The Physics of Myelin

WHITNEY LEE CENTER FOR MOLECULAR MEDICINE AND GENETICS WAYNE STATE UNIVERSITY

Outline

1) Basics of nervous system development. -ectoderm -neural plate -neural tube -brain region development -neurons and glial cells -outgrowth of axons and dendrites 2) Formation of myelin sheaths. -oligodendrocytes CNS -shwann cells PNS -make up of myelin 3) Necessity of myelin. -the physics behind it 4) Result of myelin not being formed properly -diseases -CMT in PNS -PMD in CNS

Development of the Nervous System

Derived from ectoderm

- Outermost layer of tissue
 - × Three parts:
 - External ectoderm
 - Neural crest
 - Neural tube

Development of the Nervous System



- Neural plate serves as basis for the nervous system
- Major source of neurons and glial cells
- Neural tube expands and gives rise to the brain



Development of Nervous System

• Neurons migrate and organize into different brain structures



Development of Nervous System

Neurons extend axons and dendritesThey communicate through synapses



Formation of Myelin Sheaths

- Myelin is a dielectric material that forms the myelin sheath
- Formed by schwann cells in the PNS and oligodendrocytes in the CNS







• The nervous system is the electrical system of the body





- Neuron is basic structural unit of nervous system
- Allows transmission of informatoion



- Speed of signal depends on electrical difference inside and outside of the membrane
 - Potential difference of membrane
 - × About -70mV in an axon

Capacitance

• the ability of a system to store an electric charge

- Any object that can be electrically charged exhibits capacitance
- Axon is a capacitor
- Myelin increases the thickness of an axon and decreases its capacitance/area

• Resistance

- measure of the tendency of a material to resist the flow of an electrical current
- The higher resistance a membrane has, the less current flow
- In an axon, there is current leakage from one side on the membrane to the other
 - Amount of leakage is determined by resistance of the membrane
- As capacitance increases, resistance decreases and vise versa
 - o Depends on the axon length
- Myelin increases resistance

- Stimulating an axon sends a signal down its length
- The speed of this signal depends on the capacitance and resistance
 - Higher capacitance equals slower speed
 - Higher resistance equals higher speed
- Myelin increases the speed of travel of a signal down an axon



Diseases

- When the myelin sheath is formed incorrectly it leads to a diseased state
 - Examples:
 - × Peripheral Nervous System
 - o Charcot Marie Tooth (CMT)
 - × Central Nervous System
 - Pelizaeuz-Merzbacher Disease (PMD)
- Autoimmune diseases such as multiple sclerosis also cause harm to the nervous system



Diseases

• Charcot Marie Tooth

- Most commonly due to a mutation in myelin forming protein *PMP22*
- Symptoms:
 - × Muscle wasting in extremities
 - × Lost of touch sensation
 - × Can affect breathing, hearing, and vision
- Affects 1 in 2,500 people

Diseases

Pelizaeus-Merzbacher Disease

- Most commonly due to a mutation in myelin forming protein *PLP1*
- Symptoms
 - × Nystagmus
 - × Muscular hypotonia
 - × Muscle stiffness
 - × Movement disorder including ataxia and dystonia
 - × Mild cognitive delay

• Affects 1 in 200,000 to 500,000 males

Summary

- The nervous system begins development early in fetal life
- Neurons and glial cells are formed
 - Specialized tasks
 - Glial cells schwann cells and oligodendrocytes create myelin sheaths
- Myelin sheaths are necessary for the transmission of signals quickly throughout the nervous system
- When myelin sheaths are formed incorrectly, or harmed after development, a diseased state results


