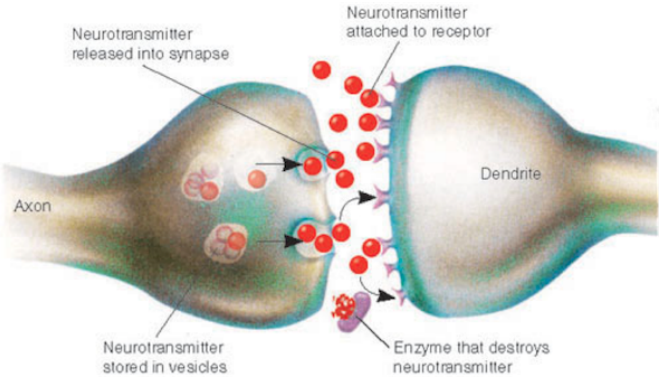
Notes: Synapse

PDF

Overview



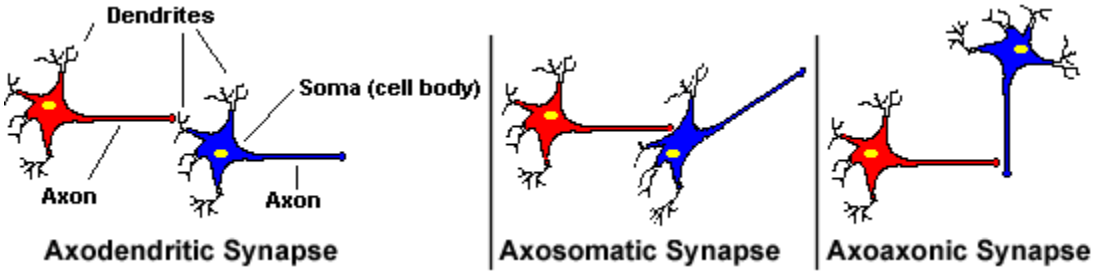
Conversion from an _____ signal to a _____ signal

- electrical signal is the _____
- chemical signal is the _____

Presynaptic - refers to _____ that sends/receives the signal

Postsynaptic - refers to _____ that sends/receives the signal

_____(PSP)
the membrane potential on the dendrite that is affected by activity in the synapse



Source: faculty.washington.edu/chudler/synapse.html

Directed and non-directed synapses

- depends on proximity between neurotransmitter and receptor

Neurotransmitter

The unit of communication between neurons

_____ neurotransmitters

- cause the post-synaptic neuron to depolarize/hyperpolarize, more/less likely to fire
- Excitatory Postsynaptic Potential (EPSP)

_____ neurotransmitters

- cause the post-synaptic neuron to depolarize/hyperpolarize, more/less likely to fire
- Inhibitory Postsynaptic Potential (IPSP)

Neurotransmitters will only influence the cells that have a receptor for it

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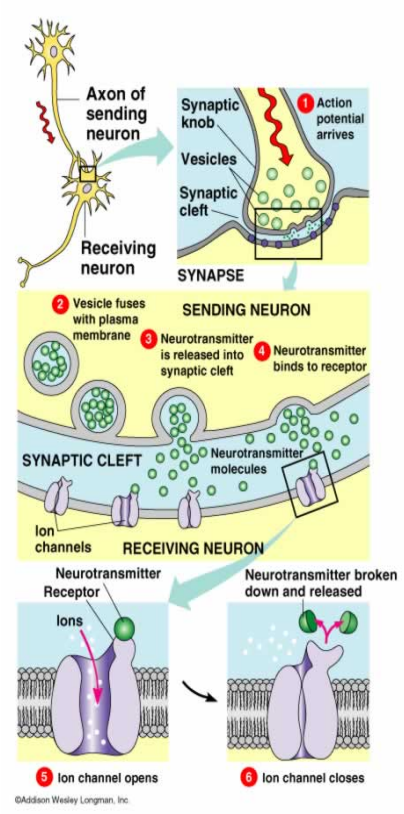


Lifecycle of neurotransmitter

Synthesized in cell

Packed into _____

_____ - released into synapse

arriving action potential causes influx of Ca++ ions, which trigger exocytosis

Interact with _____

a molecule in the post synaptic membrane that reacts to neurotransmitter

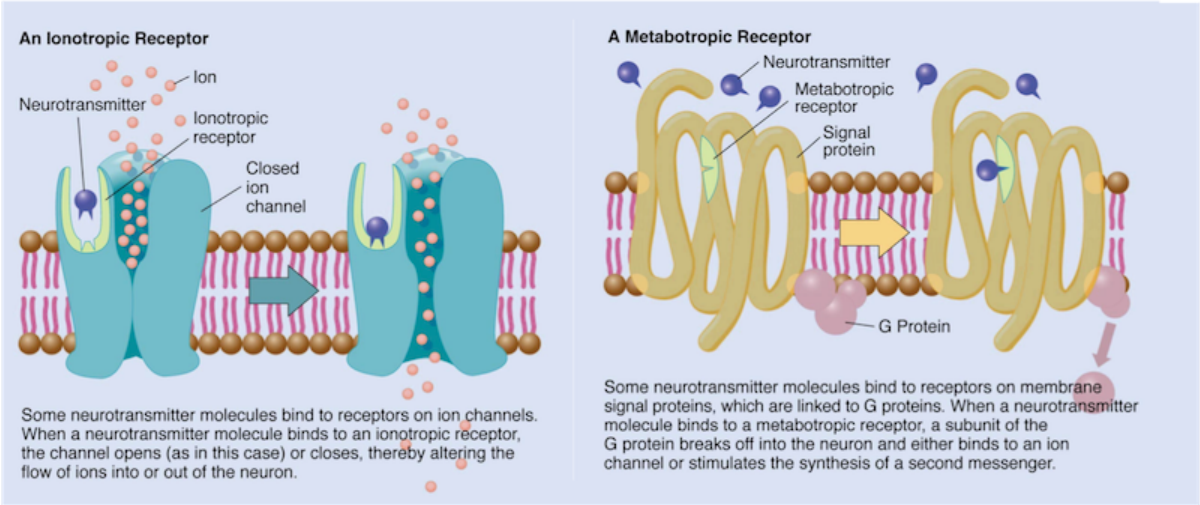
sometimes there are presynaptic receptors (autoreceptor)

Removed from synapse

- reuptake transport

- enzymatic degradation
- diffusion

Receptors



Ionotropic

Permits the flow of ions
Ligand-gated, as opposed to voltage-gated channels in action potential
Neurotransmitter can cause channel to open or close
For example:
    if Na+ channels are opened, cause EPSP/IPSP
    if K+ channels are opened, cause EPSP/IPSP
Fast/short acting

Metabotropic

G-protein-coupled receptor
Subsequently can effect
    - ion channels
    - 2nd messenger
2nd messenger can alter DNA expression, having effects on cell functioning
Slow/long acting

Integration

A depolarization at one synapse is typically not enough to trigger an action potential
Each neuron can receive signals from 1000s of synapses
Integration - combining many different signals to determine if an action potential occurs

Temporal Integration
depolarizations that _____ may combine to cause an action potential

Spatial Integration
depolarizations that _____ may combine...

Types of neurotransmitters

More than 100 identified neurotransmitter substances

_____ (small NT)
Molecules that make up proteins, found in our diet
Most common neurotransmitters for fast acting, directed synapses

_____ - main excitatory transmitter, sensory & learning systems

_____ - main inhibitory transmitter

_____ (small NT)
Not a typical synapse NT
Release NT broadly throughout brain
Produced by cells in the brain stem
More likely to modify "global" function/state of the brain

_____ - motor function and reward

_____ - (adrenaline, adrenergic)

_____- (nor-adrenaline, nor-adrenergic) - brain arousal, mood, hunger, sleep

_____ - mood, temperature, aggression, sleep

_____ (small NT)

- Neurons are called cholinergic
- Location
  - Neuromuscular junction
  - Throughout autonomic system (parts of our nervous system NOT under voluntary control)
  - In parts of central nervous system - cortical arousal, memory

_____ (large NT)

- Full proteins made up of many amino acids
- >100 neuropeptides
- Many have role as both neurotransmitter and hormone
- Typically act at metabotropic receptors
- Examples: endorphins, enkephalin (another opioid), Neuropeptide Y (food intake)
- Long lasting effects

Drug action

Antagonist - decrease the effect of a neurotransmitter
Agonist - increase the effect of a neurotransmitter

Receptor agonists

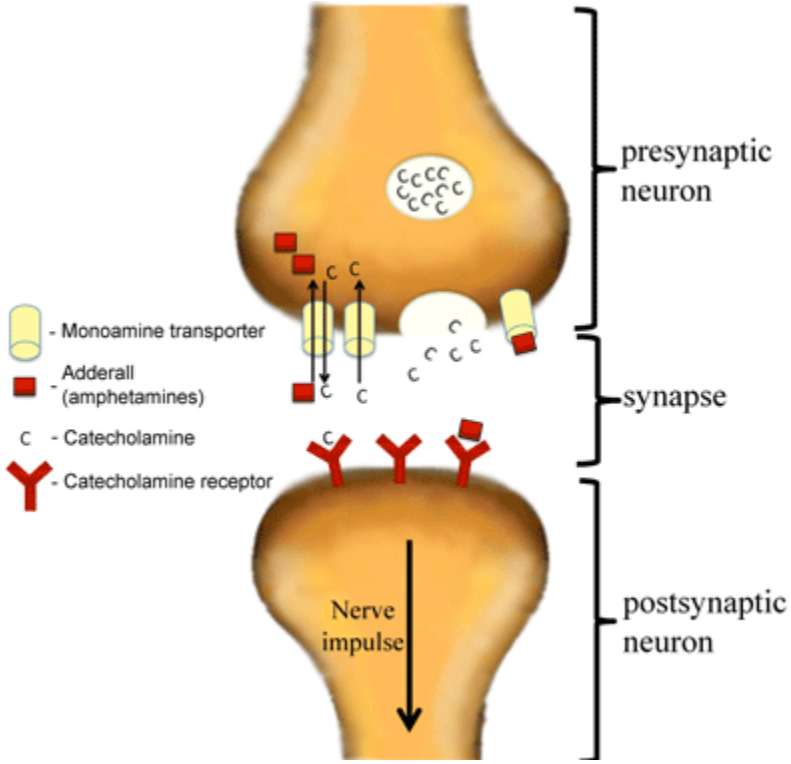
- Nicotine - stimulates acetylcholine receptors

Receptor blockers

Botox - nicotinic receptor antagonist

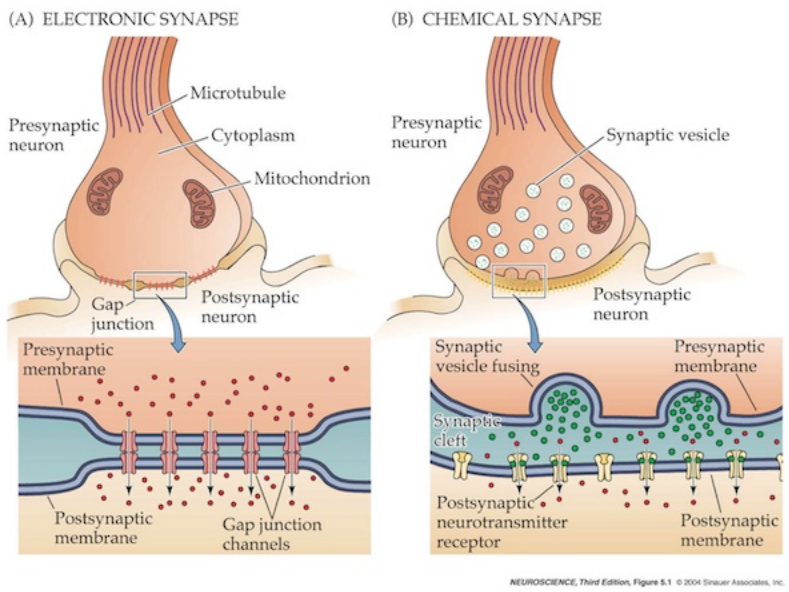
Reuptake blockers

Cocaine, amphetamines - impairs dopamine transporter



Source: http://www-scf.usc.edu/~uscience/adderall_abuse.html

Gap Junctions



A direct connection between the cytosol (internal fluid) of two cells
Faster than a chemical synapse
Doesn't require neurotransmitters
Not common in the brain, but extensive in heart muscle and retina

Synaptic Plasticity

Changes in connections between neurons can produce changes in behavior

"Neurons that fire together, wire together"
- paraphrasing Donald Hebb's 1949 theory of memory

Long Term Potentiation (LTP)

Typically studied in hippocampus

Process

1. Put a STIMULATING electrode in the upstream (presynaptic) neuron
2. Put a RECORDING electrode in the downstream (post-synaptic) neuron
3. Record the reaction of the downstream neuron to a single upstream stimulation
4. Provide high-frequency, high-intensity stimulation to upstream neuron (no measurement)

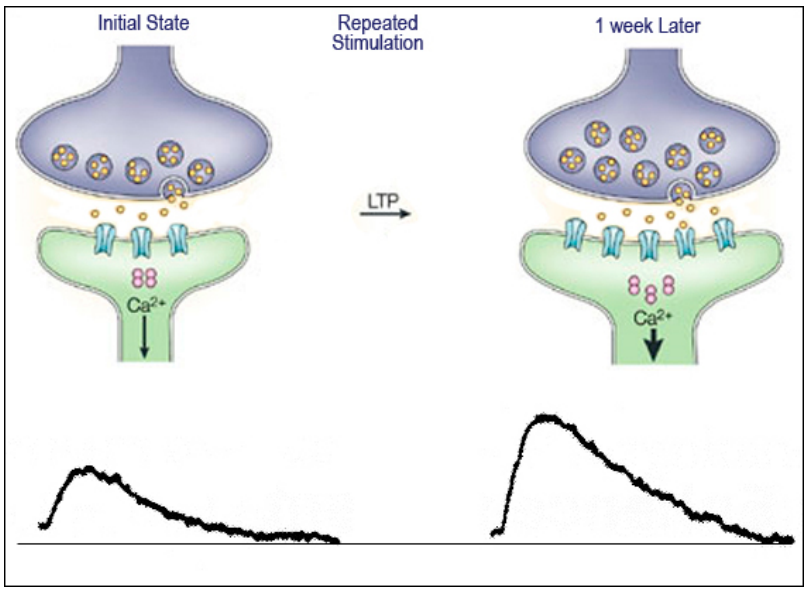
5. Record the reaction of the downstream neuron to a single upstream stimulation

Increased response in downstream neuron

Can be measured months later

Requires pre- and post- synaptic neurons to both have action potentials

Induction



Source: http://employees.csbsju.edu/ltennison/PSYC340/learning.htm

LTP Requires _____ receptors

NMDA receptors allow Ca++ to enter

Ca++ causes changes in cell functioning, such as creating new receptors

NMDA receptors are excited by _____

and require post-synaptic neuron to already be partially _____

NMDA are able to detect the co-occurrence of

_____ and _____ depolarization

Maintenance/Expression

The post-synaptic neuron does not strengthen connections with all pre-synaptic neurons,
only across synpases that were depolarized

LTP requires protein synthesis

Neuron is making new _____ to "build" or strengthen the synapse

Relation to behavior

LTP is a model for memory, and memory is probably "like" LTP,
but LTP is an artificial technique done in a laboratory setting

Rats learning a maze task fail to learn if NMDA receptors are blocked (Morris et al 1986)

Rats learning an avoidance task produce new AMPA receptors, the same receptors produced by LTP. Also, in vitro synapse that were potentiated during training could not be further induced by LTP. (Whitlock et al, 2006)

Animals undergoing fear conditioning show evidence of LTP-like processes (Rogan et al, 1997)

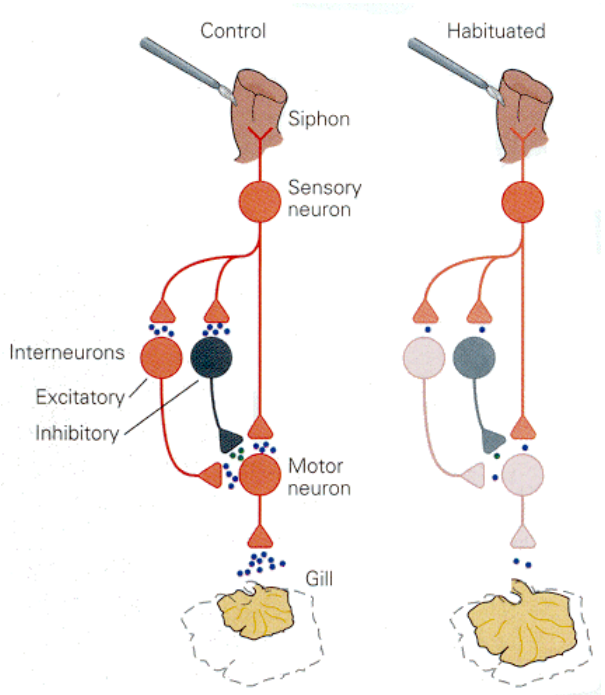
Learning in a Sea Slug

Aplysia

A sea slug with 200 neurons studied by Eric Kandel
Has a gill which it will withdraw if its siphon is touched

These are two examples of synaptic changes that explain an animal's behavior

Habituation



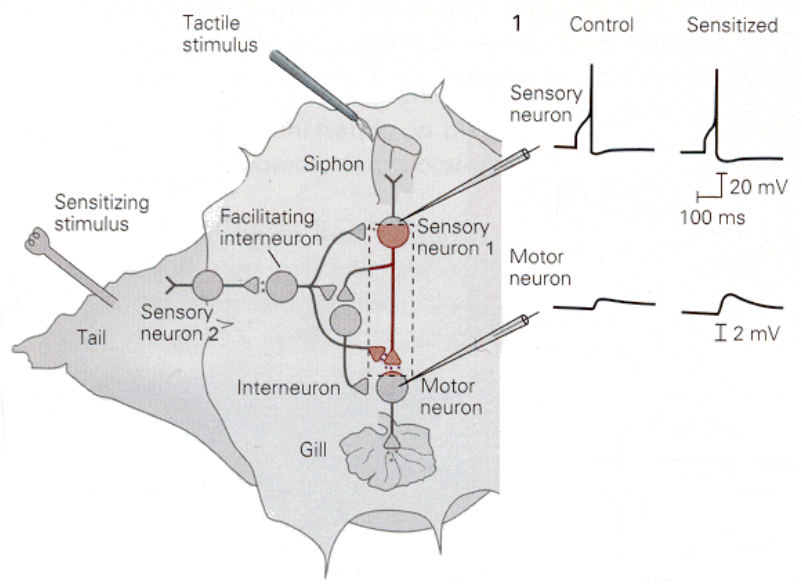
Source: http://michaeldmann.net/mann18.html

If the siphon is repeatedly touched, the gill withdrawal reflex disappears
With repeated activation, the neurons contain less dopamine and release less dopamine each time

Eventually gill withdrawal stops

A "short term" change in synaptic activity that does NOT require building new proteins

Sensitization



Source: http://michaeldmann.net/mann18.html

If the tail is shocked at the same time the siphon is touched:

Gill is more vigorously withdrawn to a siphon touch

Siphon has become "more sensitive"

Facilitating interneuron releases serotonin onto sensory neuron

Causes the sensory neuron to release more neurotransmitter when the siphon is stimulated

Causes motor neuron to react more vigorously

A "short term" change in synaptic activity that does NOT require building new proteins

(can be made "long term" with more training)