

M U N I

M E D

# 4

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

## Udržovací aktivity

### „Uvnitř“ neuronu

- ✓ ...
- ✓ Syntéza
- ✓ Transport
- ✓ ...

# Neuron

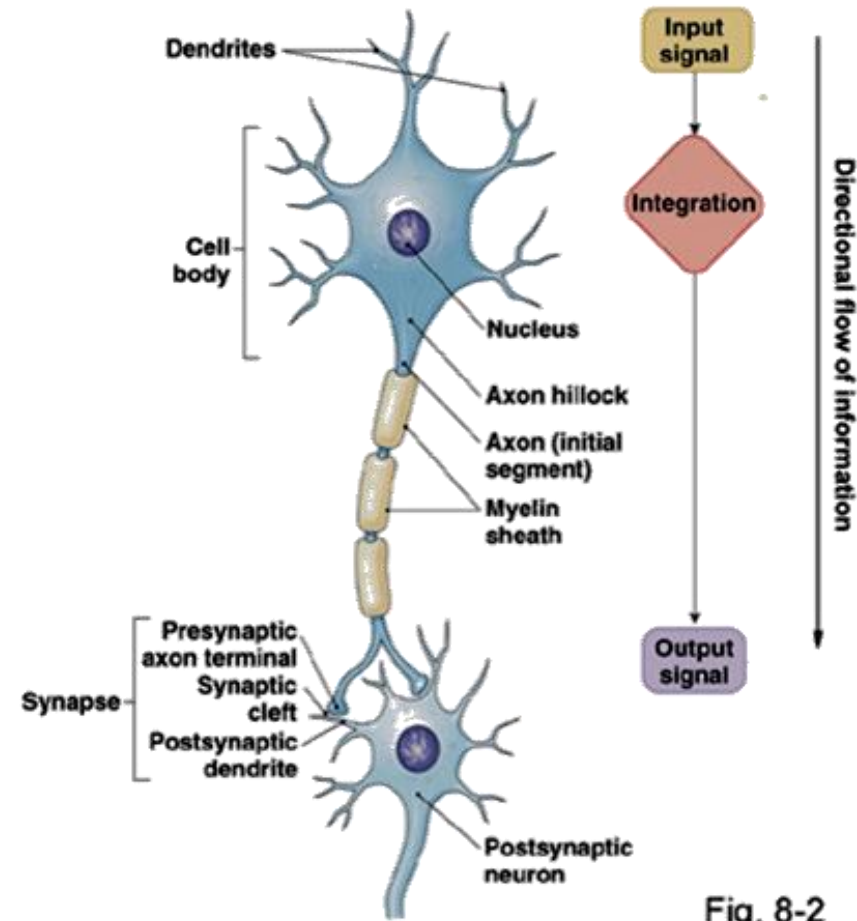


Fig. 8-2

## Zpracování a přenos informace

### Membrána neuronu

- ✓ Recepce signálu
- ✓ Integrace signálu
- ✓ Generování AP
- ✓ Vedení AP
- ✓ Přenos signálu

# Akční potenciál

- Rychlá změna napětí na membráně
- Vznik na axonovém hrbolu nebo iniciálním segmentu
- Šíří se membránou
- Princip vše nebo nic

Klidový potenciál  
cca. -70 mV

Prahový potenciál  
cca. -55 mV

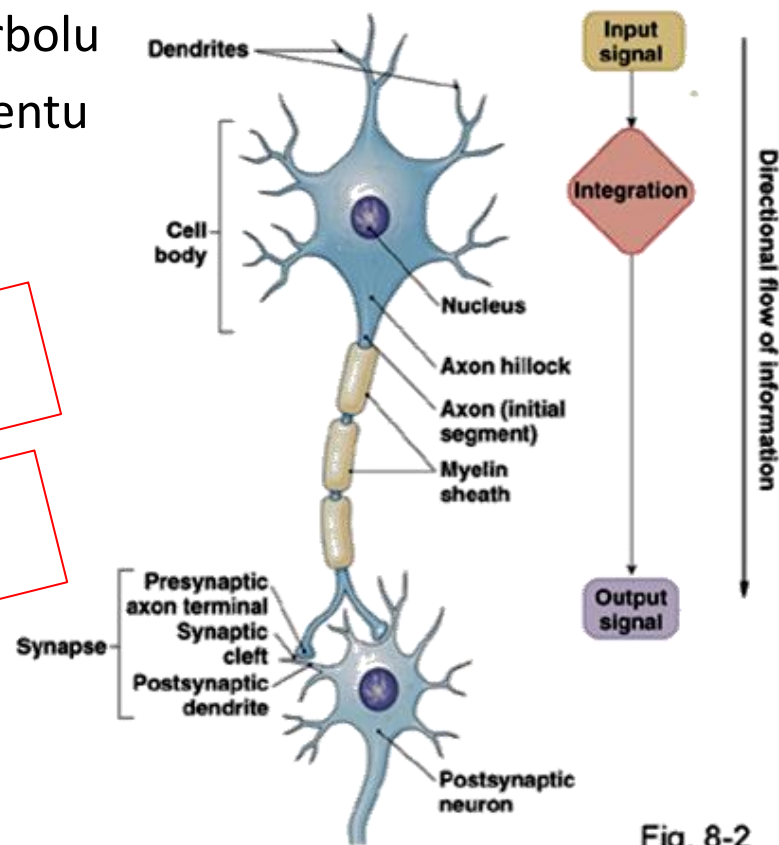
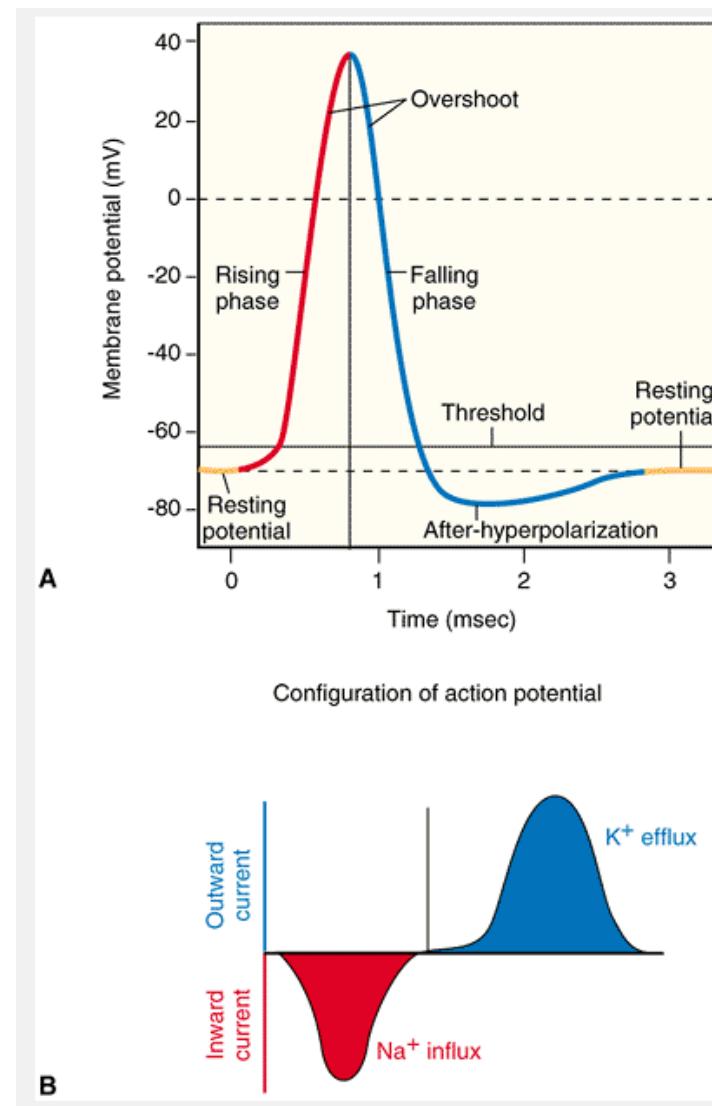


Fig. 8-2



# Synapse

- Komunikace mezi neurony

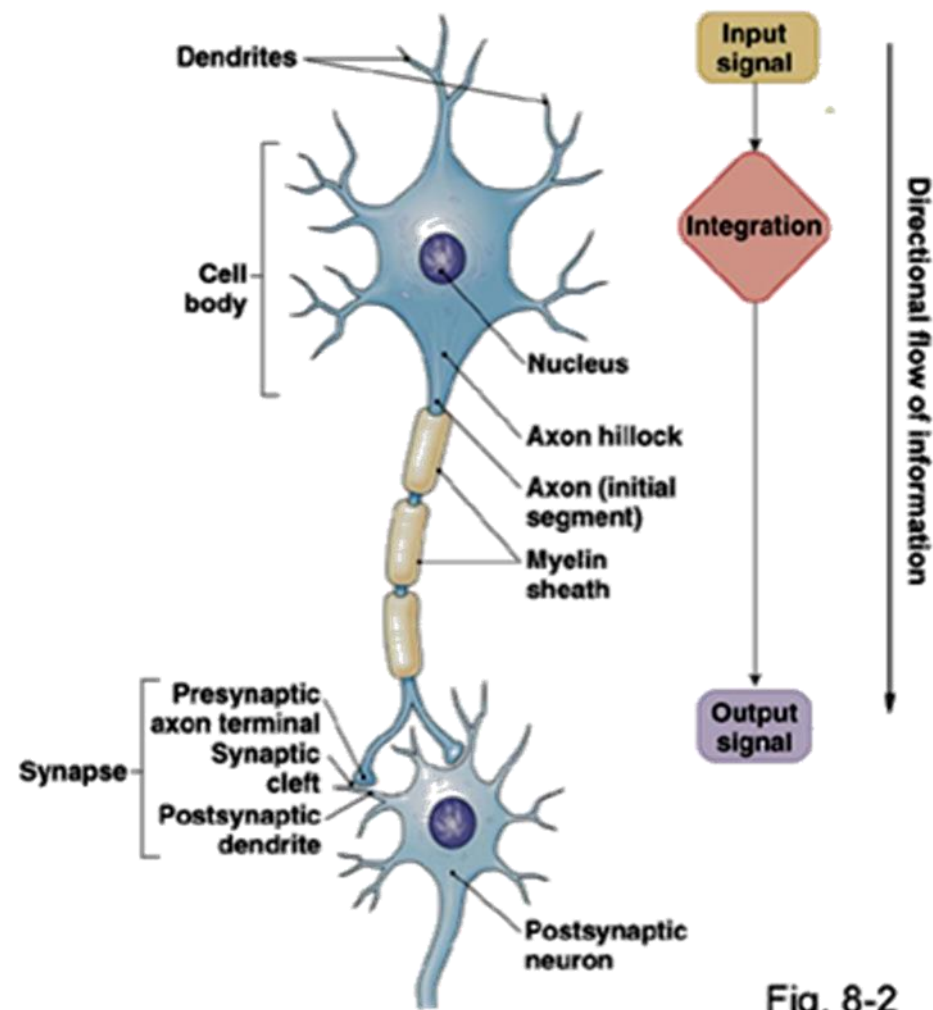


Fig. 8-2

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

# Synapse

- Komunikace mezi neurony
- Elektrické
- Chemické

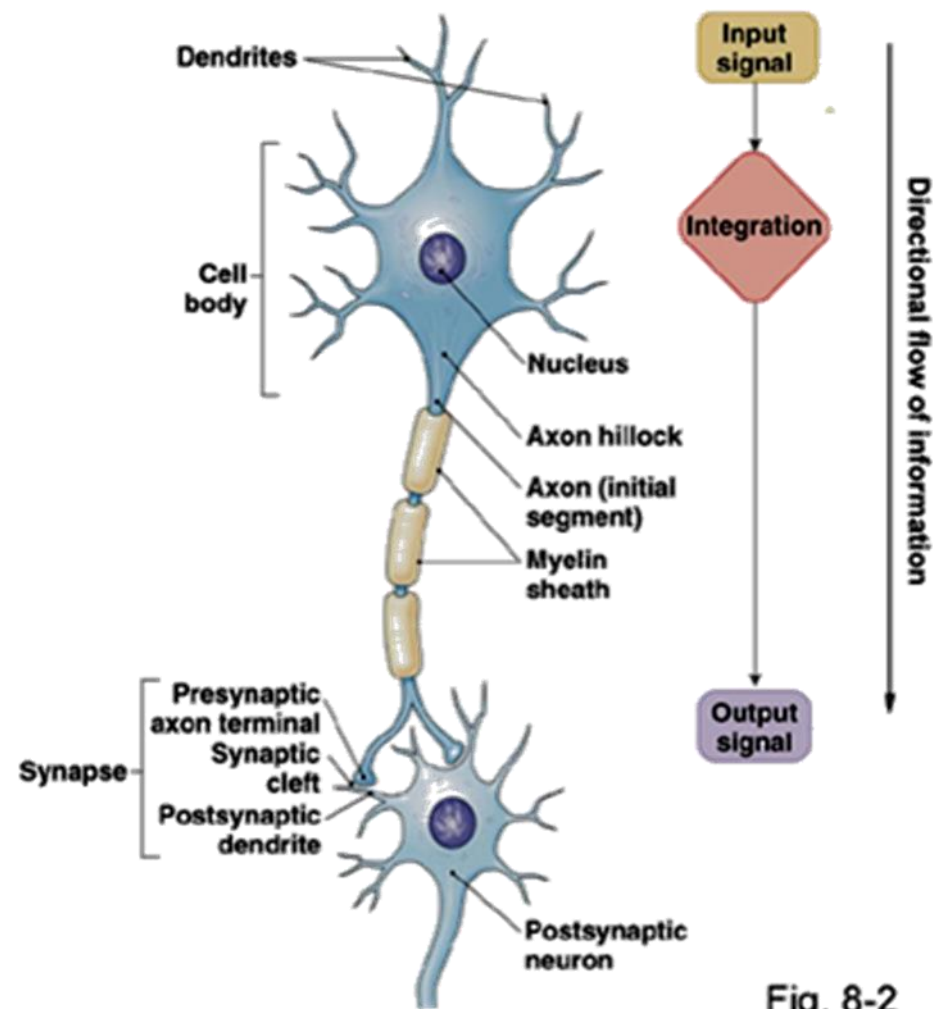
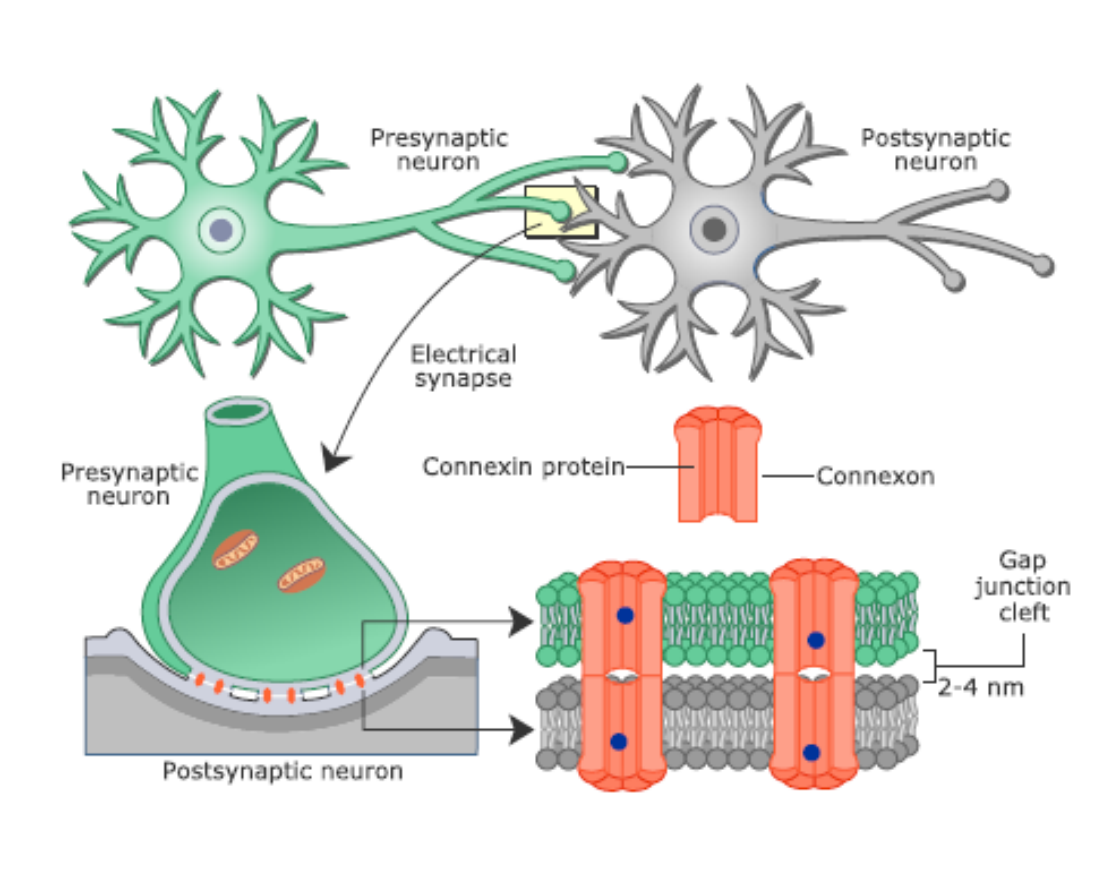


Fig. 8-2

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# Elektrické synapse

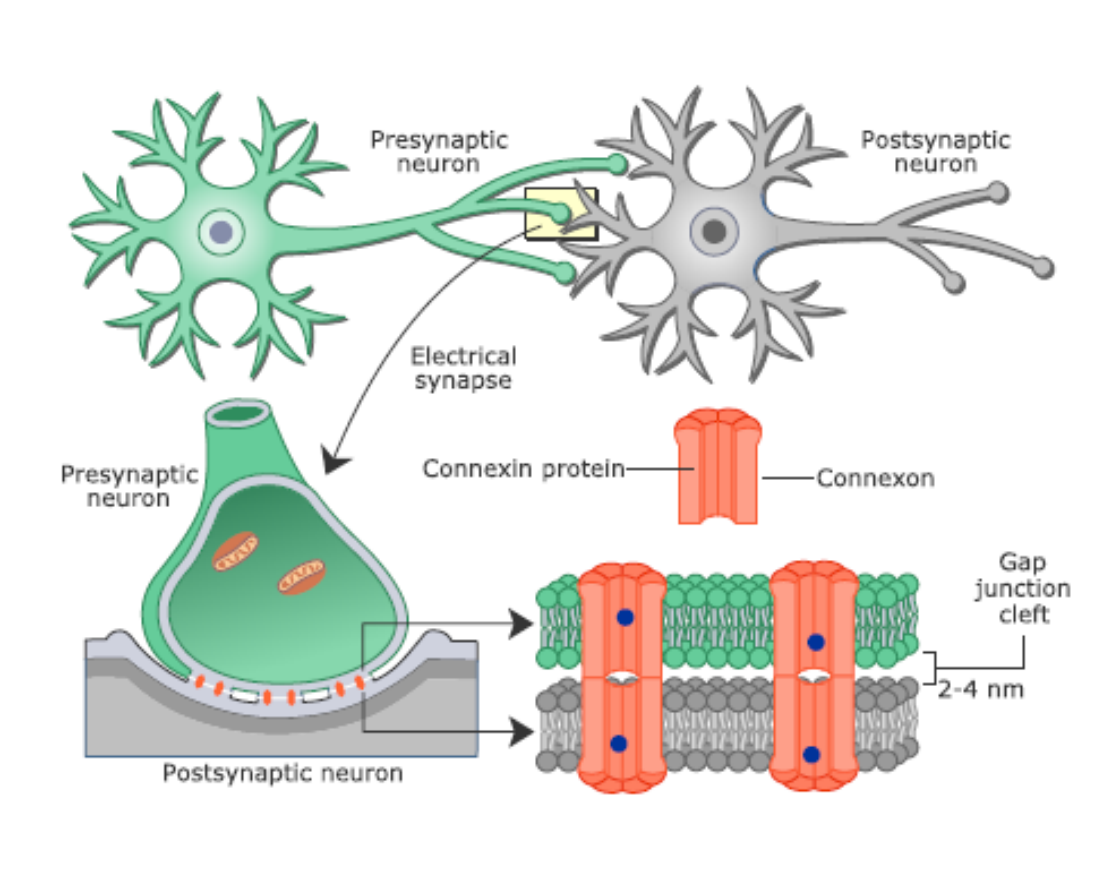
- Evolučně staré
- Méně než chemických
- Ubikvitární



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# Elektrické synapse

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

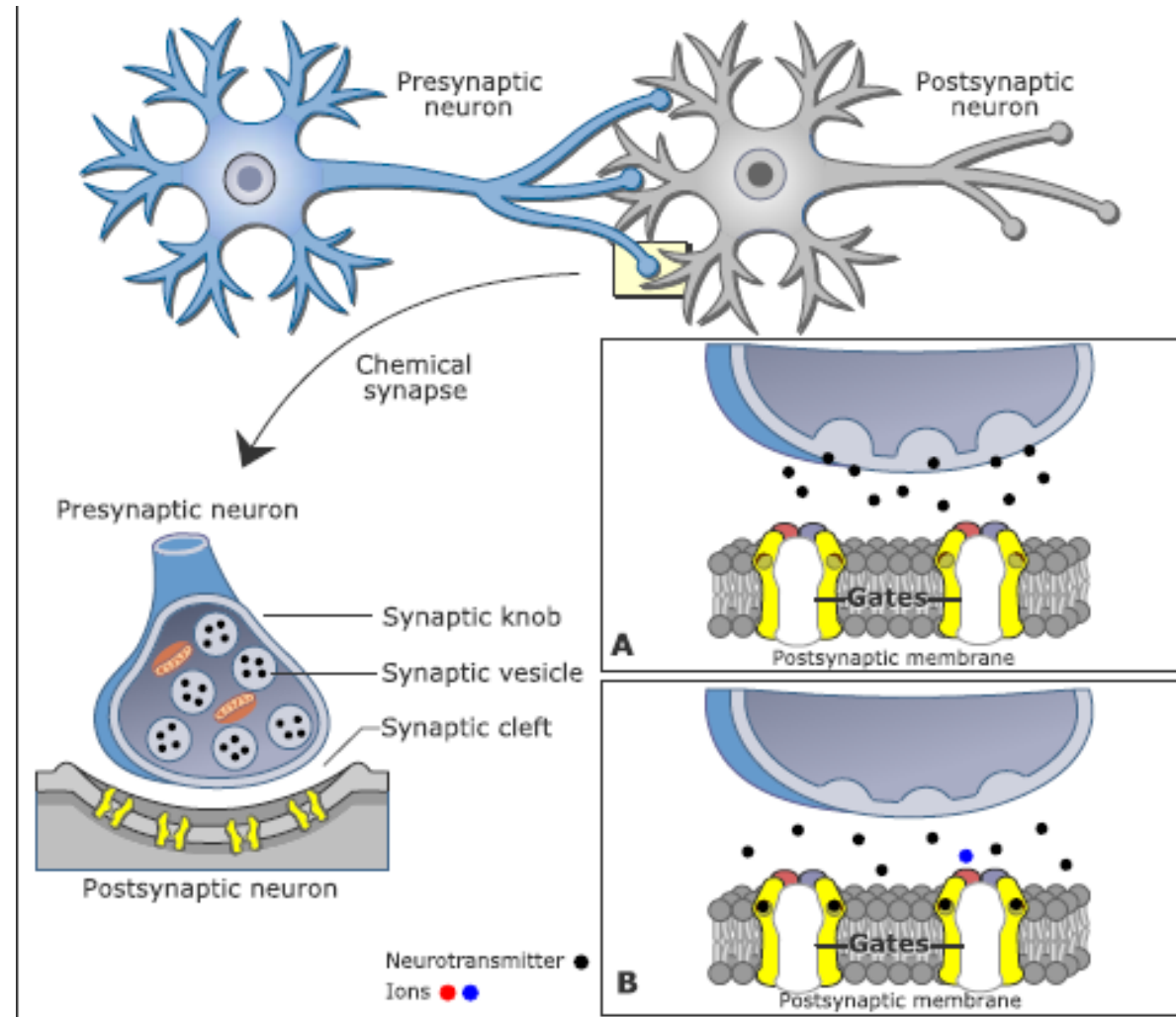


<http://www.slideshare.net/CsillaEgri/presentations>



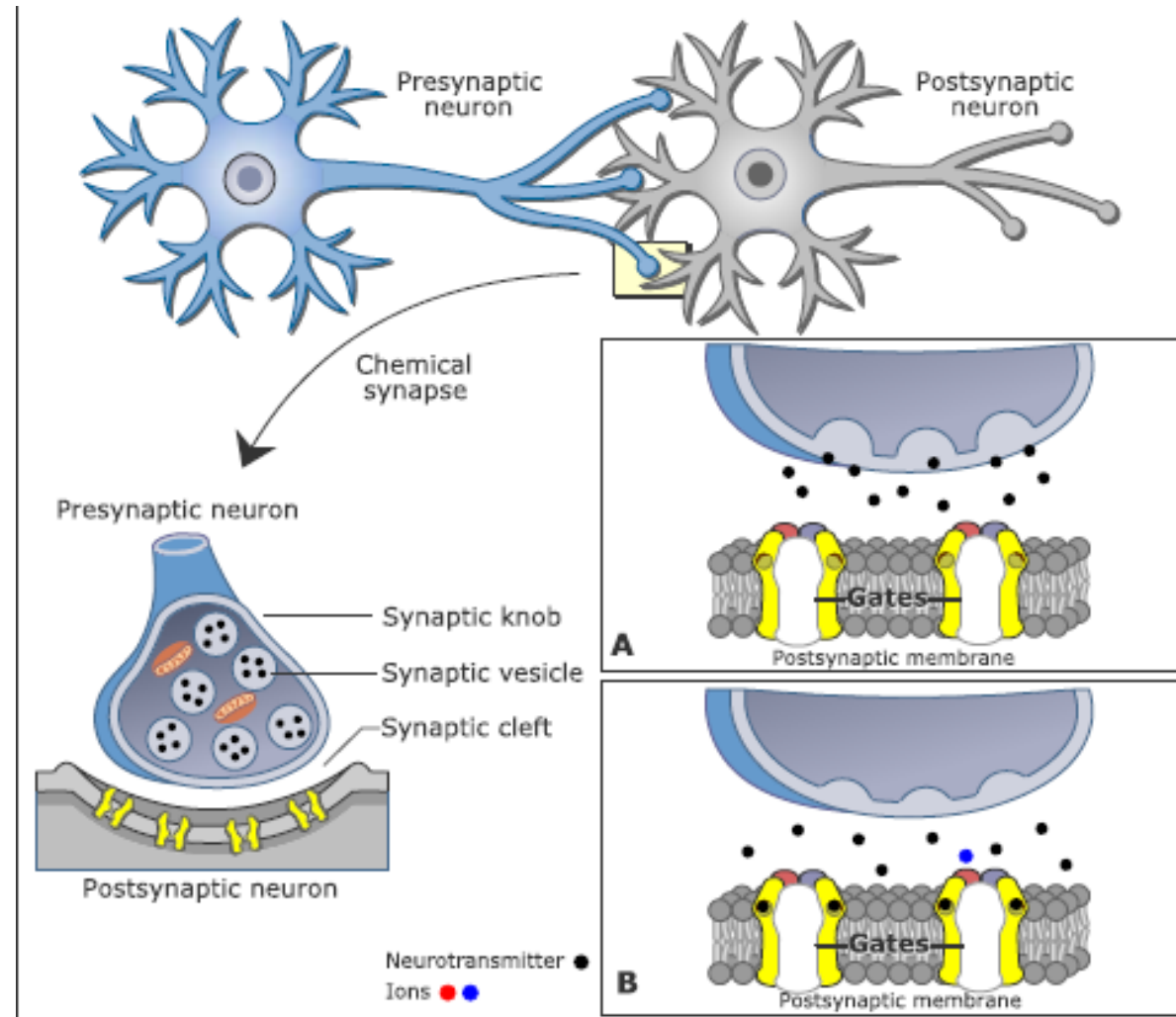
# Chemické synapse

- Evolučně mladší
- Většinový typ

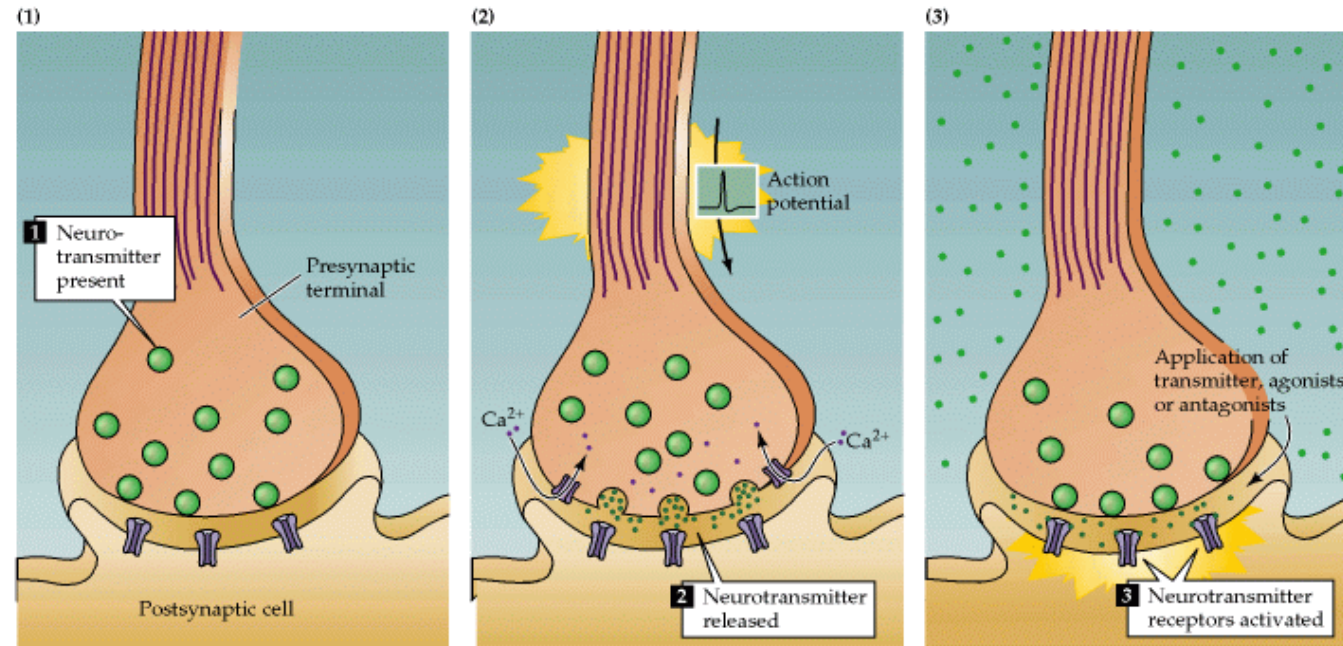


# Chemické synapse

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



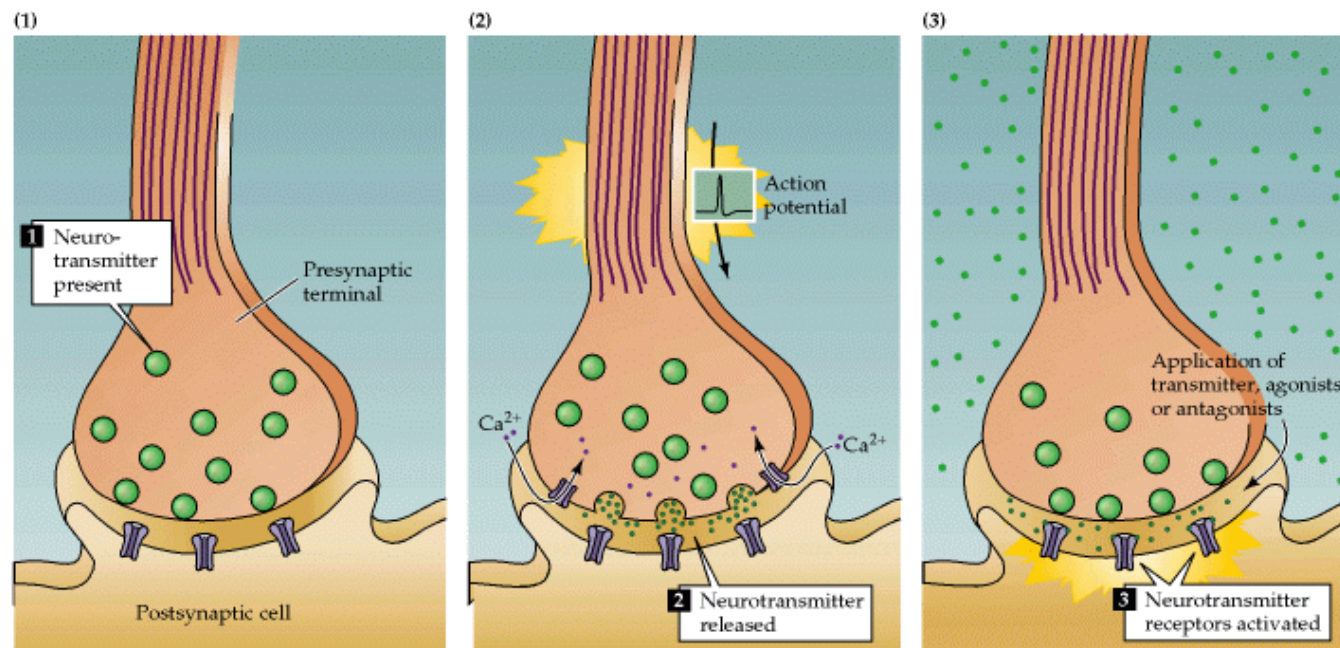
# Neurotransmitter



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

- Přítomen v presynaptickém neuronu

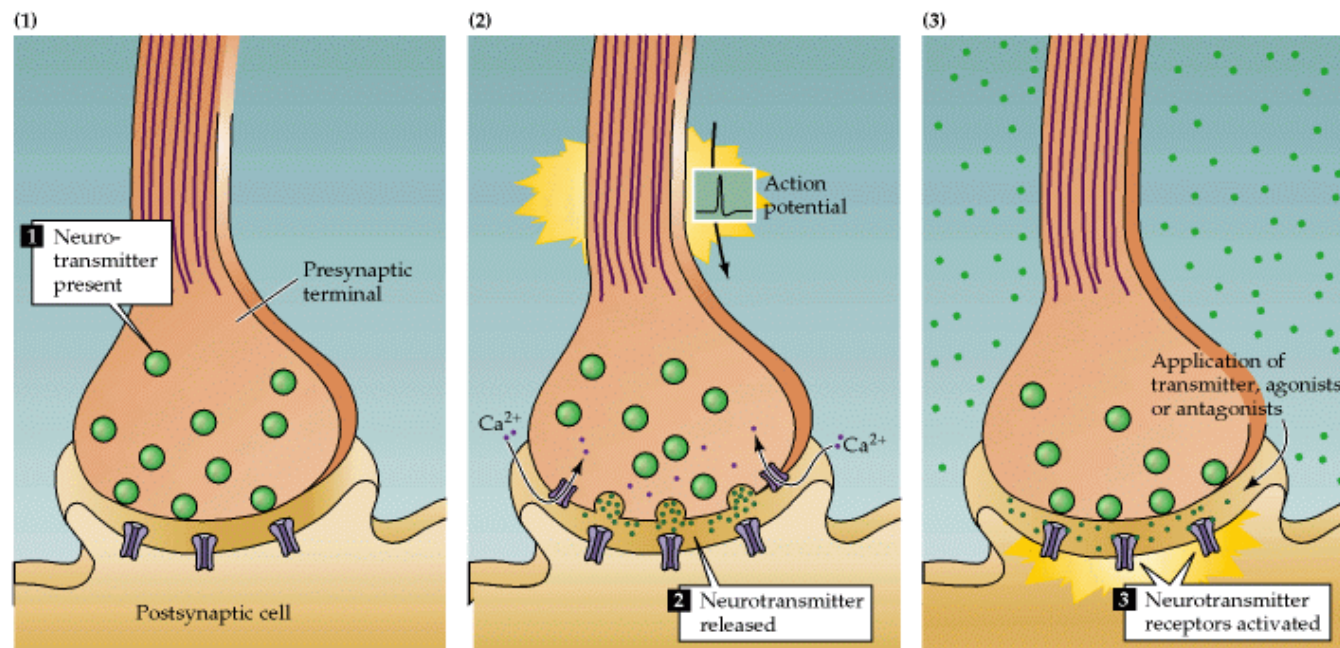
# Neurotransmitter



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

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

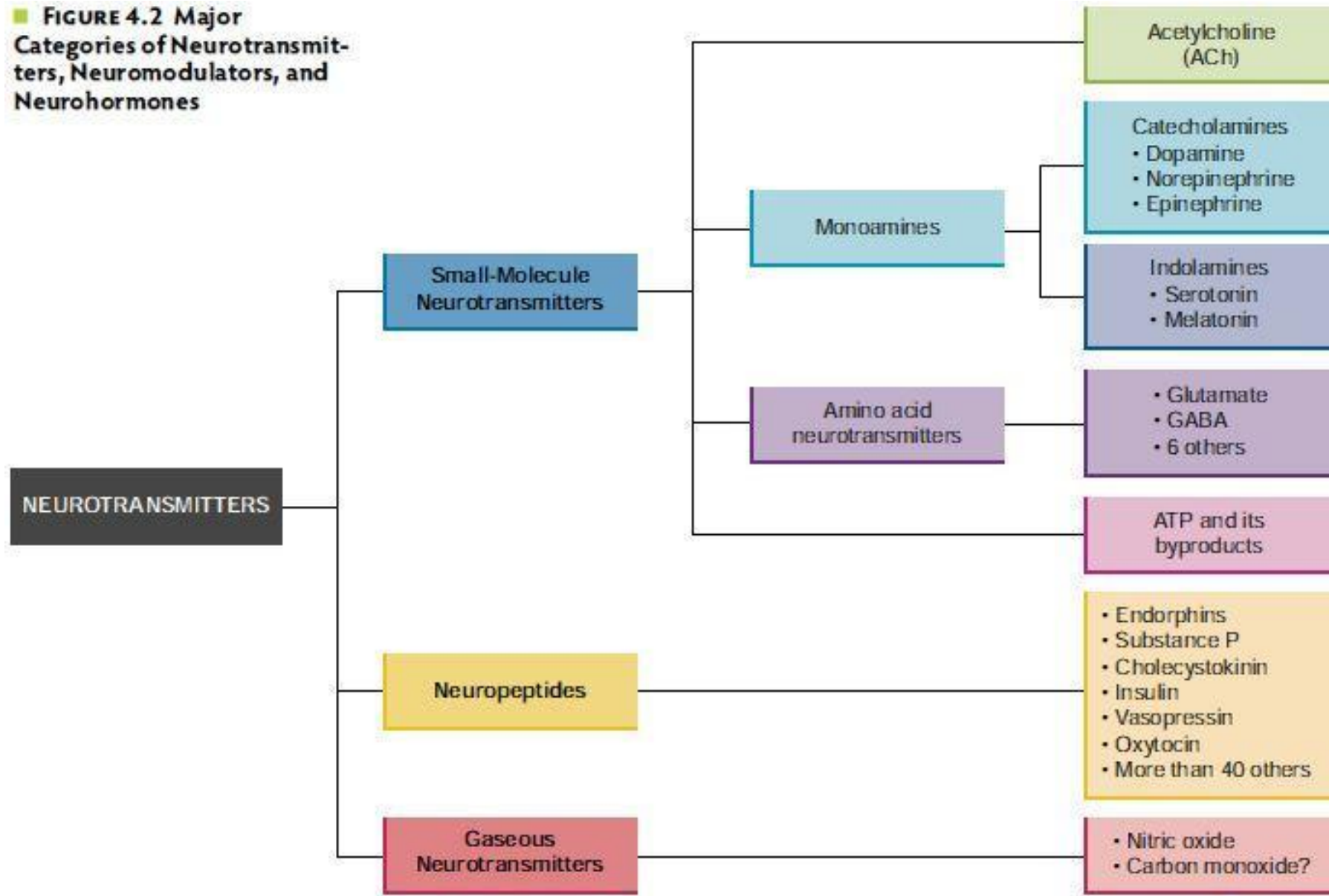
# Neurotransmitter



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

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

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



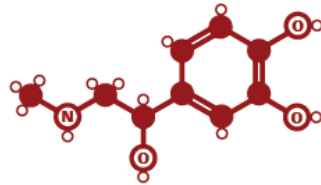
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# THE STRUCTURES OF NEUROTRANSMITTERS

STRUCTURE KEY: ● Carbon atom ○ Hydrogen atom ○ 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

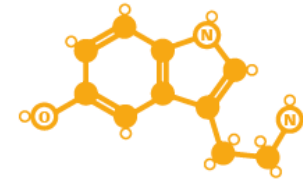
Pleasure neurotransmitter



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

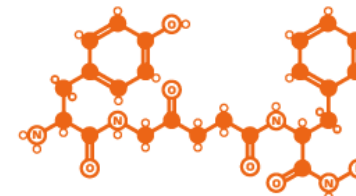
Memory neurotransmitter



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.



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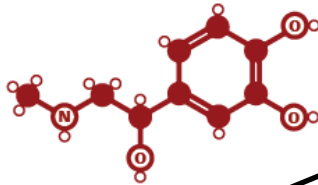


# THE STRUCTURES OF NEUROTRANSMITTERS

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

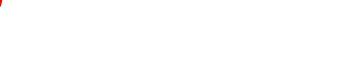
Concentration neurotransmitter



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

## ACETYLCHOLINE

Most common neurotransmitter



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

## SEROTONIN

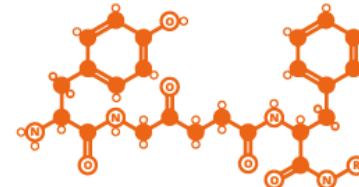
Mood neurotransmitter



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## ENDORPHINS

Euphoria neurotransmitters



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

## GABA

Calming neurotransmitter



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

**Excitační**  
(kyselina glutamová, acetylcholin)

**X**

**Inhibiční**  
(GABA)

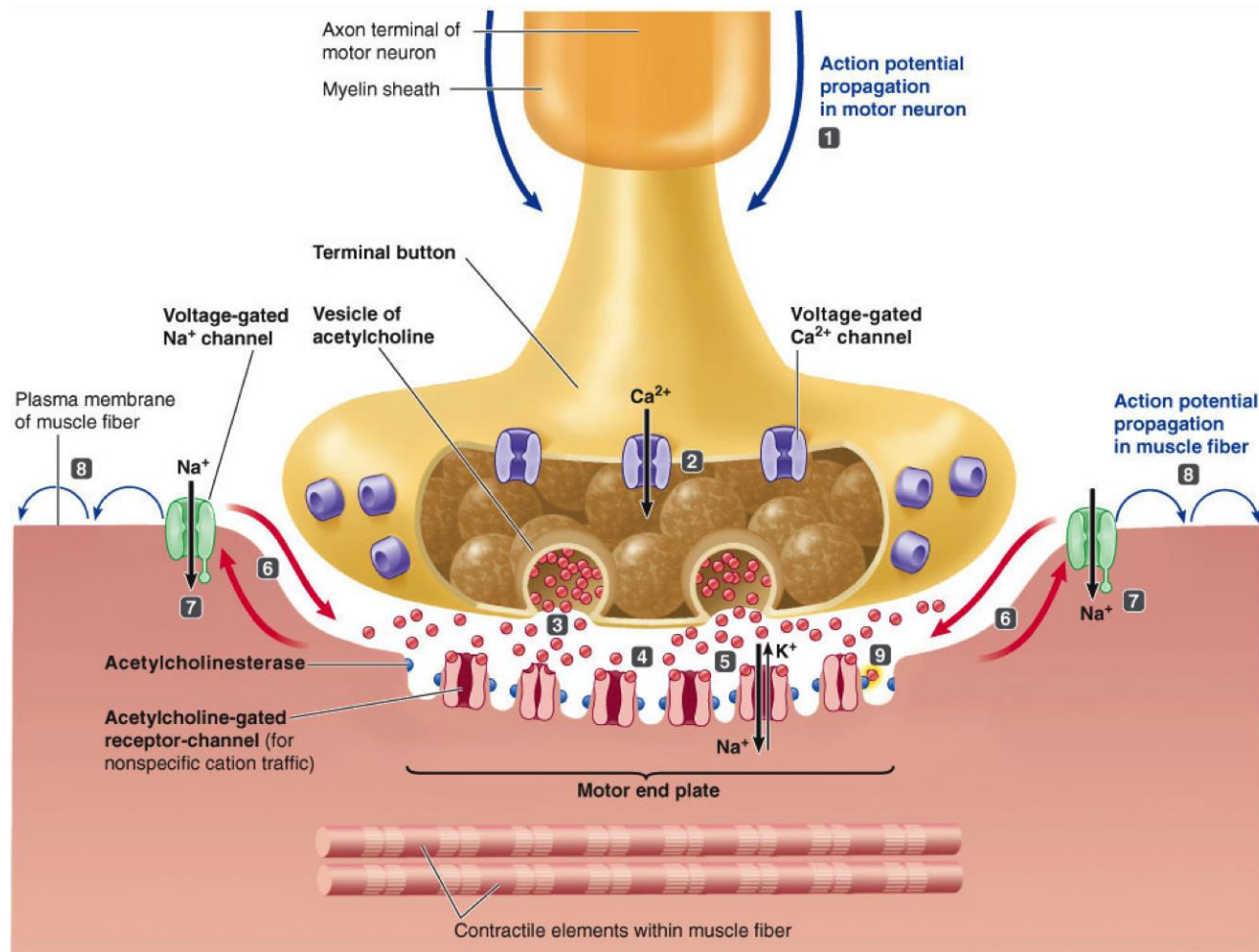


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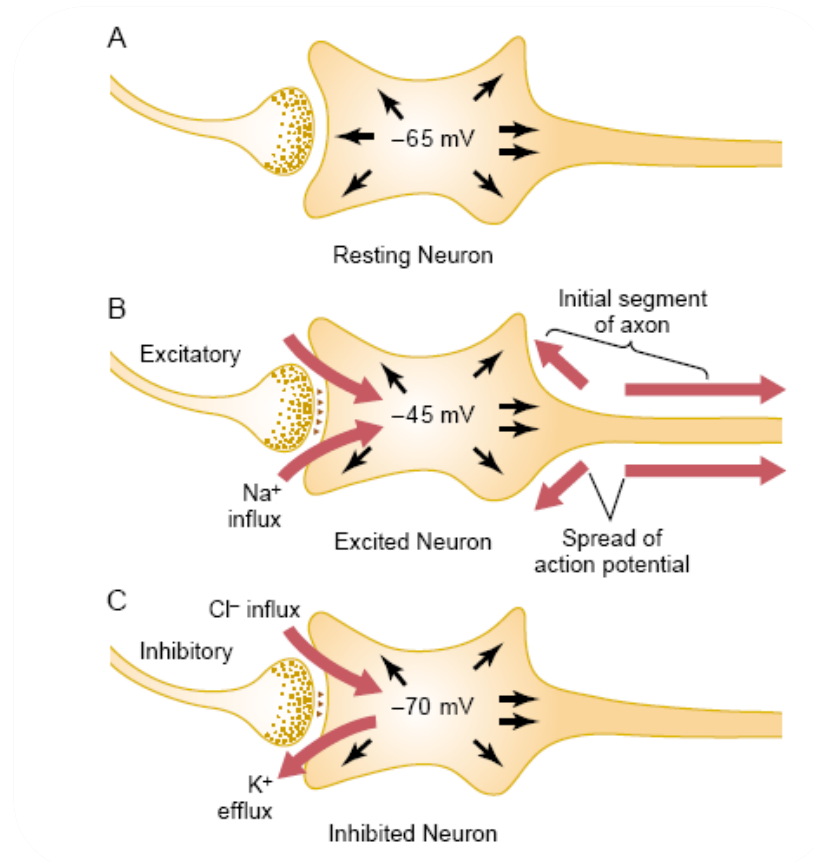


# Neuromuskulární spojení



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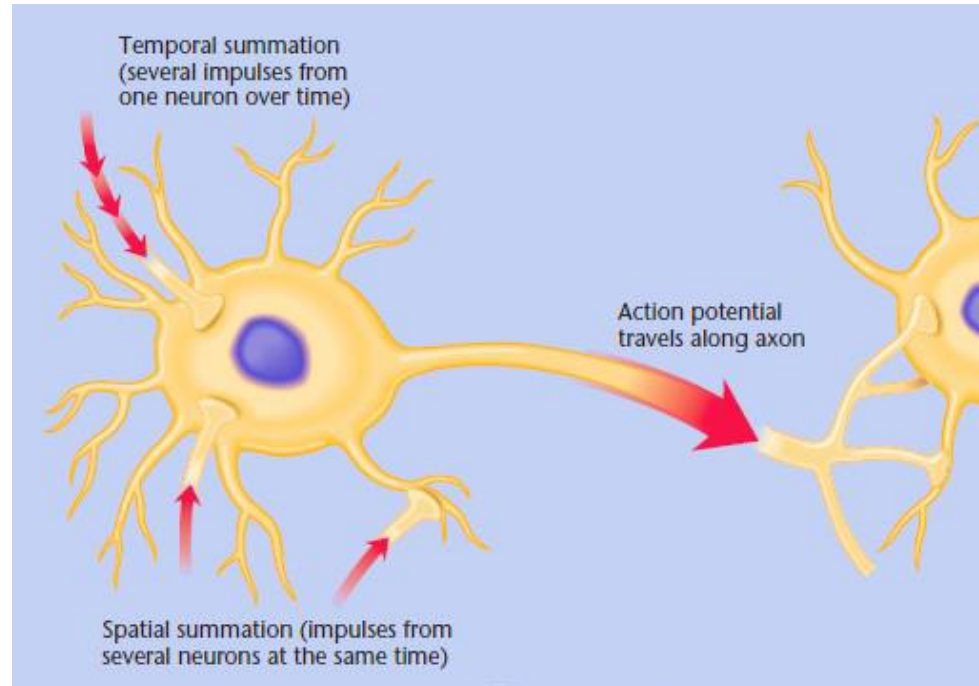
# Excitační/inhibiční postsynaptický potenciál



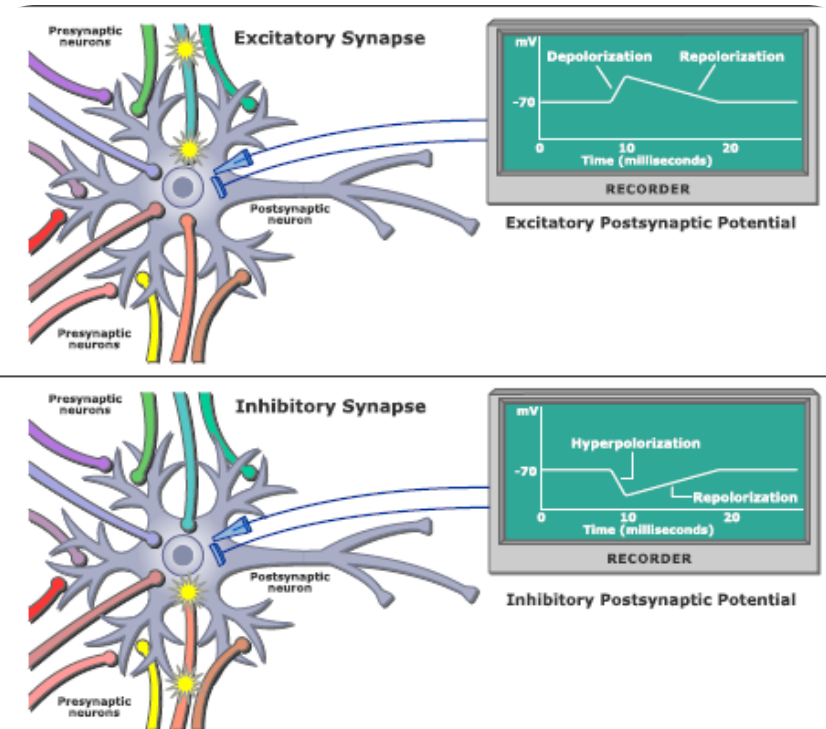
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# Sumace signálu

- Časová
- Prostorová

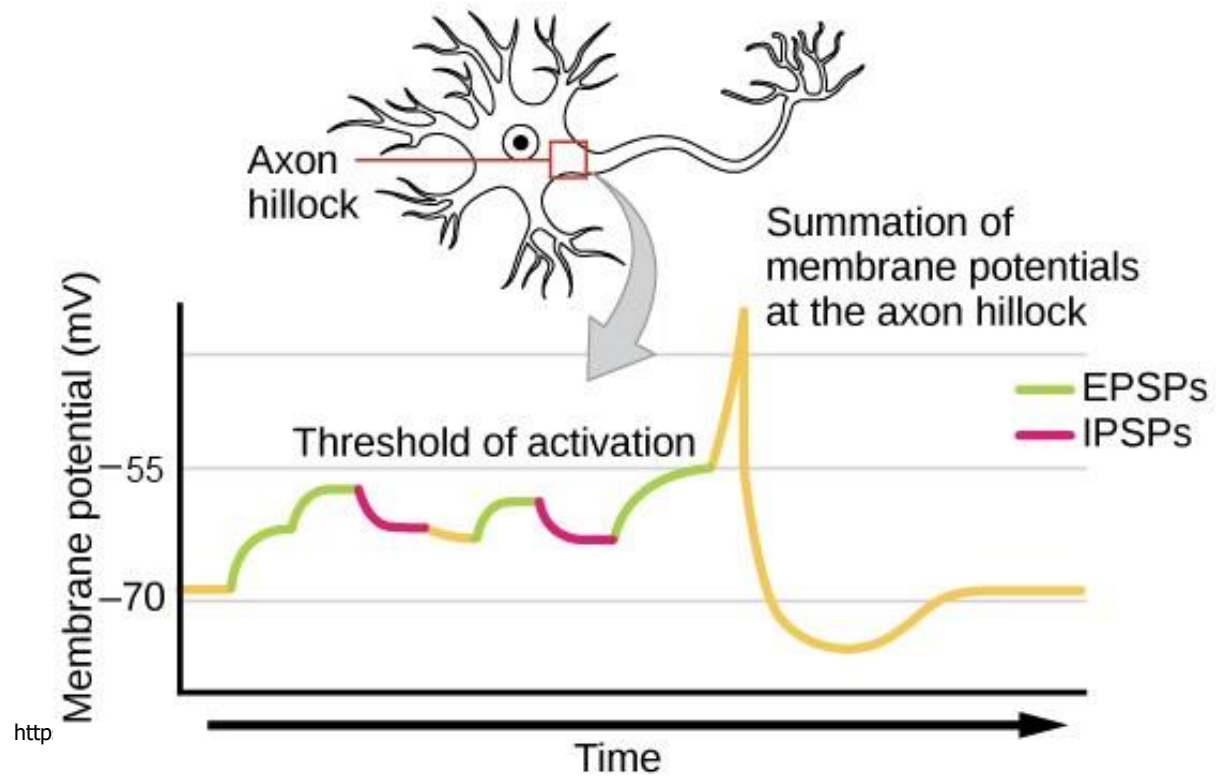


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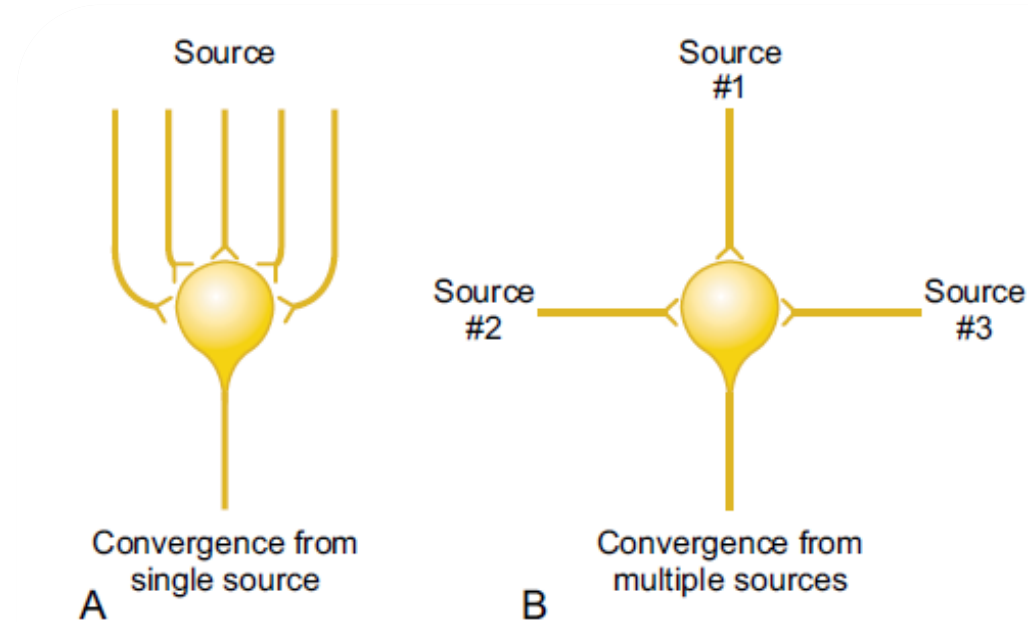
<http://www.slideshare.net/drpsdeb/presentations>

# Sumace signálu



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

# Konvergence signálu

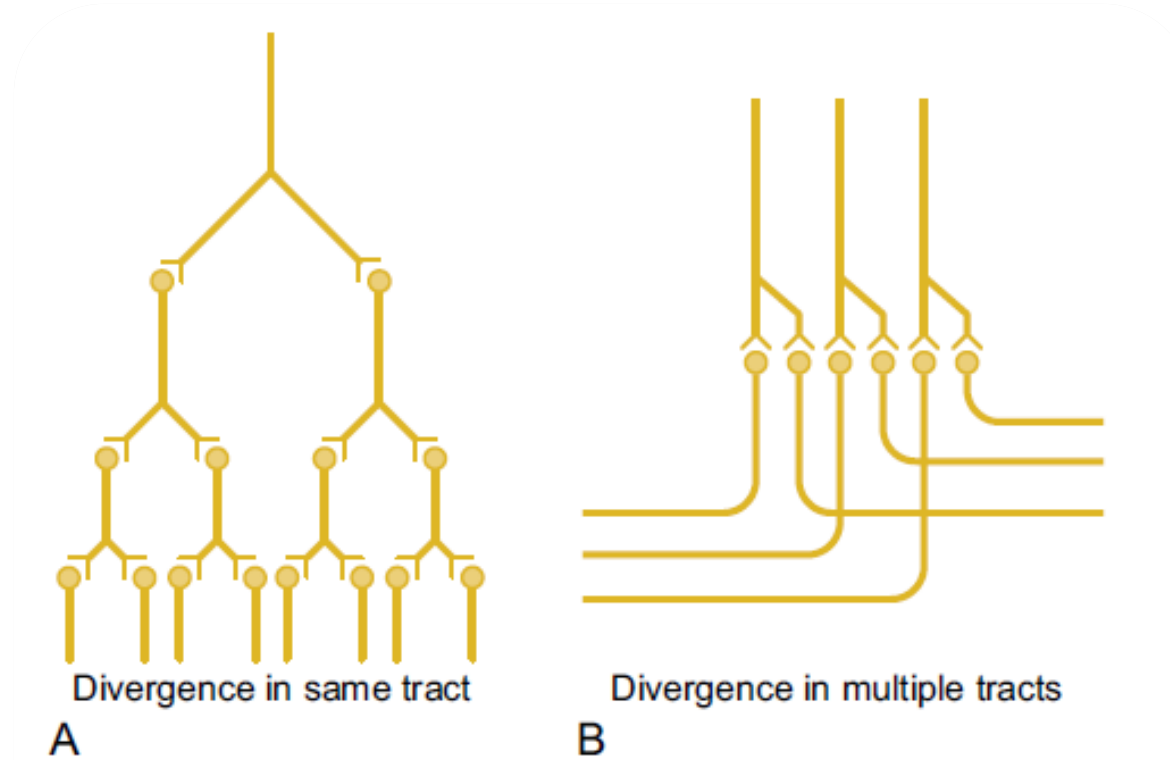


**Figure 46-12**

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

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# 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.

# Synaptická konvergence a divergence

Průměrný počet synapsí  
na neuron u primátů

✓ Primární zrakový  
kortex (area17)  
– cca. 4 000

✓ Primární motorický  
kortex (area4)  
– cca. 60 000

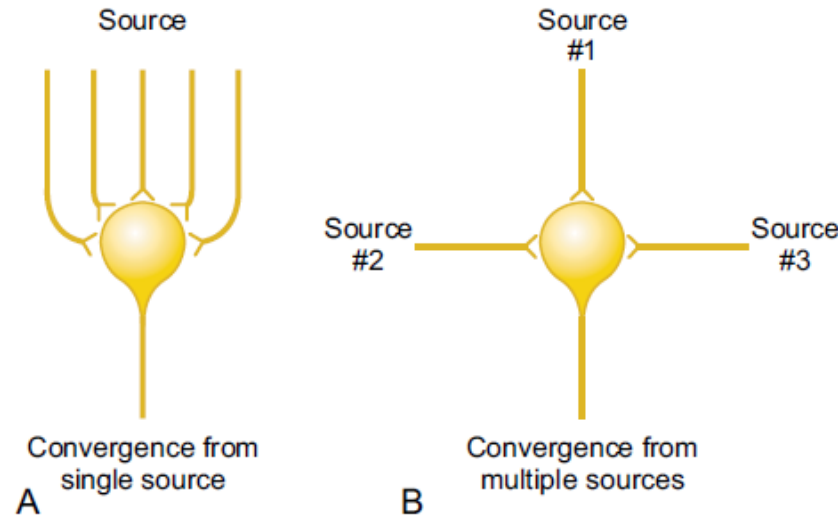


Figure 46-12

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

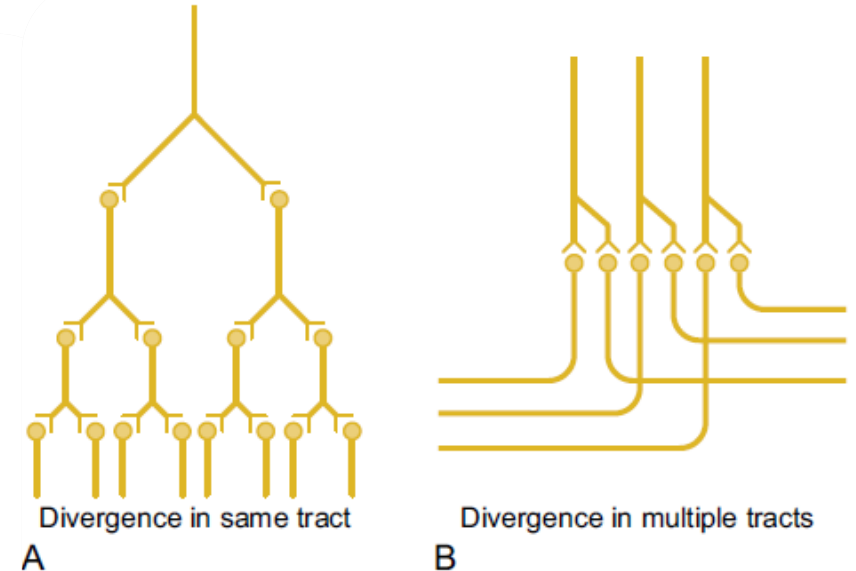
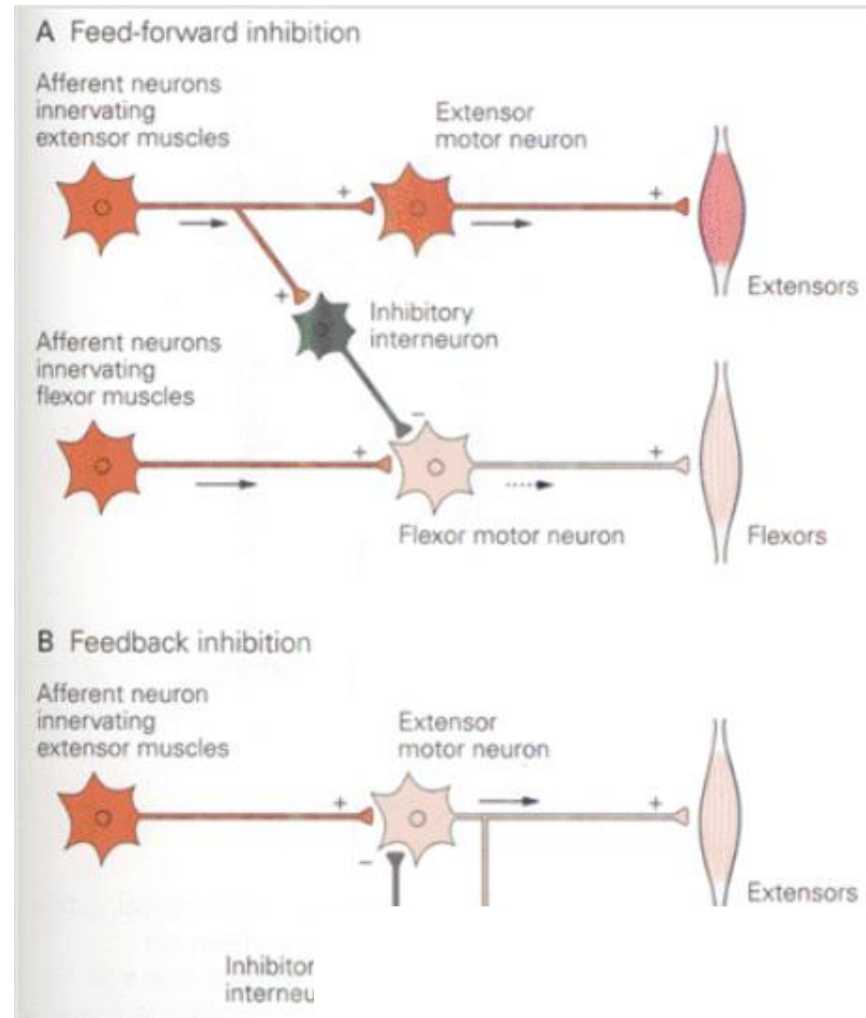


Figure 46-11

"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.

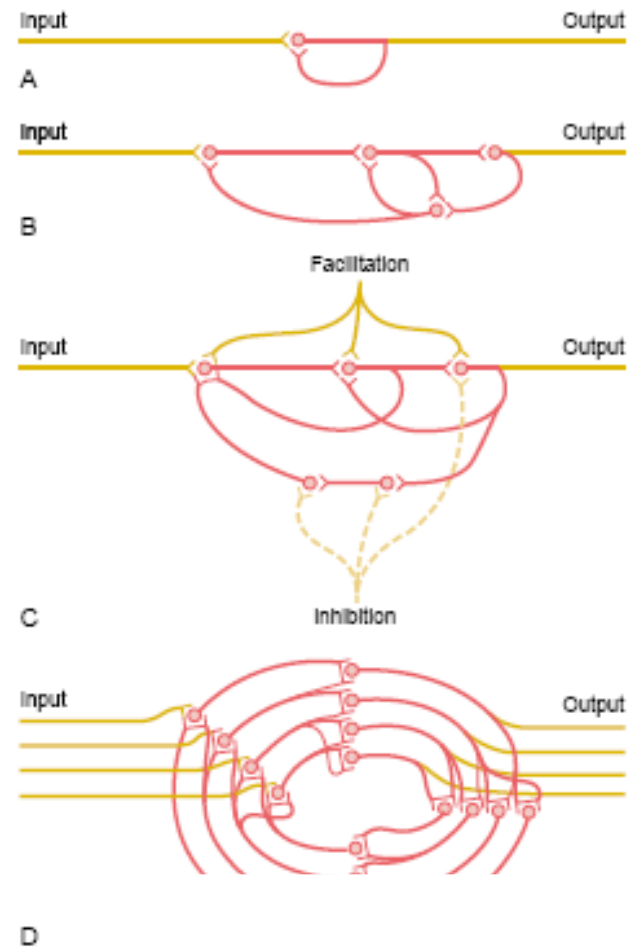
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# Networking





# Networking



# 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.

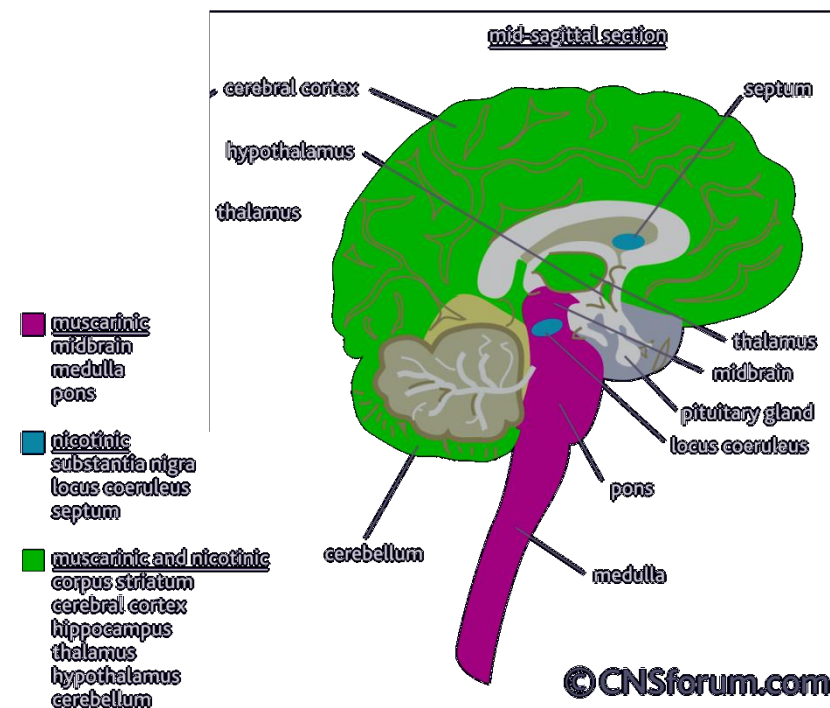
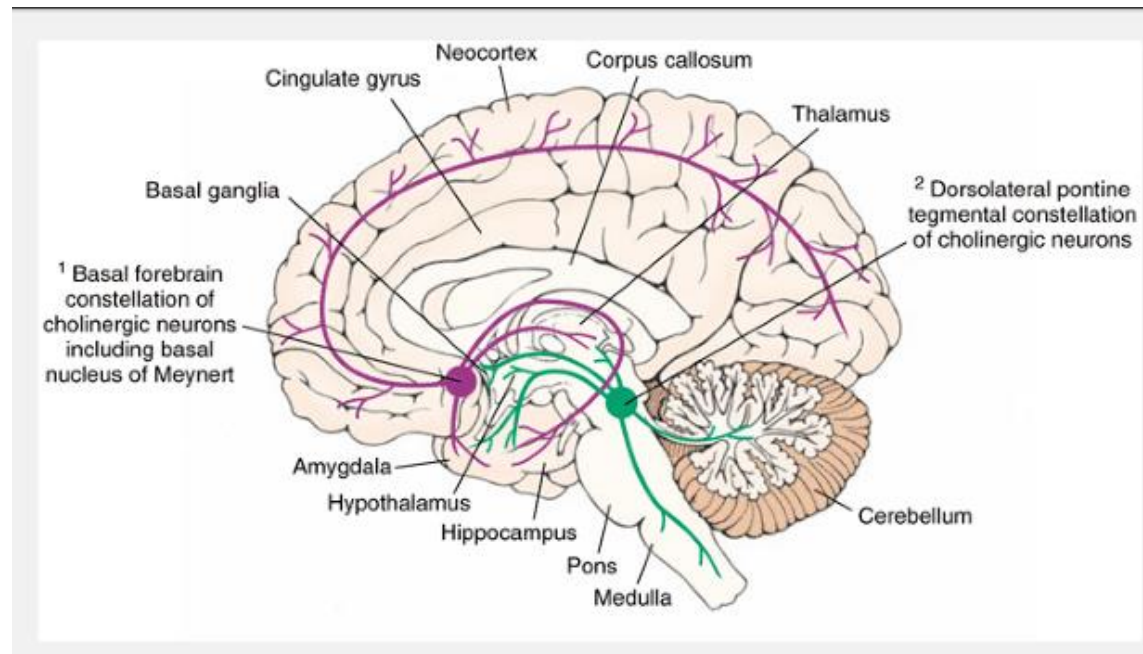
# Neuromodulace

- 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.

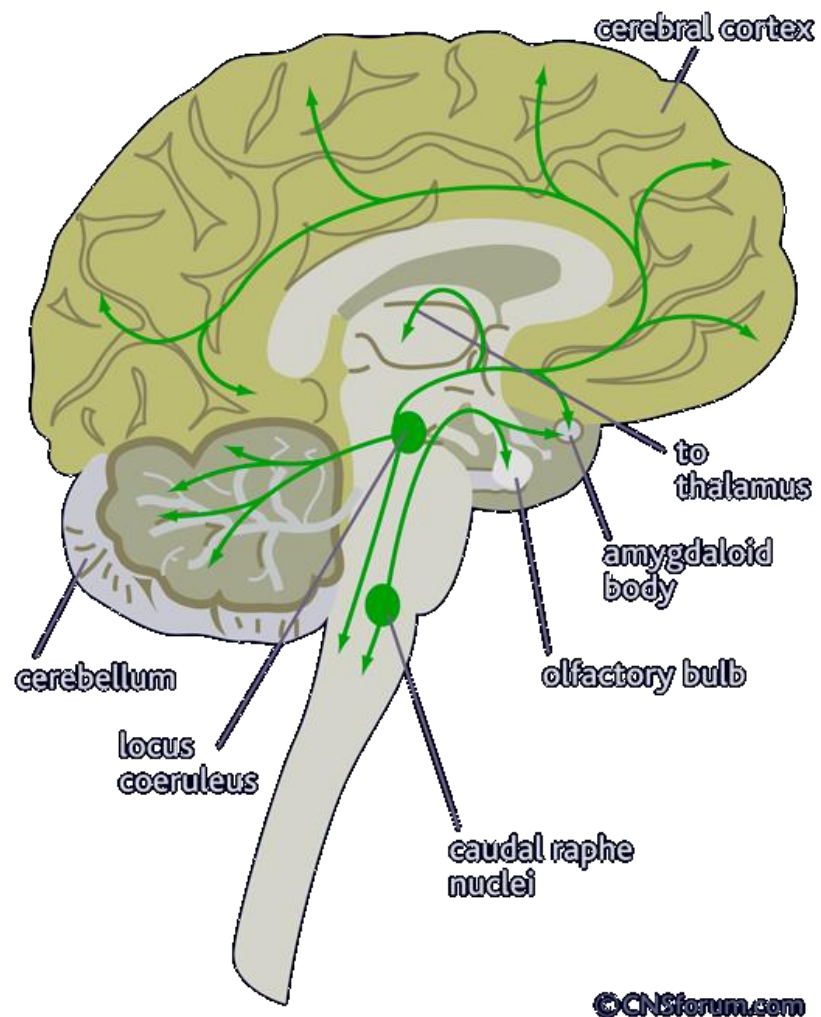
# Acetylcholin

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



# Noradrenalin

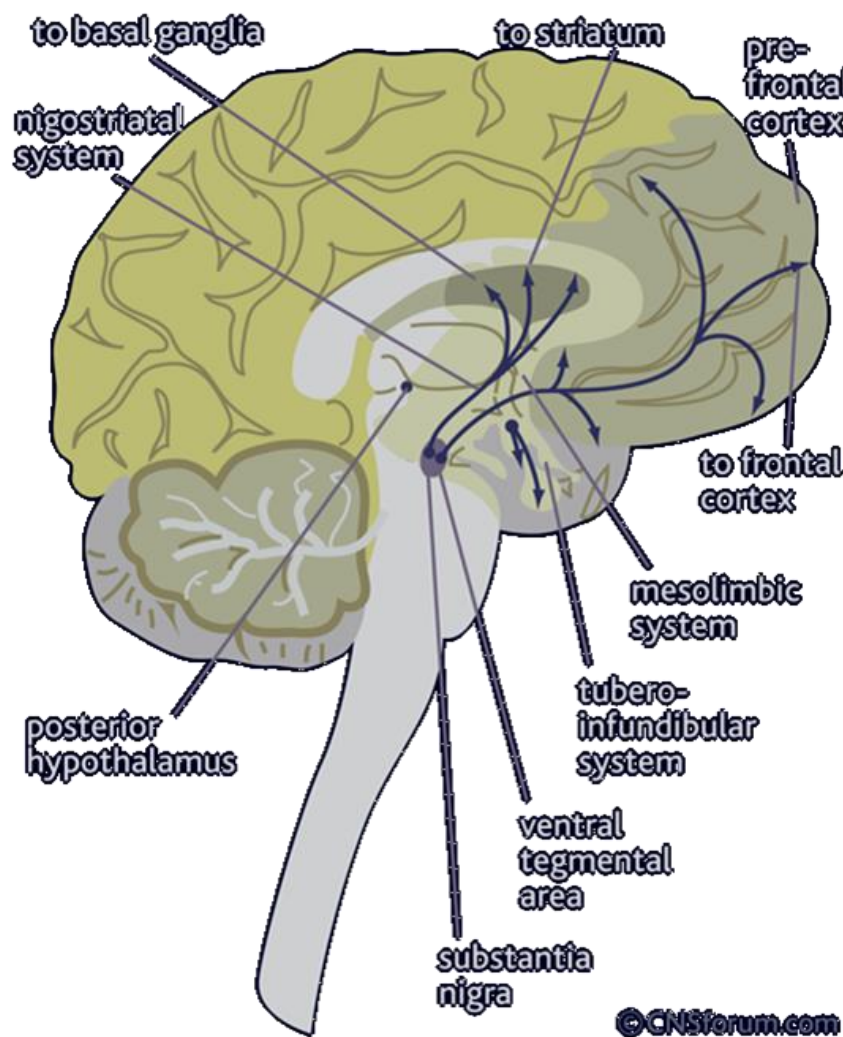
- Locus coeruleus
- Nuclei raphe caudalis
  
- Bdělost
- Responzivita na nečekané podmínky
- Paměť
- Učení



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# Dopamin

- Nigrostriatální 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

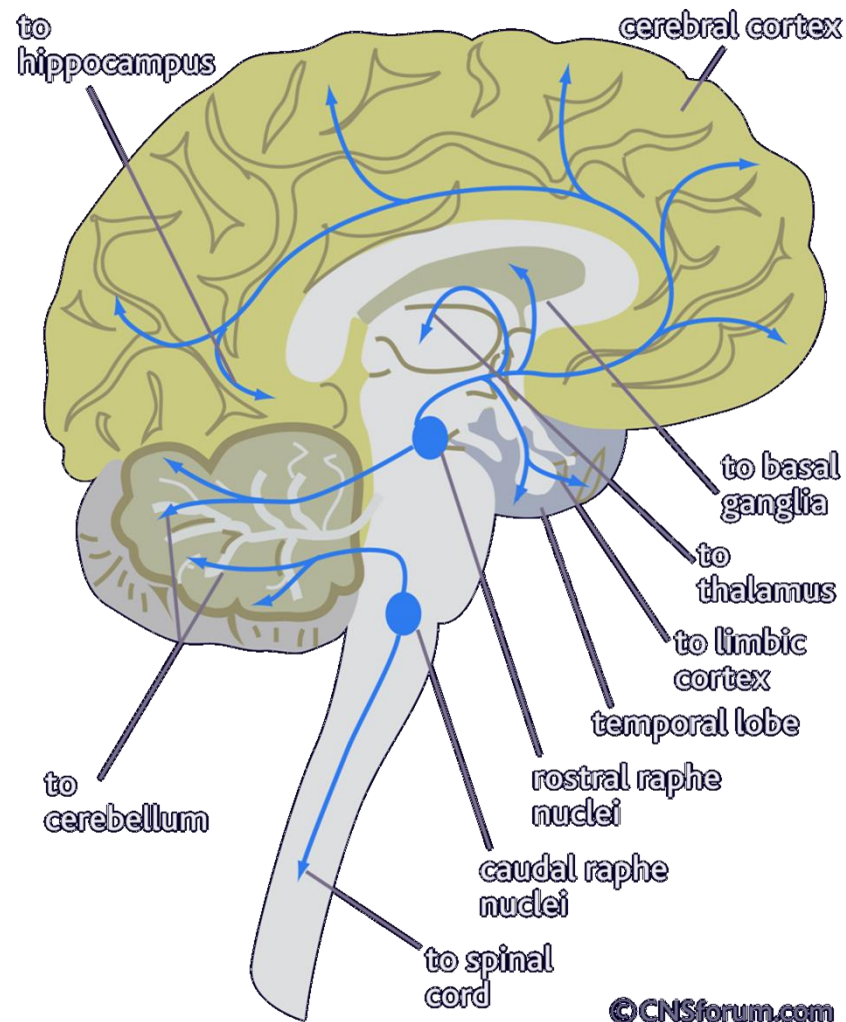


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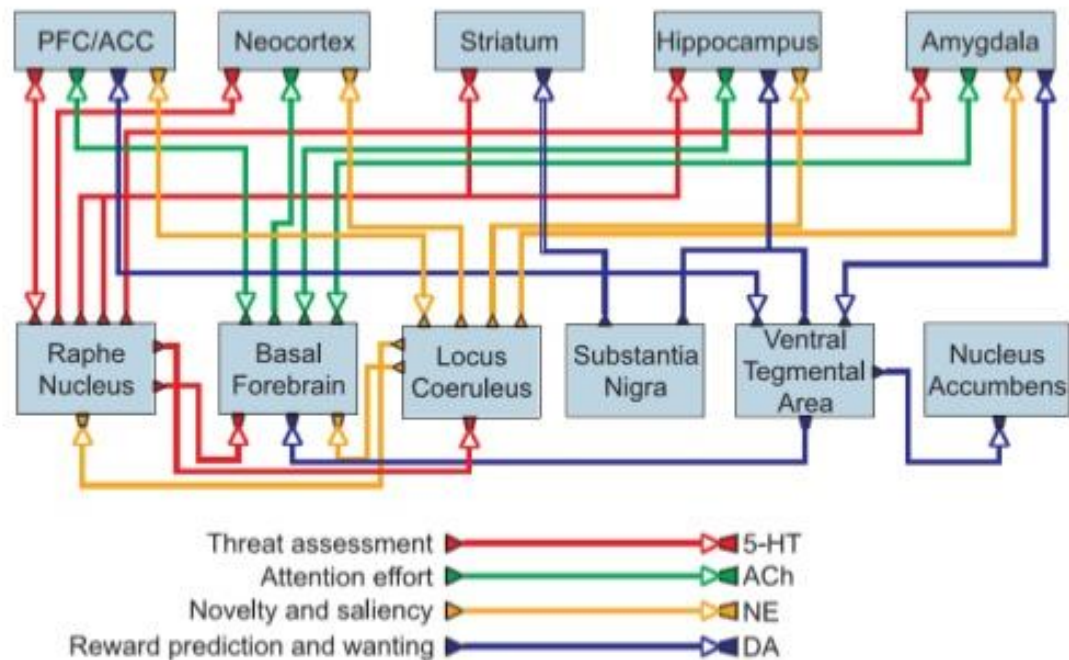
# Serotonin

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



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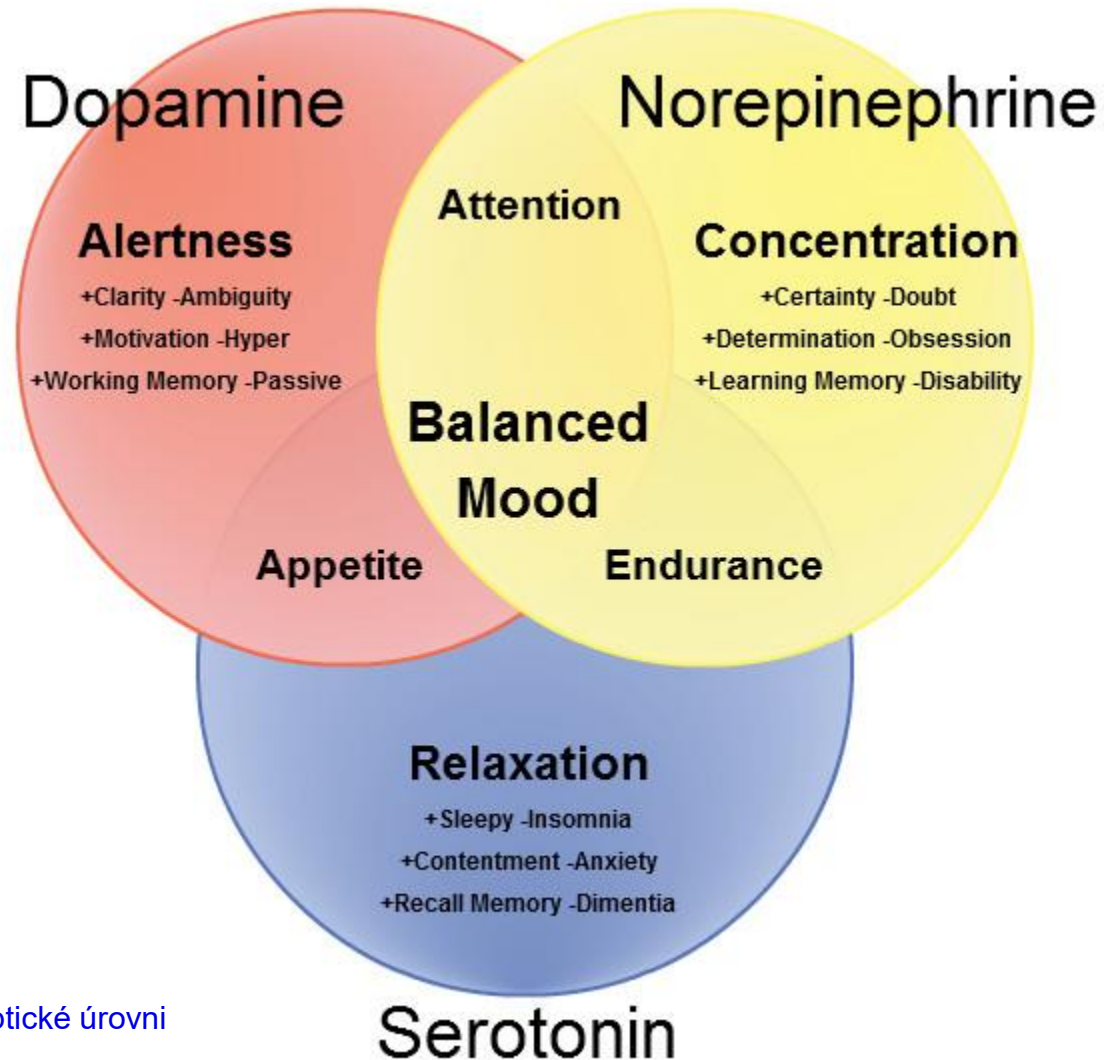
# Neuromodulační systémy



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

<http://image.slidesharecdn.com/neuromodulationincognition-140119031056-phpapp02/95/neuromodulation-incognition-5-638.jpg?cb=1419657931>

# Neuromodulační systémy



## 71. Synapse a integrace informace na synaptické úrovni, neurotransmise vs. neuromodulace

- ✓ Synapse
  - Definice
  - Elektrické vs. chemické
- ✓ Definice a základní klasifikace neurotransmiterů
- ✓ Excitační/inhibiční postsynaptické potenciály vs. Akční potenciál
  - Časová a místní sumace signálu
- ✓ Konvergence a divergence signálu
- ✓ Neurotransmise vs. neuromodulace
  - Příklady neuromodulačních systémů

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