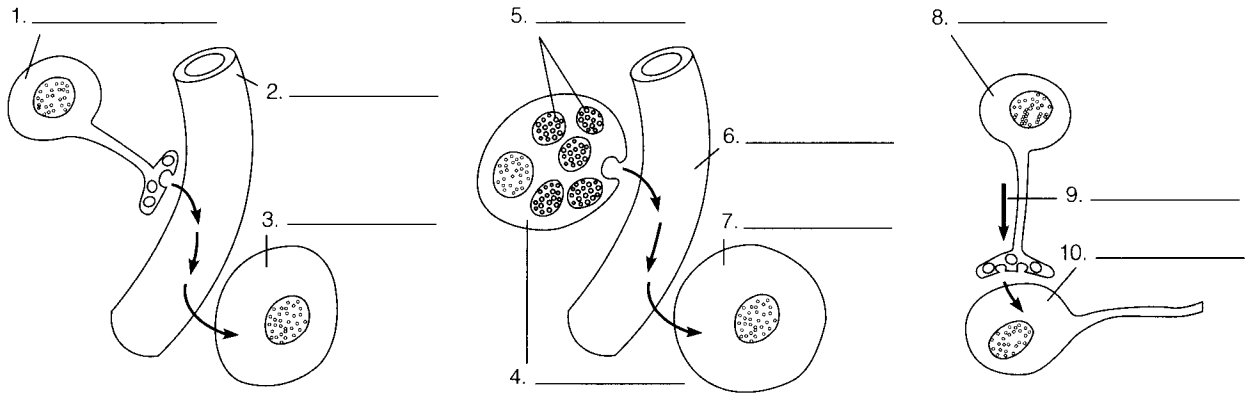
Chemical Regulation 26

As you read this, your blood is carrying dozens of different hormones from endocrine glands to target cells all over your body. These hormones are chemical signals that regulate the activities of every cell. Hormones coordinate the activities of body organs, maintaining homeostasis. Their effects on their targets range from tiny adjustments in chemistry to control of large-scale body processes, such as growth and reproduction. Hormones are produced in minuscule amounts; cells are capable of responding to very subtle signals. Hormones carry specific messages, and each cell is equipped to respond only to certain ones. Different target cells may even respond differently to the same hormone. This subtle and intricate hormone communication and control system is the subject of Chapter 26.

Organizing Your Knowledge

Exercise 1 (Module 26.1)

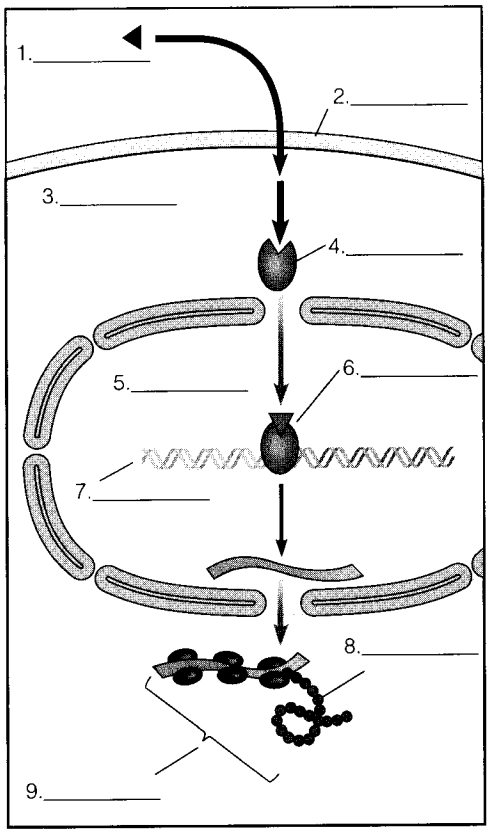
This module describes the roles of chemical signals in the function of the endocrine and nervous systems. Color and label the diagrams below, comparing the activities of endocrine cells, neurosecretory cells, and nerve cells. Label the following: **neurosecretory cell, hormone molecules, nerve signals, endocrine cell, neurotransmitter molecules, secretory vesicles, target cell, blood vessel,** and **nerve cell.** Note that the diagrams are not in the same order as those in the text. Choose a color for each of the cells. Make hormone molecules from the endocrine cell green dots, hormone molecules from the neurosecretory cell blue dots, and neurotransmitter molecules red dots.

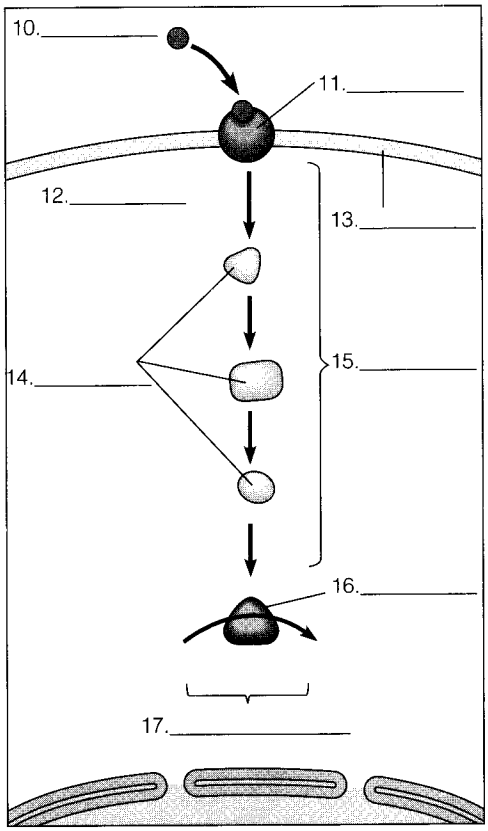


Exercise 2 (Module 26.2)

Web/CD Activity 26A *Overview of Cell Signaling*
Web/CD Activity 26B *Nonsteroid Hormone Action*
Web/CD Activity 26C *Steroid Hormone Action*

Just about everything you need to know about the mechanisms by which hormones affect their target cells is summarized in the two figures in Module 26.2. To review them, label the diagrams below. Choose from: **DNA, steroid hormone, enzyme, receptor protein, plasma membrane, target cell, new protein, signal transduction pathway, epinephrine, cellular response, nucleus, hormone-receptor complex,** and **relay molecules.**

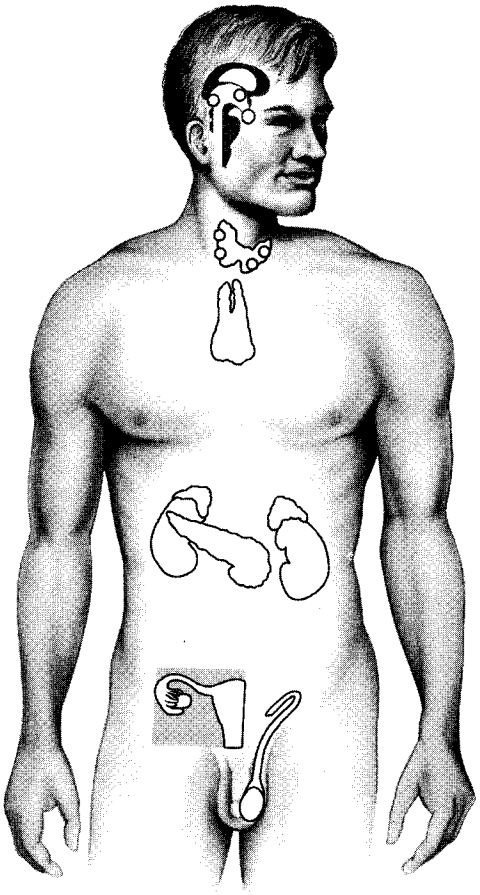




Exercise 3 (Module 26.3)

Web/CD Activity 26D *Human Endocrine Glands and Hormones*

This module is an overview of the glands and hormones discussed in this chapter. You may want to refer back to the diagram and table as references as you read about glands and hormones in the modules that follow. Label the human endocrine glands on the diagram below, and color each one a different color. Choose from **thymus, testis, pineal gland, pituitary gland, adrenal glands, parathyroid glands, pancreas, thyroid gland, hypothalamus,** and **ovary.** Consulting Table 26.3 in the text, list under the name of each gland one of the hormones it produces.



Exercise 4 (Module 26.3)

The table in Module 26.3 is a useful summary of glands, hormones, and hormone actions. Use it to complete the following chart by filling in the blanks. Note that the order of the glands here is different from the table in the text. (You may want to skip this for now and come back to it as a review after you have studied the glands and hormones in the following modules in more detail.)

Gland	*Hormone(s)*	*Action*
1.	2. & 3.	Control metabolic processes
	Calcitonin	4.
Ovaries	5.	6.
	Progesterone	7.
8.	9. & 10.	Trigger "fight or flight" response
11.	Glucocorticoids	12.
	13.	Regulate mineral gain and loss by kidneys
Pancreas	Glucagon	14.
	15.	16.
17.	18.	Raises blood calcium level
19.	Melatonin	20.
21.	22.	Stimulates growth
	Thyroid-stimulating hormone	23.
	Prolactin	24.
	25.	Stimulates adrenal cortex
	Luteinizing hormone	26.
	27.	Stimulates egg and sperm production
Posterior pituitary	Oxytocin	28.
	29.	Promotes water retention by kidneys
Thymus	30.	31.
32.	Androgens	33.
34.	Hormones that regulate anterior pituitary; hormones released by posterior pituitary	Affect pituitary

Exercise 5 (Modules 26.4 - 26.5)

The hypothalamus and pituitary glands are closely related and tie the nervous and endocrine systems together. But the anterior and posterior lobes of the pituitary do different jobs and are controlled in different ways. State whether each of the following relates to the hypothalamus (H), anterior lobe of the pituitary (A), or posterior lobe of the pituitary (P).

____ 1. Stores and secretes hormones actually made in the hypothalamus
____ 2. Secretes releasing and inhibiting hormones that stimulate the anterior pituitary
____ 3. Composed of nonnervous, glandular tissue
____ 4. Part of the brain
____ 5. Where the hormones oxytocin and ADH are released into the blood
____ 6. Responds to releasing and inhibiting hormones from the hypothalamus
____ 7. Secretes growth hormone, ACTH, and thyroid-stimulating hormone
____ 8. Is the terminus of neurosecretory cells from the hypothalamus
____ 9. Most hormones that it secretes influence other endocrine glands
____ 10. Exerts master control over the endocrine system
____ 11. Consists of nervous tissue and is actually an extension of the hypothalamus
____ 12. Negative feedback usually acts on this part of the system
____ 13. Blood vessels carry releasing hormones from here to the anterior pituitary
____ 14. Along with the brain, it secretes the body's natural painkillers

Exercise 6 (Modules 26.4 - 26.6)

Most people know at least a little about the thyroid gland. Once you understand that thyroid hormones stimulate metabolism, it is easy to remember the symptoms of over- and undersecretion and the effects of thyroid medication. Review the thyroid gland by matching each phrase on the right with a substance on the left.

A. Iodine
B. T_3
C. TSH
D. T_4
E. TRH

____ 1. Secreted by hypothalamus; stimulates anterior pituitary
____ 2. Secreted by anterior pituitary; stimulates thyroid
____ 3. Hormone secreted by thyroid
____ 4. Another hormone secreted by thyroid
____ 5. Needed for the manufacture of thyroid hormones
____ 6. T_3 and T_4 signal the hypothalamus to stop making this
____ 7. Goiter occurs if there is not enough of this in the diet
____ 8. Also called thyroxine

Exercise 7 (Module 26.7)

Two opposing, or antagonistic, hormones control the balance of calcium in the blood. To review calcium homeostasis, study Figure 26.7 in the text. Use it to help you choose the correct italicized words to complete the following paragraph.

Calcium is important for nerve impulse transmission, muscle contraction, transport of molecules through cell membranes, and (1) *digestion, protein synthesis, blood clotting.* Blood calcium concentration is held in a narrow range by the thyroid and parathyroid glands. If blood calcium drops, the (2) *thyroid gland, parathyroid glands* increase(s) secretion of (3) *parathyroid hormone, calcitonin.* This causes (4) *increased, decreased* reabsorption of calcium as the kidneys form urine, (5) *increased, decreased* absorption of calcium from food, and (6) *release of calcium from, deposition of calcium in* bone. If blood calcium concentration climbs too high, (7) *parathyroid hormone, calcitonin* is secreted by the (8) *thyroid gland, parathyroid glands.* This causes (9) *increased, decreased* reabsorption of calcium in the kidneys, and (10) *release of calcium from, deposition of calcium in* bone.

Exercise 8 (Modules 26.8 - 26.9)

To understand how the pancreas controls blood sugar, you need to remember only two things: (1) the pancreas makes two hormones, insulin and glucagon, and (2) diabetics have high blood sugar, so many of them take insulin. Given these two facts, you can figure everything else out: If diabetics have to take insulin, insulin must make blood sugar go down. It must make cells take sugar out of the blood and use it or store it. That means glucagon must make blood sugar go up, by causing cells to get it out of storage and put it into the blood. Finally, an increase in blood sugar must trigger insulin secretion (to make sugar go down), so a drop in blood sugar must trigger glucagon secretion (to make blood sugar go up).

To review control of blood sugar level, choose either the word *increase(s)* or *decrease(s)* to complete each of the following statements.

1. Eating a meal rich in carbohydrates causes blood glucose to _____.
2. When blood glucose _____, the pancreas secretes more insulin.
3. Insulin causes body cells to _____ their uptake and use of glucose.
4. Insulin also causes glycogen formation by the liver to _____.
5. Insulin therefore causes blood glucose to _____.
6. Between meals, blood glucose levels tend to _____.
7. When blood glucose _____, the pancreas secretes more glucagon.
8. Glucagon causes blood glucose to _____.
9. Glucagon _____ breakdown of glycogen in the liver and release of glucose to the blood.
10. Glucagon also triggers liver cells to _____ conversion of fats to glucose.
11. As blood glucose rises toward the set point, secretion of glucagon _____.
12. In type I diabetes, blood sugar _____ because the body is unable to produce insulin.
13. In type II diabetes, there is a _____ in cells' ability to respond to insulin.
14. Hypoglycemia results from an excess of insulin, which causes a sudden _____ in blood glucose.

Exercise 9 (Modules 26.10 – 26.11)

The adrenal gland is similar to the pituitary in that it is two glands in one. The parts have different jobs and send out different hormones. One of its parts (the medulla) is stimulated by nerve impulses to secrete its hormones, while the other part (the cortex) is stimulated by hormonal signals. The hormones from the adrenal medulla and cortex help the body deal with stress. After reading the modules and studying Figure 26.10 in the text, try to match each of the phrases on the right with adrenal stress hormones, E, M, or G.

E. Epinephrine and norepinephrine
M. Mineralocorticoids
G. Glucocorticoids

____ 1. Increase breathing rate
____ 2. Respond to short-term stress
____ 3. Secreted by the adrenal cortex
____ 4. Also secreted by the adrenal cortex
____ 5. Increase blood volume and pressure in response to long-term stress
____ 6. Triggered by nerve impulses from the hypothalamus
____ 7. Secreted by the adrenal medulla
____ 8. Cause proteins and fats to be broken down to make glucose
____ 9. Triggered by ACTH from the pituitary
____ 10. Also triggered by ACTH from the pituitary
____ 11. Suppress the inflammatory response and immune system
____ 12. Cause retention of sodium and water by kidneys
____ 13. Dilate and/or constrict blood vessels, redirecting blood flow
____ 14. Increase metabolic rate
____ 15. Often prescribed to relieve pain from athletic injuries

Exercise 10 (Module 26.12)

Web/CD Activity 26D *Human Endocrine Glands and Hormones*

Sex hormones are discussed in more detail in Chapter 27. After reading Module 26.12, try sketching on a separate sheet of paper a concept map for sex hormones. Refer to Chapter 3, Exercise 10, for a discussion of constructing a concept map. Include the following in your concept map: **testosterone, gonads, estrogens, hypothalamus, FSH and LH, progestins, testes, releasing factor, anterior pituitary, ovaries, sex hormones,** and **steroids.**

Exercise 11 (Summary)

On a separate sheet of paper, briefly describe how the items in each of the following groups are related to one another. They may affect one another, oppose one another, or have something in common.

1. luteinizing hormone estrogens androgens follicle-stimulating hormone
2. oxytocin antidiuretic hormone
3. glucagon glucocorticoids epinephrine
4. glucocorticoids ACTH
5. antidiuretic hormone mineralocorticoids parathyroid hormone calcitonin
6. thyroxine calcitonin T_3
7. glucagon insulin
8. glucocorticoids epinephrine mineralocorticoids norepinephrine
9. ACTH LH growth hormone FSH TSH prolactin
10. calcitonin parathyroid hormone
11. oxytocin prolactin

Testing Your Knowledge

Multiple Choice

1. Another system that works closely with the endocrine system to control body processes is the
   a. circulatory system.
   b. immune system.
   c. digestive system.
   d. nervous system.
   e. muscular system.

2. Every time you eat a cookie or candy bar, your blood sugar increases. This triggers an increase in the hormone
   a. thyroxine.
   b. epinephrine.
   c. adrenocorticotropin (ACTH).
   d. glucagon.
   e. insulin.

3. Every hormone
   a. is a protein.
   b. is produced in response to stress.
   c. is under the control of the pituitary gland.
   d. enters a cell and interacts with DNA.
   e. acts as a signal between cells.

4. Researchers have found increased levels of hormones from the _____ in the blood of students preparing for final exams. These hormones are produced in response to stress.
   a. thyroid gland
   b. pineal gland
   c. posterior pituitary
   d. adrenal glands
   e. parathyroid glands

5. Which of the following hormones have antagonistic (opposing) effects?
   a. thyroxine and calcitonin
   b. insulin and glucagon
   c. growth hormone and epinephrine
   d. ACTH and glucocorticoids
   e. epinephrine and norepinephrine

6. What is the role of a receptor in hormone action?
   a. It signals a cell to secrete a hormone.
   b. It informs a gland as to whether its hormones are having an effect.
   c. It enables a target cell to respond to a hormone.
   d. It stops hormone action when it is no longer needed.
   e. It carries a hormone while it is in the blood.

7. When a boy goes through puberty, the steroid hormone testosterone "puts hair on his chest" by
   a. interacting with DNA in the nuclei of cells.
   b. causing cells to change shape.
   c. altering the permeability of plasma membranes.
   d. triggering nerve impulses in cells.
   e. turning enzymes on.

8. A hormone from the parathyroid glands works in opposition to a hormone from the _____ to regulate _____.
   a. posterior pituitary . . . metabolic rate
   b. thyroid gland . . . blood calcium
   c. pancreas . . . water reabsorption
   d. adrenal medulla . . . blood calcium
   e. thyroid gland . . . blood glucose

9. Some glands produce hormones that stimulate other endocrine glands. Which of the following hormones specifically acts to trigger secretion of hormones by another endocrine gland?
   a. thyroxine
   b. progesterone
   c. adrenocorticotropin (ACTH)
   d. antidiuretic hormone (ADH)
   e. melatonin

10. How is the level of thyroxine in the blood regulated?
    a. Thyroxine stimulates the pituitary to secrete thyroid-stimulating hormone (TSH).
    b. TSH inhibits secretion of thyroxine from the thyroid gland.
    c. TSH-releasing hormone (TRH) inhibits secretion of thyroxine by the thyroid gland.
    d. Thyroxine stimulates the hypothalamus to secrete TRH.
    e. Thyroxine and TSH inhibit secretion of TRH.

11. Steroid hormones are produced only by the
    a. adrenal medulla and pancreas.
    b. thyroid gland and pancreas.
    c. anterior and posterior pituitary.
    d. thyroid gland and sex organs.
    e. sex organs and adrenal cortex.

12. It usually takes much longer for sex hormones and other steroids to produce their effects than it takes for most nonsteroid hormones. Why?
    a. Steroids are bigger, slower molecules.
    b. Steroids usually must be carried longer distances by the blood.
    c. Steroids cause target cells to make new proteins, which takes time.
    d. Steroids must relay their message via a receptor.
    e. It takes longer for endocrine cells to make and secrete steroids.
13. The pituitary is actually two glands. The anterior lobe of the pituitary secretes its hormones when stimulated by _____, and the posterior lobe of the pituitary secretes its hormones when stimulated by _____ .
    a. hormones from the adrenal cortex . . . hormones from the thyroid
    b. hormones from the hypothalamus . . . nerve impulses from the hypothalamus
    c. hormones from the hypothalamus . . . hormones from the thyroid
    d. nerve impulses from the hypothalamus . . . hormones from the hypothalamus
    e. hormones from the pineal gland . . . hormones from the pancreas
14. Injections of a hormone are sometimes given to strengthen contractions of the uterus during childbirth. What hormone might this be?
    a. adrenocorticotropin (ACTH)
    b. thyroxine
    c. oxytocin
    d. insulin
    e. follicle-stimulating hormone (FSH)
15. Which of the following hormones has the broadest range of targets?
    a. ADH
    b. prolactin
    c. TSH
    d. epinephrine
    e. calcitonin

Essay

1. The pituitary is often called the master gland. In what way is this true? In what way is it misleading?
2. Compare how the adrenal cortex and adrenal medulla deal with stress.
3. How are hormones and neurotransmitters alike? How are they different?
4. Briefly describe an example of a hormonal disease or abnormality in which
    a. too much hormone is secreted.
    b. not enough hormone is secreted.
    c. hormone is secreted in a normal amount, but cells fail to respond.
5. Why are glucocorticoids useful in treating injuries? Why is prolonged use of glucocorticoids risky?
6. Describe two different situations in which a pair of hormones have opposite (antagonistic) effects on the body.

Applying Your Knowledge

Multiple Choice

1. Jet lag occurs when a person moves rapidly from one time zone to another, causing conflict between the body's biological rhythm and the new cycle of light and dark. Some scientists suspect that jet lag may result from disruption of a daily hormone cycle. Which of the following hormones do you think is the most likely suspect?
    a. epinephrine
    b. insulin
    c. melatonin
    d. estrogen
    e. prolactin
2. Which of the following hormones triggers secretion of the other two?
    a. thyroxine
    b. thyroid-stimulating hormone (TSH)
    c. TSH-releasing hormone (TRH)
    d. Any of the above can trigger secretion of the others.
    e. None of the above can trigger secretion of the others.
3. A tumor in an endocrine gland caused Jennifer to have weakened bones and unusually high levels of blood calcium. Which of the following was affected?
    a. anterior pituitary
    b. pancreas
    c. adrenal glands
    d. parathyroid glands
    e. thymus

4. Which of the following exerts control over all the others?
   a. adrenal cortex
   b. hypothalamus
   c. thyroid gland
   d. anterior pituitary
   e. testes

5. Because only the _____ gland uses iodine to make its hormones, radioactive iodine is sometimes used as a treatment for tumors of this gland.
   a. pituitary
   b. pancreatic
   c. thyroid
   d. adrenal
   e. testicular

6. Diabetes insipidus is an inherited endocrine malfunction (unrelated to diabetes mellitus) in which the kidneys fail to reabsorb normal amounts of water. Victims of this disease produce gallons of urine each day, and their kidneys soon wear out. Treatment of this disease involves replacing a missing hormone. Which of the following do you think it is?
   a. glucagon
   b. epinephrine
   c. glucocorticoids
   d. antidiuretic hormone (ADH)
   e. thyroid-stimulating hormone (TSH)

7. In an experiment, researchers removed the ____ of young mice, and as a result, these mice were able to accept organ transplants without rejection.
   a. pineal glands
   b. thymus glands
   c. thyroid glands
   d. parathyroid glands
   e. adrenal glands

8. Tim once suffered a severe allergic reaction to a bee sting. The sting caused him to suffer a near-fatal drop in blood pressure called anaphylactic shock. Now he carries a kit containing a syringe of _____, which he can inject to speed up his heart if he reacts to a bee sting.
   a. insulin
   b. thyroxine
   c. testosterone
   d. calcitonin
   e. epinephrine

9. It has been found that certain salamanders fail to go through the normal transformation from tadpole to adult if there is a shortage of iodine in the pond water in which they live. This makes it impossible for the _____ to manufacture hormones necessary for normal development.
   a. thyroid gland
   b. posterior pituitary
   c. adrenal cortex
   d. pineal gland
   e. pancreas

10. As a young girl, Maria suffered a head injury that damaged her pituitary. An injury to the pituitary is particularly serious because of all the functions controlled by this gland. As Maria got older, she and her doctors found that all of the following except _____ were affected.
    a. metabolic rate
    b. growth
    c. her menstrual cycle
    d. milk production
    e. blood calcium level

Essay

1. Hypoglycemia is a condition in which blood sugar drops to abnormally low levels. What seems to be the cause of hypoglycemia? Why would it not be a good idea to try to correct this problem by eating more sugar?

2. One of the symptoms of severe diabetes mellitus is breath that has a sweetish, acetone smell. The smell comes from by-products of fat breakdown in the body. If another consequence of diabetes is excess sugar in the blood, why do the cells not just use the sugar instead of breaking down fat?

3. A tumor can cause enlargement of the thyroid gland. How could this result in abnormally high metabolic rate and body temperature? How could similar symptoms be produced by a tumor of the pituitary gland?

4. Some hormones, such as ADH, act on very specific targets (for ADH, the kidney). Other hormones, such as insulin, are able to affect every cell in the body. Based on what you have learned about how hormones exert their effects on target cells, speculate as to how some hormones can affect many targets, while other hormones affect only one.

5. A chemical called dioxin, or TCDD, is produced as a contaminant during some chemical manufacturing processes. Trace amounts of this substance were present in Agent Orange, a defoliant sprayed on vegetation during the Vietnam War. There has been a continuing controversy over its effects on soldiers exposed to it during the war. Animal tests have shown that dioxin can be lethal and can cause birth defects, cancer, liver and thymus damage, and immune system suppression. But its effects on humans are unclear, and even animal tests are uneven; a hamster is not affected by a dose that can kill a guinea pig. Researchers have discovered that dioxin exerts its effects like a steroid hormone. It enters a cell and binds to a receptor protein, which in turn attaches to the cell's DNA. How might this mechanism help explain the variety of effects of dioxin on different body systems and in different animals?

Extending Your Knowledge

1. Compare communication in the body via nerve impulses and hormones with everyday communication by telephone and letter. What are the characteristics of each? In what situations is each the most useful?
2. A survey indicates that over a quarter million U.S. high school students have used anabolic steroids, synthetic derivatives of testosterone. This number is in addition to the thousands of college and professional athletes who have used these hormones. Why do athletes use anabolic steroids? What are some of the dangers of steroid use? Do you know anyone who has used steroids in this way?
3. Do you know someone who has an endocrine disorder, such as diabetes? How does that person deal with his or her condition? Have there been recent discoveries or developments that have improved treatment of this condition?