# THE INTEGUMENTARY SYSTEM



Protecting skin from the sun's damaging ultraviolet (UV) rays belps prevent premature aging and cancers of the skin. Avoiding direct sunlight is the best strategy, but when not practical, a sunscreen should be used on exposed skin. These do not shield the skin completely, but they do reduce the damaging effects of the ultraviolet rays. Evidence suggests that the skin can repair some damage when sunscreens are applied consistently. But researchers warn that sunscreens can provide a false sense of security. Because they prevent burning, sunscreens may lull us into thinking the sun is not burting us, while damage is occurring.



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Of all the body's organs, none is more easily inspected or more exposed to infection; disease, and injury than the skin.

Because of its visibility, skin reflects our emotions and some aspects of normal physiology, as evidenced by frowning, blushing, and sweating. Changes in skin color or condition may indicate homeostatic imbalances in the body. For example, a skin rash such as occurs in chickenpox reveals a systemic infection, but a yellowing of the skin is an indication of jaundice, usually due to disease of the liver, an internal organ. Other disorders may be limited to the skin, such as warts, age spots, or pimples. The skin's location makes it vulnerable to damage from trauma, sunlight, microbes, or pollutants in the environment. Major damage to the skin, as occurs in third-degree burns, can be life threatening due to the loss of the protective skin functions.

Many interrelated factors may affect both the appearance and health of the skin, including nutrition, hygiene, circulation, age, immunity, genetic traits, psychological state, and drugs. So important is the skin to body image that people spend much time and money to restore it to a more youthful appearance.

\*Dermatology\* (der'-ma-TOL-ō-jē; dermato- = skin; -logy = study of) is the branch of medicine that specializes in diagnosing and treating skin disorders.

## looking back to move ahead . . .

- Types of Tissues (page 73)
- General Features of Epithelial Tissue (page 73)
- Stratified Squamous Epithelium (page 75)
- General Features of Connective Tissue (page 82)
- Areolar Connective Tissue (page 84)
- Dense Irregular Connective Tissue (page 87)

# SKIN

**OBJECTIVES** • Describe the structure and functions of the skin.

• Explain the basis for different skin colors.

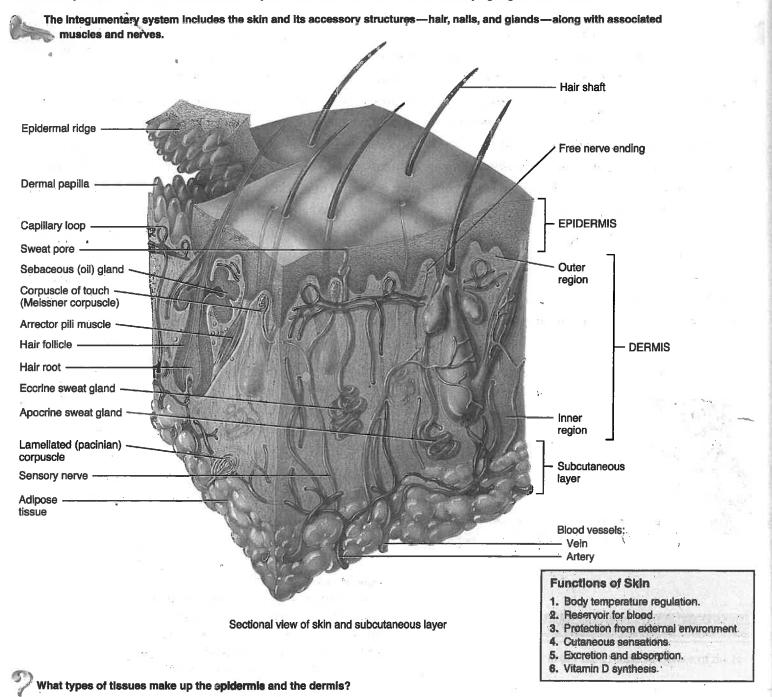
Recall from Chapter 1 that a system consists of a group of organs working together to perform specific activities. The *integumentary system* (in-teg-ū-MEN-tar-ē; *inte-* = whole; -gument = body covering) is composed of organs such

as the skin and hairs, and other structures such as nails. The skin or cutaneous membrane covers the external surface of the body. It is the largest organ of the body in surface area and weight. In adults, the skin covers an area of about 2 square meters (22 square feet) and weighs 4.5-5kg (10-11 lb), about 16% of total body weight.

### Structure of Skin

Structurally, the skin consists of two main parts (Figure 5.1). The superficial, thinner portion, which is composed of *ep*-

**Figure 5.1 Components of the integumentary system.** The skin consists of a thin, superficial epidermis and a deep, thicker dermis. Deep to the skin is the subcutaneous layer, which attaches the dermis to underlying organs and tissues.



ithetial tissue, is the epidermis (ep'-i-DERM-is; epiabove). The deeper, thicker connective tissue portion is the dermis.

Deep to the dermis, but not part of the skin, is the subcutaneous (subQ) layer. Also called the bypodermis (bypo = below), this layer consists of areolar and adipose tissues. Fibers that extend from the dermis anchor the skin to the subcutaneous layer, which, in turn, attaches to underlying tissues and organs. The subcutaneous layer serves as a storage depot for fat and contains large blood vessels that supply the skin. This region (and sometimes the dermis) also contains nerve endings called lamellated (pacinian) corpuscles (pa-SIN-ē-an) that are sensitive to pressure (Figure 5.1).

# **Epidermis**

The *epidermis* is composed of keratinized stratified squamous epithelium. It contains four principal types of cells: keratinocytes, melanocytes, Langerhans cells, and Merkel cells (see Figure 5.2). About 90% of epidermal cells are *keratinocytes* (ker-a-TIN-ō-sīts; *keratino-* = hornlike; -cytes =

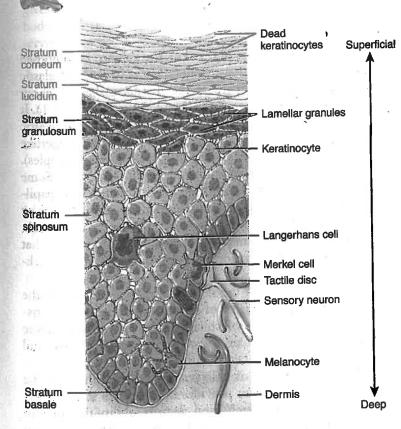
cells), which are arranged in four or five layers and produce the protein *keratin*. Recall from Chapter 4 that keratin is a tough, fibrous protein that helps protect the skin and underlying tissues from heat, microbes, and chemicals. Keratinocytes also produce lamellar granules, which release a water-repellent sealant.

About 8% of the epidermal cells are *melanocytes* (MEL-a-nō-sīts; *melano-* = black), which produce the pigment melanin. Their long, slender projections extend between the keratinocytes and transfer melanin granules to them. *Melanin* is a yellow-red or brown-black pigment that contributes to skin color and absorbs damaging ultraviolet (UV) light. Although keratinocytes gain some protection from melanin granules, melanocytes themselves are particularly susceptible to damage by UV light.

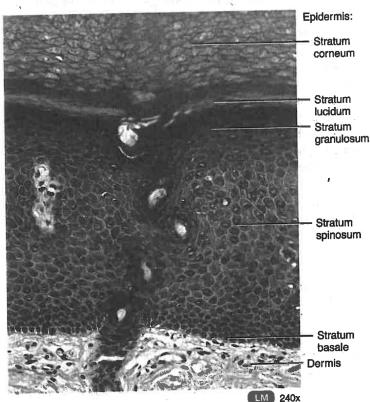
Langerbans cells (LANG-er-hans) participate in immune responses mounted against microbes that invade the skin. Langerhans cells, macrophages, and B cells help other cells of the immene system recognize an antigen (foreign microbe or substance) so that it can be destroyed (Chapter 17). Langerhans cells are easily damaged by UV light.

Figure 5.2 Layers of the epidermis.

The epidermis consists of keratinized stratified squamous epithelium.



(a) Four principal cell types in epidermis



(b) Photomicrograph of a portion of the skin

Merkel cells contact the flattened process of a sensory neuron (nerve cell), a structure called a tactile (Merkel) disc. Merkel cells and tactile discs detect different aspects of touch

Several distinct layers of keratinocytes in various stages sensations. of development form the epidermis (Figure 5.2). In most regions of the body the epidermis has four strata or layersstratum basale, stratum spinosum, stratum granulosum, and a thin stratum corneum. This is called thin skin. Where exposure to friction is greatest, such as in the fingertips, palms, and soles, the epidermis has five layers - stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and a thick stratum corneum. This is referred to as thick skin.

The deepest layer of the epidermis is the stratum basale (ba-SA-lē; basal- = base), composed of a single row of cuboidal or columnar keratinocytes. Some cells in this layer are stem cells that undergo cell division to continually produce new keratinocytes.

New skin cannot regenerate if an injury destroys the stratum basale and its stem cells. Skin wounds of this magnitude require skin grafts in order to heal. A skin graft is the transfer of a patch of healthy skin taken from a donor site to cover a wound. To avoid tissue rejection, the transplanted skin is usually taken from the same individual (autograft) or an identical twin (isograft). If skin damage is so extensive that an autograft would cause harm, a selfdonation procedure called autologous skin transplantation (aw-TOL-ō-gus) may be used. In this procedure, performed most often for severely burned patients, small amounts of an individual's epidermis are removed, and the keratinocytes are cultured in the laboratory to produce thin sheets of skin. The new skin is transplanted back to the patient so that it covers the burn wound a id generates a permanent skin. Also available as skin grafts are products grown in the laboratory from the foreskins of circumcised infants, and synthetic materials, which are products of tissue engineering.

Superficial to the stratum basale is the stratum spinosum (spi-NO-sum; spinos- = thornlike), where 8 to 10 layers of many-sided keratinocytes fit closely together. Cells in the more superficial portions of this layer become somewhat flattened.

At about the middle of the epidermis, the stratum granulosum (gran-ū-LŌ-sum; granulos- = little grains) consists of three to five layers of flattened keratinocytes that are undergoing apoptosis, genetically programmed cell death in which the nucleus fragments before the cells die. The nuclei and other organelles of these cells begin to degenerate. A distinctive feature of cells in this layer is the presence of keratin. Also present in the keratinocytes are membrane-enclosed lamellar granules, which release a lipid-rich secretion that

acts as a water-repellent sealant, retarding loss of body fluids and entry of foreign materials.

The stratum lucidum (LOO-si-dum; lucid- = clear) is present only in the thick skin of the fingertips, palms, and soles. It consists of three to five layers of flattened clear, dead keratinocytes that contain large amounts of keratin.

The stratum corneum (COR-nē-um; corne- = horn or horny) consists of 25 to 30 layers of flattened dead keratinocytes. These cells are continuously shed and replaced by cells from the deeper strata. The interior of the cells contains mostly keratin. Its multiple layers of dead cells help to protect deeper layers from injury and microbial invasion. Constant exposure of skin to friction stimulates the formation of a callus, an abnormal thickening of the stratum corneum.

Newly formed cells in the stratum basale are slowly pushed to the surface. As the cells move from one epidermal layer to the next, they accumulate more and more keratin, a process called keratinization (ker'-a-tin-i-ZA-shun). Eventually the keratinized cells slough off and are replaced by underlying cells that, in turn, become keratinized. The whole process by which cells form in the stratum basale, rise to the surface, become keratinized, and slough off, takes about four weeks in an average epidermis of 0.1 mm (0.004 in.) thickness. An excessive amount of keratinized cells shed from the skin of the scalp is called dandruff.

# Dermis

The second, deeper part of the skin, the dermis, is composed mainly of connective tissue containing collagen and elastic fibers. The superficial part of the dermis makes up about one-fifth of the thickness of the total layer (see Figure 5.1). It consists of areolar connective tissue containing fine elastic fibers. Its surface area is greatly increased by small, fingerlike projections called dermal papillae (pa-PIL-ē = nipples). These nipple-shaped structures indent the epidermis. Some contain capillary loops (blood capillaries). Other dermal papillae also contain tactile receptors called corpuscles of touch or Meissner corpuscles, nerve endings that are sensitive to touch. Also present in the dermal papillae are free nerve endings that are associated with sensations of warmth, coolness, pain, tick-

ling, and itching. The deeper part of the dermis, which is attached to the subcutaneous layer, consists of dense irregular connective tissue containing bundles of collagen and some coarse elastic fibers. Adipose cells, hair follicles, nerves, oil glands, and sweat glands are found between the fibers.

The combination of collagen and elastic fibers in the deeper part of the dermis provides the skin with strength, tensibility (ability to stretch), and elasticity (ability to return to original shape after stretching). The extensibility of skin can readily be seen in pregnancy and obesity. Extreme stretching however, may produce small tears in the dermis, causing  $STR\bar{I}-\bar{e} = streaks$ ), or stretch marks, that are visible as red or silvery white streaks on the skin surface.

# Skin Color

Melania, hemoglobin, and carotene are three pigments that impart a wide variety of colors to skin. The amount of melanin causes the skin's color to vary from pale yellow to red to tan to black. Melanocytes are most plentiful in the epidermis of the penis, nipples of the breasts, the area just around the nipples (areolae), face, and limbs. They are also present in mucous membranes. Because the number of melanocytes is about the same in all people, differences in skin color are due mainly to the amount of pigment the melanocytes produce and transfer to keratinocytes. In some people, melanin accumulates in patches called freckles. As a person grows older, age (liver) spots may develop. These flat blemishes look like freckles and range in color from light brown to black. Like freckles, age spots are accumulations of melanin. A round, flat, or raised area that represents a benign localized overgrowth of melanocytes and usually develops in childhood or adolescence is called a nevus (NE-vus), or a mole.

Exposure to UV light stimulates melanin production. Both the amount and darkness of melanin increase, which gives the skin a tanned appearance and further protects the body against UV radiation. Thus, within limits, melanin serves a protective function. Nevertheless, repeatedly exposing the skin to UV light causes skin cancer. A tan is lost when the melanin-containing keratinocytes are shed from the stratum corneum. Albinism (AL-bin-izm; albin- = white) is the inherited inability of an individual to produce melanin. Most albinos (al-BĪ-nōs), people affected by albinism, do not have melanin in their hair, eyes, and skin.

Dark-skinned individuals have large amounts of melanin in the epidermis. Consequently, the epidermis has a dark pigmentation and skin color ranges from yellow to red to tan to black. Light-skinned individuals have little melanin in the epidermis. Thus, the epidermis appears translucent and skin color ranges from pink to red depending on the amount and oxygen content of the blood moving through capillaries in the dermis. The red color is due to hemoglobin, the oxygencarrying pigment in red blood cells.

Carotene (KAR-ō-tēn; carot = carrot) is a yellow-orange pigment that gives egg yolk and carrots their color. This precursor of vitamin A, which is used to synthesize pigments needed for vision, accumulates in the stratum corneum and fatty areas of the dermis and subcutaneous layer in response to excessive dietary intake. In fact, so much carotene may be deposited in the skin after eating large amounts of carotenerich foods that the skin color actually turns orange, which is especially apparent in light-skinned individuals.

The color of skin and mucous membranes can provide clues for diagnosing certain conditions. When blood is not picking up an adequate amount of oxygen in the lungs, as in someone who has stopped breathing, the mucous membranes, nail beds, and skin appear bluish or cyanotic (si-a-NOT-ik; cyan- = blue). Jaundice (JON-dis; jaund- = yellow) is due to a buildup of the yellow pigment bilirubin in the skin. This condition gives a yellowish appearance to the skin and the whites of the eyes, and usually indicates liver disease. Erythema (er-i-THE-ma; eryth- = red), redness of the skin, is caused by engorgement of capillaries in the dermis with blood due to skin injury, exposure to heat, infection, inflammation, or allergic reactions. Pallor (PALor), or paleness of the skin, may occur in conditions such as shock and anema. All skin color changes are observed most readily in people with lighter-colored skin and may be more difficult to discern in people with darker skin. However, examination of the nail beds and gums can provide some information about circulation in individuals with darker skin.

#### CHECKPOINT

- 1. What structures are included in the integumentary system?
- 2. What are the main differences between the epidermis and dermis of the skin?
- What are the three pigments found in the skin, and how do they contribute to skin color?

# **ACCESSORY STRUCTURES** OF THE SKIN

**OBJECTIVE** • Describe the structure and functions of hair, skin glands, and nails.

Accessory structures of the skin that develop from the epidermis of an embryo-hair, glands, and nails-perform vital functions. Hair and nails protect the body. Sweat glands help regulate body temperature.

#### Hair

Hairs, or pili (PI-lē), are present on most skin surfaces except the palms, palmar surfaces of the fingers, soles, and plantar surfaces of the toes. In adults, hair usually is most heavily distributed across the scalp, over the brows of the eyes, and around the external genitalia. Genetic and hormonal influences largely determine the thickness and pattern of distribution of hair. Hair on the head guards the scalp from injury and the sun's rays; eyebrows and eyelashes protect the eyes

from foreign particles; and hair in the nostrils protects

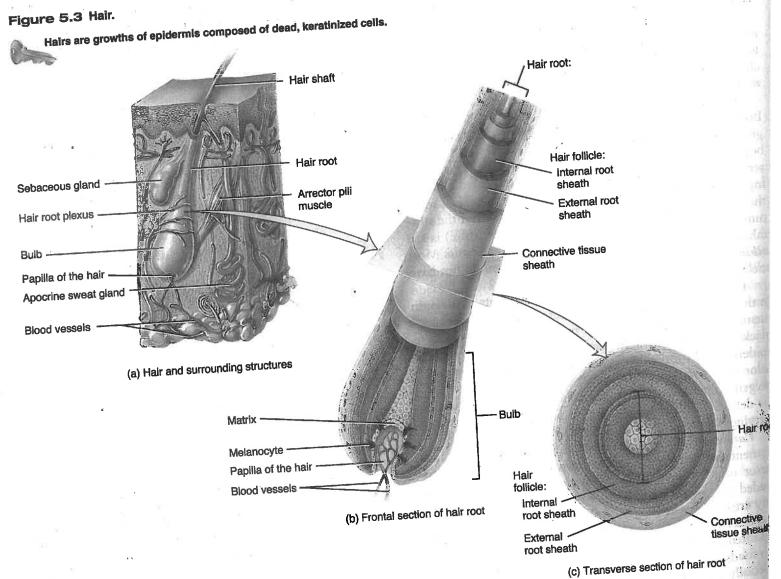
against inhaling insects and foreign particles.

Each hair is a thread of fused, dead, keratinized cells that consists of a shaft and a root (Figure 5.3). The shaft is the superficial portion, most of which projects above the surface of the skin. The root is the portion below the surface that penetrates into the dermis and sometimes into the subcutaneous layer. Surrounding the root is the bair follicle, which is composed of two layers of epidermal cells: external and internal root sheaths surrounded by a connective tissue sheath. Surrounding each hair follicle are nerve endings, called hair root plexuses, that are sensitive to touch. If a hair shaft is moved, its hair root plexus responds.

The base of each follicle is enlarged into an onionshaped structure, the bulb. In the bulb is a nipple-shaped

indentation, the papilla of the hair, that contains many blood vessels and provides nourishment for the growing hair. The bulb also contains a region of cells called the matrix, which produces new hairs by cell division when older hairs are shed.

Chemotherapy is the treatment of disease, usually cancer, by means of chemical substances or drugs. Chemotherapeutic agents interrupt the life cycle of rapidly dividing cancer cells. Unfortunately, the drugs also affect other rapidly dividing cells in the body, such as the matrix cells of a hair. It is for this reason that individuals undergoing chemotherapy experience hair loss. Since about 15% of the matrix cells of scalp hairs are in the resting stage, these cells are not affected by chemotherapy. Once chemotherapy is stopped, the matrix cells replace lost hair follicles and hair growth resumes.



Sebaceous (oil) glands (discussed shortly) and a bundle of mooth muscle cells are also associated with hairs. The mooth muscle is called arrector pili (a-REK-tor PI-lē; arrect to raise). It extends from the upper dermis to the side of the hair follicle. In its normal position, hair emerges at an ande to the surface of the skin. Under stress, such as cold or right, nerve endings stimulate the arrector pili muscles to contract, which pulls the hair shafts perpendicular to the skin surface. This action causes "goose bumps" because the skin around the shaft forms slight elevations.

The color of hair is due to melanin. It is synthesized by melanocytes in the matrix of the bulb and passes into cells of the root and shaft. Dark-colored hair contains mostly true melanin. Blond and red hair contain variants of melanin in which there is iron and more sulfur. Gray hair occurs with a decline in the synthesis of melanin. White hair results from

accumulation of air bubbles in the hair shaft.

At puberty, when the testes begin secreting significant quantities of androgens (masculinizing sex hormones), males develop the typical male pattern of hair growth, including a beard and a hairy chest. In females at puberty, the crearies and the adrenal glands produce small quantities of androgens, which promote hair growth in the axillae and rubic region. Occasionally, a tumor of the adrenal glands, pestes, or ovaries produces an excessive amount of androgens. The result in females or prepubertal males is birsutism (HER-soo-tizm; hirsut- = shaggy), a condition of excessive body hair.

Surprisingly, androgens also must be present for occurrence of the most common form of baldness, androgenic alopecia or male-pattern baldness. In genetically predisposed adults, androgens inhibit hair growth. On men, hair loss is most obvious at the temples and crown. Women are more likely to have thinning of hair on top of the head. The first drug approved for enhancing scalp hair growth was minoxidil (Rogaine®). It causes vasodilation (widening of blood vessels), thus increasing circulation. In about a third of the people who try it, minoxidil improves hair growth, causing scalp follicles to enlarge and lengthening the growth cycle. For many, however, the hair growth is meager. Minoxidil does not help people who already are bald.

## Glands

Recall from Chapter 4 that glands are single or groups of epithelial cells that secrete a substance. The glands associated with the skin include sebaceous, sudoriferous, and ceruminous glands.

### Sebaceous Glands

Sebaceous glands (se-BĀ-shus; sebace- = greasy) or oil glands, with few exceptions, are connected to hair follicles

(Figure 5.3a). The secreting portions of the glands lie in the dermis and open into the hair follicles or directly onto a skin surface. There are no sebaceous glands in the palms and

Sebaceous glands secrete an oily substance called sebum (SE-bum). Sebum keeps hair from drying out, prevents excessive evaporation of water from the skin, keeps the skin soft, and inhibits the growth of certain bacteria.

When sebaceous glands of the face become enlarged because of accumulated sebum, blackheads develop. Because sebum is nutritive to certain bacteria, pimples or boils often result. The color of blackheads is due to melanin and oxidized oil, not dirt. Sebaceous gland activity increases during adolescence.

### Sudoriferous Glands

There are three to four million sudoriferous glands (soo'dor-IF-er-us sudori- = sweat; -ferous = bearing), or sweat glands, divided into two main types: eccrine and apocrine.

Eccrine sweat glands (eccrine = secreting outwardly) are much more common than apocrine sweat glands. They are distributed throughout the skin of most parts of the body, except for the margins of the lips, nail beds of the fingers and toes, glans penis, glans clitoris, labia minora, and eardrums. Eccrine sweat glands are most numerous in the skin of the forehead, palms, and soles; their density can be as high as 450 per square centimeter (3000 per square inch) in the palms. The secretory portion of eccrine sweat glands is located mostly in the deep dermis (sometimes in the upper subcutaneous layer). The excretory duct projects through the dermis and epidermis and ends as a pore at the surface of the epidermis (see Figure 5.1). The sweat produced by eccrine sweat glands (about 600 mL per day) consists of water, ions (mostly Na<sup>+</sup> and Cl<sup>-</sup>), urea, uric acid, ammonia, amino acids, glucose, and lactic acid. The main function of eccrine sweat glands is to help regulate body temperature through evaporation. As sweat evaporates, large quantities of heat energy leave the body sur-

Apocrine sweat glands are found mainly in the skin of the axilla (armpit), groin, areolae (pigmented areas around the nipples) of the breasts, and bearded regions of the face in adult males. The secretory portion of these sweat glands is located mostly in the subcutaneous layer, and the excretory duct opens into hair follicles (see Figure 5.1). Their secretory product is slightly viscous compared to eccrine secretions and contains the same components as eccrine sweat plus lipids and proteins. Eccrine sweat glands start to function soon after birth, but apocrine sweat glands do not begin to function until puberty. Apocrine sweat glands are stimulated during emotional stress and sexual excitement; these secretions are commonly known as a "cold sweat."

# Ceruminous Glands

Ceruminous glands (se-ROO-mi-nus; cer- = wax) are present in the external auditory canal, the outer ear canal. The combined secretion of the ceruminous and sebaceous glands is called cerumen or earwax. Cerumen and the hairs in the external auditory meatus provide a sticky barrier against foreign bodies.

### **Nails**

Nails are plates of tightly packed, hard, dead, keratinized cells of the epidermis. Each nail (Figure 5.4) consists of a nail body, a free edge, and a nail root. The nail body is the portion of the nail that is visible; the free edge is the part of the body that extends past the end of the finger or toe; the nail root is the portion that is not visible. Most of the nail body is pink because of the underlying blood capillaries. The whitish semilunar area near the nail root is called the lunula (LOO-nyū-la = little moon). It appears whitish because the vascular tissue underneath does not show through due to the thickened stratum basale in the area. Nail growth occurs by the transformation of superficial cells of the nail matrix into nail cells. The average growth of fingernails is about 1 mm (0.04 inch) per week. The cuticle consists of stratum corneum.

Functionally, nails help us grasp and manipulate small objects, provide protection to the ends of the fingers and toes, and allow us to scratch various parts of the body.

Why are nails so hard?

### CHECKPOINT

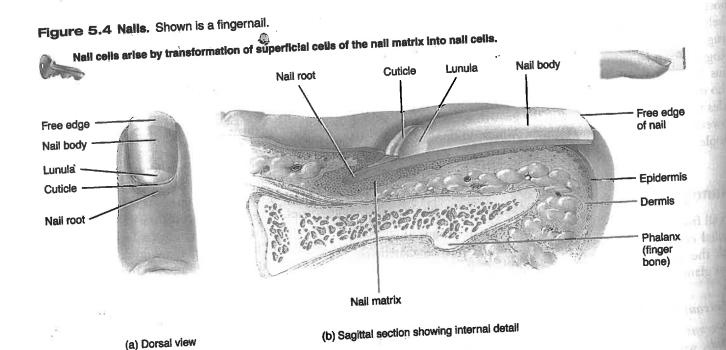
- Describe the structure of a hair. What causes "goose bumps"?
- Contrast the locations and functions of sebaceous (oil) glands and sudoriferous (sweat) glands.
- 6. Describe the parts of a nail.

# **FUNCTIONS OF THE SKIN**

**OBJECTIVE** • Describe how the skin contributes to the regulation of body temperature, protection, sensation, excretion and absorption, and synthesis of vitamin D.

Following are the major functions of the skin:

- 1. Body temperature regulation. The skin contributes to the homeostatic regulation of body temperature by liberating sweat at its surface and by adjusting the flow of blood in the dermis (discussed in detail in Chapter 20).
- Protection. Keratin in the skin protects underlying tissues from microbes, abrasion, heat, and chemicals, and the tightly interlocked keratinocytes resist invasion by microbes. Lipids released by lamellar granules inhibit evaporation of water from the skin surface, thus protecting the body from dehydration. Oily sebum prevents hairs from drying out and contains bactericidal chemicals that



# FOCUS ON WELLNESS

Skin Care for

Active

Lifestyles

Physical activity is good for your skin. During exercise, the body shunts blood to the skin to help release excess heat produced by the contracting muscles. This increased blood flow provides the skin with nutrients and gets rid of wastes.

### Fun in the Sun

From your skin's point of view, the main problem with exercise is that it often occurs outdoors, where sun exposure over the years can lead to wrinkles, age spots, and cancers of the skin. To prevent these, do what you can to minimize sun exposure. The most effective skin protection is some form of sun block. Tightly woven clothing (hold it up to a light and see how much shines through) helps keep the sun's rays from reaching the skin, and wide-brimmed hats provide some protection. Zinc oxide blocks the sun and is good for noses and lips when long-term exposure is unavoidable.

When a sun block is not practical, a sunscreen should be used. These do not shield the skin completely, but they do reduce the damaging effects of the ultraviolet rays. Evidence suggests that the skin can repair some damage when sunscreens are consistently applied. But researchers warn that sunscreens can provide a false sense of security. Because they prevent burning, sunscreens may lull us into thinking the sun is not hurting us, while damage may still be occurring.

### **Barriers to Skin Protection**

Chemists have yet to invent a sunscreen that is fun to wear. Many exercisers can't take the grease, especially, as an avid bicyclist put it, "as it illingles with sweat and dead bugs." Advice for heavy sweaters is to exercise in the early or late part of the day, take as shady a route as possible, wear a hat and protective clothing, and use as much sunscreen as you can tolerate.

Swimmers should note that "waterproof" sunscreen stays on for only about 30 minutes in the water and should be reapplied at that time.

### Dry Skin Care

Although not life threatening, dry skin can be very uncomfortable. Frequent showers and water exposure can strip the skin of its natural protective oils. The only solution is frequent moisturizing. Use of a good moisturizing cream immediately after drying off will counteract the drying effect of a "washand-wear" lifestyle.



- ➤ THINK IT OVER . . .
- Imagine you have a friend who is training for a marathon and must exercise outdoors for an hour or more on most days. He has fair skin and a family bistory of skin cancer. What advice would you give him for minimizing sun exposure while continuing his training?

kill surface bacteria. The acidic pH of perspiration retards the growth of some microbes. Melanin provides some protection against the damaging effects of UV light. Hair and nails also have protective functions.

- 3. Cutaneous sensations. Cutaneous sensations are those that arise in the skin. These include tactile sensationstouch, pressure, vibration, and tickling-as well as thermal sensations such as warmth and coolness. Another cutaneous sensation, pain, usually is an indication of impending or actual tissue damage. Chapter 12 provides more details on the topic of cutaneous sensations.
- 4. Excretion and absorption. The skin normally has a small role in excretion, the elimination of substances from the body, and absorption, the passage of materials from the external environment into body cells.

Most drugs are either absorbed into the body through the digestive system or injected into subcutaneous tissue or muscle. An alternative route, transdermal (transcutaneous) drug administration, enables a drug contained within an adhesive skin patch to pass across the epidermis and into the blood vessels of the dermis. The drug is released continuously at a controlled rate over one to several days. A growing number of drugs are available for transdermal administration, including nitroglycerin, for prevention of angina pectoris (chest pain associated with heart disease); scopolamine, for motion sickness; estradiol, used for estrogen-replacement therapy during menopause; ethinyl estradiol and norelgestromin in contraceptive patches; nicotine, used to help people stop smoking; and fentanyl, used to relieve severe pain in cancer patients.

5. Synthesis of vitamin D. Exposure of the skin to ultraviolet radiation activates vitamin D. Ultimately vitamin D is converted to its active form, a hormone called calcitriol, that aids in the absorption of calcium and phosphorus from the gastrointestinal tract into the blood. People who avoid sun exposure and individuals who live in colder, northern climates may experience vitamin D deficiency if it is not included in their diet or as supplements.

# CHECKPOINT

- 7. In what two ways does the skin help regulate body temperature?
- 8. In what ways does the skin serve as a protective barrier?
- 9. What sensations arise from stimulation of neurons in the skin?

# AGING AND THE INTEGUMENTARY SYSTEM

OBJECTIVE • Describe the effects of aging on the integumentary system.

Most infants and children encounter relatively few problems with the skin as it ages. With the arrival of adolescence, however, some teens develop acne. The pronounced effects of skin aging do not become noticeable until people reach their late forties. Most of the age-related changes occur in the dermis. Collagen fibers in the dermis begin to decrease in number, stiffen, break apart, and disorganize into a shapeless, matted tangle. Elastic fibers lose some of their elasticity, thicken into clumps, and fray, an effect that is greatly accelerated in the skin of smokers. Fibroblasts, which produce both collagen and elastic fibers, decrease in number. As a result, the skin forms the characteristic crevices and furrows known as wrinkles.

With further aging, Langerhans cells dwindle and macrophages become less-efficient phagocytes, thus decreasing the skin's immune responsiveness. Moreover, decreased size of sebaceous glands leads to dry and broken skin that is more susceptible to infection. Production of sweat diminishes, which probably contributes to the increased incidence of heat stroke in the elderly. There is a decrease in the number of functioning melanocytes, resulting in gray hair and atypical skin pigmentation. An increase in the size of some melanocytes produces pigmented blotching (age spots). Walls of blood vessels in the dermis become thicker and less permeable, and subcutaneous fat is lost. Aged skin (especially the dermis) is thinner than young skin, and the migration of cells from the basal layer to the epidermal surface slows considerably. With the onset of old age, skin heals poorly and be-

comes more susceptible to pathological conditions such as skin cancer, itching, and pressure ulcers.

Growth of nails and hair begins to slow during the second and third decades of life. The nails also may become more brittle with age, often due to dehydration or repeated use of cuticle remover or nail polish.

Several cosmetic anti-aging treatments are available to diminish the effects of aging or sun-damaged skin, including topical products that bleach the skin to tone down blotches and blemishes (hydroquinone) or decrease fine wrinkles and roughness (retinoic acid); microdermabrasion (mi-krō-DERma-brā-zhun; mikros- = small, derm = skin; -abrasio = to wear away), the use of tiny crystals under pressure to remove and vacuum the skin's surface cells to improve skin texture and reduce blemishes; chemical peel, the application of a mild acid (such as glycolic acid) to the skin to remove surface cells to improve skin texture and reduce blemishes; laser resurfacing, the use of a laser to clear up blood vessels near the skin surface, even out blotches and blemishes, and decrease fine wrinkles; dermal fillers, injections of collagen from cows, hyaluronic acid, or calcium hydroxylapatite that plumps up the skin to smooth out wrinkles and fill in furrows, such as those around the nose and mouth and between the eyebrows; fat transplantation, in which fat from one part of the body is injected into another location such as around the eyes; botulinum toxin or Botox®, a diluted version of the toxin that causes food poisoning, which is injected into the skin to paralyze muscles that cause the skin to wrinkle; radio frequency nonsurgical facelift, the use of radio frequency emissions to tighten skin of the jowls, neck, and sagging eyebrows and eyelids; and facelift, browlift, or necklift, invasive surgery in which loose skin and fat are removed surgically and the underlying connective tissue and muscle are tightened.

# CHECKPOINT

10. Which portion of the skin is involved in most age-related changes? Give several examples.

To appreciate the many ways that skin contributes 10 homeostasis of other body systems, examine the Focus an Homeostasis: The Integumentary System on page 109. This focus box is the first of ten, found at the end of selected chapters, that explain how the body system under consideration contributes to homeostasis of all the other body systems. The Focus on Homeostasis feature will help you understand how the individual body systems interact to contribute to the homeostasis of the entire body. Next, in Chapter 6, we will explore how bone tissue is formed and how bones are assembled into the skeletal system, which protects many of our in ternal organs.

### Skin Cancer

Excessive exposure to the sun causes virtually all of the one million cases of skin cancer diagnosed annually in the United States. There are three common forms of skin cancer. Basal cell carcinomas accourt for about 78% of all skin cancers. The tumors arise from cells in the stratum basale of the epidermis and rarely metastasize. Squamous cell carcinomas, which account for about 20% of all skin cancers, arise from squamous cells of the epidermis, and they have a variable tendency to metastasize. Most arise from preexisting lesions of damaged tissue on sun-exposed skin. Basal and squamous cell carcinomas are together known as nonmelanoma skin cancer. They are 50% more common in males than in females.

Malignant melanomas arise from melanocytes and account for about 2% of all skin cancers. They are the most prevalent life-threatening cancer in young women. The estimated lifetime risk of developing melanoma is now 1 in 75, double the risk only 15 years ago. In part, this increase is due to depletion of the ozone layer, which absorbs some UV light high in the atmosphere But the main reason for the increase is that more people are spending more time in the sun and in tanning beds. Malignant melanomas metastasize rapidly and can kill a person within months of diagnosis.

The key to successful treatment of malignant melanoma is early detection. The early warning signs of malignant melanoma are identified by the acronym ABCD (Figure 5.5). A is for asymmetry, malignant melanomas tend to lack symmetry. B is for border, malignant melanomas have irregular-notched, indented, scalloped, or indistinct-borders. C is for color; malignant melanomas have uneven coloration and may contain several colors. D is for diameter; ordinary moles typically are smaller than

Figure 5.5 Comparison of a normal nevus (mole) and a malignant melanoma.

Excessive exposure to the sun is the cause of most skin cancers.



(a) Normal nevus (mole)



(b) Malignant melanoma

Which type of skin cancer is the most common type?

6 mm (0.25 in.), about the size of a pencil eraser. Once a malignant melanoma has the characteristics of A, B, and C, it is usually larger than 6 mm.

Among the risk factors for skin cancer are the following:

- 1. Skin type. Individuals with light-colored skin who never tan but always burn are at high risk.
- Sun exposure. People who live in areas with many days of sunlight per year and at high altitudes (where ultraviolet light is more intense) have a higher risk of developing skin cancer. Likewise, people who engage in outdoor occupations and those who have suffered three or more severe sunburns have a higher risk.
- Family bistory. Skin cancer rates are higher in some families than in others.
- 4. Age. Older people are more prone to skin cancer owing to longer total exposure to sunlight.
- Immunological status. Individuals who are immunosuppressed have a ligher incidence of skin cancer.

### **Sun Damage**

Although basking in the warmth of the sun may feel good, it is not a healthy practice. There are two forms of ultraviolet radiation that affect the health of the skin. Longer-wavelength ultraviolet A (UVA) rays make up nearly 95% of the ultraviolet radiation that reaches the earth. UVA rays are not absorbed by the ozone layer. They penetrate the furthest into the skin, where they are absorbed by melanocytes and thus are involved in sun tanning. UVA rays also depress the immune system. Shorter-wavelength ultraviolet B (UVB) rays are partially absorbed by the ozone layer and do not penetrate the skin as deeply as UVA rays. UVB rays cause sunburn and are responsible for most of the tissue damage (production of oxygen free radicals that disrupt collagen and elastic fibers) that results in wrinkling and aging of the skin and cataract formation. Both UVA and UVB rays are thought to cause skin cancer. Longterm overexposure to sunlight results in dilated blood vessels, age spots, freckles, and changes in skin texture.

Exposure to ultraviolet radiation (either natural sunlight or the artificial light of a tanning booth) may also produce photosensitivity, a heightened reaction of the skin after consumption of certain medications or contact with certain substances. Photosensitivity is characterized by redness, itching, blistering, peeling, hives, and even shock. Among the medications or substances that may cause a photosensitivity reaction are certain antibiotics (tetracycline), nonsteroidal anti-inflammatory drugs (ibuprofen or naproxen), certain herbal supplements (St. John's Wort), some birth control pills, some high blood pressure medications, some antihistamines, and certain artificial sweeteners, perfumes, aftershaves, lotions, detergents, and medicated cosmetics.

#### Burns

A burn is tissue damage caused by excessive heat, electricity, radioactivity, or corrosive chemicals that denature the proteins in the skin cells. Burns destroy some of the skin's important contributions to homeostasis—protection against microbial invasion and desiccation, and regulation of body temperature.

Burns are graded according to their severity. A first-degree burn involves only the epidermis. It is characterized by mild pain and redness but no blisters. Skin functions remain intact. A second-degree burn destroys a portion of the epidermis and part of the dermis. Some skin functions are lost. In a second-degree burn there is redness, blister formation, edema, and pain, and scarring may result. First- and second-degree burns are collectively referred to as partial-thickness burns.

A third-degree burn or full-thickness burn destroys the epidermis, the underlying dermis, and subcutaneous layer. Most skin functions are lost. Skin grafting may be required to promote healing and to minimize scarring.

The seriousness of a burn is determined by its depth and extent, of area involved, as well as the person's age and general health. According to the American Burn Association's classification of burn injury, a major burn includes third-degree burns over 10% of body surface area; or second-degree burns over 25% of body surface area; or any third-degree burns on the face, hands, feet, or perineum (per-i-NĒ-um, which includes the anal and urogenital regions). When the burn area exceeds 70%, more than half the victims die.

#### **Pressure Ulcers**

Pressure ulcers, also known as decubitus ulcers (dē-KŪ-bi-tus) or bed-sores, are a shedding of epithelium caused by a constant deficiency of blood flow to tissues. Typically the affected tissue overlies a bony projection that has been subjected to prolonged pressure against an object such as a bed, cast, or splint. If the pressure is relieved in a few hours, redness occurs but no lasting tissue damage results. Prolonged pressure causes tissue ulceration. Small breaks in the epidermis become infected, and the sensitive subcutaneous layer and deeper tissues are damaged. Eventually, the tissue dies. Pressure ulcers occur most often in bedridden patients. With proper care, pressure ulcers are preventable.

#### Acne

Acne is an inflammation of sebaceous glands that usually begins at puberty, when the sebaceous glands grow in size and increase their production of sebum. Androgens from the testes, ovaries, and adrenal glands play the greatest role in stimulating sebaceous glands. Acne occurs predominantly in sebaceous follicles that have been colonized by bacteria, some of which thrive in the lipid-rich sebum. The infection may cause a cyst (sac of connective tissue cells) to form, which can destroy and displace epidermal cells. This condition, called cystic acne, can permanently scar the epidermis.

### MEDICAL TERMINOLOGY AND CONDITIONS

- Abrasion (a-BRĀ-shun; ab- = away; -raison = scraped) A portion of the epidermis that has been scraped away.
- Athlete's (ATH-lets) foot A superficial fungus infection of the skin of the foot.
- Blister A collection of serous fluid within the epidermis or between the epidermis and dermis, due to short-term but severe friction.
- Cold sore A lesion, usually in the oral mucous membrane, caused by type 1 herpes simplex virus (HSV) transmired by oral or respiratory routes. The virus remains dormant until triggered by factors such as ultraviolet light, hormonal changes, and emotional stress. Also called a fever blister.
- Contact dermatitis (der'-ma-TI-tis; dermat- = skin; -itis = inflammation) Inflammation of the skin characterized by redness, itching, and swelling and caused by exposure of the skin to chemicals that bring about an allergic reaction, such as poison ivy toxin.
- Corn (KORN) A painful thickening of the stratum corneum of the epidermis found principally over toe joints and between the toes, often caused by friction or pressure. Corns may be hard or soft, depending on their location. Hard corns are usually found over toe joints, and soft corns are usually found between the fourth and fifth toes.
- Hemangioma (hē-man'-jē-Ō-ma; bem- = blood; -angi = blood vessel; -oma = tumor) Localized tumor of the skin and subcutaneous layer that results from an abnormal increase in blood vessels. One type is a port-wine stain, a flat pink, red, or purple lesion present at birth, usually at the nape of the neck.

- Hives (HIVZ) Skin condition marked by reddened elevated patches that are often itchy. Most commonly caused by infections, physical trauma, medications, emotional stress, food additives, and certain food allergies.
- Impetigo (im'-pe-TI-gō) Superficial skin infection caused by Staphylococcus bacteria; most common in children.
- Intradermal (in-tra-DER-mal; intra- = within) Within the skin. Also called intracutaneous.
- Keratosis (ker'-a-TŌ-sis; kera- = horn) Formation of a hardened growth of epidermal tissue, such as a solar keratosis, a premalignant lesion of the sun-exposed skin of the face and hands.
- Laceration (las-er-A-shun; lacer- = torn) An irregular tear of the skin.
- Psoriasis (sō-RĪ-a-sis, psora = itch) A common, chronic skin disorder in which keratinocytes divide and move more quickly than normal from the stratum basale to the stratum corneum and form flaky scales, most often on the knees, elbows, and scalp.
- Pruritus (proo-RĪ-tus; pruri- = to itch) Itching, one of the most common dermatological disorders. It may be caused by skin disorders (infections), systemic disorders (cancer, kidney failure), psychogenic factors (emotional stress), or allergic reactions.
- Topical Refers to a medication applied to the skin surface rather than ingested or injected.
- Wart Mass produced by uncontrolled growth of epithelial skin cells, caused by a papilloma virus. Most warts are noncancerous.



# THE INTEGUMENTARY SYST

**Body System** 

### CONTRIBUTION OF THE INTEGUMENTARY SYSTEM

For all body systems



The skin and hair provide barriers that protect all internal organs from damaging agents in the external environment; sweat glands and skin blood vessels help regulate body temperature, needed for proper functioning of other body systems. 



The skin helps activate vitamin D, needed for proper absorption of dietary calcium and phosphorus to build and maintain bones.

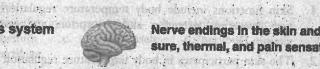
neren. Roman Gelegger († 21. 1885), iz mijorokum museko (dikogo), koj Palentere (diselet).

Muscular system



the section of the se Through activation of vitamin D, the skin helps provide calcium lons, needed for muscle contraction; the skin also rids the body of heat produced by muscular activity. inger (eine großeren in einen geber der eine der gereichte geber der geber der geber der der der geber der geber der

**Nervous system** 



Nerve endings in the skin and subcutaneous tissue provide input to the brain for touch, pressure, thermal, and pain sensations.

Endocrine system



ie in infinite con Constitue de la contratore La consentación de la contratore del la contratore della contratore della contratore della contr Keratinocytes in the skin help activate vitamin D, initiating its conversion to calcitrici, a hormone that aids absorption of dietary calcium and phosphorus. PO CONSIGNATION (CONTROLLER) ได้รับเป็น คุณการนั้นสายใหญ่และเกราะ (Controller) สายการสุดใหญ่ในการสายการ ให้เป็นการสายการสายการสายความสำเราะ (Controller) และ (Controller) และ (Controller) ในเป็นสิทธิ์ (Controller) เกมเลงการทำใหญ่ในที่ (Controller) และ (Controller) สายการสายการสายการสายการสายการสายการสายการสายการสายการสายกา

Cardiovascular system



Local chemical changes in the dermis cause widening and narrowing of skin blood vessels, which help adjust blood flow to the skin.

system and Immunity ....



The skin is the "first line of defense" in immunity, providing mechanical barriers and chemical secretions that discourage penetration and growth of microbes; Langerhans cells in the epidermis participate in immune responses by recognizing foreign antigens for destruction by immune A cells.

Respiratory system



Hairs in the nose filter dust particles from inhaled air; stimulation of pain nerve endings in the skin may alter breathing rate.

Digestive system



e, deeper region of the dermi

o surgicina arxivilizada

The skin helps activate vitamin D to become the hormone calcitriol, which promotes absorption of dietary calcium and phosphorus in the small intestine. The state of the s

Urinary system



Kidney cells receive partially activated vitamin D hormone from the skin and convert it to calcitriol; some waste products are excreted from the body in sweat, contributing to excretion by the urinary system.

Reproductive systems



Nerve endings in the skin and subcutaneous tissue respond to erotic stimuli, thereby contributing to sexual pleasure; suckling of a baby stimulates nerve endings in the skin, leading to milk election; mammary glands (modified sweat glands) produce milk; the skin stretches during pregnancy as the fetus enlarges.

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### STUDY OUTLINE

### Skin (p. 98)

- The skin and hairs and other structures such as nails constitute the integumentary system.
- The principal parts of the skin are the outer epidermis and inner dermis. The dermis overlies and attaches to the subcutaneous layer.
- 3. Epidermal cells include keratinocytes, melanocytes, Langerhans cells, and Merkel cells. The epidermal layers, from deepest to most superficial, are the stratum basale, stratum spinosum, stratum granulosum, stratum lucidum, and stratum corneum. The stratum basale undergoes continuous cell division and produces all other layers.
- The dermis consists of two regions. The superficial region is areolar connective tissue containing blood vessels, nerves, hair follicles, dermal papillae, and corpuscles of touch (Meissner corpuscles). The deeper region is dense, irregularly arranged connective tissue containing adipose tissue, hair follicles, nerves, sebaceous (oil) glands, and ducts of sudoriferous (sweat) glands.
- Skin color is due to the pigments melanin, carotene, and hemoglobin.

### Accessory Structures of the Skin (p. 101)

- 1. Accessory structures of the skin develop from the epidermis of an embryo.
- 2. They include hair, skin glands (sebaceous, sudoriferous, and ceruminous), and nails.
- 3. Hairs are threads of fused, dead keratinized cells that function in protection.
- 4. Hairs consist of a shaft above the surface, a root that penetrates the dermis and subcutaneous layer, and a hair follicle.
- 5. Associated with hairs are bundles of smooth muscle called arrector pili and sebaceous (oil) glands.
- 6. Sebaceous (oil) glands are usually connected to hair follicles; they are absent in the palms and soles. Sebaceous glands produce sebum, which moistens hairs and waterproofs the skin.

- 7. There are two types of sudoriferous (sweat) glands: eccrine and apocrine. Eccrine sweat glands have an extensive distribution; their ducts terminate at pores at the surface of the epidermis, and their main function is to help regulate body temperature. Apocrine sweat glands are limited in distribution, and their ducts open into hair follicles. They begin functioning at puberty and are stimulated during emotional stress and sexual excitement.
- 8. Ceruminous glands are modified sudoriferous glands that secrete cerumen. They are found in the external auditory canal.
- 9. Nails are hard, dead, keratinized epidermal cells covering the terminal portions of the fingers and toes.
- 10. The principal parts of a nail are the body, free edge, root, lunula, cuticle, and matrix. Cell division of the matrix cells produces new nails.

### Functions of the Skin (p. 104)

- 1. Skin functions include body temperature regulation, protection, sensation, excretion and absorption, and synthesis of
- The skin participates in body temperature regulation by liberating sweat at its surface and by adjusting the flow of blood in
- The skin provides physical, chemical, and biological barriers that help protect the body.
- Cutaneous sensations include tactile sensations, thermal sensations, and pain.

#### Aging and the Integumentary System (p. 106)

- 1. Most effects of aging occur when an individual reaches the late
- Among the effects of aging are wrinkling, loss of subcutaneous fat, atrophy of sebaceous glands, and decrease in the number of melanocytes and Langerhans cells.

- 1. Hair follieles
  - a. consist of dead cells
  - **b.** extend above the surface of the skin
  - c. can increase in number as you age
  - d. contain cells undergoing mitosis
  - e. are another name for arrector pili muscles
- Skin coloration
  - a. is due to melanin found in the subcutaneous layer
  - b. in European-Americans is due mainly to carotene
  - c. is related to apocrine glands
  - **d.** is stimulated by exposure to the sun
  - e. is produced by Merkel cells

- 3. In which portion of the skin will you find dermal papillae?
  - a. superficial region of the dermis
- b. epidermis
- c. hypodermis d. stratum spinosum
- e. deeper region of the dermis
- If you pricked your fingertip with a needle, the first layer of epidermis that it would penetrate is the
  - a. stratum basale
- **b.** stratum spinosum
  - c. stratum granulosum
- d. stratum lucidum
- e. stratum corneum
- 5. A person with albinism has a defect in the production of
  - a. carotene
- b. keratin
- c. collagen ' d. cerumen
- e. melanin

Self-Quiz 111 The red or pink tones seen in some skin are due to 14. To produce vitamin D, the skin cells need to be exposed to a. hemoglobin in the blood moving through capillaries in the b. ultraviolet light a. calcium and phosphorus c. heat d. pressure e. keratin b. the presence of carotene 15. To prevent an unwanted hair from growing back, you must the lack of oxygen destroy which structure? & a buildup of bilirubin in the blood d. hair matrix b. root sheath c. lunula a. shaft e an increased production of melanin e. arrector pili 7. When you have your hair cut, scissors are cutting through the 16. Aging can result in a. an increase in collagen and elastic fibers in the skin hair b. a steady increase in the activity of sudoriferous glands d. papilla e. bulb a. follicle c. shaft b. root c. a greater immune response from Langerhans cells 8. Which of the following is NOT true concerning eccrine sweat d. more efficient activity by macrophages e. a decline in the activity of sebaceous glands a. They are most numerous on the palms and the soles. 17. The portion of the nail that is responsible for nail growth is the b. They help regulate body temperature. d. nail body a. cuticle b. nail matrix c. lunula c. They produce a viscous secretion. e. nail root d. They function throughout life. 18. Match the following: e. They terminate at pores on the skin's surface. . \_\_\_ a. Langerhans cell A. earwax 9. Which tissue is the main type found in the inner region of the B. silvery white streaks \_\_\_\_ b. Merkel cell dermis? C. yellow-orange precursor \_\_ c. keratin a. dense irregular connective **b.** stratified squamous of vitamin A c. smooth muscle d. nervous \_ d. melanin epithelium D. function in immune e. lamellated (pacinian) e. cartilage responses corpuscle 10. Which of the following is NOT a function of skin? E. protective protein of \_ f. cerumen b. vitamin D synthesis a. calcium production skin, hair g. carotene e. temperature regulation **d.** immunity c. protection F. touch receptor found in \_ h. striae 11. Which of the following is NOT true concerning hair? epidermis ' \_\_ i. corpuscle of touch a. Hair is mainly composed of keratin. G. yellow to black pigment (Meissner corpuscle) b. Hirsutism is another name for male-pattern baldness. H. nerve endings sensitive c. Hair color is due to melanin. to pressure d. Sebaceous glands are associated with hair. I. touch receptor found in e. Contraction of the arrector pili muscles makes hair stand dermal papillae 19. Which of the following is NOT an accessory structure of the erect. skin? 12. Sebaceous glands b. sudoriferous glands a. dermal papillae a. secrete an oily substance e. nails c. sebaceous glands d. ceruminous glands b. are located on the palms and soles c. are responsible for breaking out in a "cold sweat" 20. What is the response by effectors when the body temperature

is elevated?

a. Blood vessels in the dermis constrict.

d. The body's metabolic rate increases.

b. Sweat glands increase production of sweat.

Skeletal muscles begin to contract involuntarily.

e. The ceruminous glands increase production.

d. are involved in body temperature regulation

13. As keratinocytes in the stratum basale are pushed toward the

d. lose their melanin

**b.** become more elastic

e. are found in the external auditory meatus

skin's surface, they

c. begin to die

a. begin to divide more rapidly

e. begin to assume a columnar shape



### CRITICAL THINKING APPLICATIONS

- 1. Three-year-old Michael was having his first haircut. As the barber started to snip his hair, Michael cried, "Stop! You're killing it!" He then pulled his own hair, yelling, "Ouch! See! It's alive!" Is Michael right about his hair?
- 2. Michael's twin sister Michelle scraped her knee at the playground. She told her mother that she wanted "new skin that doesn't leak." Her mother promised that new skin would soon appear under the bandage. How does new skin grow?
- 3. Andrew is training for the Megaman triathlon. After hours in running shoes and damp locker rooms, his feet are a mess! He has calluses, warts, and athlete's foot. What are the causes of his misery?
- 4. Fifteen-year-old Jeremy has a bad case of "blackheads." According to his Aunt Frieda, Jeremy's skin problems are from too much late-night TV, frozen pizza, and cheddar popcorn. Explain the real cause of blackheads to Aunt Frieda.

# 5

### ANSWERS TO FIGURE QUESTIONS

- 5.1 The epidermis is made up of epithelial tissue, and the dermis is composed of connective tissue.
- 5.2 The stratum basale is the layer of the epidermis that contains stem cells that continually undergo cell division.
- 5.3 The matrix produces a new hair by cell division.
- 5.4 Nails are hard because they are composed of tightly packed, hard, dead keratinized epidermal cells.
- 5.5 Basal cell carcinoma is the most common type of skin cancer.