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Escape from Planet Soma

Mastering the Physiological Principles of Neuronal Signaling

by
Sheri L. Boyce
Department of Biological Sciences, Messiah College, Grantham, PA

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, if it's a fair test. 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 firsthand." He smiles and clicks his clawed toes on the floor.

Fervently hoping you remember something from those dreaded neurophysiology lectures in A&P, you agree.

"Excellent!" Chief Oligodendrog grins. "Here's the first method." He barks into a small radio and a small Glialien enters with an enormous syringe. Oligodendrog explains that it contains a mutant gene for a voltage-gated sodium channel in nociceptive neurons; injection of the gene will produce channels that are non-functional, with disastrous consequences. He then hands you the card below. "Kindly transcribe your answers so there is no dispute about what you said."

How will the non-functional sodium channels affect the signaling capabilities of a neuron?

What type of information do nociceptive neurons carry?

Why would having this mutant gene be so terrible?

Oligodendrog peruses your hastily scribbled answers. "Not bad, earthling. 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 and swirls the oily fluid.

What effect will the destruction of myelin have on the signaling capability of a neuron?

Explain why this occurs.

What will happen to you if you are forced to drink the alien "orange juice"?

Oligodendrog narrows his eyes after reading this card, and calls for his assistant again. "Well, well, you've got a few neurons firing in that earthling head of yours. But we're not finished yet." His assistant enters, holding some sort of arrow with a sticky residue covering the tip. "Sometimes we use a method borrowed from earthlings and prick uncooperative prisoners with an arrow covered in batrachotoxin from a poison-dart frog. This toxin causes voltage-gated sodium channels to open at a more negative membrane potential and also prevents their inactivation. An amount equivalent to a grain of salt will have nasty effects on your motor neurons."

You smile as you take the card. This one should be a piece of cake.

How will the signaling of a neuron be affected if the voltage-gated sodium channels open at a more negative membrane potential?

How will preventing the inactivation of sodium channels affect the signaling capability of a neuron?

What nasty effects will this toxin have on motor pathways?

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 card.

You read the questions and smile broadly at Oligodendrog.

What effect will the dendrotoxin have on the signaling capability of a neuron?

What will happen to you if your motor neurons are exposed to this toxin?

Once again, the instruction from your fabulous A&P professor pays off. Oligodendrog roars in frustration and summons his assistant. He enters with a hose and mask attached to a silver canister. "Here we go. How about a little puff of general anesthetic like sevoflurane? It will open more potassium channels in neurons of the reticular formation in the brainstem, and you won't know what hit you. Oh, but be careful…it's not those voltage-gated potassium channels that are affected."

You gulp. *Other potassium channels besides the voltage-gated?? Uhhhhhh…*

To what other type of potassium channel is Oligodendrog referring?

What effect will opening more of these channels have on the excitability of a neuron?

What will happen to you when sevoflurane reaches the reticular formation neurons that control sleep and consciousness?

Beads of sweat dot your brow as you return the card. Oligodendrog notices. "Not so confident on this one, earthling?" However, his brow wrinkles as he reads your answer and crumples the card in disgust. "You got lucky with that one! 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 ten times what they should be!" This time Oligodendrog flings the card angrily in your direction. A knot forms in your stomach…the questions are getting harder.

How will increasing extracellular potassium affect the signaling capability of a neuron?

What type of cell normally regulates levels of extracellular potassium in the CNS?

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, Oligodendrog 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 and YOU suffer the treatment."

Oligodendrog considers for a moment, then grins slyly. "I'll accept your challenge. Prepare to make yourself comfortable here on Planet Soma." He leaves the room for a moment and returns with a small vial and a syringe. "This is something entirely new, that no one else in the hemisphere has ever heard of. We've been working on it for months and it looks like you'll be the first earthling to test it!"

Your heart drops to your stomach. You've remembered your A&P material pretty well so far, but something completely new? Perhaps you've overestimated…

Oligodendrog interrupts your thoughts. "Some types of epilepsy are caused by a genetic mutation that produces a voltage-gated sodium channel with a faster recovery from inactivation. You could probably tell me that this would increase the excitability or firing rate of the neuron and lead to seizure activity in the brain. However, we've created a sodium channel with a different mutation. It alters the voltage sensitivity of the sodium channel so that it only opens at more positive membrane potentials. Amazingly, it also leads to seizures, but we're not sure how. Since you seem to have such a thorough grasp of neurophysiology, perhaps you will enlighten us."

Oligodendrog hands you the final card. You both stare at the vial and wonder who will be the recipient of its contents.

How will the excitability of a neuron be affected by sodium channels that open at more positive membrane potentials?

How does this lead to seizure activity in the brain?