Medical Neuroscience | Tutorial Notes

Propagation of Action Potentials

MAP TO NEUROSCIENCE CORE CONCEPTS[1]

NCC2. Neurons communicate using both electrical and chemical signals.

LEARNING OBJECTIVES

After study of the assigned learning materials, the learner will:

1. Describe the ionic basis of the action potential in terms of the voltage- and time-dependent changes in ionic permeabilities that occur across the neuronal plasma membrane.
2. Characterize the advantages of myelination for the conduction of an action potential along an axon.

TUTORIAL OUTLINE

I. Introduction

    A. let's review the changes in membrane permeability that, in principle, underlie the neuronal action potential by viewing again a short online animation that accompanies *Neuroscience, 5th. Ed.*, Chapter 2: **Animation 2.3 The Action Potential** [click here]

II. Propagation of action potentials

    A. leakiness of axonal membranes prevents the effective conduction of subthreshold depolarizing potentials for more than just a very short distance (< 1 mm) (remember, that neurons – and their axons – are poor conductors of electricity) (see **Figure 2.3**[2])

    B. the action potential provides a means of overcoming the inherent leakiness of the axonal membrane (see **Figures 3.10–3.12**)

        1. action potential propagation requires the coordinated action of two forms of current flow:

            a. **passive flow** of current down the axon

            b. **active flow** of current through voltage-dependent membrane channels

[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.
[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

2. because resistance is inversely related to diameter, larger axons present less resistance to passive current flow and the "conduction" (speed of transmission) of electrical signals is faster in larger diameter axons
3. *CONDUCTION VELOCITY IS DIRECTLY PROPORTIONAL TO AXONAL DIAMETER*

C. as action potentials propagate along an axon, recently excited membrane becomes **refractory** for some brief period of time

1. Na+ channels remain inactivated (absolute refractory period)
2. K+ channels are activated (relative refractory period)

D. **myelination increases the speed of action potential propagation** (see **Figure 3.12**)

1. myelination increases the efficiency of passive current flow down an axon by reducing the inherent leakiness of the axonal membrane with the addition of insulating glial membranes
2. Na^+ channels are concentrated at the **Nodes of Ranvier**
3. **saltatory conduction**; action potentials "jump" from one node to the next
4. consequently, loss of myelination, such as occurs in demyelinating diseases like multiple sclerosis, severely slows and might even impede the propagation of action potentials along axons

E. view **Animation 3.2 - Impulse Conduction in Axons** [click here]

Study Question

One of the neurological diseases that can severely impair neurologic function is multiple sclerosis. Thankfully, for many patients who live with this disorder, there are interventions that may modify the progression of disease and bring relief for managing daily symptoms. Multiple sclerosis involves an immunological attach against the brain cells that make myelin. Knowing this, what do you think would be the underlying neurobiological insults that led to impairment of neurological function?

A. breakdown of the blood-brain barrier
B. insufficient clearance of neurotransmitters upon release from presynaptic terminals
C. failure of action potential propagation
D. all of the above