Topic 1- Class 3

Transmission of a signal across a synapse

Pre-class Reading Assignment

1. Read pgs 420 – 422

2. Define the following terms

a.Synapse
b.Neurotransmitter
c.Pre-synaptic neuron
d.Post-synaptic neuron
e.Inhibitory neurotransmitter
f.Excitatory neurotransmitter
g.Acetylcholine
h.Cholinesterase
i.Synaptic cleft

3. Explain the difference between excitatory and inhibitory neurotransmitters in terms of the effect they have on sodium and potassium channels and on the post-synaptic neuron.

4. What are 5 major neurotransmitters found in our bodies? Identify each as inhibitory, excitatory or both.

5. What diseases are associated with neurotransmitters? What is thought to be the cause of each?

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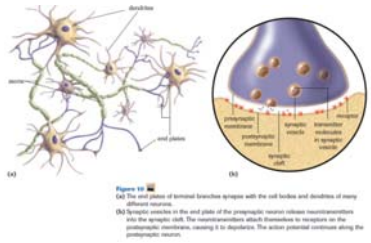
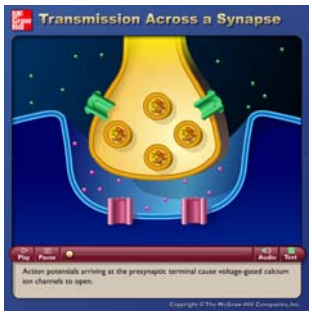
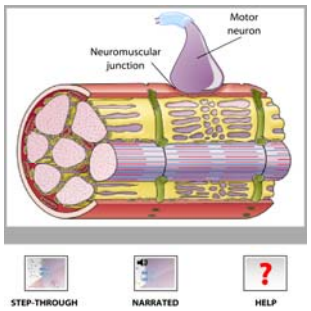
Notes

- When the action potential reaches the end of the axon (end plate) the signal needs to be relayed to the next neuron in the circuit, or to the effector (muscle, gland, etc)



What Happens at the synapse?
- The nerve impulse arrives at the axon terminal opening Ca^{2+} ion gates
- Ca^{2+} ions entering neuron triggers release of neurotransmitters
- Neurotransmitter diffuses across synapse to post-synaptic neuron (or effectors)
- Post synaptic neuron gets depolarized (or hyperpolarized) by the neurotransmitter
- **Enzymes** break down the neurotransmitter





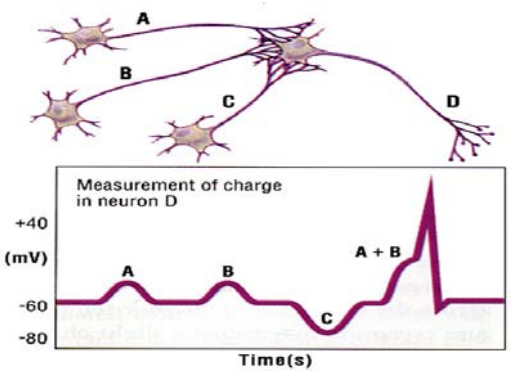
Inhibitory vs Excitatory Neurotransmitters
- Depending on the receptor they join to, a neurotransmitter can be excitatory or inhibitory
- **Excitatory** open Na+ gates causing an inrush of Na+ into the postsynaptic neuron.
  - This leads to **depolarization** of the post synaptic neuron
- **Inhibitory** opens K+ gates and cause K+ to leak out, therefore increasing polarity (more +ive membrane potential)
  - This leads to the postsynaptic neuron being **hyperpolarized.**

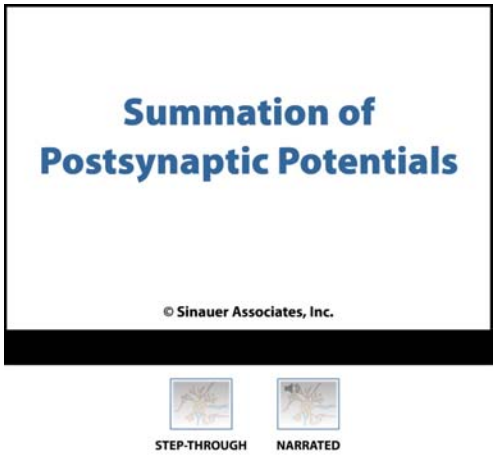
Inhibitory vs Excitatory Neurotransmitter - Tetanus example
(only watch till end of 3/9)

Summation

- Since most neurons have more than one presynaptic neuron acting on it, the sum of all the presynaptic neurons transmitters will determine the action of the postsynaptic neuron.

- This is called ***summation***.

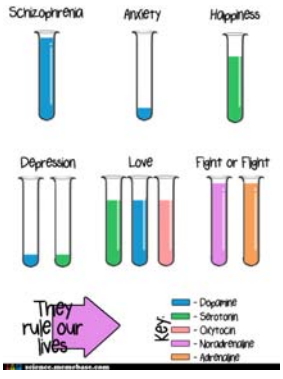




Common Neurotransmitters

Table 1 Common Neurotransmitters

Neurotransmitter	Action	Secretion sites	Major effects
acetylcholine	excitatory to skeletal muscles; excitatory or inhibitory at other locations	neuromuscular functions; CNS, PNS	skeletal muscle contraction
norepinephrine	excitatory or inhibitory	CNS, PNS	wakefulness
dopamine	generally excitatory	CNS, PNS	voluntary movement and emotions
serotonin	generally inhibitory	CNS	sleep
GABA (gamma-aminobutyric acid)	inhibitory	CNS	motor behaviour



Read Drugs and the Synapse on pg 423-424
Answer Case study questions 1-8

http://learn.genetics.utah.edu/content/addiction/mouse/

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Review Sheet

1. Number these events in the correct order.
(a) 6 An action potential is stimulated at the postsynaptic membrane, and an impulse travels down the dendrite.
(b) 7 An enzyme destroys the neurotransmitter substance and clears out the synaptic cleft.
(c) 1 The impulse reaches the synapse from the axon.
(d) 2 The impulse stimulates synaptic vesicles to move to the presynaptic membrane.
(e) 4 The neurotransmitter substance diffuses across the cleft.
(f) 5 The neurotransmitter substance fits into receptor sites on the postsynaptic membrane.
(g) 3 Synaptic vesicles dump neurotransmitter substance into the synaptic cleft.

Use the following information to answer the next three questions.

Serotonin is a naturally occurring neurotransmitter that plays an important role in a person's mood and emotions. A shortage of serotonin has been associated with phobias, schizophrenia, aggressive behaviour, depression, uncontrolled appetite, and migraine headaches. Synthetic drugs have been developed to enhance or hinder the performance of serotonin in the brain. Some of these drugs include:

I Prozac and Zoloft, which cause serotonin to remain in the brain for longer periods of time
II Drugs, such as Clozapine, that prevent serotonin from binding to post-synaptic membranes
III Diet drugs, such as Redux and Fenfluramine, that stimulate nerve cells to release more serotonin
IV Hallucinogens, such as LSD and Ecstasy, that react directly with serotonin receptors to produce the same effect as serotonin

—from *Lamoureck, 1997*

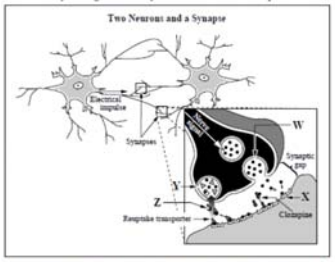
The drugs numbered above that would act as competitive inhibitors to serotonin and the drugs that would slow down the rate of removal of serotonin from the synapse are, respectively,

A. I and III
B. II and I
C. II and III
D. III and IV

If a person were suffering from clinical depression, which of the following drugs would not reduce the symptoms of depression?

A. LSD
B. Zoloft
C. Clozapine
D. Fenfluramine

Use the following additional information to answer the next question.



The row below that identifies the structure that releases serotonin and the section of the neuron that this structure is found in is

Row	Released from structure	Found in the
A.	W	axon terminal
B.	X	dendrite
C.	Y	axon terminal
D.	Z	dendrite

Use the following information to answer the next question.

The disease myasthenia gravis causes a person to experience muscular weakness because of the failure of neuromuscular junctions to transmit signals from nerve fibres to muscle fibres. The weakness is due to a reduced sensitivity to acetylcholine, which is necessary to stimulate the muscle fibre. People suffering from this disease are often treated with neostigmine, an anticholinesterase drug, which can result in some normal muscular activity within minutes.

—from *Guyton and Hall, 1996*

Neostigmine is effective in treating this disease because it

A. binds with cholinesterase to form acetylcholine
B. binds with cholinesterase to increase acetycholine production
C. reduces the amount of active cholinesterase, thereby increasing the amount of acetylcholine available to stimulate muscle contraction
D. increases the amount of active cholinesterase, thereby increasing the amount of acetylcholine available to stimulate muscle contraction

Use the following information to answer the next question.

Observations About a Synapse and Synaptic Transmission

1. Only axon terminals release neurotransmitters.
2. A neurotransmitter diffuses from an axon terminal across the synapse to the dendrites or cell body.
3. Many transmissions across a synapse in a short time may cause fatigue of synaptic transmission.
4. Electron micrographs of a synapse show that there is no direct connection between the axon terminal of a presynaptic neuron and the dendrites or cell body of a postsynaptic neuron.

The assumption that axon terminals contain a limited amount of neurotransmitter could account for observation

A. 1
B. 2
C. 3
D. 4

Two symptoms of Parkinson's disease are lack of muscular coordination and tremors, both caused by inadequate amounts of dopamine. Symptoms of Alzheimer's disease include the deterioration of memory and mental abilities, possibly caused by a decrease in acetylcholine production.

Dopamine and acetylcholine are excitatory neurotransmitters in various parts of the brain.

For the neurotransmitters dopamine and acetylcholine, the releasing sites and the receptor sites are, respectively,

A. cell bodies and dendrites
B. dendrites and Schwann cells
C. axon terminals and dendrites
D. axon terminals and Schwann cells

What role do both dopamine and acetylcholine have when they function as excitatory neurotransmitters?

A. They make the presynaptic membrane more permeable to K^+ ions.
B. They make the presynaptic membrane more permeable to Na^+ ions.
C. They make the postsynaptic membrane more permeable to K^+ ions.
D. They make the postsynaptic membrane more permeable to Na^+ ions.