Chapter 11: Functional Organization of Nervous Tissue

I. Functions of the Nervous System

A. List and describe the five major nervous system functions:

1. _____
   _____
   _____
2. _____
   _____
   _____
3. _____
   _____
   _____
   _____
4. _____
   _____
   _____
5. _____
   _____
   _____

II. Divisions of the Nervous System

A. The Central Nervous System

1. What does the CNS consist of? _____ & _____
2. At what point are the two components of the CNS continuous? _____

B. The Peripheral Nervous System

1. What does the PNS consist of?
   a. _____
   b. _____
   c. _____
   d. _____
2. What are sensory receptors? _____ or _____

3. Where are sensory receptors located?
    a. _____
    b. _____
    c. _____
    d. _____
    e. _____
4. What is a nerve? _____
5. Where do cranial nerves originate? _____
    a. How many pairs of cranial nerves are there? _____
6. Where do spinal nerves originate? _____
    a. There are how many pairs of spinal nerves? _____
7. A ganglion is a _____
8. What is a plexus? _____
9. Functionally the sensory or afferent division _____
    a. The cell bodies of sensory neurons are located in:
        1. _____ or
        2. _____
10. Functionally the motor or efferent division _____
11. The motor division is divided into the:
    a. _____ &
    b. _____
12. What is a synapse? _____
13. The somatic nervous system transmits _____ from _____ to _____
    a. Is this voluntary or involuntary (subconscious) control? _____
14. The autonomic nervous system transmits _____ from _____ to _____, _____, and _____
    a. Is this voluntary or involuntary (subconscious) control? _____
15. The ANS is subdivided into the:
    a. _____
    b. _____

c. _____

16. Functionally the sympathetic division: _____
17. Functionally the parasympathetic division: _____

_____

18. The enteric nervous system consists of: _____
    a. Why is it considered to be part of the ANS? _____

_____

III. Cells of the Nervous System

A. Neurons

1. Functionally neurons or nerve cells _____
2. Structurally neurons are organized _____
3. Each neuron consists of a:
    a. _____ or _____
    b. And two types of processes:
        1. _____
        2. _____
4. Neuron Cell Body
    a. Contains normal cellular organelles including:
        1. Nucleus which is _____
        2. Extensive _____
        3. _____ apparatuses
        4. Moderate _____
        5. Randomly arranged _____ & _____
            a. These increase as _____
        6. Large numbers of _____ & _____
        7. What are Nissl bodies? _____
5. Dendrites
    a. Describe the structure of a dendrite _____

_____

    b. What are dendritic spines? _____

c. When stimulated dendrites _____

6. Axons
   a. Describe the structure of an axon hillock? _____
      1. What arises at the axon hillock? _____
   b. The beginning of an axon is called the _____
   c. Branches of an axon are called _____ or _____
   d. What is axoplasm? _____
   e. What is an axolemma? _____
   f. Enlarged structures on the terminal end of an axon are called _____ or _____
      1. These structures contain numerous _____
   g. Functionally neurotransmitters _____ _____
   h. What is a trigger zone and what does it do? _____ _____

B. Types of Neurons
   1. Functional classification is based on the direction of action potentials:
      a. Neurons that carry action potentials toward the CNS are _____
      b. Neurons that carry action potentials away from the CNS to muscles or glands are _____ or _____
      c. Neurons that carry action potentials within the CNS are _____ or _____
   2. Structural classification is based on the number of processes:
      a. Describe the structure of a multipolar neuron: _____ _____
         1. Where would you find multipolar neurons? _____
      b. Describe the structure of a bipolar neuron: _____ _____
         1. Where would you find bipolar neurons? _____
      c. Describe the structure of a unipolar neuron: _____ _____

1. Where would you find unipolar neurons? _____

C. Neuroglia of the CNS
   1. Astrocytes
      a. Astrocytes are-star shaped because _____
      b. What is a foot process? _____
      c. What do foot processes cover?
         1. _____
         2. _____
         3. _____
      d. The extensive cytoskeleton of microfilaments allow them to _____
         _____
      e. Functionally astrocytes play a role in _____
         1. What is the blood-brain barrier? _____
            _____
         2. Functionally the blood-brain barrier:
            a. Protects _____
            b. Allows _____
            c. Prevents _____
         3. Astrocytes also regulate the concentration of _____ & _____ and _____ & _____ neurotransmitters
   2. Ependymal Cells
      a. Where do you find ependymal cells? _____
      b. What is a choroid plexus composed of? _____
         1. Where would you find a choroid plexus? _____
      c. Functionally a choroid plexus? _____
      d. What do the cilia on ependymal cells do? _____
         _____
      e. What do the long processes of ependymal cells do? _____
         _____
   3. Microglia
      a. Functionally microglia are _____ in the CNS

b. In response to inflammation they become _____ & _____

4. Oligodendrocytes
   a. Oligodendrocytes have _____ that can _____ axons
   b. If they wrap around axons many times it forms _____
   c. One oligodendrocyte can form _____ axons

D. Neuroglia of the PNS
1. Schwann cells or neurolemmocytes _____ axons
   a. If they wrap around the axon many times it forms _____
   b. Each Schwann cell wraps around _____ axon
2. Where are satellite cells found? _____
   a. Functionally satellite cells _____

E. Myelinated and Unmyelinated Axons
1. Myelin _____ and _____ axons
2. Action potentials travel fastest in _____
3. Structurally how is a myelin sheath formed? _____

   _____

   _____
4. What is the myelin sheath composed of? _____
5. Interruptions in the myelin sheath are called _____
6. The myelinated segments are known as _____
7. How is an unmyelinated axon associated with an oligodendrocyte or a Schwann cell? _____

   _____

   _____

IV. Organization of Nervous Tissue

A. White matter is composed of _____
1. The white color is due to the presence of _____

B. Gray matter is composed of _____

C. What are nerve tracts? _____

D. Functionally the gray matter of the CNS _____

E. What is the cortex? _____

F. The nuclei are _____

G. Nerves of the PNS are composed of _____

H. Ganglia are _____

V. Electric Signals

A. Concentration Differences Across the Plasma Membrane

1. What ions have a higher concentration outside the cell than inside the cell?
   a. _____
   b. _____
2. What ions have a higher concentration inside the cell than outside the cell?
   a. _____
   b. _____ such as _____ & _____
3. There is a steep concentration gradient from outside to inside for _____
4. There is a steep concentration gradient from inside to outside for _____
5. Describe the actions of the sodium-potassium exchange pump: _____

   _____

   _____

   _____

   a. Is this a one for one ion exchange? _____
6. Negatively charged proteins are synthesized _____
   a. They cannot readily diffuse across the plasma membrane because of:
      1. _____ &
      2. _____
7. The negatively charged molecules inside the cell repel _____
   a. This causes an _____ of _____ outside the cell
8. Nongated Ion Channels (Leak Channels)
   a. These channels are always _____ and are responsible for the _____ when the cell is at rest
   b. Each ion channel is _____ for _____ of ion
   c. The membrane is more permeable to K^+ and Cl^- because _____

_____

9. Gated Ion Channels
    a. Open and close in response to _____
    b. Opening and closing changes the _____ of the membrane
    c. Ligand-gated ion channels open or close in response to _____

    _____
        1. What is a ligand? _____
        2. What is a receptor? _____
    d. What four substances do ligand-gated ion channels exist for?
        1. _____ 2. _____ 3. _____ 4. _____
    e. Voltage-gated ion channels open and close in response to _____

    _____
    f. What three substances do voltage-gated ion channels exist for?
        1. _____ 2. _____ 3. _____
    g. Other-gated ion channels respond to stimuli such as:
        1. _____ of the skin in touch receptors
        2. _____ changes in the skin

B. The Resting Membrane Potential
    1. What is the potential difference? _____
    2. In skeletal muscle fibers and nerve cells the potential difference is equal to

    _____
        a. Why is this reported as a negative number? _____
        b. What does “resting membrane potential” refer to? _____
    3. Establishing the Resting Membrane Potential
        a. The resting membrane potential results from the:
            1. Permeability _____ &
            2. Difference _____
        b. Why is the membrane permeable to K^+? _____

        _____
        c. Why do K^+ move through the membrane? _____
        d. What is too big to move through the membrane? _____

e. Together the movement of K^+ and the ions that do not move make the membrane _____ inside the cell and _____ outside the cell

f. Why is the resting membrane potential at equilibrium? _____

_____

g. What other ions have a small influence on the resting membrane potential? 1. _____ 2. _____ 3. _____

h. Why does K^+ play the major role? _____

_____

i. What mechanism keeps the concentration of Na^+ high outside the cell and the concentration of K^+ high inside the cell? _____

1. Does this play a role in the resting membrane potential? _____

C. Local Potentials

1. What is a local potential? _____
2. Local potentials can result from:
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
3. The change in the membrane may be depolarization or hyperpolarization:
   a. If a stimulus opens Na^+ channels _____
   b. If a stimulus opens K^+ channels _____
4. Why are local potentials referred to as "graded"? _____

_____

5. What happens when local potentials "summate"? _____

_____

6. What happens to the intensity of a local potential as it spreads? _____

_____

D. Action Potentials

1. What is a threshold level? _____

_____

2. An action potential is _____

_____

3. For each of the following indicate if they may generate an action potential:
   a. Depolarizing local potentials _____
   b. Hyperpolarizing local potentials _____
   c. Small local potentials _____
   d. Large local potentials _____
4. Describe what is meant by the "all" part of the all-or-none principle: _____

_____

5. Describe what is meant by the "none" part of the all-or-none principle: _____

_____

6. Depolarization Phase
   a. List the events that occur after a threshold depolarization is reached:
      1. Many _____
      2. Na^+ _____
      3. Resulting _____
      4. More _____
      5. Causing _____
      6. In turn _____
         a. This is a _____ feedback cycle that continues until

            _____
   b. When the plasma membrane is at rest:
      1. Which gate on the voltage-gated Na^+ channel is closed? _____
      2. Which gate on the voltage-gated Na^+ channel is open? _____
   c. When threshold is reached the _____ to open and allows _____ into the cell
   d. When the plasma membrane is at rest voltage-gated K^+ channels are

      _____
   e. When threshold is reached the voltage-gated K^+ channels begin to _____
      1. But because the channels open _____ little K^+ moves out of cell

7. Repolarization Phase
    a. List the events that occur at maximum depolarization:
        1. Change in _____
        2. Causes _____
            a. So the permeability _____
        3. Voltage-gated K^+ channels continue _____
        4. As a result the membrane permeability to:
            a. _____ decreases
            b. _____ increases
        5. The decreased diffusion of _____ and increased diffusion of _____ causes repolarization
    b. At the end of repolarization the voltage-gated Na^+ channels are returned to their resting state by:
        1. Closing _____
        2. Opening _____
8. Afterpotential (Hyperpolarization)
    a. What causes the afterpotential? _____
    _____
    b. All the action potentials produced by a cell are identical because they all:
        1. Take _____
        2. Exhibit _____

E. Refractory Period
1. What is the refractory period? _____
_____
2. The absolute refractory period is:
    a. From _____
    b. Until _____
3. The absolute refractory period guarantees that:
    a. Once an action potential is begun _____
    b. A strong stimulus cannot _____
4. The relative refractory period follows _____

5. During the relative refractory period an action potential can be initiated by

   _____

F. Action Potential Frequency
   1. The action potential frequency is _____
   2. How many action potentials will each of the following stimuli produce:
      a. Subthreshold stimulus _____
      b. Threshold stimulus _____
      c. Maximal stimulus _____
   3. Submaximal stimulus includes all stimuli between _____ & _____
   4. What is a supramaximal stimulus? _____
   5. What determines the maximum frequency of action potentials in a cell? _____

      _____
   6. Frequency of action potentials provides information about stimulus strength:
      a. A weak stimulus generates _____
      b. A strong stimulus generates _____
   7. Is there a difference in the magnitude of action potentials produced by weak or strong stimuli? _____
   8. Frequency of action potentials determines response of muscle or gland:
      a. Less secretion or contraction is stimulated by _____
      b. More secretion or contraction is stimulated by _____

G. Propagation of Action Potentials
   1. Propagate refers to the spread _____
      a. This is accomplished because an action potential at one location _____

         _____
   2. In an unmyelinated axon, when an action potential is produced:
      a. Inside of the membrane _____
      b. On the outside positively _____
      c. On the inside positively _____
         1. The movement of positively charged ions is called _____
         2. As a result of the ion movement the membrane immediately adjacent to the action potential is _____

a. When it reaches threshold an _____

3. In a myelinated axon, an action potential is conducted from _____ to _____ in a process called _____
   a. The lipids of the myelin sheath act as _____
   b. An action potential at one node of Ranvier generates local currents that _____
4. Action potentials travel faster in myelinated axons because:
   a. They are formed _____
   b. Instead of being _____
5. Does an action potential move faster through a large-diameter axon or a small-diameter axon? _____
6. Complete the following data table:

Nerve Fiber	Diameter	Myelination	Speed
Type A			
Type B			
Type C			

7. Type A fibers are used for _____
8. Type B and C fibers are used for _____

VI. The Synapse

A. Terminology
   1. What is a synapse? _____
   2. Define presynaptic cell: _____
   3. Define postsynaptic cell: _____

B. Electrical Synapses
   1. Electrical synapses are gap junctions that allow _____ _____
   2. What are connexons? _____
   3. Movement of ions through the connexons can _____
      a. Therefore an action potential in one cell _____

4. Where would you find electrical synapses?
    a. _____
    b. _____

C. Chemical Synapses
1. Describe the three essential components of a chemical synapse:
    a. Presynaptic terminal _____
    b. Synaptic cleft _____
    c. Postsynaptic membrane _____
        1. These are typically _____, _____, or _____
2. Neurotransmitter Release
    a. List the events that occur when an action potential arrives at the presynaptic terminal:
        1. Voltage-_____
        2. Ca^{2+} _____
        3. Synaptic vesicles _____
        4. Release _____
    b. When neurotransmitters are released:
        1. Diffuse _____
        2. Bind _____
    c. Depending on the receptor, the binding produces:
        1. _____ or
        2. _____
3. Neurotransmitter Removal
    a. There are three primary methods of removing neurotransmitter:
        1. Neurotransmitter is broken down by _____
            a. An example of this is acetylcholine being broken down by _____
        2. Neurotransmitter is actively transported _____ and repackaged into _____
        3. Diffusion of neurotransmitter molecules _____ and into _____

4. Receptor Molecules in Synapses
    a. Receptor molecules in synapses are:
        1. Membrane _____
        2. Ligand _____
        3. Highly _____
    b. How many different neurotransmitters can bind to one type of receptor? _____ Why? _____
    c. Neurotransmitters only affect cells _____
    d. Different types of receptors for the same neurotransmitter results in _____
        1. One type of norepinephrine receptor will cause _____
        2. Another type of norepinephrine receptor will cause _____
5. Neurotransmitters and Neuromodulators
    a. Some neurons can secrete more than one type of _____
        1. The physiological significance is _____
    b. What is the function of a neuromodulator? _____

6. Excitatory and Inhibitory Postsynaptic Potentials
    a. What is an excitatory postsynaptic potential? _____
    b. EPSP's are important because _____
    c. What is an excitatory neuron? _____
    d. Generally an EPSP occurs because of an increase _____
    e. What is an inhibitory postsynaptic potential? _____
    f. IPSP's are important because _____
    g. What is an inhibitory neuron? _____
    h. An IPSP occurs because of an increase _____

7. Presynaptic Inhibition and Facilitation
    a. What is an axoaxonic synapse? _____
    b. Neuromodulators released in an axoaxonic synapse can alter _____
    _____
    c. In presynaptic inhibition _____
    _____
    d. Functionally endorphins inhibit neurons by _____
        1. This prevents _____
    e. In presynaptic facilitation _____
    _____

D. Spatial and Temporal Summation
1. A single presynaptic action potential does not reach _____ and produce an _____ in the postsynaptic membrane.
2. What is summation? _____
_____
3. What is the trigger zone? _____
4. The concentration of Na^+ channels at the trigger zone is _____
5. Spatial summation occurs when two action potentials arrive _____ at _____ that synapse with _____
    a. The local depolarizations in the postsynaptic neuron summate at the _____ and if it reaches threshold _____
6. Temporal summation occurs when two or more action potentials arrive ____ _____ at a single presynaptic terminal
    a. Although local depolarizations are short lived if the action potentials arrive close enough together they can _____
    b. If the summated local depolarization reaches _____ at the _____ then _____ in the postsynaptic neuron
7. If a postsynaptic neuron is receiving EPSP's and IPSP's at the same time what determines if an action potential will be created in the postsynaptic neuron? _____
_____

VII. Neuronal Pathways and Circuits

A. In convergent pathways _____

1. If some presynaptic neurons are inhibitory and some are excitatory _____

   _____

B. In divergent pathways _____

1. Describe the simplest divergent pathway _____

   _____

C. Oscillating circuits have neurons arranged in _____

1. This allows _____
   a. This response is called _____
2. Oscillating circuits are similar to _____
3. What causes an oscillating circuit to stop?
   a. _____ or
   b. _____