Medical Neuroscience | Tutorial Notes

Functional Microanatomy of Neurons

Map to Neuroscience Core Concepts[1]

NCC1. The brain is the body's most complex organ.

NCC2. Neurons communicate using both electrical and chemical signals.

Learning Objectives

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

1. Differentiate the basic classes of cells found in the central nervous system (CNS).
2. Characterize the "functional microanatomy" of neurons (differentiate neuronal cell bodies, dendrites, axons and synapses).
3. Describe the microanatomical composition of gray matter and white matter in the CNS.

Tutorial Outline

I. Functional microanatomy of neurons

- A. general features of neurons
  - 1. *Neurons are the fundamental unit of function in the CNS*
  - 2. possess all cellular and metabolic machinery common to all other somatic cells (see **Figure 1.3**[2])
  - 3. but they are distinguished from most other somatic cells by their:
    - a. rich diversity in morphology (shape)
    - b. bioelectrical properties (they generate electrical signals)
    - c. specializations for intercellular communication
- B. survey of neuronal microanatomy (see **Figure 1.2**)
  - 1. **cell body**, also called a soma (= "body"; plural = *somata*)
    - a. contains nucleus, nucleic acids, and the usual organelles
    - b. typically, neurons are very active metabolically in order to support neural signaling and the synthetic requirements that are necessary to maintain the intricate protoplasmic processes that arise from neuronal somata

[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. **dendrites**
    a. short (usually, about 100 microns in length) protoplasmic extensions that arise from somata
    b. primarily involved in receiving neural signals from other neurons
    c. dendritic spines
        i. neurons that excite their synaptic partners have very short "spines" (that typically resemble tiny mushrooms) or short filaments along the length of their dendrites
        ii. spines are primarily the sites where dendrites receive excitatory signals from the axon terminals of other neurons
        iii. the dendrites of some neurons lack spines and are called "smooth"; these neurons typically inhibit their synaptic partners
    d. exhibit an especially rich diversity of morphology among different classes of neurons
        i. pyramidal neurons in the cerebral cortex have a single long "apical" dendrite and numerous shorter "basal" dendrites
        ii. other neurons are "multipolar", meaning that their dendrites emanate from the soma in a somewhat regular array
3. **axons**
    a. long protoplasmic extension that arises from somata
    b. for some neurons, the axons are very short (<100 µm); for others, axons can be very long (> 1 meter!)
    c. involved in the transmission or sending of neural signals away from the cell body and toward other neurons or effector cells
4. synaptic terminals or "**synapses**"
    a. specialized contacts among neurons and between neurons and effector cells
    b. synapses may be "electrical" (the small minority in the mature CNS) or "chemical" (the vast majority in the mature CNS) (see **Figures 5.1 & 5.3**)
    c. usually found at the end of axons, with an axon terminal contacting a dendrite of another neuron
    d. however, axon terminals may contact cell bodies or even other axon terminals

II. Neural tissue

A. gray matter

1. appears somewhat darker in coloration (brown or gray) when observed in a brain that is cut open obtained at autopsy

2. contains:

a. neurons (cell bodies, dendrites, axons, and axon terminals or synapses)

b. glial cells

c. vascular endothelium

B. white matter

1. appears somewhat lighter in coloration (light tan or white) when observed in a brain that is cut open obtained at autopsy

2. contains:

a. the axons of neurons (but—with rare exceptions—no cell bodies, dendrites, or axon terminals)

b. glial cells (those that make myelin—insulation around axons)

c. vascular endothelium

III. classes of neurons (see **Figure 1.2**)

a. projection neurons

i. characterized by long axons that project far from somata ("project" signals to a distant target) (see blue cells in **Figure 26.2**)

ii. some project away from the CNS in peripheral nerves (see **Figure 1.7**)

- afferent neurons: projection neurons that *receive* information from the environment (e.g., via sensory receptors)

- efferent neurons: projection neurons that *send* information out to effector cells (e.g., via nerves to muscle cells or glands)

iii. however, projection neurons also make shorter connections to nearby neurons via axon collaterals

iv. most projection neurons are excitatory (i.e., they "excite" their targets)

b. interneurons

i. characterized by shorter axons that project only a short distance (100s of microns) in the CNS to nearby neurons

ii. many are excitatory (see green cells in **Figure 26.2**), but most are inhibitory (they prevent their targets from becoming "excited") (see purple cell in **Figure 1.7**)

STUDY QUESTIONS

How does information flow through a neuron?

A. dendrite --> synapse --> cell body --> axon--> dendrite
B. synapse --> dendrite --> axon--> cell body --> synapse
C. synapse --> dendrite --> cell body --> axon--> synapse
D. axon--> dendrite --> synapse --> cell body --> axon

Which set of microanatomical structures are typically found in white matter?

A. synapses, vascular endothelium, neuronal cell bodies, axons
B. vascular endothelium, axons
C. synapses, vascular endothelium, neuronal cell bodies
D. vascular endothelium, neuronal cell bodies, axons