Laboratory 1 Synaptic Density
Due Date: Laboratory Period 3 (week of February 2-6)

Purpose
This laboratory is a demonstration of a simple mathematical model as applied to the physiological problem of examining synaptic density. A simple reading of the title of this paper (Neuron network activity scales exponentially with synapse density\(^1\)) should suggest to you some implications of this issue. In addition, the model will be used to help us practice our spreadsheet and graphing skills.


The basic cell unit of the nervous system is the neuron. These are communicative cells and cannot perform their fundamental function(s) without the presence of other cells. Their talking space, that is where they communicate with each other, is called a synapse. Unipolar neurons connect with only one other neuron, bipolar neurons connect with 2 other neurons, multipolar neurons can connect with any number of neurons, leading to multiple synapses/neuron. The number of connections leading from other cells to a single neuron may reach up to 100,000, though most will have far fewer. We will be looking at how the density of synapses can be expected to change with numbers of connecting neurons for a small number of cells, given some simplifying rules.

Rules
We will be counting the number of synapses expected for a small set of neurons when each set is of one of the following classes (unipolar, bipolar, tripolar and multipolar). The following rules will apply.

a. A neuron can have no more connections than allowed for its class.

b. A neuron can have fewer cellular connections than allowed for its class but it must have as many connections, given rule (a), as made possible by the number of its neighbors.

Logistics
Make a table. If using Excel, introduce a worksheet with title (Synaptic density). We will go over the steps for this in lab. The following organization will be useful.

This table has 4 columns. First column (Number of Neurons), write down a series from 1 to 25. This represents the number of neurons present.

In the second column (Number of Synapses, Unipolar), find the number of synapses expected for these numbers of neurons, where all are unipolar.

In The Third Column (Bipolar), find the number of synapses expected for these numbers of neurons where all are bipolar.

In the 4th Column (Tripolar), find the number of synapses expected for these numbers of neurons where each neuron is connected with three neurons.
In the 4th Column (Multipolar), find the number of synapses expected for these numbers of neurons where ALL neurons are connected with ALL other neurons but ONLY once each.

In order to do this exercise, you might be able to calculate the numbers in your head. I would find this difficult. Start by drawing a small set of neurons and count the numbers of connections needed for unipolarity, bipolarity, tripolarity and multipolarity. It is best to find a numerical pattern early in each relationship in order to reduce the time spent counting connections.

**Lab report**

1) Show table with the columns of numbers you generated for each case (Uni-, bi-, tri- and multi-).
2) Draw your interpretation of this exercise for each case, when the number of cells is 5.
3) There may be more than one way to count the number of connections for certain cases based upon your interpretation of this exercise. That is, there may be other rules you can devise (negation of rules is not allowed) which will change your results relative to what is expected based upon the instructor’s ‘hidden’ assumptions. Based upon your drawings, state any additional rules you might have used to generate these pathways.
4) Predict the number of synapses expected for each case when the number of neurons is 50.
5) We will learn how to graph and interpret the generated patterns next week in laboratory. The following observations can be made at that time.

Observation A - Which of these patterns is linear? Which might be better fitted to a logarithm? To a polynomial? (Remember to delete the display between each option. The numbers are NOT refreshed in Excel).

Observation B - What are the slopes of the lines for each?

Observation C - What is the biological meaning of the value of the intercept for any of these cases?