Medical Neuroscience | Tutorial Notes

Overview of Neural Signaling

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 student will:

1. Differentiate the resting membrane potential from the action potential.
2. Describe one means for encoding information in the activity of neurons.

TUTORIAL OUTLINE

I. Introduction to neural signaling

- A. *ELECTRICAL SIGNALING IS THE FUNDAMENTAL NEURONAL PROCESS THAT UNDERLIES ALL ASPECTS OF BRAIN FUNCTION*
- B. neurons process and transmit information via the generation of **electrical signals**
  1. neurons are intrinsically poor conductors of electricity
  2. however, neurons develop mechanisms for the generation of electrical signals
  3. electrical signals are based upon the flow of ions across plasma membranes
- C. overview of the electrical signals of nerve cells (see **Figure 2.2**[2])
  1. neurons have a means of generating a steady-state electrical potential across their plasma membrane, called a **resting membrane potential**; this potential is *negative*, usually in the range of –40 to –90 mV (thus, the neuronal membrane is said to be negatively "polarized")
  2. when an electrical stimulus is applied to a neuron (either via electrical signals of other neurons or artificially by a stimulating microelectrode), the resting membrane potential may become ***hyper*polarized** (= more negative) or ***de*polarized** (= less negative)
  3. if a depolarizing stimulus is strong enough, a very large, explosive depolarizing event may suddenly occur and the membrane potential may actually become

[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]

positive for a brief period of time; this sudden, all-or-none electrical event is called an **action potential**

a. the membrane potential at which an action potential is triggered is called **threshold**

b. the action potential is said to be "**all-or-none**" because it either occurs at full amplitude or not at all

c. if a supra-threshold stimulus is very strong, more than one action potential may be elicited

d. thus, the strength of a stimulus may be encoded by the *number* of action potentials elicited (not the amplitude of the action potential)

4. action potentials are "**propagated**" along axons until the end of the axons is reached where a special junction, called a **synapse** (located at a synaptic terminal), exists for the purpose of communicating the electrical signal from one axon to another cell (usually to the dendrites or soma of another neuron)

II. Ionic movements produce electrical signals

A. Two molecular mechanisms account for the generation of electrical signals in nerve cells (see **Figure 2.4**): **ion pumps** and **ion channels**

1. there are differences in the concentrations of specific ions across the nerve cell membrane; these **concentration gradients** are generated by ion pumps

2. the nerve cell membrane is **selectively permeable** to certain ions; the passage of ions across the membrane occurs via the opening of ion channels

B. thus, *PUMPS ESTABLISH THE CONCENTRATION GRADIENTS THAT PROVIDE THE "***DRIVING FORCE***" FOR THE DIFFUSION OF THE IONS THROUGH CHANNELS*

STUDY QUESTION

Pinch yourself (really!). Now pinch yourself again, only this time, apply just a little more pinch so that you notice that this one is stronger. So what's the difference between the first gentle pinch and the second stronger pinch?

A. The first pinch generated passive responses in the sensory axons of the relevant spinal nerve, while the second pinch generated action potentials.

B. The second stronger pinch generated more action potentials in the sensory axons of the relevant spinal nerve, compared to the first weaker pinch.

C. The second stronger pinch generated larger action potentials in the sensory axons of the relevant spinal nerve, compared to the first weaker pinch.