

## **A&P II**

### **Autonomic Nervous System and Endocrine System**

#### **PART I: Autonomic Nervous System**

##### **Introduction**

The autonomic nervous system (ANS) is the first physiological control system that we will study. Its activities complement, and sometimes control, the activities of the endocrine system. In general, the ANS provides rapid onset, short duration control while the control exerted by the endocrine system has a slower onset and longer duration.

The ANS is composed of two divisions, the parasympathetic and the sympathetic. The actions of the two divisions on their targets are quite different. In some cases, they are exactly opposite. In other cases, the two divisions control different aspects of a complex physiological response. Although the activities of the two divisions differ, their basic anatomical organization is similar. The pathways all start with a preganglionic cell in the CNS, which projects to a postganglionic cell located in a ganglion outside the CNS. The postganglionic cell is therefore considered to be part of the PNS. The sympathetic and parasympathetic divisions differ in the location of their pre- and postganglionic cells.

##### **Readings**

This handout and sections 16-1 to 16-3.

##### **Objectives**

1. Locate the regions of the CNS and PNS associated with the sympathetic and parasympathetic divisions of the ANS.
2. Describe the general locations of the sympathetic and parasympathetic ganglia and give specific examples.
3. Describe the major routes that sympathetic and parasympathetic neurons take to reach their peripheral targets.
4. On a diagram or model of a thoracic spinal section, locate: lateral horn, white ramus, gray ramus, paravertebral ganglion.

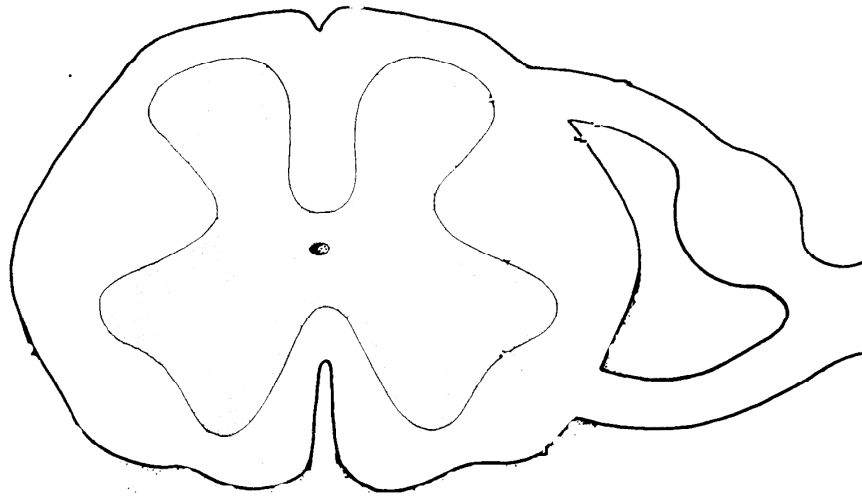
##### **Laboratory**

Complete all italicized questions.

Prepare for the laboratory practical by testing yourself on the learning objectives. Can you do what they tell you to do?

A. Review

This is a diagram of a \_\_\_\_\_.



*You should be able to label all of its structures without consulting a book.*

*Shade the gray matter. What is the difference between white matter and gray matter in the CNS?*

*In the space below, draw (or describe) how a skeletal muscle cell receives the signal to contract from the central nervous system. Include all the structures needed and the specific molecules that carry the signal.*

## B. ANS Gross Anatomy

Your goal in these activities is to “have a good sense” of the location of ANS structures. What does that mean? A really fussy anatomist could assemble quite a long list of structures – mostly subdivisions of the sympathetic trunk and various nerves. We aren’t after that level of detail here. We will settle for locating some of the more prominent structures and using this knowledge to generalize about the pathways of autonomic neurons.

*1) On the diagram of the CNS, color the regions associated with the sympathetic NS and the parasympathetic NS (different colors of course).*

Using Figures 16-4, 16-5, 16-8 examine the Autonomic Nervous System. Locate: the sympathetic trunk (ganglion chain), white and gray rami (a few of them so that you can see the pattern), celiac ganglion, superior and inferior mesenteric ganglia, adrenal gland, vagus nerve.

*2) Which segments of the spinal cord have white and gray rami associated with them?*

*3) One of the diagrams provided shows the pathway of sympathetic division neurons and the other shows the parasympathetic division. Which is which? How do you know?*

*4) If you look closely you will see that part of a pathway is indicated by dots and part by dashes. What is the reason for this difference?*

*5) What generalization can you make regarding the proximity of the sympathetic ganglia vs. the parasympathetic ganglia relative to their target organs?*

*Examine the ciliary ganglion pathways (Figures 14-21, 16-8 and provided images).*

*6) Describe the location of the superior cervical ganglion and ciliary ganglion.*

*7) In which division of the ANS are these structures?*

*8) Where are the preganglionic cells that project to each of these structures?*

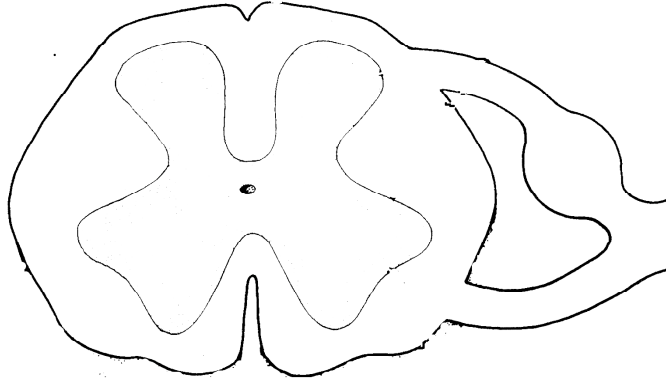
9) Briefly describe the location of these structures and state whether they are part of the sympathetic or the parasympathetic division. Trace the path of the post-ganglionic axons to their targets.

<b>Structure</b>	<b>Location</b>	<b>Division</b>	<b>Targets</b>
Cervical sympathetic ganglion			
Sympathetic ganglion chain			
Celiac ganglion			
Superior and inferior mesenteric ganglia			
Ciliary ganglion			

10) What is in the ganglia listed above?

11) What generalization can you make about the relative lengths of the pre- and post-ganglionic axons in the parasympathetic and sympathetic nervous systems?

12) Draw the path of the pre- and postganglionic sympathetic neurons on this diagram. You will need to add some structures. Label any structures through which the neurons pass.



13) Describe the path taken by the parasympathetic preganglionic cells that target the heart and the stomach. How does it differ from the path taken by the cells that target the bladder?

### B. The Polygraph

The polygraph is most commonly known as the lie detector. Basically, it is an instrument that records different physiological variables as a subject is asked a series of questions. While being asked these questions, subjects have physiological data collected from different systems in their body including respiratory, cardiac, skin and the eye.

If a subject lies in response to a question, the limbic system causes ANS responses (this is not fool proof, however, as some people can lie without emotion and avoid ANS responses).

When a person hears a question and decides to lie, hearing the questions signals an alarm to the ANS and the sympathetic nervous system is activated. First you hear the question (the temporal lobe is activated), and then the frontal lobe (judgment and reasoning) makes a decision. If the question threatens the individual, the frontal lobe sends out a response (via the hypothalamus) to the sympathetic system to generate a response.

"Fight or flight" mode then kicks in. The adrenal medulla glands release adrenaline (epinephrine and norepinephrine) and blood is diverted to the important areas

(brain and large muscles) from less important areas like the digestive tract as the individual prepares to fight or run away (mentally, in the case of a lie detector test).

Symptoms of this can include:

- \* The mouth gets dry, due to the salivary glands producing much thicker saliva.
- \* The heart pumps harder and faster, thereby increasing blood volume and pulse.
- \* Stimulation of the respiratory muscles leads to breathing changes.
- \* The sweat glands are stimulated and forced to release perspiration.
- \* The iris of the eye dilates permitting more light into the eye.
- \* The anal and urinary sphincters contract and the bladder relaxes.
- \* Involuntary muscles contract.

Consider the following responses to a lie detector test and identify what nerve pathway(s) (and hormonal responses) the ANS uses to elicit the response when the subject lies.

*1) The examiner detects a slight increase in the subject's respiratory rate.*

*2) Galvanic skin sensors detect a slight increase in conductivity indicating the subject broke into a light sweat.*

*3) A blood pressure cuff and pulse rate sensor indicate that the subject's BP and pulse rate experienced a momentary jump.*

*4) The examiner detected a slight dilation of the pupil.*

You will be watching your 'subject' for signs that the ANS is triggering a 'flight or flight' response. **Prepare to watch and analyze the below five signals.**

**Procedure:**

1) Hook your lab partner up to our 'lie detector' kit. Sweat will increase the degree of electrical conduction across the skin of your 'subject' and the dial on the Ohm meter will swing upward.

2) Swab on the betadine solution (this contains iodine) and, when it has dried, lightly powder over the brown area with flour. When your 'subject' sweats, the moisture will cause the iodine to mix with starch. This mixture will then quickly oxidize to a black color.

3) Practice taking the pulse of your 'subject'. You will need to be able to determine if their heart rate picks up.

4) Watch their breathing rate to see if they begin to breath more rapidly.

5) Watch their pupils to determine if the eye dilates.

Now, with one student as the 'subject' and another student as the 'examiner' set up a game of 'Go Fish'. The subject should be playing against another student or two. The subject should at times lie in response to the "Do you have a ... fish." The other two students should be perfectly honest. Every time the subject is asked for a fish, the examiner should record if he thinks the subject was telling the truth. The two players should keep a record of which fish are asked for and which are handed over. At the end of the game, determine if you were able to detect the subject's lies.

If you wish, you may also test a 'subject' by playing a hand of poker or by developing a list of questions to which the subject will predetermine (and keep to himself for now) to which question he will lie.

*5) Addressing the five signs you were asked to observe, record your overall results here. Do you think you were able to pick up on the lies?*

## **PART II: Endocrine System**

### **Introduction**

The endocrine system is the second of two physiological control stems that we will study. This system exerts its control by secreting hormones that travel through the blood to their target organs. The organs of the endocrine system are dispersed throughout the body, often at a distance from the target organs. Some hormones are secreted by endocrine tissue embedded within organs not usually considered to be a part of the endocrine system at all. Most endocrine organs secrete more than one hormone. When you examine micrographs of these organs, you can observe different cells or even different regions within the organ. These histological differences correspond to differences in function – the production of different hormones.

In Part II you will locate the major endocrine organs, examine microscope slides of several organs, and conduct pregnancy tests (a test relying upon the production of a hormone).

### **Objectives**

1. Locate the following endocrine organs relative to structures of the musculoskeletal system: pituitary, hypothalamus, pineal gland, thyroid, parathyroid glands, thymus, pancreas, adrenal gland, ovaries, testes.
2. Describe the physical and functional relationship between the hypothalamus and pituitary gland.
3. Describe the histological structure of the pituitary, thyroid, pancreas, and adrenal glands.
4. Identify thyroid follicles, islets of Langerhans, adrenal medulla, and adrenal cortex on microscope slides of images of tissues.
5. Explain how and when hCG is produced and how a home pregnancy test works.

### **Reading**

Ch. 18 of Martini

### **Materials**

Bring your PhysioEx CD and manual to lab for the endocrine system. We will be using the Histology module. Also bring your Atlas.

### **Laboratory**

#### **A. Endocrine Organs - Overview**

Using the torso model, locate: pituitary, hypothalamus, pineal gland, thyroid, parathyroid glands, thymus, pancreas, adrenal gland, ovaries, testes.

1) Describe the location of each organ relative to nearby structures of the musculoskeletal system.

<b>Organ</b>	<b>Description of Location</b>
Hypothalamus	
Pituitary	
Pineal	
Thyroid	
Parathyroid	
Thymus	
Adrenal	
Ovary	
Testes	

2) Identify the endocrine organs that are visible on the torso model.

Examine microscope slides of the pituitary, thyroid, pancreas, and adrenal glands. Refer to the figures in the Atlas and text to identify cells and structures in the glands. The Histology module in PhysioEx also has good images of these tissues – with labels. Answer the questions below.

**B. Thyroid Gland**

3) Draw or describe the appearance of the thyroid gland.

4) What proportion of tissue is made of cells? Extracellular material? What is in the extracellular material?

C. Pancreas

5) *Locate the islets of Langerhans. What proportion of pancreatic tissue is endocrine gland?*

6) *What non-endocrine functions does the pancreas have?*

D. Adrenal Gland

7) *Describe the difference in appearance between the medulla and the cortex. Do they have the same functions?*

E. Pituitary

8) *Describe the difference in appearance between the anterior and posterior pituitary. Does this correspond to functional differences?*

9) Which “endocrine” glands have functions other than the secretion of hormones?

#### F. Pregnancy Tests

Another hormone produced (by the chorion) only in response to the implantation of a developing fetus is human chorionic gonadotropin (hCG). This hormone appears in the blood stream soon after implantation in the uterus (at about 7 days after fertilization) and appears in the urine as well. While physicians can use a blood test for pregnancy, home kit tests use urine. The function of hCG is to maintain the corpus luteum so that progesterone continues to be produced thereby supporting the pregnancy until the placenta can secrete estrogens and progesterone (about 3-4 months into the pregnancy).

Home pregnancy tests measure the amount of hCG in urine using an ELISA test. An ELISA test is simply the binding of anti-hCG antibodies to any hCG present in the urine and then eliciting a color reaction. In 1999, there were 23 million kits sold for over \$242 million (between \$6 and \$14 each). A wide variety of kits are available: Answer, Clearblue Easy, ClearPlan, e.p.t., Fact, and First Response. Quite simply, a woman wishing to know if she is pregnant collects urine into a cup and then dips the test strip into the sample for a few seconds (or holds the strip in the stream of urine). After a few minutes, the strip wicks the urine across two bands: one is a control that indicates that enough urine was applied (a positive control), and the other is a band with anti-hCG antibodies. If the woman is not pregnant, there is no hCG to bind the antibodies and no color will develop. If the woman is pregnant, the hCG will bind to the antibodies and a colored line will appear. As a woman’s menstrual cycle typically begins around the time implantation will occur (~7 days after ovulation), a woman may choose to take this test when she discovers she is ‘late’.

Read the below scenarios. Based on the above information, predict the pregnancy status of each of the women concerned (do not guess) and state why you have made this prediction. Now, after reading the pregnancy test instructions carefully, test the provided urine samples to determine pregnancy status and record your results. Finally, answer the below questions.

#### **Janine**

I am 18 years old and a freshman at Westfield State College. I am currently living at home because I can’t afford the dorms or an apartment and pay for tuition *and* books (particularly those expensive biology textbooks). Because my dad lost his regular job last year, and with it his health insurance, I’ve gone off the Pill. I made this decision because it is an expensive prescription and I’m not currently sexually active anyway (I just broke up with my high school boyfriend). Well, last weekend, I went to the party of a friend on campus and drank a little too much. I kind of remember flirting with a guy and drinking more wine than I normally would have. The next thing I remember is waking up naked

in his dorm room. I have no idea what happened that night! Today, I noticed that I am one day late in having my period. That may not seem like much, but I'm usually so regular. I'm terrified – how could this have happened to me!?!

**Megan**

I'm 20 years old and living in the dorms here at WSC. Last night, I went out with my friend Emma and hung out at a local bar. We met some guys there and ended up having a one-night fling with them. Although I used protection, I'm late for my period. I'm so upset I can't focus in class and I have exams coming up soon.

**Dave**

I'm a sophomore at WSC and have been dating Courtney for only a few weeks. Last night we finally got around to having sex, but our protection broke. I feel sick to my stomach. I am worried that she might be pregnant but don't know how to bring this up with her. What should I do?

**Rachel**

I've been dating quite a bit this past year at college as a freshman. Its fun to finally live in the dorms on my own and not have to worry about my parents and a curfew. My mom took me to Planned Parenthood before I started college and got me a prescription for the Pill - because she remembers what college was like for her, I guess. Anyway, at first I was really good about taking that little pill everyday, but during exams last week I got so stressed out I missed a few days. The problem is, the night after my last big test, I slept with this guy, Joe, but we didn't use any protection. The next morning I realized I hadn't taken the last four pills! Now I'm really worried – I just know I'm pregnant. How am I going to tell my mom!?!

These people are your friends who come to you for help. Your advice to Janine, Megan and Rachel is to use a home pregnancy test before they do anything else. You tell Dave, however, not to have Courtney do anything.

**Predictions and Results of the Pregnancy Test:**

**Janine**

**Megan**

**Courtney**

**Rachel**

*10) Explain to your friends how a human pregnancy test kit works.*

*11) Should any of these women be tested again?*

*12) Why did we decide not to have Courtney perform a pregnancy test?*

*13) In the late 1970's and early 1980's, home pregnancy tests often required women to use the first urine of the morning. Why would this have been the case?*

G. Extra Credit

On your own time, you may complete Exercise 4: Hormones and Metabolism from *PhysioEx*. You will be graded upon your answers to the below questions and the completion of the associated worksheet. You can earn up to 5 bonus points that will be added to this lab grade. This extra credit option is due at the same time as the rest of the lab.

*14) Describe the type of experiment that is done to determine a hormone's function.*

*15) Why can we use oxygen consumption as a measure of metabolic rate?*

<b>Hypothalamus</b>					
↓					
GHRH & RHIH	PRH	TRH	CRH	GnRH	
Growth Hormone RH & IH	Prolactin RH	Thyroid RH	Corticotropin RH	Gonadotropin RH	
↓	↓	↓	↓	↓	↓
hGH	PRL	TSH	ACTH	LH	FSH
Human Growth	Prolactin	Thyroid Stimulating	Adenocorticotropic	Luteinizing	Follicle Stimulating
↓	↓	↓	↓	↓	↓
Liver, muscle, bone, cartilage, other cells	Mammary glands	Thyroid	Adrenal cortex	F: ovary – Graafian follicle M: testis Leydig cells	F: ovary - primordial follicle M: testis sertoli cells
Secretion of insulinlike growth factor Milk production		Secretion of T3 and T4 Secretion of glucocorticoids	Protein catabolism, glucose synthesis, lipolysis, resistance to stress, anti-inflammatory, high levels depress immune response	F: ovulation M: secretion of DHT to produce testosterone	F: development of 2° oocyte M: spermatogenesis
Growth of body cells, protein synthesis, tissue repair, raises blood glucose		Controls PMR, protein synthesis, glucose us, ATP production, accelerates growth			

Parathyroid Gland Chief Cells	Pancreas		Posterior pituitary		Ovaries	Testes	Pineal gland
	Alpha cells	Beta cells					
PTH	glucagon	insulin	ADH	Oxytocin	Estrogens and progesterone	Testosterone	Melatonin
Regulates Ca <sup>++</sup> balance in blood	Liver breakdown of glycogen into glucose	Helps transport glucose into cells	Influences water balance	Smooth muscle contraction in breasts and uterus	Female sex characteristics	Male sex characteristics	Influences day/night cycles and rhythmic physiological processes