Take Home Lessons from Today 9-12-23

1. Neurons are not connected to each other directly, they communicate through a structure called a synapse. There are two kinds, the most common are chemical synapses. A chemical synapse has space (synaptic cleft) between the presynaptic membrane (from neuron sending signals) to the postsynaptic neuron (the dendrites of the neuron receiving signals).

2. When an action potential travels down an axon to the end of the effector arms of a neuron in the presynaptic neuron, this causes calcium channels to open and allow Ca^{2+} ions to rush in.

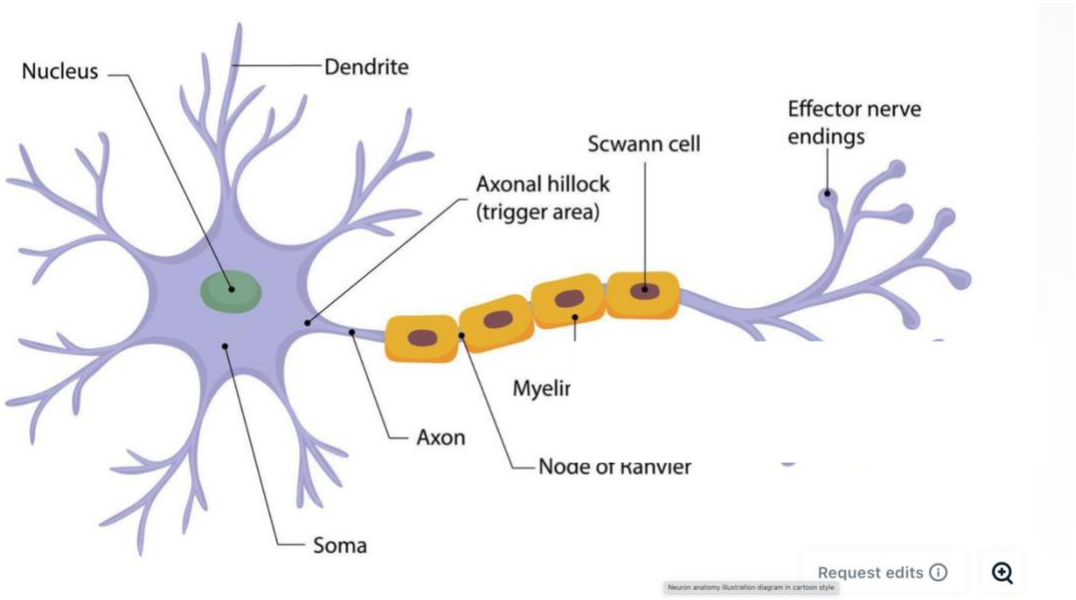
3. The calcium ions trigger vesicles ("sacks") filled with neurotransmitters to release the neurotransmitters into the synaptic cleft. The neurotransmitter is received by specific receptors waiting on the postsynaptic membrane, causing them to open sodium channels. If enough neurotransmitter is received, the action potential is transferred to the postsynaptic neuron and it fires off an action potential that proceeds down the axon and might activate other neurons that are attached by chemical synapses

4. There are 9 different neurotransmitters used in different kinds of pathways in our central nervous system. Some activate action potentials in post synaptic neurons, some are deactivating when released. (for example GABA). Having so many different neurotransmitters means that neurons can send signals in different directions and in the same area without mixing signals.

5. Right after neurotransmitters are released and the postsynaptic neuron fires, the neurotransmitters must undergo reuptake (or degradation) so the presynaptic neuron can be ready to fire again.

6. Neuropeptides and endocannabinoids are released by certain presynaptic neurons and these have the effect of changing the susceptibility of nearby neurons to fire when the small neurotransmitters are released. This can amplify or depress overall firing of neurons. In this way, the central nervous system can respond to changes in the environment that must be factored into an animal's overall actions or behavior. Much complex human behavior is modulated by these neuropeptides in particular.

Neuron Review



Resting State

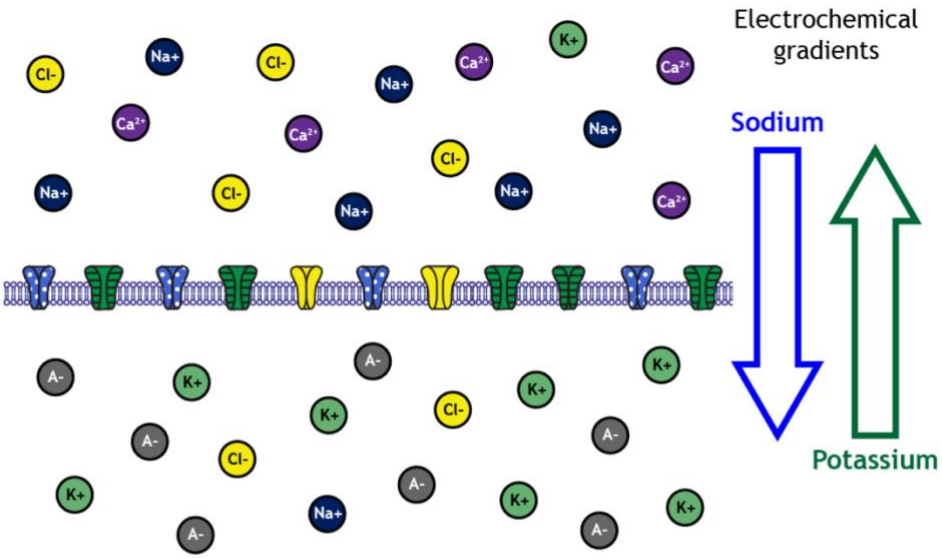
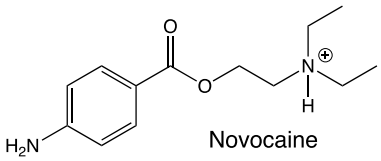


Figure 3.5. The distribution of ions on either side of the membrane lead to electrochemical gradients for sodium and potassium that drive ion flow in different directions. If the membrane is permeable to sodium, ions will flow inward. If the membrane is permeable to potassium, ions will flow outward. The dotted, blue channels represent sodium channels; the striped, green channels represent potassium channels; the solid yellow channels represent chloride channels. 'Gradients Across Membrane' by Casey Henley is licensed under a Creative Commons Attribution Non-Commercial Share-Alike (CC BY-NC-SA) 4.0 International License.



Great Animation of Action Potential and Na^+/K^+ pump
https://pdb101.rcsb.org/learn/videos/neuronal-signaling-and-sodium-potassium-pump

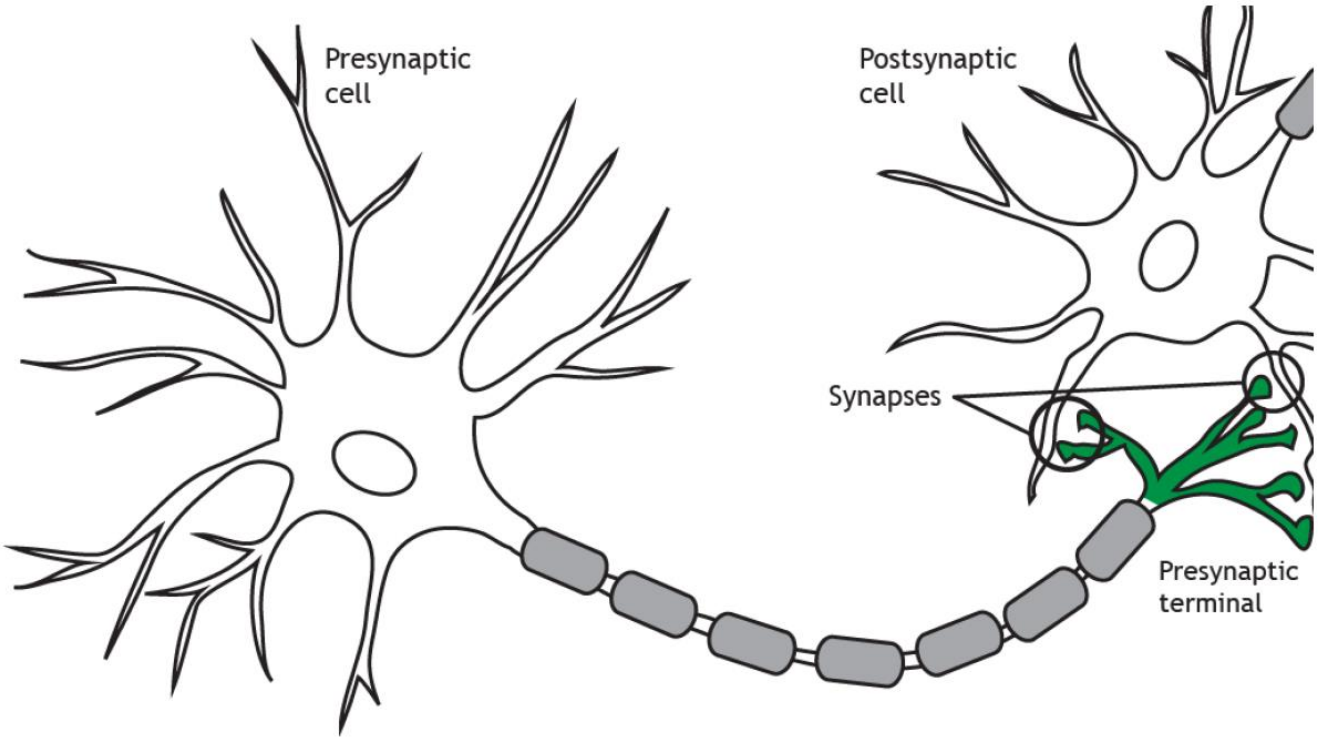


Figure 8.1. The terminal of a presynaptic neuron comes into close contact with a postsynaptic cell at the synapse. 'Synapse' by Casey Henley is licensed under a Creative Commons Attribution Non-Commercial Share-Alike (CC BY-NC-SA) 4.0 International License.

Chemical Synapse

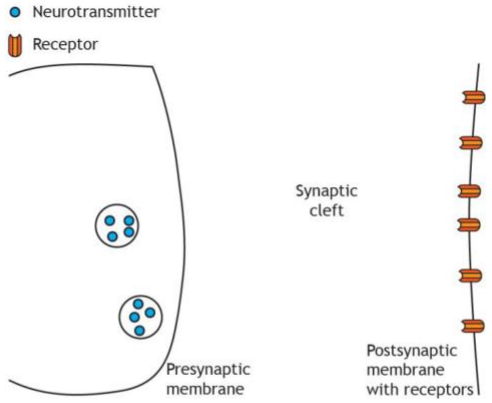
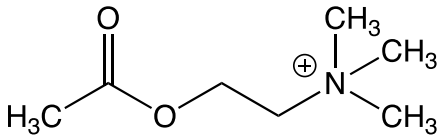
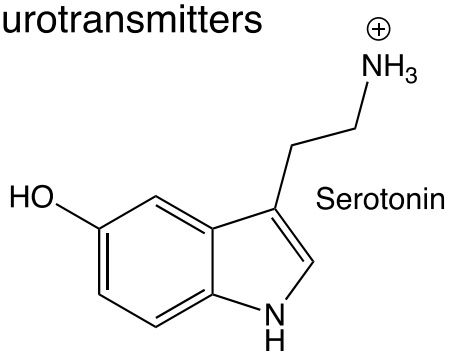


Figure 8.2. A chemical synapse does not make direct contact between the two neurons. The presynaptic terminal and the postsynaptic membrane are separated by the synaptic cleft. Neurotransmitters are stored in the presynaptic cell, and the postsynaptic cell has neurotransmitter receptors in the membrane. 'Chemical Synapse' by Casey Henley is licensed under a Creative Commons Attribution Non-Commercial Share-Alike (CC BY-NC-SA) 4.0 International License.

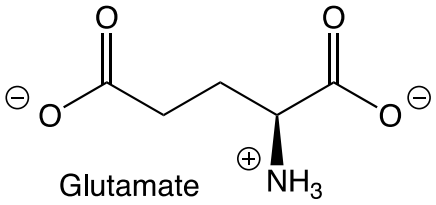
Small Molecule Neurotransmitters



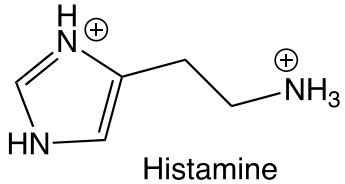
Acetylcholine



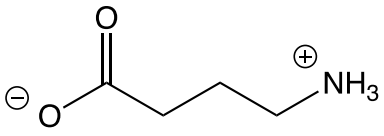
Serotonin



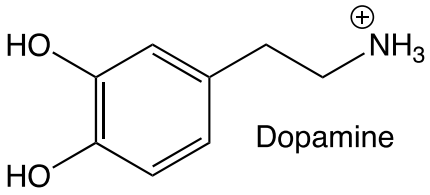
Glutamate



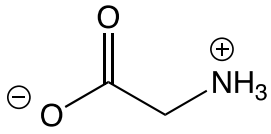
Histamine



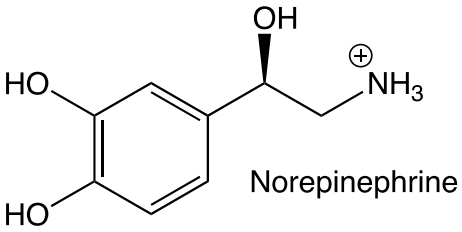
γ-Aminobutyric Acid (GABA)



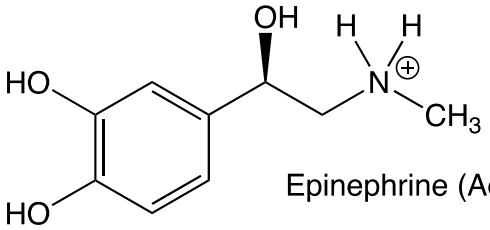
Dopamine



Glycine



Norepinephrine



Epinephrine (Adrenaline)

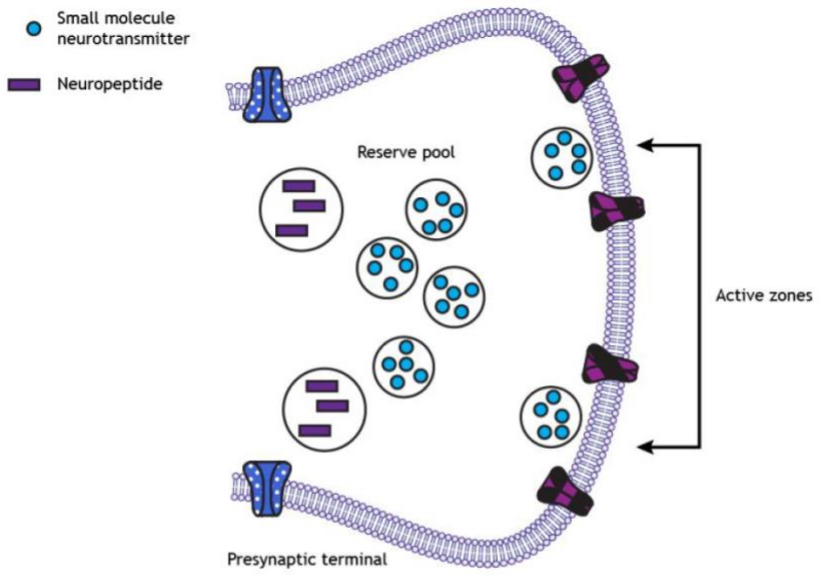


Figure 10.1. Some synaptic vesicles filled with small molecule neurotransmitters dock at active zones on the presynaptic membrane, ready for immediate release. Other synaptic vesicles remain nearby in reserve pools, ready to move into empty active zones. Neuropeptide-filled vesicles do not dock at active zones. The blue, dotted channels represent voltage-gated sodium channels, and the purple, striped channels represent voltage-gated calcium channels. 'Active Zones' by Casey Henley is licensed under a Creative Commons Attribution Non-Commercial Share-Alike (CC-BY-NC-SA) 4.0 International License.

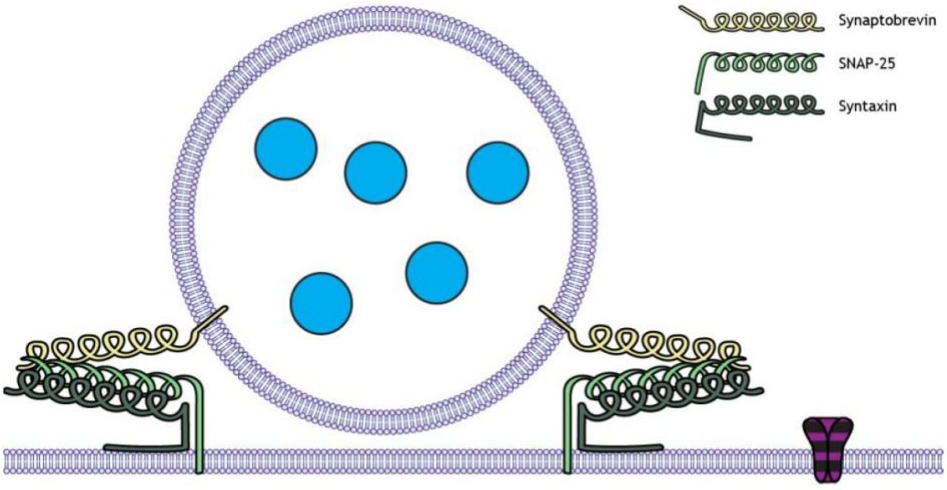


Figure 10.2. Synaptic vesicles filled with small molecule neurotransmitters are able to dock at active zones by the interaction of v- and t-SNARE proteins. Synaptobrevin is embedded in the membrane of the vesicle whereas SNAP-25 and Syntaxin are embedded in the presynaptic terminal membrane. The purple, striped channels represent voltage-gated calcium channels. 'SNARE proteins' by Casey Henley is licensed under a Creative Commons Attribution Non-Commercial Share-Alike (CC-BY-NC-SA) 4.0 International License.

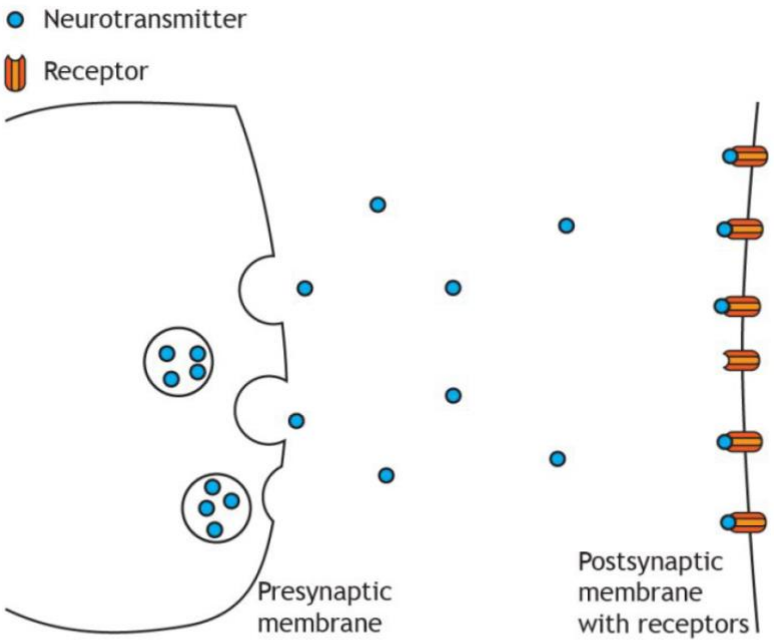
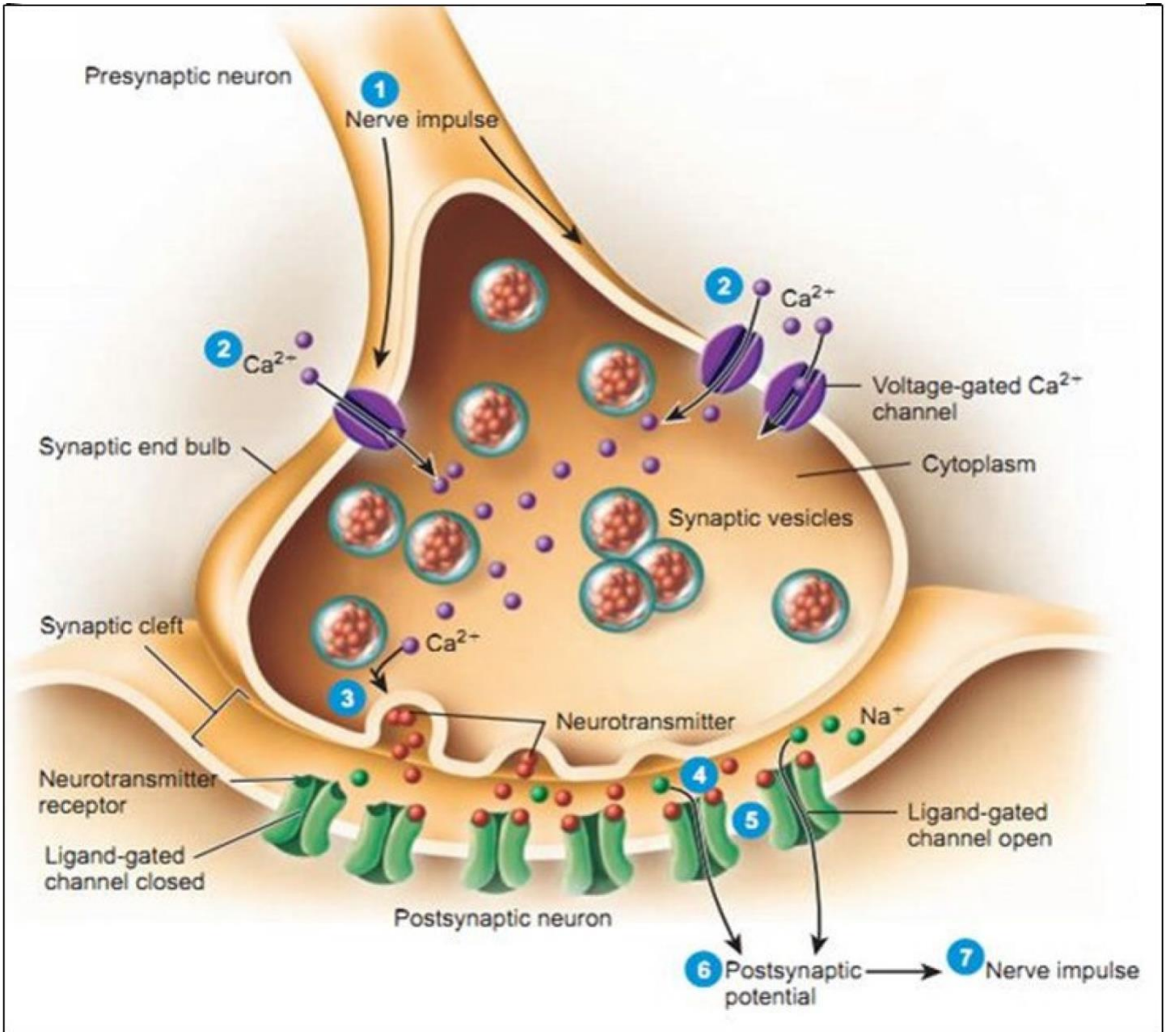


Figure 10.4. After exocytosis of the neurotransmitters into the synaptic cleft, the transmitters bind to receptors present on the postsynaptic membrane. 'Neurotransmitter in Synapse' by Casey Henley is licensed under a Creative Commons Attribution Non-Commercial Share-Alike (CC-BY-NC-SA) 4.0 International License.


Presynaptic neuron
1
Nerve impulse
2
Ca2+
2
Ca2+
Voltage-gated Ca2+ channel
Synaptic end bulb
Cytoplasm
Synaptic vesicles
Synaptic cleft
Ca2+
3
Neurotransmitter
Na+
Neurotransmitter receptor
4
5
Ligand-gated channel open
Ligand-gated channel closed
Postsynaptic neuron
6
Postsynaptic potential
7
Nerve impulse

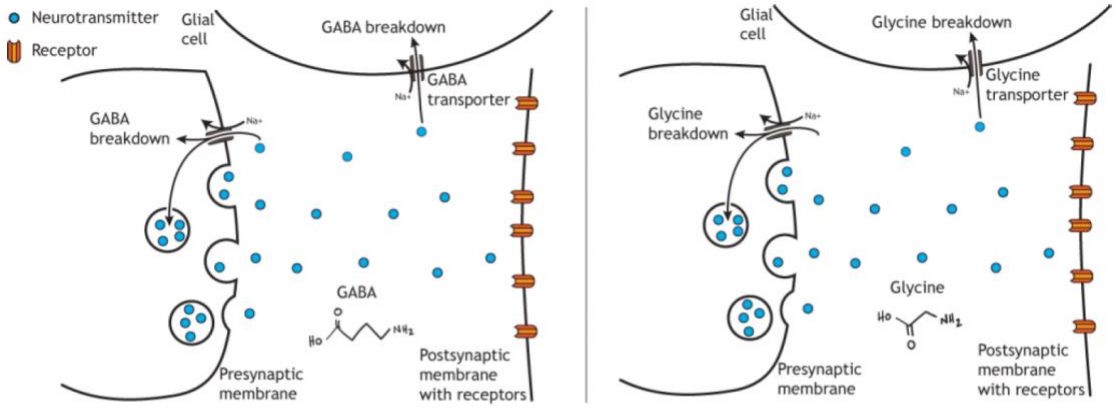


Figure 13.3. GABA and glycine action is terminated by reuptake by sodium co-transporters into either glial cells or back into the presynaptic terminal. In both locations, the neurotransmitters can be broken down by enzymes, whereas in the presynaptic terminal, the transmitters can be repackaged in synaptic vesicles. 'GABA and Glycine Degradation' by Casey Henley is licensed under a Creative Commons Attribution Non-Commercial Share-Alike (CC-BY-NC-SA) 4.0 International License.

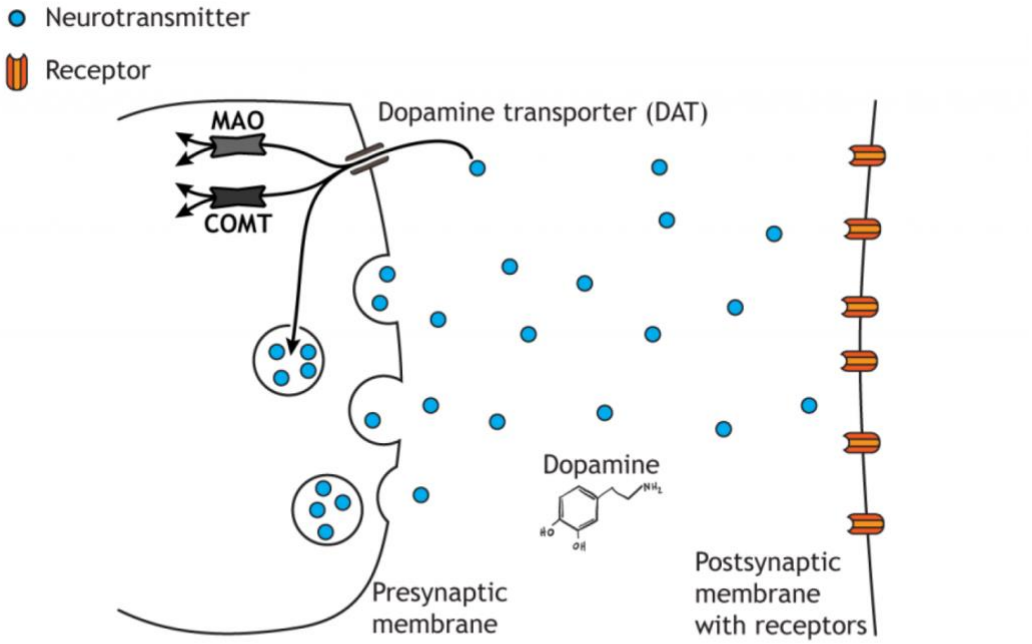
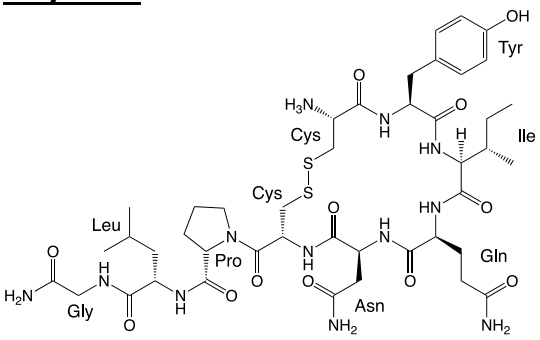


Figure 13.4. Dopamine action is terminated by reuptake into the presynaptic terminal via DAT. Dopamine is then either degraded by MAO or COMT or repackaged into synaptic vesicles. 'Dopamine Degradation' by Casey Henley is licensed under a Creative Commons Attribution Non-Commercial Share-Alike (CC-BY-NC-SA) 4.0 International License.

Larger Neurotransmitters – Often called Neuropeptides – These do not directly transmit signal but diffuse more slowly over a larger area and modulate the activity of the small molecule neurotransmitters.

Oxytocin



Known as the "love hormone", it is related to bonding, trust and connection. It plays an important role in experiences involving romance or childbirth. Oxytocin also lowers NA and reduces stress in similar forms as contented happiness.

Endorphins (Endogenous m**orphin**es**)**

α-Endorphin

H_3N–**Tyr-Gly-Gly-Phe-Met-**Thr-Ser-Glu-Lys-Ser-Gln-Thr-Pro-Leu-Val-Thr-O

β-Endorphin

H_3N–**Tyr-Gly-Gly-Phe-Met-**Thr-Ser-Glu-Lys-Ser-Gln-Thr-Pro-Leu-Val-Thr-Leu-Phe-Lys-Asn-Ala- Ile-Ile-Lys-Asn-Ala-Tyr-Lys-Lys-Gly-Glu-O

γ-Endorphin

H_3N–**Tyr-Gly-Gly-Phe-Met-**Thr-Ser-Glu-Lys-Ser-Gln-Thr-Pro-Leu-Val-Thr-Leu-O

Endorphins play an important role in relieving pain, or generating happiness through energized or euphoric varieties. Exercising is a common example as well as expressing anger. It relates to hedonic and chaironic happiness.

Endogenous Opioid

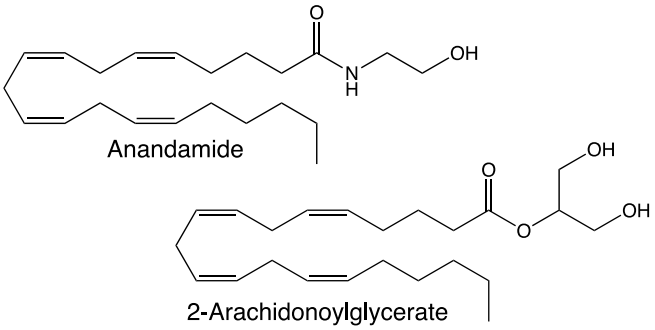
Met-enkephalin

H_3N–**Tyr-Gly-Gly-Phe-Met-**O

Endogenous opioids are powerful pain and mood-altering substances that are produced by the body.

Larger Neurotransmitters (cont.) – These are not neuropeptides because of their structure, but like neuropeptides these do not directly transmit signal but diffuse more slowly over a larger area and modulate the activity of the small molecule neurotransmitters.

Endocannabinoids



- Linked to harmonic happiness – homeostasis and balance within your body – influences appetite and metabolism and body systems.
- Hedonic – runner's high and the pleasure of exercise.
- Produced naturally during relaxing activities such as meditation.