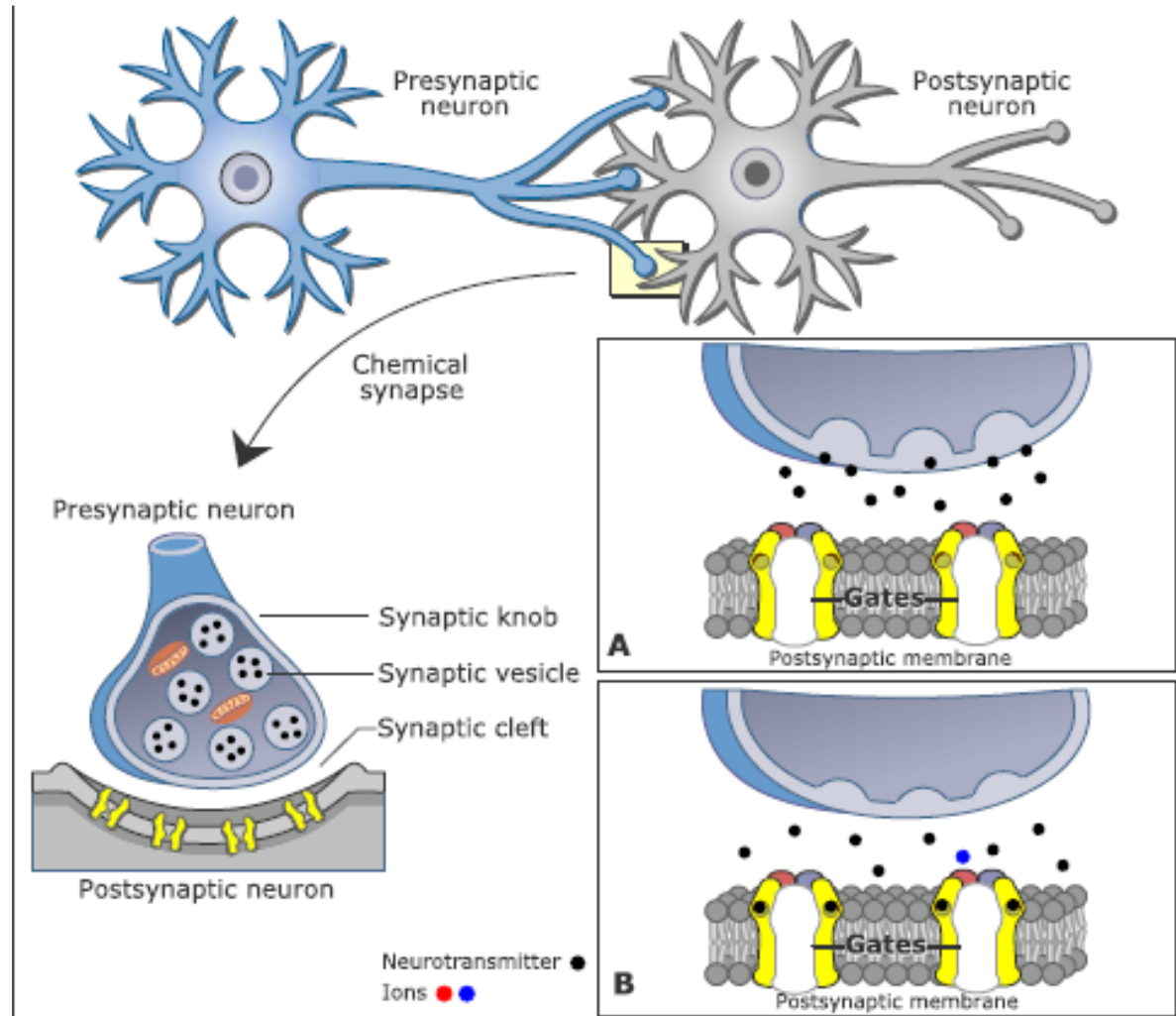
Electrical synapse

- Evolutionary old
- Less frequent than ch.
- Ubiquitous
- Gap junctions
- Bidirectional transmission
- Fast
- Strength of signal may decrease



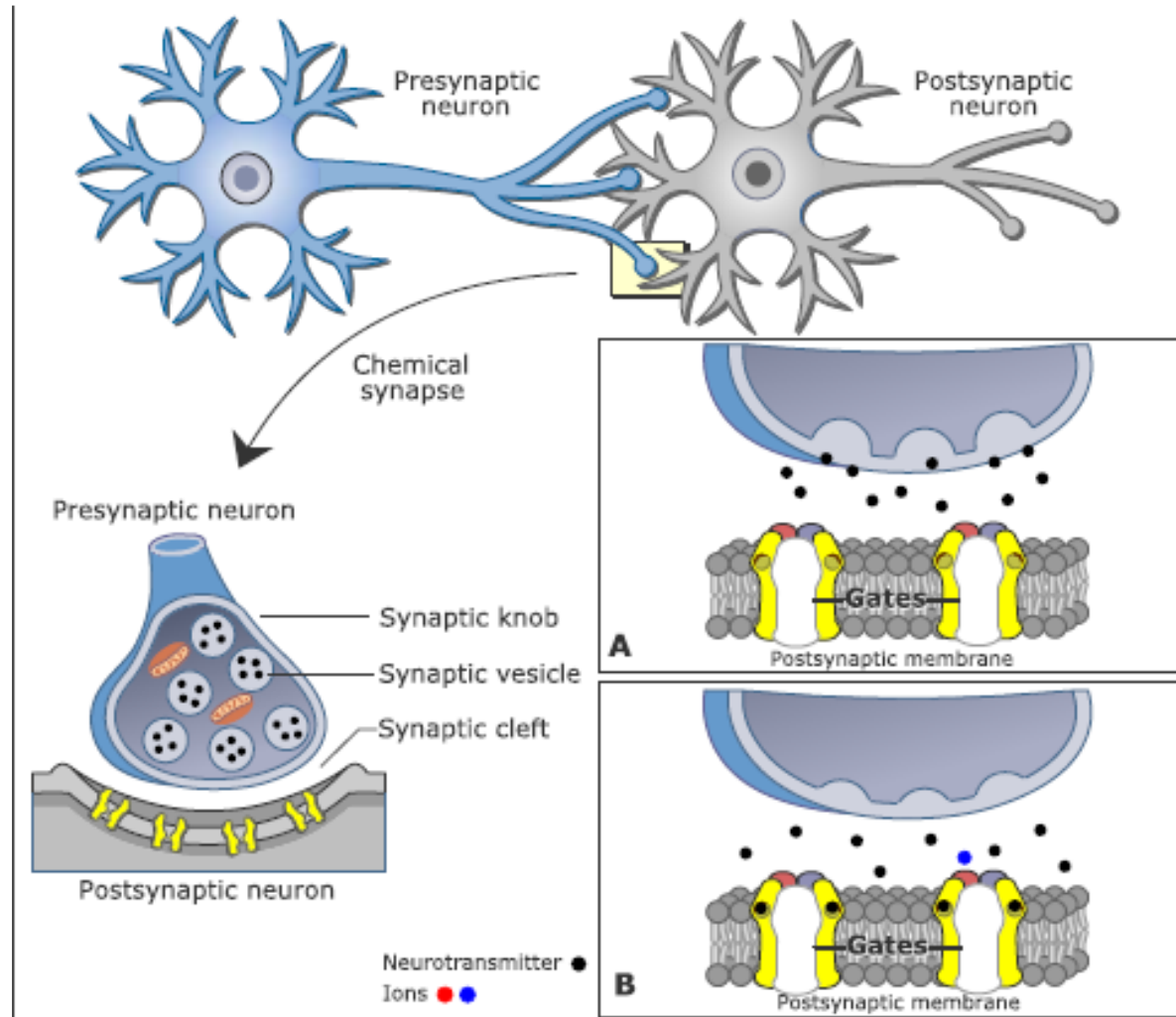
Chemical synapse

- Evolutionary young
- Majority type of s.

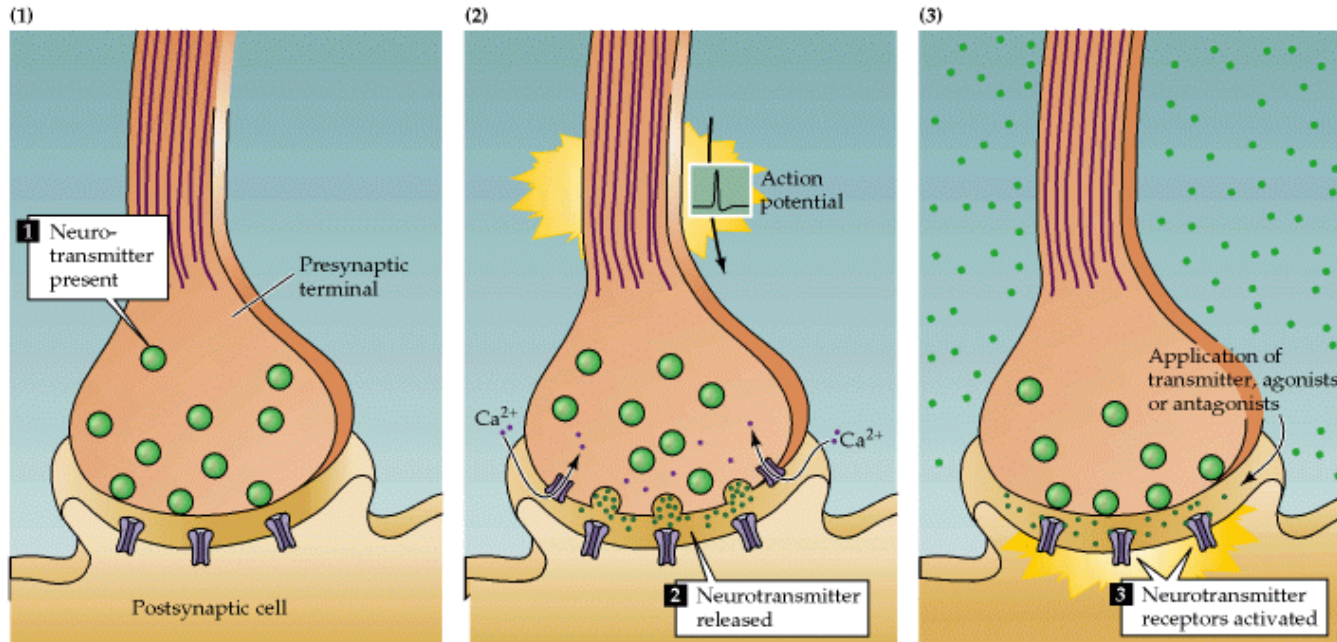


Chemical synapse

- Evolutionary young
- Majority type of s.
- Unidirectional
- Synaptic cleft
- Neurotransmitter
- Constant signal strength

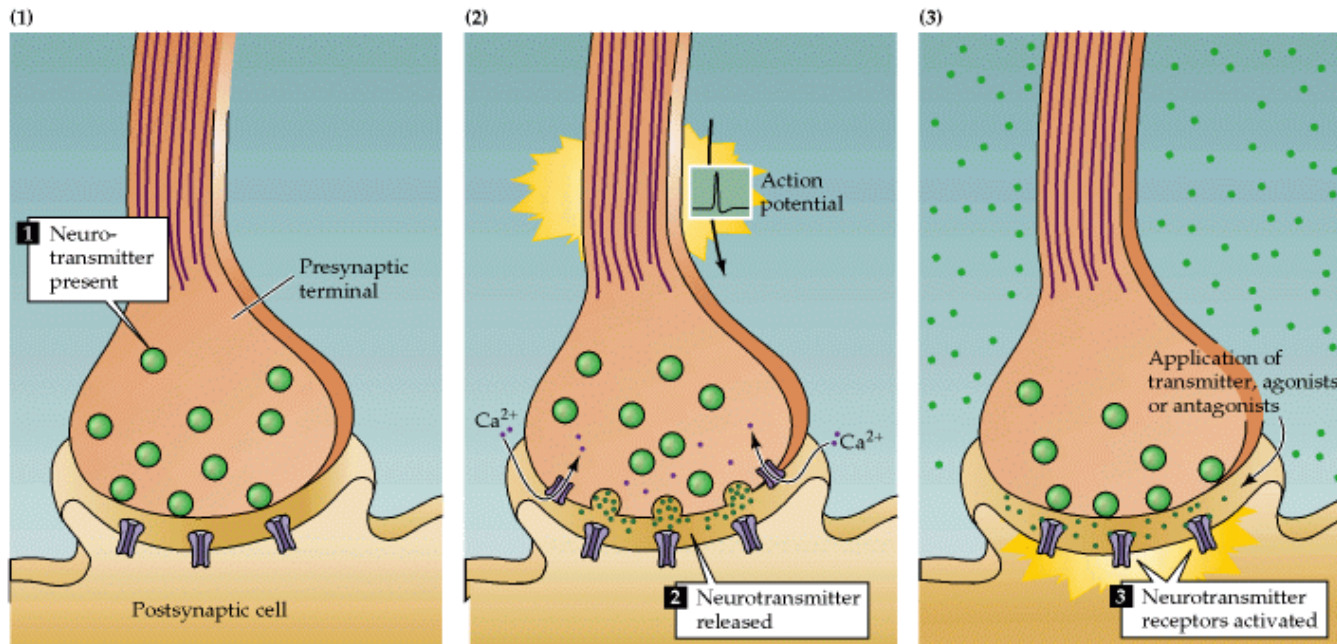


Neurotransmitter



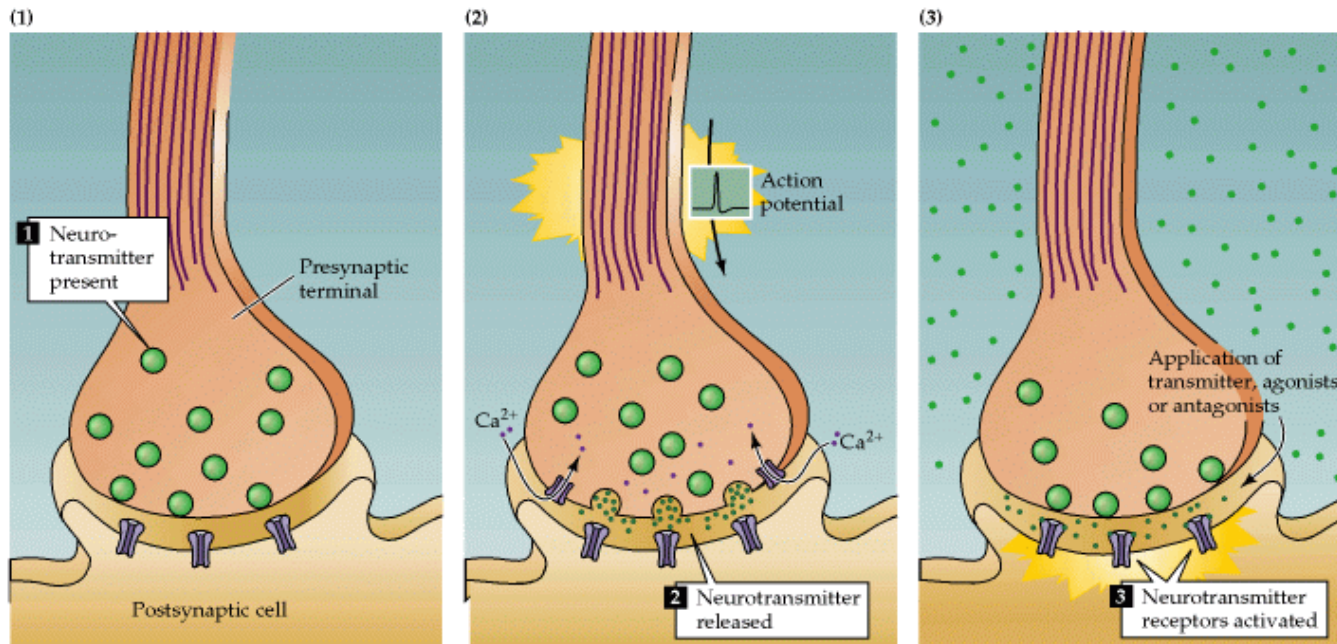
- Present in presynaptic neuron

Neurotransmitter



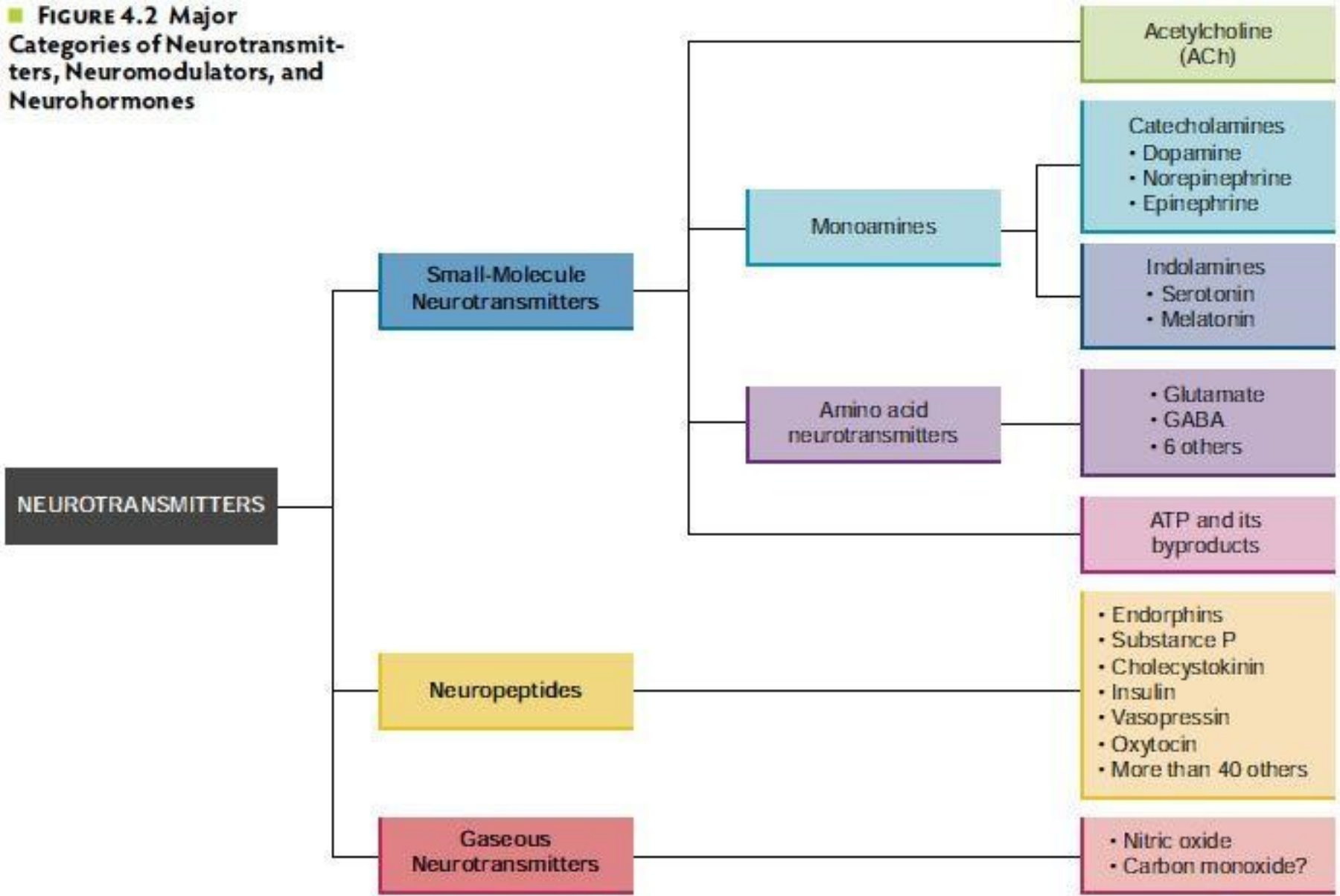
- Present in presynaptic neuron
- Released into the synaptic cleft due to depolarization of presynaptic neuron (Ca^{2+} dependent mechanism)

Neurotransmitter



- Present in presynaptic neuron
- Released into the synaptic cleft due to depolarization of presynaptic neuron (Ca^{2+} dependent mechanism)
- Specific receptor has to be present in postsynaptic membrane

■ **FIGURE 4.2 Major Categories of Neurotransmitters, Neuromodulators, and Neurohormones**

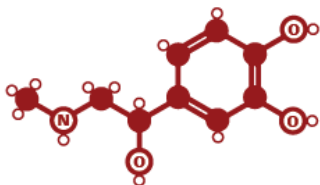


THE STRUCTURES OF NEUROTRANSMITTERS

STRUCTURE KEY: ● Carbon atom ○ Hydrogen atom ○ Oxygen atom ○ Nitrogen atom ○ Rest of molecule

ADRENALINE

Fight or flight neurotransmitter



Produced in stressful or exciting situations. Increases heart rate & blood flow, leading to a physical boost & heightened awareness.

NORADRENALINE

Concentration neurotransmitter



Affects attention & responding actions in the brain, & involved in fight or flight response. Contracts blood vessels, increasing blood flow.

DOPAMINE

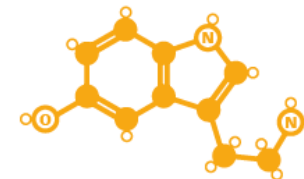
Pleasure neurotransmitter



Feelings of pleasure, and also addiction, movement, and motivation. People repeat behaviours that lead to dopamine release.

SEROTONIN

Mood neurotransmitter



Contributes to well-being & happiness; helps sleep cycle & digestive system regulation. Affected by exercise & light exposure.

GABA

Calming neurotransmitter



Calms firing nerves in CNS. High levels improve focus; low levels cause anxiety. Also contributes to motor control & vision.

ACETYLCHOLINE

Learning neurotransmitter



Involved in thought, learning, & memory. Activates muscle action in the body. Also associated with attention and awakening.

GLUTAMATE

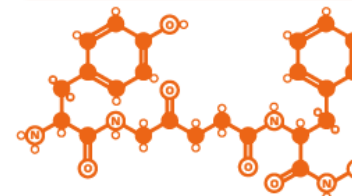
Memory neurotransmitter



Most common brain neurotransmitter. Involved in learning & memory, regulates development & creation of nerve contacts.

ENDORPHINS

Euphoria neurotransmitters



Released during exercise, excitement, & sex, producing well-being & euphoria, reducing pain. Biologically active section shown.



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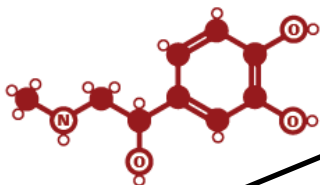


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DOPAMINE

Motivation neurotransmitter



Most common brain neurotransmitter. Involved in learning & memory, regulates development & creation of nerve contacts.

SEROTONIN

Mood neurotransmitter



Contributes to well-being & happiness; helps sleep cycle & digestive system regulation. Affected by exercise & light exposure.

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Involved in thought, learning, & memory. Activates muscle action in the body. Also associated with attention and awakening.



Most common brain neurotransmitter. Involved in learning & memory, regulates development & creation of nerve contacts.

Excitatory
(Glutamate, acetylcholin)

X

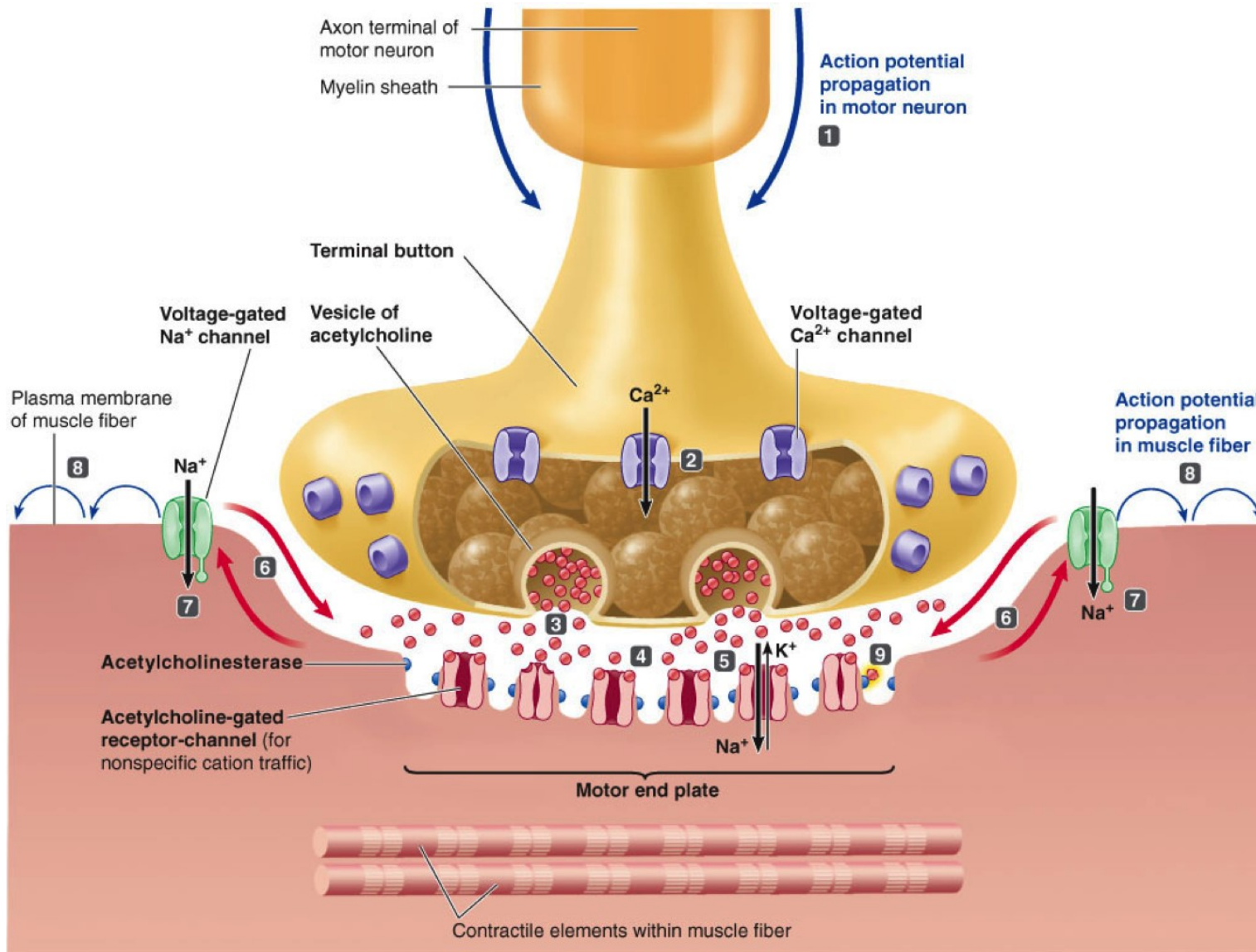
Inhibitory
(GABA)



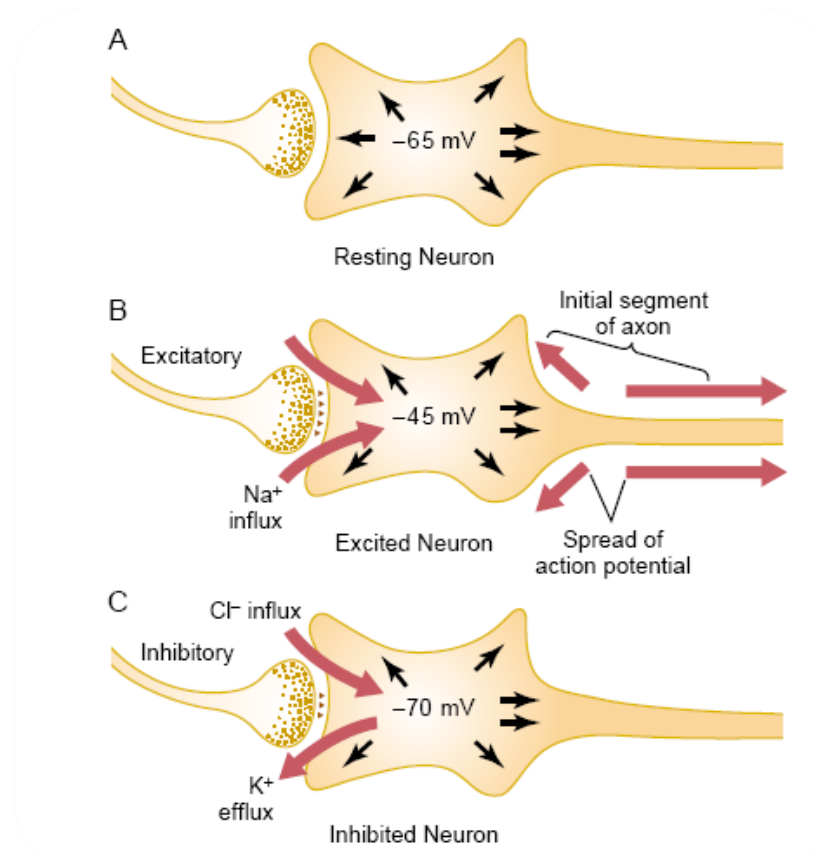
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Neuromuscular junction

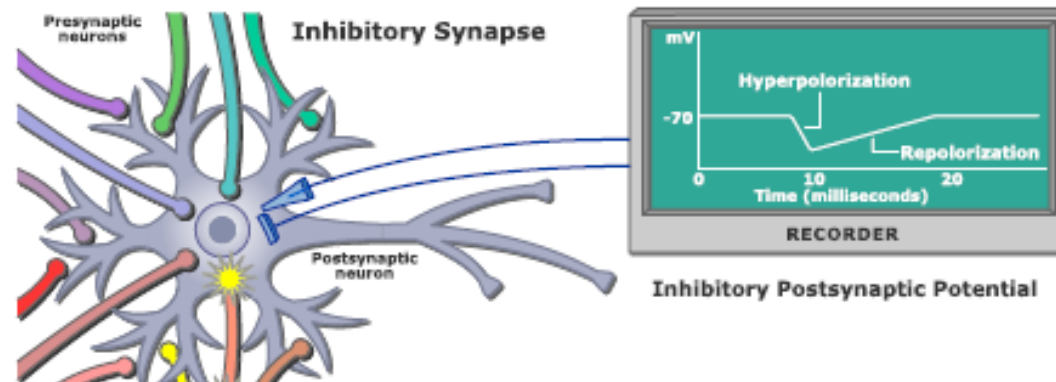
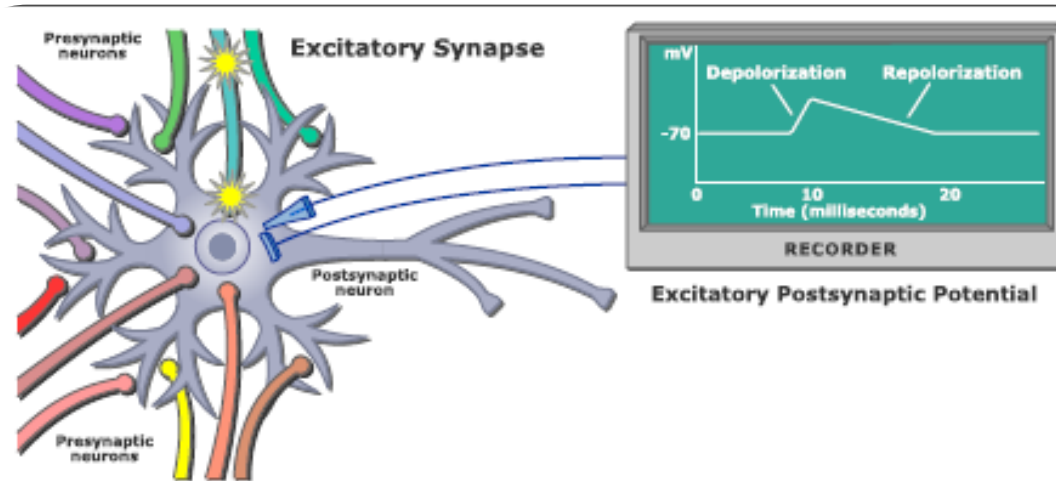


Excitatory/inhibitory postsynaptic potential

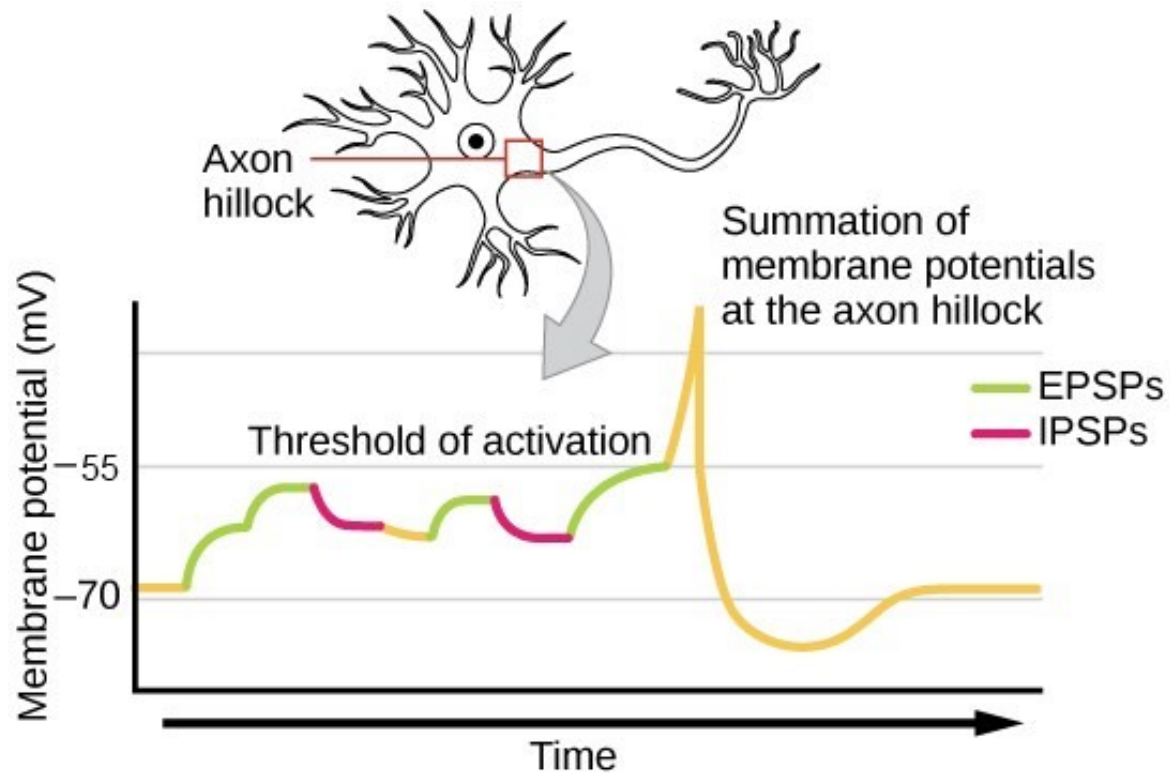


Signal summation

- Temporal
- Spatial



Signal summation



Synaptic convergence

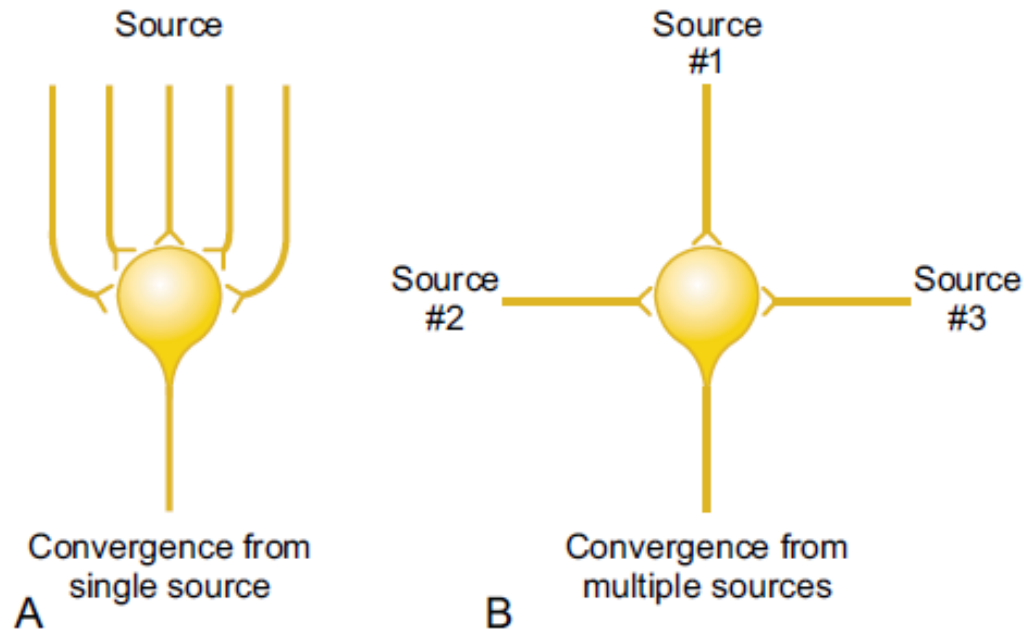


Figure 46-12

“Convergence” of multiple input fibers onto a single neuron. *A*, Multiple input fibers from a single source. *B*, Input fibers from multiple separate sources.

Synaptic convergence

Average number of synapses in one neuronal cell in primates

✓ Primary visual cortex (area17)

– aprox. 4 000

✓ Primary motor cortex (area4)

– aprox. 60 000

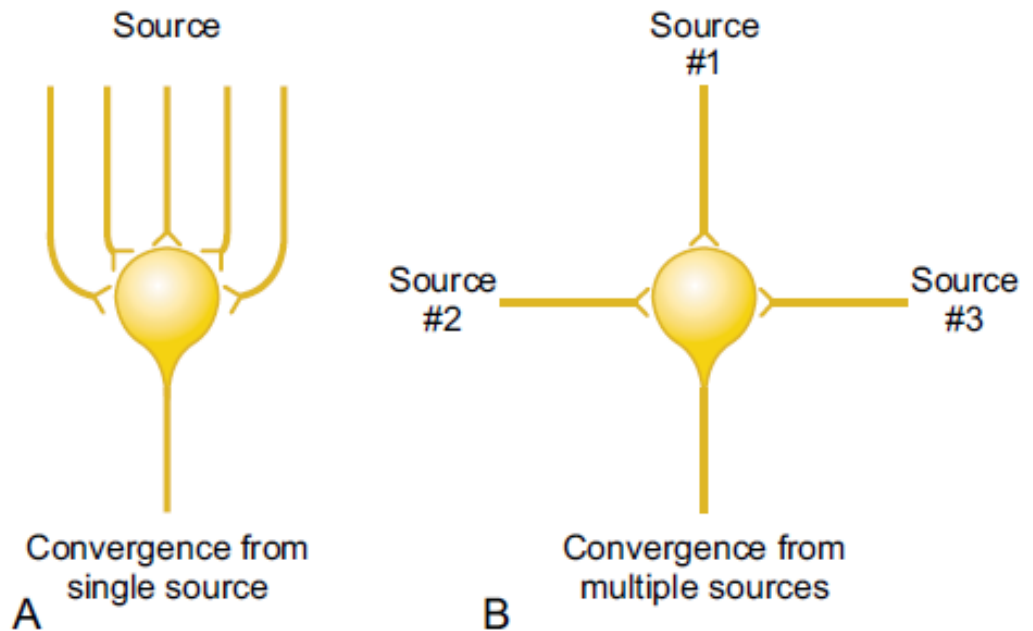


Figure 46-12

“Convergence” of multiple input fibers onto a single neuron. A, Multiple input fibers from a single source. B, Input fibers from multiple separate sources.

Synaptic divergence

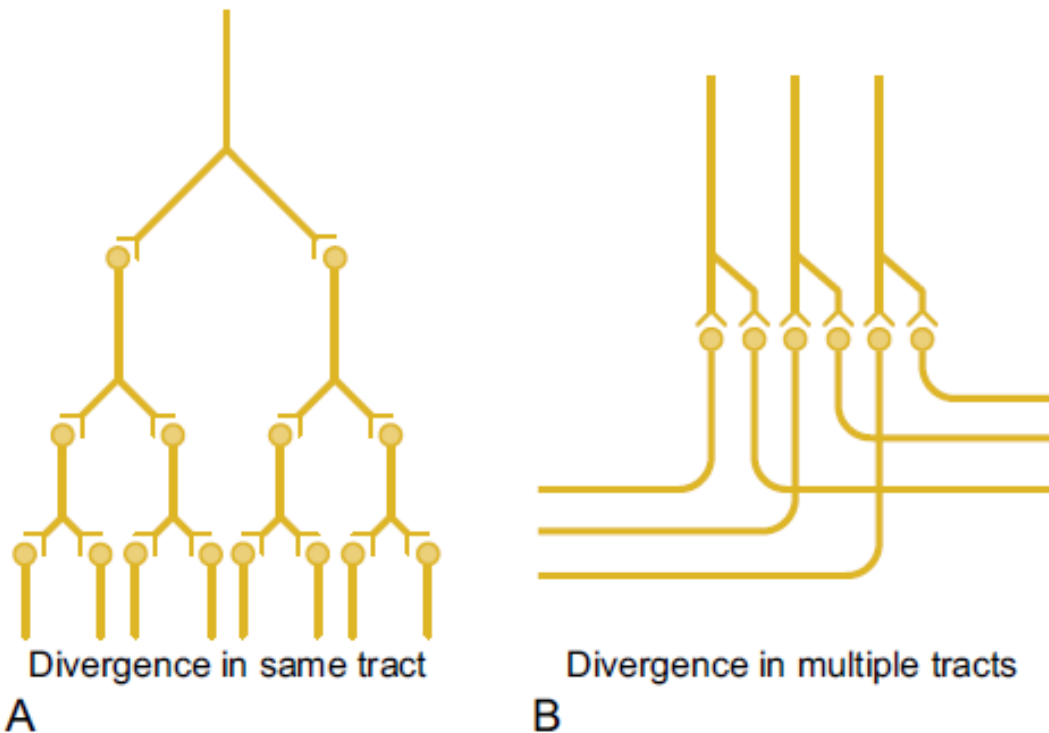
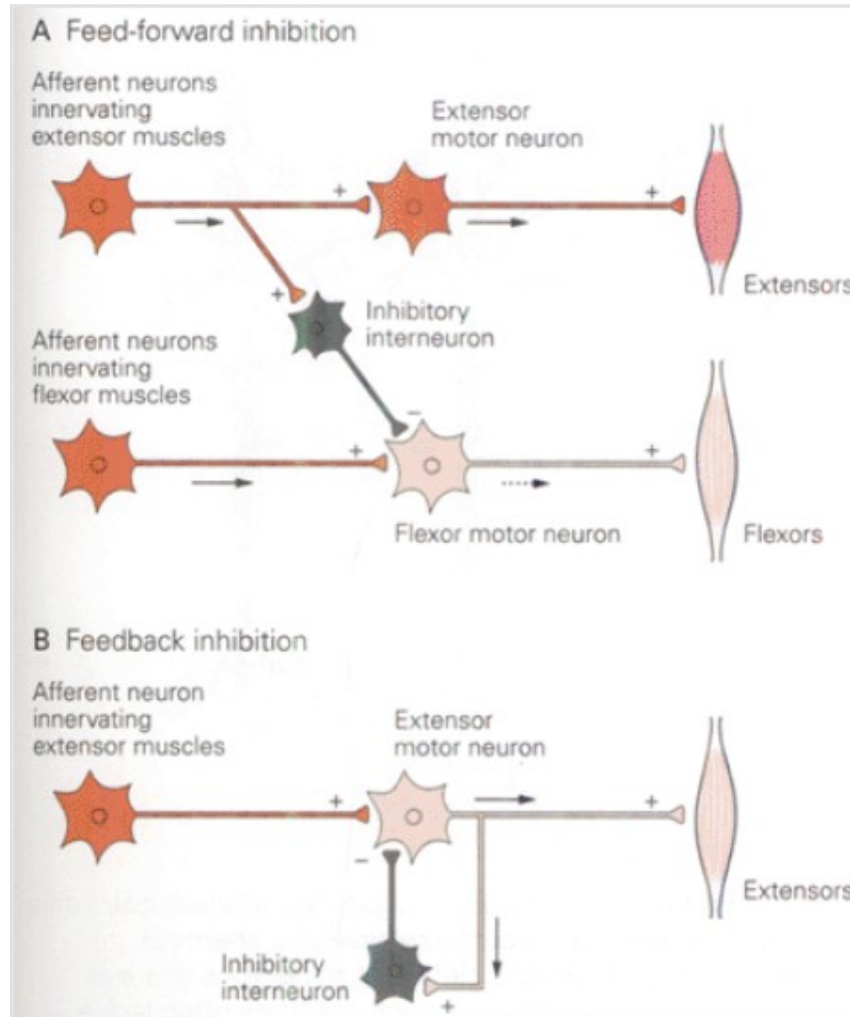


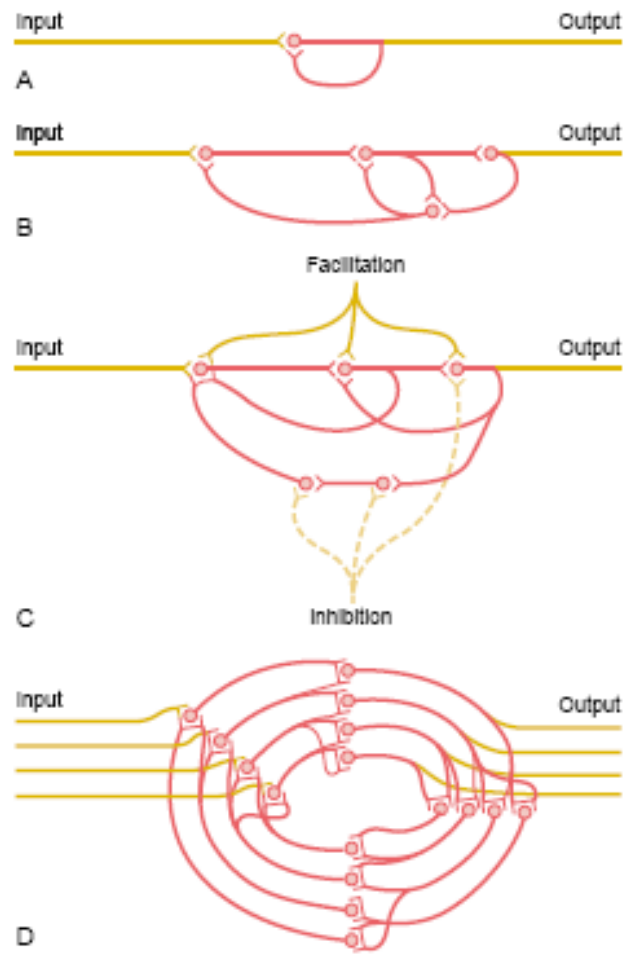
Figure 46-11

“Divergence” in neuronal pathways. *A*, Divergence within a pathway to cause “amplification” of the signal. *B*, Divergence into multiple tracts to transmit the signal to separate areas.

Networking



Networking



Neurotransmission vs. Neuromodulation

Neurotransmission vs. Neuromodulation

- Information transmission
- Regulation of NS activity

Neurotransmission

- Information transmission
- Specific

vs. Neuromodulation

- Regulation of NS activity
- Difuse (volume transmission)

Neurotransmission

- Information transmission
- Specific
- Receptors – ion channels

vs. Neuromodulation

- Regulation of NS activity
- Diffuse (volume transmission)
- Receptors – G-proteins

Neurotransmission

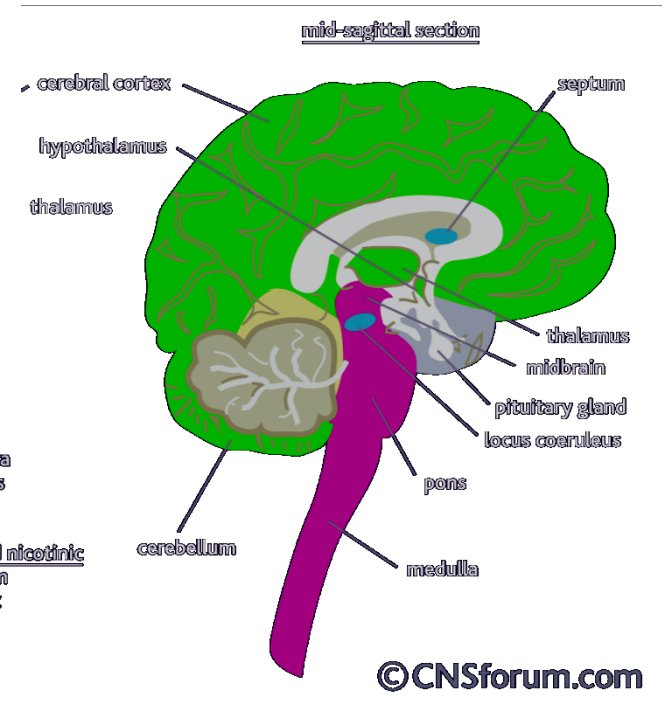
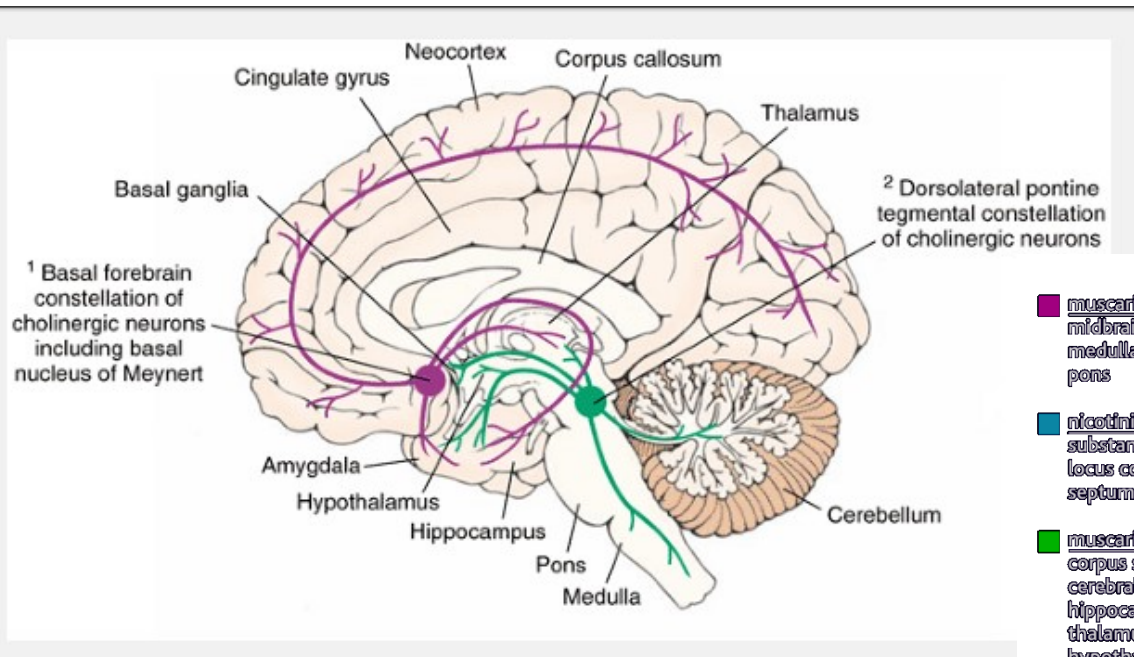
- Information transmission
- Specific
- Receptors – ion channels
- Short duration
 - membrane potential changes

vs. Neuromodulation

- Regulation of NS activity
- Diffuse (volume transmission)
- Receptors – G-proteins
- Longer duration
 - changes in synaptic properties

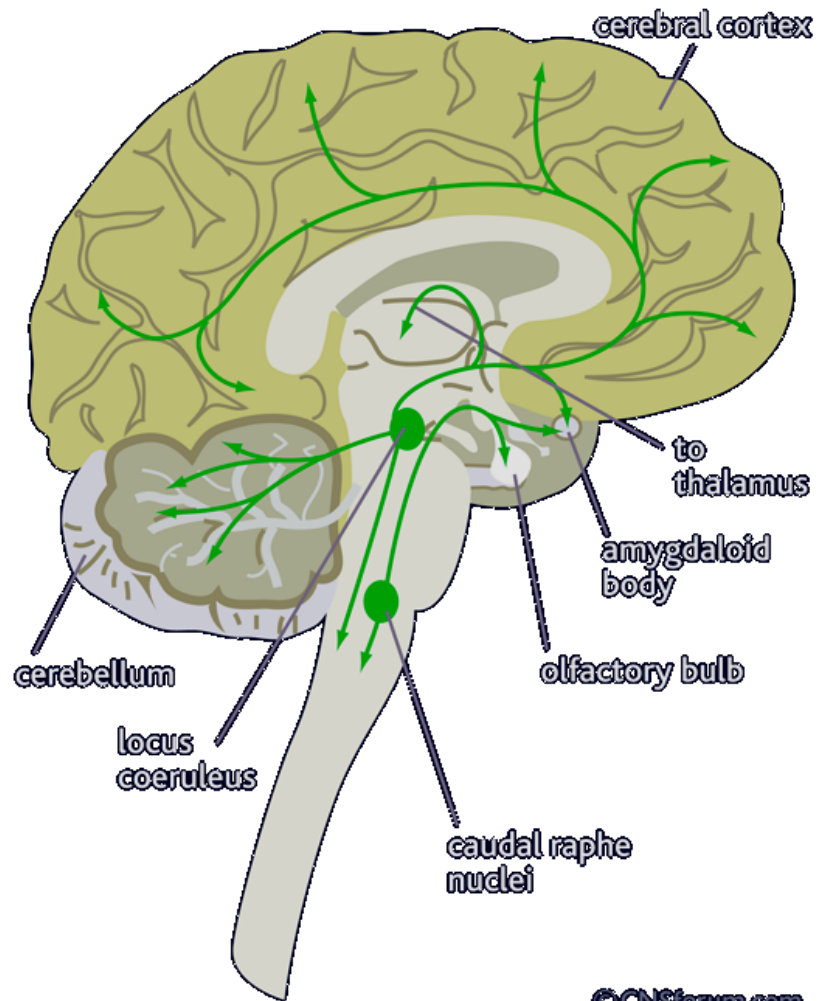
Acetylcholin

- Nucleus basalis (Meynerti) and other nuclei
- Nicotin receptors
- Muscarin receptors
- Sleep/wake regulation
- Cognitive functions
- Behavior
- Emotions



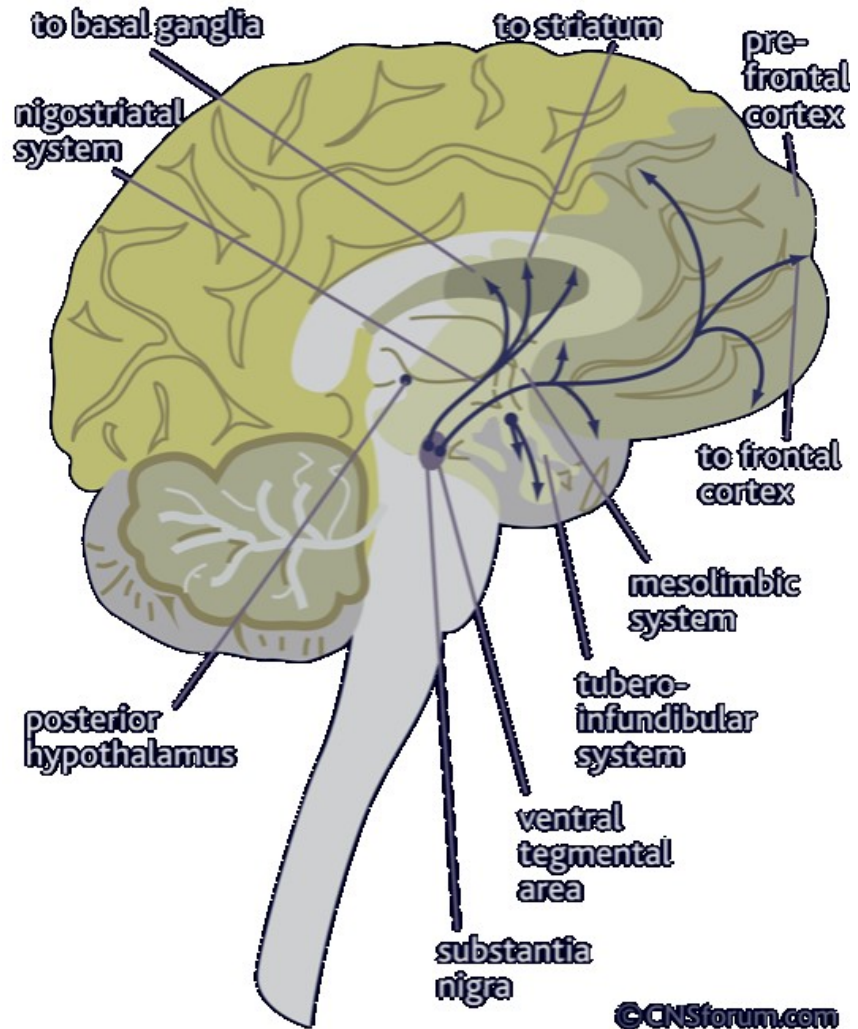
Noradrenalin

- Locus coeruleus
- Nuclei raphe caudalis
- Vigilance
- Responsiveness to unexpected stimuli
- Memory
- Learning



Dopamin

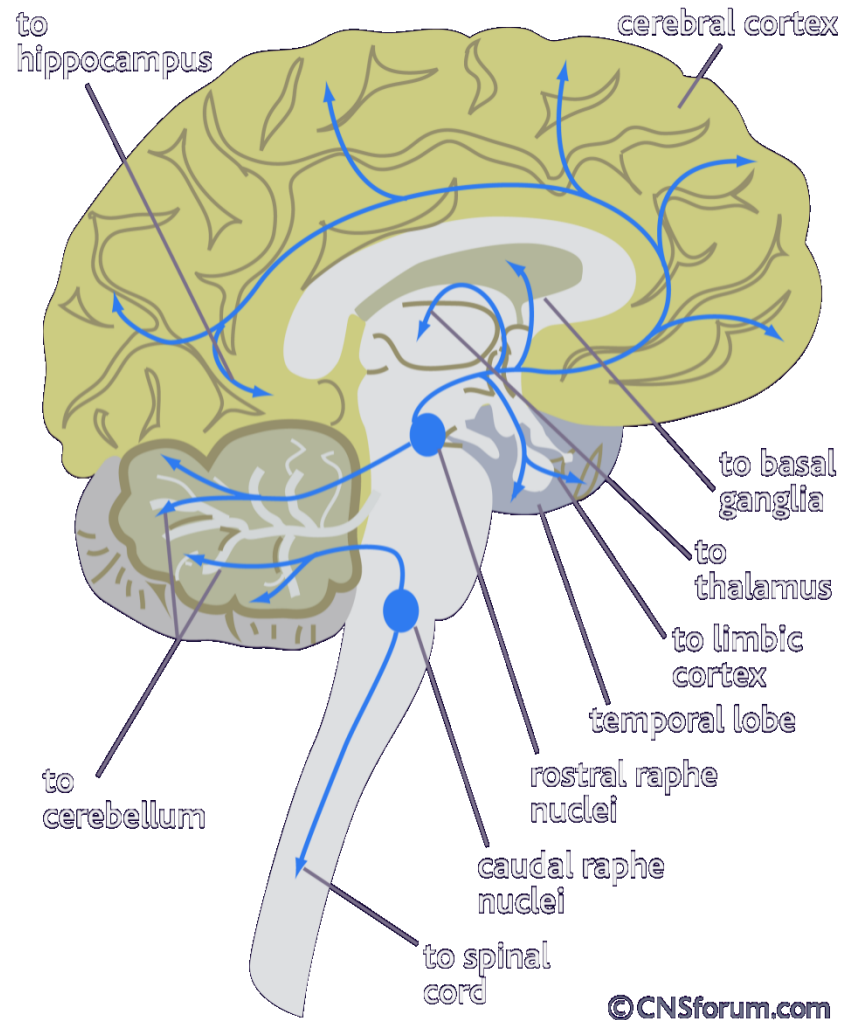
- Nigrostriatal system
 - Movement
 - Sensory stimuli
- Ventro tegmentno-mesolimbic-frontal system
 - Reward
 - Cognitive function
 - Emotional behavior
- Tubero-infundibular system
 - Hypothalamic-pituitary regulation
- D1 receptors – excitatory
- D2 receptors - inhibitory



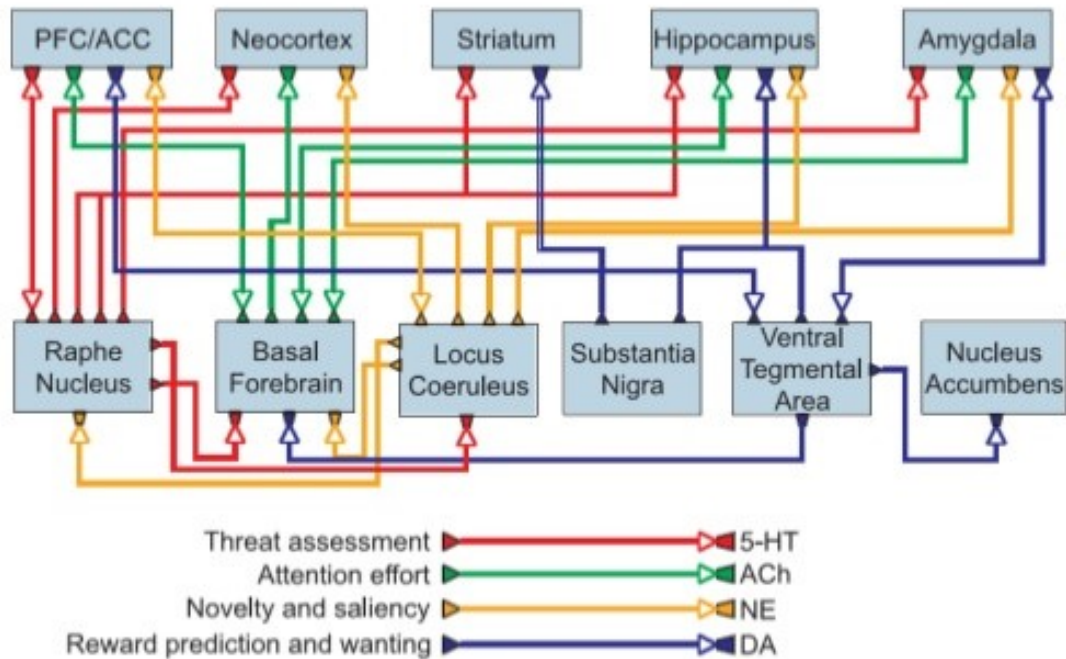
Serotonin

- Nuclei raphe rostralis
- Nuclei raphe caudalis

- Anxiety/relaxation
- Impulsive behavior
- Sleep



Neuromodulatory systems



Jeffrey L. Krichmar, Adaptive Behavior 2008; 16; 385

Neuromodulatory systems

