Recitation 3 Worksheet

1) What are the important differences between electrical and chemical synapses in terms of both structure and function? Why does the nervous system predominantly use chemical synapses?

2) Why does the squid have a giant axon and why do vertebrates have myelin? Describe how these two evolutionary mechanisms help to increase the speed of signal transmission in the nervous system.

Answers:

1) At electrical synapses the current flows through gap junctions, which are formed by proteins called connexons (made of 6 subunits called connexins), one on each of the two apposed cells of the synapse. Electric transmission is fast and reliable.
   Chemical synapses are formed by a presynaptic neuron and a post-synaptic neuron separated by a synaptic cleft which is about 30nm wide (electrical synapses are still separated by a gap, but it is only 2-3nm wide). Chemical synapses are slower, indicated by a synaptic delay of about 1ms, corresponding to the time it takes for the presynaptic cell to release neurotransmitter that then acts on the postsynaptic cell. Chemical synapses are also less reliable (ie. there are more opportunities for synaptic transmission to fail), and can be acted on by neurotoxins.
   Electrical synapses are used mainly for quick, reflex responses. However, chemical synapses are predominant because they are subject to modulation and feedback, which allows signaling to be much more dynamic.

2) The squid's giant axon increases conduction velocity by increasing the diameter of the axon and therefore increasing the space constant λ (which increases with the square root of the diameter). This effect is a combination of slightly decreasing r_m and decreasing r_i by a larger factor. In vertebrates, myelination increases membrane thickness, which leads to a decrease in membrane capacitance. It also provides better insulation, such that there is less leakage across the membrane (r_m increases).

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