LESSON ASSIGNMENT

LESSON 6
Review of the Autonomic Nervous System.

TEXT ASSIGNMENT
Paragraphs 6-1 through 6-12.

LESSON OBJECTIVES
6-1. From a list, select the names of the two major divisions of the human nervous system.
6-2. From a list, select the names of the two divisions of the peripheral nervous system.
6-3. Given a group of statements, select the statement that best describes the autonomic nervous system.
6-4. Given a list, select the names of the two divisions of the autonomic nervous system.
6-5. Given a group of statements, select the statement that best describes the sympathetic nervous system.
6-6. Given a group of that best describes the statements, select the statement parasympathetic nervous system.
6-7. Given a group of statements, select the statement that best describes the physiology of the sympathetic nervous system.
6-8. Given a list of chemical substances, select the neurotransmitters of the sympathetic nervous system.
6-9. Given a group of statements and the name of one of the types of receptor sites of the sympathetic nervous system (alpha or beta), select the physiological effect produced by the stimulation of that receptor.
6-10. Given the name of a part of the body and a group of effects, select the effect produced on that part of the body by the sympathetic nervous system.
6-11. Given a group of statements, select the statement that best describes the physiology of the parasympathetic nervous system.

6-12. Given a list of chemical substances, select the chemical transmitter of the parasympathetic nervous system.

6-13. Given the name of a part of the body and a group of effects, select the effect produced on that part by the parasympathetic nervous system.

SUGGESTION
After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.
LESSON 6

REVIEW OF THE AUTONOMIC NERVOUS SYSTEM

Section I. INTRODUCTION

6-1. BACKGROUND

a. At some time in your life, you have faced a situation in which you have undergone a real scare. For example, have you ever been walking down a dark street at night and heard someone running toward you from behind? At that time, certain physiological changes took place in your body. Many of these changes directly involved the autonomic nervous system.

b. The autonomic nervous system (ANS) with its ability to make rapid internal adjustments is one of the most important systems present in the body in terms of the maintenance of body balance. The autonomic nervous system is very complex. Almost every organ of the body receives some type of effect produced by the autonomic nervous system.

c. Because of the wide distribution of the autonomic nervous system, many drugs produce definite effects upon it. This can occur as a blockade of natural activity or a direct effect mimicking natural stimulation. Many so-called side effects of drugs can also be traced to interference with normal autonomic function. Therefore, you must have an understanding of how the autonomic nervous system works and how various drugs can affect its operation. Many drugs used routinely and in emergencies are classified as autonomic nervous system drugs.

6-2. REVIEW OF THE HUMAN NERVOUS SYSTEM

a. The nervous system is divided into two major divisions--the central nervous system and the peripheral nervous system. As you will recall, the central nervous system is composed of the brain and spinal cord. The peripheral nervous system includes the parts of the nervous system other than the brain and spinal cord. Figure 6-1 illustrates the division of the human nervous system.

b. The peripheral nervous system has two divisions: the somatic nervous system and the autonomic nervous system. Figure 6-2 illustrates this division.

(1) Somatic nervous system. The somatic nervous system innervates skeletal muscle. It is under voluntary control and contains no ganglia. Acetylcholine is the chemical transmitter in the somatic nervous system (see lesson 2 of this subcourse).
(2) Autonomic nervous system. The autonomic nervous system is involuntary. It innervates smooth muscles, cardiac muscles, and gland cells. The autonomic nervous system aids the body in the fight or flight response.

Section II. THE AUTONOMIC NERVOUS SYSTEM

6-3. INTRODUCTION

As was previously mentioned, the autonomic nervous system is one part of the peripheral nervous system. The autonomic nervous system is involuntary. It innervates smooth muscles, cardiac muscles, and gland cells. It aids the body in the fight or flight response. The autonomic nervous system helps to control urinary output, sweating, body temperature, arterial pressure, and gastrointestinal motility and secretion.

6-4. CONTROL OF THE AUTONOMIC NERVOUS SYSTEM

Centers located in the brain stem, hypothalamus, and spinal cord activate the autonomic nervous system.
6-5. ORGANIZATION OF THE AUTONOMIC NERVOUS SYSTEM

The autonomic nervous system is divided into two divisions: the sympathetic and the parasympathetic. Figure 6-3 illustrates this division.

![Diagram of the autonomic nervous system]

- **Sympathetic Nervous System.** The sympathetic nervous system is frequently referred to as the adrenergic nervous system. Because of its transmitter epinephrine, which is more commonly known by its trade name "Adrenalin," it prepares the body for stress situations. Stimulation of the adrenergic nervous system has the general effect of expending energy. When a person is scared, this system prepares the body for the fight or flight response. In other words, it prepares the body to either fight or run. More information on this important system will be provided later in this lesson.

- **Parasympathetic Nervous System.** The parasympathetic nervous system is usually referred to as the cholinergic nervous system. The cholinergic nervous system is responsible for bringing the body back to normal after the fight or flight response. The effects of the cholinergic nervous system are generally the opposite of those produced by the adrenergic nervous system. More information on the cholinergic nervous system will be provided later in this lesson.

Section III. THE SYMPATHETIC NERVOUS SYSTEM

6-6. INTRODUCTION TO THE SYMPATHETIC NERVOUS SYSTEM

You have already been told that the sympathetic nervous system is one component of the autonomic nervous system. Although this system is essential for a person in normal living, it is not crucial for a person to have this system if that individual is in a controlled environment (no stress, excitement, change in temperature, and so forth). Without the presence of this system, one's temperature would not adjust to the environmental temperature, one's level of blood glucose would not increase during times of stress, and one's resistance to fatigue would decrease.
6-7. PHYSIOLOGY OF THE SYMPATHETIC NERVOUS SYSTEM

a. The sympathetic nervous system (figure 6-4) is stimulated by the hypothalamus. The nerves of the sympathetic nervous system arise from the thoracolumbar section of the spinal cord. These nerves have short postganglionic fibers. These fibers synapse in the sympathetic chain ganglia that lie near the spinal cord. A ganglion is a joining of nerve fibers. Following synapse, the impulses travel down long postganglionic fibers and synapse at the effector organ.

b. The neurotransmitter at the preganglionic synapse is acetylcholine, while the neurotransmitters at the effector organ are norepinephrine and epinephrine. Norepinephrine and epinephrine are released by the adrenal medulla and circulate in the blood. Norepinephrine is also released by the postganglionic adrenergic neuron. The enzymes, catechol-o-methyltransferase (COMT) and monoamine oxidase (MAO) terminate transmission.

c. Circulating epinephrine and norepinephrine are destroyed by COMT. The norepinephrine, which is released by the neuron, is either reabsorbed by the neuron or destroyed in the synapse by MAO.

Figure 6-4. Sympathetic nervous system.
6-8. ALPHA AND BETA RECEPTOR SITES

It has been found that different effector organs have either alpha or beta predominant receptor sites.

a. Alpha Receptors. Alpha-receptors are associated mainly with increased contractibility of vascular smooth muscle and intestinal relaxation. Alpha-receptors have been classified into two types.

   (1) **Alpha\textsubscript{1}**. Alpha\textsubscript{1} receptors are located at the postsynaptic effector sites to stimulate transmitter release in smooth muscle (that is, contracts smooth muscle of peripheral blood vessels.

   (2) **Alpha\textsubscript{2}**. Alpha\textsubscript{2} receptors are located presynaptic on axon terminals to inhibit release of transmitter (norepinephrine). These predominate in the intestinal tract to cause relaxation.

b. Beta Receptors. Beta-receptors are associated with vasodilation and relaxation of nonintestinal smooth muscle and cardiac stimulation. Beta-receptors are divided into two types (example: bronchial dilation).

   (1) **Beta\textsubscript{1}**. Beta\textsubscript{1} receptors cause cardiac stimulation and lipolysis.

   (2) **Beta\textsubscript{2}**. Beta\textsubscript{2} receptors cause bronchodilatation, relaxation of blood vessels (usually skeletal muscles), and muscle glycogenolysis.

6-9. EFFECTS PRODUCED BY THE SYMPATHETIC NERVOUS SYSTEM

The sympathetic nervous system produces a variety of physiological effects upon the body. Listed below are some of these effects/responses:

a. Eye (Pupil). Mydriasis (dilation) of the pupil is produced by alpha stimulation.

b. Heart. Both an increase in heart rate and an increase in the contraction strength of the heart are produced by beta stimulation.

c. Bronchi. Relaxation of the bronchial muscle is produced by beta\textsubscript{2} stimulation.

d. Blood Vessels.

   (1) Blood vessels in skeletal muscle. Constriction or dilation is produced--over the usual concentration range of physiologically released and circulating epinephrine, the beta-receptor response (vasodilation) predominates in blood vessels of skeletal muscle and liver. The alpha-receptor response (vasoconstriction) is obtained in blood vessels of other abdominal organs.
(2) Blood vessels in the skin and mucous membranes. Constriction is produced by alpha stimulation.

e. Salivary Glands. Thick and viscous secretions are produced by alpha stimulation.

f. Stomach. The motility and tone of the stomach muscle is usually decreased (alpha\textsubscript{2} and beta\textsubscript{2} stimulation) and the stomach sphincters are contracted (alpha stimulation).

g. Intestines. The motility and tone of the intestinal muscles are decreased (alpha\textsubscript{2} and beta\textsubscript{2} stimulation) and secretions are inhibited.

h. Urinary Bladder. The wall of the bladder is usually relaxed (beta stimulation) and the sphincter of the bladder is contracted (alpha stimulation) by stimulation from the sympathetic nervous system.

Section IV. THE PARASYMPATHETIC NERVOUS SYSTEM

6-10. INTRODUCTION TO THE PARASYMPATHETIC NERVOUS SYSTEM

You have already been told that the parasympathetic nervous system is one component of the autonomic nervous system. The parasympathetic nervous system (also referred to as the cholinergic nervous system) is responsible for bringing the body back to normal after the fight or flight response. The effects of the cholinergic nervous system are generally the opposite of those produced by the sympathetic (adrenergic) nervous system. The parasympathetic nervous system is responsible for maintaining the daily functions performed within the body. This division of the autonomic nervous system serves to conserve energy—it is necessary for life. Without the presence of this nervous system, the absorption of necessary nutrients would be hindered, gastrointestinal motility would be decreased, gastrointestinal secretions would be increased, and the urinary bladder and rectum would fail to empty.

6-11. PHYSIOLOGY OF THE PARASYMPATHETIC NERVOUS SYSTEM

a. The parasympathetic nervous system is stimulated by the hypothalamus. It has long preganglionic fibers and short postganglionic fibers (Figure 6-5). The short postganglionic fibers are usually located within the effector organ.

b. The chemical transmitter at both the preganglionic synapse and at the effector organ is acetylcholine. As mentioned previously, acetylcholine is also the transmitter at skeletal muscle for the somatic nervous system; however, the receptors for the two nervous systems are different. Transmission of impulses is terminated by the destruction of acetylcholine by the enzyme acetylcholinesterase. Acetylcholinesterase is frequently referred to as cholinesterase. The general effects of parasympathetic stimulation are conservation and restoration of energy.
c. The parasympathetic nervous system does not have alpha and beta receptor sites.

6-12. EFFECTS PRODUCED BY THE PARASYMPATHETIC NERVOUS SYSTEM

The parasympathetic physiological activity on the organs is generally the opposite of the sympathetic with a few exceptions. The effect of the parasympathetic nervous system effects on some areas of the body are listed below:

a. **Eye (Pupil).** Contraction of the pupil (miosis) is produced by parasympathetic stimulation.

b. **Heart.** The parasympathetic nervous system produces a decrease in heart rate and a slight decrease in the contraction strength of the heart.

c. **Bronchi.** The bronchi are contracted by parasympathetic stimulation.

d. **Salivary Glands.** Parasympathetic nervous system stimulation of the salivary glands leads to profuse, watery secretions.

e. **Stomach.** Parasympathetic stimulation of the stomach leads to increased motility and tone and relaxed (usually) sphincters.

f. **Intestines.** Increased intestinal motility and tone and stimulated secretion of intestinal fluids are products of parasympathetic stimulation.

g. **Urinary Bladder.** Parasympathetic stimulation causes contraction of the bladder wall and relaxation of the sphincter.
Figure 6-5. The parasympathetic nervous system.

Continue with Exercises

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EXERCISES, LESSON 6

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes the incomplete statement.

After you have completed all the exercises, turn to “Solutions to Exercises” at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. What are the two major divisions of the human nervous system?
   a. The central nervous system and the somatic nervous system.
   b. The central nervous system and the peripheral nervous system.
   c. The central nervous system and the autonomic nervous system.
   d. The central nervous system and the parasympathetic nervous system.

2. What are the two divisions of the peripheral nervous system?
   a. The central nervous system and the somatic nervous system.
   b. The autonomic nervous system and the parasympathetic nervous system.
   c. The somatic nervous system and the autonomic nervous system.

3. The autonomic nervous system is best described as:
   a. The part of the peripheral nervous system that is under voluntary control.
   b. The part of the peripheral nervous system that innervates skeletal muscle and which has acetylcholine as the chemical transmitter.
   c. The part of the peripheral nervous system that is involuntary and innervates smooth muscles, cardiac muscles, and gland cells.
   d. The part of the peripheral nervous system that is involuntary and is frequently referred to as the adrenergic nervous system.
4. Which of the following statements best describes the sympathetic nervous system?
   a. The component of the autonomic nervous system that has acetylcholine as its primary transmitter.
   b. The component of the autonomic nervous system that has epinephrine as its chemical transmitter.
   c. The component of the autonomic nervous system which is responsible for bringing the body back to normal after the fight or flight response.
   d. The component of the autonomic nervous system which is not crucial for a person to have if they live in a controlled environment (no stress).

5. The parasympathetic nervous system is best described as the component of the autonomic nervous system which:
   a. Has acetylcholinesterase as its chemical transmitter.
   b. Has epinephrine as its chemical transmitter.
   c. Is not crucial for a person to have if he/she lives in a controlled environment (no stress).
   d. Is responsible for bringing the body back to normal after the fight or flight response.

6. The neurotransmitter of the sympathetic nervous system at the preganglionic synapse is ________________ while the neurotransmitters at the effector organ are ________________ and _________________.
   a. Epinephrine, norepinephrine, and acetylcholine.
   b. Acetylcholine, norepinephrine, and epinephrine.
   c. Epinephrine, acetylcholine, and acetylcholinesterase.
   d. Acetylcholine, catechol-o-methyltransferase, and monoamine oxidase.
7. Stimulation of beta-receptor sites results in:
   a. Vasodilation and relaxation of nonintestinal smooth muscle and cardiac stimulation.
   b. Increased contractility of vascular smooth muscle and intestinal relaxation.
   c. Contraction of smooth muscle.
   d. Vasocontraction of vascular smooth muscle.

8. Select the effect produced on the eye by the sympathetic nervous system.
   a. Mydriasis (dilation) of the pupil.
   b. Miosis (contraction) of the pupil.

9. Select the effect produced on the eye by parasympathetic stimulation.
   a. Mydriasis (dilation) of the pupil.
   b. Miosis (contraction) of the pupil.

10. Parasympathetic stimulation of the salivary glands leads to:
    a. Profuse, watery secretions.
    b. Thick and viscous secretions.
    c. None of the above.

11. Sympathetic stimulation of the intestines results in:
    a. Decreased motility and tone of the muscles.
    b. Increased motility and tone of the muscles.
    c. None of the above.
12. The chemical transmitter of the parasympathetic nervous system is:
   a. Epinephrine.
   b. Norepinephrine.
   c. Acetylcholinesterase.
   d. Acetylcholine.

13. Parasympathetic stimulation of the heart results in: (more than one response can be correct)
   a. Increased heart rate.
   b. Decreased heart rate.
   c. Increased contraction strength.
   d. Decreased contraction strength.

Check Your Answers on Next Page
SOLUTIONS TO EXERCISES, LESSON 6

1. b  (para 6-2a)
2. c  (para 6-2b)
3. c  (para 6-2b(2))
4. b  (para 6-5a)
5. d  (para 6-5b)
6. b  (para 6-7b)
7. a  (para 6-8b)
8. a  (para 6-9a)
9. b  (para 6-12a)
10. a (para 6-12d)
11. a (para 6-9g)
12. d  (para 6-llb)
13. b  (para 6-12b)
   d  (para 6-12b)

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