

# 3

## **Synapse a integrace informace na synaptické úrovni**

# Neuron

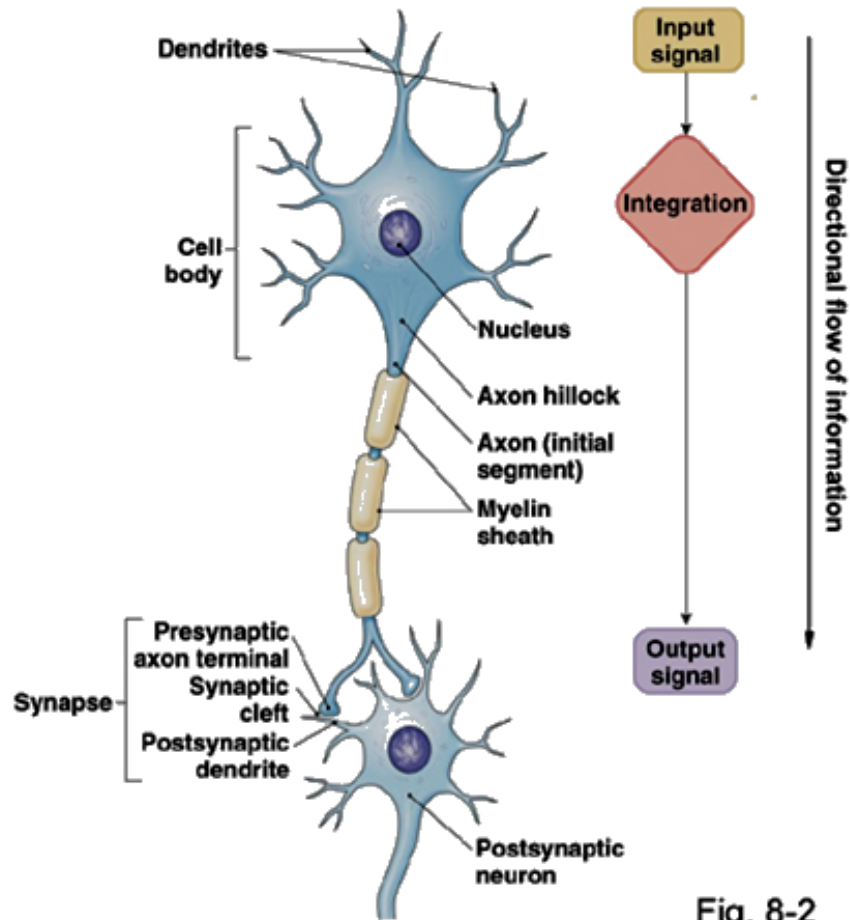
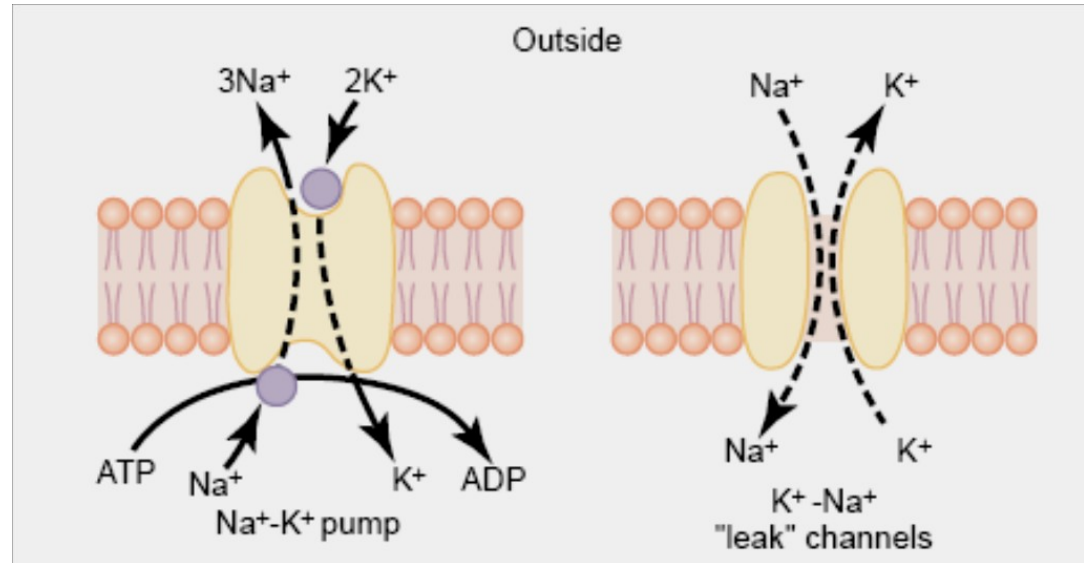
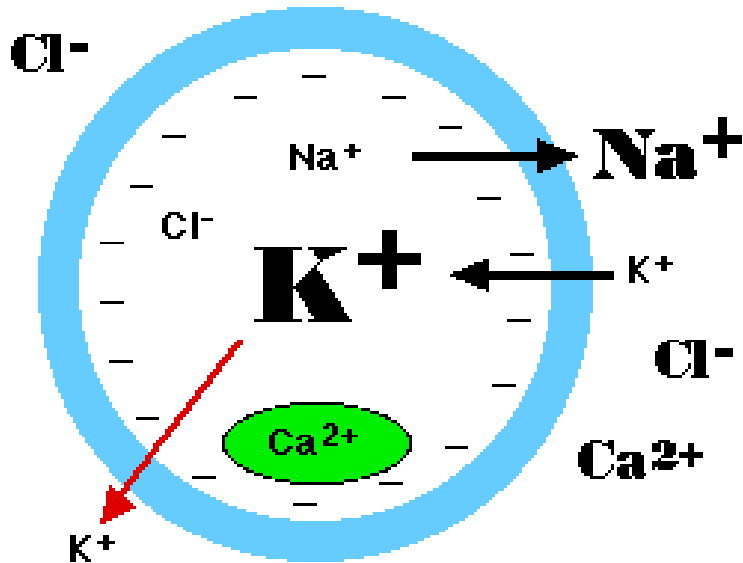


Fig. 8-2

# Membránový potenciál

- Vzniká díky rozdílům v koncentracích iontů na opačných stranách semipermeabilní membrány



# Klidový membránový potenciál neuronu



<http://assassinscreed.ubi.com>

- Vysoce nestabilní stav membrány
- Proč? – Rychlost!
- Mozková spotřeba
  - ✓ Kyslík - 20% celkové tělesné spotřeby
  - ✓ Glukóza – 25% celkové tělesné spotřeby

# Akční potenciál

- Rychlá změna napětí na membráně
- Šíří se membránou
- Princip vše nebo nic

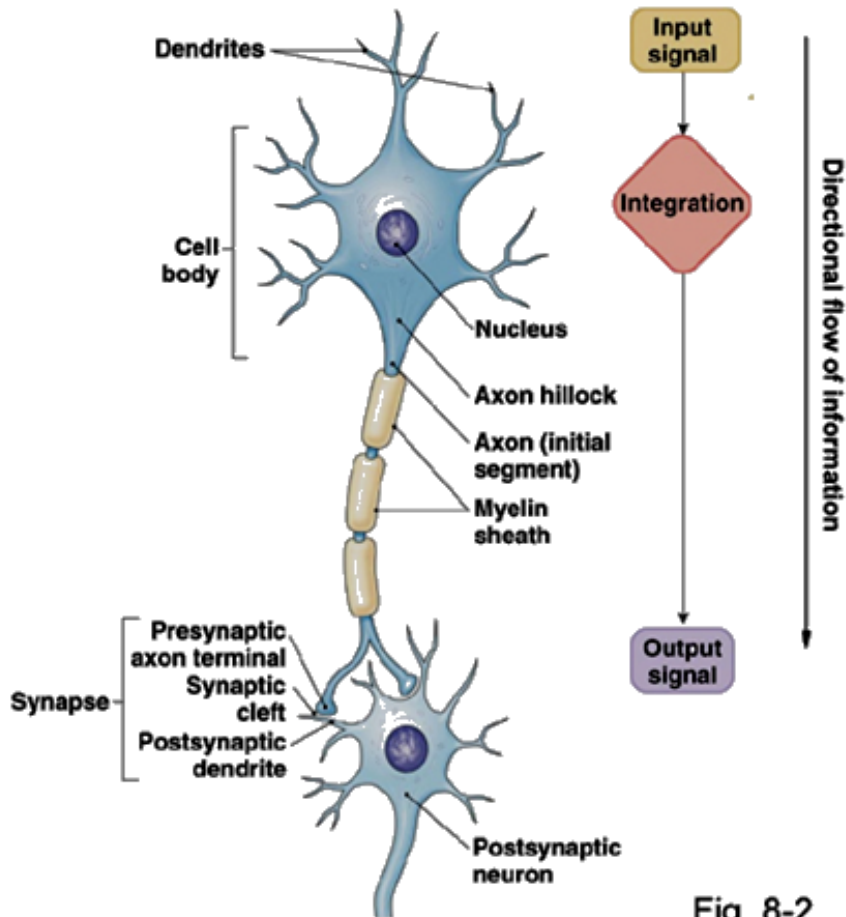
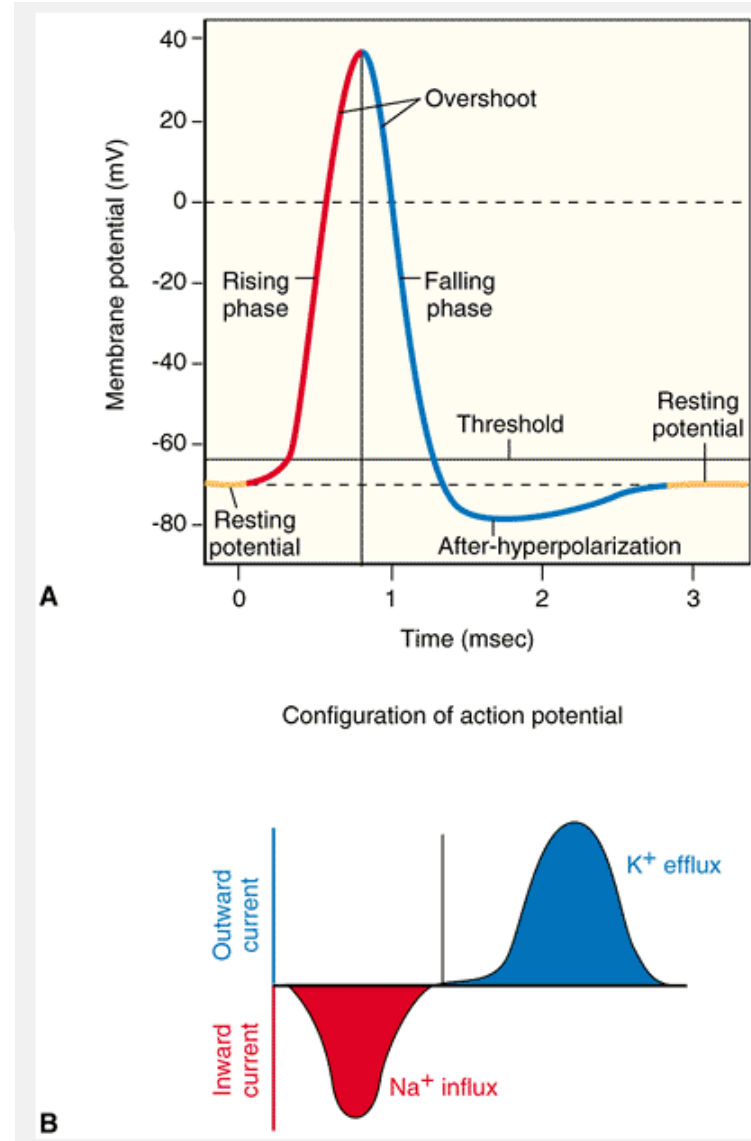
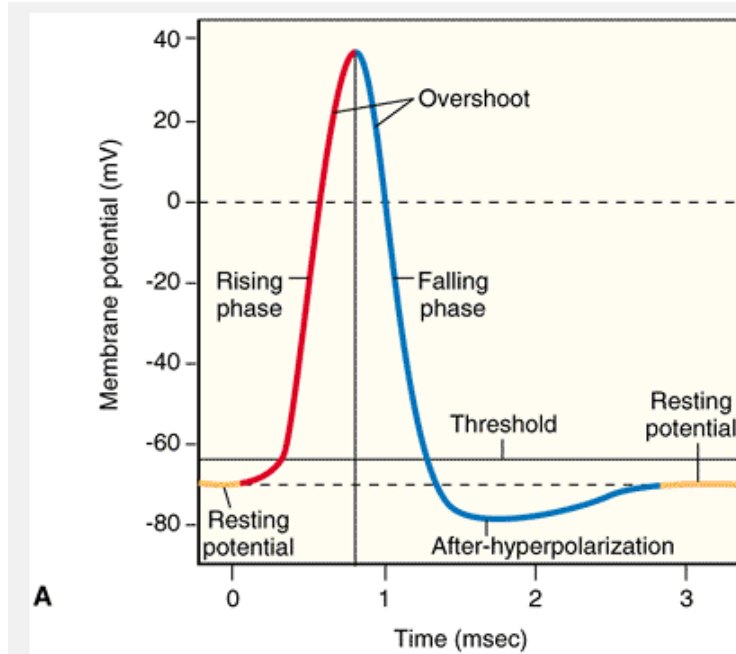


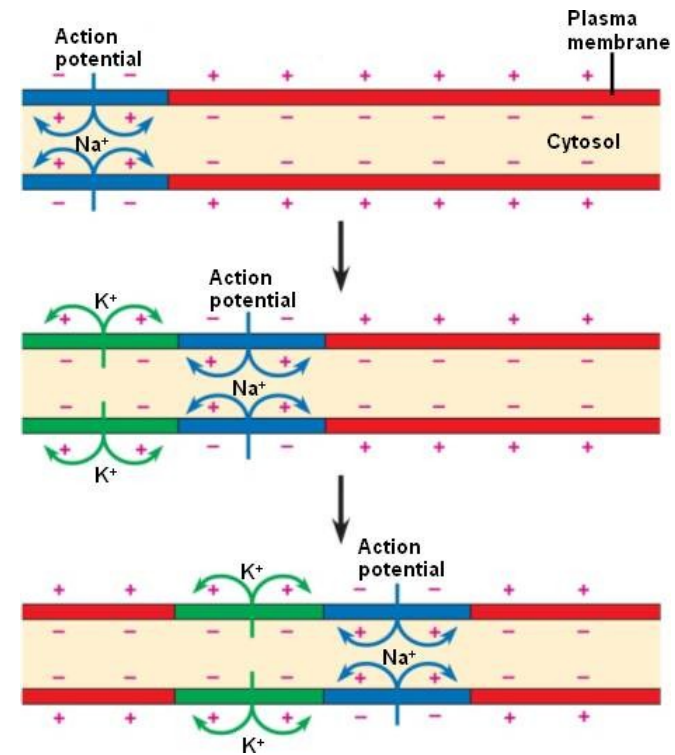
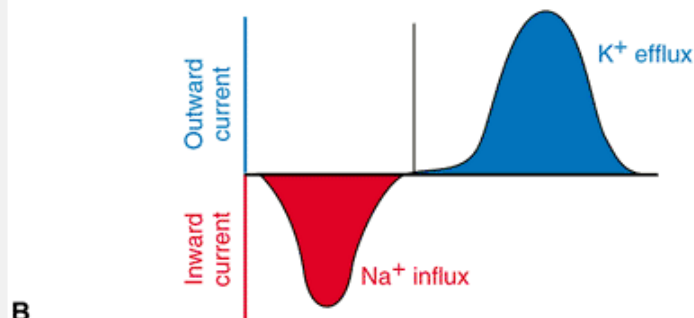
Fig. 8-2



# Šíření akčního potenciálu



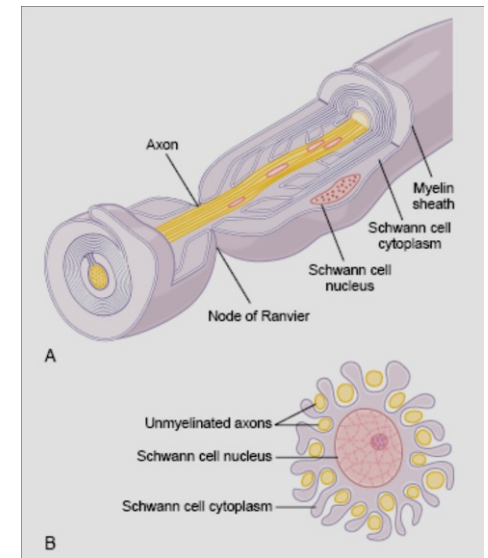
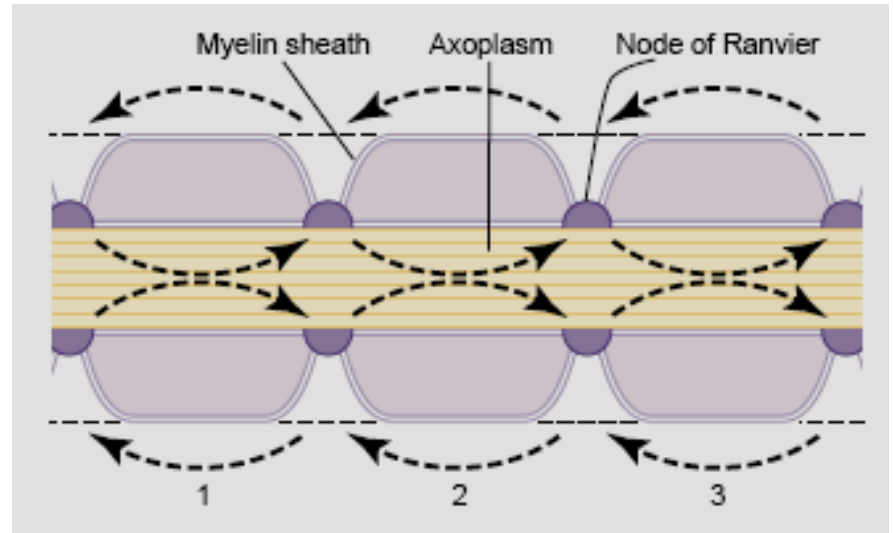
Configuration of action potential



- Lokální proudy
- Anterográdní směr

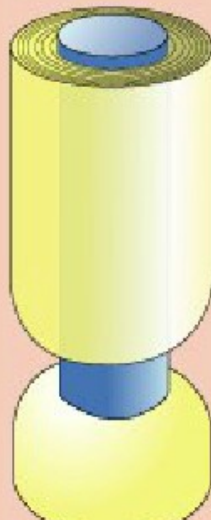



# Saltatorní vedení

- Myelinová pochva
- Ranvierovy zářezy
- Energetická úspora
- Rychlost
- Rychlost vedení dále ovlivněna průřezem vlákna
  - elektrický odpor nepřímo úměrný průřezu



# Klasifikace nervových vláken

- Axony
- U člověka většina myelinizovaná (V CNS všechna)
- Nemyelinizovaná pouze evolučně nejstarší vlákna

	A $\alpha$	A $\beta$	A $\delta$	C
1 <sup>o</sup> Axon to skin				
1 <sup>o</sup> Axon to muscle				
	<b>Group I</b>	<b>Group II</b>	<b>Group III</b>	<b>Group IV</b>
				
Diameter (um)	12-20	6-12	1-6	0.2-1.5
Speed(m/sec)	70-170	30-70	5-30	0.5-2
Sensory receptors	Proprioceptors of skeletal muscle	Mechanoreceptors of skin	Pain, temperature	Temp, pain, itch



# Synapse

- Komunikace mezi neuro

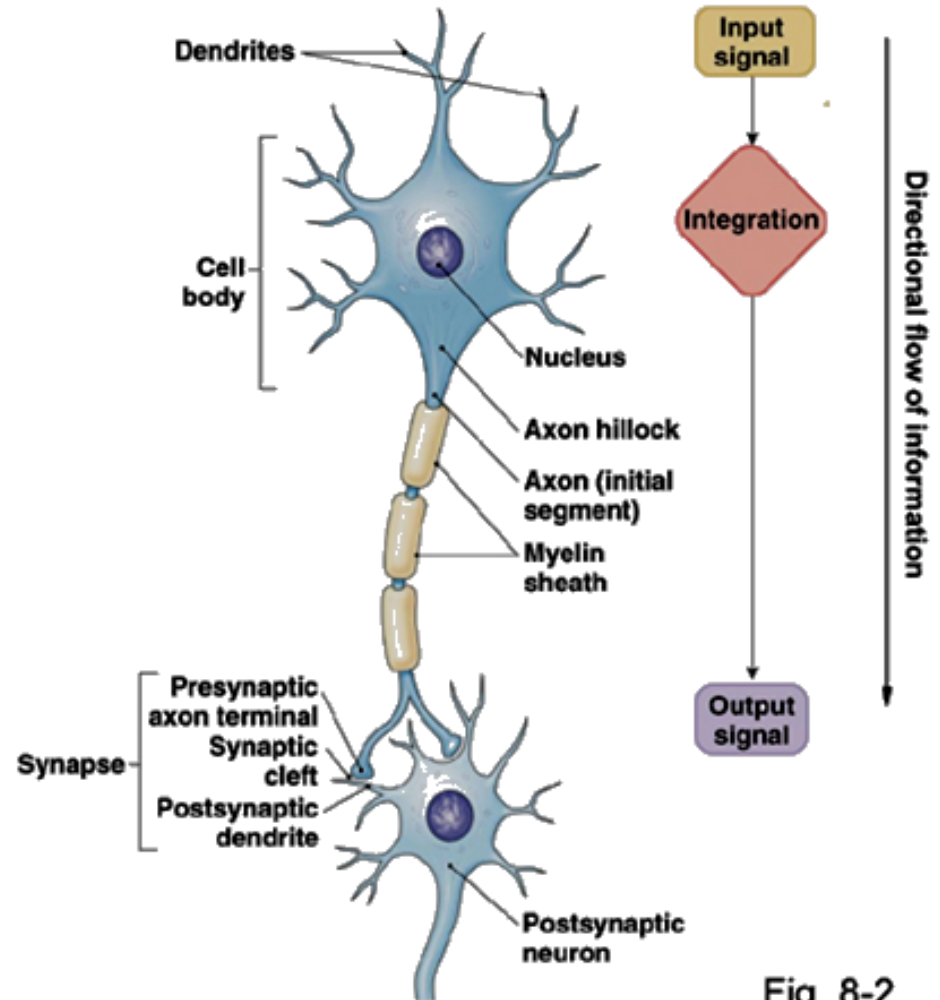


Fig. 8-2

# Synapse

- Komunikace mezi neuro
- Elektrické
- Chemické

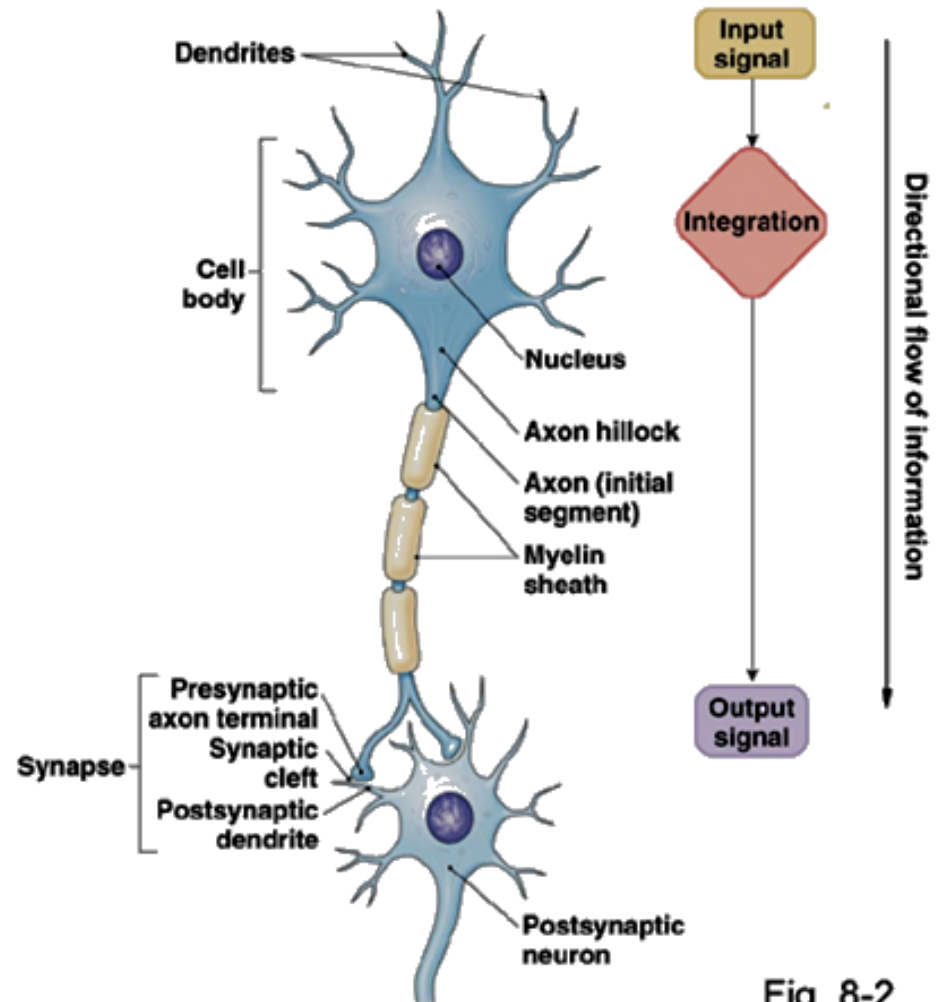
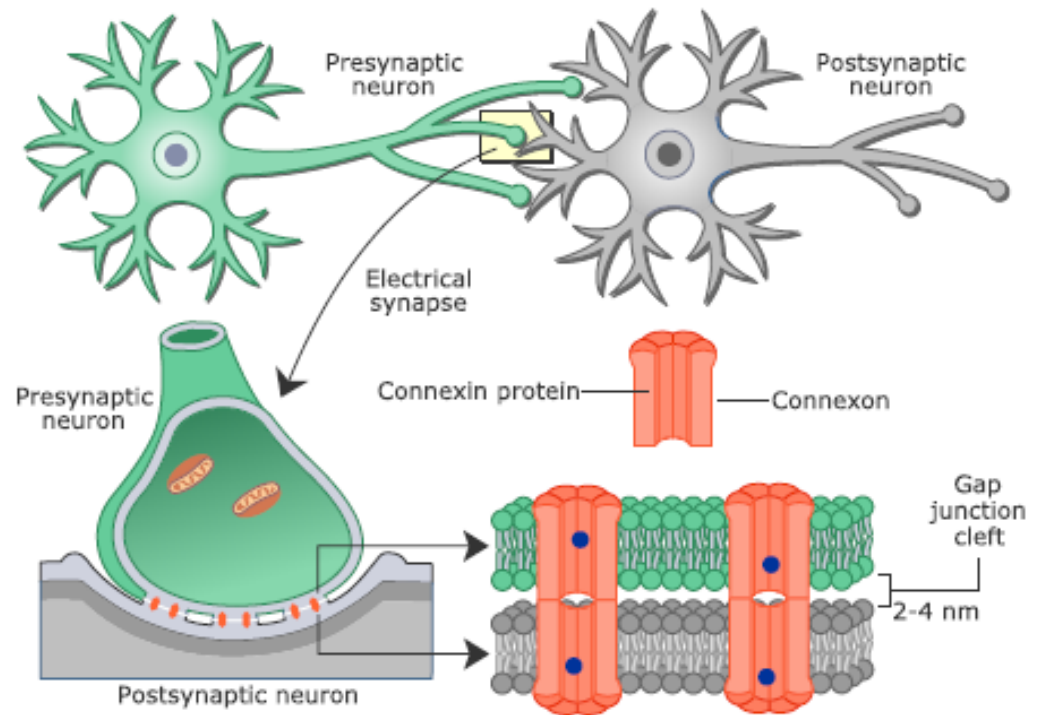


Fig. 8-2

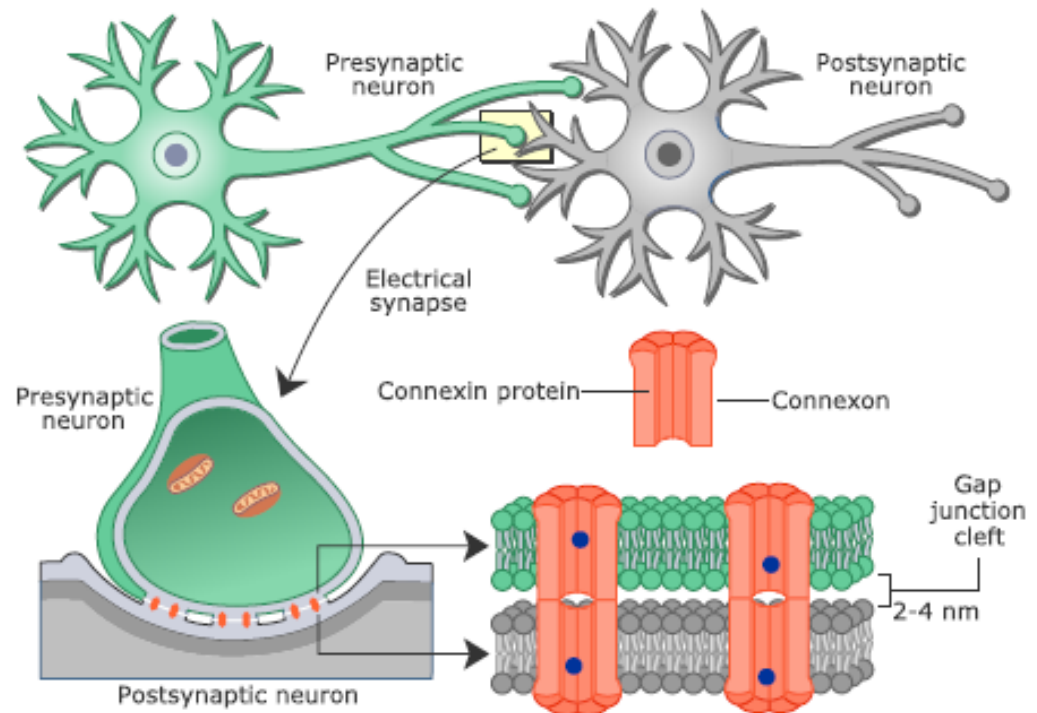
# Elektrické synapse

- Evolučně staré
- Méně než chemických
- Ubikvitární



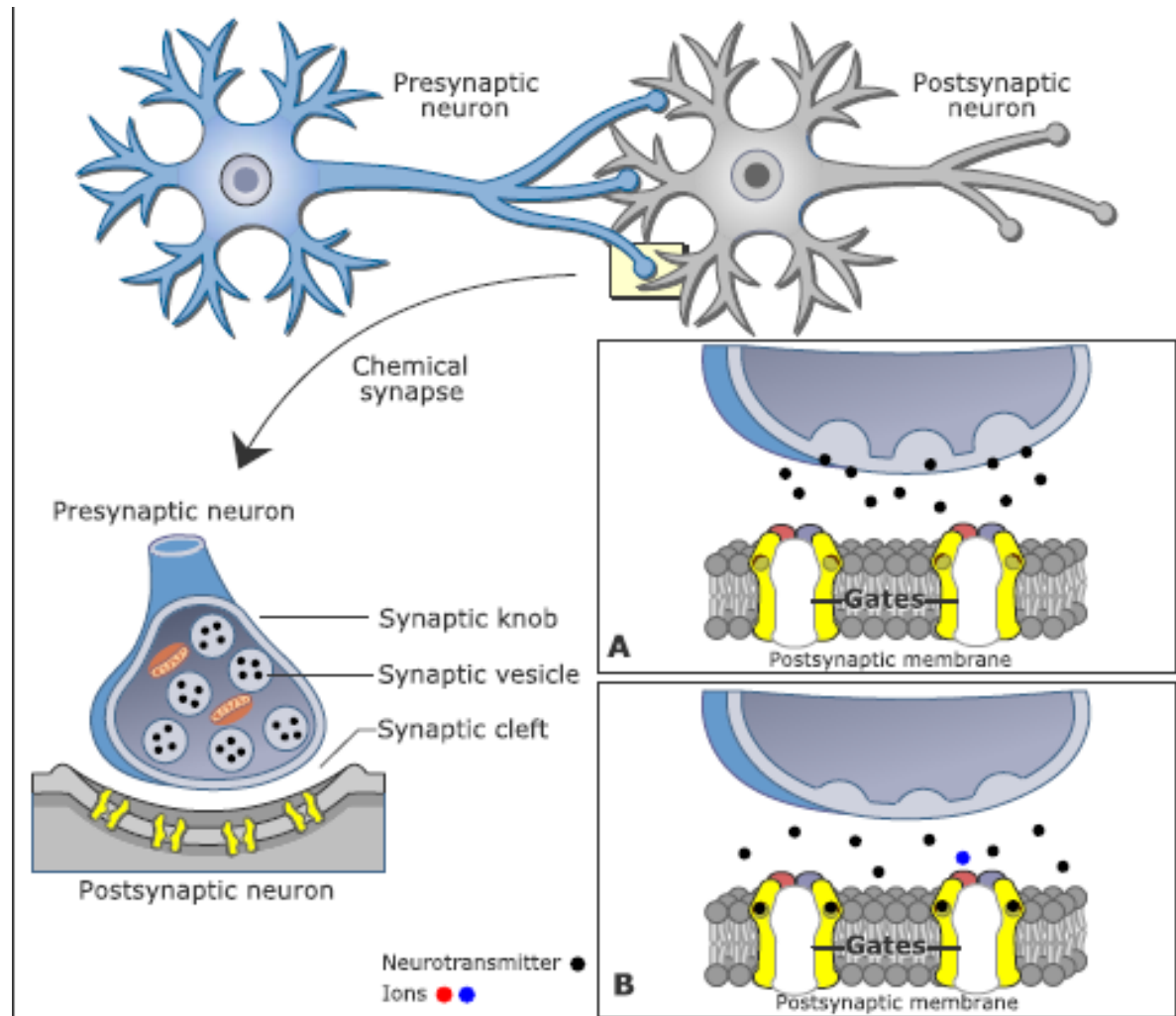
# Elektrické synapse

- Evolučně staré
- Méně než chemických
- Ubikvitární
- Gap junctions
- Obousměrný přenos
- Rychlost



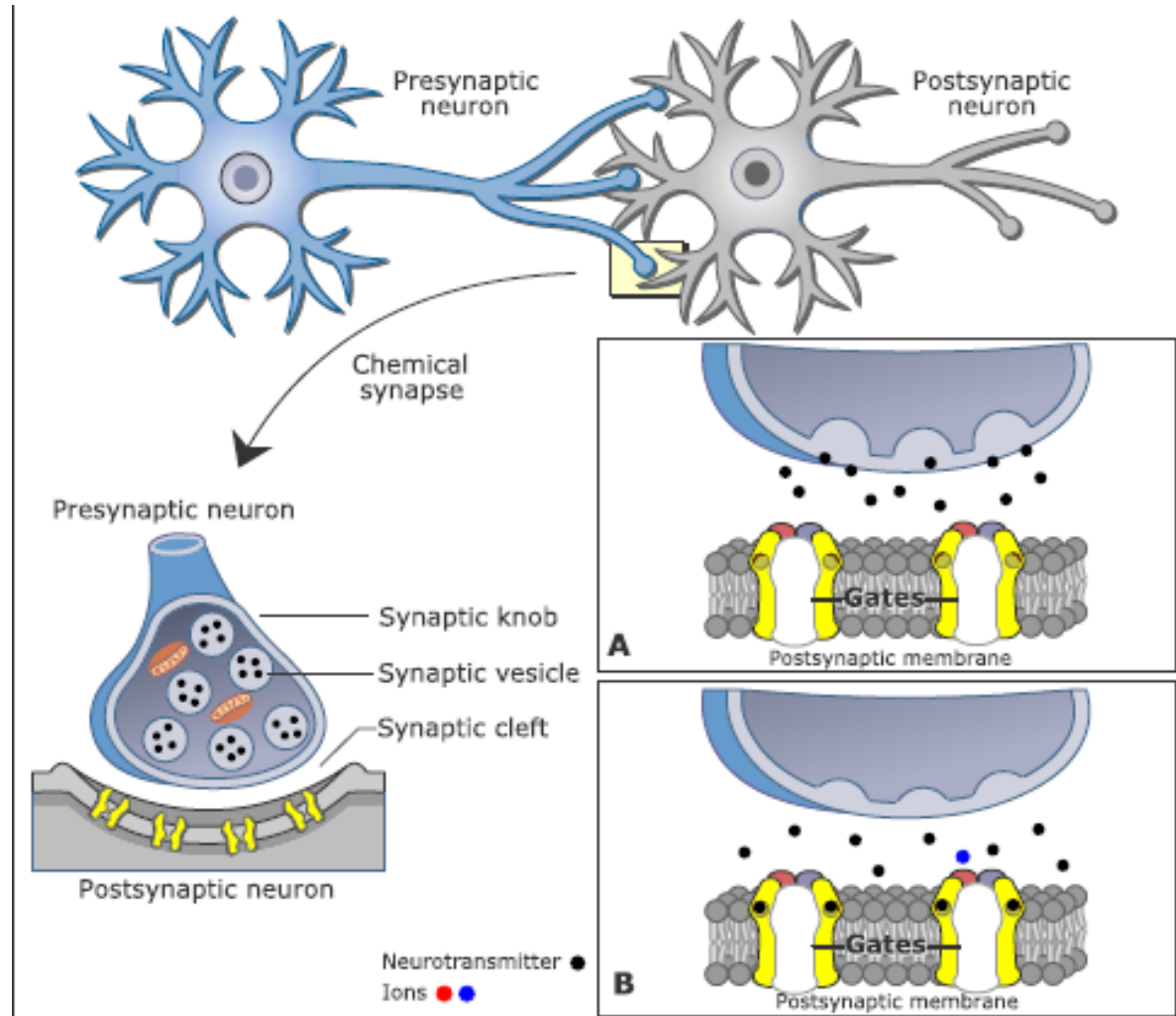
# Chemické synapse

- Evolučně mladší
- Většinový typ

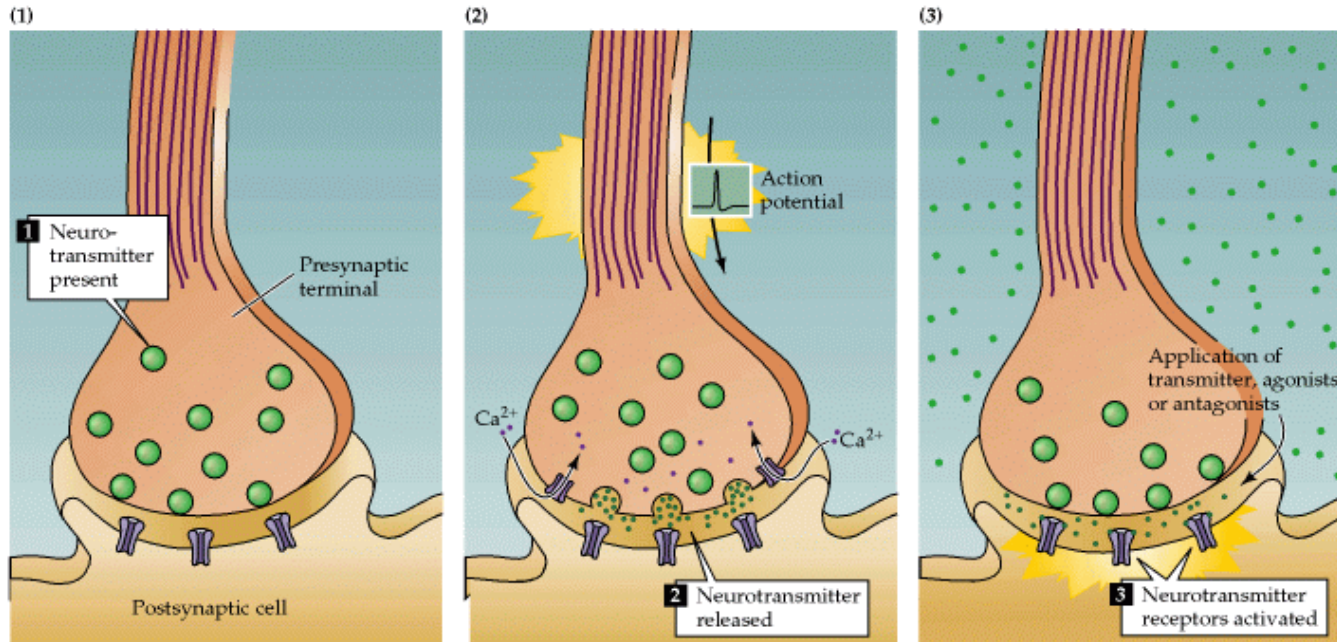


# Chemické synapse

- Evolučně mladší
- Většinový typ
- Jednosměrný přenos
- Synaptická štěrbina
- Neurotransmitter

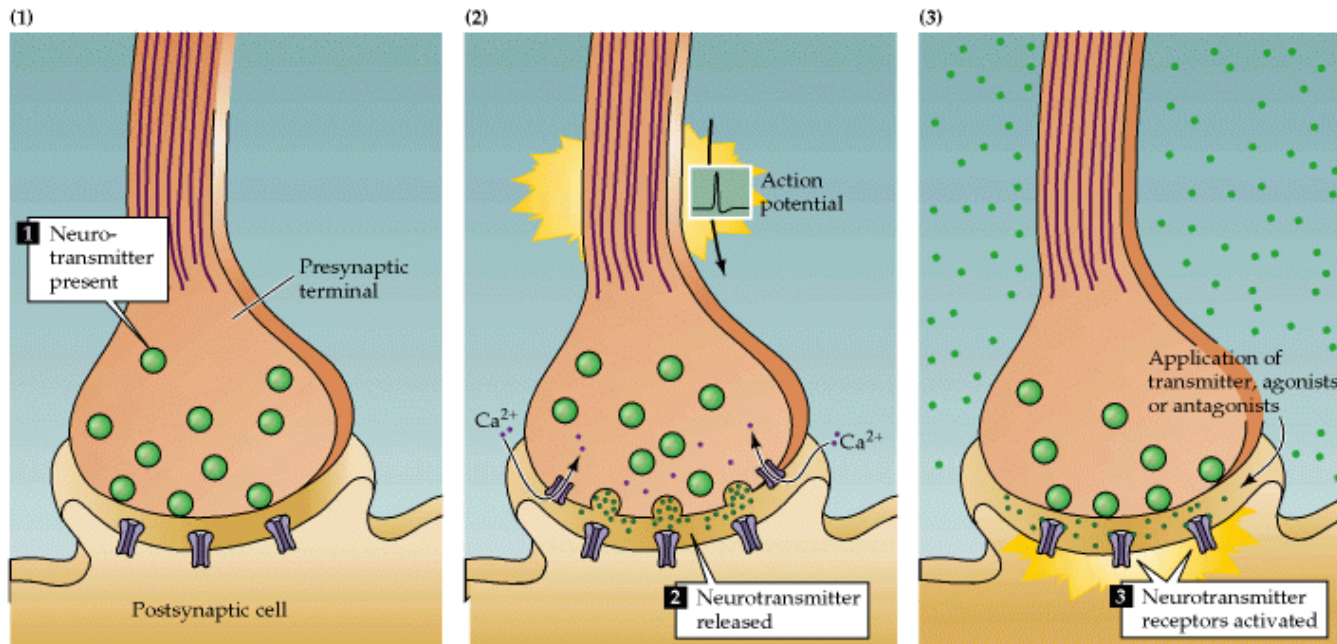


# Neurotransmitter



- Přítomen v presynaptickém neuronu

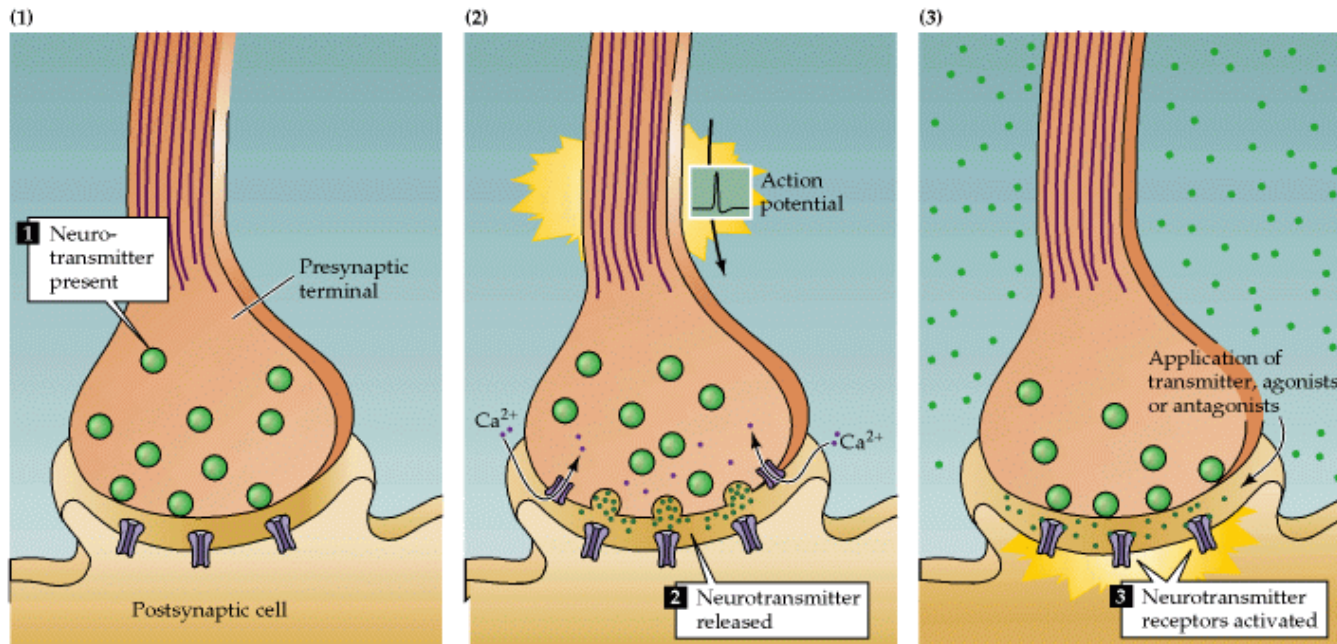
# Neurotransmitter



- Přítomen v presynaptickém neuronu
- Uvolněn do synaptické štěrby následkem depolarizace presynaptického neuronu ( $\text{Ca}^{2+}$  dependentní mechanismus)

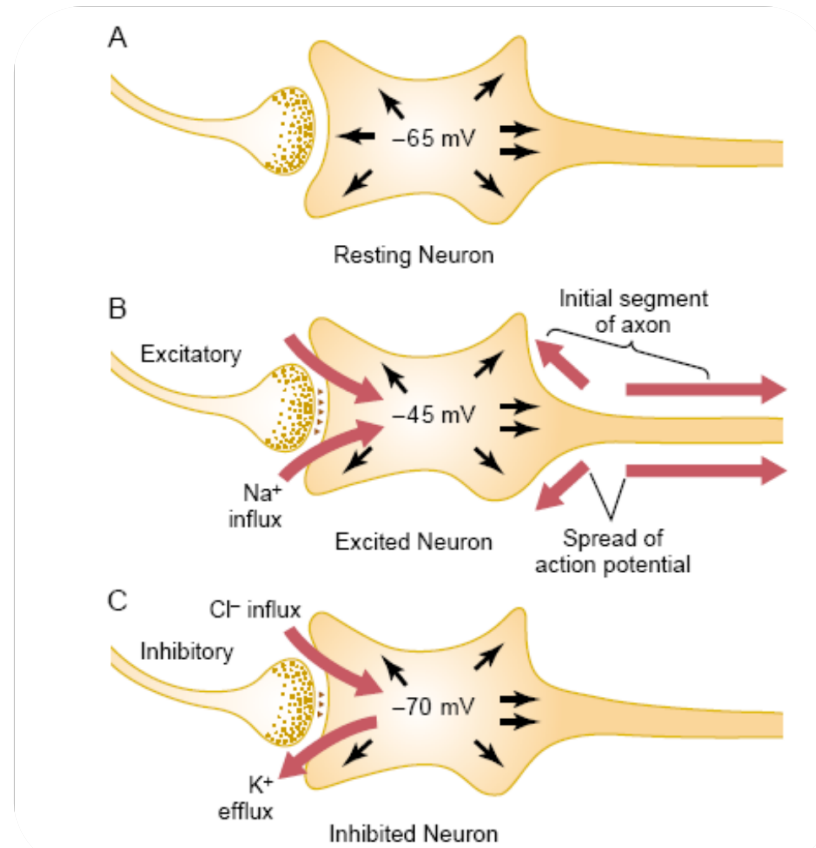


# Neurotransmitter



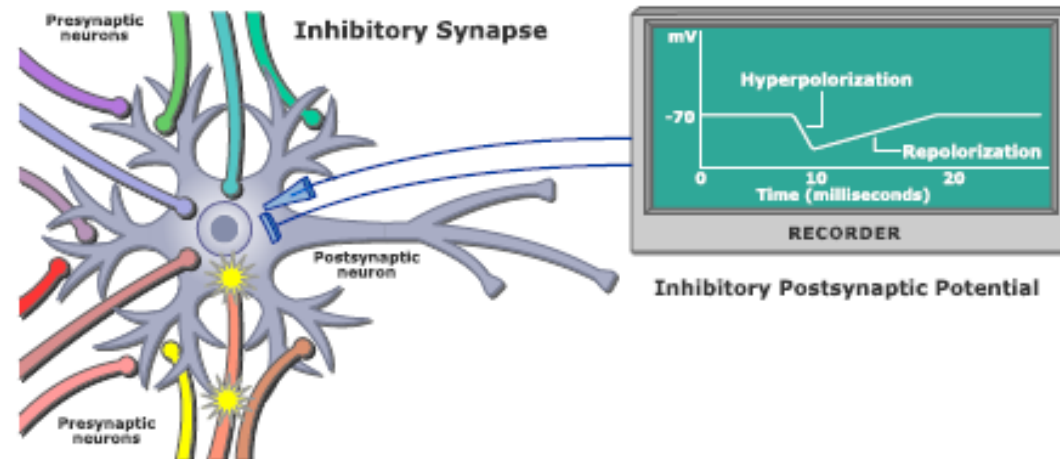
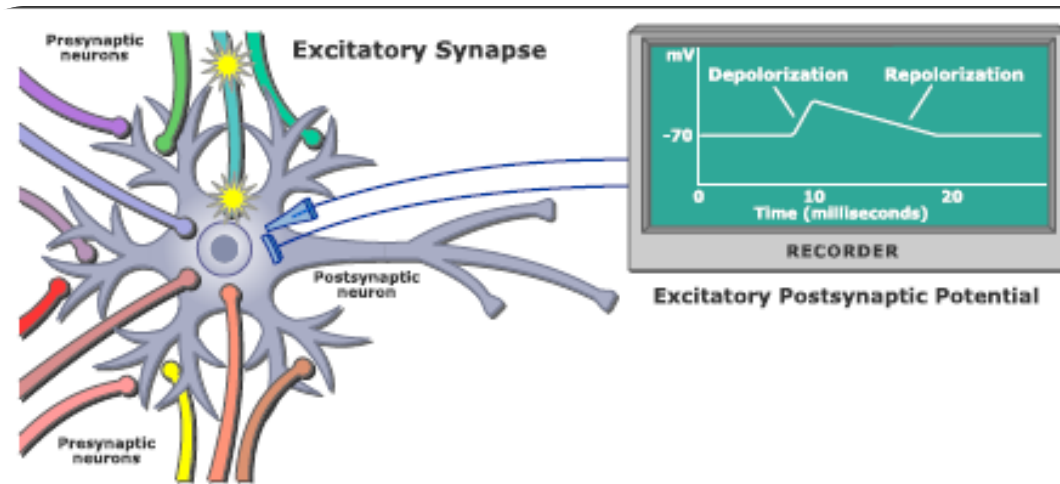
- Přítomen v presynaptickém neuronu
- Uvolněn do synaptické štěrby následkem depolarizace presynaptického neuronu ( $Ca^{2+}$  dependentní mechanismus)
- Postsynaptická membrána musí obsahovat specifické receptory

# Excitační/inhibiční postsynaptický potenciál

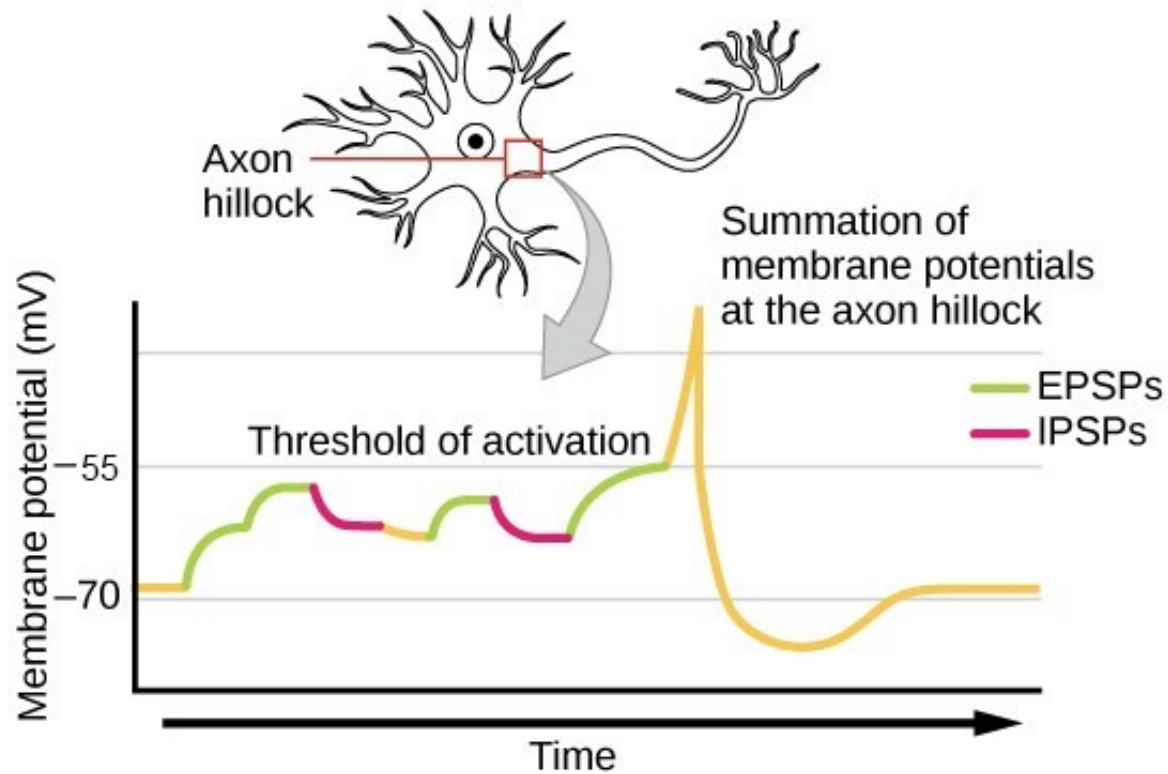


# Sumace signálu

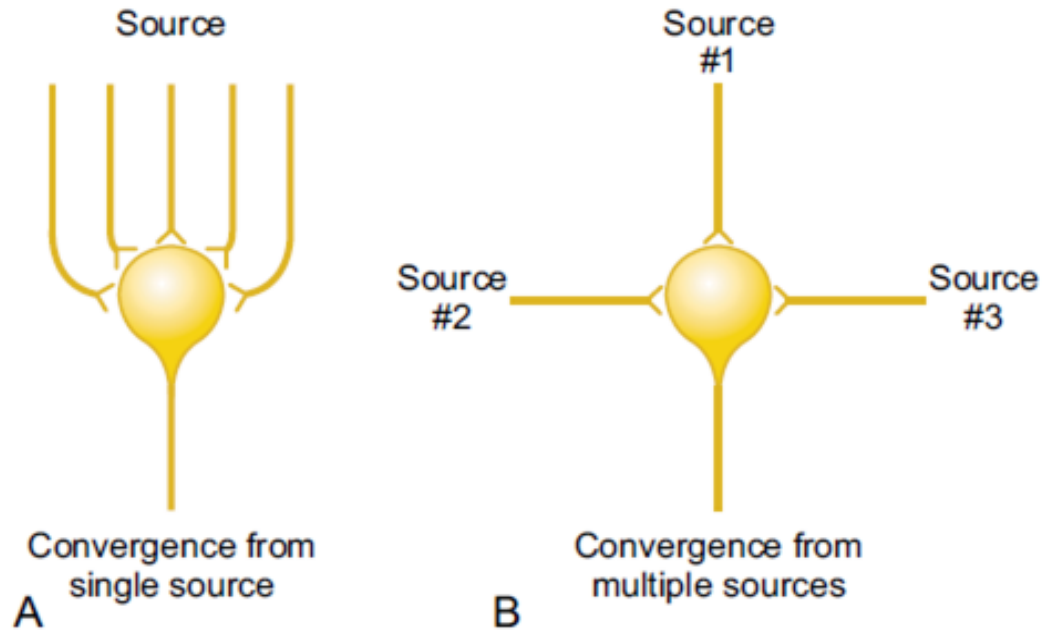
- Časová
- Prostorová



# Sumace signálu



# Konvergence signálu



**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.

# Konvergence signálu

Průměrný počet synapsí  
na neuron u primátů

- ✓ Primární zrakový  
kortex (area17)  
– cca. 4 000
- ✓ Primární motorický  
kortex (area4)  
– cca. 60 000

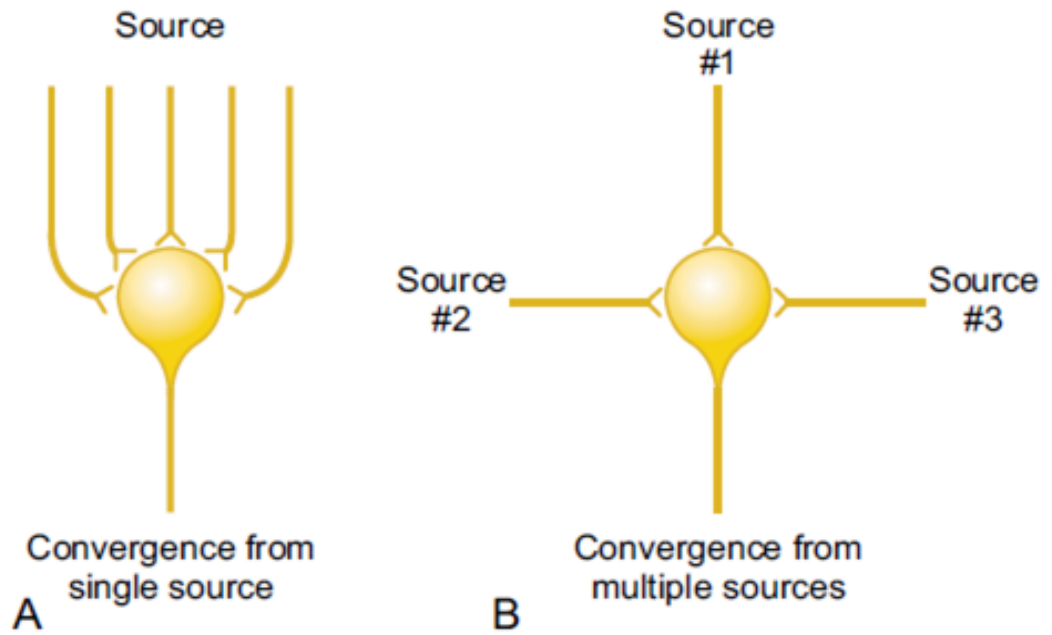
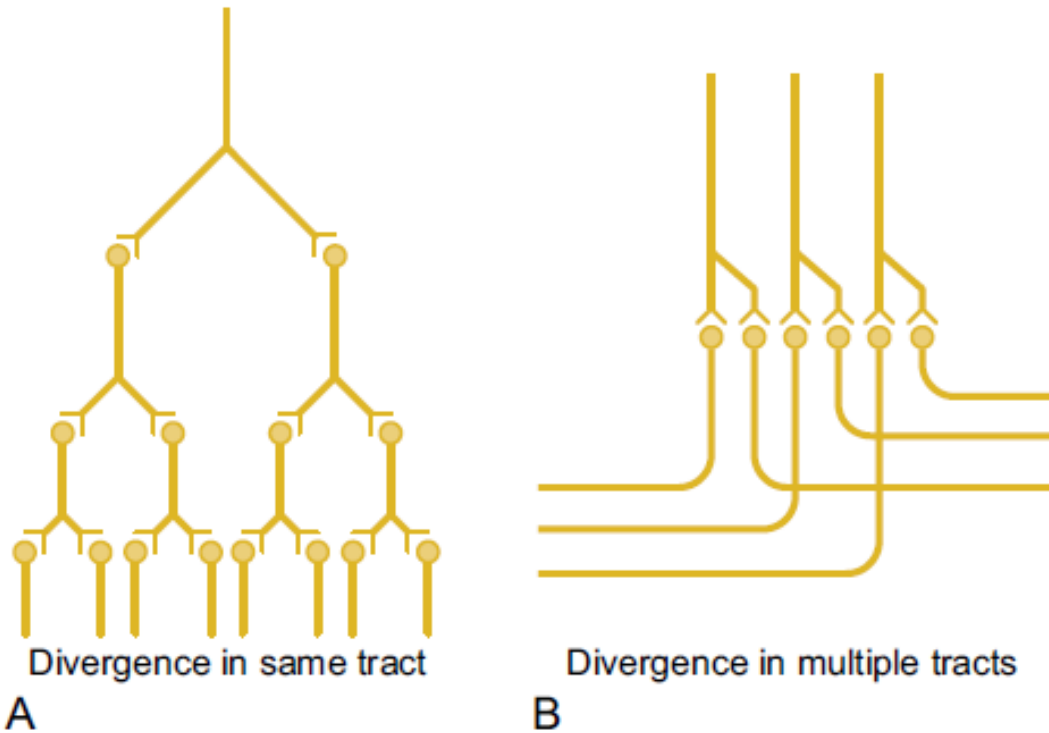


Figure 46-12

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

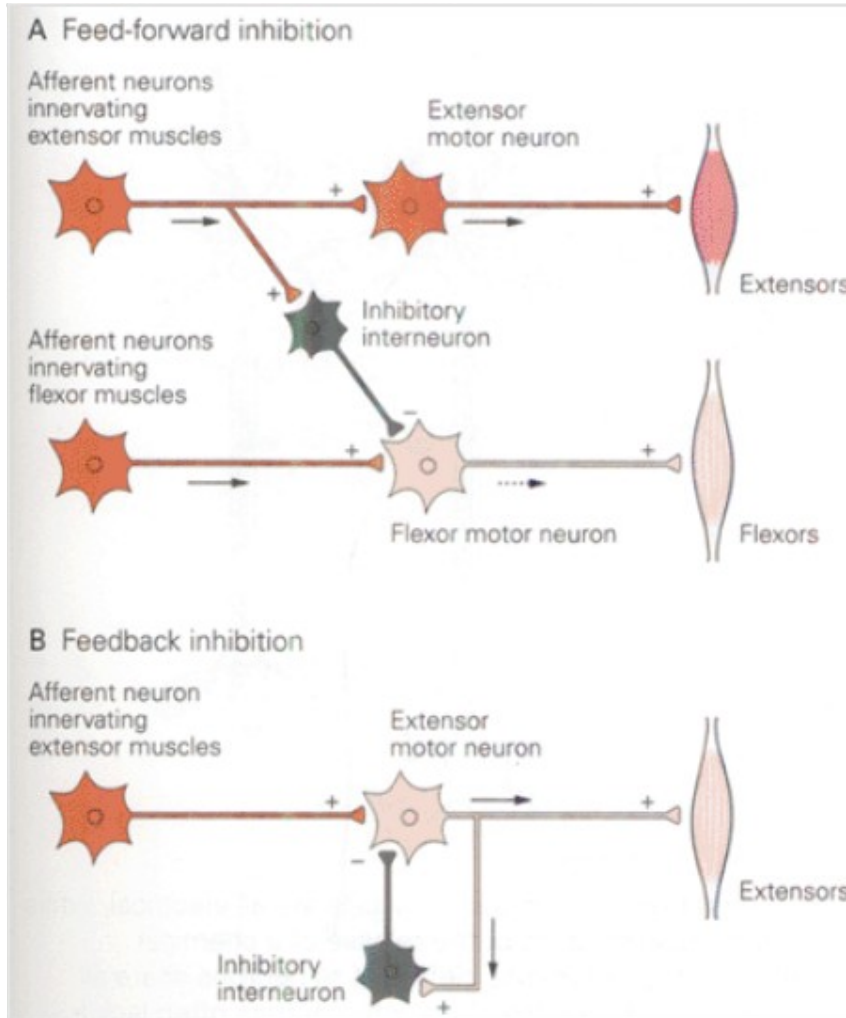
# Divergence signálu



**Figure 46–11**

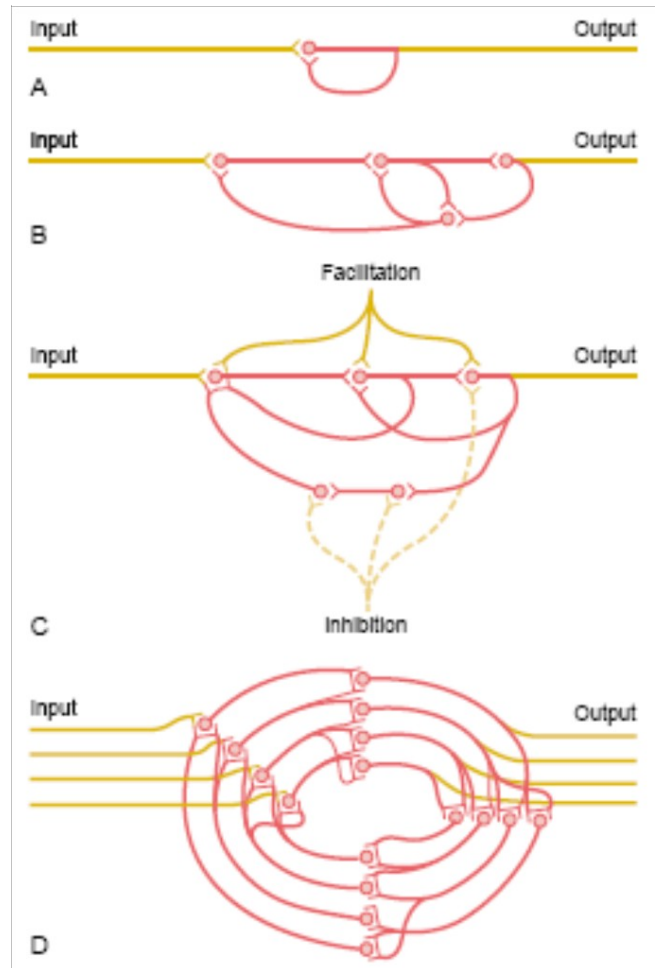
“Divergence” in neuronal pathways. *A*, Divergence within a pathway to cause “amplification” of the signal. *B*, Divergence into multiple tracts to transmit the signal to separate areas.

# Networking

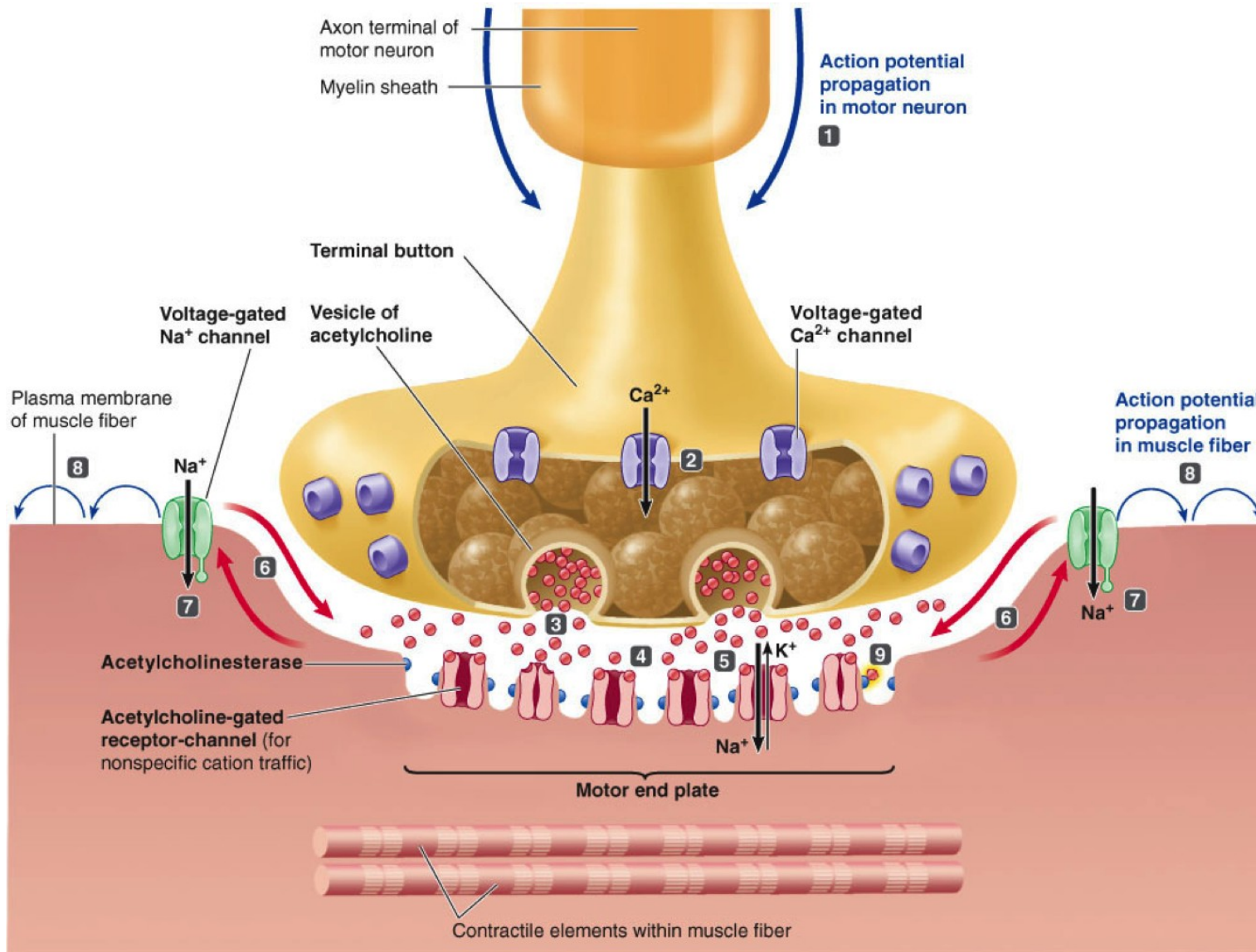




# Networking



# Neuromuskulární spojení



**Neurotransmission**

**vs.**

**Neuromodulation**

# Neurotransmise

vs.

# Neuromodulace

- Přenos informace

- Regulace aktivity NS

# Neurotransmise

vs.

# Neuromodulace

- Přenos informace
- Specifická

- Regulace aktivity NS
- Difúzní (volume transmission)

# Neurotransmise

vs.

# Neuromodulace

- Přenos informace
- Specifická
- Receptory – iontové kanály

- Regulace aktivity NS
- Difúzní (volume transmission)
- Receptory – pomalé G-proteiny

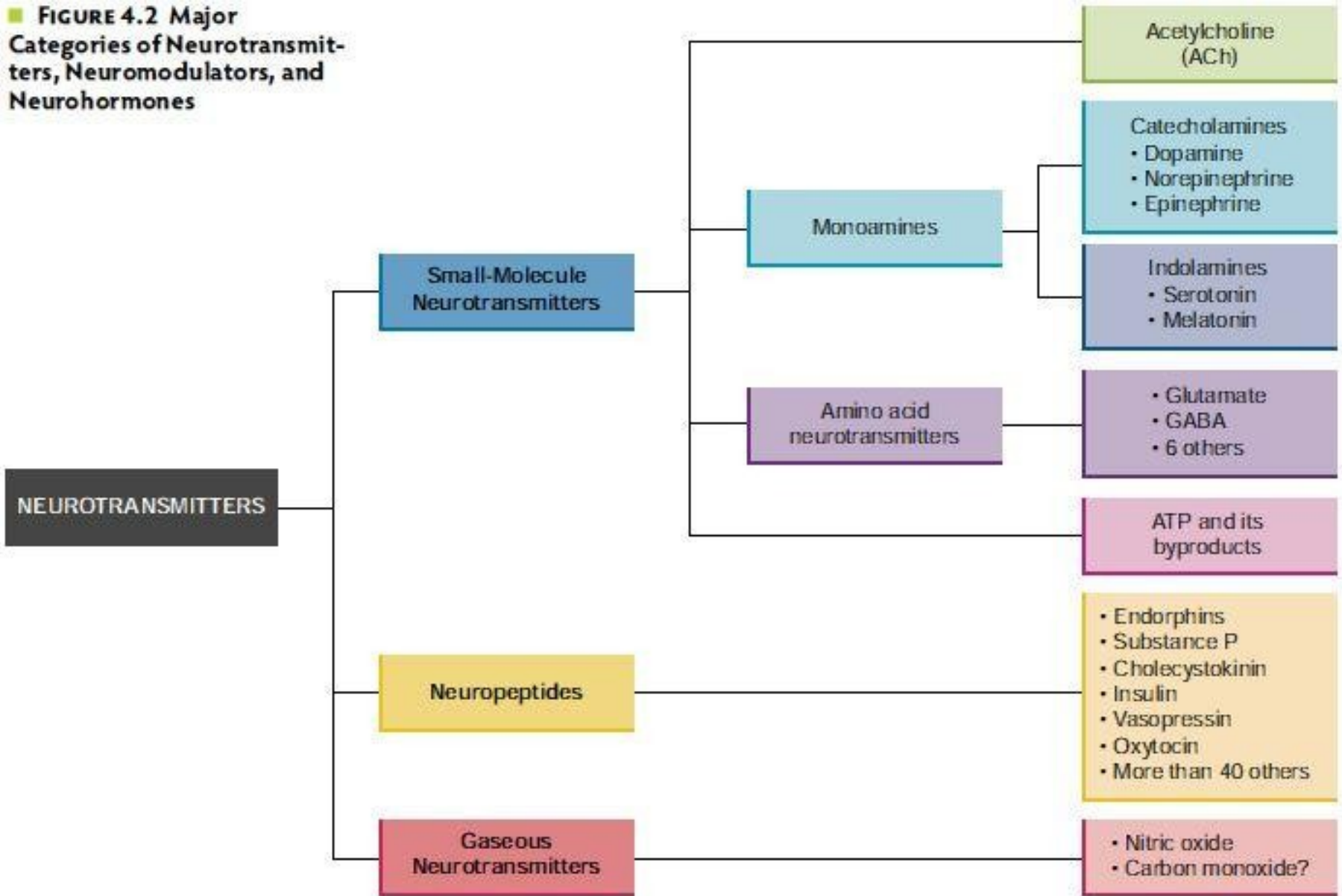
## Neurotransmise

vs.

## Neuromodulace

- Přenos informace
  - Specifická
  - Receptory – iontové kanály
  - Krátký účinek -Změny membránového potenciálu
- Regulace aktivity NS
  - Difúzní (volume transmission)
  - Receptory – pomalé G-proteiny
  - Déletrvající účinek - Změny vlastností synapsí atd.

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



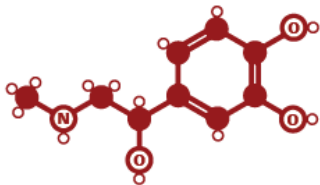


# THE STRUCTURES OF NEUROTRANSMITTERS

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

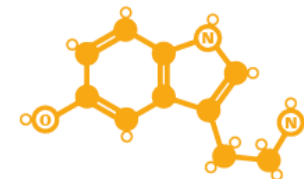
Pleasure neurotransmitter



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

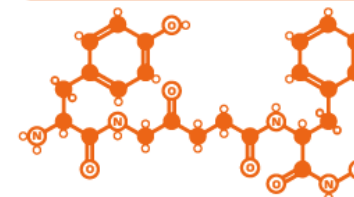
Memory neurotransmitter



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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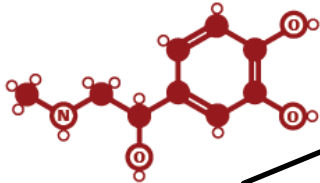


# THE STRUCTURES OF NEUROTRANSMITTERS

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



**Excitaciční**  
(kyselina glutamová, acetylcholin)

**X**

**Inhibični**  
(GABA)

## GABA

Calming neurotransmitter



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



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.

## DOPAMINE

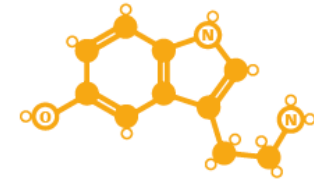
Motivation neurotransmitter



...

## SEROTONIN

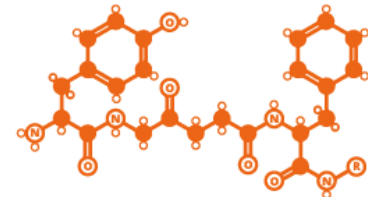
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Euphoria neurotransmitters



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

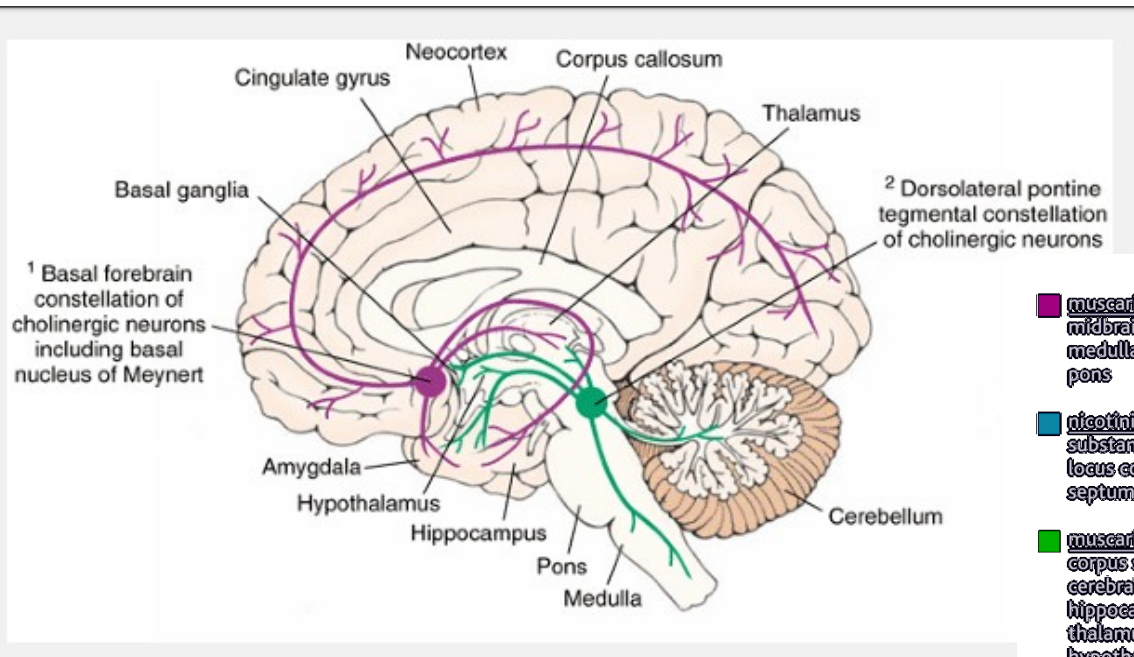


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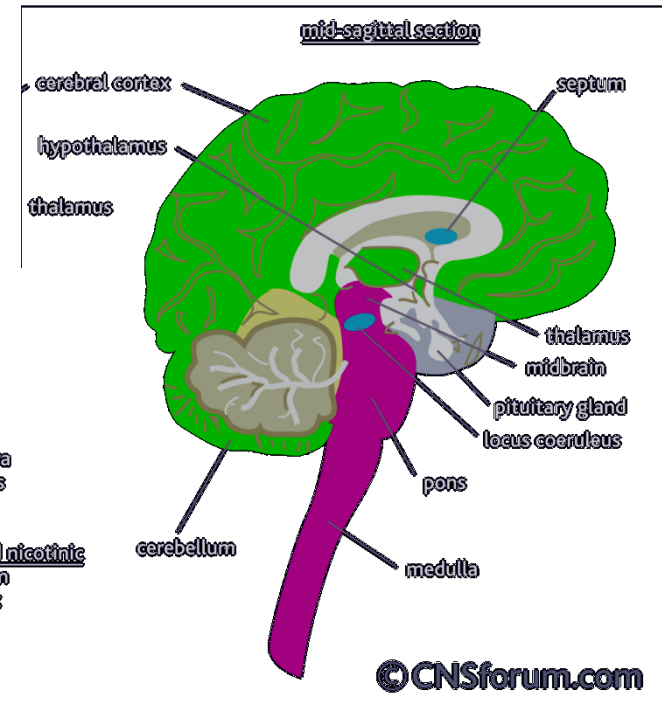


# Acetylcholin

- Nucleus basalis (Meynerti) a řada dalších jader
- Nikotinové receptory
- Muskarinové receptory
- Regulace spánku/bdění
- Kognitivní funkce
- Chování
- Emoce

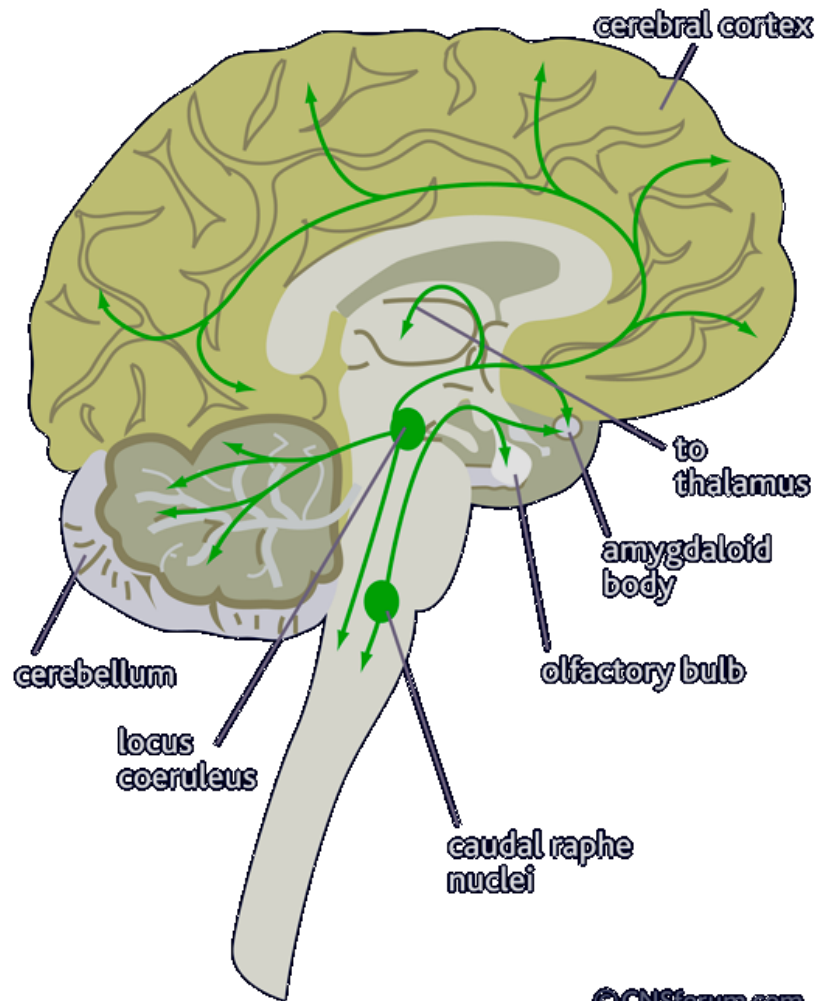


- muscarinic midbrain medulla pons
- nicotinic substantia nigra locus coeruleus septum
- muscarinic and nicotinic corpus striatum cerebral cortex hippocampus thalamus hypothalamus cerebellum



# Noradrenalin

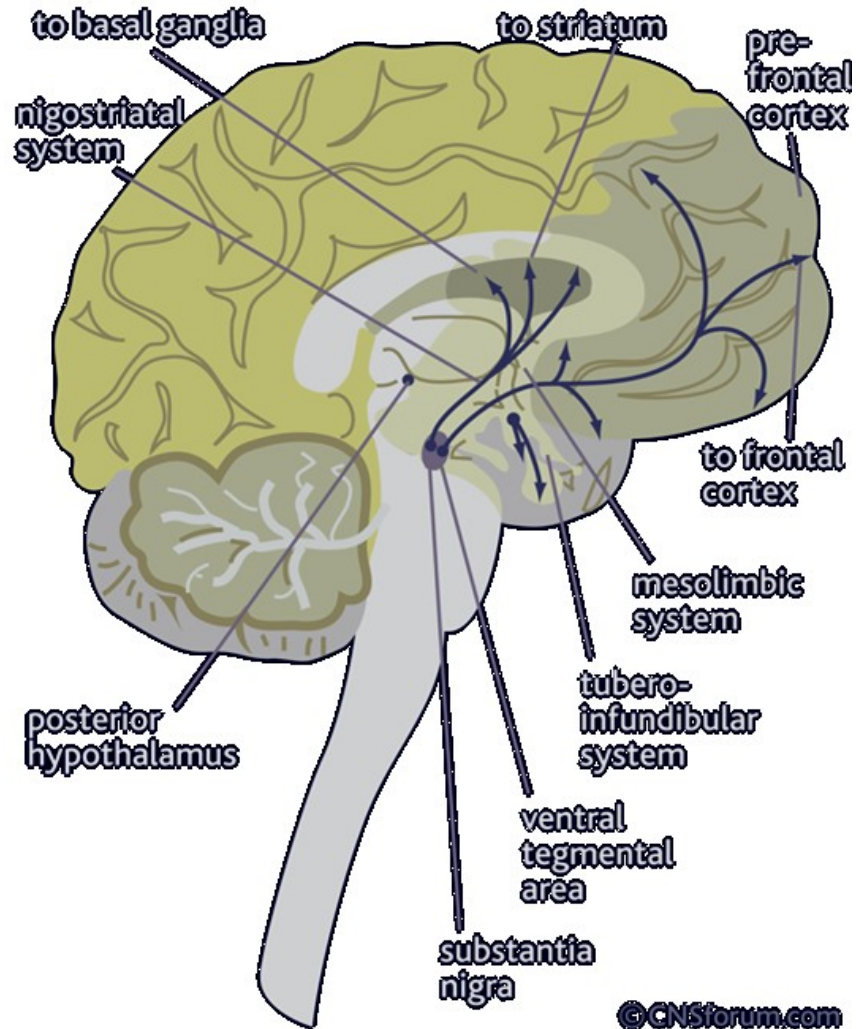
- Locus coeruleus
- Nuclei raphe caudalis
- Bdělost
- Responzivita na nečekané podmínky
- Paměť
- učení



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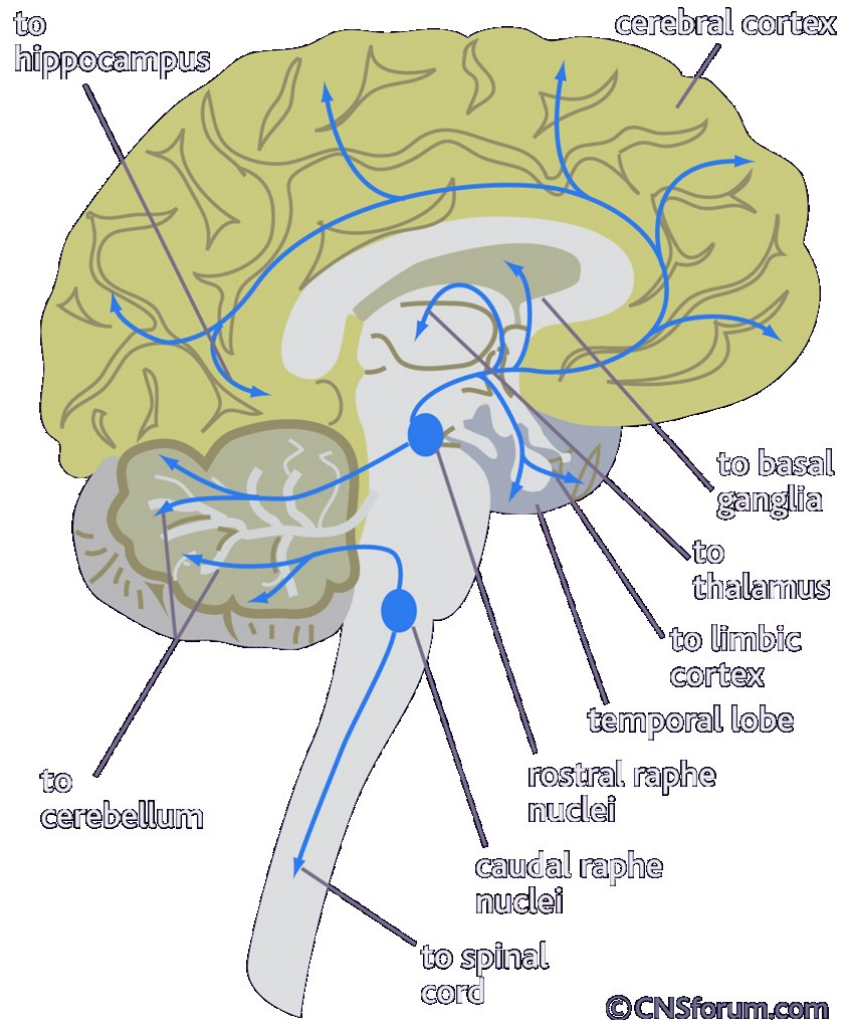
# Dopamin

- Nigrostriální systém
  - Pohyb
  - Senzorika
- Ventrosegmentno-meso-  
limbicko-frontální systém
  - Systém odměny
  - Kognitivní funkce
  - Emoční chování
- Tubero-infundibulární systém
  - Regulace hypotalamo-  
hypofyzárního systému
- D1 receptory – stimulační
- D2 receptory - inhibiční

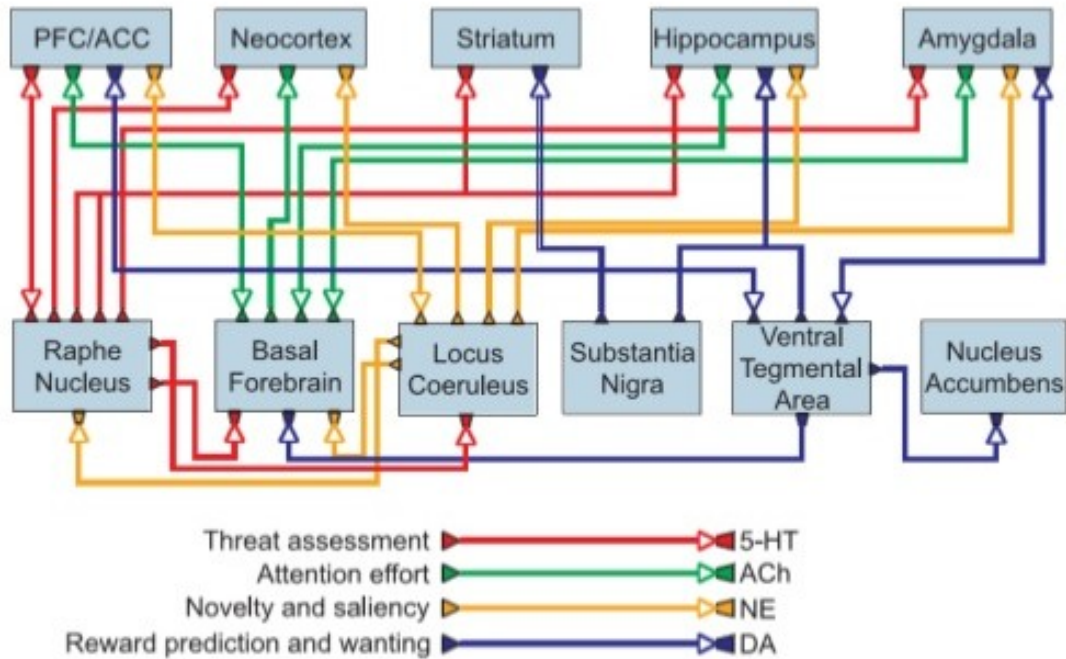


# Serotonin

- Nuclei raphe rostralis
- Nuclei raphe caudalis
  
- Úzkost/relaxace
- Impulzivnost
- Spánek



# Neuromodulační systémy



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

# Neuromodulační systémy

