The Incredible Edible Excitable Neuron

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Abstract

The neuron is the basic unit of the nervous system and therefore an integral concept to understand at the 2003 Kids Judge Neuroscience Fair. Although neurons come in various shapes and sizes and function in a variety of different ways, all have a fundamental plan of organization. Our model simplified the basic concept (structure and function) of the neuron for fifth grade students by using marshmallows, toothpicks, clear straws and Fruit by the Foot® to illustrate somas, dendrites, axons, and myelin, respectively. The functions of each of these elements of the neuron were explained prior to the construction of their neuron. Evaluations conclude that many students enjoyed the presentation and several retained the information given to them. On a scale of 1 to 5, 5 being the highest, students rated our group averages of 4.5 for understanding, a 4.59 for friendliness, 4.67 for enjoyment, and a 3.92 for wish to learn more about the topic. Our group placed second in the judging contest among our section. Generalization was necessary in order to relay a comprehensible introduction to the concept of the neuron.

Introduction

Because it is the most basic unit of the nervous system, my group and I decided that the neuron would be the best concept of the nervous system to model for fifth grade students during Brain Awareness Week. It was Santiago Ramón y Cajal who originally provided the fundamental evidence for the neuronal doctrine, the principle that individual neurons are the elementary signaling units of the nervous system (Ramón y Cajal, 1908). Cajal's life work supplied neuroscientists with a general concept of the nervous system as well as several methods of histological and morphological research (Ramón y Cajal, 1934). Specifically, Cajal established that the brain is made up of networks upon networks of communicating neurons.

Our goal for the 2003 Kids Judge Neuroscience Fair was to simplify the morphology and basic function of the neuron in an accurate and enjoyable model. Although the overall shape of different neurons may vary considerably, they all share the same underlying plan of organization. The unipolar neuron is the simplest class of neurons because it has only a single process arising from the soma from which dendrites and an axon branch off (Jones, 1988). This type of neuron is remarkably common in invertebrates but rare in vertebrates. Bipolar neurons are characterized as relatively symmetrical cells with dendritic poles arising on opposite ends of an elongated soma (Jones, 1988). These axons can be short or long and can vary greatly in diameter. The rest of the neurons that do not fall under the abovementioned classes are called multipolar neurons, meaning that the parent soma gives rise to more than just one dendritic trunk (Jones, 1988).

Neurons differ greatly in size and shape. Among the smallest are hypothalamic neurons with somata that can measure to just a little more than 3 to 4 μm in diameter, and the largest are the giant pyramidal cells of the motor area that can measure as much as 120 μm in diameter

(Jones, 1988). Two factors determine the size and shape of a neuron: the number, length, and diameter of its processed and the number of synapses that it receives on its surface (Jones, 1988).

Myelinated axons are said to be those wrapped by a variable number of concentric layers of Schwann cell plasma membrane forming the so-called myelin sheath (Wheater et al., 1979). Myelin is formed in both the peripheral and central nervous system by cells called oligodendrocytes (Wheater et al., 1979). The process of myelination starts during fetal development and continues for a considerable time after birth. It begins with the invagination of a nerve fiber by a Schwann cell and wraps around the axon until by maturity, the inner plasma membrane layers fuse with each other and the axon becomes surrounded by several layers of modified membranes (Wheater et al., 1979).

Axons end by forming functional contacts with other nerve cells or muscle fibers. In the central nervous system the axon of a neuron terminates on other nerve cells in synapses, specialized junctions. As an axon approaches the region of the nervous system in which it terminates, it generally branches repeatedly; if it has a myelin sheath, the initial branches are myelinated, but as they approach the neurons with which they are destined to make synaptic contact, they usually branch again (Jones, 1988).

Methods

We chose the soma, dendrite, axon, axon terminal, and myelin as the most important elements of the neuron to exemplify in our edible models. The soma was represented by a large marshmallow. Broken toothpicks served as dendrites. The axon was embodied by one-third of a clear straw with slits made at one end of it to signify the axon terminal. Two strips of Fruit by the Foot® wrapped around the straw myelinated the axon (please refer to Figure 1 for a visual diagram of the students' model of the neuron).

Before allowing the students to construct their neurons, however, we provided them with a brief description of each of these parts. For simplification purposes, we described the dendrites as the site at which input enters the neuron. The soma was described as the "tiny brain" for the nerve cell, or where the cell processes the information coming from the dendrites in order to send it down the axon. The information from the soma then travels down the axon to the axon terminal, where it communicates with the next neuron and so on. The myelin serves as insulation for the neuron. The students were given the example of touching a hot stove. We explained that the information that the stove is hot has to travel very quickly from the hand to the brain and then back to the hand in order to keep from burning one's self. The myelin allows for speedy delivery of this information by wrapping around sections of the axon so that the information, or action potential, need only fire at the little sections in between each section of myelin. These little sections are known as nodes of Ranvier.

Clarification of this last part was made easier by displaying the large version of the neuron that students would be making we had built. A large Styrofoam ball served as the cell body and deformed metal wires protruding from the ball functioned as dendrites. The axon was made of toilet paper rolls with clear, cylindrical containers with the bottoms cut off interspersed between them. The toilet paper acted as myelin and the clear containers acted as the nodes of Ranvier. Connected to the cell body and running along the axon was a black yarn, which connected at its other end to a Styrofoam cone, or axon terminal. The yarn worked as the "information" running from the soma to the axon terminal. When the Styrofoam cone was shaken, movement of the yarn was seen only in the clear containers, or nodes, which provided the students with a visual representation of the process of action along the axon.

Our initial plan was to offer "neuron facts" to the children as they ate their edible neurons to make our concept more accurate than the models allowed. For example, we intended to explain that although the axons used in the model were relatively the same in size, axons vary greatly in length and diameter from neuron to neuron. Also, some neurons have more than one axon. We also hoped to elucidate that unmyelinated axons carry information at about 2 m/s whereas a myelinated axon can send information at up to 200 m/s so that they would understand what an important role myelin plays in propagation velocity. Unable to predict the amount of time we would have with each group of students, we made a poster exhibiting a cross section of the soma and axon terminal, using candy to represent the nucleus, endoplasmic reticulum, golgi complex, mitochondria, and synaptic vesicles. We also posted diagrams of a few different types of neurons: unipolar, bipolar, and multipolar neurons. A voltage versus time graph illustrating the action potential was also put up on the poster in wishful thinking that we would have enough time to explain it.

Results

In reality, time limited our presentation rather extensively. After being cut off before the students were even able to make their edible neurons in the first group, we realized that brief explanations of our primary concepts were the only objectives we would be able to meet. We were able to explain that the soma was the neuron's "tiny brain," it carries DNA, it receives information from one part of the cell and sends to the other. The dendrites were described as the site at which information enters the neuron. From there, information goes through the soma to the axon, where it leaves the neuron via the axon terminal to the next neuron. Students were told that myelin makes it possible for this information to travel very quickly. This is the point when we discussed the hot stove example mentioned previously. We demonstrated that action need only occur at the nodes shaking the yarn in our larger model of the neuron as our visual.

Any questions the students or group leaders had were answered after the explanation. Most questions related to the pronunciation of words like "myelin" and so forth. Students were then given materials to construct their own edible neurons with a marshmallow, toothpicks, a cut straw, and two strips of Fruit by the Foot®. After each student had finished making a neuron, we called on them separately to tell us what each part of the neuron discussed was called, and what it did. The kids did well answering our questions about the presentation and we felt good about their knowledge of the concept. It was about at this point when the students were told to fill out their evaluations and move on the next presentation.

Evaluations consisted of six questions, including: (1) Could you understand what the presenters were trying to tell you? (2) Were the presenters friendly? (3) Was the exhibit fun? (4) Would you like to learn more about this topic? (5) Would you like to learn more about this topic? and (6) What did you learn from this exhibit? The first four questions were answered on a scale of 1 to 5, 5 being the highest or best score possible. Our group received an average score of 4.50 for question 1, 4.59 for question 2, 4.67 for question 3, and 3.92 on question 4. Some of the most common responses to question 5, what was your favorite part about this exhibit, included: "making the neuron," "eating," and "candy." A few students also made reference to learning more about neurons and the display as their favorite parts of the exhibit. The most popular responses to question 6, what did you learn from this exhibit, included: "about neurons" and "how messages travel to the brain." Quite a few made the connection that myelin is what enables signals to travel quickly in the brain. Additional comments included: "do this again," "thanks for the food," and "I loved it!" The Incredible Edible Excitable Neuron ranked second place in the judging contest, although we averaged fourth highest in the evaluation responses.

Discussion

Overall, I was impressed by the level of comprehension displayed by the students. They grasped the material much better than I had anticipated and even retained it well enough to relay their understanding in their own words in the evaluations. We were perplexed by the contradictory low averages on the evaluations forms compared to our second place ranking in the judging contest. One possible explanation may be that we felt very rushed presenting to our first group so perhaps they gave us lower scores than the rest of the students. Another possible reason may be that the submitted averages of the other presenters were not entirely accurate. Contest placement and evaluation averages may have also differed because the students realized at the end of the presentations that perhaps they enjoyed our presentation in comparison to the others more than they had originally assessed.

The best part of our exhibit, in my opinion, was the fact that the students were given a hands-on presentation of the concept of the neuron in addition to verbal and visual explanation. Distinguishing each element of the nerve cell with food made it easy and fun for the fifth graders to see the basic structure of the neuron, and they were able to remember what each of these parts did from the talk that preceded the building of the neuron. I am glad we were able to provide different forms of the same information for the students so that when they did not understand one way, we could present the concept in another fashion.

If I were able to present my model again, I am not sure I would change anything. The majority of the students understood what the structure and function of the neuron were, and this was our primary goal. There were, however, a few factors that may have restricted our capacity to make the presentation better. One issue for the students was an inability to hear what we were saying. This, for the most part, was due to the extremely limited space in which each group presented. Because each exhibit was placed so close to the next one, the students had an awfully small area to gather in order to see, and it was troublesome trying to hear one presentation in the presence of four others. This was a particularly disruptive problem for our group because we were placed next to a group presenting the concept of the tympanic membrane. They used a very loud speaker in the middle of their presentation and it was very distracting both for us and the students. Perhaps next time the presenters and the students will be given a little more room.

The time constraint also kept us from delivering a better presentation. Had we had a few more minutes, we may have been able to provide the students with more information about neurons and the accuracy of our model would not have been as greatly compromised. For instance, another minute or two would have allowed us to explain that although all of the models being made look about the same, neurons can vary considerably in shapes and sizes. Offering actual speed differences in myelinated versus unmyelinated axons of signals may have made the concept of myelination clearer. Furthermore, those students who were not able to grasp the concept in the time given would have had the opportunity to ask us to clarify. Only if our presentation went without a hitch did we have time for questions and even then only one or two students were able to inquire about the model. More time would definitely made the model more clear to the students.

References

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Figure 1. The Incredible Edible Excitable Neuron