

BIO 131 PAL

Week 3 – Problem Set 2

Escape from Planet Soma

Mastering the Physiological Principles of Neuronal Signaling

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Questions and text were modified, and questions were added by **Larissa Eiselein** to fit **BIO 131A** course content.

After a valiant but doomed battle in the distant Purkinje Galaxy, you are captured by the Glialiens, the most evil beings in all of the Cerebral Hemisphere. They imprison you in their outpost on the desolate planet Soma, from which no one has ever been known to escape.

Chief Oligodendrog eyes you with glee. “Well, well, if it isn’t the intrepid ____ (make up a name for your space alter ego). I’ve heard of your daring deeds, and I must say your bravado impresses even me. However, bravado is nothing if your little earthling neurons can’t produce some obvious intelligence to go along with it. I’ve yet to meet an earthling who possesses both.”

You shrug nonchalantly. “There’s always a first time.”

The chief laughs. “Oh, you’ve got an attitude as well!” His yellow eyes gleam as he leans closer. “Would you care to prove the extent of your intelligence?”

You warily eye his neuron incapacitator gun. “Sure. And if I pass, you have to release me.”

Oligodendrog considers for a moment. “Very well. Let me explain the test. When prisoners try to escape, we use a variety of methods based on neurophysiology principles to, uh, discourage them from trying again. My assistant will select several methods at random and you must predict the terrible effects produced when that method is used. Predict correctly and you earn your release. Predict incorrectly and you experience the effects first hand.” He smiles and clicks his clawed toes on the floor.

Fervently hoping you remember something from those neurophysiology lectures in BIO 131, you agree.

“Excellent!” Chief Oligodendrog grins. He barks into a radio and a Glialien enters with an enormous syringe. Oligodendrog explains that it contains a mutant gene for voltage-gated sodium channels in nociceptive neurons; injection of the gene will produce channels that have much lower thresholds than normal (for example -65 mV rather than the normal -55mV).

Questions:

1. **What is “threshold”? What will happen in the genetically modified neurons?**
2. **What type of information do nociceptive neurons carry? Why would having this mutant gene be so terrible?**

Oligodendrog pursues your hastily scribbled answers. “Not bad, earthlings. But that was only one technique out of many.” The small alien enters again, this time with a flask of fluorescent orange fluid. “This is one of my favorites. We’ve engineered a synthetic toxin that destroys the myelin covering your optic nerves and motor neurons. Care to have a sip of our special orange juice? It’s really quite tasty.” He hands you another card with questions and swirls the oily fluid.

Questions:

1. **What effect will the destruction of myelin have on the signaling capability of a neuron? Clearly explain why this occurs.**
2. **Make a sketch comparing the conduction of an action potential along a myelinated vs. an unmyelinated neuron.**
3. **What symptoms should you experience if you are forced to drink alien “orange juice”?**

A low growl rises from deep within Oligodendrog. “You think you’ll get them all correct? Don’t be so smug.” This time, the assistant brings in a cage containing an enormous black mamba snake. Oligodendrog rattles the cage, which makes the snake open its inky black mouth and hiss angrily. “We’ve purified dendrotoxin K from the venom, and injecting it will block your voltage-gated potassium channels in no time. That will wipe the smile right off your face....or maybe it won’t.” He laughs and presents yet another question card.

You read the questions and smile broadly at Oligodendrog.

Questions:

1. **What effect will the dendrotoxin have on the signaling capability of a neuron?**
2. **What will happen to you if your motor neurons are exposed to this toxin?**

Beads of sweat dot your brow as you return your answer card. Oligodendroglia notices. "Not so confident on this one, earthling?" I'll trip you up yet." He turns to his assistant and roars, "What's next?!"

It's yet another syringe. "OK, tell me what happens when we flood your brain tissue with potassium until extracellular potassium levels are much higher than what they should be!" This time Oligodendroglia flings the card angrily in your direction.

A knot forms in your stomach...the questions are getting harder.

Questions:

- 1. How will increasing extracellular potassium affect the strength of the concentration gradient for K⁺ (assume K⁺ concentration inside CNS neurons is still larger). What will happen to the membrane potential of the CNS neurons as a result? How will this affect the signaling capability of those neurons?**
- 2. What "terror" will this method produce if injected into your brain tissue?**

The answers come to you at the last second, and instead of becoming angry, Oligodendroglia appears almost resigned.

You sense an opportune moment and venture an offer. "Suppose we do one more method, any method of your choice. If I answer it incorrectly, I am your prisoner for the remainder of my days. But if I respond correctly, I earn my freedom."

Oligodendroglia considers for a moment, then grins slyly. "I'll accept your challenge. Since you seem to have such a thorough grasp of neurophysiology, perhaps you can be of use to us. We are always looking for new methods to keep our prisoners from escaping. I challenge you to devise at least two new methods for us that impair neuronal signaling with target cells."

Questions:

- 1. Design at least two new methods in which signaling between a neuron and its target cells can be disrupted.**

Were you able to regain your freedom???