- **NERVOUS SYSTEM: TISSUES AND ORGANIZATION**

- **NERVOUS TISSUES**
  - Nervous & Endocrine systems evolved to coordinate the activity of multicellular animals
  - nerve and muscle cells are excitable – they can rapidly change their membrane potentials

- Neuron or Nerve cell is the basic cellular unit of the nervous system:

- **dendrites** = projections form the surface of a neuron's cell body (soma) that carry signals from presynaptic neurons toward the cell body (soma)
- **nucleus** = a membrane bound organelle in the cell body of the neuron which contains the cell's DNA and is the site of transcription and other metabolic events
- **cell body (soma)** = the portion of the neuron that houses the nucleus and the organelles
- **axon** = a single, elongated tubular extension of a neuron that conducts action potentials away from the cell body toward the neuron terminal
- **axon hillock** = the first portion of a neuronal axon plus the region of the cell body from which the axon leaves: the site of action potential initiation in most neurons
- **nerve terminals** = the branched endings of a neuronal axon, which release a neurotransmitter that influences postsynaptic cells in close association with the axon terminals across a synapse
- **synapse** = the specialized junction between two neurons where an action potential in the presynaptic neuron influences the membrane potential of the postsynaptic neuron by means of the release of a neurotransmitter that diffuses across the small cleft (the synapse) that separates the two neurons Synapses are one way because the neurotransmitter released from the presynaptic neuron has to bind to receptors that are found on the postsynaptic. Calcium usually mediates exocytosis: Calcium levels are high in the ECF

Myelinated Neurons

A myelinated neuron is a neuron in which the axon is intermittently encased in multiple layers of a lipid sheath called myelin. **Myelin** consists of multiple layers of a glial cell (Schwann cell or oligodendrocyte) membrane wrapped around the axon of a neighboring neuron. This myelin "insulation" greatly increases the conduction rate along the axon. That is, non-myelinated neurons carry impulses about 50 times slower than myelinated neurons. The portions of the axon of a myelinated neuron that are not wrapped in myelin are called the **nodes of Ranvier**.

- **Neuroglial cells (or glial cells)** = serve as the connective tissue of the CNS (central nervous system) and help support the neurons both physically and metabolically; include astrocytes and oligodendrocytes; oligodendrocytes are the glial cells that form myelin sheaths around some neurons in the CNS: astrocytes are cells that help hold neurons together in their proper spatial relationships.

NEUROGLIA (OR GLIAL CELL; SUPPORTIVE, NON-NEURONAL, CELLS OF THE NERVOUS SYSTEM)

GLIAL CELL TYPE	FUNCTIONS
ASTROCYTES	Maintaining the blood-brain barrier, create the 3-dimensional framework (scaffolding) for the CNS, performing repairs, guiding neuron development, controlling composition of the extracellular fluid
OLIGODENDROCYTES	**myelination of neurons in the CNS**
MICROGLIA	specialized immune cells of the CNS
EPENDYMAL CELLS	line the chambers and passage filled with CSF; assist in the circulation of CSF
SCHWANN CELLS	**myelination of neurons in the PNS**

With regard to the microstructure of neurons, be sure that you can identify the
cell body (soma), axon hillock, axon, dendrites, and synaptic knobs (terminals) of a neuron

With regard to myelinated neurons, in which action potentials travel more quickly as the signal is transmitted from one node to another, note the presence of the membranous myelin sheaths of the **internodes** between the **Nodes of Ranvier**.

- **TYPES OF NEURONS BASED ON THEIR STRUCTURE**

Anaxonic = small neurons found in the CNS and sense organs in which the dendrites cannot be distinguised from the axons
Unipolar = a neuron with continuous dendritic and axonal processes with the cell body lying off to one side. Sensory neurons are usually unipolar.
Bipolar = neurons with one dendrite and one axon with the cell body directly between them. These are rare, but important in some specialized sensory structures.
Multipolar = neurons with several dendrites and a single axon with one or more branches. These are the most common CNS neuron types, including all of the myelinated motor neurons that control skeletal muscle movement.

- **Convergence** = the converging of many presynaptic terminals from thousands of other neurons on a single neuronal cell body and its dendrites so that activity in the single neuron is influenced by the activity in many other neurons
- **Divergence** = the diverging, or branching (via axon collaterals or branches), of a neuron's axon terminals, so that activity in this single neuron influences the activity of many other cells with which its terminals synapse.

SYNAPSE = the very small (microns) distance that separates two neurons; communication between the two neurons involves the release of a neurotransmitter chemical such as norepinephrine, acetylcholine, dopamine, serotonin, glutamate, or other neurotransmitter. The generation of an action potential in the presynaptic neuron will cause the release of a neurotransmitter (which is stored in vesicles) from the synaptic terminal of the presynaptic neuron. The neurotransmitter will cross the synapse and bind to protein receptors that reside in the cell membrane of the postsynaptic neuron. Binding of these receptors can modulate a change in the membrane potential of the postsynaptic neuron (it may stimulate the postsynaptic neuron and cause it to generate and action potential).

Divergence and convergence refer to the fact that the CNS is not linked together in a linear fashion, but rather in a network of billions of interconnected neurons.

BASIC ORGANIZATION OF THE NERVOUS SYSTEM

See table 13-1 in the text for a list of important terms to know with regard to the nervous system.
Be sure to review and know all of the terms in this table.
With regard to the generation of action potentials (electrical impulses), recall that these are caused by the movement of voltage gated ion channels for sodium (Na^+) and potassium (K^+) that reside in the cell membrane of neurons. There is a higher concentration of sodium ion outside the cell than inside the cell. There is a higher concentration of potassium ion inside the cell than outside the cell. Using these diffusion gradients and special protein channels, nerve cells can generate and conduct action potentials.
The nervous system includes all of the nervous tissue in the body made of neurons and the cells which support these neurons (glial cells).

central nervous system (CNS) = the neurons that make up the brain and spinal cord

peripheral nervous system (PNS) = all of the neurons outside of the CNS. The PNS is subdivided into afferent and efferent divisions.

afferent (sensory) division = carries sensory information to the CNS

efferent (motor) division = carries command messages from the CNS to effector organs (muscles, glands, etc.). The efferent division is divided into the somatic and autonomic systems.

somatic nervous system = controls all voluntary skeletal muscle contractions

autonomic nervous system (ANS) = regulates all of the smooth muscle, cardiac muscle, glandular activity and other responses that are under involuntary control. The autonomic system is divided into parasympathetic and sympathetic divisions.

sympathetic nervous system (SNS) = the "fight or flight" division of the ANS that is active when a person is exercising or in the active state.

parasympathetic nervous system (the PNS of the ANS) = the "rest and response" division of the ANS that is active when a person is at rest.

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Sensory organ = the organ which detects the stimulus

Sensory neurons = the unipolar neurons that carry information from the sensory organ through the dorsal root of the spinal nerve to the dorsal columns of the spinal cord; the cell bodies of the sensory neurons are found in the **dorsal root ganglia**

Interneurons = neurons that reside entirely in the CNS to communicate incoming sensory signals to motor neurons and other regions of the CNS (e.g. to the brain)

Motor neurons = multipolar neurons that carry information from the ventral side of the spinal cord out through the ventral roots to the spinal nerves to regulate the activity of motor effector organs; the cell bodies of the motor neurons are mostly found in the **anterior gray horn** of the spinal cord

Motor effector organ = the organ (e.g. muscle, gland) whose activity is regulated by a motor neuron