**Researcher Bio**

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**Professional Title:**

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**Lesson Plan Title, Grade Level, and Keywords:**

Title: Myelin gets on my nerves

Grade Level: 9-12

Keywords: Neuroscience, nervous system, brain, spinal cord, neuron, glia, anatomy and physiology, myelination, information processing, neurological disorders, ALS, multiple sclerosis

**Brief Description of Research Interests:**

My research focuses on neuroinflammation in neurological and neurodegenerative diseases (especially ALS, stroke, and TBI). In addition to basic research on the role of neuroinflammation in these disorders, I am actively working on improving model systems to study these disorders and developing/assessing potential therapeutics.

**Lesson Plan Information Sheet**

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| Author(s): | Austin Passaro |
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| Introduction/Abstract to Lesson Plan (max. 100 Words)  Include aspects of the lesson that are unique and innovative. | The nervous system is vital to the body’s information processing capacity, including cognition as well as basic life-sustaining functions. The structure and function of the cells and tissues that comprise the nervous system are very tightly linked, and these structures and organization help ensure proper functioning. This organization and structure, both on a large-scale and cellular level, is disrupted in neurological and neurodegenerative conditions, such as ALS and multiple sclerosis. In this lesson, students will learn the structure-function relationships and key disease mechanisms by first constructing neuronal models, then playing a quick game to demonstrate the importance of myelination. |
| List of Standards Addressed  (This should be list of all full standards addressed by the lesson.) | SAP1. Obtain, evaluate, and communicate information to analyze anatomical structures of the human body.  a. Develop and use models to demonstrate the orientation of structures and regions of the human body.  b. Construct an explanation about the relationship between a body structure (i.e., cells, tissues, organs, and organ systems) and its function within the human body.  SAP3. Obtain, evaluate, and communicate information to explain the coordination of information processing in the endocrine and nervous systems.  a. Ask questions to investigate how the structures of the nervous system support the function of information processing (detection, interpretation, and response).  b. Analyze and interpret data to explain how the hormones of the endocrine system regulate physical and chemical processes to maintain a stable internal environment. (Clarification statement: This should include positive and negative feedback mechanisms, e.g. heart rate, blood sugar, childbirth, temperature, growth, etc.)  c. Ask questions about how the interdependence of the endocrine and nervous systems makes information processing (detection, interpretation and response) possible. (Clarification statement: Questions should address the homeostatic mechanisms, as well as the effects of and responses to aging, diseases, and disorders). |
| Learning Objectives using Measurable Verbs (what students will be able to do) | * Explain how the nervous system is organized (system (central nervous system, peripheral nervous system) > organs (brain, spinal cord) > tissues (nerves, nerve tracts) > cells (neurons, glia)) * Evaluate how this organization enables communication and information processing via electrical signals and neurotransmission * Describe which parts of the nervous system are disrupted in various diseases and disorders (primarily MS) |
| Appropriate Grade Levels | 9-12 |
| Group Size/# of students activities are designed for | Adaptable to classroom size – ideally 2 groups of 2-10, but can be larger or rotate if necessary |
| Setting (e.g. indoors, outdoors, lab, etc.) | Outdoors or indoors if enough space is available |
| Approximate Time of Lesson (Break down into 20-50 minute periods) | Day 1  Intro (20 mins)  Activity – pipe cleaner neuron models (20 mins)  Discussion (10 mins)  Day 2  Intro (15 mins)  Activity – myelin game (20 mins)  Discussion (15 mins) |
| Resources Needed for Students (e.g. scissors, paper, pencils, glue, etc.) | Pipe cleaners  Beads (optional) |
| Resources Needed for Educators (e.g. blackboard, Powerpoint capabilities, etc.) | Tennis balls (or other ball/object easy and safe to throw and catch)  Buckets/bins  PowerPoint capabilities |
| Apps/Websites Needed | YouTube (optional) |
| Lesson Activity (step by step description of activity) | Introduction  Day 1 – Nervous system and neurons: organization, structure, and function   1. Start by introducing the background information on the nervous system (see slides, up to neuronal structure). 2. After brief introduction, students will be able to create their own neuron models from pipe cleaners, stopping at each stage to discuss the function of each subcellular structure. 3. As a class or in several groups (ideally large groups of 10+), have students demonstrate knowledge of neuronal function and nervous system organization by tying neurons together in small bundles (nerves) then linking them end-to-end (axon terminal-to-dendrite) to reinforce the structure-function relationship.   Day 2 – Myelination and its role in neural communication   1. Recap important information from Day 1 about neuronal structure 2. Discuss neurotransmission (high-level) and myelination (see slides) 3. Split into groups and play myelin game to demonstrate how myelin insulates neurons, resulting in faster neural communication 4. After the activity, break into smaller groups (~2-4) and have students hypothesize how the human body might function differently without myelin 5. Finally, finish the slides, using MS to show an example of what can happen when myelin is lost |
| Background (this info is in slides, as well)   * As with most organ systems, the nervous system is organized in a hierarchy:   + Organ system: central nervous system, peripheral nervous system   + Organs: Brain, spinal cord   + Tissues: Nerves   + Cells: Neurons, glia (astrocytes, oligodendrocytes, microglia, Schwann cells) * Neurons are highly specialized cells with a unique structure that allows for communication * Glia have many functions that support neurons (note: will be describing myelination, but astrocytes and microglia aren’t discussed in this lesson, so no need for too much detail on them)   + Oligodendrocytes (CNS) and Schwann cells (PNS) provide myelination, which acts like insulation on an electrical wire and speeds up neural signaling   + Astrocytes support neurons and assist with many functions   + Microglia are the resident immune cell in the CNS * Myelination allows for significantly faster neural communication * MS is an autoimmune disease in which the immune system attacks the myelin sheath |
| Step by Step Activity  Day 1 – Pipe cleaner neuron models   1. Pass out pipe cleaners and beads (if using) to students. 2. Demonstrate how to build neuronal models out of pipe cleaners, using the following videos as guides:    1. <https://www.youtube.com/watch?v=BHQcea-EhqA>    2. <https://www.youtube.com/watch?v=_P9yGQ787d4>    3. Note: there are plenty of ways and other videos for how to do this! Alternatively, there are also guides for candy or other materials!    4. Note: While you’re welcome to play one of these videos for the class, it may be better to demo it yourself since the videos tend to target a younger crowd, so students may write the activity off. That also allows for more flexibility with discussion and you can ask students to guess functions, etc.! 3. **At each step of building, pause to discuss the role of each subcellular structure** (e.g., the cell body coordinates responses and serves as the “command center,” the axon transmits signals, dendrites receive signals, etc.).    1. This is important because it allows students to learn and understand the structure-function relationship as they’re building their models 4. After models are finished, have students bundle their neurons together (a few at a time) into “nerves” and end-to-end to create networks (as an entire class or small groups depending on space and logistics). Let them come up with the proper organization on their own to assess their understanding of the earlier part of the lecture on body organization. 5. Finally, discuss information flow (soma > axon > synapse > dendrites) and have students fix “backwards” connections in their connected models. 6. At the end of class, students can take the networks apart and keep their individual models, if desired.   Day 2 – Myelin relay (incl. MS, plasticity, etc.)   1. Split students into 2 groups and have each group line up facing the other, 10-20 feet apart (depending on space) (think Red Rover, egg toss, etc.). 2. Each team should have an empty bucket on one end, and tennis balls on the other (equal amount per team). 3. On a signal, teams will pass their tennis balls down the line in a relay, eventually dropping them in the empty bucket at the end. This process represents neurotransmission (with the tennis ball as the electrical signal and the bucket as the axon terminal). This can be a contest to add excitement/fun! Discuss and reinforce the concept of neurotransmission before the next round. 4. To explain the role of myelination, one team should now remove at least half their students, still spacing out to cover the same distance as the other team (to avoid excluding anyone, they can split into several “myelinated” groups). The gaps that have formed between students now represent insulated internodes, while students represent Nodes of Ranvier. During this round, these students can now throw the tennis balls to each other across the gaps, and should finish passing all of theirs much quicker than the “unmyelinated” group, showing how myelination increases conduction speed. Have students switch and repeat so everyone gets to be “unmyelinated.” |
| Reflection/Assessment  Day 1  As a class or in several groups (ideally large groups of 10+), have students demonstrate knowledge of neuronal function and nervous system organization by tying neurons together in small bundles (nerves) then linking them end-to-end (axon terminal-to-dendrite) to reinforce the structure-function relationship.  Day 2  Break into small groups (~2-4) and have students hypothesize how the human body might function differently without myelin. “Popcorn” around groups and ask them to share some of their hypotheses. |
| Final Product/Assessment (e.g. quiz, presentation, essay, etc.) | Neuron models |