Nerve Channel Basketball

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Abstract: A model of a ligand-gated ion channel was constructed for Brain Awareness Day at Washington State University. The model was geared toward fifth grade students who came to the university for a day to observe our presentation. The kids were first told about the structure and function of an ion channel. They were then allowed to throw ions (tennis balls) through the channel in order to demonstrate how an ion passes through a cell membrane. Afterwards they evaluated our model and performance. Many kids enjoyed our model though some thought it

was a little hard to understand. Despite this, we received high ratings for having a fun presentation and being friendly. Our model also placed fourth out of five overall.

Introduction:

The question of how electrical signals are transmitted throughout the brain and body has wracked the brains of many scientists since the 1800s. It was proposed that there must be some sort of mechanism that allows ions to pass through a cell membrane, which therefore causes excitation of the cell. The idea of the ion channel is not a new one. In 1976, Erwin Neher and Bert Sakmann invented the "patch clamp" method that allowed for the observation of the functioning of a single protein molecule in a lipid bilayer (4). And since their recent discovery, research concerning the structure and function of ion channels has shed light on how they may operate, though much is still left unknown (1,2,3).

Ion channels are large integral membrane proteins that span the cell membrane. The pore of an ion channel is hydrophilic and contains a selectivity filter that recognizes only certain ions and allows them to pass through into the cytoplasm of the cell. Ion channels conduct ions at high rates and open and close in response to specific electrical, mechanical, or chemical signals. Ion channels allow the passage of ions when open. Voltage-gated channels are regulated by changes in voltage, ligand-gated channels by chemical transmitters, and mechanically gated channels by pressure or stretch (1).

Malfunctioning of ion channels in nerve and skeletal muscle can cause a wide variety of neurological diseases such as cystic fibrosis and certain types of cardiac arrhythmia. Ion channels are also often the site of action of drugs, poisons, or toxins (2). Therefore the study of ion channels is an important field and may lead to the further understanding of the nervous system, certain diseases, and the effects of drugs on the body.

We chose to construct a working model of an ion channel in order to explain its structure and function to the visiting fifth graders on brain awareness day. Our model demonstrated the components of an ion channel and its location in the body through its construction. Our model consisted of a pore surrounded by protein subunits embedded within the cell membrane phospholipid bilayer. It also had a ligand binding site which, when a neurotransmitter was bound to it, opened the gate of the channel and allowed ions to enter the pore and pass through the channel into the cell. We explained to the kids that when ions pass through the cell a current is created often resulting in an action potential which in turn allows us as human beings to do all the neat stuff we can do such as run, walk, talk, and think.

Methods:

Materials: hinged-lid garbage can with bottom removed, short piece of PVC pipe, plastic bags, Styrofoam packing peanuts, duct tape, ribbon, poster board, markers, glitter pens, tennis balls, bucket, ball labeled neurotransmitter.

Construction: We first obtained a hinged-lid garbage can and removed its bottom. The garbage can served as our pore of the ion channel. We then stuffed plastic bags full of Styrofoam packing peanuts and shaped them into five separate sections resembling protein subunits and attached them to the garbage can with duct tape. We then had an ion channel complete with pore and multiple protein subunits. In order to distinguish the different subunits from each other, we decorated them with different colored ribbons. In order to open the hinged-lid, which served as the gating mechanism for the channel, we attached a short piece of PVC pipe to the pedal and the end of the pipe served as the binding site for the ball labeled neurotransmitter. We then drew a phospholipid bilayer onto a piece of poster board with markers and traced the polar heads and tails with glitter pens. We cut out the phospholipid bilayer and attached it to the ion channel with duct tape so that the ion channel appeared to be embedded within a cell membrane. The tennis balls served as ions and the bucket as the inside of the cell.

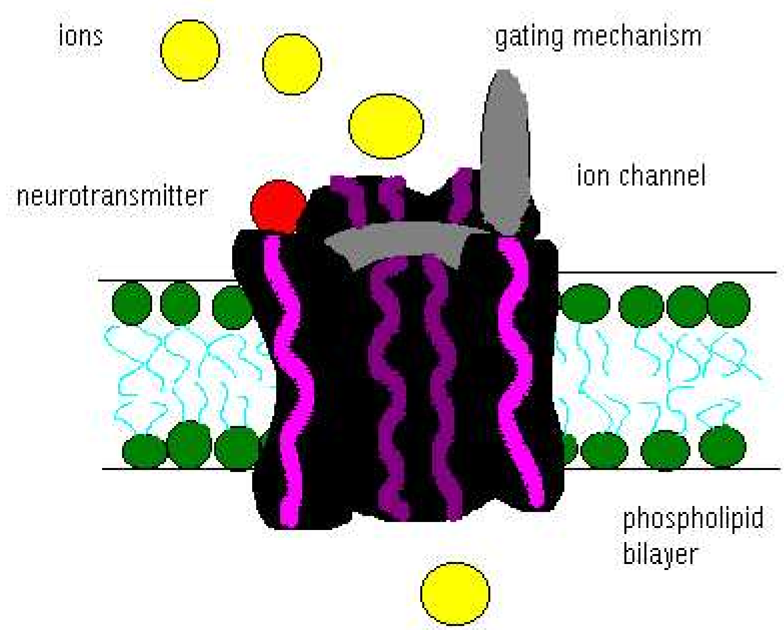

Fig 1. Ion Channel Construction

Presentation: We began our presentation by giving the kids a short explanation on the structure and function of an ion channel. We explained the location of an ion channel by asking for a description of a cell. Once the kids were able to tell us what a cell was, we told them to imagine our ion channel model embedded within a cell wall. This image gave them the general idea of location and size of an actual ion channel. Next we explained the different parts that make up the ion channel and what they did. The protein subunits create the channel itself and enclose the pore, the gating mechanism allows ions to enter the cell only when it is open, and the ligand-binding site opens the gate when the right neurotransmitter is bound to it. We then explained what an ion was and how the flow of ions through an ion channel and into a cell creates action potentials that allow us to do all the cool things that we as humans can do. When the explanation was complete and all questions were answered, the kids were allowed to throw 'ions' into the 'ion channel' in order to further demonstrate the structure and function of a ligand-gated ion channel.

Results:

	1	2	3	4	5	Average	Standard Deviation
Q1	0	3	3	10	21	4.32	0.944
Q2	0	0	2	5	30	4.76	0.554
Q3	0	0	4	4	29	4.68	0.669
Q4	2	3	6	6	19	4.03	1.15
Overall						4.45	0.33777458

The model seemed to be well received by the kids during the presentations. However, after our explanation all they wanted to do was throw the "ions" into the "ion channel". When asked if they had any questions few responded with a question, yet quite a few reported on their evaluation forms that they did not really understand what was being said. Some asked very good questions, others seemed to be more interested in throwing the balls, and a few did not seem interested whatsoever. Good questions included: "Why does the channel open and close?", "What is an ion?", and "How many ions can pass through the channel at once?".

Our average score for the 'did you understand' question (Q1) was 4.32 +/- 0.944. Our average score for the 'were the presenters friendly' question (Q2) was 4.76 +/-0.554. Our average score for the ' was it fun' question (Q3) was 4.68 +/-0.669. Our average score for the 'would you like to learn more' question (Q4) was 4.03 +/-1.15. And our overall average score was 4.45 +/- 0.334. We placed fourth out of five in the B section of exhibits.

Favorite parts of our exhibit included: shooting the ions into the ion channel, seeing how the ions bounced off the ion channel when it was closed, and being an ion. Comments regarding what the kids learned included: that ions need to go through the ion channel, about nerve/ion channels, about [cell] membranes, that the ions cannot get through the ion channel when it is closed, ions can only make it through the channel when it is open, the ion has to make in before the channel closes, about cells, how ions get into cells, what an ion is, ion stuff, it [the ion channel] opens by [as a result of] another cell, ion channels open and close, ion channels are opening and closing very fast, I couldn't really understand what they were talking about, I was in the bathroom, and not much/nothing.

Discussion:

I was disappointed with the overall results because it seemed that the majority of the kids had really enjoyed our model and did not have many questions when asked if there was anything they did not understand. We came to find out that the lack of questions meant that they did not fully understand our presentation. This was the first experience we have had in presenting an aspect of neurophysiology to younger kids and we were not really sure how to go about it. We would definitely prepare a simpler speech explaining the structure and function of an ion channel if we were to present this model again to kids of the same age range. Unfortunately, we were not able to accurately gauge the level of understanding occurring during the presentation and we are afraid that our explanation may have become more elaborate as the day went on. The kids were mostly very attentive during our presentation and seemed interested in learning, but unfortunately when looking at their comments on the evaluation sheets we found that not many were interested in learning more on this topic.

The kids definitely enjoyed tossing the "ions" through the "ion channel" and into the "cell". That was the best part of the presentation as reflected in the evaluations. Almost every single kid wrote that their favorite part of the presentation was when they were allowed to make nerve channel baskets. We think therefore the idea of our model and construction was well thought out for a fifth grade audience and seemed to be well received. The only aspect of our presentation that could have been made better was a simpler, clearer explanation of what we were trying to convey through our model, the structure and function of an ion channel.

We tried to make the model as realistic as possible, but often that is hard to do when you are trying to balance simplicity with accuracy. Our model was a general representation of a ligand-gated ion channel and therefore was not as accurate as if we had chosen an actual specific type of ion channel to represent, such as a Na^+ or K^+ channel. Proportions of the channel may have been incorrect and the gate opened out into what would be the extracellular space around the cell. Our channel had a pore, however it was not selective for one type of ion, although we only provided one type of ion for the kids to throw. We could have demonstrated the selectivity of the channel by giving them different sizes of balls to throw and allowing only one size of ball to actually fit through the ion channel. We also did not show what became of the ions after they entered the cell in order to keep things simple.

In comparing the results of the evaluation forms to the overall results of the vote, I was a little disappointed to see that we missed third place by a very small amount. In fact there seemed to be many discrepancies between the evaluations and the overall judgment. Some inconsistency between evaluations and rank comes from the large standard error in the evaluations. Perhaps the kids were trying to be nice and gave higher scores when they actually did not feel the way they marked on the sheets. Also the last station that the kids were at may have influenced their vote by being fresh in their minds. Most importantly, we came to realize through analysis of the results that the 'fun' score (Q3) correlates best to the overall vote.

For the next presentation of this model, we would definitely prepare a simpler, more exciting and interesting speech for the kids and incorporate questions into the presentation to make sure that they understood what we were telling them. We are satisfied with our placement after comparing it to our performance, yet feel that perhaps we should have placed a little higher if the official vote was taken from the evaluation forms.

References

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