Chapter 12: Nervous Tissue and Homeostasis
Read pages 403 to 434

NAME_____

Topic Outline And Objectives:

A. Overview and organization of the nervous system
1. Identify the three basic functions of the nervous system.
2. Organize the nervous system into two divisions (CNS and PNS)

B. Histology
3. Contrast neuron and nerve.

C. Electrical signals- the *nerve impulse*
4. Compare the basic types of ion channels and how they relate to action potentials.
5. Describe the factors that maintain a resting membrane potential.
6. List the sequence of events involved in the generation and conduction of a nerve impulse.

D. Signal transmission at synapses; neurotransmitters; the general components of a reflex arc
7. Define a synapse and list the factors involved in the conduction of a nerve impulse across a synapse.
8. Give examples of excitatory and inhibitory neurotransmitters and describe how they act.
9. Effects of drugs on the nervous system.
10. Explain the sequence of events involved in a reflex arc.

E. Clinical Applications

A Organization (pages 404 - 406)

A1. List three principal functions of the nervous system.

A2. Only one part of the structural organization of the nervous system is depicted in **Figure 12-1**. Identify that part by coloring its structures on the diagram **using green color**. Then, include (draw-in) the following *organs: heart, skin (sweat gland), and skeletal muscle*. Draw-in and color-code the other subdivision of the nervous system.
*Use **blue lines** to represent the **Sensory (afferent)** and **red lines** to represent the **Motor (efferent)** division.
*Use **arrows** to indicate the direction of the nerve impulses. **See Figure 12.2, page 406 for extra help!**

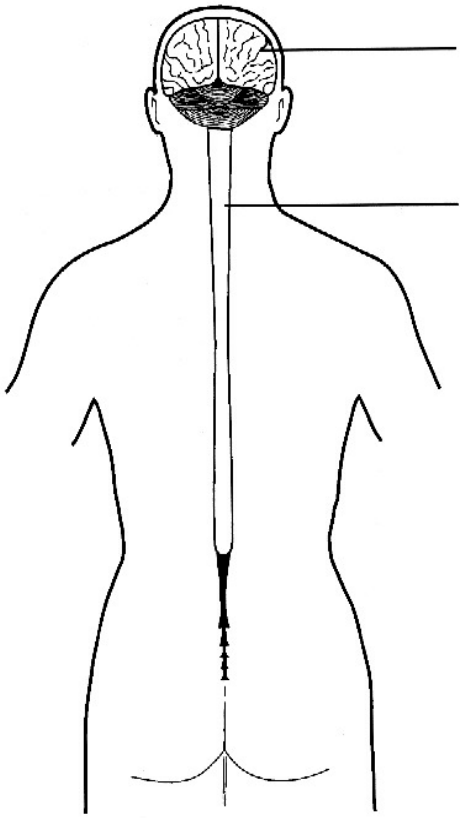


Figure 12-1

A3. Check your understanding of organization of the nervous system by selecting answers that best fit descriptions below. Hey! More than one answer may apply.

Aff. Afferent	**Eff.** Efferent
ANS. Autonomic nervous system	**PNS**. Peripheral nervous system
CNS. Central nervous system	**SNS.** Somatic nervous system
ENS. Enteric nervous system	

_____a. Brain and spinal cord

_____b. Carry information from CNS to skeletal muscles.

_____c. Consists of *sympathethic* and *parasympathetic* divisions.

_____d. Carry information from CNS to smooth muscles of the GI tract.

_____e. Sensory nerves

B. Histology (pages 406 – 414)

B1. On **Figure 12-2**, label all structures with header lines. Next draw arrows beside the figure to indicate direction of nerve impulses. Then, **color structures** with color code ovals.

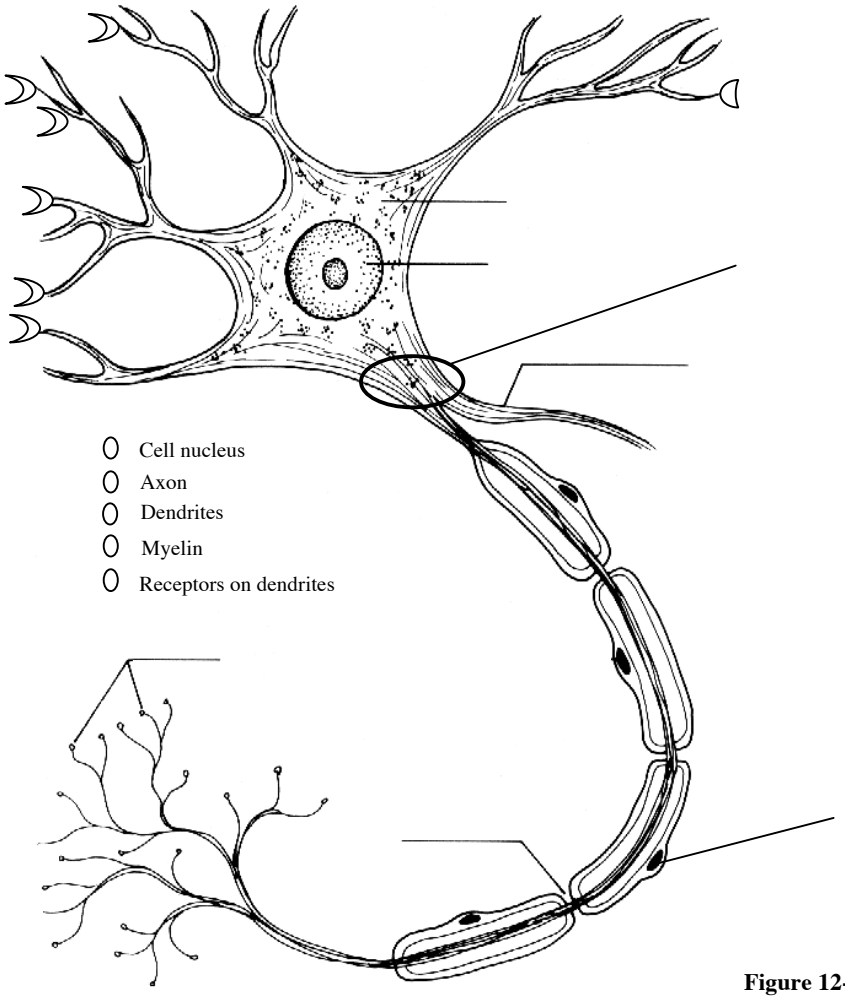


Figure 12-2

B2. Identify phrases that describe a ***neuron*** and those that describe a ***nerve***.

a. A single nerve cell; consists of a cell body with axon and dendrites: _____.

b. Bundle of axons and dendrites of many neurons, both afferent and efferent, somatic and autonomic; contains no cell bodies:_____.

B3. Using the list in the box, identify the type of nerve fiber that transmits each of the kinds of nerve impulses listed. Some may be used more than once!

SA. Somatic afferent	**VA**. Visceral afferent
SE. Somatic efferent	**VE**. Visceral efferent

_____ a. All ANS fibers are of this type.

_____ b. Pain from a thorn in your skin is sensed via fibers of this type.

_____ c. Pain from a spasm of smooth muscle in the gallbladder is sensed by means of fibers of this type.

_____ d. With your eyes closed, you can tell the position of your skeletal muscles and joints due to nerve impulses that pass along this type of fiber.

_____ e. In order to increase your heart rate, impulses pass from your brain to your heart via this type of nerve fiber.

_____ f. These nerve fibers carry impulses from the CNS to muscles in yo' fingers used in writing.

C. Electrical signals in neurons – nerve impulses (pages (414 – 424)

C1. Complete **Figure 12-3** on the next page describe the two principal factors contributing to RMP.

a. Note that one ion is 14x more concentrated outside the nerve cell; this is *(K^+? Na^+?)*.

b. Potassium is _____X more concentrated *(outside? inside?)* the neuron.

c. Now label the major cations in each site. Also label the major anion inside the neuron. **(Values for all of these ions are shown graphically in Figure 27-6, page 1042 in the text).**

d. Color large arrows across membranes using color code ovals to indicate types of transport process for each ion. **(Differences in thickness of arrows indicate relative permeability.)**

e. The inside of a resting membrane is more *(positive? negative?)* than the outside.

f. Explain why based on **Figure 12-3**. (Give 3 reasons)

g. Since a difference in electrical charge exists between inside and outside of the neuron, the resting cell membrane is said to be *(polarized? depolarized?)*.

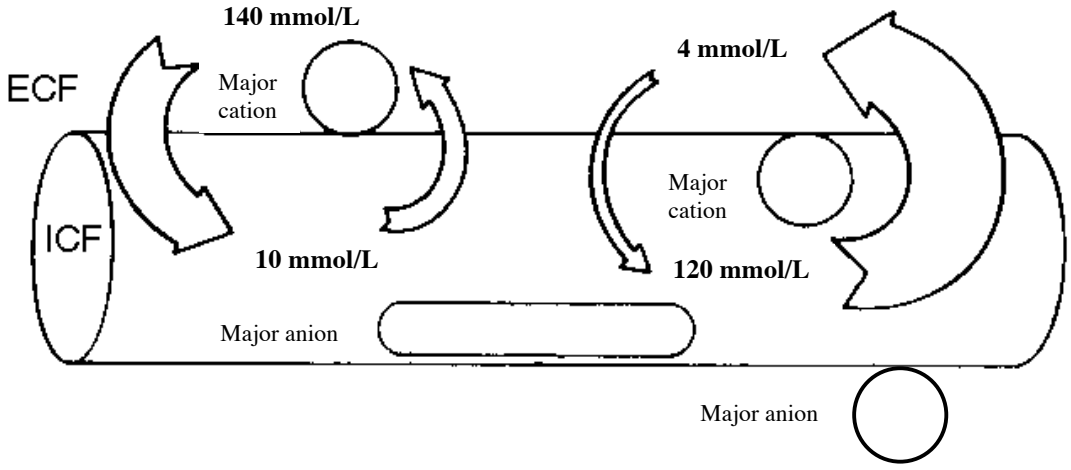
h. This difference in charge (between inside and outside of the membrane) is said to be the

membrane _____. This value is _____ millivolts (mV) in a resting membrane.

◯ **Diffusion**

◯ **Active Transport: "The Na^+/K^+ Pump"**

Figure 12-3: A Resting Neuron (–70mV)



C2. Check your understanding of how a nerve impulse occurs in this exercise.

a. A stimulus causes the nerve cell membrane to become (more? less?) permeable to Na^+.

Na^+ can enter the cell as voltage-sensitive Na^+ _____ become activated and open.

b. At rest, the membrane had a potential of _____ mV. As Na^+ enters the cell, the inside of the membrane becomes more *(positive? negative?)*. The potential will tend to go towards *(-80? –60?)* mV. The process of *(polarization? depolarization?)* is occurring. This process causes structural changes in more Na+ channels so that even more Na^+ enters. This is an example of

(positive? negative?) feedback mechanism. The result is a nerve impulse or *action* _____.

c. The membrane is completely depolarized at exactly *(-50? 0? +30?)* mV. Na^+ channels stay open until inside of the membrane potential is *(reversed? repolarized?)* at **+30 mV**.

d. The nerve impulse is essentially a wave of negativity along the *(inside? oustide?)* of the cell

membrane. The impulse is propagated (or _____) along the nerve, as adjacent areas are depolarized, causing more channels to be activated and more (*Na^+? K^+?*) to enter.

e. After a fraction of a second, K^+ voltage-sensitive channels <u>at the site of the original stimulus</u> become activated and open. K^+ is more concentrated *(outside? inside?)* the cell **(as you showed on Figure 12-3)**; therefore, K^+ diffuses *(in? out?)*. This causes the inside of the membrane to become

more negative and return to its resting potential of _____ mV. The process is known as *(de? re?)* –polarization.

f. During depolarization, the nerve cannot be stimulated at all. This period is known as the *(absolute? relative?)* refractory period. <u>Only stronger-than-normal stimulus</u> will result in an action

potential during the _____ refractory period, which corresponds roughly with (de? re?)-polarization.

C2 is continued on next page

g. Depolarization and repolarization can occur *(only one time? thousands of times?)* before sufficient Na^+ and K^+ have shifted across the neuron cell membrane so as to interfere with continued nerve impulse formation. When that does finally occur, then Na^+ and K^+ are returned to their original

sites. This occurs by an (*active? passive?*) process known as the _____ pump.

(see figure 12-3)

h. What affect do anesthetics such as procaine (Novocaine) have on action potentials? Discuss how this blocks pain.

C3. Write a correct letter label in **Figure 12-4** next to each description below. (One is used twice).

_____a The stimulus is applied at this point.

_____b. Resting membrane potential is at this level.

_____c. Membrane becomes so permeable to K^+ that K^+ diffuses rapidly out of the cell.

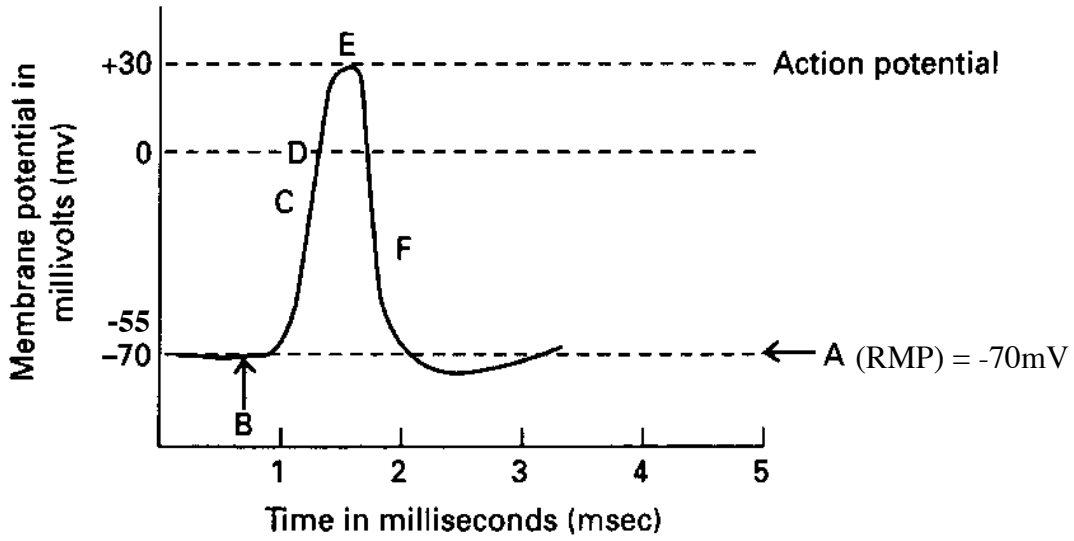
_____d. The membrane is becoming more positive inside as Na+ enters; its potential is +30mV. The process of depolarization is occurring.

_____e. The membrane is completely depolarized at this point.

_____f. The membrane is repolarizing at this point. The cell is said to be in "refractory".

_____g. Reversed polarization occurs; enough Na^+ has entered so that this part of the cell is more positive inside than outside.

Figure 12-4



C4. Define these terms.

a. Threshold stimulus (give a value in mV with your definition)

b. All-or-none principle.

D. Signal transmission at synapses; neurotransmitters; circuits (pages 424 – 432)

D1. In chapter 10, you studied the point at which a neuron comes close to contacting a muscle. This is known as a _____ junction, shown in **Figure 10-10, page 303**. The small space between two neurons is known as a _____, which is quite similar in structure to a neuromuscular junction.

a. Does a nerve impulse actually "jump" across the space between two neurons? Explain briefly.

D2. Write these structures in order to show the pathway of transmission at a chemical synapse.

EB. End bulb of presynaptic neuron receives a nerve impulse	
SC. Into Synaptic cleft	**SV.** Synaptic vesicles fuse with membrane
N. Release of neurotransmitter	**R.** Removal of neurotransmitter
NR. Neurotransmitter binds to receptors on postsynaptic neuron	

_____ → _____ → _____ → _____ → _____ → _____

First Last

D3. Complete the following exercise on neurotransmission

a. A transmitter-receptor interaction refers to the effect that a certain chemical (neurotransmitter) has upon the receptors of the _____-synaptic neuron.

b. An excitatory interaction *(raises? lowers?)* the –70 mV resting potential of the postsynaptic neuron for example, to –65 mV. Such a potential is called an **EPSP** which stands for

_____.

c. EPSP's result primarily from inflow of (Na^+? K^+? Cl^-?) through chemically-gated channels.

D4. Name two neurotransmitters that cause **EPSP**.

D5. Complete the following exercise on neurotransmission

a. A transmitter-receptor interaction refers to the effect that a certain chemical (neurotransmitter) has upon the receptors of the _____-synaptic neuron.

b. If a neurotransmitter causes inhibition of a postsynaptic neuron, the process is known as *(de? hyper?) – polarization*, and the PSP is *(excitatory? inhibitory?)*. IPSP's often result from influx of (Na^+? K^+? Cl^-?) and/or outflow of (Na^+? K^+? Cl^-?) through chemically-gated ions channels.

c. An inhibitory interaction *(raises? lowers?)* the –70 mV resting potential of the postsynaptic neuron for example, to –80 to –90 mV. Such a potential is called an **IPSP** which stands for

_____.

d. In other words, a neuron with an IPSP is *(closer? farther?)* from threshold than a neuron at resting membrane potential (RMP), so a cell with an IPSP is less likely to have an action potential.

D6. Name two neurotransmitters that cause **IPSP**.

D7. *A clinical correlation*. Once a neurotransmitter completes its job, it must be removed from the synaptic cleft. Describe two mechanisms for getting rid of these chemicals. Notice the consequences of alterations of these mechanisms.

a. Inactivation of a neurotransmitter may occur, such as breakdown of _____ (*hint: ACh*) by the enzyme named _____ . Certain drugs (such as nerve gas) destroy enzymes, so postsynaptic neurons (or muscles) *(remain? are less?)* activated. Predict the effects of such a drug.

b. A neurotransmitter such as norepinephrine (NE) can be removed from the synapse by a different mechanism. Describe this method.

c. Explain how the anti-depressant ***Prozac*** alters transmission at synapses.

D8. Contrast the effects of dopamine with respect to *Parkinson's disease* and *schizophrenia*.

D9. Check your understanding of chemicals that affect transmission at synapses and neuromuscular junctions by completing this activity. Write **E** if the effect is **excitatory** or **I** if the effect is **inhibitory**. (Lines following descriptions are for the *clinical challenge* activity below.)

_____ a**.** A chemical that inhibits release of Ach __3___

_____ b. A chemical that competes for the Ach receptor site on muscle cells _____

_____ c. A chemical that de-activates acetylcholinesterase _____

_____ d. A chemical that increases threshold (for example, from –55mV to –30mV) of a neuron ____

_____ e. A chemical that decreases threshold (for example, from –55mV to –65mV) of a neuron ____

_____ f. A bacteria which interferes with inhibitory mechanisms; the excitatory input remains unchecked. Results in involuntary skeletal muscle contraction. _____

A clinical challenge: Match the following chemicals with related mechanisms of actions. Write the number of the chemicals on lines to the right of the above descriptions. One is done for you.

1. **Hypnotics, tranquilizers, anesthetics**
2. **Caffeine, Benzedrine, Dexadrine (speed)**
3. **Botulism toxin, inhibiting muscle contraction**
4. **Curare, a muscle relaxant**
5. **Nerve gas such as di-isopropyl fluorophosphate**
6. **Tetanus "Lockjaw"**

D10. *A clinical challenge:* Crack, a form of _____, (*enhances? interferes with?)*

"uptake pumps" of certain a neurotransmitter, such as _____. This drug creates a short-term feeling of euphoria since the neurotransmitters continues to remain in the cleft.

Long-term effects include depression related to eventual *(excesses? depletion?)* of the body's natural neurotransmitter production.

D11. Answer these questions about *opioid peptides* such as *enkephalins*. (see page 430 in your text)
a. Briefly explain the relationship between these chemicals and acupuncture.

b. Besides serving as painkillers, *enkephalins* have several other functions. **List four** of these functions.

General Components of a reflex arc (See Chapter 13, Fig. 13.13, pages 460 - 461)
D12. Refer to **Figure 12-5** on the next page, showing a reflex arc, as you complete the following exercise.

First, briefly answer the following questions by writing your answers in the blanks below.

1. What is the stimulus? _____

2. What tissue is the effector? _____

3. How many synapses occur in this reflex arc? _____

Second, select <u>different colors</u> for each of the following structures, and use them to color the diagram.

Finally, <u>draw arrows</u> on the figure indicating the direction of impulse transmission through this reflex pathway.

◯ **Receptor region** ◯ **Interneuron**

◯ **Sensory neuron** ◯ **Motor neuron**

◯ **Spinal cord** ◯ **Effector**

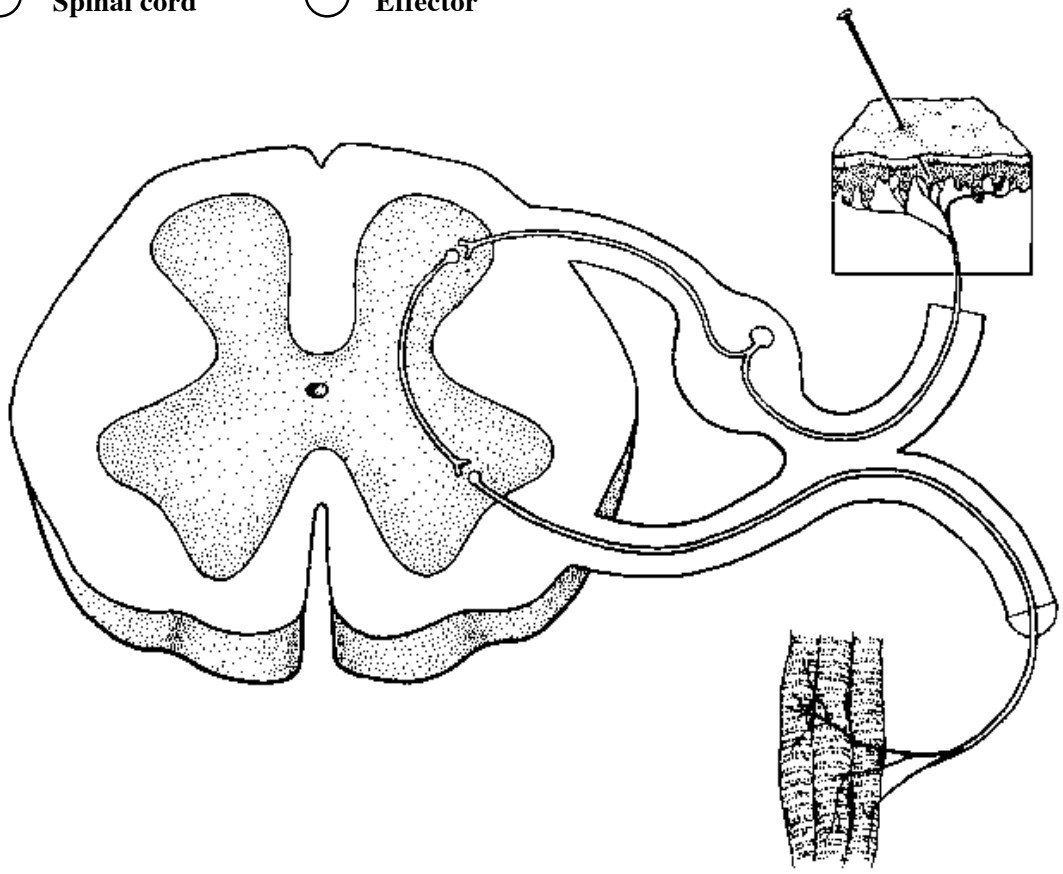


Figure 12-5

E. Clinical Applications: Complete thought PLEASE!

1. Being a long-time herpes virus sufferer, Brad was not surprised to learn (at a herpes information session) that herpes viruses tend to "hide out" in a nerve tissue to avoid attack by the body's immune system. However, their mode of travel in the body did surprise him. How do herpes viruses travel to the neuron's cell body?

2. With what specific process does the lack of myelination seen in *multiple sclerosis*(MS) interfere?

3. Sally has been diagnosed as having a certain type of epilepsy associated with a lack of GABA. Why would this deficiency lead to the increase and uncontrolled neuron activity exhibited by Sally's seizures?

4. Mr. Jacobson, a tax accountant, comes to the clinic complaining of feeling very "stressed out" and anxious. He admits to drinking 10 to 12 cups of coffee daily. His doctor (knowing that caffeine alters the threshold of neurons) suggests that he reduce his intake of coffee. What is caffeine's effect on the threshold of neurons, and how might this effect explain Mr. Jacobson's symptoms?

5. Mr. Morgan staggered home after a "good night" at the local pub. While attempting to navigate the stairs, he passed out cold and lay (all night) with his right armpit straddling the staircase banister. When we awoke him the next day, he had a severe headache, but what bothered him more was that he had no sensation in his right arm and hand, which also appeared to be paralyzed. Explain.

6. Neurotransmitter remains in the synaptic cleft only briefly because it is removed by enzymes or other mechanisms. If the mechanism for removal of neurotransmitter is impaired, will the postsynaptic cell remain excitatory? Explain.

7. Shortly after birth, no new neurons are formed. This being the case, how can the enhancement of certain pathways, such as those promoting more acute hearing in blind people, develop?

Essay Questions for Chapter 12:

1. Draw, label and describe the events that take place in the excitatory transmission across a synapse. Show the events that take place between a pre and post-synaptic neuron. Mention the neurotransmitter and ions that might be involved. *Be sure to use appropriate terminology in your discussion. i.e. include the anatomical(parts) and the physiology(how it works).

2. Draw and describe the chemical changes that take place as a nerve impulse moves along a neuron. Be sure to discuss Na^+ & K^+ with respect to ICF & ECF, also depolarization, repolarization, and relative mV.

3. The venom of most scorpions and many insecticides act by causing Na^+ channels to remain open and by blocking the K^+ channels. What effects would such venoms have on the duration(time/length) of an action potential? Would its amplitude (mV) be changed significantly?
* Please support your response with a diagram of this action potential.
* Refer to the characteristics of this action potential in your discussion.

4. List 3 ways in which chemical synaptic transmission (in the synaptic junction) may be modified.
Also, explain how the following synaptic modifiers work, and what their effects are.

Nerve gas **Botulism toxin**
Morphine/Heroin **Strychnine poisoning**
Methamphetamine