Neuron Race

What is a Neuron? - A neuron is a nerve cell found in the nervous system. The nervous system consists of the brain, spinal cord, and nerves that control movement and bodily functions. A neuron sends signals within the brain and throughout the body.

(Throughout these instructions, keep an eye out for the *Neuroscience Connections. *These include explanations of other neuroscience facts.)*

Ages: 11+
Players: 3 - 5

Rules:

Game Pieces:

- 1 signal token per player
- 10 current point tokens per player
- 10 sodium ion tokens per player
- 1 antagonist token
- 1 game board
- 2 dice (preferably of different colors)

Note: Suggested tokens include pennies, nickels, paper clips, colored beads, pieces of paper, etc.

Objective:

To send your signal through three neurons to reach the cell body of the *Finish Neuron* before the rest of your opponents.

Set-up:

- Place all signal tokens in the cell body of the *Starting Neuron.*
- Gather Current Point tokens and Ion tokens into separate piles. There should be ten of each kind of token per player.
- Place antagonist token in the space marked "antagonist."

Rules of Play:

- Take turns collecting Sodium Ion tokens and Current Point Tokens to generate an action potential, sending your signal down the axon of the neuron.

> **Neuroscience Connection:* An *ion* is a charged particle, meaning that it has electrical properties. A *current* is a flow of electricity.

- To generate an action potential, a player must accumulate 10 Current Points.

> **Neuroscience Connection:* A neuron must accumulate enough electrical current to reach *threshold*. At threshold, voltage-gated sodium ion channels open in the cell membrane of the *axon hillock*.

- Before accumulating 10 Current Points, a player must acquire 10 Sodium Ions.

> **Neuroscience Connection:* When a player acquires ions, he/she is accumulating them outside of the cell membrane. When *sodium ion channels* open, sodium ions flow into the cell, affecting the electrical charge of the cell membrane.

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- On your turn, you can:
  - Roll both dice to accumulate Current Points. The sum of the numbers you roll determines the number of current points you receive:

Sum Rolled	Current Points Received
2, 3, 4	None
5, 6	1 Current Point
7	2 Current Points
8, 9	3 Current Points
10, 11, 12	4 Current Points

  - Roll only the Ion die to accumulate Sodium Ion tokens. The number rolled determines the number of Ion Tokens received.

Number Rolled	Sodium Ion Tokens Received
1	None
2	1 Ion
3	2 Ions
4	3 Ions
5	4 Ions
6	5 Ions

  - Roll only the Risk die to do the following:

Number Rolled	Result
1	Return 1 Current Point token to the pile. (If a player has no current points, they do nothing)
2	Steal 1 token of your choice from an opponent
3	Take 1 token of your choosing from and opponent and give them 1 token in return
4	Steal 2 tokens of your choice from an opponent (They do not have to be the same kind of token)
5	Return 1 Ion token to the pile (If a player has no Ion tokens, they do nothing)
6	Take 6 Current Point tokens from the pile

You must choose an option from this page (rolling both dice, only the Ion die, or only the Risk die) before you roll on your turn.

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- After you roll and carry out the action determined by the dice, play passes to the left.

- Once a player has accumulated 10 Current Point tokens and 10 Ion tokens, she/he immediately advances his or her signal token down the axon of the neuron to the axon terminals.
  - *Note: If a player accumulates 10 Current Point tokens before acquiring 10 Ion tokens, their voltage-gated sodium ion channels open and all their ions flow into the cell. This means that he/she must return all Current Point tokens and Ion tokens to their piles without advancing.*

- Once a player reaches the axon terminals, he/she must send their signal across the *synaptic gap*.

> **Neuroscience Connection*:* Signals are sent across the *synaptic gap* by *neurotransmitters*, which are small proteins. These are released from the *axon terminals* and bind to receptors on the cell body of the next neuron. These receptors are located on special processes, or branches, called *dendrites*.

- When a player reaches the axon terminals, he/she rolls both dice three times. If the player rolls doubles, they immediately cross the synaptic gap. If the player does not roll doubles, he/she must wait in the axon terminals until their next turn, when they can roll the dice three more times to try to roll doubles. If they fail to roll doubles on this turn, the player advances to the next neuron, but skips their next turn.

> **Neuroscience Connection*:* Rolling doubles signifies an *agonist*, a molecule that mimics neurotransmitters. The presence of an agonist increases the probability that a signal will pass across the synaptic gap.

- If a player rolls doubles while *not* waiting to cross the synaptic gap, he/she can choose carry out one of the following two actions in addition to their normal turn:
  1. Steal 1 Current Point Token -*or*- 1 Sodium Ion Token from a player of their choice
  2. Move or remove the *antagonist* into any of the 3 synaptic gaps. The antagonist prevents all players' signals from crossing the synaptic gap.

Note: Any player who rolls doubles can remove the antagonist from a synaptic gap (it can be returned to the "Antagonist" square or moved to another synaptic gap). If a player rolls doubles while waiting to cross a synaptic gap blocked by an antagonist, he/she can remove the antagonist, but cannot advance immediately.

> **Neuroscience Connection*:* An *antagonist* is a molecule that blocks the neurotransmitters from binding to the next neuron.

Winning the game:

- Whichever player advances their signal to the cell body of the finish neuron first wins the game!

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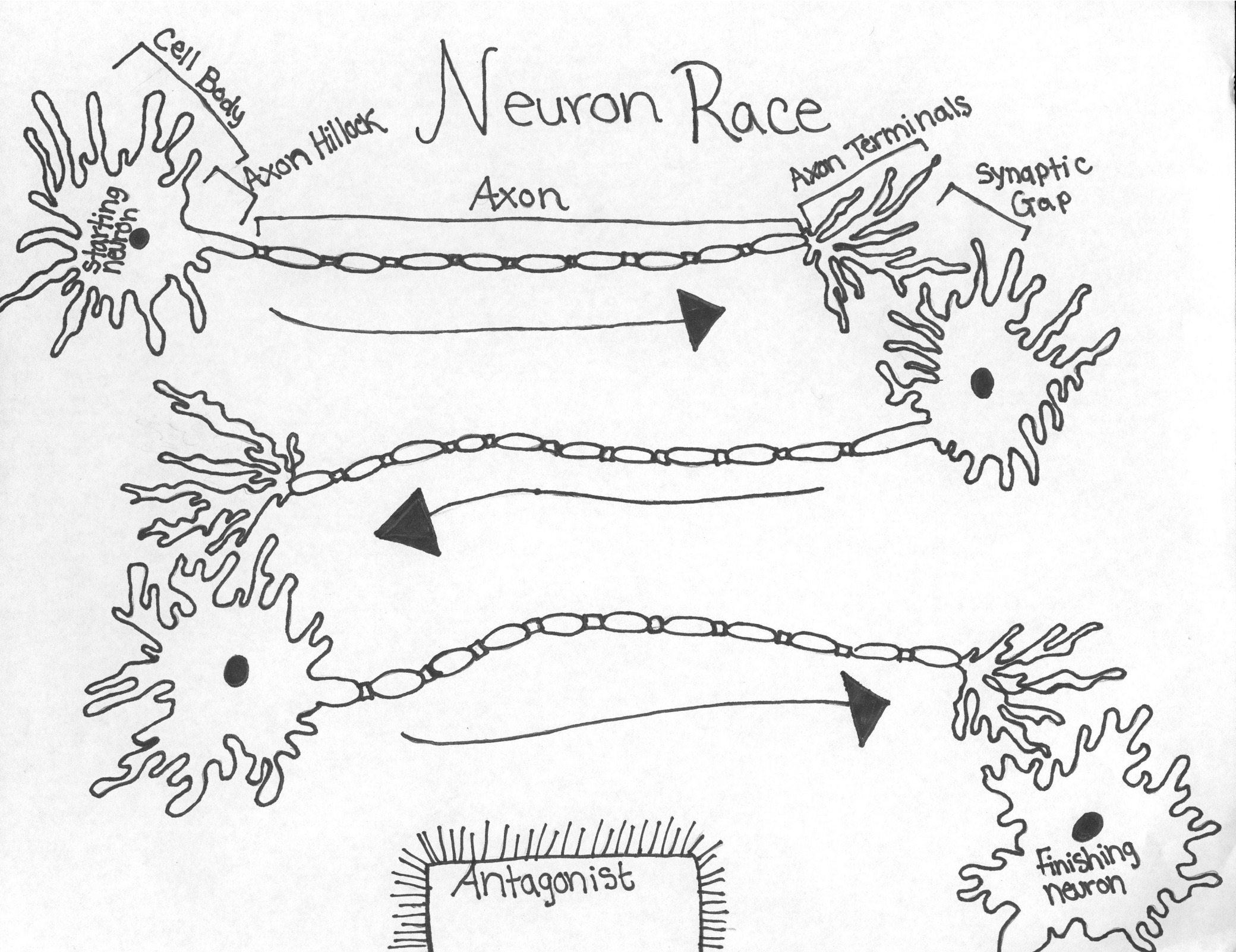
Neuron Race
Cell Body
Axon Hillock
Axon
Axon Terminals
Synaptic Gap
Starting neuron
Antagonist
Finishing neuron