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9.01 Introduction to Neuroscience
Fall 2007

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9.01 Recitation (R02)

RECITATION #3: Tuesday, September 25th

Review of Lecture: 5 (some overlap with 6)

Reading: Chapter 5 of *Neuroscience: Exploring the Brain* (3rd edition)

Outline of Recitation:

- I. Previous Recitation:
 - a. Finish material from last recitation
 - b. Questions on practice exam questions from last recitation?
 - c. Questions on previous problem set?
- II. Review of Material:
 - a. ELECTRICAL SYNAPSE
 - b. CHEMICAL SYNAPSE
 - c. SYNAPTIC INTEGRATION
- III. Practice Exam Questions

Synaptic transmission: the process of information transfer at a synapse

ELECTRICAL SYNAPSES:

Electrical synapses occur at specialized sites called _____.

CHEMICAL SYNAPSES:

History: In the 1920s, Otto Loewi conducted the following experiment that showed synaptic transmission between nerve and heart is chemically mediated (p. 103):

Structure:

Process of Transmission:

Presynaptic cell:

1. Neurotransmitter synthesis
2. Neurotransmitter packaged in vesicles
3. Action potential arrives in terminal and voltage-gated Ca^{2+} channels open
4. In response to increased $[\text{Ca}^{2+}]$, synaptic vesicles fuse to membrane and neurotransmitters are released into synaptic cleft
5. Vesicle membrane is recycled and reenters the cycle of transmission

Postsynaptic cell:

6. Neurotransmitters diffuse across cleft
7. Binds to postsynaptic receptors
8. Transmitter is enzymatically destroyed and reuptake occurs

1. Neurotransmitter synthesis

Three types of transmitters:

Amino Acids

Amines

Peptides

* For synthesis of each transmitter, refer to page 143-147.

2. Neurotransmitter packaged in vesicles (p. 113)

Amino Acids and Amines packaging:

Peptides packaging:

3. **Action potential arrives in terminal and voltage-gated Ca^{2+} channels open**
4. **In response to increased $[\text{Ca}^{2+}]$, synaptic vesicles fuse to membrane and neurotransmitters are released into synaptic cleft (p. 113-115)**
5. **Vesicle membrane is recycled and reenters the cycle of transmission**

*More info on SNAREs on page 116.

6. **Neurotransmitters diffuse across cleft**
 7. **Binds to postsynaptic receptors (p.115-119)**
- Transmitter-gated ion channel:

Metabotropic "G-protein-coupled" receptors:

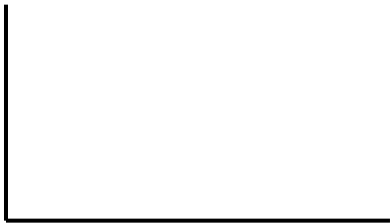
8. Transmitter is enzymatically destroyed or reuptake occurs (p. 119-120)

Neurotransmitters must be cleared from the synaptic cleft to allow another round of synaptic transmission by:

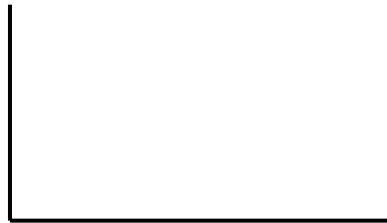
SYNAPTIC INTEGRATION:

Synaptic integration is the process by which multiple synaptic potentials combine with one postsynaptic neuron.

EPSP: Excitatory Postsynaptic Potential
- Influx of _____ in postsynaptic cell



IPSP: Inhibitory Postsynaptic Potential
- Influx of _____ in postsynaptic cell



Integration of EPSP:

- Postsynaptic EPSPs are a given synapse are quantized

Spatial summation:



Temporal summation:



Dendritic Properties of Integration: (p. 125)

$$V_x = V_o/e^{-x/\lambda}$$

V_o = depolarization at the origin

x = distance from the synapse

$$V_\lambda = 0.37 V_o$$

Shunting Inhibition:

Inward movement of negatively charged chloride ions = outward positive current flow

PRACTICE EXAM PROBLEMS: From Brown Exam I (2005)

23. Gap Junctions:

- a) transform electrical signals into chemical signals
- b) are more common in neurons than glial cells
- c) let electrical signals pass through, but block the flow of ions
- d) all of the above
- e) none of the above

24. If a neuron did not have vesicular transporters, synaptic vesicles could not be loaded and therefore

- a) the neuron could NOT fire action potentials or release neurotransmitters
- b) the neuron could fire action potentials, but NOT release neurotransmitters
- c) the neuron could NOT fire action potentials, but could still release neurotransmitters
- d) the neuron would still be able to fire action potentials and release neurotransmitters

25. Which of the following are characteristics of peptide neurotransmitters?

- a) They are stored in dense core vesicles
- b) They are synthesized in the soma
- c) They are not released as quickly as amino acid neurotransmitters
- d) All of the above
- e) None of the above

26. All of the following are criteria for classifying a molecule as a neurotransmitter EXCEPT:

- a) It is synthesized and stored in neurons
- b) It is released when the presynaptic cell is stimulated
- c) It is the only molecule released at the synapse
- d) It always evokes the same post-synaptic response
- e) It is degraded or removed from the synapse

27. Feedback inhibition in the synthesis of the neurotransmitter norepinephrine:

- a) opposes the action of end product inhibition
- b) modulates the activity of the rate limiting enzyme, tyrosine hydroxylase
- c) is higher if the neuron is more active
- d) blocks the production of epinephrine from norepinephrine
- e) is an exception to Dale's principle

28. All of the following statements about presynaptic Ca^{++} action are correct EXCEPT:

- a) the terminal bouton has a high concentration of Ca^{++} channels
- b) Ca^{++} channels open when the membrane depolarizes
- c) the Ca^{++} concentration is higher inside than outside the cell membrane
- d) Ca^{++} binds to synaptotagmin and consequently SNARES pull vesicles to fuse with the membrane
- e) with catecholamine neurotransmitters, the Ca^{++} channels are next to presynaptic vesicle docking locations

29. In discovering vagusstoff, Otto Loewi demonstrated that:

- a) the vagus nerve releases GABA when stimulated
- b) there are exceptions to Dale's principle
- c) nerve stimulation causes the release of a chemical transmitter
- d) a single neurotransmitter can be both excitatory and inhibitory
- e) Kermit has a big loving heart

Answers:

23. a b c d e

24. a b c d

25. a b c d e

26. a b c d e

27. a b c d e

28. a b c d e

29. a b c d e