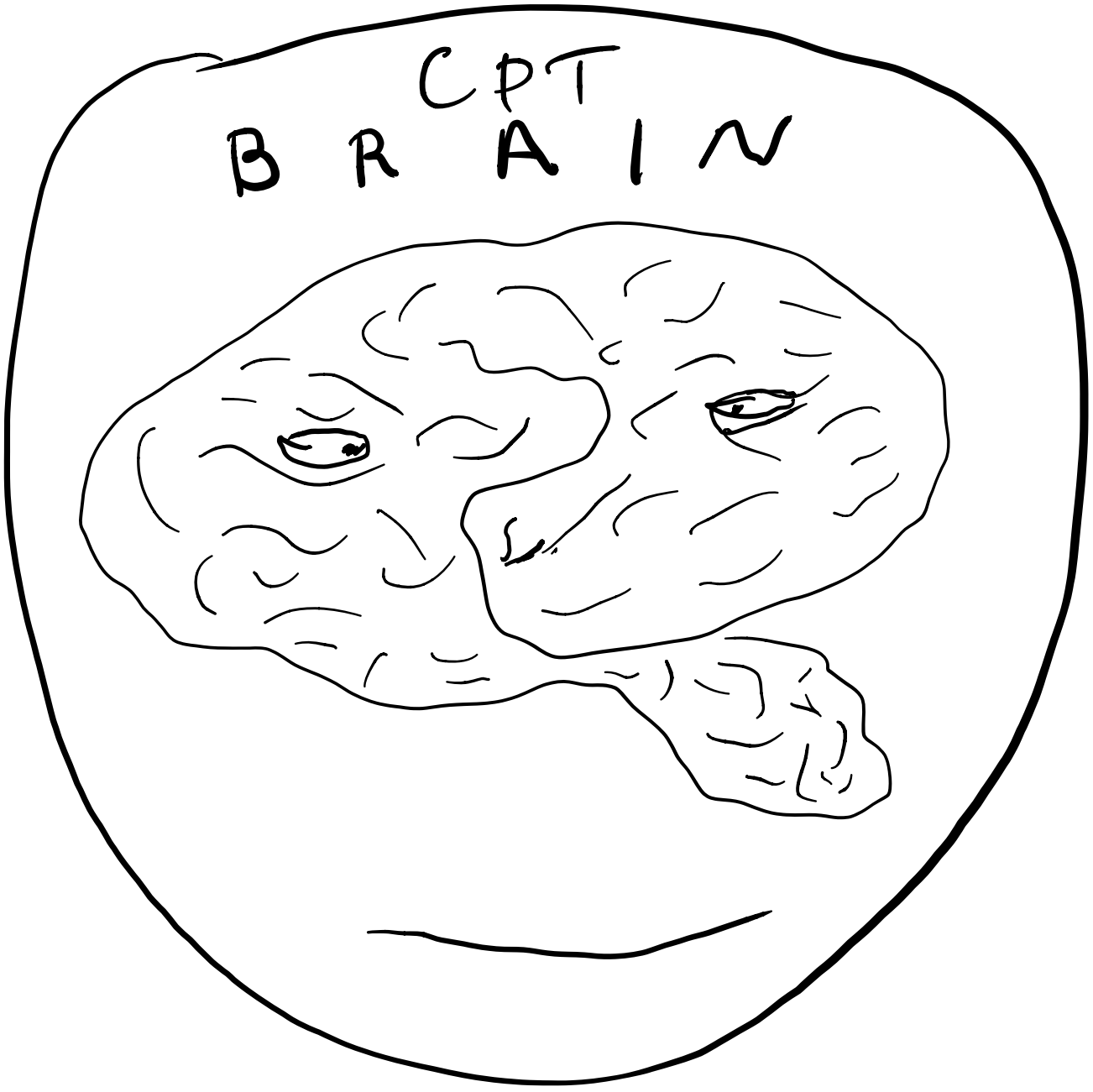
CPT
BRAIN

Lecture 1: Organization of the Nervous System

Dr. Andrew Bass

Pre-lecture Preparation

Watch Pre-class video if posted on the website, though not all Bass lectures may use them.
Review lecture outline below, which is intended to complement content in slides presented in class.

Reading

Bear et al.: Chapter 1, Chapter 2: pp. 24-27, Chapter 7: pp. 183-186.

Further Optional Reading

Bear et al. – Chapter 2: pp. 41-48; Chapter 7: 192-207.

Learning Objectives

1. Be able to discuss the major functions of the nervous system.
2. Be able to discuss how the organization of the nervous system allows for the functions in objective 1.
3. Be able to describe the history and aspects of the neuron doctrine.
4. Be able to describe the direction of flow of information in a generalized neuron.
5. Be able to list the major types of neurons and how their anatomy influences their function.

General Lecture Outline (complements content in slides presented in class)

1. What does the nervous system do?
    a. Sensation
    b. Movement
    c. Survival functions

2. How does the structure of the nervous system allow it to do its job?
   a. Gross anatomy – The nervous system has **two major divisions**.

- Central Nervous System (CNS) – brain and spinal cord
- Peripheral Nervous System (PNS) – sense organs and nerves

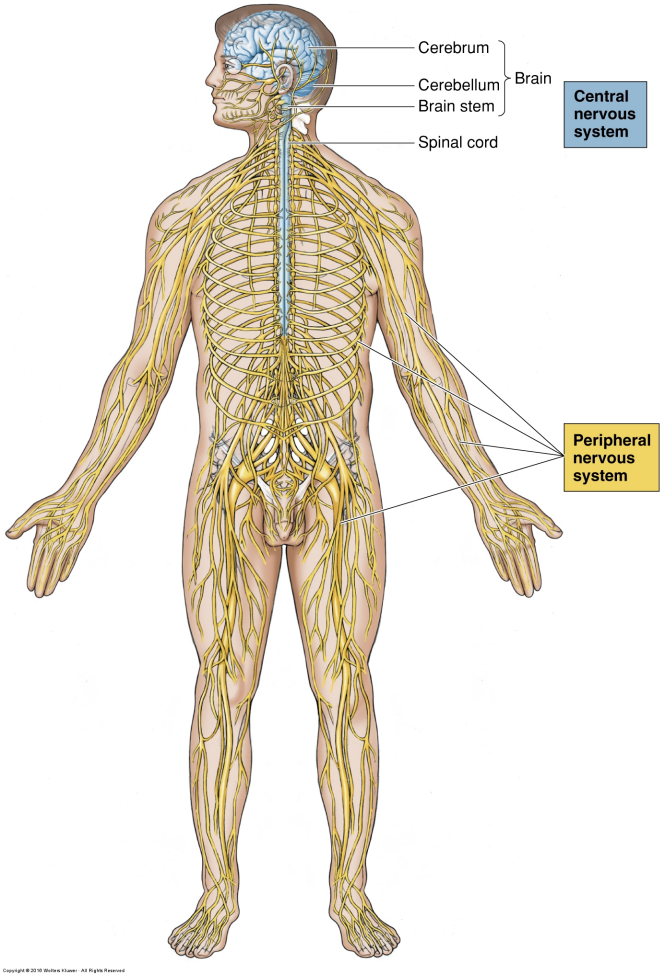

Figure 1.7 from Bear et al.

   b. Cellular anatomy – The nervous system has **two major types of cells**.

- *Neurons* – individual cells that are connected via synapses
- *Glia* – supporting cells that form myelin and regulate the external environment of neurons, including getting rid of "debris"

3. Neuron Doctrine - Neurons are distinct cells that are separated from each other and communicate with each other and other cell types via **specialized contacts** (figure 2-1 from Kandel et al., 2013).

4. Neurons have **two structural compartments**.

    - *cell body* or *soma.*
    - *neurites* - major feature distinguishing neurons from other cell types. Two types of neurites – *dendrite* and *axon*.

dendrites receive information

axons send information

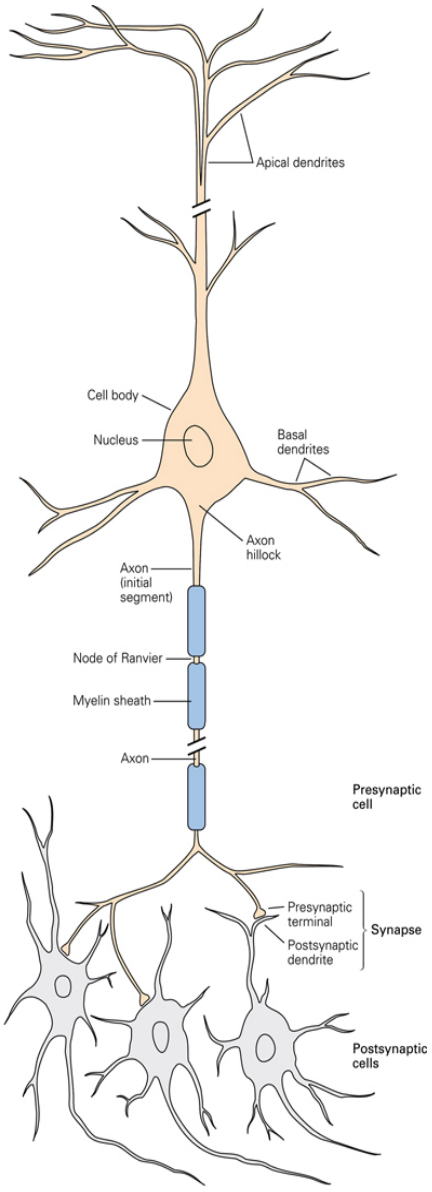

Figure 2–1 The structure of a neuron. Most neurons in the vertebrate nervous system have several main features in common. The cell body contains the nucleus, the storehouse of genetic information, and gives rise to two types of cell processes: axons and dendrites. Axons are the transmitting element of neurons; they vary greatly in length, some extending more than 2 m within the body. Most axons in the central nervous system are very thin (between 0.2 µm and 20 µm in diameter) compared with the diameter of the cell body (50 µm or more). Many axons are insulated by a sheath of fatty myelin that is regularly interrupted at gaps called the nodes of Ranvier. The action potential, the cell's conducting signal, is initiated at the initial segment of the axon and propagates to the synapse, the site at which signals flow from one neuron to another. Branches of the axon of the presynaptic neuron transmit signals to the postsynaptic cell. The branches of a single axon may form synapses with as many as 1,000 postsynaptic neurons. The apical and basal dendrites together with the cell body are the input elements of the neuron, receiving signals from other neurons.

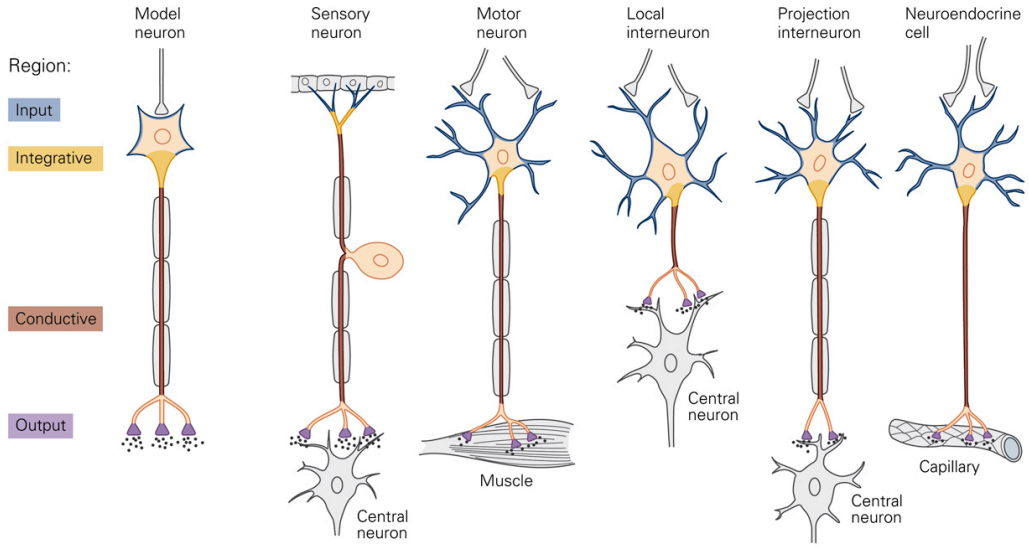

Figure 2–9 Most neurons, regardless of type, have four functional regions in which different types of signals are generated. Thus the functional organization of most neurons can be represented schematically by a model neuron. The input, integrative, and conductive signals are all electrical and integral to the cell, whereas the output signal is a chemical substance ejected by the cell into the synaptic cleft. Not all neurons share all these features; for example, local interneurons often lack a conductive component.

5. How do neurons direct the flow of information? The prototypical, **neuron is polarized and has 4 functional regions**.
    a. input — from cell body
    b. integrative
    c. conductive — axon is conductive part
    d. output — dendrites
6. **Four functional classes of neurons** (figure 2-9 from Kandel et al., 2013).
    a. *Sensory* neuron - carry information to the CNS (brain and spinal cord)
    b. *Motor* neuron - carry information from CNS to other organ systems
    c. *Interneuron* – any neuron that is not a sensory or motor neuron. Two types:
        - *local*
        - *projection*
    d. *Neuroendocrine cells* in the hypothalamus synthesize hormones that release their contents into the circulatory system via contacts with blood vessels. Some of these hormones control the release of other hormones synthesized in the pituitary gland. Hormones then reach other organ systems via the general circulation. See next page (figure 47-12 from Kandel et al., 2013).

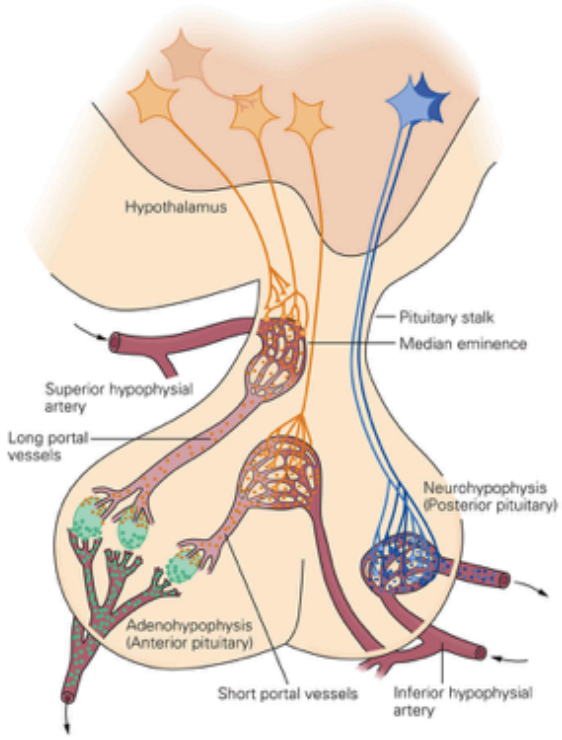

Figure 47–12 The hypothalamus controls the pituitary gland both directly and indirectly through hormone-releasing neurons. Neurons in the *magnocellular neuroendocrine system* (**blue**) send their axons directly to the posterior pituitary (neurohypophysis) where they release the peptides vasopressin and oxytocin into the general circulation. Neurons in the *parvicellular neuroendocrine system* (**yellow**) send their axons to a venous portal system in the median eminence and pituitary stalk. Long and short portal veins transport hypothalamic hormones (peptides and dopamine) to the anterior pituitary (adenohypophysis) where they bind to five classic types of endocrine cells and influence the release of their hormones (see Figure 47–11). The output of neuroendocrine neurons is regulated in large part by inputs from other regions of the brain. (Reproduced, with permission, from Reichlin 1978; and Gay 1972.)

7. Neurons produce **action potentials** – they are electrical signals that provide the principal mechanism by which neurons encode information that they send to each other and to other organ systems (figure 2-2 from Kandel et al., 2013).

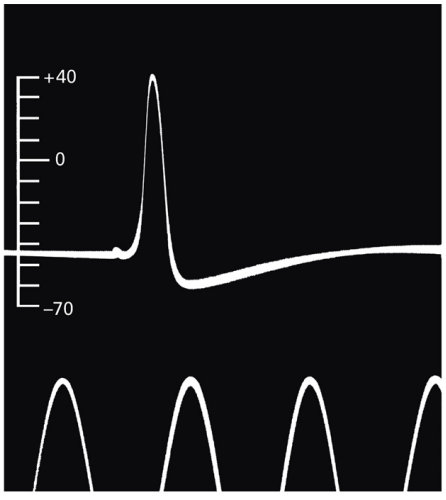

Figure 2–2 This historic tracing is the first published intracellular recording of an action potential. It was recorded in 1939 by Hodgkin and Huxley from a squid giant axon, using glass capillary electrodes filled with sea water. The timing pulses are separated by 2 ms. The vertical scale indicates the potential of the internal electrode in millivolts, the sea water outside being taken as zero potential. (Reproduced, with permission, from Hodgkin and Huxley 1939.)

Study Questions

1) What are the functions of the nervous system? In your own words, write a definition of nervous system function that is complete but concise (no more than 1-2 short sentences, or 2 lines).

2) Describe how the direction of information flow can be inferred using only structural (anatomical) information about the nervous system.

3) All neurons have at least one neurite, but different types or kinds of neurons have different numbers or combinations of neurites. For example, some neurons have only a single major branch of dendrites, while others have two or more separate branches emerging from their soma. Based on your understanding of how neurons work, what do you hypothesize could be different about how these two kinds of neurons function in a neural circuit.

- Central nervous system – brain + spinal cord
- Peripheral nervous system – everything else

- nerves connect brain to other organ systems
  - most body structures are innervated (contacted by nerve endings)
    - some more then others
  - nerves converge @ CNS
  - nerves are **NOT** hollow tubes

STRUCTURES THAT SUPPORT BRAIN

1. Skull
2. Meninges
   - Dura Mater, Arachnoid membrane, pia mater
3. Cerebrospinal Fluid
4. Blood Vessels

Neurons: Direct the flow of information } basic unit of nervous system

Glia:

- Insulate neurons from one another
- Make myelin
- Release growth factors
- Provide nourishment
- Remove toxins
- Regulate neurotransmitter levels.

*WATCH VIDEO IN SLIDES!

Gray Matter - Cell Bodies and Dendrites
White Matter - Myelinated Axons