**Synapse Pong**

**Topic: Neuronal synapses and communication**

**Developed by:** CUNO graduate students, Taiga Abe, Leslie Sibener

**Grades:** K-5 adaptable

**Vocabulary words:** neuron, synapse, neuromuscular junction

**Materials:** synapse posters (2), small cups, small cotton balls, large cups, large cotton balls.

**Time needed: 10-15 min**

**Summary:** A fun, carnival-type activity that is useful for teaching principles of synaptic signal transmission. The lesson can help to establish direct connections between this a low-level, subcellular process like synaptic signal transmission, and high-level ideas like learning (Hebbian Learning), and control of movement.

**Prerequisites for Students:** None. Helpful if students understand the basics of neurons

**Learning Goals:**

* Reinforce that neurons are the building block of the brain
* Introduce how cells communicate with each other via neurotransmitter release

**Background for instructor:**

* Neurons must communicate to each other in order to have a functioning brain, how do they do this?
* Through the release of small molecules (called neurotransmitters) at the end of their axons (axon terminals). These molecules travel a very small gap to attach to receptors on the dendrites of neurons that are close by (see the visuals below).
* The molecules are signals that let neurons talk to one another
* The more a neuron “talks” to another neuron, the more molecules they send.
* The more molecules sent, the more changes in the receiving neuron! This is how activity from one neuron can activate another neuron, which can make up a long chain of activated neurons!

**Set-up: For the poster (see image at bottom of lesson plan)**: The synapse posters should have velcro patches corresponding to receptor locations on the postsynaptic cell. On one of the posters, place small cups on some of these patches. This poster corresponds to a “Central Nervous System (CNS)” synapse. On the other, place the large cups on all of the patches (or as many will fit). This poster corresponds to a “Neuromuscular Junction (NMJ) synapse”. On the presynaptic side, place clusters of the small cotton balls inside the vesicles of the CNS synapse, and clusters of the large cotton balls inside the vesicles of the NMJ synapse.

**Lesson Outline:**

Game Play: Allowing for traffic, have people play the NMJ version of the game first, as it is easier. Have children stand on the presynaptic side of the poster, and throw cotton balls one by one towards the receptor cups. Explain to them that each time they successfully make a shot, it corresponds to a successful signal sent from their cell to ours. Once they are done, point out to them that there is a more challenging version of the activity, the CNS version. Make the point that this is reflected in biology: that everytime we send a command to our muscles, we want it to be reflected in action with a high level of consistency. This leads to very reliable synapses with reliably strong neurotransmitter release, and lots of receptors on the postsynaptic side (thus, large cotton balls and large cups). In comparison as visitors play the CNS version of the game (they will probably struggle significantly more), communicate to them that individual synapses are in general much weaker, and unlikely to successfully communicate a message on their own. Ask people to consider why that might be a difference in the systems we observe across different parts of the nervous system (we don’t want to know about everything bombarding our sensory systems at any point in time).

**Possible extensions**:Alpha-bungarotoxin (NMJ): Once you’ve told people that a successful message communicated across the neuromuscular junction results in movement, tell them about alpha-bungarotoxin: a toxin that blocks postsynaptic receptors in the neuromuscular junction. Represent the action of alpha-bungarotoxin as covering the cups, or otherwise making it impossible to get cotton balls inside them. Ask visitors what they would expect to happen if this toxin affected their arm (paralysis).

Hebbian/Anti Hebbian Plasticity (CNS): Once you’ve compared the NMJ and CNS, you can mention that there are ways to make the communication in the central nervous system more reliable and consistent, like that in the NMJ. One way is through plasticity: if people succeed in landing a shot, then another bucket is added (we assume throughout here that a spike has been fired), representing the mechanism of Hebbian plasticity. Ask people to consider how the task changes when more buckets are added. Ask people to think about how this might correspond to what we call learning (rote memorization, learning your times tables are good examples)

