Keywords (reading p. 1022-1038)
- Integration of synaptic signals
- Neurotransmitters
- Acetyl choline
- Norepinephrine
- Serotonin
- Dopamine
- Amino acid neurotransmitters
- Endorphins
- Nitric oxide (NO)
- Guanylate cyclase

Sample test question:
- True or False: The concentrations shown in this diagram are correct

Outside cell

<table>
<thead>
<tr>
<th></th>
<th>[Na⁺]</th>
<th>[K⁺]</th>
<th>[Cl⁻]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 mM</td>
<td>150 mM</td>
<td>10 mM</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Inside cell

<table>
<thead>
<tr>
<th></th>
<th>[Na⁺]</th>
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</tr>
</thead>
<tbody>
<tr>
<td>150 mM</td>
<td>5 mM</td>
<td>120 mM</td>
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</tbody>
</table>
During which part of the action potential does this occur (Na\(^+\) entering axon)?

(A) Action potential
(B) Threshold potential
(C) Resting potential

During which part of the action potential does this occur (K\(^+\) leaving axon)?

OUTSIDE CELL

Na\(^+\)

INSIDE CELL
K\(^+\)
Integration of multiple synaptic inputs

Summation of postsynaptic potentials
Neurotransmitters

- Acetylcholine (ACh) - excitatory to vertebrate skeletal muscle; other effects at other sites

\[
\text{H}_3\text{C} \xrightarrow{\text{C}} \text{O} \xrightarrow{\text{C}} \text{CH}_2 \xrightarrow{\text{CH}_2} \text{N}^+ \xrightarrow{\text{(CH}_3)_3}
\]
Biogenic amine neurotransmitters

- Norepinephrine
- Dopamine
- Serotonin
- Usually function within the central nervous system

Dopamine

- High levels are linked to schizophrenia

Serotonin

- Low levels linked to clinical depression
- Prozac: Selective serotonin reuptake inhibitor
Amino acid neurotransmitters

- GABA (gamma amino butyric acid)
- Glycine
- Glutamate
- Aspartate
- Used in the central nervous system

GABA

- Inhibitory synapses in brain
- Produces hyperpolarization by opening chloride channels

Neuropeptide neurotransmitters

- Substance P
- endorphins
Substance P

- Excitatory signal gives rise to perception of pain

Endorphins

- Decrease perception of pain
- Receptors for endorphins also recognize opiates (e.g., morphine and heroin)
- Endorphins are also hormones produced by the anterior pituitary

Norepinephrine/serotonin and depression

- Catecholamine hypothesis - depression represented a decreased availability of norepinephrine and/or serotonin
- Treatments are electroshock therapy and drugs to increase norepinephrine and/or serotonin availability
Drug treatments

• Selective serotonin reuptake inhibitors (SSRI)
  – Fluoxetine HCl – Prozac
  – Trazodone – Desyrel
  – Sertraline HCl – Zoloft
  – Paroxetine HCl – Paxil

Drug treatments

• Tricyclic antidepressants
  – Block high affinity serotonin and norepinephrine reuptake systems
  – Increase sensitivity of serotonin receptors
  – Example: Amitriptyline - Elavil

Drug treatments

• Monoamine oxidase (MAO) inhibitors
  – Example: Phenelzine-Nardil
A newly discovered class of neurotransmitters (gases)
- Late 80’s nitric oxide (NO) and carbon monoxide (CO)
- NO causes smooth muscle cells to relax, resulting in dilation of blood vessels

NO has rapid effects
- Produced from the amino acid arginine
- NO can readily diffuse through tissues
- Half life of NO is only 5-10 seconds
  - Turned into nitrates and nitrites
- Effects of NO occur within seconds, and also end within seconds