STRESS AND THE NERVOUS SYSTEM

Shirley Fraser
Park Hill High School
7701 NW Barry Road
Kansas City, MO 64152

Directions for Teachers

SYNOPSIS

In this lab, students will examine the stress response and the roles of the nervous and endocrine systems in the response. They will analyze data collected from "stressful" activities, then design experiments to study how different factors influence stress.

LEVEL

Exploration, Concept/Term Introduction Phases

Application Phase

STUDENT PRIOR KNOWLEDGE

Before participating in this activity, students should be able to:

- Describe the basic structure and function of neurons, synapses, neural pathways, and the endocrine system.

INTEGRATION

Into the Biology Curriculum

- Health
- Biology I, II
- AP Biology
- Anatomy and Physiology

Across the Curriculum

- Physical Education
- Psychology

OBJECTIVES

At the end of this activity students will be able to:

- Observe, measure, and record body responses to various stressful situations.
- Describe the role of the nervous system in the stress response and its relationship to the endocrine system.
- Analyze data regarding the effects of stress on human behavior and physiology.

Getting Ready

See sidebars for additional information regarding preparation of this lab.

Directions for Setting Up the Lab

C Make photocopies of Figure 2.

Teacher Background

The nervous system regulates the homeostasis of the body either directly by sending messages to various parts of the body, or indirectly by relaying them via the hypothalamus, the pituitary gland, and other endocrine organs. Reaction to stress is particularly complex and affects many physiological mechanisms. Selye (1974), the researcher who first used the term "stress," called stress the "non-specific response of the body to any demand." The stress reaction helps the body deal with stimuli perceived as a threat, or it can contribute to peak performance during an athletic or intellectual task. This response to stress requires that large amounts of stored energy be released quickly. Overall, this response is an inefficient use of the body's energy, as the body must use energy to regain a homeostatic state and replenish the depleted stores of energy. Even with ample supplies of energy, the ability to resist chronic or prolonged stress will diminish until a state of exhaustion occurs.

Stimuli come from two general areas—peripheral nerves and the brain—to activate the stress response system of the body. Environmental stimuli that cause pain, an allergic reaction, or an internal stimulus caused by a drastic fall in blood pressure send messages over peripheral sensory nerves to the midbrain. From the midbrain, the messages pass to the thalamus located deep within the brain's core. The thalamus relays sensory information to the hypothalamus located below it, and to the cortex of the brain, as shown in Figure 1.

LENGTH OF LAB

A suggested time allotment follows:

Day 1

E *15 minutes* — Perform ***Exploration I*** or ***Exploration II.***

C *15 minutes* — Discuss results of ***Exploration*** in groups and as a class.

A *15 minutes* — Write hypothesis and procedure to test it.

Day 2

30 minutes — Test hypothesis.

MATERIALS NEEDED

For all phases of this lab, you will need the following for each group of four students in a class of 24:

- 1 watch/clock with second timer
- 1 stress sensor
- 1 thermometer
- 4 pairs of safety glasses (optional)
- 1 metric ruler (optional)
- 1 light meter (optional)
- 1 blood pressure sensor (optional)

PREPARATION TIME REQUIRED

E *1 hour* to collect and order materials

C *15 minutes* to photocopy Figure 2

SAFETY NOTES

- Wear safety glasses when measuring eye pupil diameter.
- Excuse students with heart or respiratory problems from exercise activities.
- Parents should sign exercise exemption forms for all students.
- Do not use any stressor that will cause a student any type of harm or that will provoke anger.

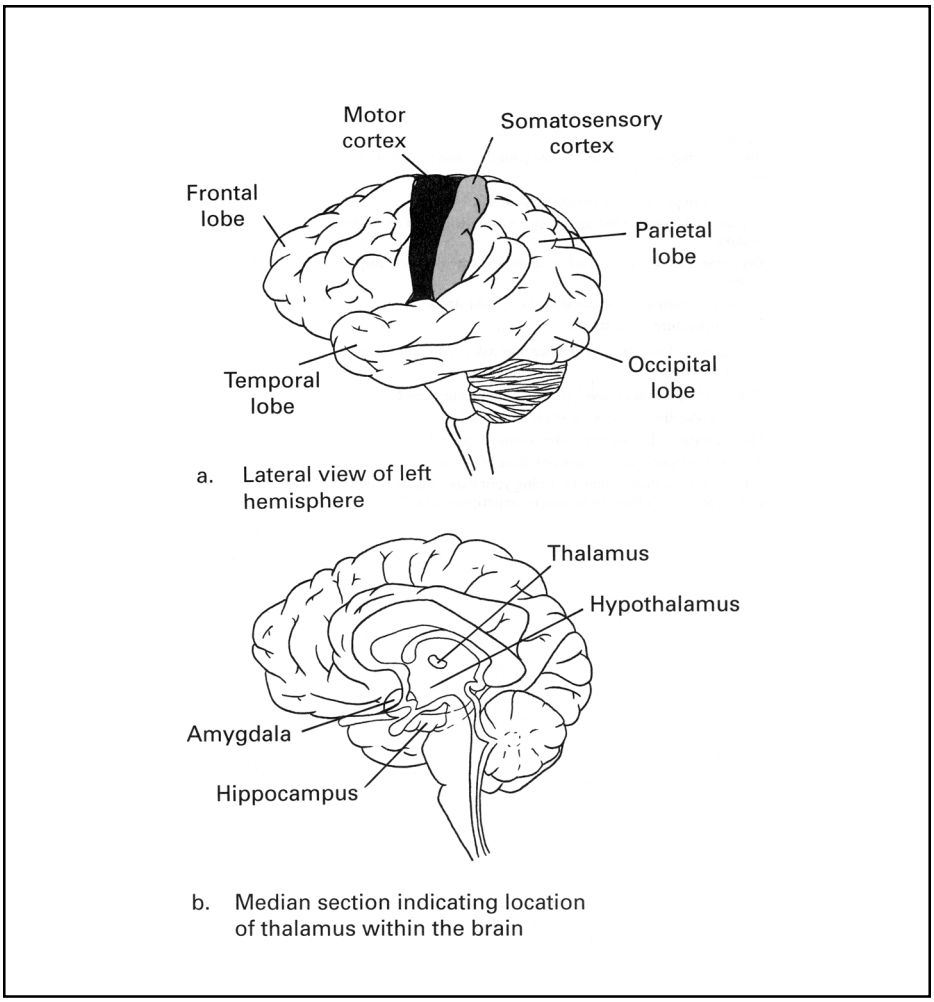


Figure 1. Location of thalamus.

The second source of stimuli is from the brain. Fear or anxiety may occur when one perceives situations similar to previous unpleasant experiences. The prospect of a pop quiz is an example that is incorporated into this activity. In this case, anxiety stimulates messages to be sent from the cortex and limbic system to the hypothalamus. The response to stress varies with the individual's age, gender, and genetic makeup. Environmental factors, such as diet, drugs, and temperature extremes, also influence the response to stress.

The hypothalamus is powerful because it is the meeting place for the body's two control networks: the nervous system that exerts control via electrical messages through the nerves to release chemical neurotransmitters and the endocrine system that sends chemical messengers called hormones through the blood to act on organs directly (McQuade & Aikman, 1974). The hypothalamus coordinates the stress response by releasing corticotropin-releasing hormone (CRH). Recent evidence shows that CRH is released also as a neurotransmitter. CRH was discovered first as a hormone, hence its name. As a hormone, CRH controls the pituitary and the cortex of the adrenal gland. As a neurotransmitter, CRH controls behavior in higher

brain centers and also appears to control the autonomic nervous system. The hypothalamus receives messages from peripheral nerves, the cortex, and the limbic system, and sends messages out that induce the body's three characteristic types of response to stress: behavior, autonomic nervous system, and endocrine system.

The behavioral responses to stress are numerous, complex, and only partially understood. One behavioral response is nervous eating. Another is alternately freezing and running in the face of danger. In the classroom, nervous behavior may occur when a pop quiz is announced. The message enters the ears and goes to the cortex and limbic system where it is recognized as a cause for concern, especially if one has not studied. From here, the message is sent to the hypothalamus that returns messages to the limbic system to stimulate complex behavioral patterns, such as fidgeting, tremors, and increased talkativeness. One of the hypothalamic messages is CRH, the same chemical that stimulates the endocrine and autonomic nervous systems. Consequently, students may also experience the autonomic symptoms of dilated pupils, sweaty palms, and increased heart and respiratory rates. The hypothalamus uses CRH as one of its messengers to coordinate the stress response to the pop quiz.

A second type of response stimulated by the hypothalamus is the autonomic nervous system. The autonomic responses are often the easiest to identify and may include increased heartbeat, breathing, and the passage of food through the body; contraction of the bladder and the gut; and the influence of sweating and shivering on body temperature. The autonomic nerves send their messages to organs and glands by the sympathetic and the parasympathetic systems. These two pathways counterbalance each other, keeping the body in a steady state. The motor neurons in these systems are located outside the central nervous system (CNS) in small encapsulated clusters called ganglia. The sympathetic ganglia lie alongside the spinal cord, as shown in Figure 2.

Most of the autonomic nerve activity in the stress response is due to sympathetic nerves that release the neurotransmitter norepinephrine. Action of the parasympathetic system tends to restore the body to its state prior to the stressful stimulus (see Table 1).

The third type of response stimulated by the hypothalamus occurs in the endocrine system. In reaction to continued stress, the hypothalamus secretes CRH and thyrotropin-releasing hormone (TRH). These hormones are carried to the pituitary gland through the blood vessels of the pituitary stalk that connects the hypothalamus and the pituitary. See Figure 3.

CRH and TRH stimulate the anterior pituitary to release two additional hormones into the blood of the systemic circulation. CRH stimulates the adrenocorticotropic hormone (ACTH) and TRH stimulates thyroid-stimulating hormone (TSH) release. ACTH stimulates the outer layer of the adrenal gland, called the adrenal cortex, to release cortisol. Cortisol stimulates an increase in glucose available in blood for use by the body's cells. TSH stimulates the thyroid gland to release the hormone thyroxine. Thyroxine stimulates the cells of the body to use glucose at a faster rate.

TEACHING TIPS

- Stress sensors: Instruments that measure physiological correlates of stress are available in a range of complexity and price. An inexpensive one is the Stress Tester ($1.98) from Carolina Biological Supply Co., Box 187, Gladstone, OR 97027, or 2700 York Rd., Burlington, NC 27215. Phone (800) 334-5551. This credit-card sized device is a liquid crystal display that, held against the skin, changes color in response to body heat; body heat is sometimes regarded as an index of stress levels.

  An alternative stress sensor that may be used is the "biodot." The "biodot" is the size of the end of a pencil eraser and is easily affixed and removed from the skin.
  It is available from Biodot International, P.O. Box 2246, Indianapolis, IN 46206. Phone (317) 637-5776. The cost is $10.00/100, plus $1.50 postage and handling.

  For the "biodots," the colors, temperatures and levels of stress they indicate are as follows:
  - Violet – 94.6° F – Very relaxed
  - Blue – 93.6° F – Calm
  - Turquoise – 92.6° F – Relaxing
  - Green – 91.6° F – Involved (normal)
  - Yellow – 90.6° F – Unsettled
  - Amber – 89.6° F –Tense
  - Black – 87° F – Very tense
- Instruct the students always to use the right

—Continued

TEACHING TIPS
—Continued

index finger when using the Stress Tester. If there are instructions and other information on the sensor, it should be discussed so the students will not know the purpose of the exercise.

- If blood pressure is measured, the sensor ideally should be of the type that measures blood pressure at the index finger; these may cost around $100.
- To measure respiration rate, count the number of inspirations in one minute as the seated subject breathes normally.
- Room temperature should be recorded at the time data are recorded because it could affect stress sensor color and respiration rate. In a hot room, skin vascular beds will open to release body heat; in a cold room, skin vascular beds will close and may not open with the stress response. Therefore, excessively warm or cool environments will override the stress skin temperature responses.
- Safety glasses should be used for measuring pupil dilation. Also, use a light meter for recording room light that can affect dilation. Extremes of room light or darkness will override pupil diameter measurements.

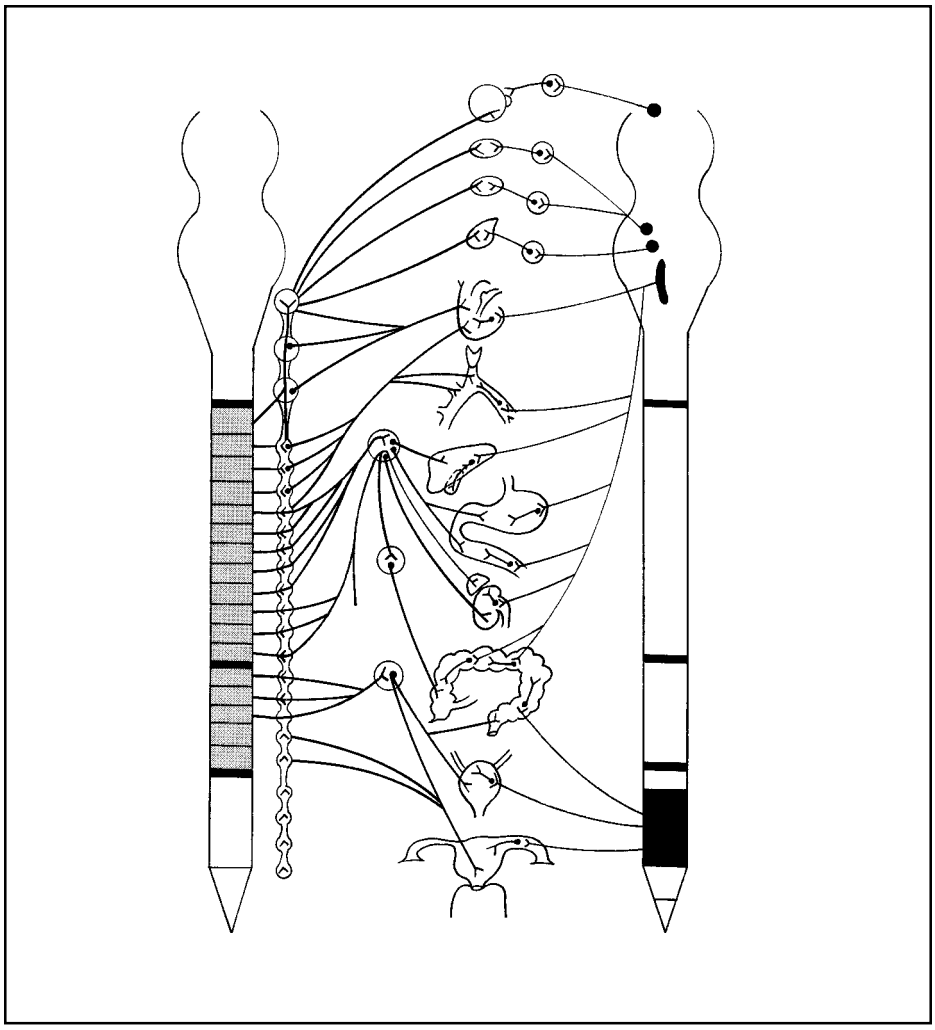


Figure 2. Innervations of the autonomic nervous system. Sympathetic system represented by darker lines on the left; parasympathetic system by lighter lines on the right.

Together cortisol and thyroxine help to supply energy to cells that are stimulated by stress stimuli and to cope with the increased metabolic demands on the cells brought on by increased activity. See Figure 4.

All three stress response systems — behavior, autonomic, and endocrine — are coordinated in part by the hypothalamic release of CRH. These systems work together to help the body work at peak performance during athletically, intellectually, physiologically, or emotionally stressful activities. Acute stress is generally seen as beneficial in this way. However, during prolonged stress, the stress response may damage certain body tissues and functions. Cortisol acts as a negative feedback mechanism to prevent overreaction of the several CRH-stimulated stress response systems. This is fairly effective with acute stress, but long-term or chronic stress is still associated with harmful effects. It is generally best if one can manage a lifestyle with intermittent acute stress rather than continuous stress.

Table 1. Response to stimulation of the two parts of the autonomic nervous system

Stimulation of the sympathetic nervous system causes an immediate response that includes:	Stimulation of the parasympathetic nervous system includes:
Increase in heart rate and blood pressure	Decrease in heart rate and blood pressure
Sweat	None
Glycogen released from the liver to handle increased energy demands	Slight glycogen synthesis
Increase in skeletal muscle strength	None
Decrease in blood flow to the skin, kidneys, and digestive tract	None
Dilation of lung bronchi and constriction of blood vessels	Constriction of lung bronchi and dilation of blood vessels
Dilation of pupils	Constriction of pupils
Increase in mental alertness	None

Adapted from Asterita, M.F. (1985). *The physiology of stress*. New York: Human Sciences Press, Inc., Table I, pp. 22–26. (This table is adapted from Guyton, A.C. (1981). *Textbook of medical physiology*. 6th ed. Philadelphia, PA: W.B. Saunders Co., p. 175.)

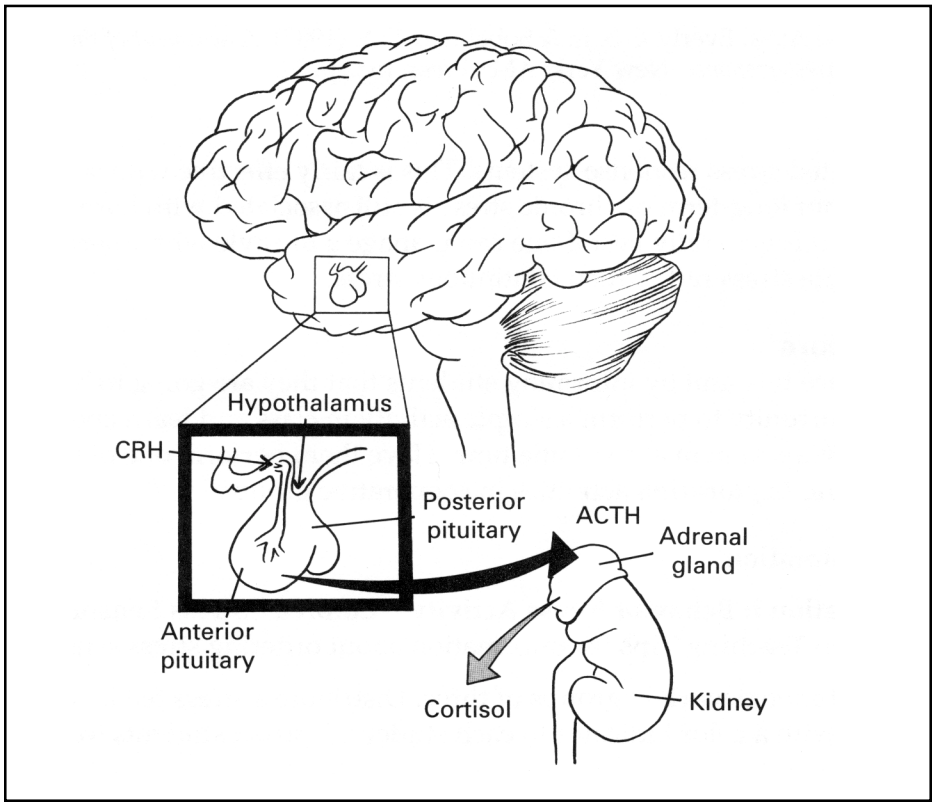


Figure 3. Outline of control of cortisol secretion.

SUGGESTED MODIFICATIONS FOR STUDENTS WHO ARE EXCEPTIONAL

Below are possible ways to modify this specific activity for students who have special needs, if they have not already developed their own adaptations. General suggestions for modification of activities for students with impairments are found in the AAAS *Barrier-Free in Brief* publications. Refer to p. 19 of the introduction of this book for information on ordering **FREE** copies of these publications. Some of these booklets have addresses of agencies that can provide information about obtaining assistive technology, such as Assistive Listening Devices (ALDs); light probes; and talking thermometers, calculators, and clocks.

Blind or Visually Impaired

- A student who is blind would be aided in collecting data by a talking clock or braille wristwatch and a talking thermometer. He/she would need help in reading the stress sensor.
- Auditory stressors may be used for the student who is blind, such as music that repeats a phrase over and over as on a broken record. Be sure to check with the student in advance to be sure this stressor is not too annoying.

—Continued

SUGGESTED MODIFICATIONS — Continued

- Embossed graph sheets are available for blind students from the American Printing House for the Blind in 1/2-, 3/4-, and 1-inch squares.
- A student who has low vision should be able to collect all data independently. Provide photo-enlarged copies of text and diagrams for these students.

Gifted

- Students who are gifted can do library research about physiological stress experiments on lab animals, then design a computer program simulation to illustrate the research findings.

Mobility Impaired

A student who has limited use of the lower extremities may need to be excused from the exercise portion of this activity, depending upon the type of exercise that is done. This student could participate as a time keeper or pulse recorder for the group instead of as a subject. This student could also participate in the behavioral stress activity.

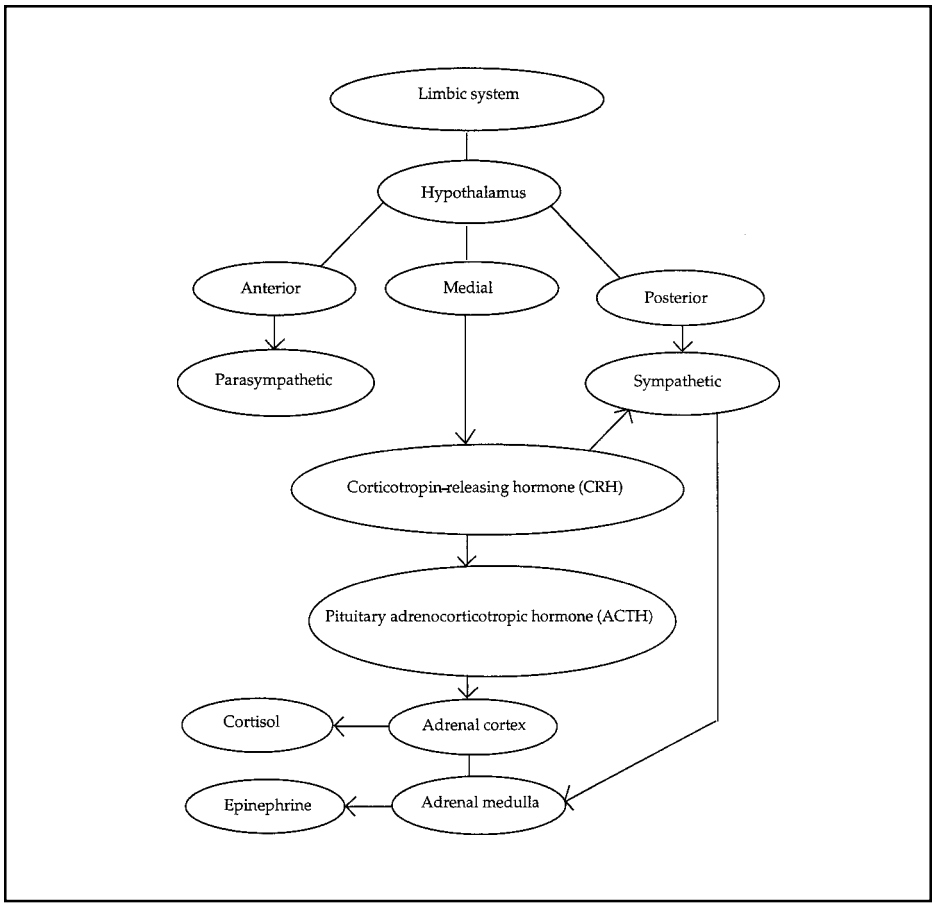


Figure 4. Mediation of stress. Adapted from Figure 2.2 The Three Stress Response Axes. Everly, G.S. Jr. & Sobelman, S.A. (1987). *Assessment of the human stress response.* New York: AMS Press, Inc., p. 22.

Procedure

Introduce this unit by informing students that they are going to have an opportunity to perform a simple activity in class and learn about the nervous system at the same time. Have them perform one of the following ***Exploration*** activities in cooperative groups:

E Exploration

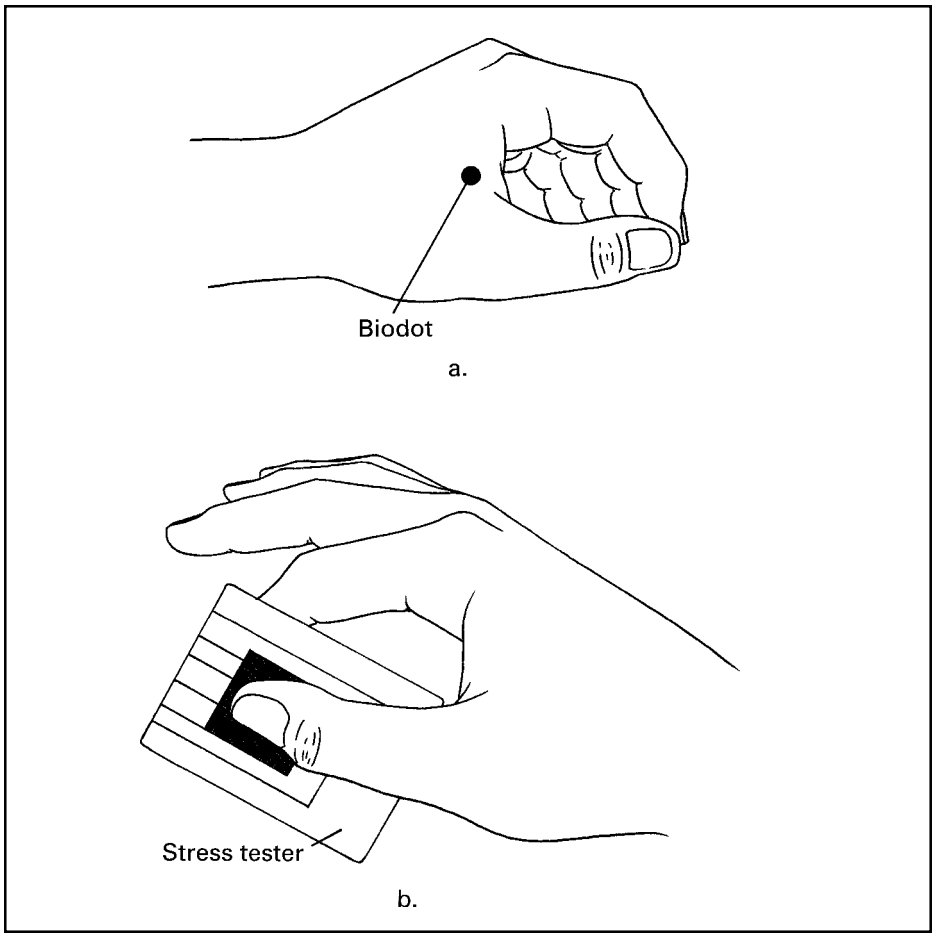
Exploration I: Behavior Stress Activity—Colored "Stress Sensor"

(Refer to **Teaching Tips** for information about ordering stress sensors.)

Have students work in groups of three. Distribute a stress feedback sensor with a color indicator to each student. Instruct students to:

- Attach it to the tops of their hands, as shown in Figure 5a, if using the "Biodot™" sensor, or
- Hold it between their thumbs and index fingers, as shown in Figure 5b, if using the "Stress Tester™".

Have students record the color of the stress sensor.



Figures 5a and 5b. Proper way to use the stress feedback sensors for ***Exploration I****.*

Then give students the following instructions:

1. Place the sensors at the tops of their desks.
2. Place all books and notes under their desks or away and out of sight.
3. Take out a piece of paper and number it one to five for a pop quiz.

When students have numbered their paper from one to five, instruct them to place the sensors again as they had them before, either on top of their hands, or between their thumbs and index fingers. After 15 seconds, have them write the color on the sensor next to number one. When they have recorded their responses, ask them to keep the sensor where it is and announce that there is no pop quiz. After 15 seconds, have them record the color of the sensor beside number 2 on their "quiz" paper. Ask them what event was occurring when they answered numbers 1 and 2. In groups of three, have students devise ways to elicit three additional color changes on the sensor and record the event and color of the sensor on numbers 3 to 5. When students have completed this activity, ask them questions such as the following:

- What was the color of the sensor before you held it?
- What color did it become after you held it?

- Can you develop a relationship between the color of the sensor and the event that occurred?
- What causes the sensor to change color? Does this have any relationship to the physiology of the body? If so, explain.
- Are the color changes for each event consistent for all members of the class? Why or why not?

(NOTE to teachers about timing: ***Exploration I*** is a behavior stress activity that relies on the element of surprise of a pop quiz. Therefore, the best time to announce the pop quiz is immediately after students have collected their baseline data. It is imperative that data be collected again immediately after each announcement.)

Exploration II: Physical Stress Activity—Heartbeat (Pulse)

If stress sensors are not available, the wrist pulse can be taken by pressing two fingers, not the thumb, on the thumb side of the inside of the wrist. See Figure 6.

A suggested procedure for this ***Exploration*** follows:

1. Students should form groups of three. Assign each student in the group a role as follows:
   - Subject
   - Time keeper
   - Pulse recorder.
2. The pulse recorder should locate the pulse of the subject, as shown in Figure 6.
3. To establish a baseline pulse, the pulse recorder should take the pulse of the subject for one minute using the technique shown in Figure 6. The time keeper should record this rate.
4. The subject should run in place for three minutes, then the pulse recorder should take the pulse again, as done in Steps 2 and 3. The time keeper should record this rate.

C Concept/Term Introduction

Students should work in small groups to study the data they have collected and make inferences about what the data tell them. They should answer the **Focus Questions** in **Directions for Students**. Each group should share its ideas with the class, if time permits. Following the students' sharing of ideas, the following questions could stimulate further discussion:

- Why does your heart beat faster when you get excited?
- Why do your hands sweat when you are afraid or nervous?
- Why do you breathe faster when you are angry?
- How do you feel when you are under pressure?
- What systems of the body react to help protect you from danger? How would those systems change during this time, and after the danger had passed?

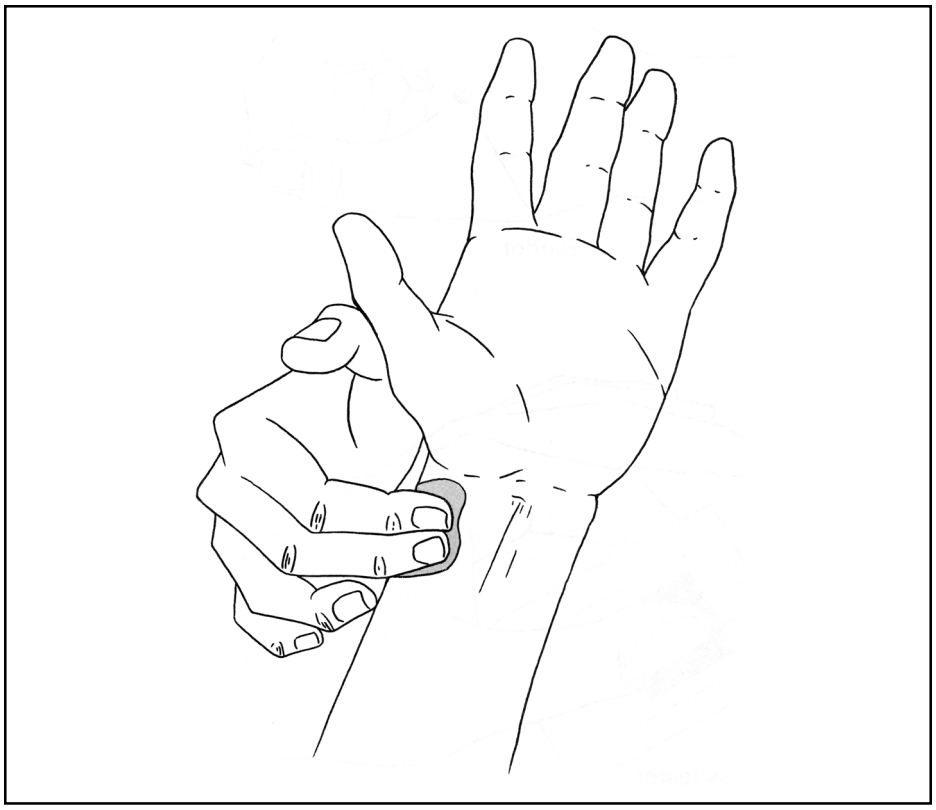


Figure 6. Technique for taking wrist pulse. Note the position of the two fingers on the thumb side of the wrist.

- Cite examples of the above bullet from the animal kingdom.

From the answers to the **Focus Questions**, you should be able to help students understand that stress is a reaction of the whole body. You might even mark the areas affected on a model of a person on the board or an overhead projector.

Present material about the nervous system, especially the parts of the brain, central nervous system, autonomic nervous system (with emphasis on the sympathetic system), and the endocrine system involved in stress.

Have the students color Figure 2, tracing the pathway from the spinal cord to the different organs affected by the sympathetic system. Use different colors for each body system.

Then students should state in words how stimulation of the sympathetic system affects all of the organs in the diagram at the same time, because fibers from different segments of the spinal cord innervate all the body systems simultaneously.

A Application

Students can now build on their previous experiences to extend the ***Exploration*** tasks and learn more about the physiology of stress. Have

them work in their groups to design and conduct their experiments and analyze their data. Make sure students are consistent in how stress is administered. They should not administer stress that might injure another student or insult or provoke him/her to anger. Be sure they are collecting quantitative data. Tell students that they must have a control for their experiment. It may be "before stress" measurements. Afterwards, each group should answer the Analysis Questions 1 to 5 in **Directions for Students**, then share its results with other members of the class. You may also want students to answer Analysis Questions 6 to 10.

Experiments should assess other factors that influence stress reactions. These factors may include the following:

- Regular exercise
- Age
- Competition
- Gender
- Sleep deprivation
- Ingestion of soft drinks containing caffeine
- Ingestion of a safe dose of an over-the-counter drug, such as ibuprofen, aspirin, or an antihistamine
- Meditation
- Mental imagery
- Counting backwards from 10 while thinking of relaxing specific body parts in sequence
- Taking several deep breaths
- Thinking positively about capabilities.

Questions you might ask students to help them start thinking about their own experiments include the following:

- Will a person who exercises frequently show less of a stress reaction than a person who rarely exercises?
- Will consuming a soft drink containing caffeine 30 minutes before the "stressing event" increase the stress reaction?
- Will males show a stronger stress reaction than females of the same age?
- Will a person who is taking an over-the-counter antihistamine for a cold have a decreased stress reaction?

In addition to looking at the color of the stress sensor or measuring pulse rate, students may measure one of the following as an indicator of stress:

- Respiration rate
- Blood pressure
- The diameter of the pupils of the student's eyes in millimeters.

Your students probably will develop other questions related to factors affecting stress reactions. In the sidebar are sample hypotheses and procedures that students might derive related to this activity. These examples have been included as suggested outcomes of the activity and are not meant to be given to the students. Students should develop their own

SAMPLE HYPOTHESES

- Under the same circumstances, males will show a stronger stress reaction than will females of the same age.
- Individuals who do aerobic exercise for at least 30 continuous minutes, at least 5 times a week, will show a decreased stress reaction as compared to individuals of the same age and gender who do aerobic exercise for 30 continuous minutes less than once a month.

SAMPLE PROCEDURES

1. Using the stress sensor system, gather baseline data as done in ***Exploration I*** for all students in a biology class. The baseline data should be gathered during the biology class period on a date when no test is scheduled or announced.
2. Record the class data. Determine the most frequent color for all the male students in the class, and the most frequent color for all the female students in the class.
3. On the day of a major biology test that has been announced well in advance, record the color of the stress sensor for each student as done in ***Exploration I*** immediately before the test is distributed. Record the color for each student again 15 seconds after the completed test has been handed in.
4. For the two readings taken in Step 3,

—Continued

hypotheses and procedures. Make sure they understand that there is not just one correct hypothesis and procedure.

Answers to Questions in "Directions for Students"

C Concept/Term Introduction

Focus Questions

1. Answers will vary, but students may say that the skin temperature determines the color of the stress sensor.

2–3. Refer to Table 1 in the **Teacher Background** for information about what parts of the body are activated in times of danger, and how.

4. Peripheral nerves and the brain. Refer to the **Teacher Background** for more information.

5. Refer to the **Teacher Background** for information about how the heart, brain, and hormones are involved in stress responses.

A Application

Analysis

1. Answers will vary depending on student experiments.

2–3. Answers will vary depending on student experiments. Refer to the **Teacher Background** for more information.

4. Answers will vary depending on student experiments.

5. Temperature does affect stress measurements in some cases. Refer to the **Teaching Tips** for more information.

6–9. Answers will vary. Refer to the **Teacher Background** for more information.

10. Answers will vary depending on student experiments.

References

Asterita, M.F. (1985). *The physiology of stress*. New York: Human Sciences Press, Inc.

Everly, G. & Sobelman, S. (1987). *Assessment of the human stress response*. New York: AMS Press, Inc.

Guyton, A.C. (1981). *Textbook of medical physiology*. 6th ed. Philadelphia, PA: W.B. Saunders Co., p. 175.

McQuade, W. & Aikman, A. (1974). *Stress*. New York: E.P. Dutton & Co., Inc.

Selye, H. (1974). *Stress without distress*. Philadelphia, PA: Lippincott.

Suggested Reading

Bieliausfas, L.A. (1982). *Stress and its relationship to health and illness*. Boulder, CO: Westview Press.

Chrousos, G.P., Loriaus, D.L. & Gold, P.W. (1988). *Mechanisms of physical and emotional stress*. New York: Plenum Press.

SAMPLE PROCEDURES
—Continued

determine and record most frequent colors for males and females.

5. Compare all color frequency readings for males and females.

 Repeat ***Exploration II***, comparing the pulse rates of three female students of the same age who exercise frequently with those of three female students of the same age who rarely exercise. Be sure that, as much as possible, all other factors that might influence the outcome are held constant. For example, the tests should all be done at the same time of day and the temperature of the room should be the same.

Newberry, B., Jaikins-Maden, J. & Gerstenberger, T. (1991). *A holistic conceptualization of stress and disease*. New York: AMS Press, Inc.

Sapolsky, R.M. (1994). *Why zebras don't get ulcers*. New York: W.H. Freeman and Co.

Vander, A.J., Sherman, J.H. & Luciano, D.S. (1990). *Human physiology*. 5th ed. New York: McGraw-Hill Publishing Company.

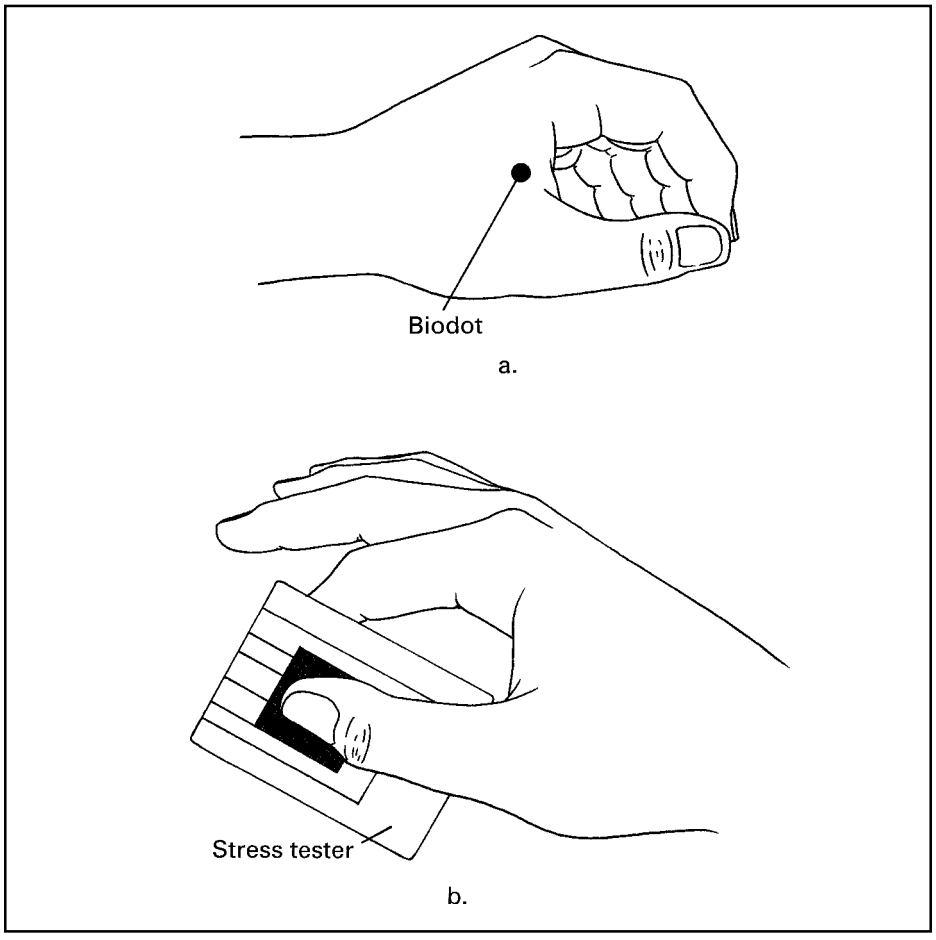
STRESS AND THE NERVOUS SYSTEM

Directions for Students

Introduction

Have you ever been "stressed out"? How did you feel? Some people describe stress as feeling like they are about to jump out of their skin! Others feel "down" and depressed. What causes stress in your life? Too much homework, too many demands put on you, "heat" from parents or friends?

Reaction to stress is a particularly complex nervous system response that affects many parts of the body. Hans Selye, the researcher who first used the term "stress," called it the "non-specific response of the body to any demand." The stress reaction helps the body deal with stimuli perceived as a threat. But stress is not always harmful; it can, for example, contribute to peak performance during an athletic or intellectual task. If stress is prolonged, however, health may suffer.



Figures 1a and 1b. Proper way to use the stress feedback sensors for ***Exploration I****.*

MATERIALS

If materials are to be used in this activity, they will be provided by your teacher.

SAFETY NOTES

- Wear safety glasses when measuring eye pupil diameter.
- If you have heart or respiratory problems, let your teacher know immediately so that you can be excused from exercise activities.
- Have your parents sign the exercise exemption forms your teacher gives you.
- Do not use any stressor that will cause you or another student any type of harm, or that will provoke anger.

In this laboratory activity, you will collect data to help you understand how stress affects the body. This activity will also help you learn what parts of the nervous system are involved with the stress response.

Procedure

E Exploration

Your teacher will lead you through an exploration activity. Follow your teacher's directions.

C Concept/Term Introduction

Work with your teacher and other students to analyze the data just gathered. Develop an explanation of what took place. Brainstorm ideas about what occurred and why in the ***Exploration*** activity. Your teacher may give you a diagram to help you understand the neuroscience concepts involved in the activity.

FOCUS QUESTIONS

Using your textbook or other materials supplied by your teacher, answer the following questions:

1. How do you think the stress sensor works?
2. What parts of your body are activated in times of danger?
3. How does the nervous system affect the parts of the body you named in Question 2?
4. What parts of the nervous system are involved in the stress response?
5. Explain how an EKG, measurement of heart activity; an EEG, measurement of electrical activity of the brain; and blood hormone analyses would help to measure stress levels.

A Application

Develop a hypothesis about a factor influencing stress. Design a procedure for an experiment to test your hypothesis. Make sure that the stress you apply is consistent from one student to the next as you do your test. Be sure you include enough details so that anyone could repeat your experiment. Make a data table to record data.

After the teacher has checked your design, measure and collect the data for the experiment you designed.

Teacher approval must be obtained before you begin this activity!

Analysis

Use the following questions to analyze your data and record your results:

1. Was your hypothesis supported by your data? Explain.
2. Explain in detail how the stress you measured affected the nervous system.
3. Draw some tentative conclusions about the way the body responds to stress.
4. What classroom activities produced the most stress?
5. Did temperature affect stress levels?

For further consideration, your teacher may ask you to ponder the following questions:

6. Why is it important to develop ways of reducing stress?
7. Of what adaptive value is the stress response?
8. How can you tell if you are under too much stress?
9. Explain the positive and negative values of stress.
10. What other questions came up during your experiment? How could you answer these questions by experimentation?

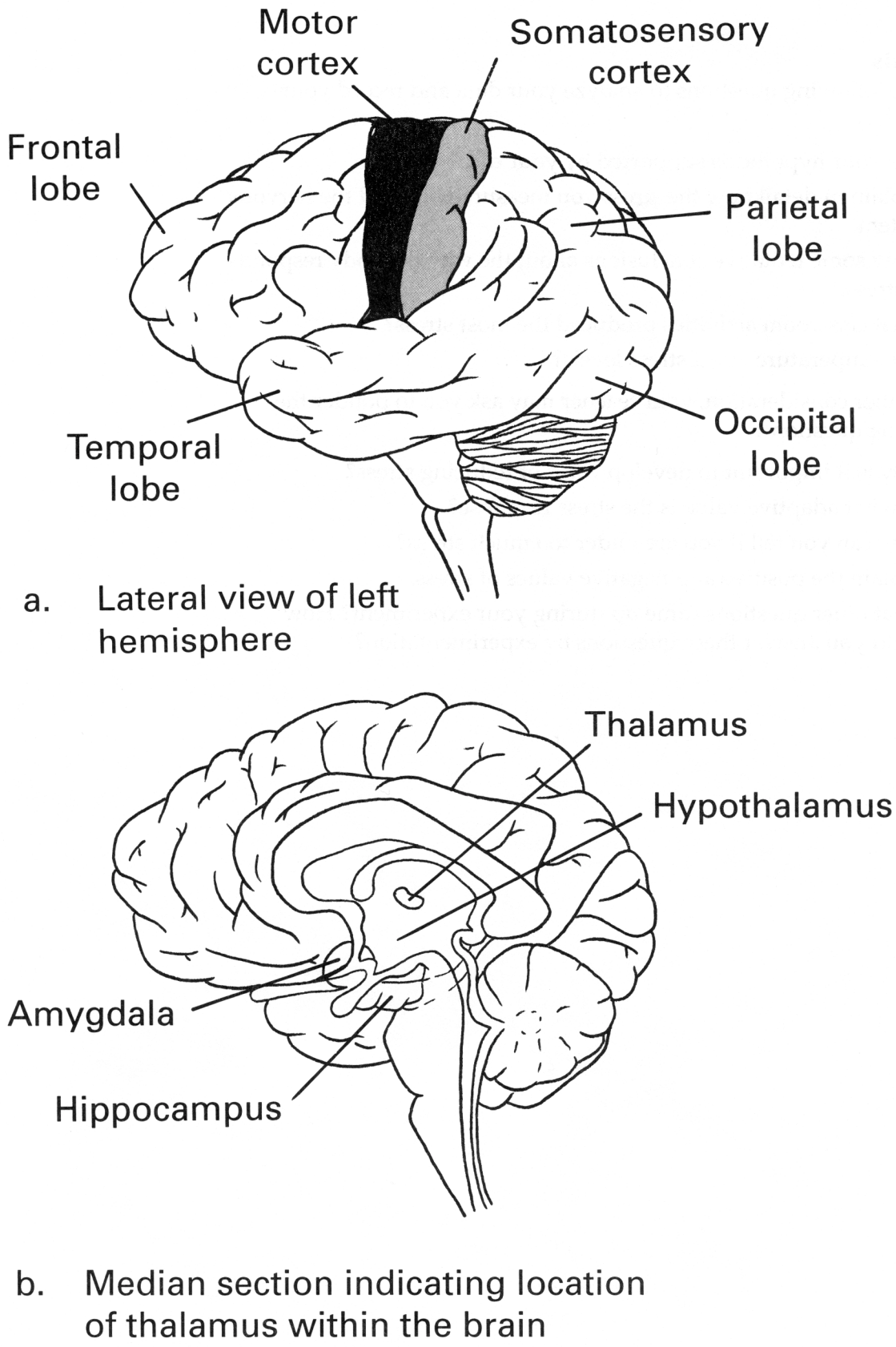


Figure 1. Location of thalamus.

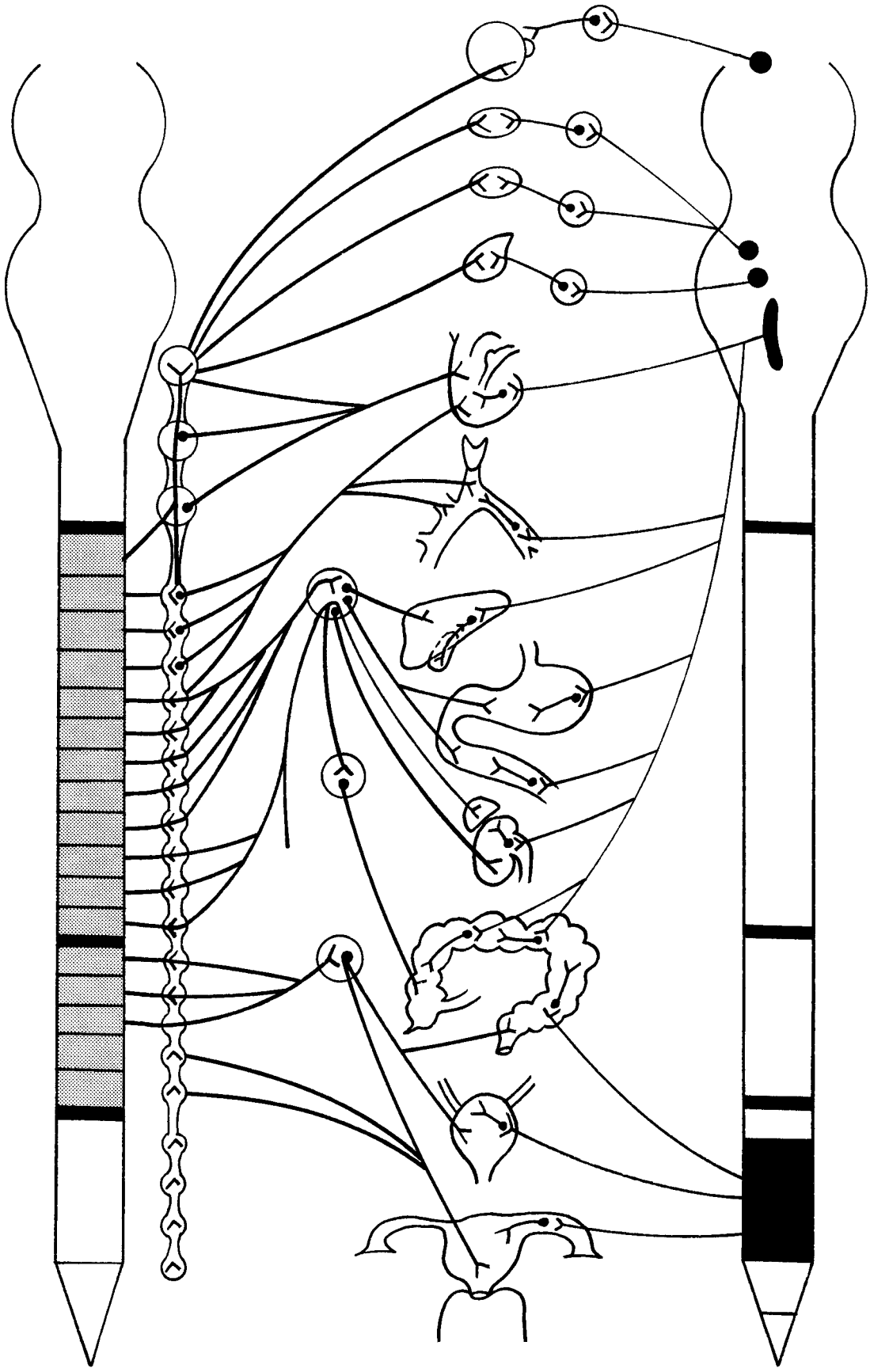


Figure 2. Innervations of the autonomic nervous system. Sympathetic system represented by darker lines on the left; parasympathetic system by lighter lines on the right.

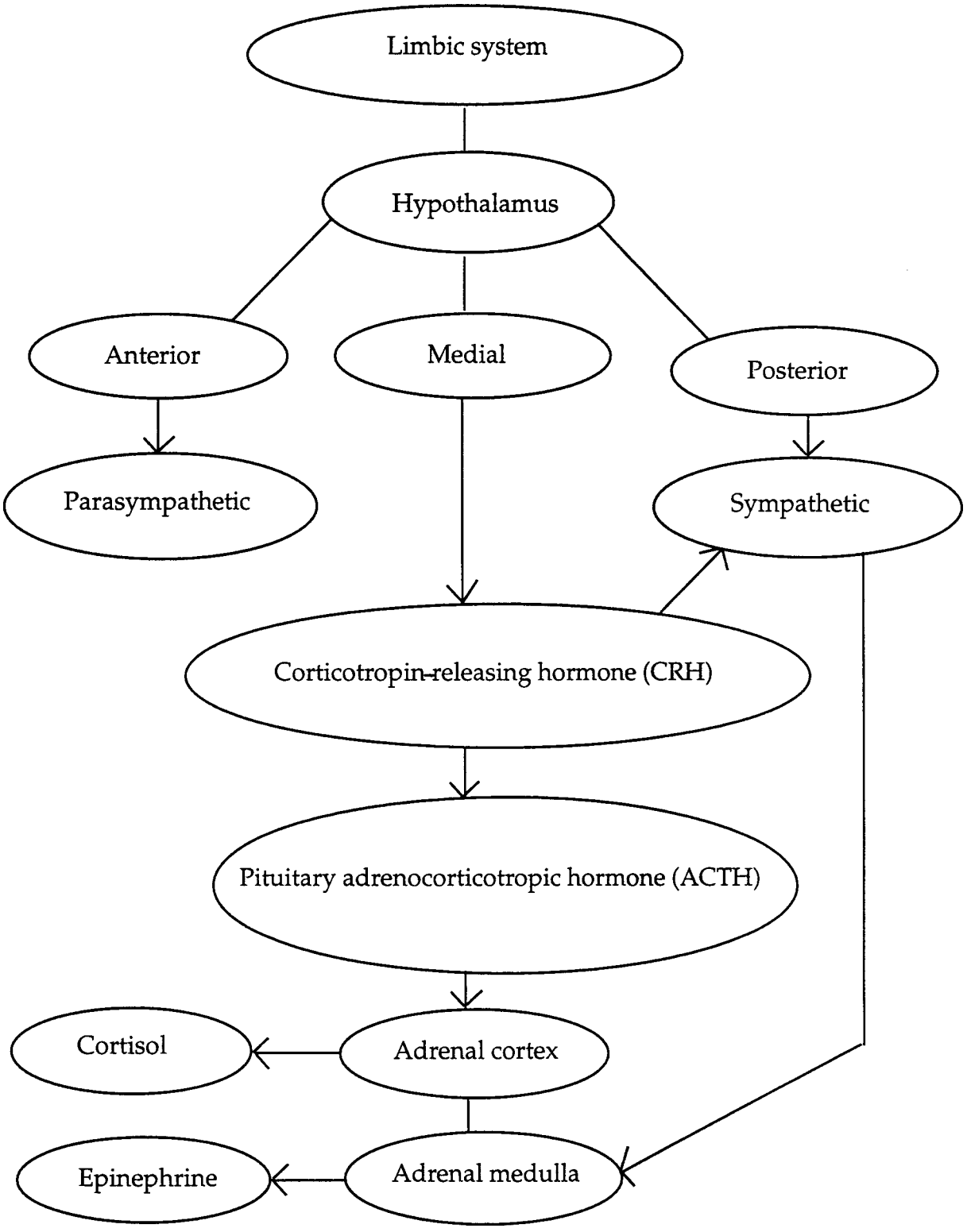
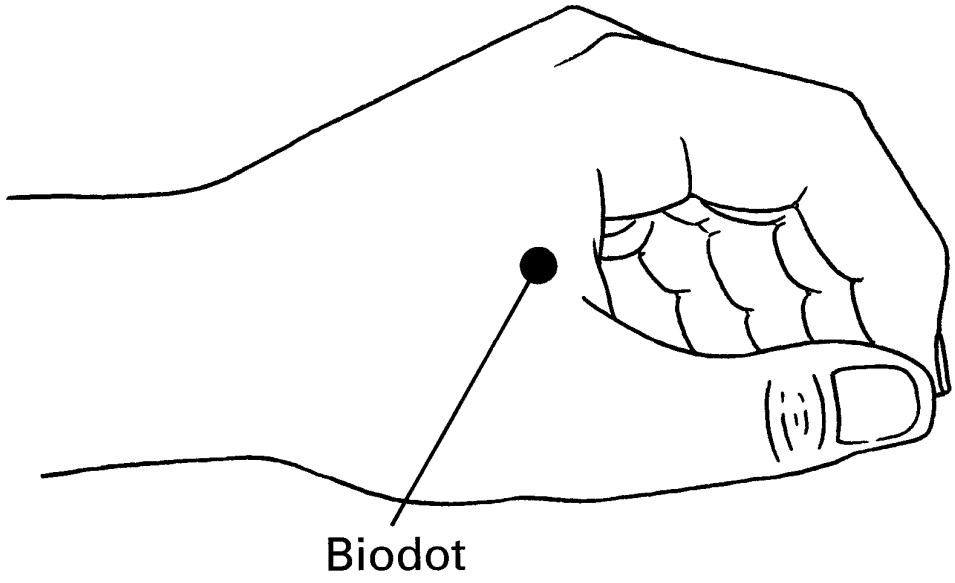
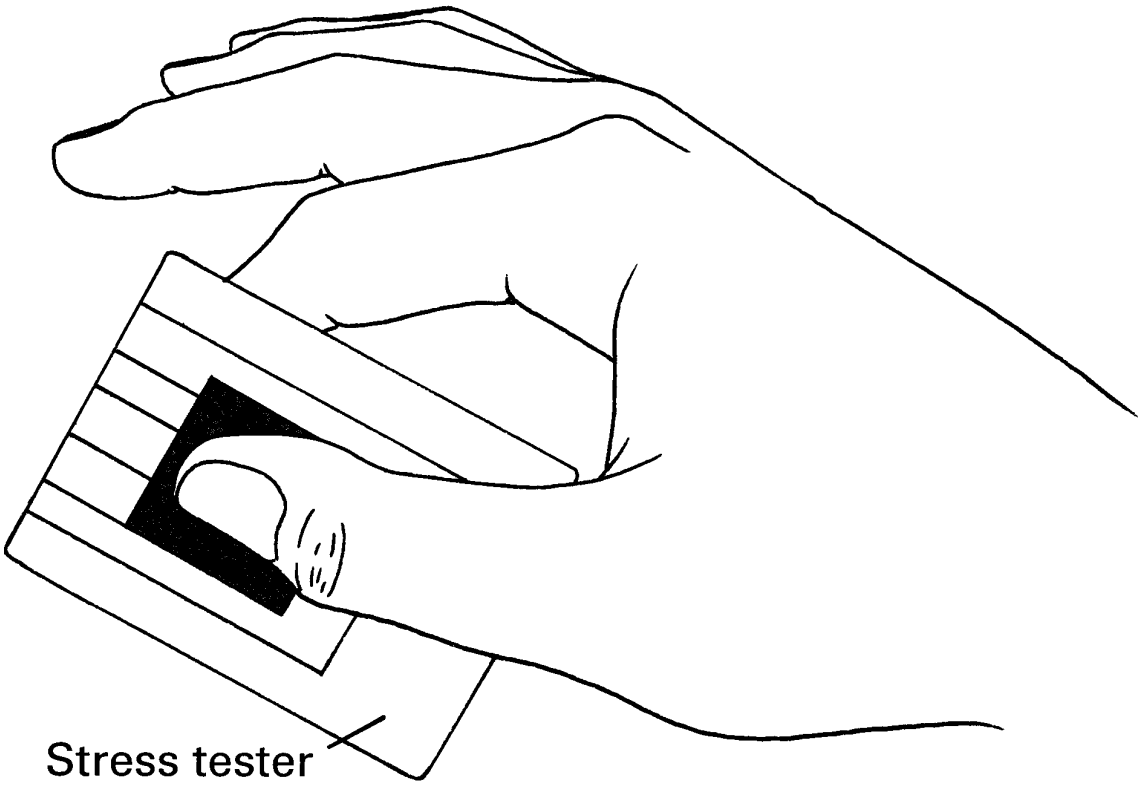


Figure 4. Mediation of stress. Adapted from Figure 2.2 The Three Stress Response Axes. Everly, G.S. Jr. & Sobelman, S.A. (1987). *Assessment of the human stress response.* New York: AMS Press, Inc., p. 22.



a.



b.

Figures 5a. and 5b. Proper way to use the stress feedback sensors for ***Exploration I****.*

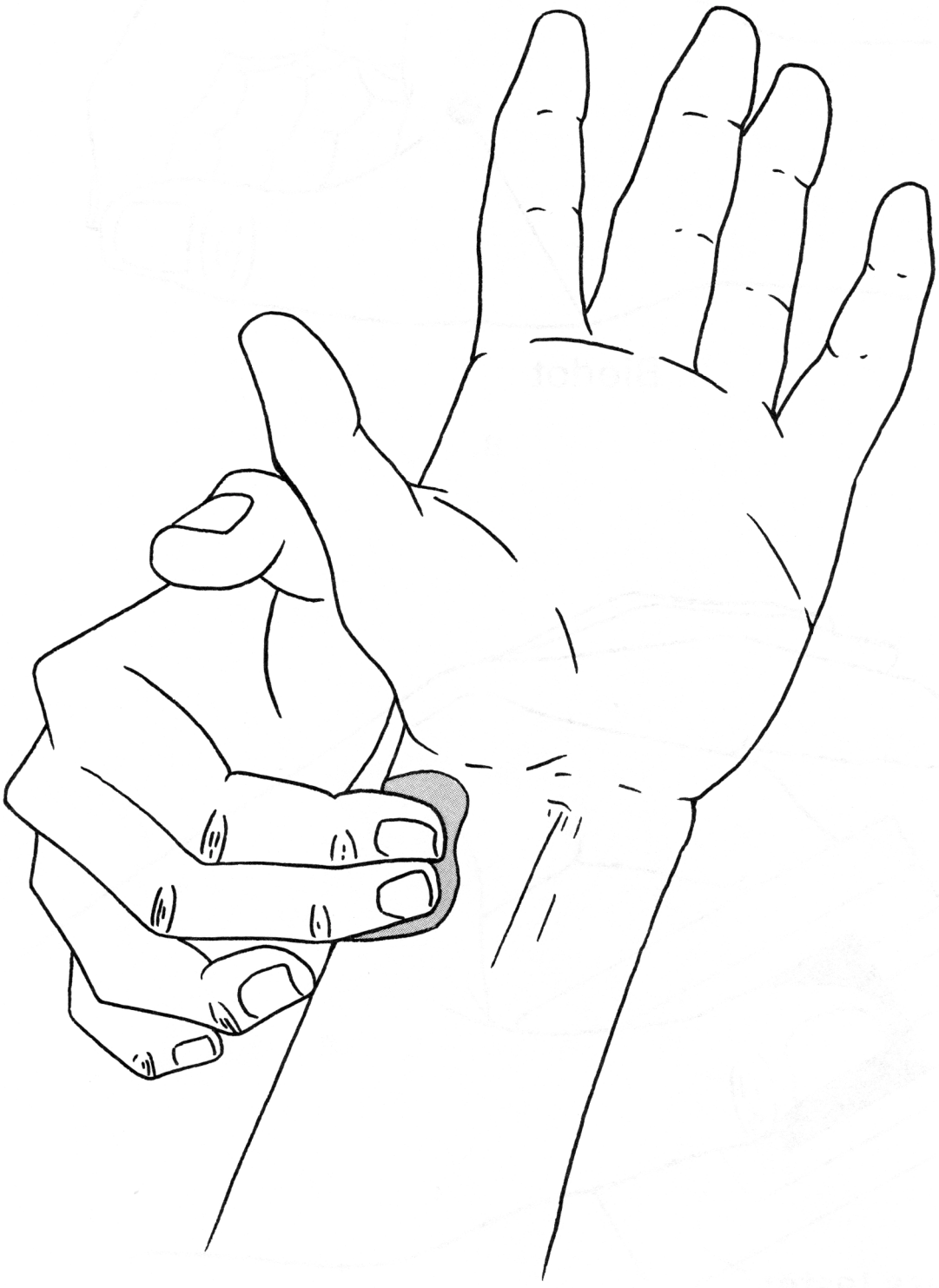


Figure 6. Technique for taking wrist pulse. Note the position of the two fingers on the thumb side of the wrist.