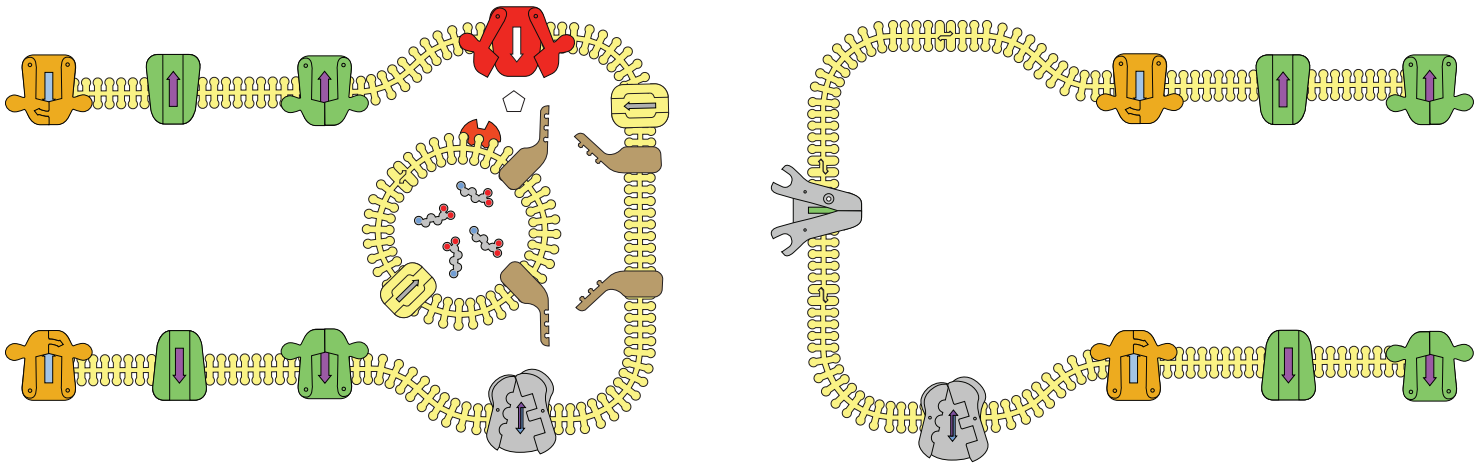
Part VII: Modeling Neurotransmission - A GABAergic Synapse

The cholinergic and dopaminergic synapses previously modeled are shown as examples of **excitatory synapses** because a depolarization occurs in the postsynaptic neuron. In the central nervous system, acetylcholine is mainly an excitatory neurotransmitter; however, it can serve both excitatory and inhibitory functions in the nervous system. Dopamine may also function as an excitatory or inhibitory neurotransmitter depending on the receptor to which it binds. **Inhibitory synapses** reduce the postsynaptic neuron's ability to generate an action potential. You will next model the events of neurotransmission at a **GABAergic synapse**. GABAergic synapses utilize **gamma-amino butyric acid (GABA)** as the chemical of neurotransmission.

1a. Model the **GABAergic synapse** shown below. Be sure to label the following: voltage-gated sodium channel, voltage-gated potassium channel, voltage-gated calcium channel, GABA, synaptic vesicle, presynaptic cell, postsynaptic cell, potassium leak channel, sodium-potassium pump, synaptic cleft, synaptotagmin, SNAP/SNARE proteins, reuptake channel, and vesicular transporter GABA receptor.



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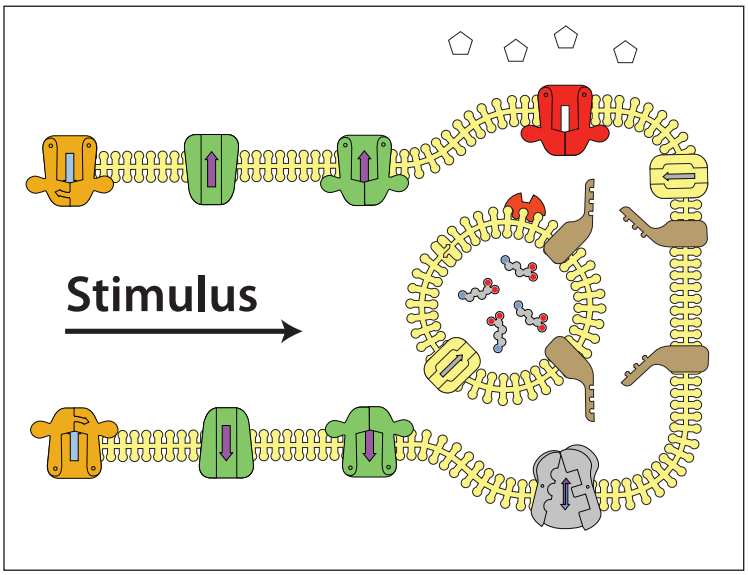
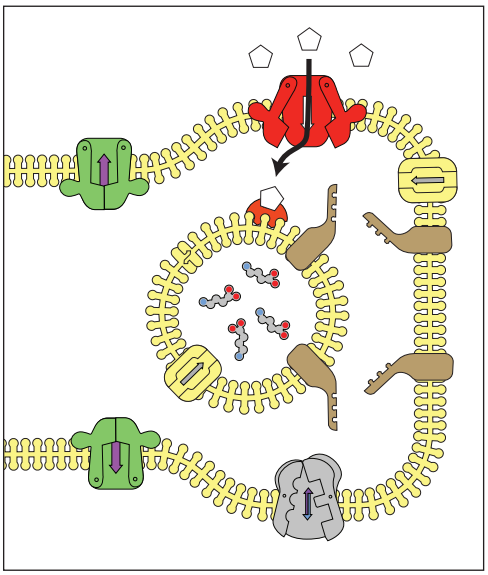
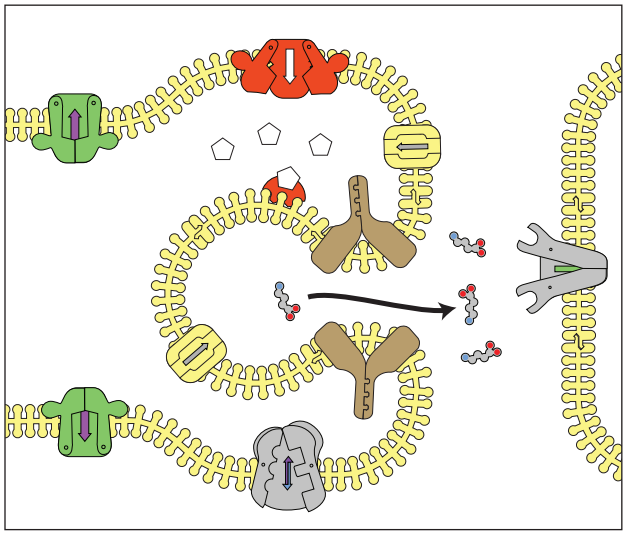


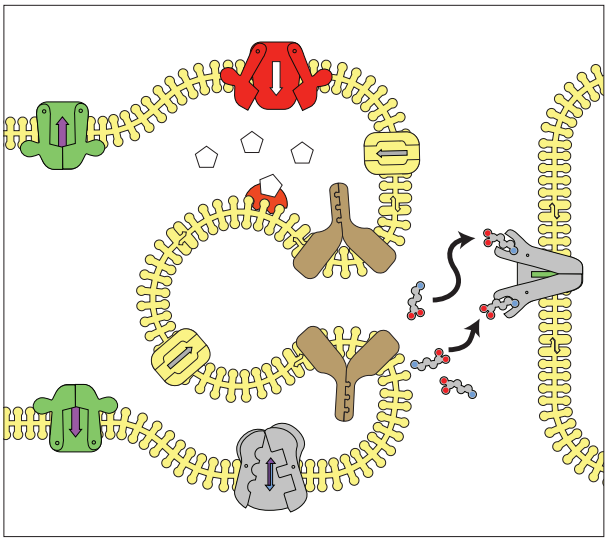
Step 1 - Action potential arrives at the terminal end of the presynaptic cell.



Step 2 - Calcium channels open in the presynaptic axon terminal. Open the calcium channels (red) and move some calcium ions to the interior of the neuron. Calcium ions bind to synaptotagmin.



Step 3 – Bound Ca^{2+} triggers SNAP/SNARE protein interaction to bring the vesicle in position for fusion with the presynaptic cell membrane. GABA is released into the synaptic cleft.



Step 3 – GABA traverses the synaptic cleft to bind to the GABA receptor embedded in the postsynaptic membrane. Both binding sites must be occupied by GABA for the channel to open.

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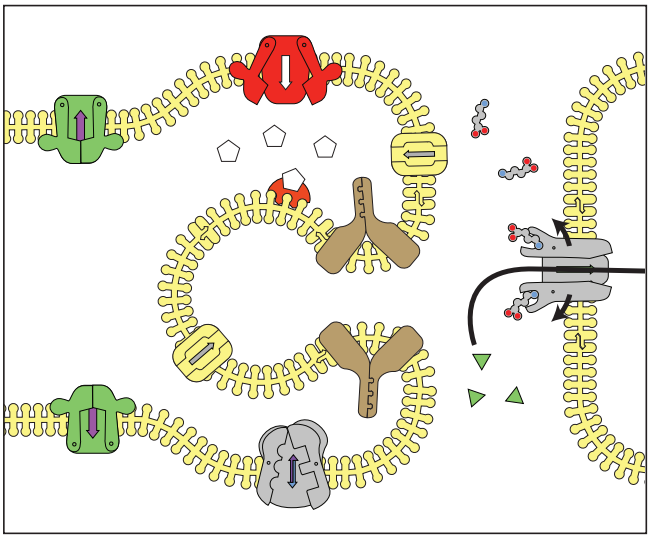
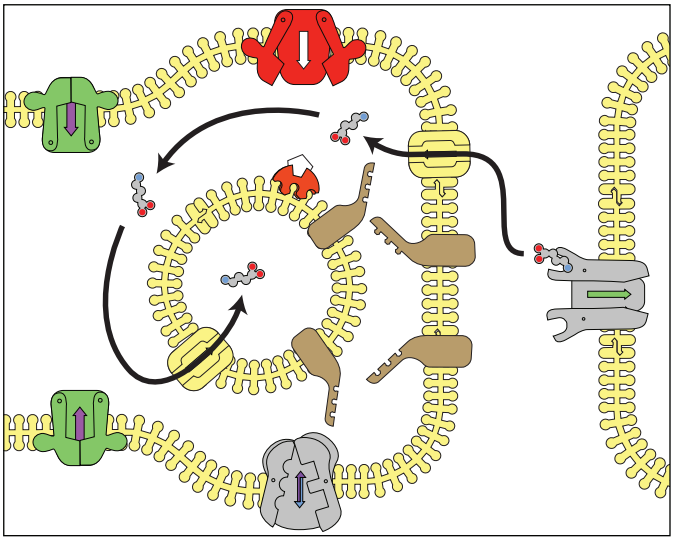


Step 5 - The GABA receptor opens to allow chloride ions (Cl^-) to follow their concentration gradient into the postsynaptic cell. Hyperpolarization of the postsynaptic cell occurs inhibiting the generation of an action potential.



Step 6 - Uptake transporters terminate the action of GABA by moving it from the synaptic cleft to the cytoplasm of the presynaptic cell. Once inside the cell, vesicular transporters load the vesicles with GABA for the next round of neuronal signaling.

1b. Identify the GABAergic synapse as ionotropic or metabotropic. Explain your choice.

1c. What molecule is released into the synaptic cleft in this model?

1d. What ion enters the postsynaptic cell once the BAGA receptor opens?

1e. Why is the GABAergic synapse considered to be inhibitory?