chapter 7

Integumentary System and Body Temperature

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Key Terms

apocrine glands (p. 99)
ceruminous glands (p. 100)
conduction (p. 101)
convection (p. 101)
cutaneous membrane (p. 94)
dermis (p. 94)
eccrine glands (p. 100)
epidermis (p. 94)
evaporation (p. 101)
integument (p. 94)
keratin (p. 94)
melanin (p. 96)
radiation (p. 101)
sebaceous glands (p. 99)
stratum corneum (p. 94)
stratum germinativum (p. 94)
subcutaneous layer (p. 95)
sudoriferous glands (p. 99)
thermoregulation (p. 101)

Objectives

1. List seven functions of the skin.
2. Discuss the structure of the skin, including:
   - Describe the two layers of skin: the epidermis and the dermis.
   - Define *stratum germinativum* and *stratum corneum*.
   - List the two major functions of the subcutaneous layer.
3. List the factors that influence the color of the skin.
4. Describe the accessory structures of the skin: hair, nails, and glands.
5. Discuss heat production in the body, including:
   - Explain four processes whereby the body loses heat.
   - Describe how the skin helps regulate body temperature.
   - Describe how burns are classified and list ways to protect the skin.

Oh no, a zit! How many times have you looked in the mirror only to see a pimple, rash, wrinkle, or unwanted hair? No other organ in the body is so scrutinized, scrubbed, lifted, and painted over as the skin. Yet, year after year, the skin withstands the effects of harsh weather, the burning rays of the sun, constant bathing, friction, injury, and microorganisms that are constantly trying to penetrate its surface.

The skin, its accessory structures (sweat glands, oil glands, hair, and nails), and the subcutaneous tissue below the skin form the integumentary system.

FUNCTIONS OF THE INTEGUMENTARY SYSTEM

The integumentary (in-teg-yoo-MEN-tar-ee) system is a complex organ that performs many different functions:

- Acts as a mechanical barrier. It keeps harmful substances out of the body and helps retain water and electrolytes. The acid pH of the skin surface serves as a protective chemical barrier.
- Protects the internal structures and organs from injuries caused by blows, cuts, harsh chemicals, sunlight, burns, and pathogenic microorganisms.
- Participates in the immune response against invading microbes by housing specialized cells, called *dendritic* or *Langerhans' cells*. When the skin is broken, the dendritic cells alert the immune system so that it can ward off infection.
- Performs an excretory function. Although excretion is a minor role, the skin is able to excrete water, salt, and small amounts of waste, such as urea.
- Acts as a gland by synthesizing vitamin D when exposed to sunlight. Vitamin D is necessary for the absorption of calcium from the digestive tract.
- Performs a sensory role by housing the sensory receptors for touch, pressure, pain, and temperature. In this way, the skin helps detect information about the environment.
- Plays an important role in the regulation of body temperature.

? Re-Think

What does the integumentary system do for the body?

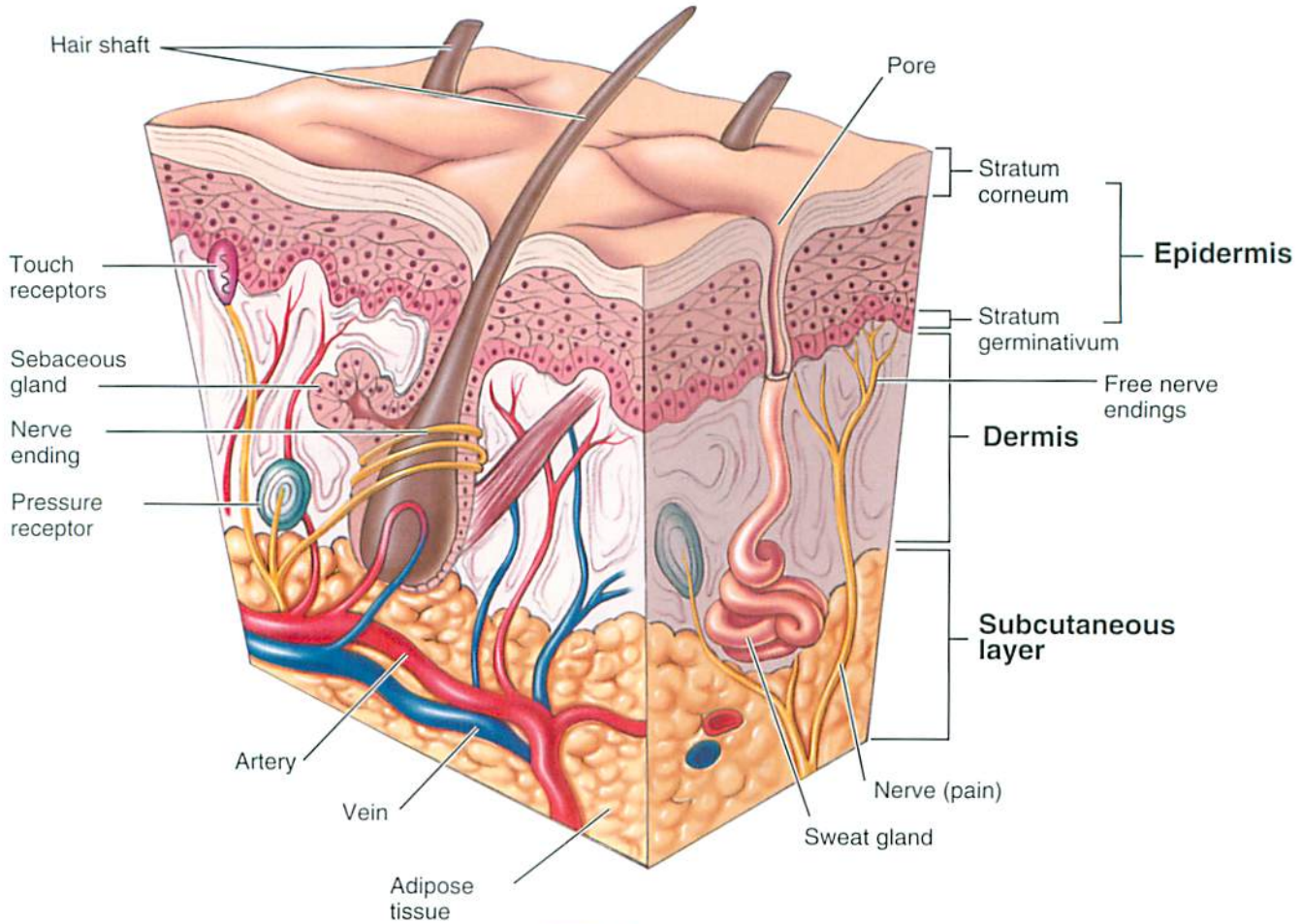


FIGURE 7-1 The skin.

STRUCTURE OF THE SKIN

The skin is called the **integument** or **cutaneous membrane** and is considered an organ; it is the largest organ in the body. The skin has two distinct layers—the outer, or surface, layer is the **epidermis** and the inner layer is the **dermis**. The dermis is anchored to a subcutaneous layer (Figure 7-1). The study of skin and skin disorders is referred to as *dermatology*.

LAYERS OF THE SKIN

EPIDERMIS

The epidermis (ep-i-DER-mis) is the thin outer layer of the skin and is composed of stratified squamous epithelium. Like all epithelial tissue, the epithelium is avascular; it has no blood supply of its own. Oxygen and nutrients, however, diffuse into the lower epidermis from the rich supply of blood in the underlying dermis. The epidermis can be divided into five layers. Two of the layers are the deeper stratum germinativum and the more superficial stratum corneum.

The **stratum germinativum** (jer-mi-nah-TIV-um) lies on top of the dermis and thus has access to a rich supply of blood. The cells of this layer are continuously dividing, producing millions of cells per day. As the cells divide, they push the older cells up toward the surface of the epithelium. As the cells move away from the dermis, two changes take place. First, as they move away from their source of nourishment, the cells begin to die. Second, the cells undergo a process of keratinization, whereby a tough protein, **keratin** (KER-ah-tin), is deposited within the cell. The keratin hardens and flattens the cells as they move toward the surface of the skin. In addition to hardening the cells, the keratin makes the skin water-resistant. Have you ever noticed that your hand does not dissolve when you place it in water?

The **stratum corneum** is the surface layer of the epidermis and is composed of about 30 layers of dead, flattened, keratinized cells. The dead cells are continuously sloughed off, exfoliated (eks-FOH-lee-a-tid), or desquamated (des-kwah-MAY-tid) through wear and tear. The dead sloughed cells are called *dander;* when dander is clumped together by the oil on the skull, it is called *dandruff*. The sloughed cells are replaced by other cells that are constantly moving up from the deeper layers. You shed about 40,000 skin cells each minute; each month you have a new layer of epithelium.

Do You Know...

If Toad Did It?

Did Toad have anything to do with the wart on Helga's nose? No. A wart is an epidermal growth on the skin and is caused by a virus. Although Toad is innocent of this charge, there are several other health concerns. Toad skin can harbor and therefore transmit *Salmonella*, and some toad skins secrete toxins that are harmful to pets and humans. However, from Toad's perspective, handling can damage his skin.

DERMIS

The dermis is located under the epidermis and is the largest portion of the skin; it is composed of dense fibrous connective tissue. It contains numerous collagen and elastin fibers surrounded by a gel-like substance. The fibers make the dermis strong and stretchable; note how well the skin stretches during pregnancy and weight gain. Sometimes, however, excessive stretching of the skin causes small tears in the skin producing white lines. These lines are called stretch marks, or striae (STRYE-ay). The thickness of the epidermis and dermis varies according to the location on the body. Look at the skin on the palms of your hands and the soles of your feet; it is much thicker here than it is over your inner arm or eyelids.

Do You Know...

What's in That Bathtub Ring and What Are You Dusting?

The bathtub ring: What's in it? Dirt, grime...and, yes, a piece of yourself—dead skin (stratum corneum). How much dead skin? A person sheds about 1.5 lb per year, or about 105 lb over a lifetime. This means that you will scrape the equivalent of your entire body from the sides of your tub and watch it go down the drain. Also, about 75% of household dust is human skin flakes. What doesn't wash down the drain gets sucked up by a vacuum cleaner.

Dead skin on your furniture? Dust not only looks nasty but also feeds critters such as the house dust mite *(Dermatophagoides)*. Those who have been diagnosed as having house dust allergy will be relieved to know that they are really allergic to the inhaled feces of the dust mite.

The wavy boundary between the epidermis and dermis resembles the ridges of corrugated cardboard. The interlocking ridges prevent the slippage of the skin layers. More importantly, for you forensic sleuths, the ridges form the fingerprints.

Although derived from the epidermis, the accessory structures such as the hair, nails, and certain glands are embedded within the dermis. Located within the dermis are blood vessels, nervous tissue, and some muscle tissue. Many of the nerves have specialized endings called *sensory receptors* that detect pain, temperature, pressure, and touch.

Re-Think

1. What "happens" in the stratum germinativum?
2. Describe two changes that the cells undergo as they "ascend" to the stratum corneum.

THE SKIN TELLS A STORY

- The skin reflects disease processes in the body. For example, a person with herpes zoster (shingles)—an inflammation of nerves caused by the chickenpox virus—develops painful skin lesions along the path of the nerve. A person with a severe generalized staphylococcal infection may develop scalded skin syndrome, a condition in which the skin appears scalded and peels off in layers. Many clinical disorders present initially with skin rashes; the rashes offer clues to the underlying problems.
- Drug reactions are often revealed by skin changes. For example, a person allergic to penicillin may develop hives, or urticaria (er-ti-KAIR-ee-ah). Similarly, a person allergic to sulfa drugs may develop a generalized rash that can progress to a lethal syndrome called *Stevens-Johnson syndrome*.
- The skin responds to chronic irritation. Epidermal cell growth increases in response to certain stimuli. For example, constant irritation or rubbing of an area causes the rate of epidermal cell division to increase, producing a thickened area called a *callus*. Constant rubbing of a toe by a poorly fitting shoe can also produce an overgrowth of epidermal cells arranged in a conical shape. This overgrowth is called a *corn*.
- The skin mirrors your stress level. How many times have you become stressed out and then broke out? The skin truly reveals on the outside what is going on inside!

SUBCUTANEOUS LAYER

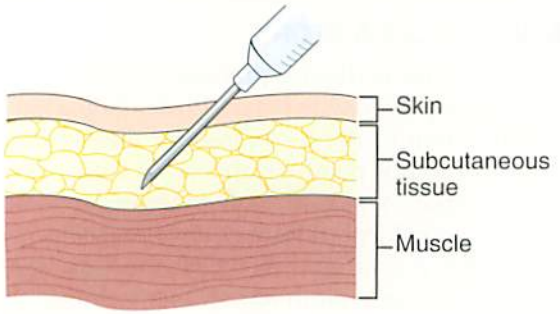
The dermis lies on the subcutaneous layer. This layer is not considered part of the skin; it lies under the skin and is therefore called the **subcutaneous layer**, or the hypodermis. The subcutaneous layer is composed primarily of loose connective and adipose tissue. The subcutaneous tissue performs two main roles: it helps insulate the body from extreme temperature changes in the external environment, and it anchors the skin to the underlying structures. A few areas of the body have no subcutaneous layer and the skin anchors

directly to the bone. Look at the skin over your knuckles. It is wrinkled and creased because it attaches directly to bone. Imagine what you would look like if all your skin were anchored directly to underlying bone.

Do You Know...

How You Inject a Medication into the Subcutaneous Layer?

When injecting medication subcutaneously, you need to use a correctly sized needle and insert the needle at the proper angle. The needle penetrates the epidermis and dermis so that the tip of the needle is located in the subcutaneous layer, where the medication is deposited.



THE SKIN, DRUGS, AND CHEMICALS

The skin can absorb many chemicals; this is good news and bad news. The good news is concerned with drug absorption. Drugs can be placed on the surface of the skin and absorbed transdermally (across the skin) in order to achieve a systemic effect (throughout the body). For example, nitroglycerin can be applied using an adhesive patch on the skin. The drug penetrates the skin, is absorbed by the dermal blood vessels, and is transported by the blood throughout the body where it exerts its effects. The skin can also be used to detect allergies by injecting antigens (possible allergic substances) intradermally. An allergic response will appear as a skin reaction (redness, swelling, and itching). Drugs can also be applied topically; the drug is meant to exert its effect on the surface of the skin. Lastly the subcutaneous route is a common way to inject drugs.

The bad news? Skin can absorb toxins; these include pesticides, cleaning fluids, the acetone in nail polish remover, mercury, and many other toxic chemicals that we encounter daily. Farm workers, exposed to chemical sprays, are commonly treated for pesticide poisoning. Are your hands in household chemicals? Wear gloves, and do not underestimate the ability of the skin to absorb toxins!

Re-Think

Describe the role of the skin in drug administration (i.e., four routes of administration).

SKIN COLOR

Why are there different colors of skin? Skin color is determined by many factors: some genetic, some physiological, and some caused by disease. When we think of skin color, we generally think of black, brown, yellow, and white, as well as the many shades in between! These skin colors are genetically determined.

Deep within the epidermal layer of the skin are cells called *melanocytes*. Melanocytes (meh-LAN-oh-sytes) secrete a skin-darkening pigment called **melanin**; the melanin stains the surrounding cells, causing them to darken. The more melanin secreted, the darker the skin color. Interestingly, we all have the same numbers of melanocytes. What determines our skin color is not the numbers of melanocytes but the amount of melanin secreted. The following factors play a role in changes in skin color:

- *Melanin.* Can melanocytes increase their secretion of melanin? Yes! When exposed to the ultraviolet radiation of sunlight, the melanocytes secrete more melanin. The skin darkens in an attempt to protect the deeper layers from the harmful effects of radiation. This effort creates the famous summer tan. A number of conditions involve malfunctioning melanocytes. If the melanocytes completely fail to secrete melanin, the skin, hair, and the colored part of the eye (iris) are white. This condition is referred to as *albinism*. Other persons develop a condition called *vitiligo* (vit-i-LYE-go). This condition involves a loss of pigment (melanin) in certain areas of the skin, creating patches of white skin. Melanin can also stain unevenly. Freckles and moles are examples of melanin that becomes concentrated in local areas.
- *Carotene.* The yellowish tint of carotene in most persons is hidden by the effects of melanin. Because people of Asian descent have little melanin in their skin, the carotene gives their skin a yellow tint.
- *Blood.* What accounts for the pinkish color of fair-skinned people? So little melanin is produced that the blood in the dermal blood vessels is visible, thereby providing a pinkish tinge to the skin. Poorly oxygenated blood causes the skin to look blue. This condition is called *cyanosis* (sye-ah-NO-sis). Embarrassment causes the blood vessels in the skin to dilate. This condition increases blood flow to the skin, causing the person to blush or flush. What about the saying, "He was white as a sheet"? A person who is scared experiences a constriction of the blood vessels in the skin and a decrease in the amount of oxygenated blood. The resulting pale or ashen color is called *pallor*. A black and blue discoloration (bruise) indicates that blood has escaped from the blood vessels into the injured tissue. A black and blue area is called an *ecchymosis* (ek-ih-MOH-sis).
- *Bilirubin.* Skin color may also change in response to disease processes. A person with liver disease is

unable to excrete a pigment called *bilirubin* (bil-ih-ROO-bin). This pigment is instead deposited in the skin, causing it to turn yellow—a condition known as *jaundice*.

- *Diet*. Finally, skin color may also change in response to diet. For example, it is possible to impart a yellow tint to the skin by overeating carotene-rich vegetables such as carrots.

2+2 Sum It Up!

The integumentary system is composed of the skin and accessory organs (hair, nails, and glands). It is a complex organ that performs many functions. It affords protection for the entire body, acts as a barrier, regulates temperature, detects sensations (e.g., touch, pressure, temperature, and pain), synthesizes vitamin D, participates in the immune response, and acts as an excretory organ. The skin is composed of two layers: the epidermis and dermis. The dermis sits on a subcutaneous layer called the *hypodermis*. There are different colors of skin. Our natural skin color is genetically determined; we are light-skinned, dark-skinned, and many shades in between. Our skin color changes in response to certain stimuli or underlying conditions; these changes include tanning, blushing, cyanosis, and jaundice. The skin can also reveal certain disease states, such as allergic responses, infections, and liver disease. The skin often announces on the outside what is happening on the inside.

? Re-Think

Describe the underlying causes of the following color changes: cyanosis, flushing, pallor, jaundice, tanning, and vitiligo.

ACCESSORY STRUCTURES OF THE SKIN

The skin is the home of several accessory structures, including the hair, nails, and glands.

HAIR

Thousands and thousands of years ago, we humans were a hairy lot. Like our furry pets, we depended on a thick crop of hair to keep us warm. Today, most of the hair covering our bodies is sparse and very fine, with the exception of the hair on our heads (and for some, that too is sparse). The main function of our sparse body hair is to sense insects on the skin before they can sting us. Some body parts are hairless. These include the palms of the hands, soles of the feet, lips, nipples, and parts of the external reproductive organs.

Some areas of hair perform other functions. For example, the eyelashes and eyebrows protect the eyes from dust and perspiration. The nasal hairs trap dust and prevent it from being inhaled into the lungs. The hair of the scalp helps keep us warm and, of course, plays an important cosmetic role.

Hair growth is influenced by the sex hormones estrogen and testosterone. The onset of puberty is heralded by the growth of hair in the axillary and pubic areas in males and females. In the man, the surge of testosterone also produces a beard and hairy chest. Estrogen, of course, does not have this effect. When a woman has too much testosterone, excessive hair growth occurs, including facial hair. The excessive growth of hair is called *hirsutism* (HER-soo-tiz-em), from a Greek word meaning "shaggy." One more thing: apparently, hair growth responds rather well to mind–body signals. The beards of men who have been at sea for an extended period experience a growth spurt of hair when told that they are going ashore.

The chief parts of a hair are the shaft (the part above the surface of the skin) and the root (the part that extends from the dermis to the surface) (Figure 7-2). Each hair arises from a group of epidermal cells that penetrate down into the dermis. This downward extension of epithelial cells forms the hair follicle. The epidermal cells of the hair follicle receive a rich supply of blood from the dermal blood vessels. As these cells divide and grow, the older cells are pushed toward the surface of the skin. As they move away from their source of nourishment, the cells die. Like other cells that compose the skin, the hair cells also become keratinized. The hair that we brush, blow-dry, and curl every day is a collection of dead, keratinized cells.

Hair color is determined by the type and amount of melanin secretion. An abundance of melanin produces dark hair, whereas less melanin produces blond hair. With age, the melanocytes become less active; the absence of melanin produces white hair. Gray hair is caused by a mixture of pigmented and nonpigmented hairs. Interestingly, red hair is caused by a modified type of melanin that contains iron.

Curly, wavy, or straight—this is determined by the shape of the hair shaft. A round shaft produces straight hair, whereas an oval shaft produces wavy hair. Curly and kinky strands of hair are the result of flat hair shafts. Hair can be curled by chemically flattening the hair shafts.

How does Frightened Kitty get her hair to stand on end? Attached to the hair follicle is a group of smooth muscle cells called the *arrector pili* (ah-REK-tor PYE-lye) muscles (see Figure 7-2). Contraction of these muscles causes the hair to stand on end. When frightened, the cat's brain sends its panic message along the nerves to these muscles. The muscles then contract and pull the hair into an upright position. Kitty looks more ferocious with her fur standing on end, and the spiked look helps frighten off her attackers. Her fur also

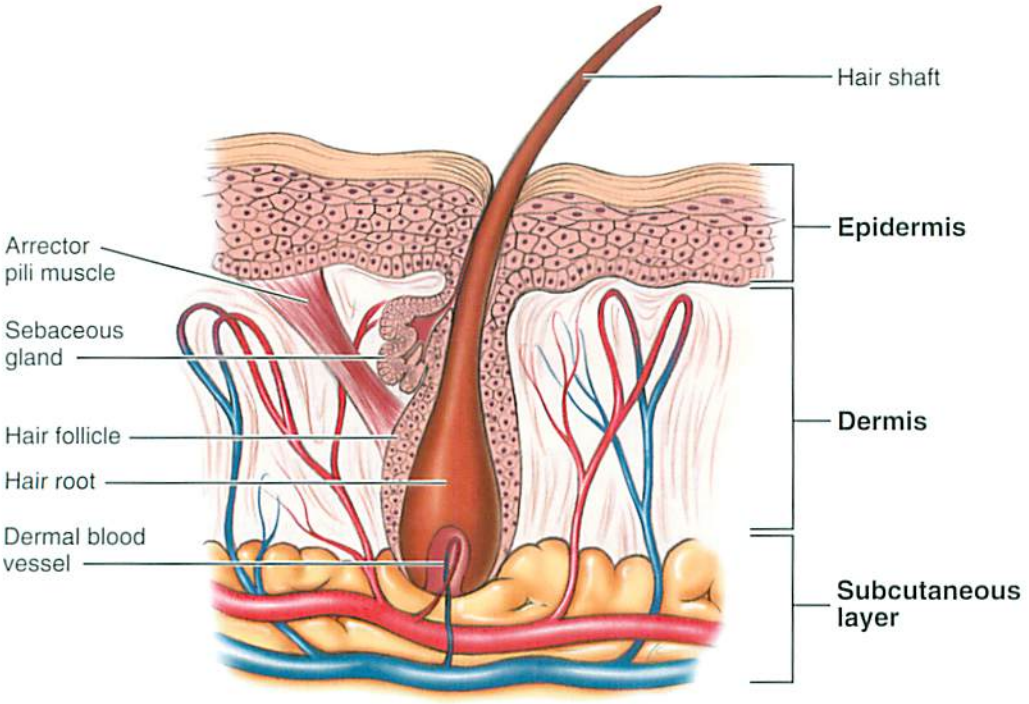
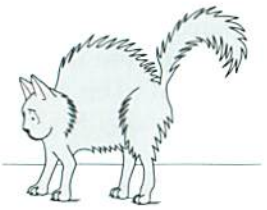


FIGURE 7-2 Hair follicle and parts of the hair.

stands on end when she is cold; the raised fur traps heat and helps keep her warm.



Although humans may not benefit as much from hair as do our furry friends, we respond to fear and cold in the same way. Contraction of the arrector pili muscles also causes our hair to stand on end. As the hair stands, it pulls the skin up into little bumps. This reaction is the basis of goose flesh, or goose bumps. Unlike Kitty, the erect human hair does not do much to trap heat.

Cosmetically, hair is important. Hair loss to the point of baldness is distressing—enter the comb-over. Loss of hair is called *alopecia* (al-o-PEE-sha), which comes from a word meaning "fox mange." The most common type of baldness is male pattern baldness, which is a hereditary condition characterized by a gradual loss of hair with aging—hair today, gone tomorrow! A second common cause of hair loss is related to drug toxicity, as with chemotherapy or radiation therapy. Anticancer drugs are so cytotoxic that they often destroy hair-producing epithelial cells. When drug therapy is terminated, the cells regenerate and start to grow hair again. Interestingly, the new hair may be a different color or texture from the original (pre-drug) hair.

Forensically, hair is a gold mine. For example, arsenic is called *inheritance powder*, because it is a long-time favorite for dispatching wealthy family members. Chronic arsenic poisoning is difficult to detect medically, but analysis of the hair not only detects the presence of arsenic—it can also detect the time course of the poisoning.

Re-Think

1. What is the function of the hair follicle?
2. Differentiate between hirsutism and alopecia.

NAILS

Nails are thin plates of stratified squamous epithelial cells that contain a very hard form of keratin (Figure 7-3). The nails are found on the distal ends of the fingers and toes and protect these structures from injury.

Each nail has the following structures: a free edge, a nail body (fingernail), and a nail root. The cells of the nail body develop and are keratinized in the nail root. The extent of nail growth is represented by the half-moon–shaped lunula (LOO-nyoo-lah), located at the base of the nail. As the nail body grows, it slides over a layer called the *nailbed*, a part of the epidermis. The pink color of nails is caused by the blood vessels in the underlying dermal layer beneath the nail. The cuticle is a fold of stratum corneum that grows onto the proximal portion of the nail body.

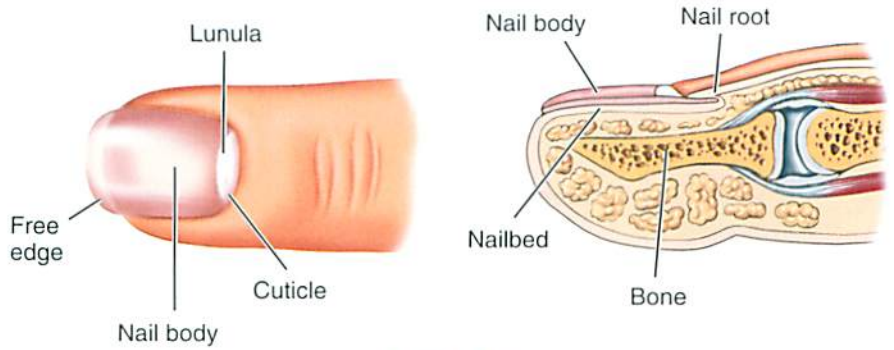


FIGURE 7-3 Nail.

Like the skin, the nails also tell stories. The condition of the nails provides important diagnostic information regarding systemic disease. Nails should be examined for shape, dorsal curvature, adhesion to the nail bed, color, and thickness. Some clinical observations include the following:

- *Clubbing.* Chronic lung and heart disease cause clubbing, a condition that indicates that the fingertips have received an insufficient supply of oxygenated blood over a period of time. Clubbing involves changes in the fingertips and nails; the fingertips enlarge and the nails become thick, hard, shiny, and curved at the free end. With severe clubbing, the nail may detach from its base.
- *In the pink...or not.* Nail color should be pink. Poor oxygenation makes the blood appear bluish-red (cyanosis), which in turn makes the nails appear bluish. Other color changes include pigment bands; these dark bands are normally seen in dark-skinned individuals. When present in light-skinned persons, the bands may indicate melanoma.
- *Brittle.* Nails may also be described as brittle; this is generally caused by poor oxygenation, thyroid gland dysfunction, and nutritional anemia.

? Re-Think

What is clubbing and why is it indicative of heart and/or lung disease?

GLANDS

Two major exocrine glands are associated with the skin: the sebaceous glands and the sweat glands (Figure 7-4).

Most **sebaceous** (seh-BAY-shus) **glands**, or oil glands, are associated with hair follicles and are found in all areas of the body that have hair. They secrete an oily substance called *sebum* that flows into the hair root and then out onto the surface of the skin. A small number of sebaceous glands open directly onto the surface of the skin. The sebum lubricates and helps waterproof the hair and skin, as well as inhibits the growth of bacteria on the surface of the skin. With aging, sebum production gradually decreases. This change accounts, in part, for the dry skin and brittle hair seen in older persons. The sebaceous glands play a unique role in the fetus. Babies are born with a covering that resembles cream cheese. The covering is called the *vernix caseosa* (VERN-iks kay-see-OH-sah) and is secreted by the sebaceous glands. The vernix caseosa protects the skin of the fetus from the macerating effects of amniotic fluid.

Sometimes, the sebaceous glands become blocked by accumulated sebum and other debris. When the sebum is exposed to the air and dries out, it turns black, forming a blackhead. When the blocked sebum becomes infected with staphylococci, it is a pimple (pustule). You have seen the contents of a pimple. Blackhead and pimple formation is common among adolescents, because sebaceous gland activity responds to the hormonal changes associated with puberty. Babies may also have a problem with their sebaceous glands. The sebaceous glands on the scalp can oversecrete sebum, producing oily scales. Because this condition occurs during infancy, the cradle period, it is called *cradle cap*.

Do You Know...

About Blackheads, Pimples, and Worms?

There is a long history of persons squeezing (not a good idea!) or expressing the contents (sebum) of a blackhead or comedo. The expressed sebum resembles a long worm. The ancients concluded that the skin was being eaten into by a worm—hence, the word *comedo* (from a Latin word meaning "to eat into").

The sweat glands, or **sudoriferous** (soo-dor-IF-er-us) **glands**, are located in the dermis (see Figure 7-4). As the name implies, these glands secrete sweat; the sweat is secreted into a duct that opens onto the skin as a pore. An individual has approximately 3 million sweat glands.

Two types of sweat glands are the apocrine and eccrine sweat glands. The **apocrine** (AP-oh-krin) **glands** are usually associated with hair follicles and are found in the axillary and genital areas. The apocrine glands

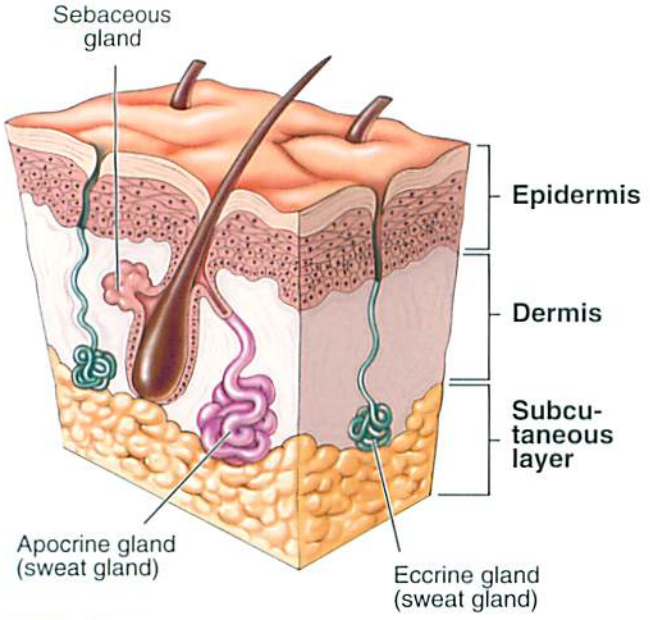


FIGURE 7-4 Skin glands: sebaceous glands and sweat glands.

respond to emotional stress and become active when the person is frightened, upset, in pain, or sexually excited. Because the development of these glands is stimulated by the sex hormones, they become more active during puberty. The sweat produced by these glands does not have a strong odor. If allowed to accumulate on the skin, however, the substances in sweat are degraded by bacteria into chemicals with a strong unpleasant odor. This is called *body odor* and is the reason we use deodorant.

Do You Know...

'Bout Them "Apples"?

In some species of animals, the olfactory area of the brain, the "smell brain," is the largest part of the brain. The survival of these animals depends heavily on the sense of smell. Humans also have a smell brain that, although very small, plays a powerful role in our emotional responses and is responsible for some very strange responses. For example, in Elizabethan times, lovers exchanged "love apples." And where did you get them? You made them. A woman peeled a common apple and placed it in her armpit until it was saturated with her perspiration (thanks to the apocrine glands). The sweat-soaked apple was then given to her lover to smell—for his pleasure, at his leisure.

Some of these secretions act as sex attractants. Watch how eagerly Rover sniffs when a potential mate is in the immediate area. These sex attractants are called *pheromones* (FAIR-o-mohns). The vaginal secretions of an ovulating female contain pheromones called *copulines*. The copulines can cause a testosterone surge (and an urge to merge) in the male.

The **eccrine** (EK-rin) **glands** are the more numerous and widely distributed of the sweat glands. They are located throughout the body and are especially numerous on the forehead, neck, back, upper lip, palms, and soles. Unlike apocrine glands, the eccrine glands are not associated with hair follicles.

The sweat secreted by the eccrine glands plays an important role in body temperature regulation. As sweat evaporates from the skin surface, heat is lost. These are the glands that sweat profusely on hot days or during periods of strenuous exercise. Unlike the apocrine glands, which become active during puberty, the eccrine glands function throughout an entire lifetime. Eccrine secretion is composed primarily of water and a few salts.

Modified sweat glands include the mammary glands and ceruminous (ser-ROO-mi-nus) glands. The mammary glands are located in the breasts and secrete milk. (The secretion of milk is discussed further in Chapter 27.) The **ceruminous glands** are found in the external auditory canal of the ear. They secrete cerumen (seh-ROO-men), or ear wax. This yellow, sticky, waxlike secretion repels insects and traps foreign material. Silkworms and spiders use modified sweat glands to secrete silk and weave intricate webs.

Think all sweat looks the same? Not so! Some dyes, foods, and drugs are excreted in the sweat and may color the sweat in a variety of bright hues. This condition is called *chromhidrosis*.

Re-Think

State the most important roles of the sebaceous, apocrine, and eccrine glands.

Do You Know...

Why Perspiration Is Sensible...or Insensible?

About 500 mL/day of water is normally lost through the skin and is called *insensible perspiration*. If the epidermis is damaged, as in severe burns, the rate of insensible perspiration increases enormously; fluid loss is so great that the untreated patient may die from shock because of low blood volume. The eccrine glands are largely responsible for sensible perspiration. As body temperature rises, as in exercise, the eccrine glands increase the secretion of sweat, thereby cooling the body. When operating maximally, the eccrine glands can secrete 1 gallon of sweat per hour in an attempt to cool the body.

2+2 Sum It Up!

The skin is the home of several accessory structures, including the hair, nails, and glands. There are two major exocrine glands: the sebaceous glands and the sweat glands (also called sudoriferous glands). There are two types of sweat glands: the eccrine glands and the apocrine glands. Modified sweat glands include the ceruminous glands, which secrete ear wax, and the mammary glands, which secrete milk.

BODY TEMPERATURE

Normal body temperature is said to be 98.6° F, although it can range from 97° to 100° F. The temperature, however, fluctuates about 1.8° F in a 24-hour period, being lowest in the early morning and highest in the late afternoon. Body temperature also differs from one part of the body to another. The inner parts of the body (cranial, thoracic, and abdominal cavities) reflect the higher core temperature. The more surface areas (skin and mouth) reflect the cooler shell temperature. For example, the rectal temperature measures core temperature and ranges between 99° to 99.7° F, whereas the oral temperature is about 1° F lower.

Body temperature is maintained by balancing heat production and heat loss. The mechanism whereby the body balances heat production and heat loss is called **thermoregulation**. Failure to thermoregulate causes body temperature to fluctuate; an excessive decrease in body temperature is called *hypothermia* and an excessive increase is called *hyperthermia*. Extreme changes in body temperature are often fatal.

Do You Know...

Why You Shouldn't Offer a Hypothermic Individual a Rum Punch?

Although this is a thoughtful gesture, the alcohol in the rum causes dilation of the blood vessels in the skin, thereby increasing blood flow and the loss of heat. Mr. Hypothermia needs his heat. He may prefer the rum punch, but he is better served with a cup of hot tea.

HEAT PRODUCTION

Heat is thermal energy and is produced by the millions of chemical reactions occurring in the cells of the body. The heat is distributed throughout the body by the blood. The heat produced by metabolizing cells is the basis of body temperature. In the resting state, the greatest amount of heat is produced by the muscles, liver, and endocrine glands. The resting brain produces only about 15% of the heat. Interestingly, the studying brain does not produce much more heat.

The amount of heat produced can be affected by many factors, such as food consumption, the amounts and types of hormones secreted, and physical activity. With exercise, the amount of heat produced by the muscles may increase enormously. The hormonal effects on heat production are dramatically illustrated by persons with thyroid gland disease. The hypothyroid person generally has a lower-than-normal body temperature, but the hyperthyroid person has an elevated temperature. In fact, an extreme hyperthyroid state (thyroid storm) can elevate body temperature into a range that is potentially lethal.

HEAT LOSS

Most heat loss (80%) occurs through the skin. The remaining 20% is lost through the respiratory system (lungs) and in the excretory products (urine and feces). Heat loss occurs by four means: radiation, conduction, convection, and evaporation.

The amount of blood in the dermal blood vessels influences the amount of heat that can be lost or dissipated by radiation, conduction, and convection. **Radiation** means that heat is lost from a warm object (the body) to the cooler air surrounding the warm object. Thus, a person loses heat in a cold room. **Conduction** is the loss of heat from a warm body to a cooler object in contact with the warm body. For example, a person (warm object) becomes cold when sitting on a block of ice (cooler object). Clinically, a cooling blanket may reduce a dangerously high fever. **Convection** is the loss of heat by air currents moving over the surface of the skin. For example, a fan moves air across the surface of the skin, thereby constantly removing the layer of heated air next to the body.

Finally, heat may be lost through evaporation. **Evaporation** occurs when a liquid becomes a gas. For example, when liquid alcohol is rubbed on the skin, it evaporates and cools the skin. Similarly, during strenuous exercise, sweat on the surface of the skin evaporates and cools the body. Note that the evaporation of water is associated with a loss of heat. On a hot humid day, water cannot evaporate from the surface of the skin. Hence, heat loss is diminished. This is why we feel the heat so intensely on a hot humid day.

Check out some of the thermoregulatory mechanisms of some of our animal friends. Squirrels cool off by waving their bushy tails, and elephants flap their wonderful ears. And we all know that Rover pants. On a less appealing note, the vulture cannot sweat and cools itself by excreting waste along its own legs. The vulture? Not a house-friendly pet.

? Re-Think

1. Differentiate between core and shell temperature.
2. What is the origin of body temperature?
3. List three factors that can change heat production.

REGULATION

Normal body temperature is regulated by several mechanisms. The thermostat of the body is located in a part of the brain called the *hypothalamus*. The

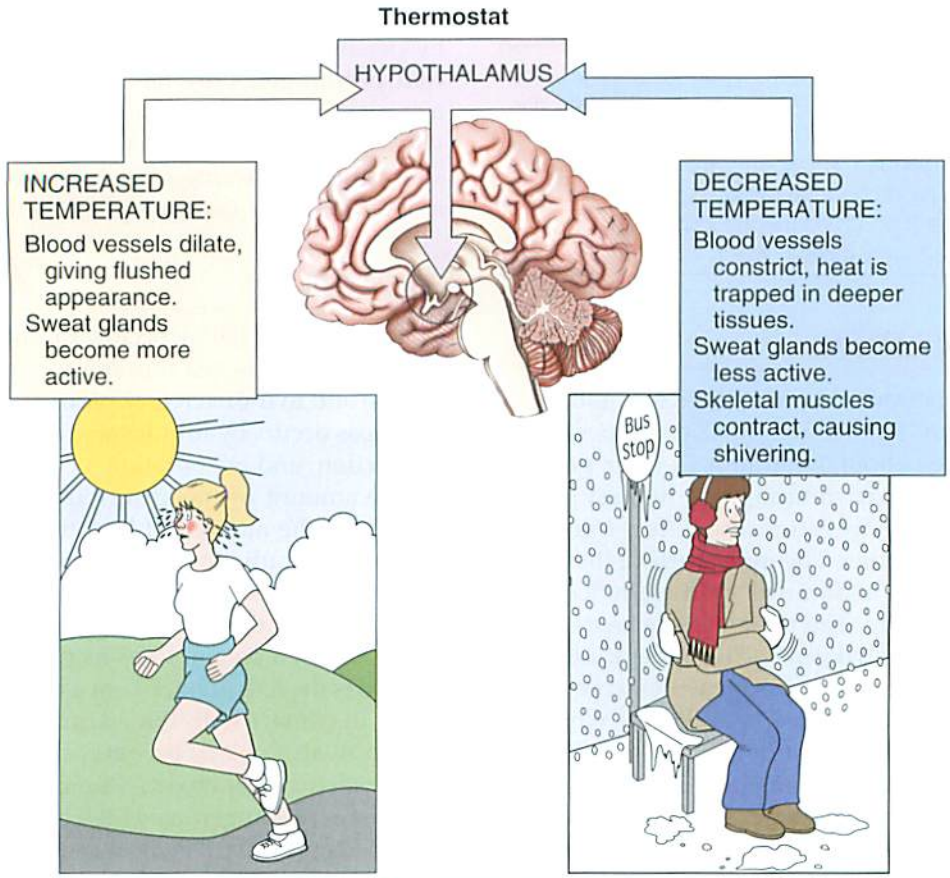


FIGURE 7-5 Temperature regulation.

hypothalamus (hye-poh-THAHL-ah-mus) senses changes in body temperature and sends information to the skin (blood vessels and sweat glands) and skeletal muscle.

With exercise and temperature elevation, the blood vessels dilate, thereby allowing more blood to flow to the skin. This activity transfers heat from the deeper tissues to the surface of the body. Note how flushed our jogger is because of the blood coming to the surface (Figure 7-5). Temperature elevation also stimulates the activity of the sweat glands. As the sweat evaporates from the surface of the body, heat is lost. Under extreme conditions of heat, 12 L of sweat can be secreted in a 24-hour period. These two activities lower body temperature.

What about Mr. Ear Muffs in Figure 7-5? How does his body respond as his temperature decreases? First, the blood vessels constrict, reducing blood flow to the skin. This response traps the blood and heat in the deeper tissues, preventing heat loss. Second, the sweat glands become less active, also preventing heat loss. Third, skeletal muscles contract vigorously and involuntarily, causing shivering and an increase in the production of heat. These three activities raise body temperature. Contraction of the arrector pili muscles causes goose bumps, indicating a decline in body temperature, but contributes minimally to heat production. In furry animals the story is a little different; contraction of the arrector pili muscles pulls the fur upright, thereby trapping warm air. So, it's not good to shave Rover in the winter.

NEWBORNS AND BODY TEMPERATURE

In the delivery room everyone is relieved when Baby (neonate) takes her first breath and delivers her first wail, waa waa waa. Next to establishing respiratory activity, however, is the infant's need to regulate body temperature. In short, the neonate produces only about two thirds of the heat produced by an adult, but loses twice as much. Several factors contribute to the excess heat loss:

- The neonate generally has a large surface area that increases heat loss. (The curled-up position of the infant decreases surface area and conserves heat.) Interestingly, considerable heat is lost from the head area; hence, the use of caps in the newborn nursery.
- The neonate generally has only a thin layer of subcutaneous fat. (Fat acts as an insulator, thus preventing heat loss.)
- The neonate cannot shiver. (Shivering produces heat.)

The neonate, like a squirrel, produces heat by a process called *nonshivering thermogenesis*. A neonate has brown adipose tissue (BAT), or brown fat, scattered throughout its body, especially around the neck and shoulder area. Metabolism of BAT generates more

heat than the metabolism of ordinary adipose tissue (white fat). The heat produced by BAT is picked up by the blood and dispersed throughout the body.

Although we are generally concerned about excessive heat loss in the neonate, we must also be concerned about excess heat. An infant has a very limited capacity to dissipate heat and is therefore at risk for hyperthermia. Do not leave Baby in a hot car!

Re-Think

1. Explain why shivering and vasoconstriction increases body temperature.
2. Explain how the body cools itself.

WHEN SKIN IS BURNED

Large areas of skin are often lost because of burns. Burns are classified according to the depth of the burn and the extent of the surface area burned (Figure 7-6, *A*). On the basis of depth, burns are classified as partial-thickness burns or full-thickness burns. Partial-thickness burns are further divided into first-degree and second-degree burns. A first-degree burn is red, painful, and slightly edematous (swollen). Only the epidermis is involved. Sunburn is an example of a first-degree burn. A second-degree burn involves damage to both the epidermis and dermis. With little damage to the dermis, the symptoms of a second-degree burn include redness, pain, edema, and blister formation. With greater damage to the dermis, the skin may appear red, tan, or white.

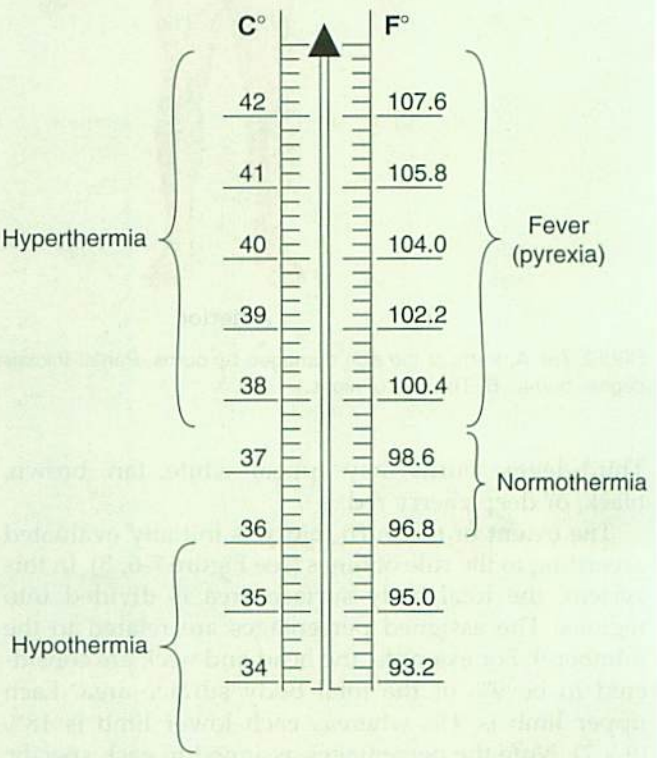
Full-thickness burns are also called *third-degree burns*. With a burn this severe, both the epidermis and dermis are destroyed, often with destruction of the deeper underlying layers. Although first- and second-degree burns are painful, third-degree burns are painless because the sensory receptors have been destroyed.

Ramp It Up!

Temperature Terms and the Body Thermostat

Unlike your cold-blooded pet boa, you are warm-blooded and therefore maintain your body temperature within a narrow range. Body temperature, however, changes under many clinical conditions and gives rise to several confusing terms. Refer to the diagram of the thermometer as we define these terms. The temperatures on the thermometer were recorded orally; temperatures recorded by other techniques (rectal or axillary) are higher or lower.

- *Normothermia.* This refers to the normal range of body temperature from 97° to 99.6°F (36.1° to 37.6°C).
- *Fever (pyrexia).* The right side of the thermometer illustrates an increase in temperature that is called a *fever,* or *pyrexia*. Pyrogenic cytokines, often secreted by pathogens, increase the hypothalamic set point (thermostat). Then, vasoconstriction (to conserve heat) and shivering (to produce heat) cause the body temperature to reach the elevated set point. The set point can be lowered, usually by resolving its cause (often infection) or by the use of a fever-lowering drug (e.g., aspirin), called an *antipyretic*. Then the body loses heat through vasodilation and sweating. Laypersons often describe this late phase as the "fever has broken." A very high, life-threatening fever is called *hyperpyrexia* (105.8°F [41°C]).
- *Hyperthermia.* The left side of the thermometer illustrates hyperthermia and hypothermia. Hyperthermia refers to an elevation of body temperature caused by the inability of the body to get rid of excess heat; the body simply cannot cool itself. The cause of hyperthermia is most often environmental; the person is subjected to prolonged exposure to high temperatures, as in an infant being left in a car during the hot weather. Unlike fever, hyperthermia is not caused by resetting the thermostat; the set point is normal. Treatment measures focus on cooling the body; antipyretics are not effective because the set point is normal. In the advanced state (104°F [40°C]), hyperthermia is called *heat stroke* or *sunstroke* and represents thermoregulatory failure. Death ensues without immediate treatment.
- *Hypothermia.* This refers to a decrease in body temperature and is usually caused by prolonged exposure to cold, as in falling through ice into cold water. Body temperature becomes too low for the body to sustain body metabolism. Death usually ensues when the body temperature drops below 95°F (35°C).



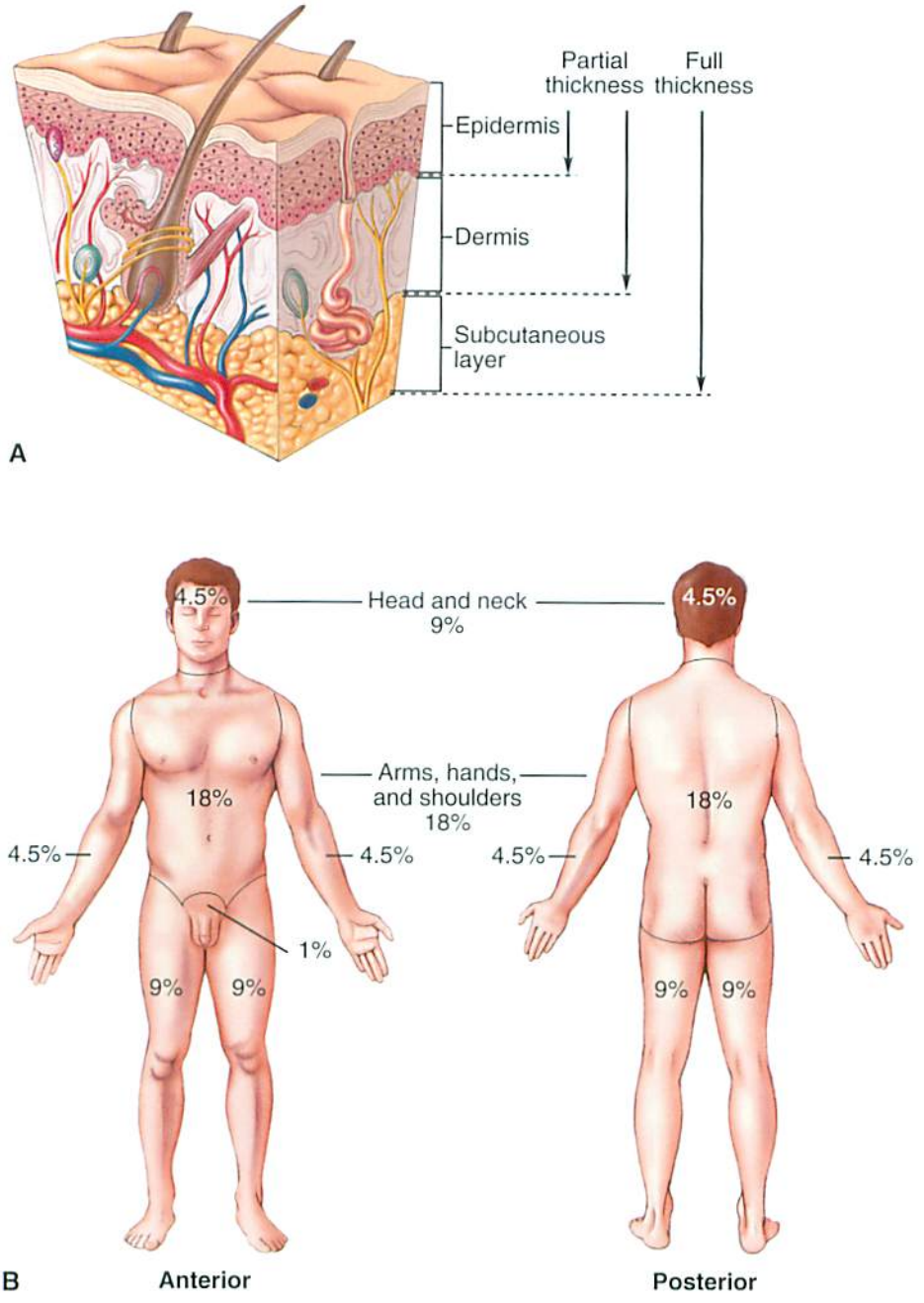


FIGURE 7-6 **A,** Parts of the skin damaged by burns. Partial-thickness (first- and second-degree burns) and full-thickness burns (third-degree burns). **B,** The rule of nines.

Third-degree burns may appear white, tan, brown, black, or deep cherry red.

The extent of the burn injury is initially evaluated according to the rule of nines (see Figure 7-6, *B*). In this system, the total body surface area is divided into regions. The assigned percentages are related to the number 9. For example, the head and neck are considered to be 9% of the total body surface area. Each upper limb is 9%, whereas each lower limb is 18% (9×2). Note the percentages assigned to each specific body region. To determine proper treatment, the clinician needs to evaluate the depth and extent of the burn injury.

ESCHAR

Severe burns are associated with eschar (ESS-kahr) formation. Eschar is dead burned tissue that forms a thick, inflexible, scablike layer over the burned surface. Eschar is a problem for two reasons. First, it may surround an area, such as a leg, and act like a tourniquet, thereby cutting off the flow of blood to the extremity. More seriously, if the eschar surrounds the chest, it prevents chest expansion and breathing. Second, eschar, which is initially sterile, becomes a breeding ground for bacteria and secretes toxins into the blood. These toxins adversely affect various organs in the body, such as the lungs and kidneys. Because eschar

can have such serious consequences, it is often slit (escharotomy) to allow expansion of the burned area or removed to rid the body of a source of toxin.

Re-Think

Explain why an extensive body burn causes fluid and electrolyte imbalance.

A NOTE ABOUT SKIN CARE

The skin is constantly exposed to all sorts of insults, such as the drying effects of soap and water, the damaging effects of the ultraviolet radiation of the sun, friction, numerous bumps, and exposure to sharp objects. Although we cannot avoid normal wear and tear, we can protect the skin in several ways. For example, we can lessen exposure of the skin to ultraviolet radiation. Sunbathing is deadly to the skin. Sun exposure both dries and irreversibly damages the skin. It also makes the skin leather-like and increases the risk of skin cancer and malignant melanoma.

Do You Know...

What "Vagabond Syndrome" Is and Why It Makes You "Feel Lousy"?

The skin of people who continuously harbor body lice becomes hardened and darkly pigmented; this condition is known as *vagabond syndrome*. Chronic infestation of lice also causes the person to feel tired and irritable, hence the term *feeling lousy*.

Skin care is particularly important in older adults. The skin of an older person is normally drier, more easily injured, and slower to heal. Because the skin is so dry, excessive use of soap should be discouraged. Limiting the use of soaps and excessive bathing can help prevent additional drying of the skin. Moreover, maintaining the acid surface of the skin discourages the growth of bacteria. In addition to becoming drier with aging, the skin changes in another important way. Both the dermis and underlying subcutaneous layer become thinner. As a result, older people bruise more easily because the blood vessels are not as well protected. In addition, heat is lost from the blood vessels so that older people often feel cold.

2+2 Sum It Up!

Body temperature is caused by metabolizing cells. Metabolism, in turn, is affected by several factors: food consumption, hormones, exercise, and disease states. Thermoregulatory mechanisms balance heat production and heat loss. These mechanisms include the coordinated activities of the hypothalamus, blood vessels, and sweat glands. Because the skin performs so many vital functions, burns severely compromise many organ systems, often causing death.

As You Age

1. Aging causes a generalized thinning of the epidermis; the epidermal cells reproduce more slowly and are larger and more irregular. These changes result in thinner, more translucent skin.
2. Melanocyte activity decreases, resulting in decreased protection from ultraviolet light and greater susceptibility to sunburn and skin cancer. Selected melanocytes increase melanin production, resulting in brown spots, or age spots, especially in areas exposed to the sun.
3. The dermis becomes thinner, with a decreased amount of collagen and decreased number of elastin fibers. The result is increased fragility of the skin, as well as increased wrinkles. The skin also heals more slowly.
4. There is a decreased number of dermal blood vessels with a slower rate of repair. This change causes the skin to become more susceptible to small hemorrhages and pressure ulcers.
5. Blood vessels in the subcutaneous tissue decrease, so that drugs administered subcutaneously are absorbed more slowly.
6. The amount of adipose tissue in the subcutaneous layer decreases, resulting in increased and wrinkled skin that has a decreased ability to maintain body temperature. The person tends to feel cold.
7. Sebaceous gland activity decreases, resulting in dry, coarse, itchy skin.
8. Sweat gland activity decreases, resulting in decreased ability to regulate body temperature and intolerance to cold.
9. The rate of melanin production by the hair follicle decreases. As a result, hair may become lighter in color, turning gray or white. Hair does not replace itself as often and becomes thinner.
10. Blood supply to the nailbed decreases. Consequently, the nails can become dull, brittle, hard, and thick; their growth rate also slows.

MEDICAL TERMINOLOGY AND DISORDERS Disorders of the Integumentary System

Medical Term	Word Parts	Word Part Meaning or Derivation	Description
Words			
cutaneous	cutane/o-	skin	**Cutaneous** means "relating to the skin," which is comprised of two layers: the epidermis and the dermis.
	-ous	pertaining to	
dermis	derm/o-	skin	The **dermis** is *the thick layer of skin under the epidermis.* Drugs may be administered using the skin.
epidermis	epi-	upon	The **epidermis** is *the layer that lies upon the dermis and forms the outer layer of skin.*
	derm/o-	skin	
melanocyte	melan/o-	black	A **melanocyte** is *an epidermal cell that secretes melanin, a pigment that darkens the skin.*
	-cyte	cell	
thermogenesis	therm/o-	heat	**Thermogenesis** refers to *the production of heat by physiological processes, as in shivering.*
	-genesis	production	
xeroderma	xer/o-	dry	**Xeroderma** refers to *dry skin.*
	-derm/a	skin	
Disorders			
Cancers of the Skin			
nonmelanomas	non-	not	**Nonmelanomas** are *neoplasms that arise from epithelial tissue and most commonly occur on sun-exposed areas of the body.* **Actinic keratosis** (kerat/o- = hard), or **solar keratosis,** is *a premalignant form of squamous cell carcinoma.* **Basal cell carcinoma (BCC)** is *the most common skin cancer and arises from epidermal basal cells that fail to mature and keratinize.* **Squamous cell carcinoma (SCC)** arises from squamous epithelial cells.
	-melan/o-	black	
	-oma	tumor	
malignant melanoma	melan/o-	From the Greek *melas-*, for "dark"	**Malignant melanoma** is *a malignant neoplasm of the melanocytes.* Because of its tendency to metastasize extensively, it is the most deadly form of skin cancer. All moles should be monitored. Remember the **ABCDs** of "mole watch": **A**symmetry, **B**order irregularity, **C**olor, **D**iameter.
	-oma	tumor	
Cutaneous Lesions			
macule	-ule	-ule means "little one"	A **macule** is a flat lesion, also called a blemish. Macules include **freckles, flat mole (nevus), vitiligo, port-wine stains,** the rash of **measles** and **smallpox,** some **drug-induced reactions,** and **petechiae** (pinpoint hemorrhages under the skin). A congenital nevus is a **birthmark.** There are many types of nevi, including **hemangiomas (strawberry mark),** a vascular nevus.
papule		From a Latin word meaning "pustule"	*An elevated lesion that looks like a solid blister.* Examples of a papule include elevated moles **(nevi), lichen planus, insect bites,** some **skin cancers,** and **verrucae** (wart). A **wart** is a contagious viral infection caused by one of the many human papillomaviruses (HPVs). A **nodule** is *a firm papule that extends into the dermis or subcutaneous tissue. Nodules include cysts, lipomas, and fibromas.*
pustule		From a Latin word meaning to "swell up" or "blow up"	*A small pus-containing elevation of the skin that is seen in conditions such as acne and impetigo.* A **pimple** is *a small pustule.*
wheal		From an Old English word meaning "to go round," as a wheel	Also called a **hive.** Multiple hives are called **urticaria,** a pruritic or itchy skin eruption. Urticaria is usually an allergic response to medication, food, and insect venom.
vesicle	vesic/o-	From a Latin word meaning "little bladder"	Also called a **blister.** *A vesicle is a round lesion filled with serous fluid.* Vesicular lesions characterize herpes zoster (shingles), herpes simplex infection, and contact dermatitis. A larger vesicle is called a **bulla.**
	-icle	vesic/o- refers to *bladder,* -icle refers to *small*	

MEDICAL TERMINOLOGY AND DISORDERS Disorders of the Integumentary System—cont'd

Medical Term	Word Parts	Word Part Meaning or Derivation	Description
ulcer		From a Latin word meaning "wound"	*A crater-like lesion formed by the loss of the epidermis and dermis.* Examples include a decubitus ulcer and a chancre. A **decubitus ulcer** is *a pressure-induced ulcer.* A **chancre,** meaning "little ulcer," is *the lesion that develops in response to infection by* Treponema pallidum *(syphilis).*
Disorders of Pigmentation			
hypopigmentation	hypo-	insufficient	**Vitiligo** and **albinism** are conditions of **hypopigmentation,** in which *the melanocytes fail to secrete melanin.*
	-pigment-	pigment	
	-a/tion	state or condition	
hyperpigmentation	hyper-	more than normal	**Hyperpigmentation** is *a condition wherein there is an abnormally high amount of pigment in the skin.* **Dermal melanocytosis (mongolian spots)** is congenital; the spots appear as a blue-gray pigmentation in the sacral area. **Melasma,** related to hormone sensitivity, occurs during pregnancy **("mask of pregnancy")** and with the use of oral contraceptives. **Lentigo** refers to brown to black flat lesions, called **"liver spots,"** often seen in older persons **(senile lentigo).** The spots may occur in sun-exposed areas **(solar lentigo).** Infections, allergic reactions, and trauma can also induce a **post-inflammatory hyperpigmentation.**
	-pigment-	coloring matter	
	-a/tion	state or condition	
Infections of the Skin			
bacterial	bacteri-	Derived from New Latin, from Greek *baktērion,* for "staff"	**Impetigo** (from a word meaning "to attack") is *a bacterial infection that appears most often on the face and is caused by beta-hemolytic streptococci or staphylococci.* It is characterized by vesiculopustular lesions that are itchy and have a thick, honey-colored crust. A **furuncle** is *a deep staphylococcal infection around a hair follicle.* A **carbuncle** is *a group of interconnecting furuncles.* **Cellulitis** is *an inflammation of the subcutaneous tissue and is most commonly caused by* S. aureus *or streptococci.*
	-al	pertaining to	
viral		From a Latin word meaning "poison"	The most common viral infections of the skin are herpes simplex, herpes zoster, and warts. Herpes comes from a word meaning "to creep along," a reference to the progression of the vesicular development. The *herpes varicella* virus causes **chickenpox** (see Chapter 5), a highly contagious infection characterized by pruritic crusty vesicles. **Warts (veruccae)** are hyperkeratotic papular growths caused by the human papillomavirus (HPV).
fungal infections		From a Latin word meaning "mushroom," in reference to the appearance of fungi	**Dermatophytosis,** or **"ringworm,"** refers to *infection by a group of fungi called dermatophytes and occurs primarily in the skin, nails, and hair.* Ringworm conditions are named according to location: **tinea pedis (athlete's foot), tinea cruris ("jock itch"), tinea capitis (scalp), tinea corporis (body), tinea faciei (face), tinea manuum (hands). Candidiasis,** also called **moniliasis,** is a yeast infection caused by *Candida albicans.* **Cutaneous candidiasis** appears primarily in moist areas such as the thigh and beneath the breasts. Other common sights of infection are the mouth and vagina.
infestations and insect bites			There are numerous possibilities with regard to insect bites and infestations. The physiological response is due to a reaction to the venom, or to a reaction to the ova, body parts, or feces of the invading organism. *Infestation with lice* is called **pediculosis** (head, body, and pubic). **Scabies** develops in response to a parasitic mite that seeks out skin creases or folds in which to deposit eggs.

Continued

MEDICAL TERMINOLOGY AND DISORDERS Disorders of the Integumentary System—cont'd

Medical Term	Word Parts	Word Part Meaning or Derivation	Description
Disorders of the Hair and Nails			
onychocryptosis	onych/o-	nail	An **onychocryptosis** is *an ingrown nail, usually on the big toe.* It is most often caused by improper cutting of the toenails or the wearing of tight shoes.
	-crypt/o-	hidden, secret	
	-osis	condition of	
onychomycosis	onych/o-	nail	**Onychomycosis** is called *"ringworm of the nail," a fungal infection.*
	-myc/o-	fungus	
	-osis	condition of	
paronychia	para-	alongside of	A **paronychia** is *a skin infection around the nail usually at the site of a hangnail or cuticle.*
	-onych/o-	nail	
	-ia	condition of	
trichotillomania	trich/o-	hair	**Trichotillomania** is *an impulse control disorder in which the person compulsively twists strands of hair until it breaks off.*
	-tilo-	From a Latin word meaning "I pull out"	
	-mania	abnormal impulse	
Skin Diseases			
acne		From a Latin word meaning "point," as in the point of a pimple	**Acne vulgaris**—*common acne*—is characterized by scaly red skin, comedones (whiteheads and blackheads), papules, nodules, and pustules. These changes are due to sebaceous ducts that are plugged by sebum and dead skin cells.
dermatitis	dermat/o-	skin	**Dermatitis** is *a general term referring to inflammation of the skin.* There are different forms of dermatitis, including contact, seborrheic, and atopic dermatitis. Contact dermatitis may be allergic or irritant dermatitis. Allergic contact dermatitis is a skin allergy to something that touches the skin, as in poison ivy. Irritant contact dermatitis is dermatitis that develops in response to repeated exposure to an irritating substance. Atopic dermatitis, also called *eczema,* from a Greek word meaning "to erupt," is often associated with allergies and asthma. Atopic refers to the genetic predisposition to the allergen. Seborrheic dermatitis is a greasy (skin oil, or sebum), white to yellow scaling on the face (forehead, side of nose), scalp, or genitals.
	-itis	inflammation	
psoriasis	psor-	From a Greek word meaning "to have the itch"	An autoimmune disease often confused with eczema. Psoriasis affects the life cycle of skin cells, causing them to build up on the surface of the skin. The accumulation of skin cells forms thick silvery scales and itchy and painful red patches.

Get Ready for Exams!

Summary Outline

The integumentary system includes the skin, accessory structures, and subcutaneous tissue that covers the body, protects the internal organs, and plays an important role in the regulation of body temperature.

I. Structures: Organs of the Integumentary System

A. Skin

1. Called the *cutaneous membrane* or *integument*
2. Functions: acts as mechanical barrier, protects internal organs, performs immune function, excretes waste, synthesizes vitamin D, houses sensory receptors, contributes to temperature regulation
3. Has two layers: an outer layer called the *epidermis* and an inner layer called the *dermis*
4. The epidermis has five layers. The stratum germinativum is the layer in which cell division takes place. The outer layer is the stratum corneum and consists of flattened, dead, keratinized cells.
5. The dermis is the largest part of the skin and contains blood vessels, nerves, and sensory receptors.

6. The dermis lies on the subcutaneous tissue.
7. Skin color is determined by many factors, some genetic, some physiological, and some caused by disease. Melanin causes skin to darken. Carotene causes skin to appear yellow. The amount of blood in the skin affects skin color (e.g., flushing) as does the appearance of abnormal substances such as bilirubin (jaundice) and a low blood oxygen content (cyanosis).

B. Accessory structures of the skin
1. The location of the hair determines its function. Eyebrows and eyelashes protect the eyes from dust and perspiration.
2. Main parts of a hair: shaft, root, and follicle
3. Hair color: determined by the amount and type of melanin
4. Nails are thin plates of stratified squamous epithelial cells that contain a hard form of keratin.
5. Two major exocrine glands: sebaceous glands and sweat glands
6. Sebaceous glands secrete sebum (lubricates hair and skin). In the fetus, these glands secrete vernix caseosa, a cheeselike substance that coats the skin of a newborn.
7. Two types of sweat glands (sudoriferous glands): apocrine glands and eccrine glands (especially important in temperature regulation)
8. Modified sweat glands: Mammary glands secrete milk and the ceruminous glands secrete ear wax.

C. Subcutaneous tissue (hypodermis)
1. Anchors the dermis to underlying structures
2. Acts as an insulator; it prevents heat loss.

II. Regulation of Body Temperature (Thermoregulation)

A. Heat production
1. Heat produced by metabolizing cells constitutes the body temperature.
2. Shivering and nonshivering thermogenesis

B. Heat loss
1. Most of the heat (80%) is lost through the skin.
2. Heat loss occurs through radiation, conduction, convection, and evaporation.
3. Normal body temperature: set by the body's thermostat in the hypothalamus
4. Heat: lost through sweating and vasodilation. Heat is conserved by vasoconstriction and produced by shivering.

III. When Skin Is Burned

A. Physiological effects
1. Short-term effects (e.g., fluid and electrolyte losses, shock, inability to regulate body temperature, infection)
2. Long-term effects (e.g., scarring, loss of function, and cosmetic and emotional problems)

B. Classification of burns
1. Classified according to the thickness of the burn (partial, full); also first-, second-, and third-degree burns
2. The rule of nines is a way to evaluate burns.

Review Your Knowledge

Matching: Skin

Directions: Match the following words with their descriptions below. Some words may be used more than once.

a. keratin
b. dermis
c. subcutaneous layer
d. epidermis

1. ___ Thin outer layer of skin
2. ___ Layer that sits on the hypodermis and supports the epidermis
3. ___ A protein that flattens, hardens, and makes the skin water-resistant
4. ___ A layer of insulation
5. ___ Contains the stratum germinativum and stratum corneum
6. ___ Contains blood vessels that nourish the stratum germinativum

Matching: Glands

Directions: Match the following words with their descriptions below. Some words may be used more than once.

a. eccrine
b. sebaceous
c. ceruminous
d. mammary

1. ___ Oil glands
2. ___ Glands that secrete vernix caseosa
3. ___ Glands that play a crucial role in body temperature regulation
4. ___ Modified sweat glands that secrete ear wax
5. ___ Modified sweat glands that secrete milk
6. ___ Classified as sudoriferous
7. ___ Most related to blackhead, pimple, and cradle cap
8. ___ Pours sweat during intense exercise

Matching: Colors

Directions: Match the following words with their descriptions below. Some words may be used more than once.

a. jaundice
b. cyanosis
c. melanin
d. vitiligo
e. ecchymosis

1. ___ Tanning pigment
2. ___ Condition in which the skin has a bluish tint because of poor oxygenation
3. ___ Yellowing of the skin because of bilirubin
4. ___ Patches of white skin caused by loss of pigmentation
5. ___ Black and blue mark; bruising

Multiple Choice

1. Which of the following is most apt to increase body temperature?
   a. Dilation of the blood vessels in the skin
   b. Shivering
   c. Secretion of the eccrine glands
   d. Secretion of sebum
2. The stratum germinativum
   a. is a dermal layer.
   b. gives rise to epidermal cells.
   c. contains the blood vessels that nourish the epidermis.
   d. is part of the hypodermis.

3. The epidermis is nourished by the
   a. air in the environment that diffuses into the pores.
   b. blood vessels in the hair shafts.
   c. blood vessels in the underlying dermis.
   d. oxygen and glucose in the sebum.
4. Which of the following is true of the stratum corneum?
   a. Continuously produces epidermal cells
   b. Secretes keratin for making the skin water-resistant
   c. Is the dead layer that is sloughed off
   d. Continuously secretes bilirubin
5. Which word best describes the function of the stratum germinativum?
   a. Desquamation
   b. Mitosis
   c. Keratinization
   d. Shivering thermogenesis
6. Secretion of the eccrine glands
   a. "oils" the hair shafts.
   b. produces vernix caseosa that protects the skin of the fetus.
   c. lowers body temperature.
   d. tans the skin.
7. Cyanosis occurs when
   a. the blood in the cutaneous blood vessels is unoxygenated.
   b. bilirubin deposits in the skin and mucous membrane.
   c. cutaneous blood vessels dilate.
   d. sebum is exposed to air and changes color.
8. Which word pertains to all the following: apocrine, sudoriferous, eccrine, and sebaceous?
   a. Sweat glands
   b. Vernix caseosa
   c. Sebum
   d. Exocrine glands
9. Shivering thermogenesis
   a. is due to metabolism of brown fat.
   b. increases body temperature.
   c. is primarily due to the contraction of the arrector pili muscles.
   d. is triggered by hypoxemia and cyanosis.

Go Figure

1. **According to Figures 7-1 and 7-2**
   a. There is a rich supply of blood vessels within the epidermis.
   b. The dermis sits on the epidermis.
   c. Blood vessels, touch receptors, and free nerve endings are located within the dermis.
   d. The stratum corneum and the stratum germinativum are dermal layers.
2. **According to Figures 7-1 and 7-2**
   a. The stratum germinativum sits on the hypodermis.
   b. The hair arises within the cells of the epidermis.
   c. The arrector pili muscles attach the epidermis to the hypodermis.
   d. Dermal cells arise within the stratum germinativum.
3. **According to Figures 7-1 and 7-2**
   a. All glands arise from cells at the base of the hair shaft.
   b. All touch and pressure receptors are located within the epidermis.
   c. Some epidermal cells are imbedded within the dermis.
   d. All sensory receptors are located in the hypodermis.
4. **Which of the following is not consistent with Figure 7-4?**
   a. Sweat glands are located in the dermis.
   b. The sebaceous gland is associated with the hair root.
   c. Apocrine, sebaceous, and eccrine glands are sweat glands.
   d. Eccrine glands secrete sweat into ducts that carry it to the surface of the skin.
5. **According to Figure 7-5**
   a. Blood vessel constriction and shivering increase body temperature.
   b. The thermostat is located in the brain.
   c. Blood vessel dilation and sweating lower body temperature.
   d. All of the above are true.