Synapse and integration of information at the synaptic level

Introduction

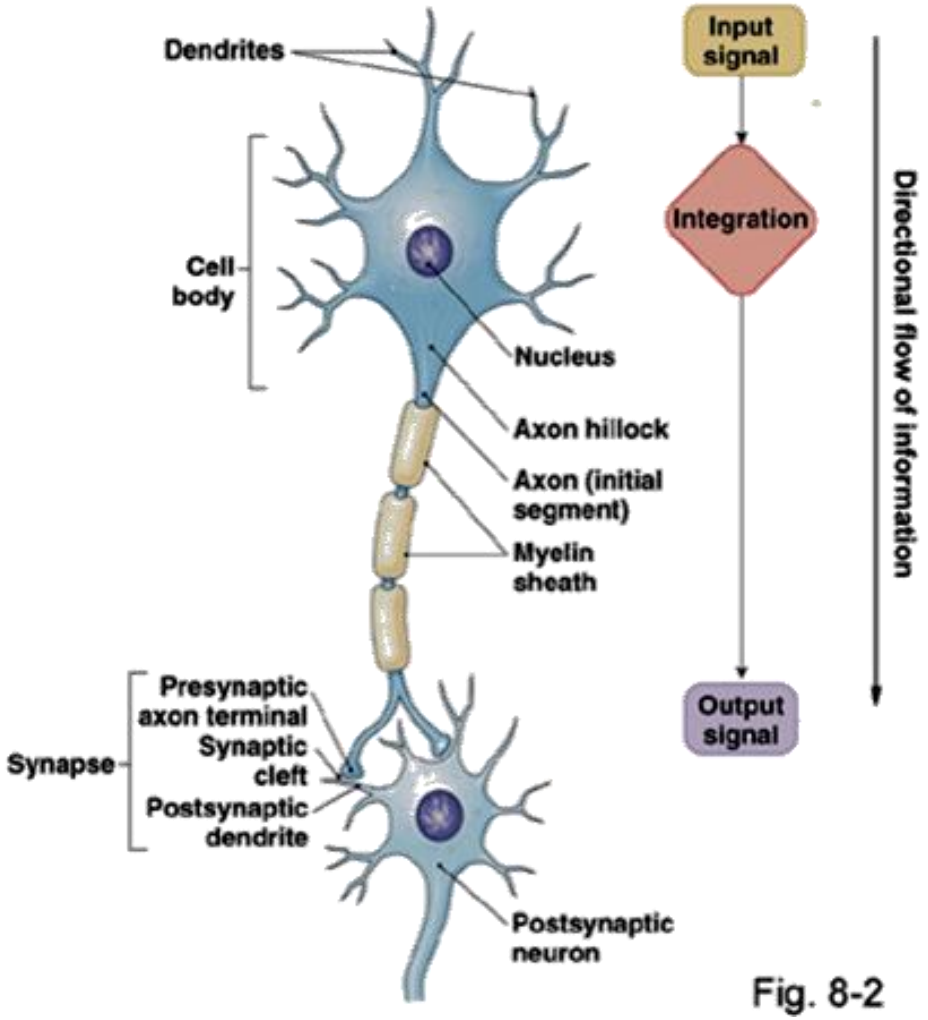
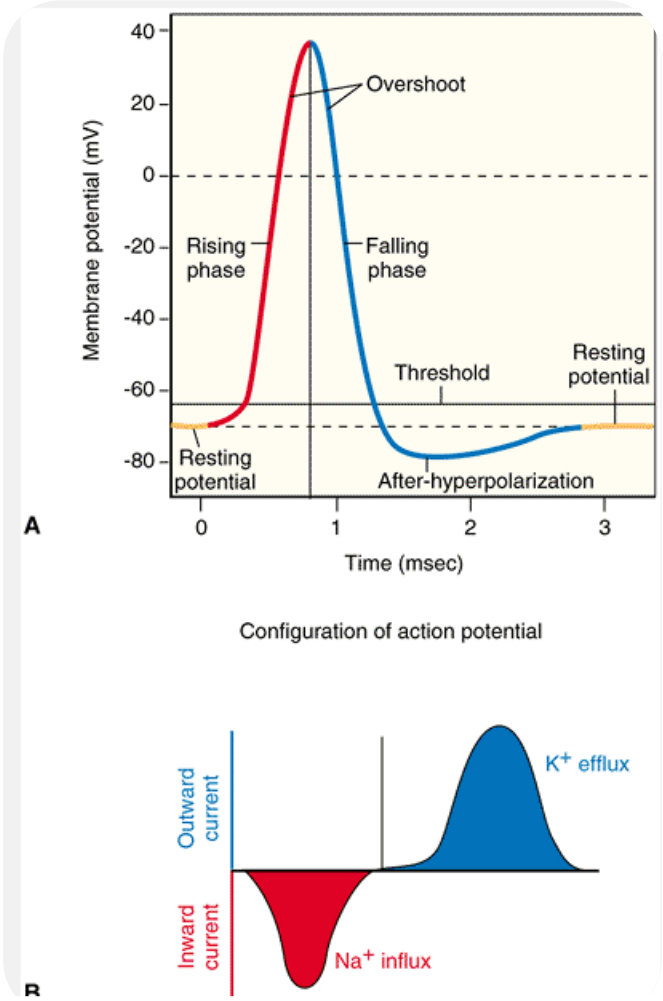


Fig. 8-2

http://www.slideshare.net/CsillaEgri/presentations



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Synapse

- Communication between neurons

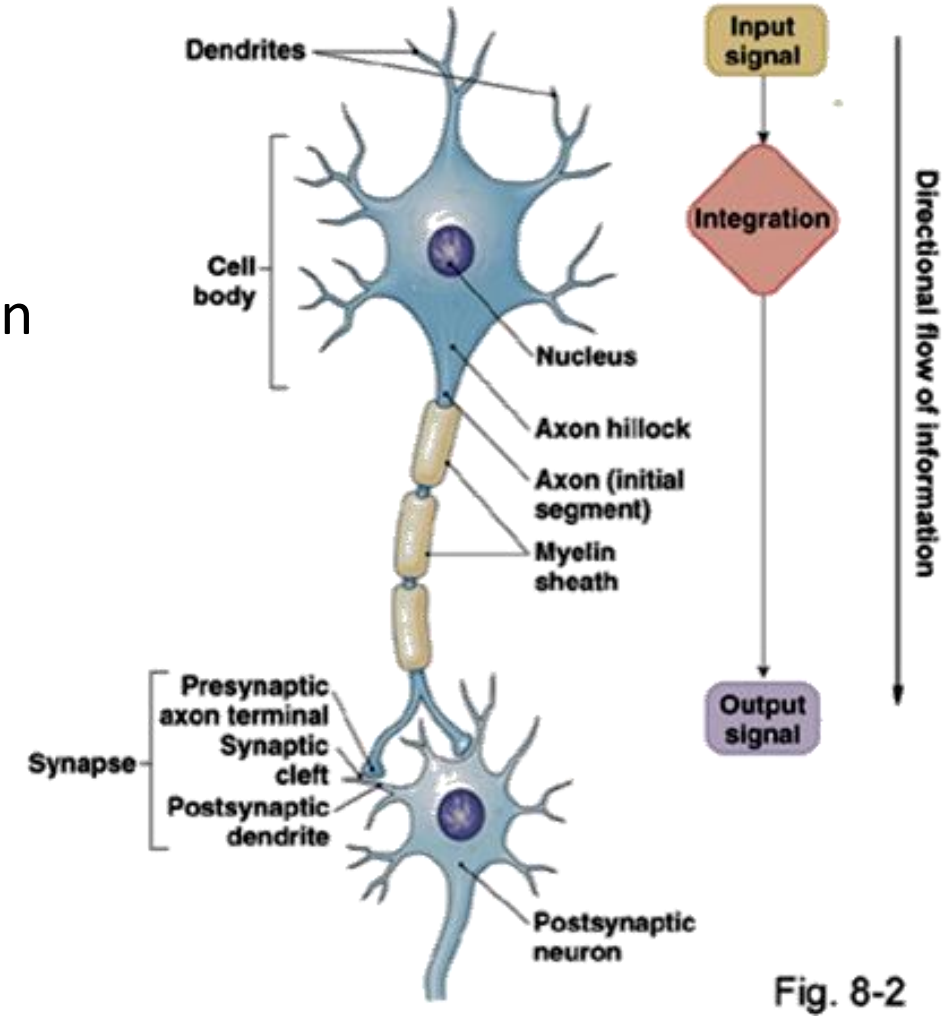

Fig. 8-2

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Synapse

- Communication between neurons

- Electrical
- Chemical

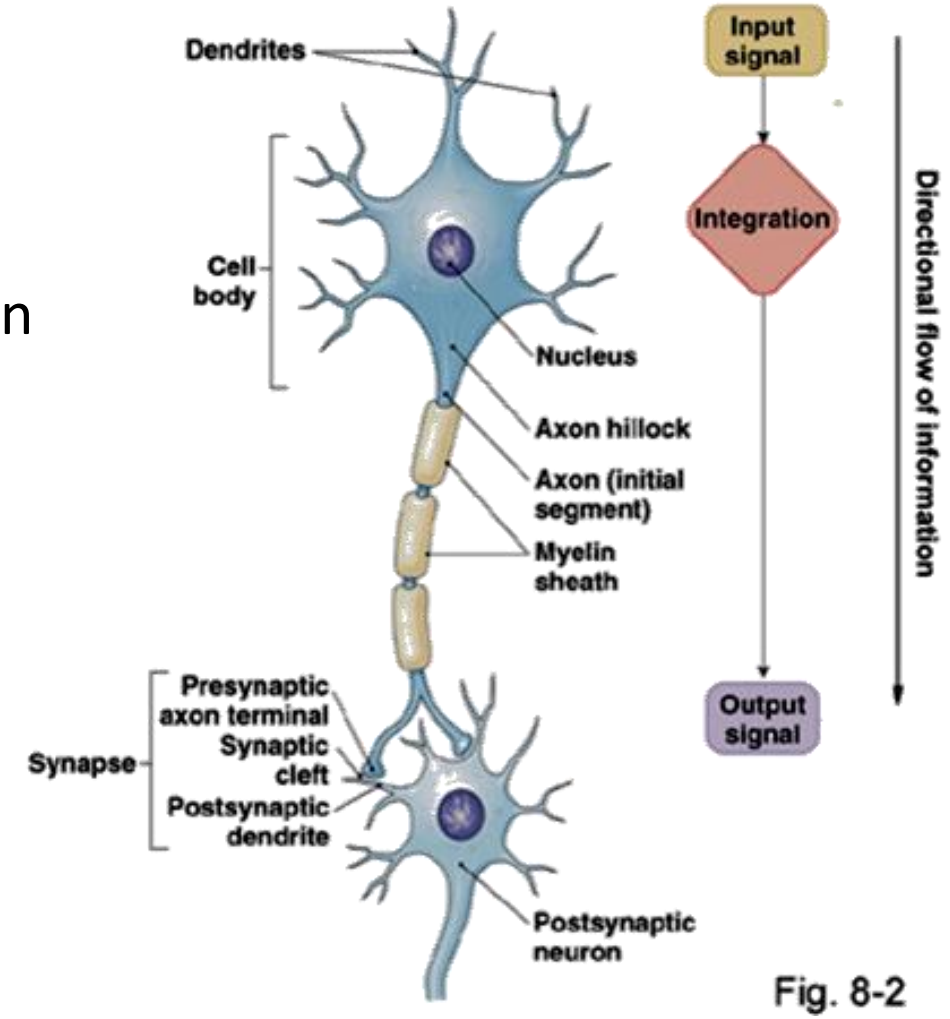
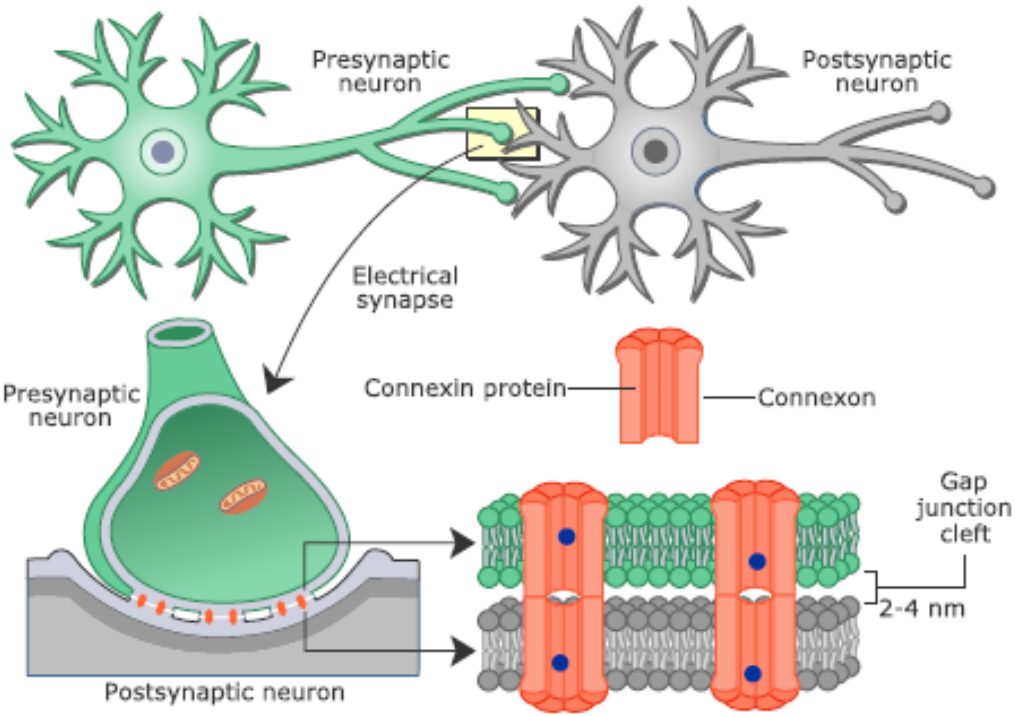


Fig. 8-2

http://www.slideshare.net/CsillaEgri/presentations

Electrical synapse

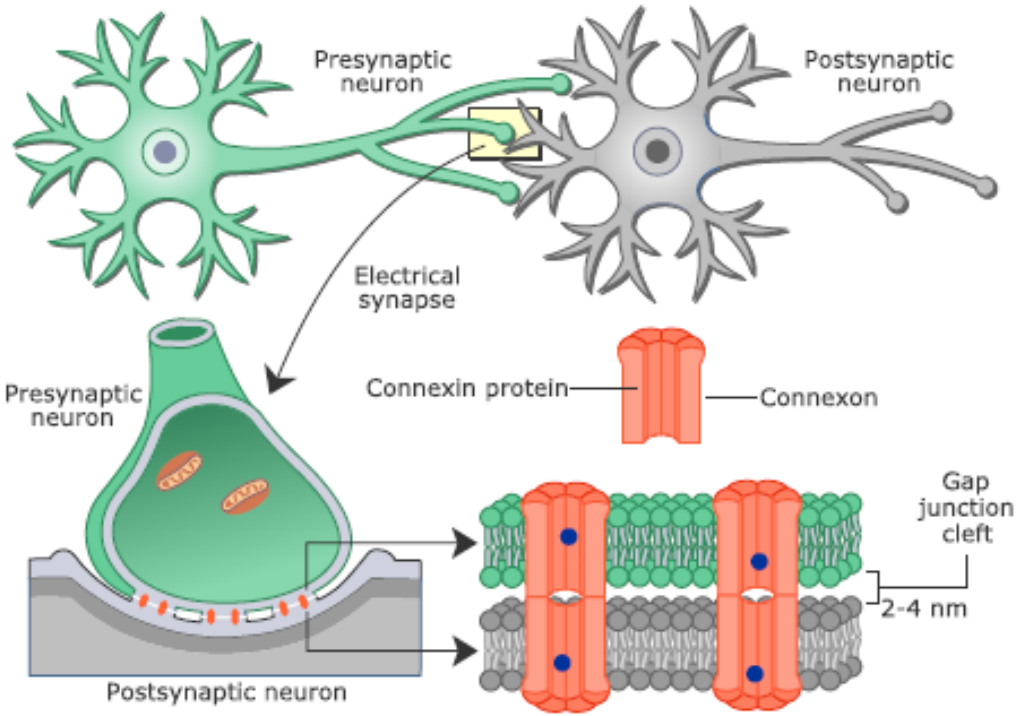
- Evolutionary old
- Less frequent than ch.
- Ubiquitous



Electrical synapse

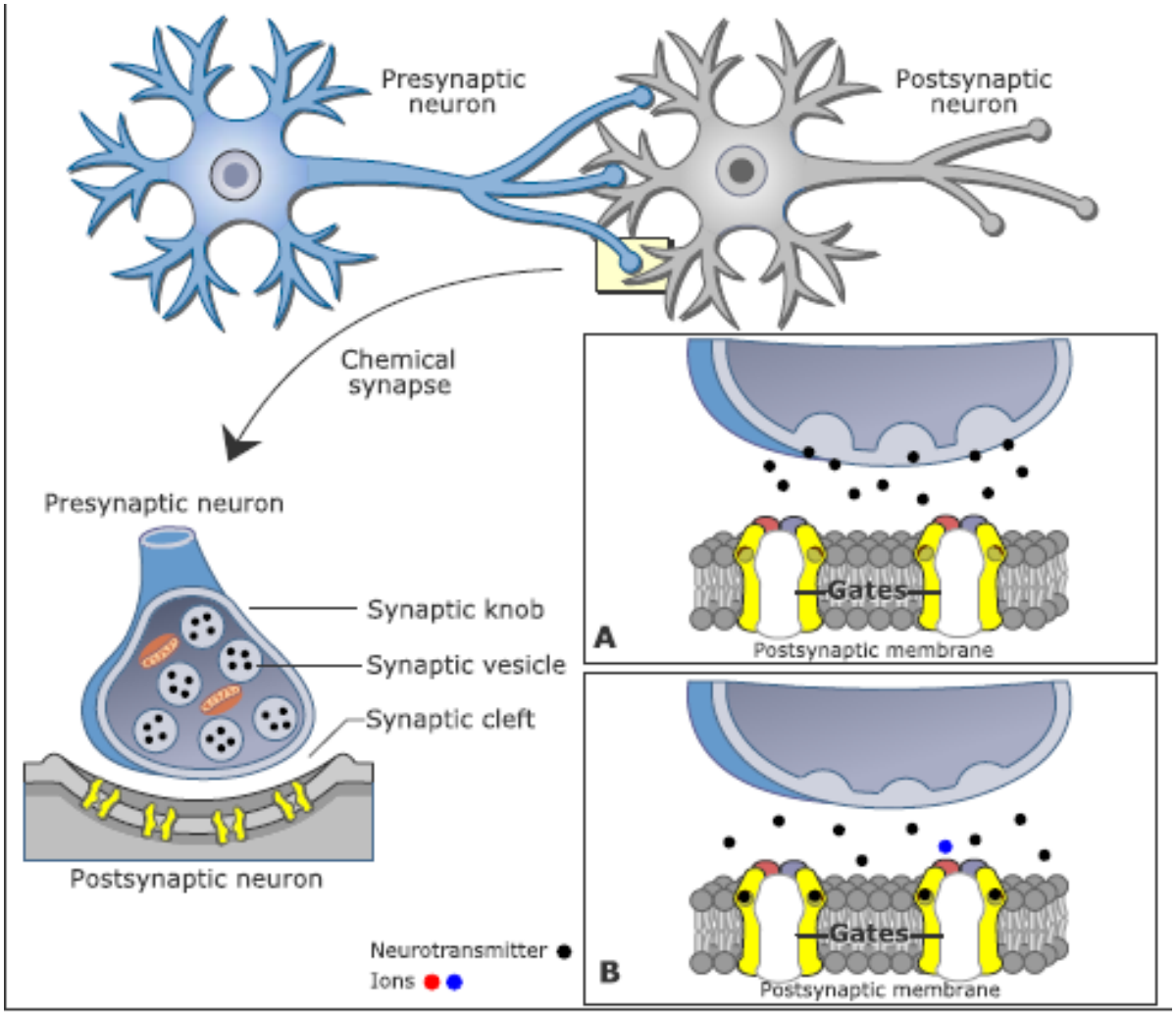
- Evolutionary old
- Less frequent than ch.
- Ubiquitous

- Gap junctions
- Bidirectional transmission
- Fast
- Strength of signal may decrease



Chemical synapse

- Evolutionary young
- Majority type of s.

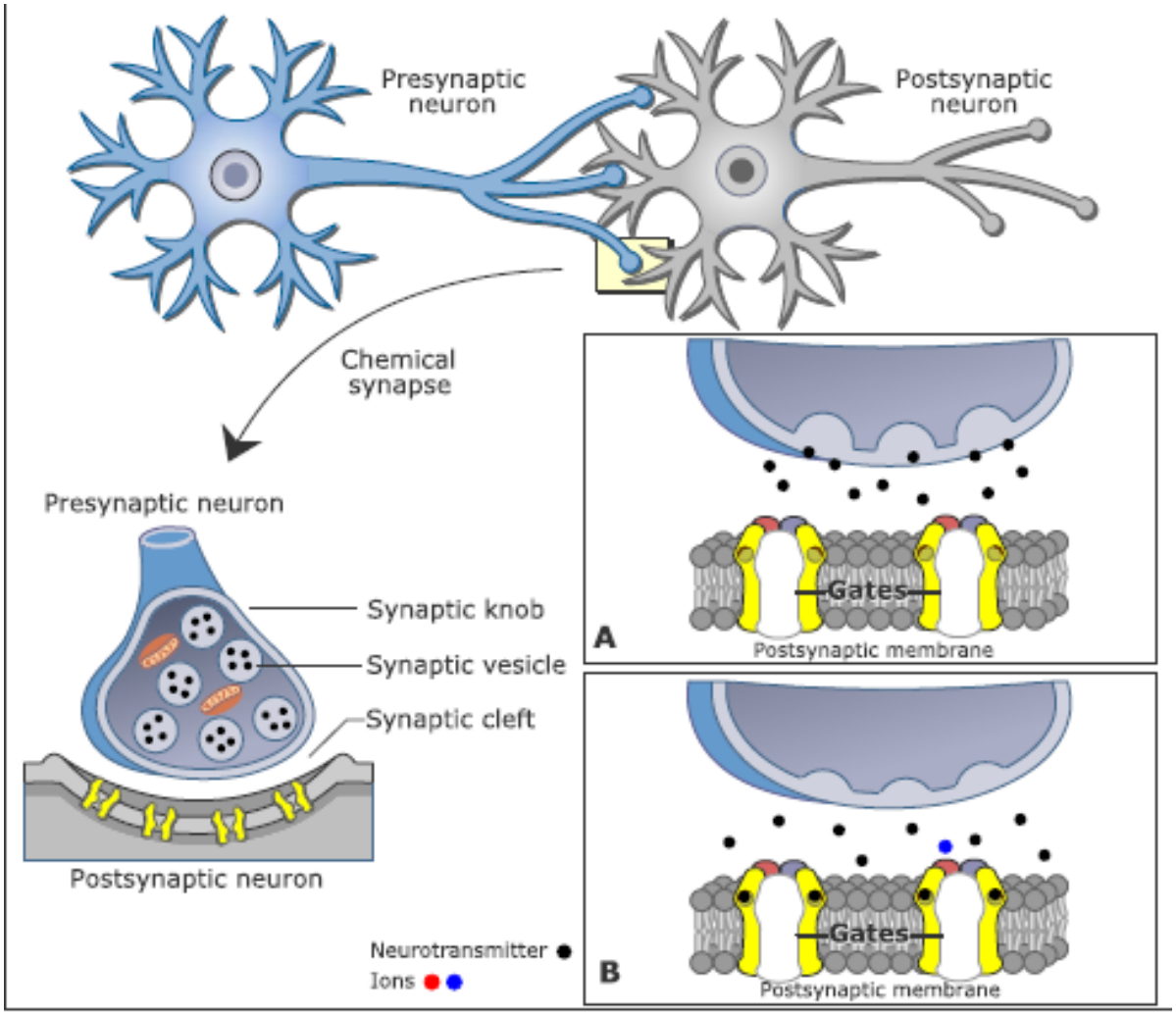


http://www.slideshare.net/CsillaEgri/presentations

Chemical synapse

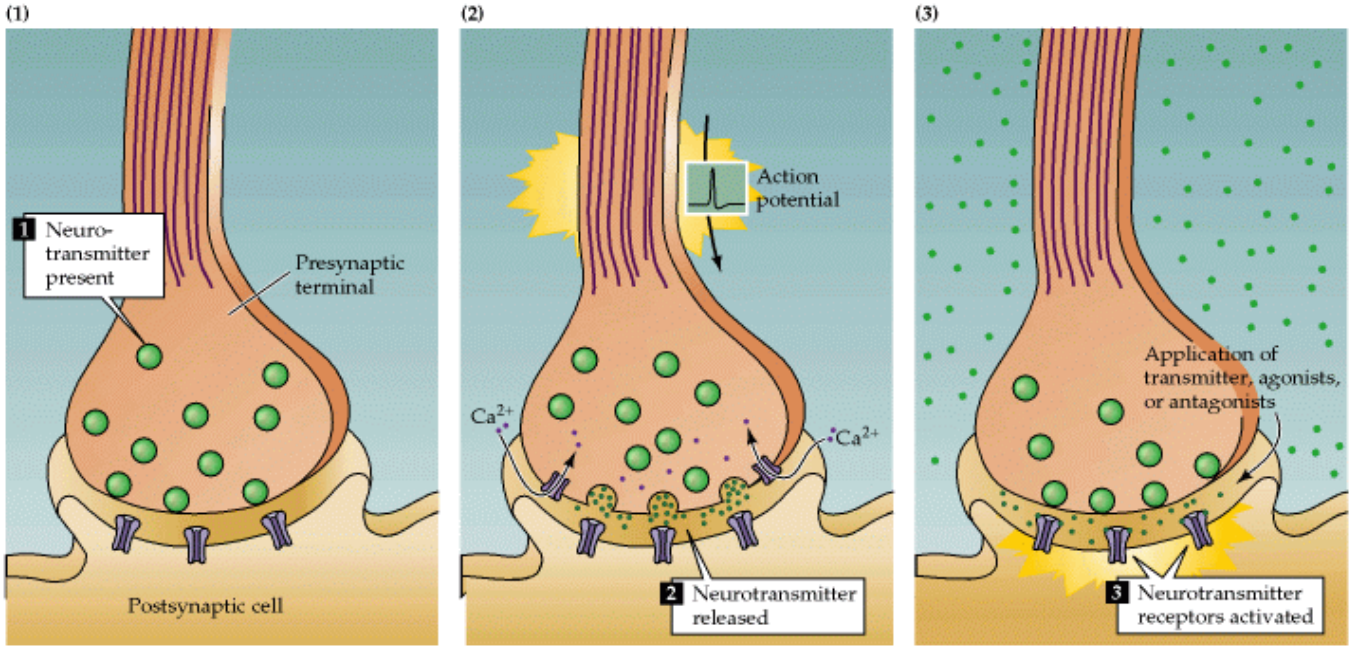
- Evolutionary young
- Majority type of s.

- Unidirectional
- Synaptic cleft
- Neurotransmitter
- Constant signal strength



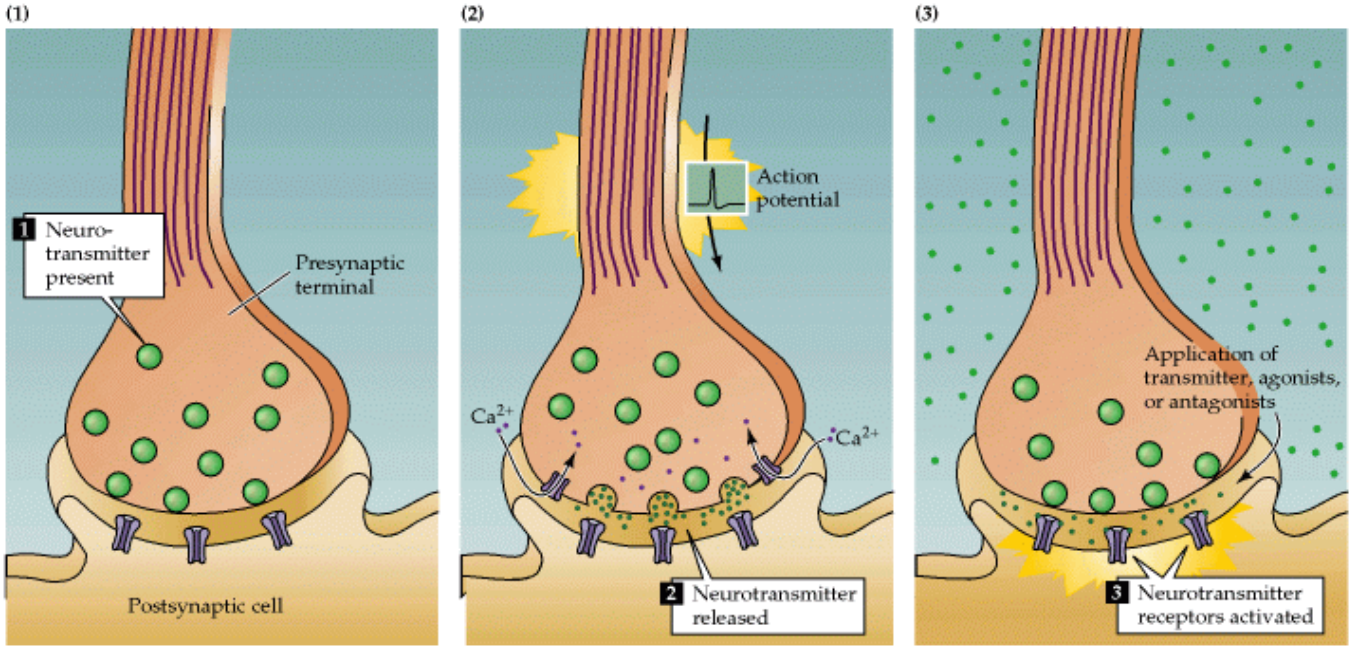
http://www.slideshare.net/CsillaEgri/presentations

Neurotransmitter



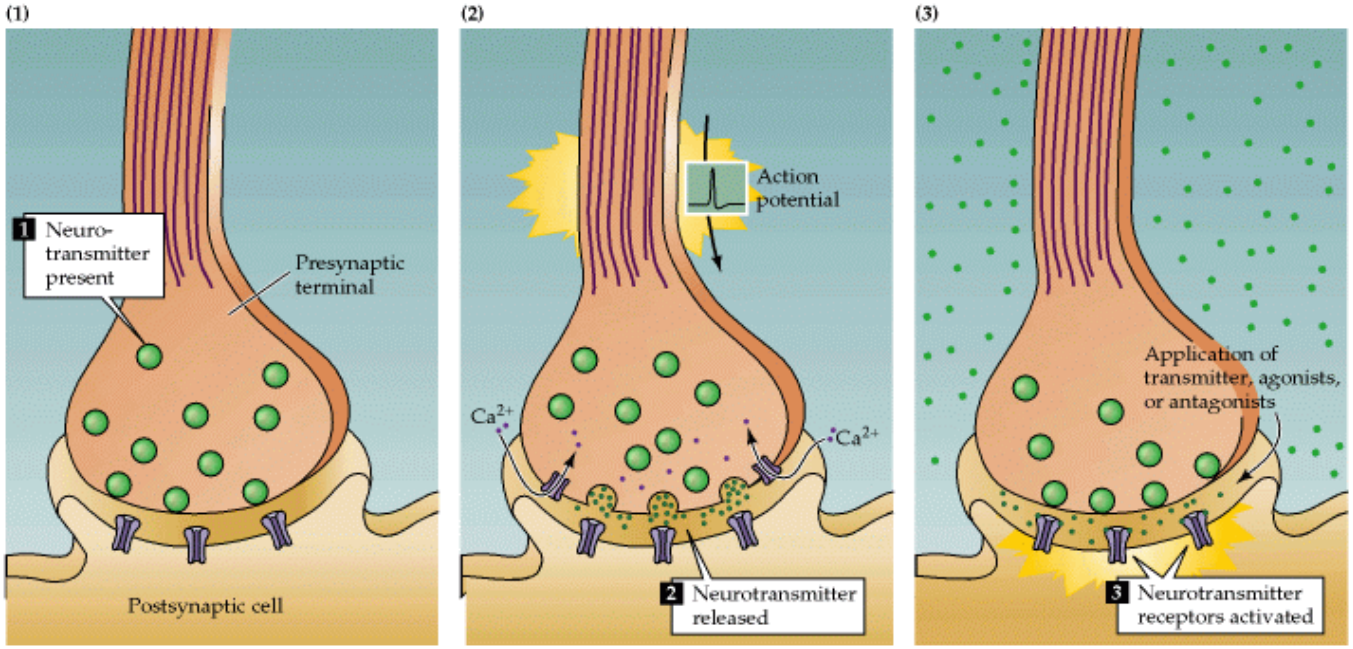
- Present in presynaptic neuron

Neurotransmitter



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

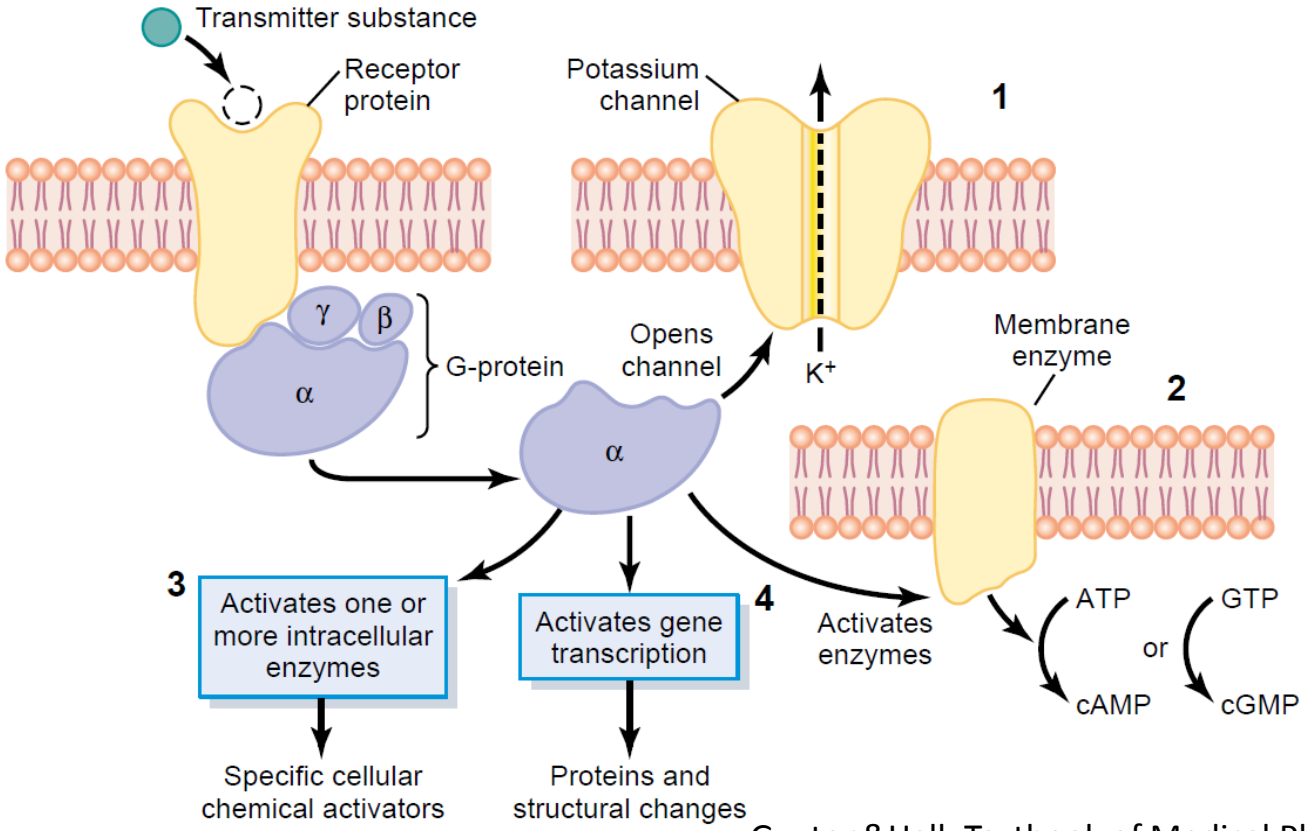
Neurotransmitter



- 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

Neurotransmitter

- Specific receptor has to be present in postsynaptic membrane:
  A. Ionic channel
  B. Second messenger system



Guyton&Hall. Textbook of Medical Physiology, 11th ed.

Neurotrans

Small-Molecule, Rapidly Acting Transmitters

Class I
- Acetylcholine

Class II: The Amines
- Norepinephrine
- Epinephrine
- Dopamine
- Serotonin
- Histamine

Class III: Amino Acids
- Gamma-aminobutyric acid (GABA)
- Glycine
- Glutamate
- Aspartate

Class IV
- Nitric oxide (NO)

Neuropeptide, Slowly Acting Transmitters or Growth Factors

Hypothalamic-releasing hormones
- Thyrotropin-releasing hormone
- Luteinizing hormone–releasing hormone
- Somatostatin (growth hormone inhibitory factor)

Pituitary peptides
- Adrenocorticotropic hormone (ACTH)
- β-Endorphin
- α-Melanocyte-stimulating hormone
- Prolactin
- Luteinizing hormone
- Thyrotropin
- Growth hormone
- Vasopressin
- Oxytocin

Peptides that act on gut and brain
- Leucine enkephalin
- Methionine enkephalin
- Substance P
- Gastrin
- Cholecystokinin
- Vasoactive intestinal polypeptide (VIP)
- Nerve growth factor
- Brain-derived neurotropic factor
- Neurotensin
- Insulin
- Glucagon

From other tissues
- Angiotensin II
- Bradykinin
- Carnosine
- Sleep peptides
- Calcitonin

Guyton&Hall. Textbook of Medical Physiology, 11th ed.

Neurotransmitter

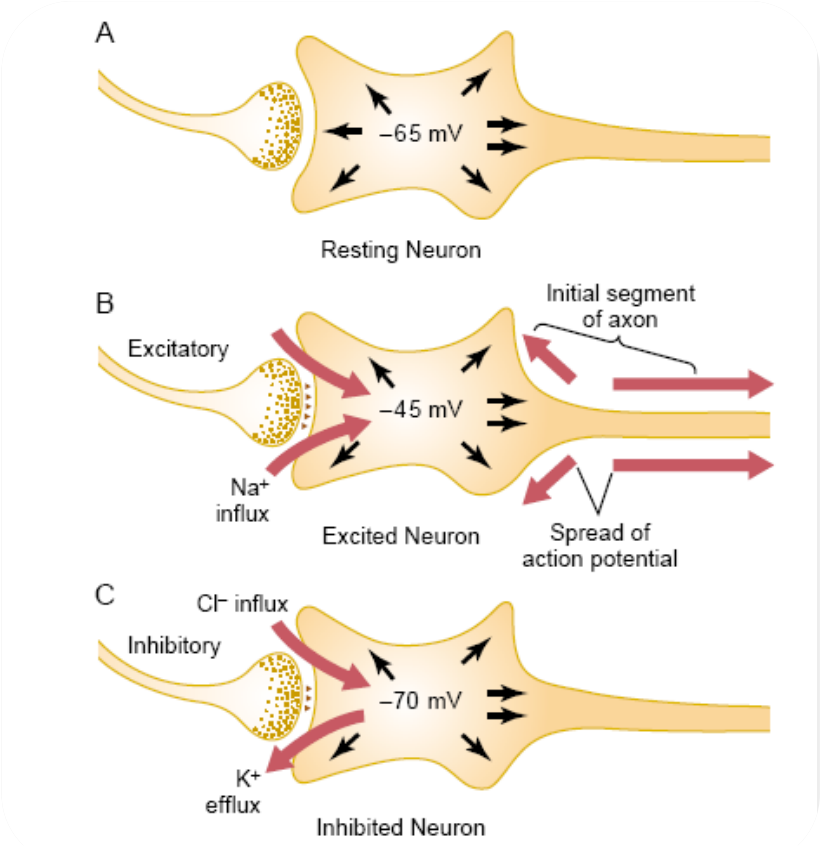
- Specific receptor has to be present in postsynaptic membrane:

A. Ionic channel
B. Second messenger system

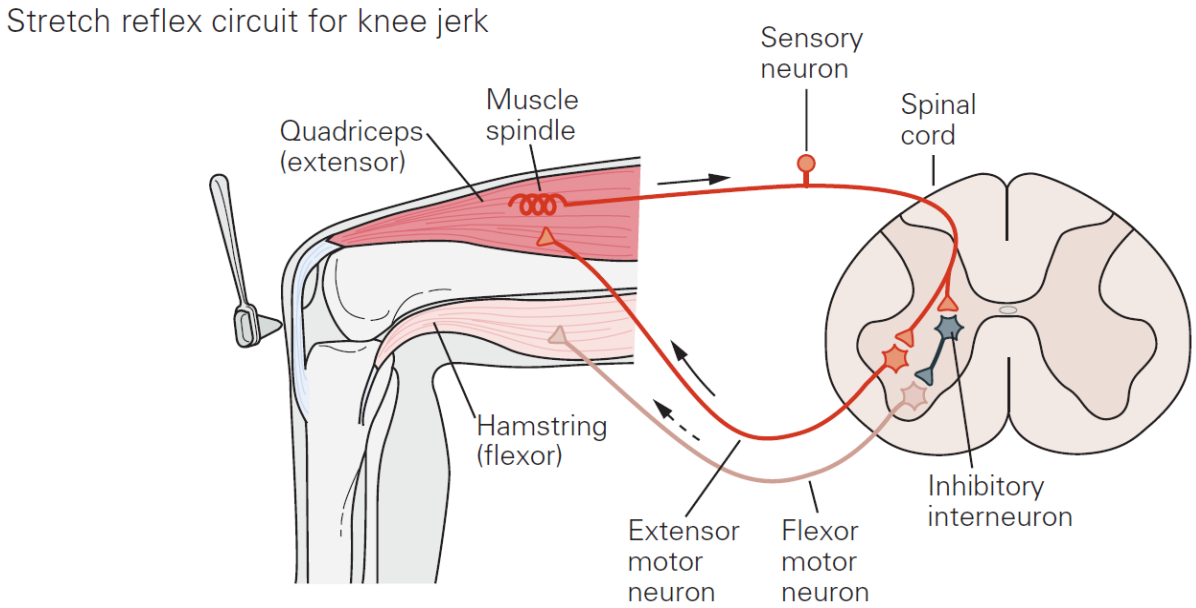
1) Excitatory transmitters
   - opening of sodium channels
   - decreased conduction through chloride and/or potassium channels
   - changes in internal metabolism of the postsynaptic neuron exciting cell activity

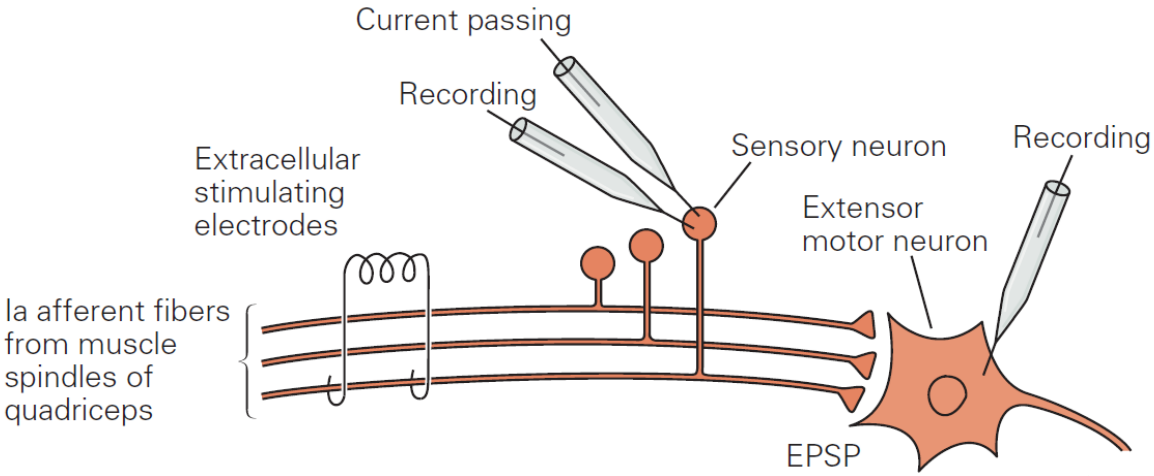
2) Inhibitory transmitters
   - opening of chloride channels
   - increased conduction through potassium channels
   - changes in internal metabolism of the postsynaptic neuron decreasing cell activity

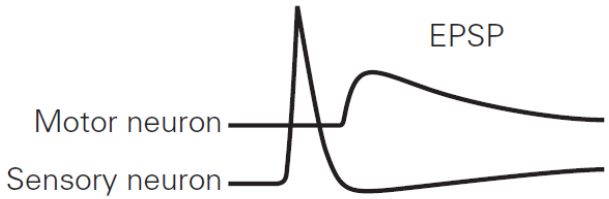
Excitatory/inhibitory postsynaptic potential



Excitatory/inhibitory postsynaptic potential

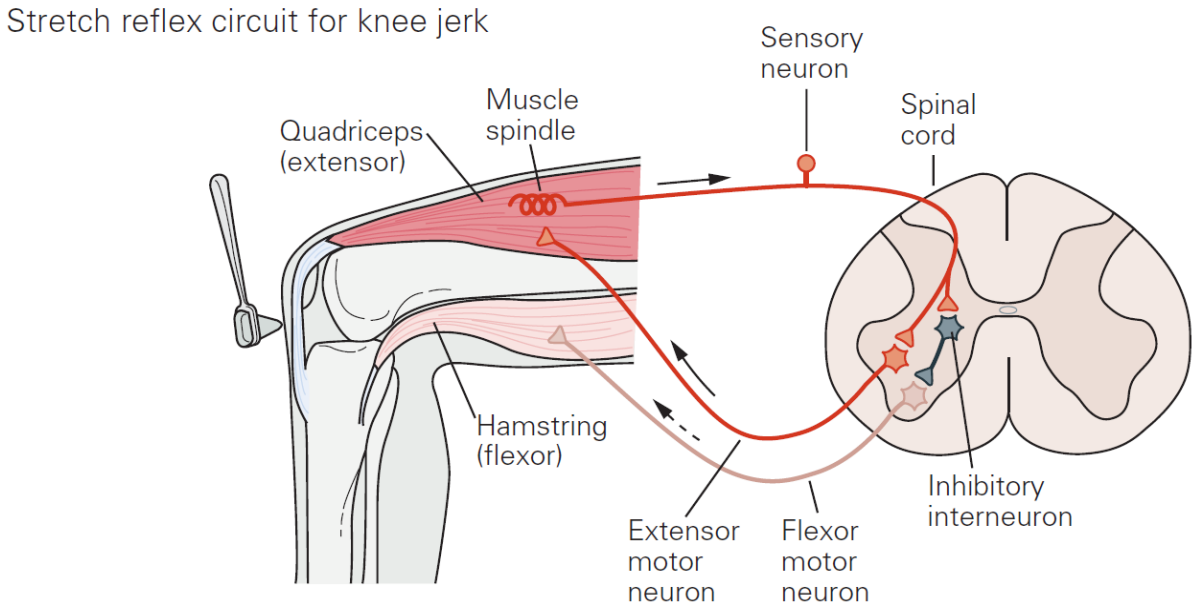


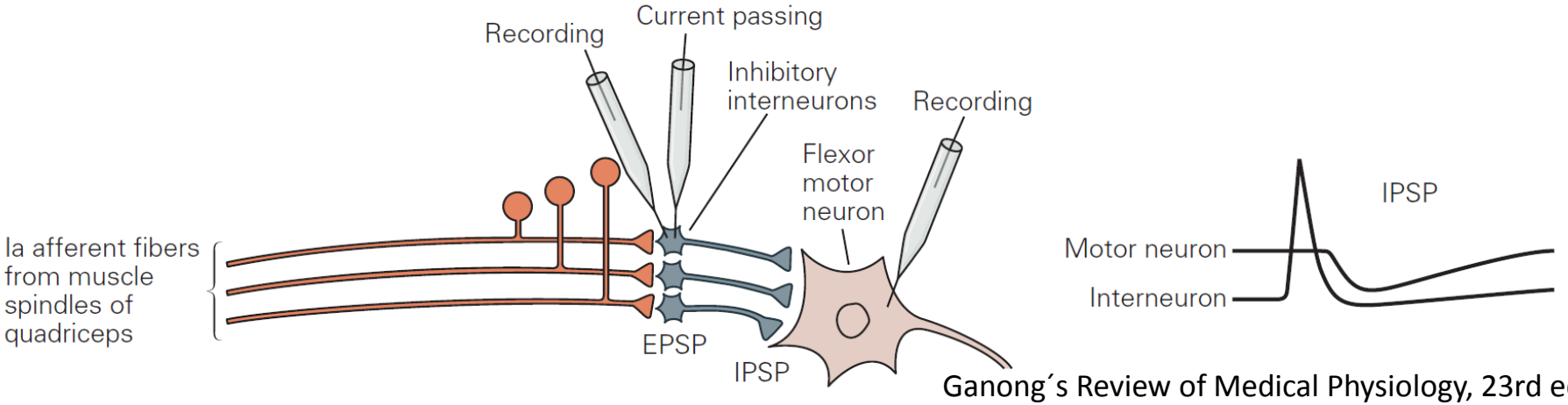




Ganong´s Review of Medical Physiology, 23rd ed.

Excitatory/inhibitory postsynaptic potential

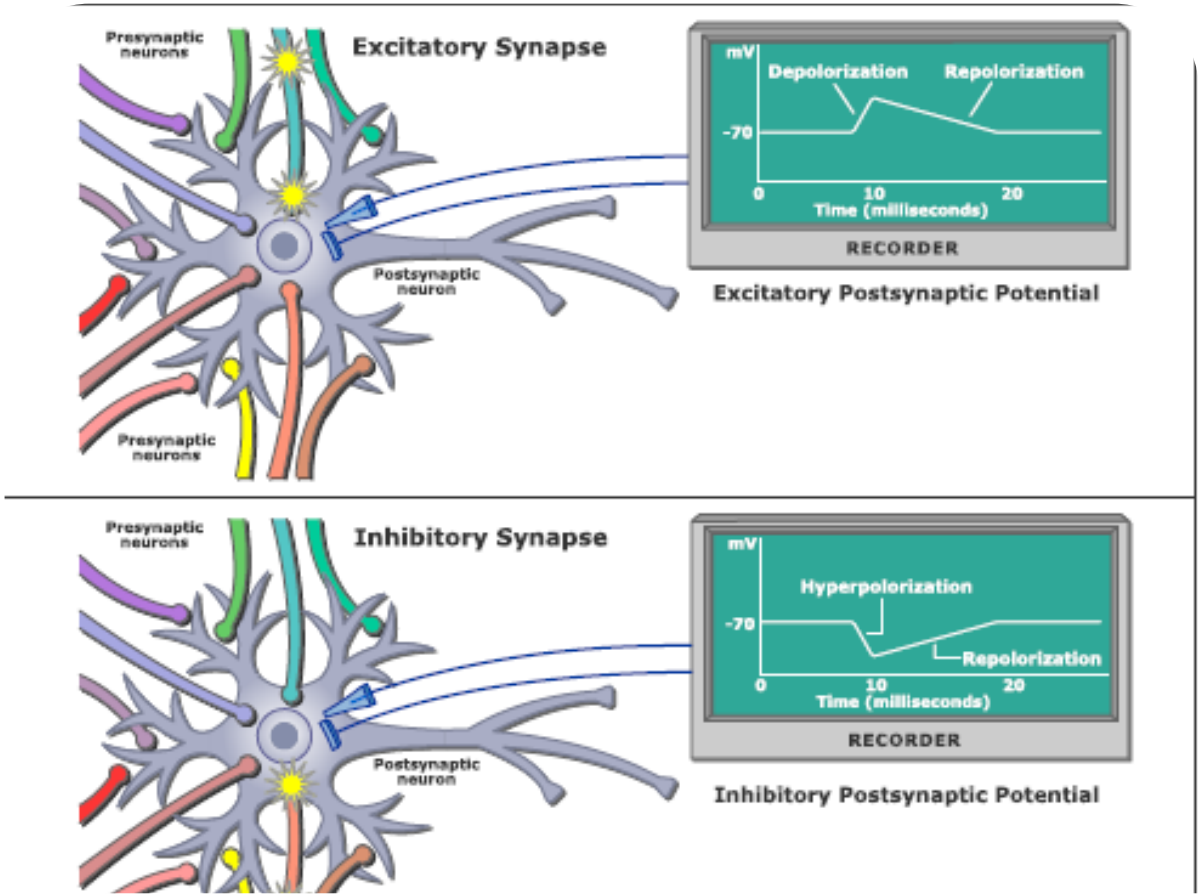




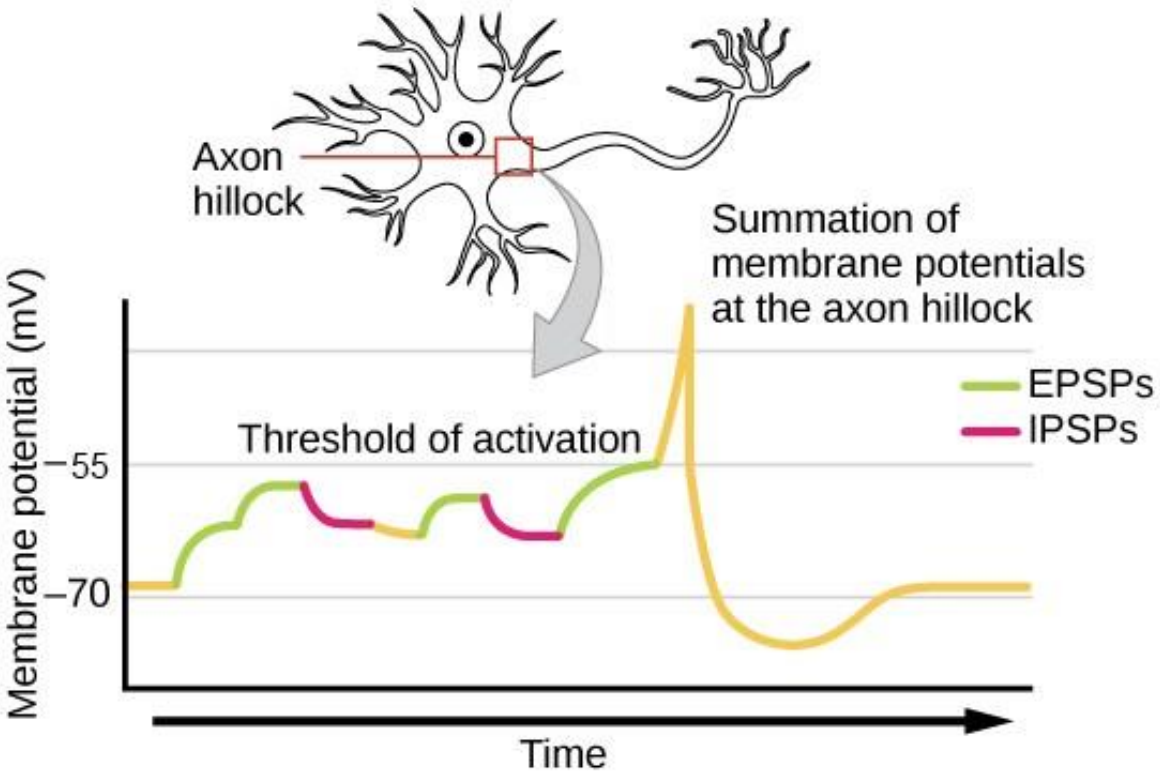
Ganong´s Review of Medical Physiology, 23rd ed.

Signal summation

- Temporal
- Spatial



Signal summation



http://www.geon.us/Memory/images/Summation.jpg

Synaptic convergence

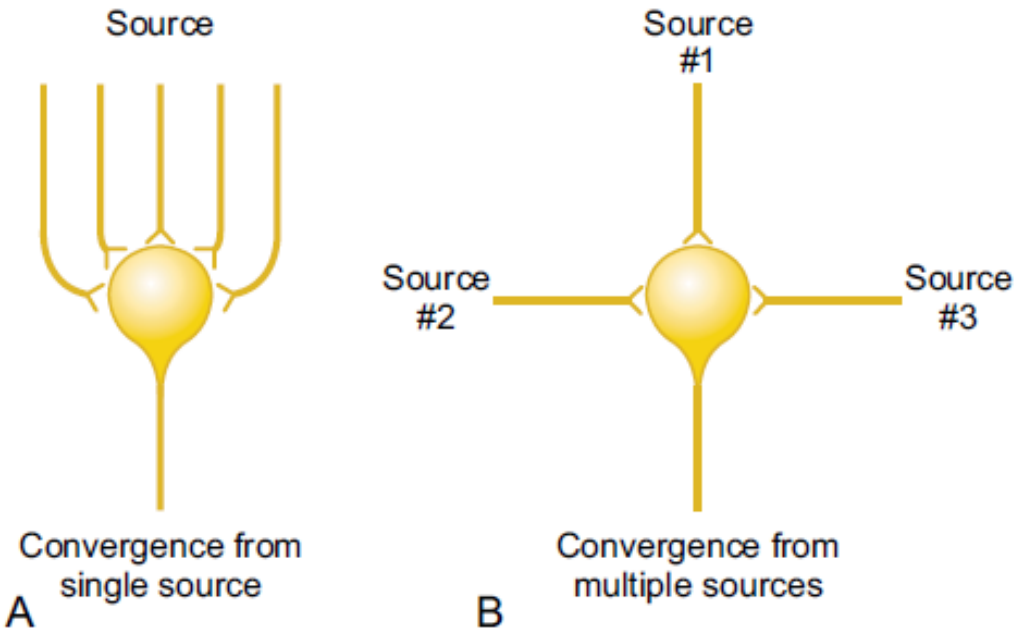


Figure 46–12

"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

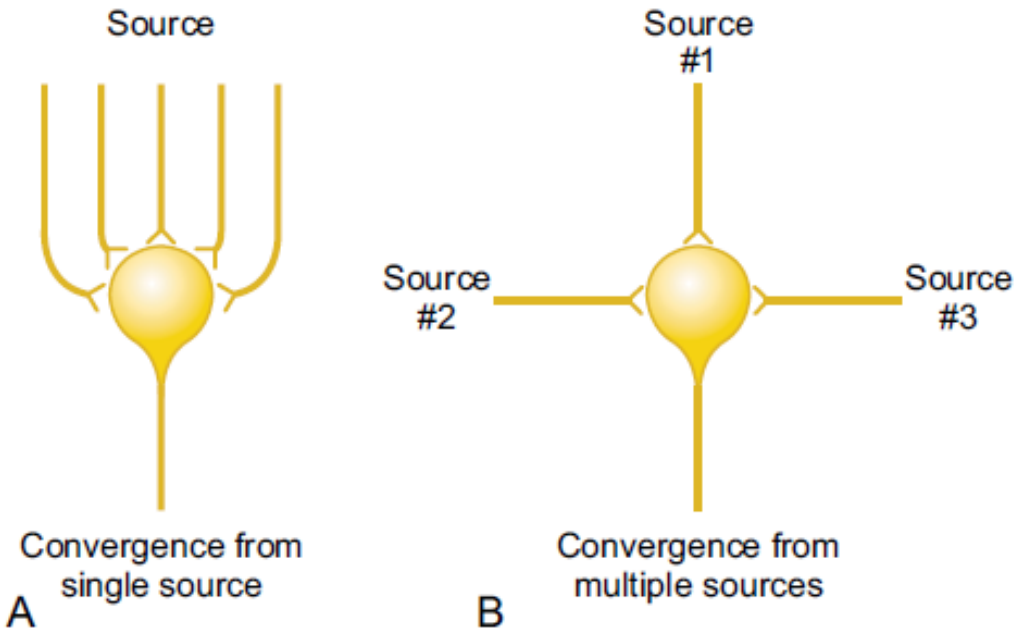


Figure 46–12

"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

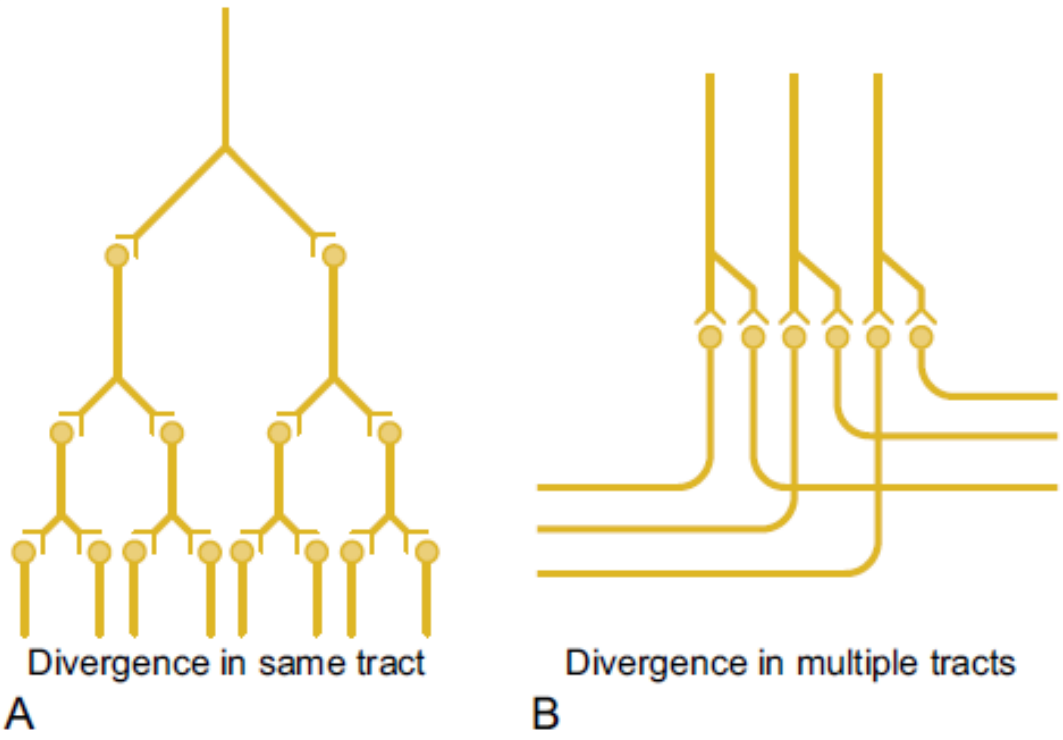
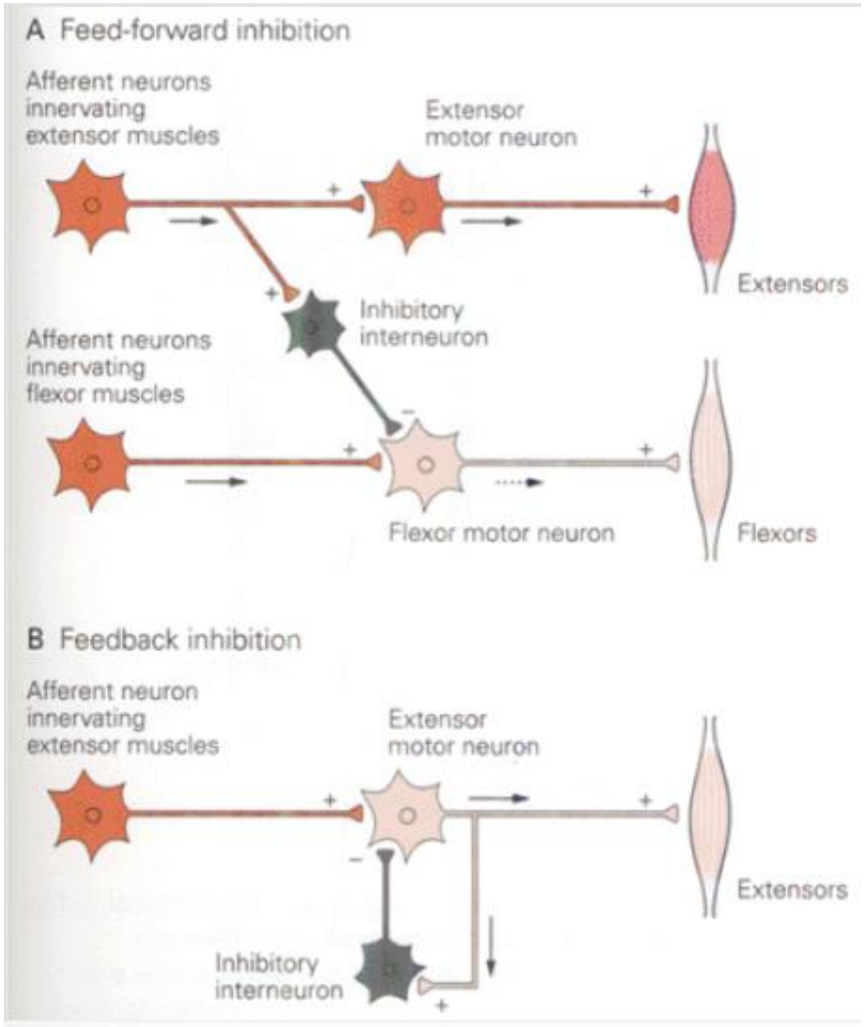


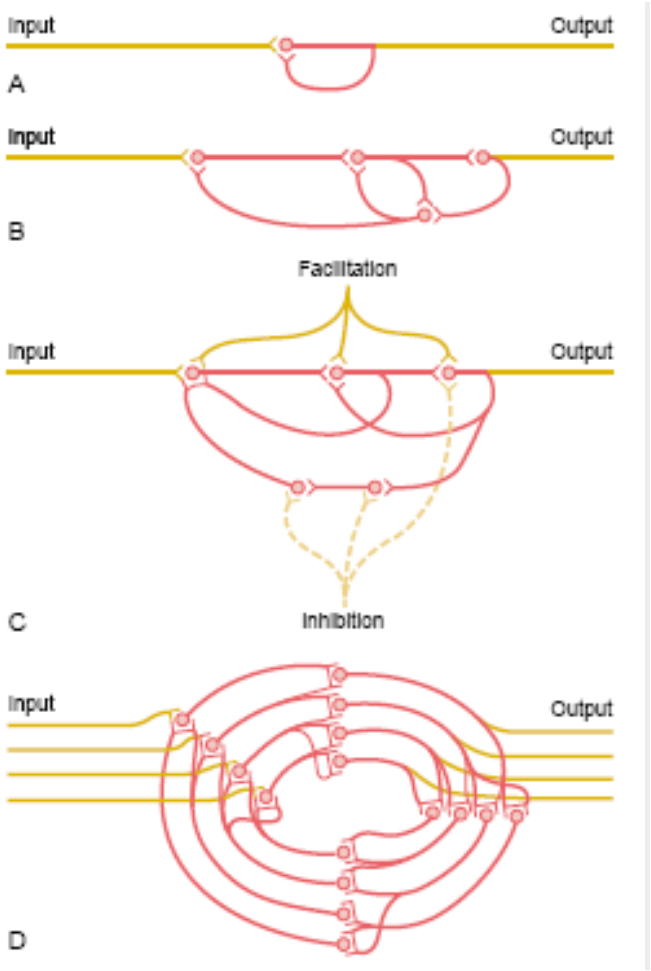
Figure 46–11

"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

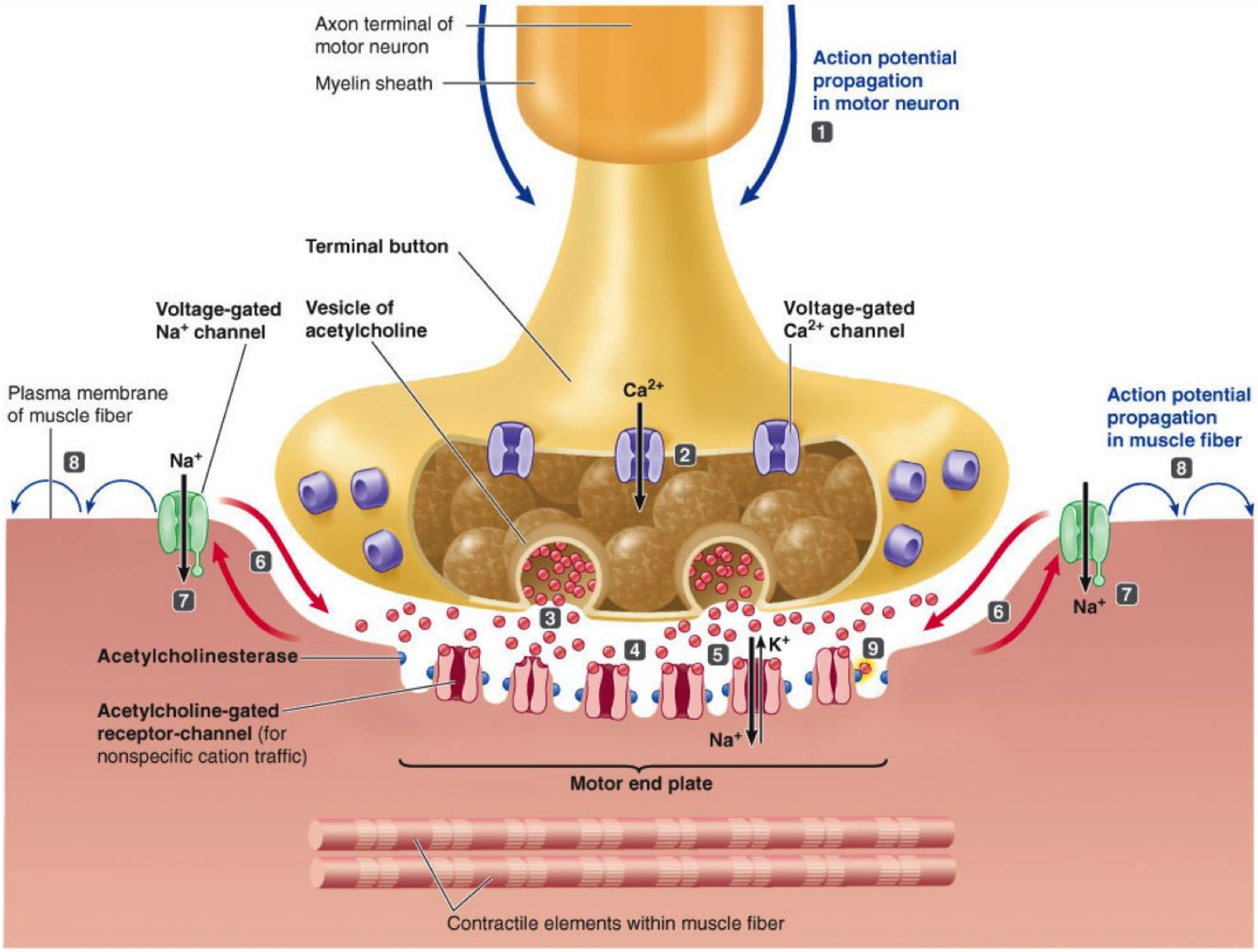

A Feed-forward inhibition
Afferent neurons innervating extensor muscles
Extensor motor neuron
Extensors
Inhibitory interneuron
Afferent neurons innervating flexor muscles
Flexor motor neuron
Flexors
B Feedback inhibition
Afferent neuron innervating extensor muscles
Extensor motor neuron
Extensors
Inhibitory interneuron

Networking



http://www.slideshare.net/drpsdeb/presentations

Neuromuscular junction



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Neurotransmission vs. Neuromodulation

Neurotransmission vs. Neuromodulation

- Information transmission
- Regulation of NS activity

Neurotransmission vs. Neuromodulation

- Information transmission
- Specific

- Regulation of NS activity
- Difuse (volume transmission)

Neurotransmission vs. Neuromodulation

- Information transmission
- Specific
- Receptors – ion channels

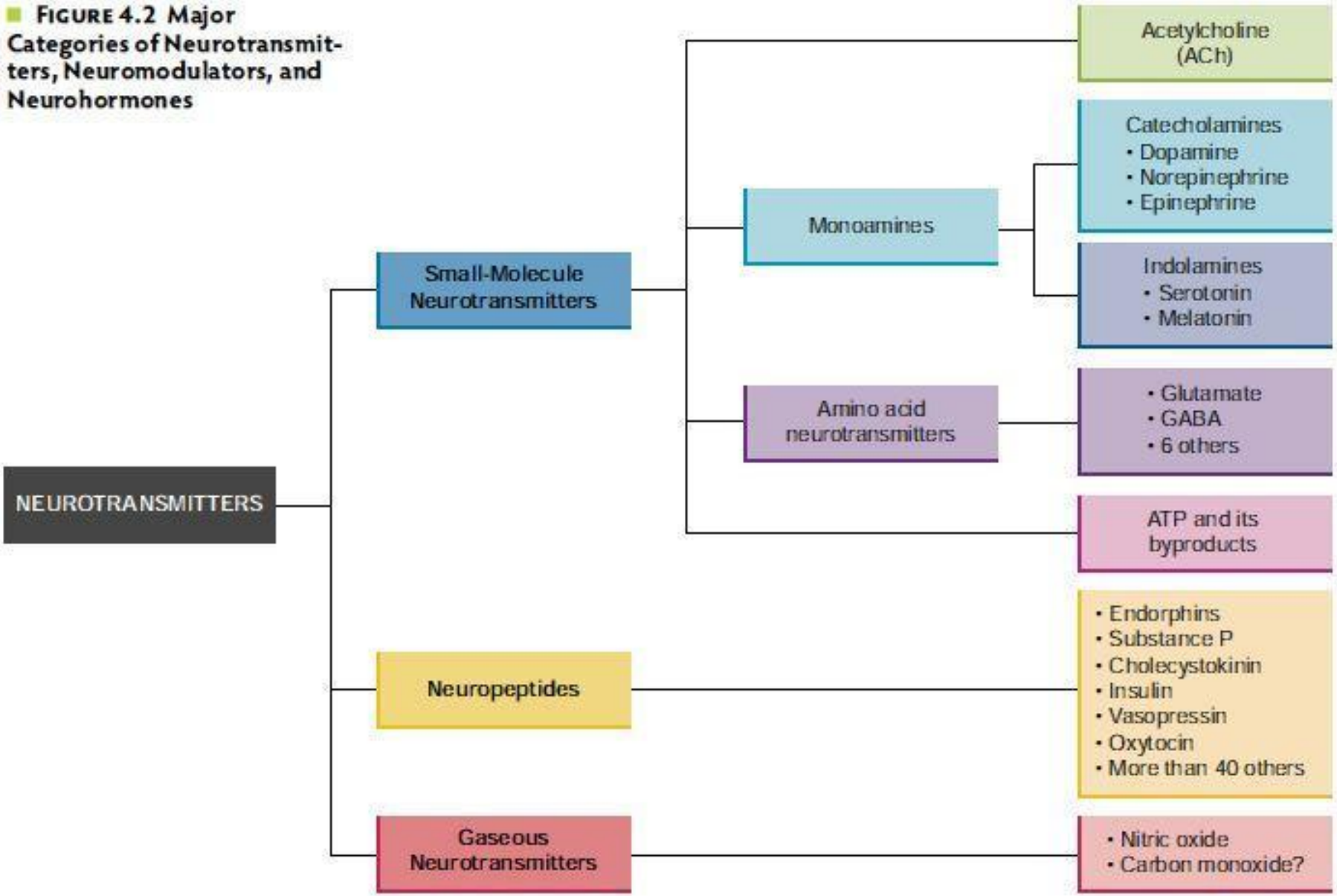
- Regulation of NS activity
- Difuse (volume transmission)
- Receptors – G-proteins

Neurotransmission vs. Neuromodulation

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

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

FIGURE 4.2 Major Categories of Neurotransmitters, Neuromodulators, and Neurohormones



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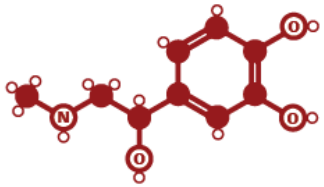
THE STRUCTURES OF NEUROTRANSMITTERS

STRUCTURE KEY: Carbon atom · Hydrogen atom · O Oxygen atom · N Nitrogen atom · R 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.

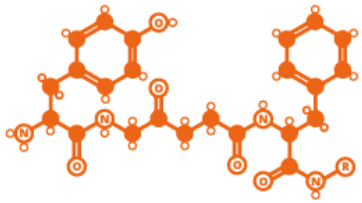
ACETYLCHOLINE
Learning neurotransmitter

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

GLUTAMATE
Memory neurotransmitter

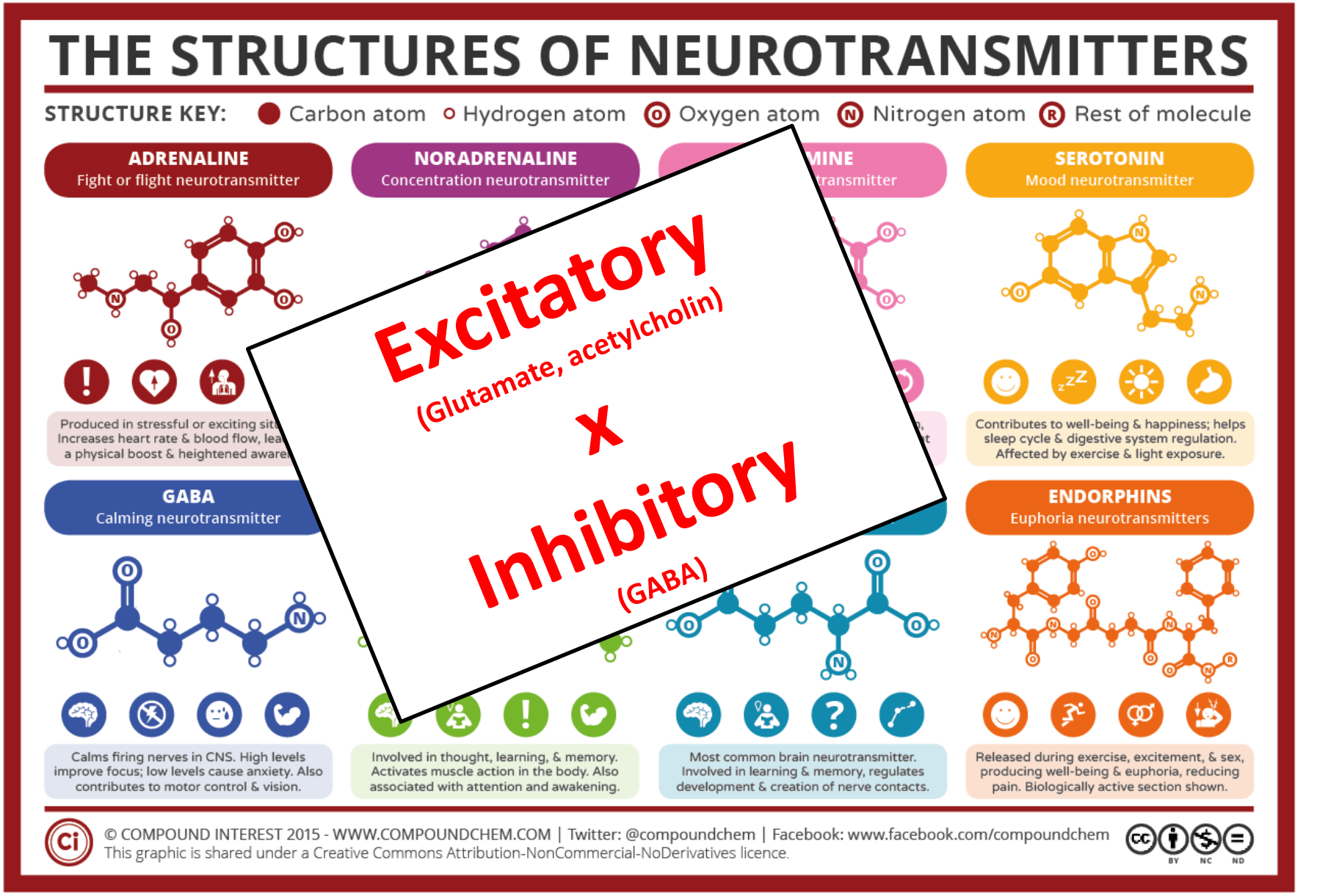
Most common brain neurotransmitter. Involved in learning & memory, regulates development & creation of nerve contacts.

ENDORPHINS
Euphoria neurotransmitters



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

http://www.compoundchem.com/2015/07/30/neurotransmitters/

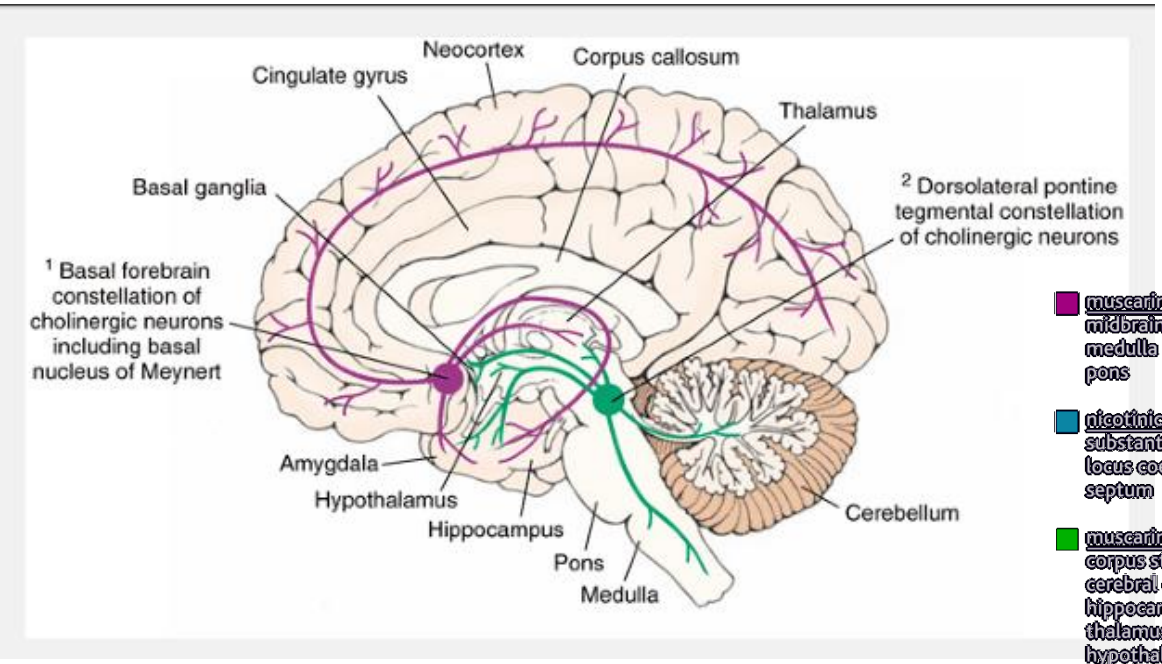


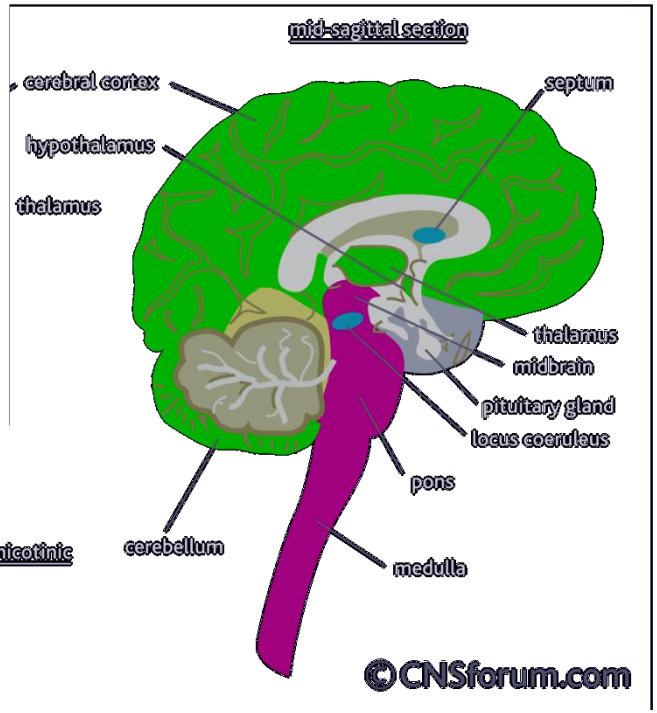
http://www.compoundchem.com/2015/07/30/neurotransmitters/

Acetylcholin

- Nucleus basalis (Meynerti) abd other nuclei
- Nicotin receptors
- Muscarin receptors

- Sleep/wake regulation
- Cognitive functions
- Behavior
- Emotions





muscarinic
midbrain
medulla
pons

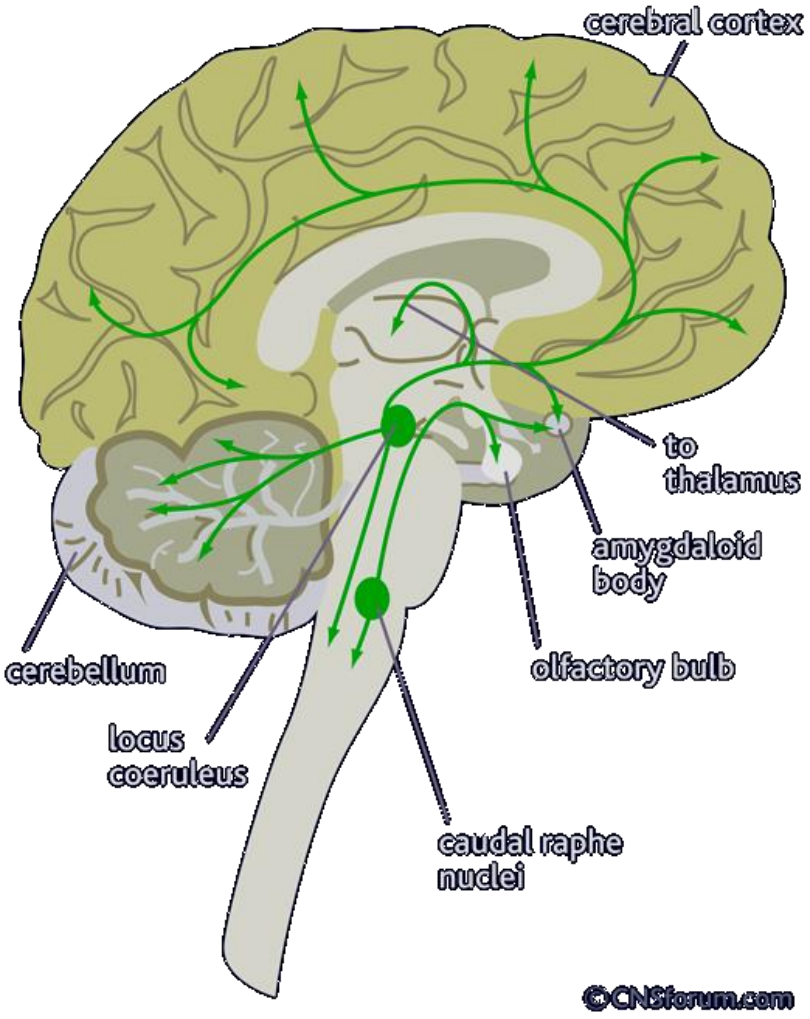
nicotinic
substantia nigra
locus coeruleus
septum

muscarinic and nicotinic
corpus striatum
cerebral cortex
hippocampus
thalamus
hypothalamus
cerebellum

Noradrenalin

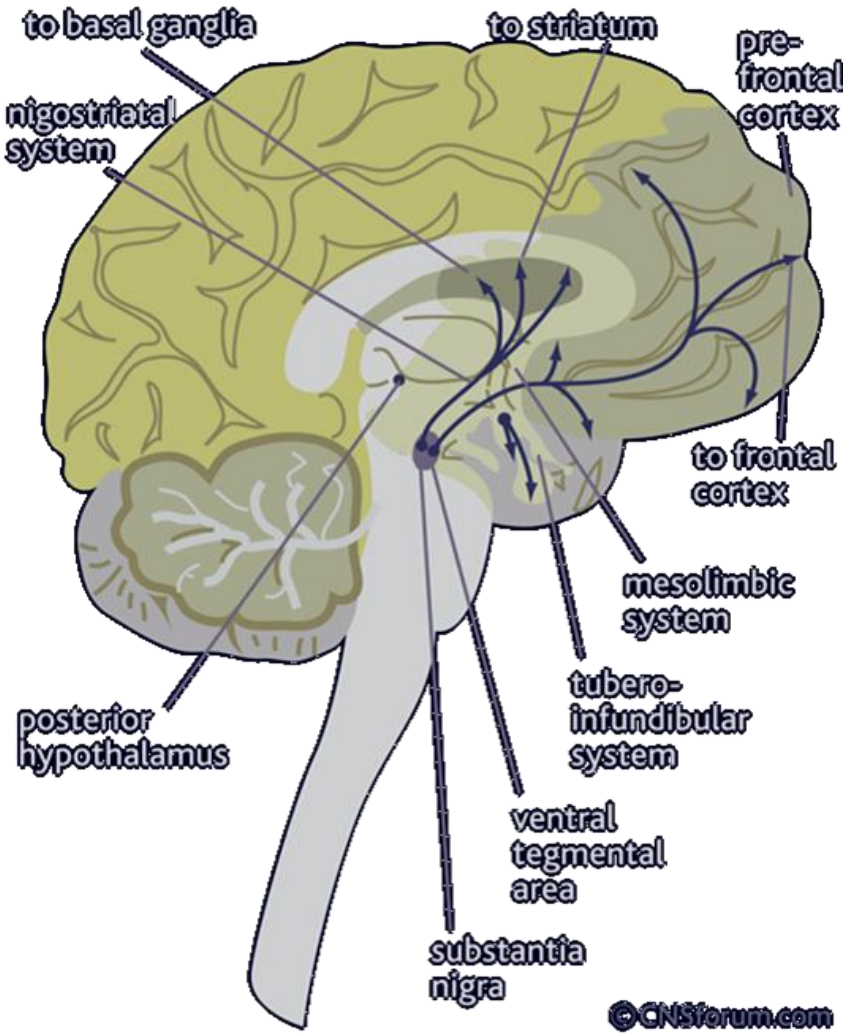
- Locus coeruleus
- Nuclei raphe caudalis

- Vigilance
- Responsiveness to unexpected stimuli
- Memory
- Learning



Dopamin

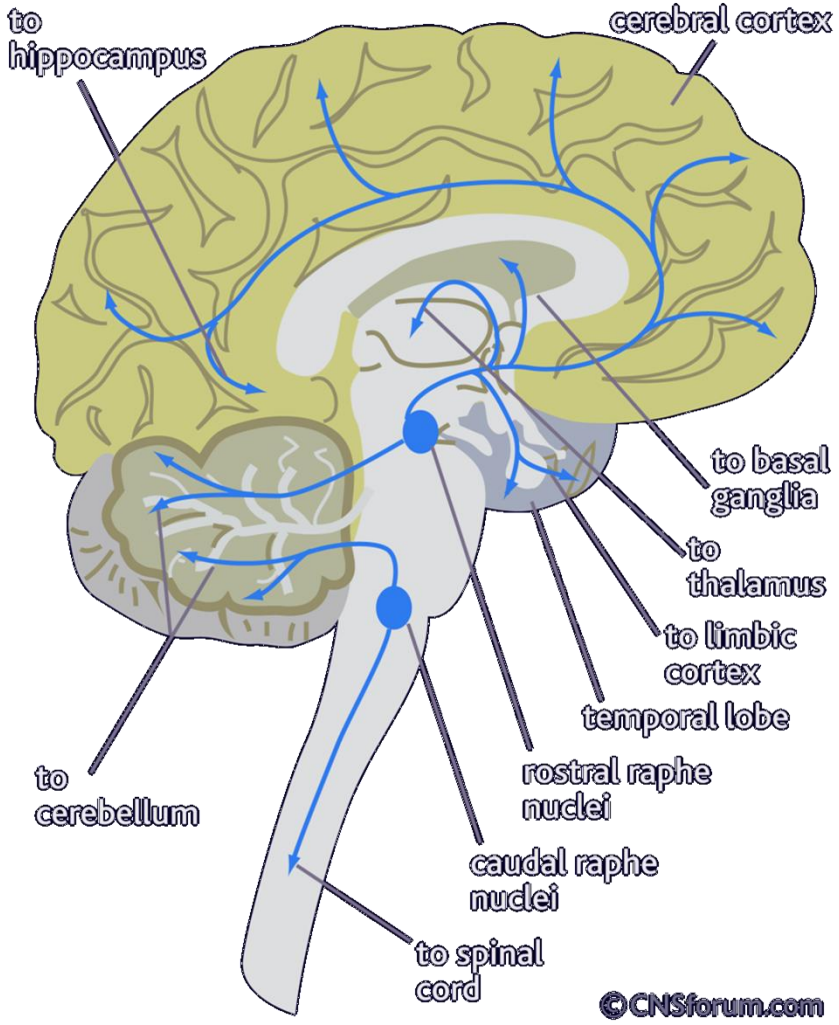
- Nigrostriatal system
  - Movement
  - Sensory stimuli
- Ventrotegmentno-mesolimbic-frontal system
  - Reward
  - Cognitive function
  - Emotional behavior
- Tubero-infundibular system
  - Hypotalamic-pituatory regulation
- D1 receptors – excitatory
- D2 receptors - inhibitory



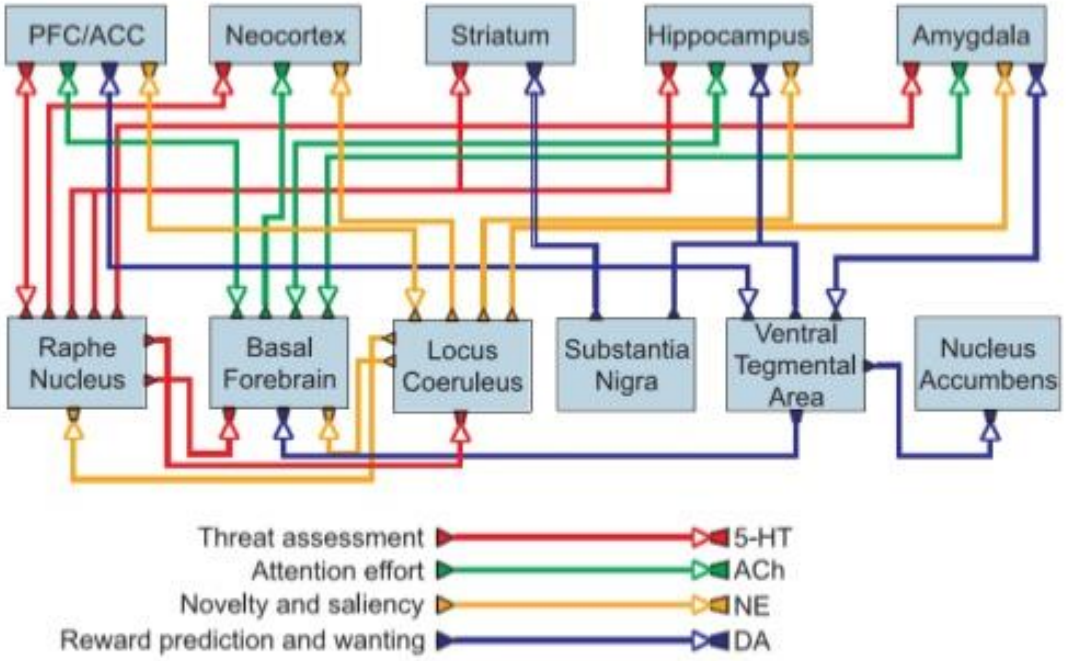
Serotonin

- Nuclei raphe rostralis
- Nuclei raphe caudalis

- Anxiety
- Impulsive behavior

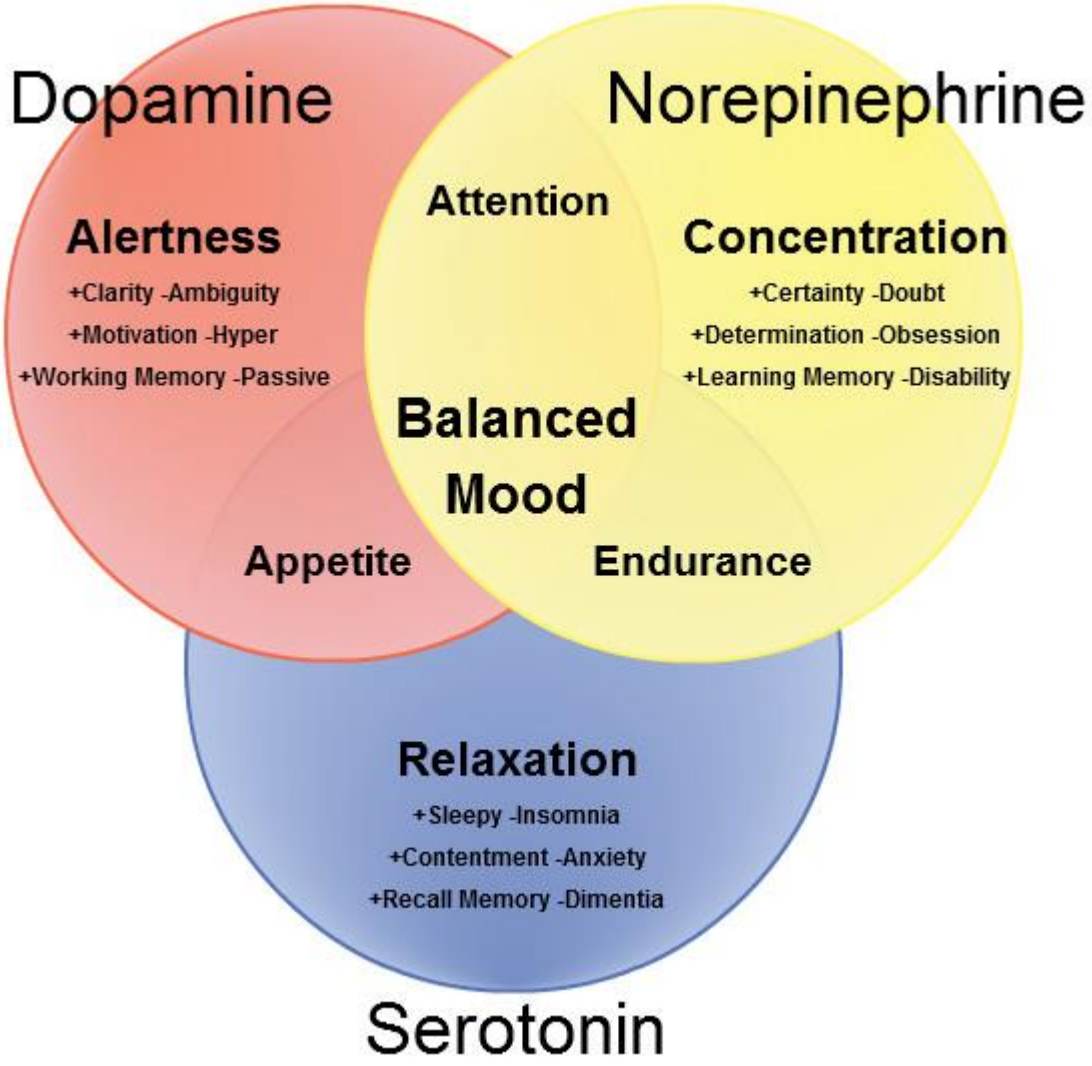


Neuromodulatory systems



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

Neuromodulatory systems



http://ausm.org.uk/wp-content/uploads/2015/02/Dopamine_Norepinephrine_Serotonin.jpg