chapter 6

Skin and the Integumentary System

TOO MUCH SWEAT. Sweating is a highly effective mechanism for cooling the body. Becoming drenched with sweat following heavy exertion or an intense workout can feel good. But for people with hyperhidrosis, sweating is profuse, uncontrollable, unpredictable, and acutely embarrassing.

Sweat consists of water released from about 5 million eccrine glands in the skin, in response to stimulation by the nervous system. About 2 million of these glands are in the hands, which explains why our palms become sweaty when we are nervous. For the 1% of the population with hyperhidrosis, the body, often for no apparent reason, breaks out in torrents of sweat. An affected person cannot grasp a pen, clothes become drenched, and social interactions become very difficult. Some people may inherit the condition, but usually the cause isn't known.

Jeffrey Schweitzer, a surgeon at Northwestern University Medical School in Chicago, has developed a treatment for hyperhidrosis. He inserts an endoscope (a small lit tube) through an opening in the patient's chest wall and removes the nerves that signal sweat glands in the palms. The success rate is greater than 80% in alleviating the sweaty palms.

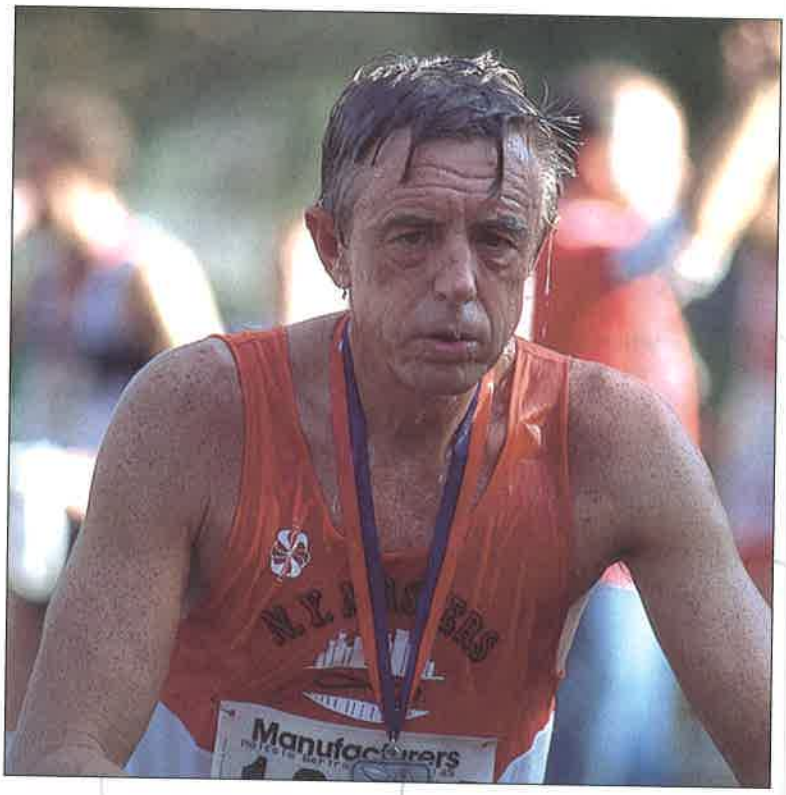


Photo:
Sweating in response to exertion is a normal way for the body to cool itself.

Chapter Objectives

After studying this chapter, you should be able to do the following:

6.1 Introduction

1. Describe what constitutes an organ, particularly as it relates to membranes and systems. (p. 113)

6.2 Types of Membranes

2. Describe the four major types of membranes. (p. 113)

6.3 Skin and Its Tissues

3. Describe the structure of the layers of the skin. (p. 113)
4. List the general functions of each layer of skin. (p. 114)
5. Summarize the factors that determine skin color. (p. 116)

6.4 Accessory Organs of the Skin

6. Describe the accessory organs associated with the skin. (p. 117)

6.5 Regulation of Body Temperature

7. Explain how the skin helps regulate body temperature. (p. 120)

6.6 Healing of Wounds

8. Describe the events that are part of wound healing. (p. 120)

Aids to Understanding Words

cut- [skin] sub*cut*aneous: Beneath the skin.
derm- [skin] *derm*is: Inner layer of the skin.
epi- [upon] *epi*dermis: Outer layer of the skin.
follic- [small bag] hair *follic*le: Tubelike depression in which a hair develops.
kerat- [horn] *kerat*in: Protein produced as epidermal cells die and harden.
melan- [black] *melan*in: Dark pigment produced by certain cells.
seb- [grease] *seb*aceous gland: Gland that secretes an oily substance.

Key Terms

cutaneous membrane (ku-ta´ne-us mem´brān)
dermis (der´mis)
epidermis (ep´´ĭ-der´mis)
hair follicle (hār fol´ĭ-kl)
integumentary (in-teg-u-men´tar-e)
keratinization (ker´´ah-tin´´ĭ-za´shun)
melanin (mel´ah-nin)
mucous membrane (mu´kus mem´brān)
sebaceous gland (se-ba´shus gland)
serous membrane (se´rus mem´brān)
subcutaneous layer (sub´´ku-ta´ne-us la´er)
sweat gland (swet gland)
synovial membrane (sĭ-no´ve-al mem´brān)

6.1 Introduction

Chemicals, cells, tissues, organs, and finally, organ systems build a human body. Two or more kinds of tissues grouped together and performing specialized functions constitute an organ. For example, the thin, sheetlike membranes composed of epithelium and connective tissue that cover body surfaces and line body cavities are organs. The cutaneous membrane (commonly called *skin*) together with certain accessory organs make up the **integumentary** (in-teg-u-men´tar-e) **system.**

6.2 Types of Membranes

The four major types of membranes are serous, mucous, synovial, and cutaneous. **Serous membranes** (se´rus mem´branz) line body cavities that lack openings to the outside. They form the inner linings of the thorax (parietal pleura) and abdomen (parietal peritoneum), and they cover the organs within these cavities (visceral pleura and visceral peritoneum, respectively). A serous membrane consists of a layer of simple squamous epithelium and a thin layer of loose connective tissue. Cells of a serous membrane secrete watery *serous fluid,* which lubricates membrane surfaces.

Mucous (mu´kus) **membranes** line cavities and tubes that open to the outside of the body. These include the oral and nasal cavities and the tubes of the digestive, respiratory, urinary, and reproductive systems. A mucous membrane consists of epithelium overlying a layer of loose connective tissue. Goblet cells within a mucous membrane secrete *mucus.*

Synovial (sĭ-no´ve-al) **membranes** form the inner linings of the joint cavities between the ends of bones at freely movable joints (synovial joints). These membranes usually include dense connective tissue overlying loose connective tissue and adipose tissue. Cells of a synovial membrane secrete a thick, colorless *synovial fluid* into the joint cavity, which lubricates the ends of the bones within the joint. The **cutaneous** (ku-ta´ne-us) **membrane,** or skin, is described in detail in this chapter.

6.3 Skin and Its Tissues

The skin is one of the larger and more versatile organs of the body, and it is vital in maintaining homeostasis. The skin is a protective covering, helps regulate body temperature, retards water loss from deeper tissues, houses sensory receptors, synthesizes various biochemicals, and excretes small quantities of wastes.

The skin includes two distinct tissue layers (fig. 6.1). The outer layer, called the **epidermis** (ep´ĭ-der´mis), is composed of stratified squamous epithelium. The inner layer, or **dermis** (der´mis), is thicker than the epidermis, and it contains connective tissue consisting of collagenous and elastic fibers, epithelial tissue, smooth muscle tissue, nervous tissue, and blood. A *basement membrane* that is anchored to the dermis separates the two skin layers.

Beneath the dermis are masses of loose connective and adipose tissues that bind the skin to the underlying organs. These tissues form the **subcutaneous** (sub´´ku-ta´ne-us) **layer** (hypodermis).

If the skin of a 150-pound person were spread out flat, it would cover approximately 20 square feet.

CHECK YOUR RECALL

1. Name the four types of membranes, and explain how they differ.
2. List the general functions of the skin.
3. Name the tissue in the outer layer of the skin.
4. Name the tissues in the inner layer of the skin.

Epidermis

Since the epidermis is composed of stratified squamous epithelium, it lacks blood vessels. However, the deepest layer of epidermal cells, called the *stratum basale* (stratum germinativum), is close to the dermis and is nourished by dermal blood vessels (fig. 6.1*A*). As the cells of this layer divide and grow, the older epidermal cells are pushed away from the dermis toward the skin surface. The farther the cells move, the poorer their nutrient supply becomes, and in time, they die.

The older cells (keratinocytes) harden in a process called **keratinization** (ker´´ah-tin´ĭ-za´shun). The cytoplasm fills with strands of a tough, fibrous, waterproof *keratin* protein. As a result, many layers of tough, tightly

Subcutaneous injections are administered through a hollow needle into the subcutaneous layer beneath the skin. *Intradermal injections* are injected within the skin. Subcutaneous injections and *intramuscular injections,* administered into muscles, are sometimes called hypodermic injections.

Some substances are introduced through the skin by means of an adhesive transdermal patch that includes a small reservoir containing a drug. The drug passes from the reservoir through a permeable membrane at a known rate. It then diffuses into the epidermis and enters the blood vessels of the dermis. Transdermal patches are used to protect against motion sickness, chest pain associated with heart disease, and elevated blood pressure. A transdermal patch that delivers nicotine is used to help people stop smoking.

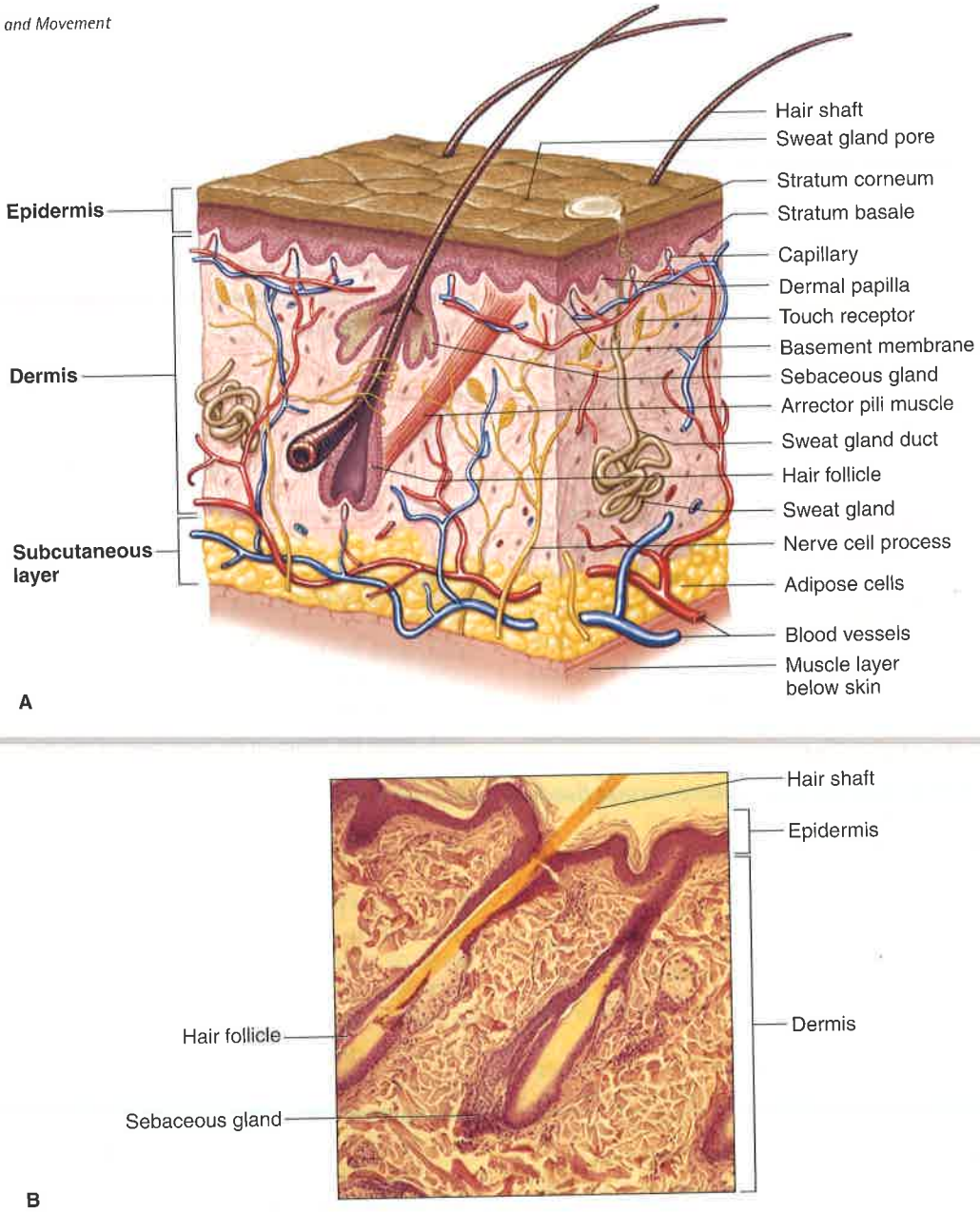


Figure 6.1
Skin. (*A*) A section of skin. (*B*) A light micrograph depicting the layered structure of the skin (75×).

packed dead cells accumulate in the outer epidermis, forming an outermost layer called the *stratum corneum*. Dead cells that compose it are eventually shed.

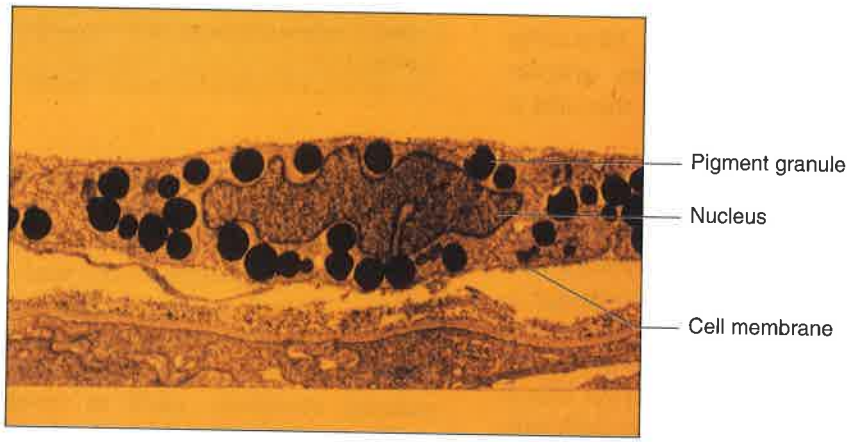
The thickness of the epidermis varies from region to region. In most areas, only four layers can be distinguished. They are the *stratum basale, stratum spinosum, stratum granulosum,* and *stratum corneum*. An additional layer, the *stratum lucidum*, is in the thickened skin of the palms and soles. The stratum granulosum may be missing where the epidermis is thin (fig. 6.2).

In healthy skin, production of epidermal cells is closely balanced with loss of dead cells from the stratum corneum, so that the skin does not wear away completely. In fact, the rate of cell division increases where the skin is rubbed or pressed regularly, causing growth of thickened areas called *calluses* on the palms and soles, and keratinized conical masses on the toes called *corns*.

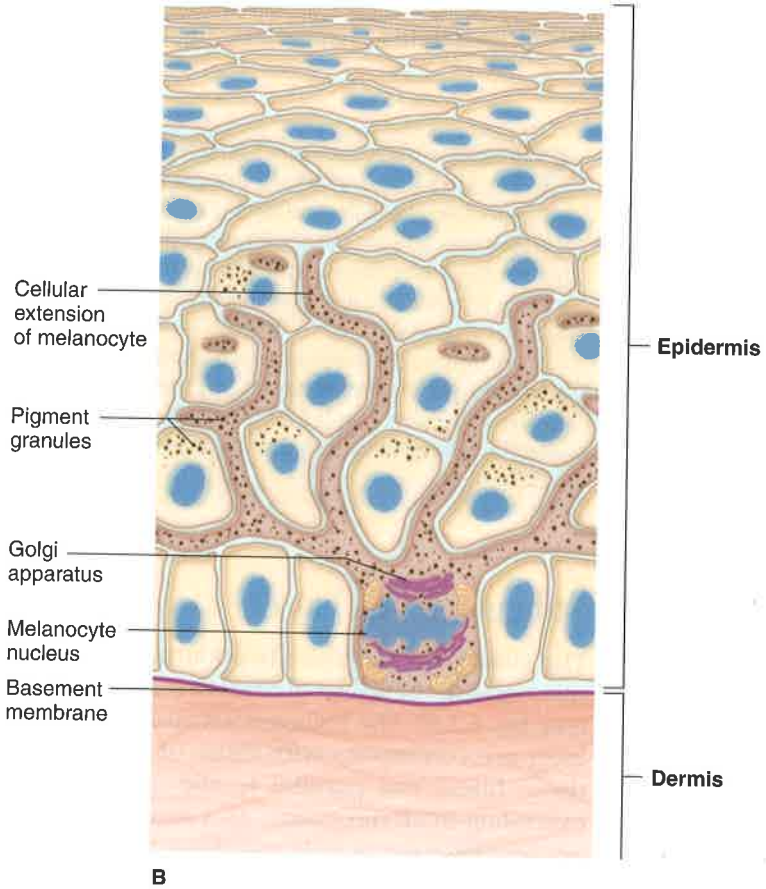
The epidermis has important protective functions. It shields the moist underlying tissues against excessive water loss, mechanical injury, and the effects of harmful chemicals. When unbroken, the epidermis also keeps out disease-causing microorganisms.

Specialized cells in the epidermis called *melanocytes* produce **melanin** (mel´ah-nin), a dark pigment that provides skin color (fig. 6.3*A*). Melanin absorbs ultraviolet radiation in sunlight, preventing mutations in the DNA of skin cells and other damaging effects. Melanocytes lie in the deepest portion of the epidermis. Although they are the only cells that can produce

Figure 6.2
Melanocytes that are mainly in the stratum basale, the deepest layer of the epidermis, produce the pigment called melanin (300×).



A



B

Figure 6.3
Melanocyte. (*A*) Transmission electron micrograph of a melanocyte with pigment-containing granules (10,600×). (*B*) A melanocyte may have pigment-containing extensions that pass between epidermal cells and transfer pigment into them.

melanin, the pigment also may be present in other epidermal cells nearby. This happens because melanocytes have long, pigment-containing cellular extensions that pass upward between epidermal cells. The extensions transfer melanin granules into these other cells by a process called *cytocrine secretion*. Nearby epidermal cells may contain more melanin than the melanocytes (fig. 6.3*B*).

Skin Color

Skin color is due largely to melanin. All people have about the same number of melanocytes in their skin. Differences in skin color result from differences in the amount of melanin that melanocytes produce and in the distribution and size of the pigment granules. Skin color is mostly genetically determined. If genes instruct melanocytes to produce abundant melanin, the skin is dark.

Environmental and physiological factors also influence skin color. Sunlight, ultraviolet light from sunlamps, or X rays stimulate production of additional pigment. Blood in the dermal vessels may affect skin color as physiological changes occur. When blood is well oxygenated, the blood pigment (hemoglobin) is bright red, making the skin of light-complexioned people appear pinkish. On the other hand, when blood oxygen concentration is low, hemoglobin is dark red, and the skin appears bluish—a condition called *cyanosis*. Other physiological factors affecting skin color include diet (carotene in yellow vegetables) and chemicals (bilirubin accumulation in skin of newborns).

CHECK YOUR RECALL

1. Explain how the epidermis is formed.
2. Distinguish between the stratum basale and the stratum corneum.
3. What is the function of melanin?
4. What factors influence skin color?

Dermis

Epidermal ridges projecting inward and conical projections of dermis called dermal papillae passing into the spaces between the ridges cause the boundary between the epidermis and dermis to be uneven (see fig. 6.1*A*). Fingerprints form from these undulations of the skin at the distal end of the palmar surface of a finger. Genes determine fingerprint patterns but they can change slightly as a fetus moves and presses the forming ridges against the uterine wall. For this reason, the fingerprints of identical twins are usually not exactly alike.

The dermis binds the epidermis to underlying tissues (see fig. 6.1*A*). It is largely composed of dense connective tissue that includes tough collagenous fibers and elastic fibers within a gel-like ground substance. Networks of these fibers give the skin toughness and elasticity.

Because dermal blood vessels supply nutrients to the epidermis, interference with blood flow may kill epidermal cells. For example, when a person lies in one position for a prolonged period, the weight of the body pressing against the bed blocks the skin's blood supply. If cells die, the tissues begin to break down (necrosis), and a *pressure ulcer* (also called a decubitus ulcer or bedsore) may appear.

Pressure ulcers usually occur in the skin overlying bony projections, such as on the hip, heel, elbow, or shoulder. Frequently changing body position or massaging the skin to stimulate blood flow in regions associated with bony prominences can prevent ulcers.

Dermal blood vessels supply nutrients to all skin cells. These vessels also help regulate body temperature, as explained later in this chapter.

Nerve cell processes are scattered throughout the dermis. Motor processes carry impulses out from the brain or spinal cord to dermal muscles and glands. Sensory processes carry impulses away from specialized sensory receptors, such as touch receptors located within the dermis, and into the brain or spinal cord. The dermis also contains hair follicles, sebaceous (oil-producing) glands, and sweat glands, which are discussed later in the chapter (see fig. 6.1*A*).

Skin cells help produce vitamin D, which is necessary for normal bone and tooth development. This vitamin can form from a substance (dehydrocholesterol) that is synthesized by cells in the digestive system or obtained in the diet. When dehydrocholesterol reaches the skin by means of the blood and is exposed to ultraviolet light from the sun, it is converted to another chemical, which becomes vitamin D.

Certain skin cells (keratinocytes) assist the immune system by producing hormonelike substances that stimulate development of certain white blood cells (T lymphocytes) that defend against infection by disease-causing bacteria and viruses (see chapter 14, p. 377).

Subcutaneous Layer

The subcutaneous layer (hypodermis) beneath the dermis consists of loose connective and adipose tissues (see fig. 6.1*A*). The collagenous and elastic fibers of this layer are continuous with those of the dermis. Most of these fibers run parallel to the surface of the skin, extending in all directions. As a result, no sharp boundary separates the dermis and the subcutaneous layer.

The adipose tissue of the subcutaneous layer insulates, helping to conserve body heat and impeding the entrance of heat from the outside. The subcutaneous layer also contains the major blood vessels that supply the skin and underlying adipose tissue.

CHECK YOUR RECALL

1. What kinds of tissues make up the dermis?
2. What are the functions of these tissues?
3. What are the functions of the subcutaneous layer?

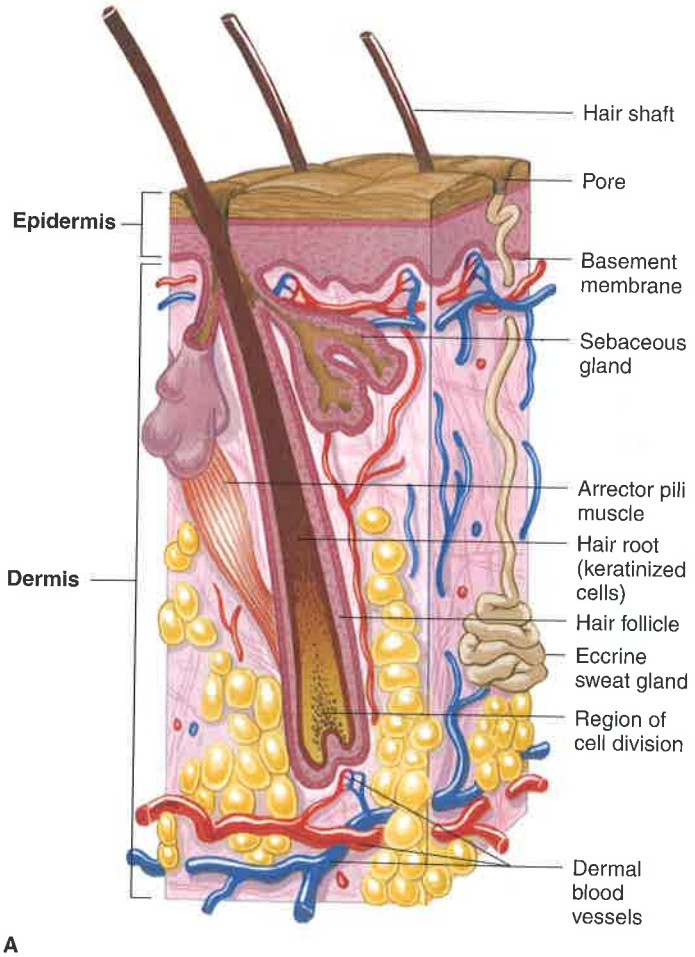
6.4 Accessory Organs of the Skin

Hair Follicles

Hair is present on all skin surfaces except the palms, soles, lips, nipples, and parts of the external reproductive organs. Each hair develops from a group of epidermal cells at the base of a tubelike depression called a **hair follicle** (hār fol′i-kl) (figs. 6.1 and 6.4). This follicle extends from the surface into the dermis and contains the hair *root*. The epidermal cells at its base are nourished from dermal blood vessels in a projection of connective tissue at the deep end of the follicle. As these epidermal cells divide and grow, older cells are pushed toward the surface. The cells that move upward and away from their nutrient supply become keratinized and die. Their remains constitute the structure of a developing hair, whose *shaft* extends away from the skin surface (fig. 6.5). In other words, a hair is composed of dead epidermal cells.

Genes determine hair color by directing the type and amount of pigment that epidermal melanocytes produce. If these cells, which lie at the deep end of a follicle, produce an abundance of melanin, the hair is dark; if an intermediate quantity of pigment is produced, the hair is blond; if no pigment appears, the hair is white. Another pigment, trichosiderin, is found only in red hair. A mixture of pigmented and unpigmented hair usually appears gray.

A bundle of smooth muscle cells, forming the *arrector pili muscle*, attaches to each hair follicle (see figs. 6.1*A* and 6.4*A*). This muscle is positioned so that a short hair within the follicle stands on end when the muscle contracts. If a person is emotionally upset or very cold, nerve impulses may stimulate the arrector pili muscles to contract, causing gooseflesh or goose bumps.



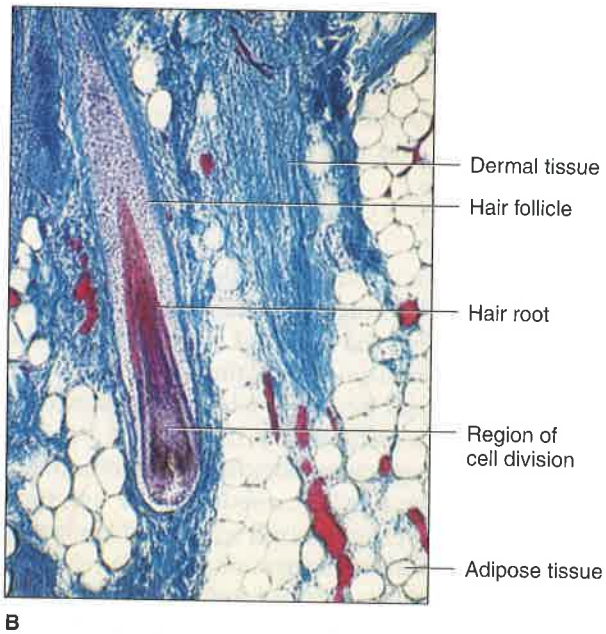


Figure 6.4
Hair follicle. (*A*) A hair grows from the base of a hair follicle when epidermal cells divide and older cells move outward and become keratinized. (*B*) Light micrograph of a hair follicle (160×).

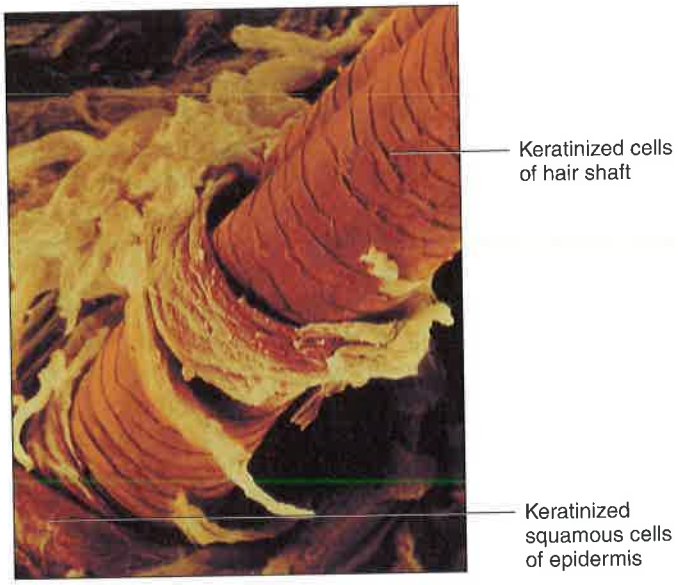


Figure 6.5
Scanning electron micrograph of a hair emerging from the epidermis (875×).

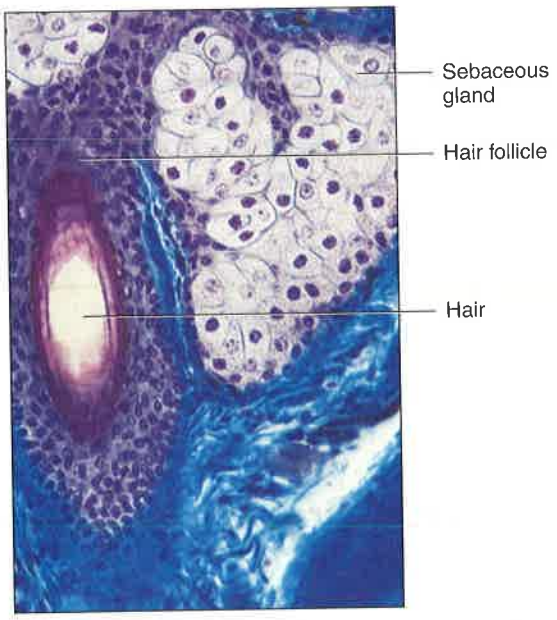


Figure 6.6
A sebaceous gland secretes sebum into a hair follicle, shown here in oblique section (300×).

Just above the "bulge" region at the base of a hair follicle are stem cells that can give rise to hair as well as epidermal cells. The first clue to the existence of these "young transient amplifying cells" was that new skin in burn patients arises from hair follicles. Then, experiments in mice that mark stem cells and their descendants showed that the young transient amplifying cells give rise to both hair and skin.

Sebaceous Glands

Sebaceous glands (se-ba´shus glandz) contain groups of specialized epithelial cells and are usually associated with hair follicles (figs. 6.4*A* and 6.6). They are holocrine glands (see chapter 5, p. 97) that secrete an oily mixture of fatty material and cellular debris called *sebum* through small ducts into the hair follicles. Sebum helps keep the hair and skin soft, pliable, and waterproof.

Nails

Nails are protective coverings on the ends of the fingers and toes. Each nail consists of a *nail plate* that overlies a surface of skin called the *nail bed*. Specialized epithelial cells that are continuous with the epithelium of the skin produce the nail bed. The whitish, thickened, half-moon–shaped region (lunula) at the base of a nail plate is the most active growing region. The epithelial cells here divide, and the newly formed cells are keratinized. This gives rise to tiny, keratinized scales that become part of the nail plate, pushing it forward over the nail bed. In time, the plate extends beyond the end of the nail bed and with normal use gradually wears away (fig. 6.7).

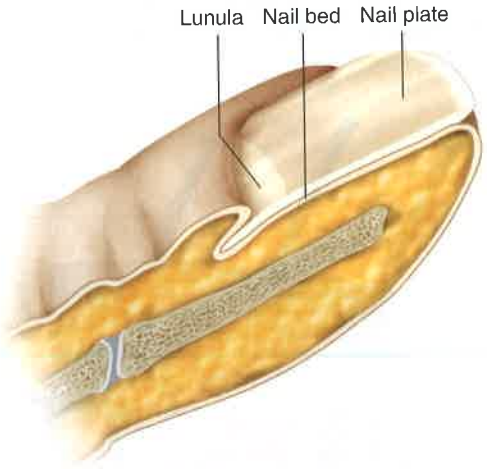


Figure 6.7
Nails grow from epithelial cells that divide and become keratinized as the rest of the nail.

Many teens are all too familiar with a disorder of the sebaceous glands called *acne* (acne vulgaris). Overactive and inflamed glands in some body regions become plugged and surrounded by small red elevations containing blackheads (comedones) or pimples (pustules).

The thumbnail grows the slowest; the middle nail grows the fastest.

Topic of Interest

SKIN CANCER

Skin cancer usually arises from nonpigmented epithelial cells within the deep layer of the epidermis or from melanocytes. Skin cancers originating from epithelial cells are called *cutaneous carcinomas* (basal cell carcinoma or squamous cell carcinoma); those arising from melanocytes are *cutaneous melanomas* (melanocarcinomas or malignant melanomas) (fig. 6A).

Cutaneous carcinomas are the most common type of skin cancer, occurring most frequently in light-skinned people over forty years of age. These cancers usually appear in individuals who are regularly exposed to sunlight, such as farmers, sailors, athletes, and sunbathers, and may be the result of failure of normally protective apoptosis—peeling of sun-damaged cells.

Cutaneous carcinomas often develop from hard, dry, scaly growths (lesions) that have reddish bases. Such lesions may be either flat or raised, and they firmly adhere to the skin. Fortunately, cutaneous carcinomas are typically slow growing and can usually be cured completely by surgical removal or radiation treatment.

Because melanomas develop from melanocytes, they are pigmented with melanin, often with a variety of colored areas, such as variegated brown, black, gray, or blue. They usually have irregular rather than smooth outlines, and may feel bumpy.

Cutaneous melanomas may appear in people of any age, and seem to be caused by short, intermittent exposure to high-intensity sunlight. Risk is highest in people who stay indoors but occasionally sustain blistering sunburns. Melanoma is not associated with sustained sun exposure, as are the other types of skin cancers.

A cutaneous melanoma may arise from normal-appearing skin or from a mole (nevus). The lesion spreads horizontally through the skin, but eventually may thicken and grow downward into the skin, invading deeper tissues. If the melanoma is surgically removed while it is in its horizontal growth phase, it may be arrested. Once it thickens and spreads into deeper tissues, unfortunately, it becomes difficult to treat, and the survival rate is very low. A type of gene therapy called a "cancer vaccine" attempts to stimulate a person's immune system to locate and destroy melanoma cells that have spread.

To reduce the chances of developing skin cancer, avoid exposing the skin to high-intensity sunlight, use sunscreens and sunblocks, and examine the skin regularly. Report any unusual lesions—particularly those that change in color, shape, or surface texture—to a physician.

A B C

Figure 6A

Skin cancer. (A) Squamous cell carcinoma. (B) Basal cell carcinoma. (C) Malignant melanoma.

Sweat Glands

Sweat glands (swet glandz), or sudoriferous glands, are exocrine glands that are widespread in the skin. Each gland consists of a tiny tube that originates as a ball-shaped coil in the deeper dermis or superficial subcutaneous layer. The coiled portion of the gland is closed at its deep end and is lined with sweat-secreting epithelial cells.

The most numerous sweat glands, the *eccrine glands*, respond throughout life to body temperature elevated by environmental heat or physical exercise (see fig. 6.4A). These glands are common on the forehead,

neck, and back, where they produce profuse sweat on hot days or during intense physical activity.

The fluid (sweat) that eccrine glands secrete is carried away in a duct that opens at the surface as a *pore*. Sweat is mostly water, but it also contains small quantities of salt and wastes, such as urea and uric acid. Thus, sweating is also an excretory function.

Other sweat glands, known as *apocrine glands,* become active when a person is emotionally upset, frightened, or in pain. Although they are currently called apocrine, these glands secrete by the same mechanism as eccrine glands. They are most numerous in the axillary regions and groin, and usually connect to hair follicles.

Other sweat glands are structurally and functionally modified to secrete specific fluids, such as the ceruminous glands of the external ear canal that secrete earwax. The female mammary glands that secrete milk are another example of modified sweat glands.

The average square inch of skin holds 650 sweat glands, 20 blood vessels, 60,000 melanocytes, and more than a thousand nerve endings.

CHECK YOUR RECALL

1. Explain how a hair forms.
2. What is the function of the sebaceous glands?
3. Distinguish between the eccrine and apocrine sweat glands.

6.5 Regulation of Body Temperature

Regulation of body temperature is vitally important because even slight shifts can disrupt rates of metabolic reactions. Normally, the temperature of deeper body parts remains close to a set point of 37°C (98.6°F). Maintenance of a stable temperature requires that the amount of heat the body loses be balanced by the amount it produces. The skin plays a key role in the homeostatic mechanism that regulates body temperature.

Heat is a product of cellular metabolism; thus, the more active cells of the body are the major heat producers. These cells include skeletal and cardiac muscle cells and the cells of certain glands, such as the liver.

In intense heat, nerve impulses stimulate structures in the skin and other organs to release heat. For example, during physical exercise, active muscles release heat, which the blood carries away. The warmed blood reaches the part of the brain (the hypothalamus) that controls the body's temperature set point, which signals muscles in the walls of specialized dermal blood vessels to relax. As these vessels dilate (vasodilation), more blood enters them, and some of the heat the blood carries escapes to the outside.

At the same time the skin loses heat, the nervous system stimulates the eccrine sweat glands to become active and to release sweat onto the skin surface. As this fluid evaporates (changes from a liquid to a gas), it carries heat away from the surface, cooling the skin further.

If too much heat is lost, as may occur in a very cold environment, the brain triggers different responses in the skin structures. Muscles in the walls of dermal blood vessels are stimulated to contract; this decreases the flow of heat-carrying blood through the skin and helps reduce heat loss. Also, the sweat glands remain inactive, decreasing heat loss by evaporation. If body temperature continues to drop, the nervous system may stimulate muscle fibers in the skeletal muscles throughout the body to contract slightly. This action requires an increase in the rate of cellular respiration and produces heat as a by-product. If this response does not raise body temperature to normal, small groups of muscles may contract rhythmically with still greater force, and the person begins to shiver, generating more heat. Figure 6.8 summarizes the body's temperature-regulating mechanism.

Most of the body's heat (80%) escapes through the head.

CHECK YOUR RECALL

1. Why is regulation of body temperature so important?
2. How does the body lose excess heat?
3. Which actions help the body conserve heat?

6.6 Healing of Wounds

A wound and the area surrounding it usually become red and painfully swollen. This is the result of **inflammation,** which is a normal response to injury or stress. Blood vessels in affected tissues dilate and become more permeable, forcing fluids to leave the blood vessels and enter the damaged tissues. Inflamed skin may become reddened, warm, swollen, and painful to touch (table 6.1). However, the dilated blood vessels provide the tissues with more nutrients and oxygen, which aids healing.

The specific events in healing depend on the nature and extent of the injury. If a break in the skin is shallow, epithelial cells along its margin are stimulated to divide more rapidly than usual, and the newly formed cells fill the gap.

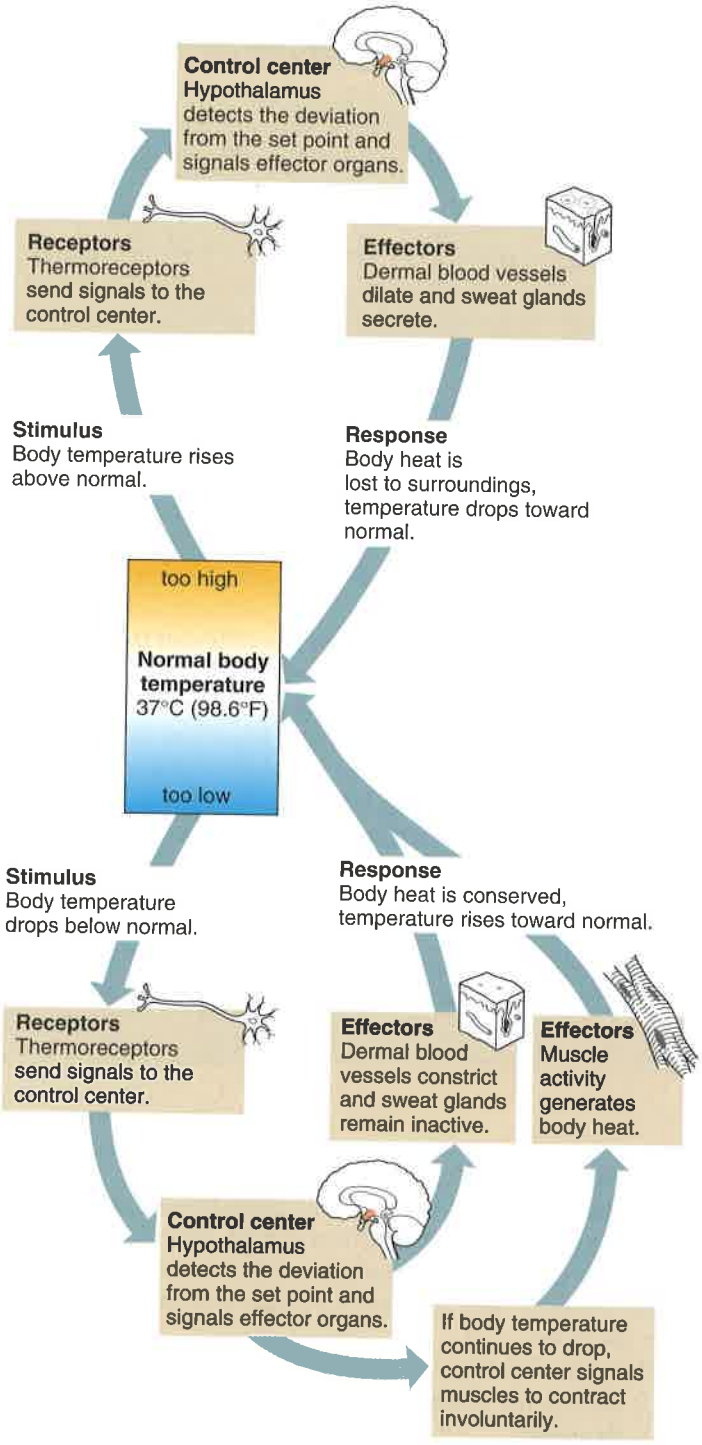


Figure 6.8
Body temperature regulation is an example of homeostasis.

If the injury extends into the dermis or subcutaneous layer, blood vessels break, and the escaping blood forms a clot in the wound. The blood clot and dried tissue fluids form a *scab* that covers and protects underlying tissues. Before long, fibroblasts migrate into the injured region and begin forming new collagenous fibers that bind the edges of the wound together. Suturing or otherwise closing a large break in the skin speeds this process.

As healing continues, blood vessels extend into the area beneath the scab. Phagocytic cells remove dead cells and other debris. Eventually, the damaged tissues are replaced, and the scab sloughs off. If the wound is extensive, the newly formed connective tissue may appear on the surface as a *scar*.

In large, open wounds, healing may be accompanied by formation of small, rounded masses called *granulations* in the exposed tissues. A granulation consists of a new branch of a blood vessel and a cluster of collagen-secreting fibroblasts that the vessel nourishes. In time, some of the blood vessels are resorbed, and the fibroblasts migrate away, leaving a scar.

TABLE 6.1 INFLAMMATION

SYMPTOM	CAUSE
Redness	Increased vasodilation, more blood in area
Heat	By-product of increased metabolic activity in tissue as white blood cells attempt to destroy invaders
Swelling	Increased interstitial fluid in area due to change in osmotic pressure of tissues caused by increased numbers of white blood cells
Pain	Swelling puts pressure on nerve endings in area

CHECK YOUR RECALL

1. Describe how inflammation helps a wound heal.
2. Distinguish between the activities necessary to heal a wound in the epidermis and those necessary to heal a wound in the dermis.
3. Explain the role of phagocytic cells in wound healing.
4. Define granulation.

Common Skin Disorders

acne (ak´ne) Disease of the sebaceous glands that produces blackheads and pimples.
alopecia (al´´o-pe´she-ah) Hair loss, usually sudden.
athlete's foot (ath´-lētz foot) Fungus infection (*Tinea pedis*) usually in the skin of the toes and soles.
birthmark (berth´ mark) Congenital blemish or spot on the skin, visible at birth or soon after.
boil (boil) Bacterial infection (furuncle) of the skin, produced when bacteria enter a hair follicle.
carbuncle (kar´bung-kl) Bacterial infection, similar to a boil, that spreads into the subcutaneous tissues.
cyst (sist) Liquid-filled sac or capsule.
dermatitis (der´´mah-ti´tis) Inflammation of the skin.
eczema (ek´zĕ-mah) Noncontagious skin rash that produces itching, blistering, and scaling.

Topic of Interest ELEVATED BODY TEMPERATURE

It was a warm June morning when the harried and hurried father strapped his five-month-old son Bryan into the backseat of his car and headed for work. Tragically, the father forgot to drop his son off at the babysitter's. When his wife called him at work late that afternoon to ask why the child was not at the sitter's, the shocked father realized his mistake and hurried down to his parked car. But it was too late—Bryan had died. Left for 10 hours in the car in the sun, all windows shut, the baby's temperature had quickly soared. Two hours after he was discovered, the child's temperature still exceeded 41°C (106°F).

Sarah's elevated body temperature was more typical. She awoke with a fever of 40°C (104°F) and a terribly painful sore throat. Peering down the five-year-old's throat with a flashlight, her mother spotted the whitish lesions that can indicate a *Streptococcus* infection. Sarah indeed had strep throat, and the fever was her body's attempt to fight the infection.

The true cases of young Bryan and Sarah illustrate two reasons why body temperature may rise: (1) inability of the temperature homeostatic mechanism to handle an extreme environment and (2) an immune system response to infection.

In Bryan's case, sustained exposure to very high heat overwhelmed the temperature-regulating mechanism, resulting in hyperthermia. Body heat built up faster than it could dissipate, and body temperature rose, even though the set point of the thermostat was normal. His blood vessels dilated so greatly in an attempt to dissipate the excess heat that after a few hours, his circulatory system collapsed.

Fever is a special case of hyperthermia, in which molecules on the surfaces of the infectious agents (usually bacteria or viruses) stimulate phagocytes to release a substance called interleukin-1 (IL-1, also called endogenous pyrogen, meaning "fire maker from within"). The bloodstream carries IL-1 to the hypothalamus, where it raises the set point controlling temperature. In response, the brain signals skeletal muscles to increase heat production, blood flow to the skin to decrease, and sweat glands to decrease secretion. As a result, body temperature rises to the new set point, and a fever develops. The increased body temperature helps the immune system kill the pathogens.

Rising body temperature requires different treatments, depending on the degree of elevation. Hyperthermia in response to exposure to intense, sustained heat should be rapidly treated by administering liquids to replace lost body fluids and electrolytes, sponging the skin with water to increase cooling by evaporation, and covering the person with a refrigerated blanket. Fever can be lowered with ibuprofen or acetaminophen, or with aspirin in adults. Some health professionals believe that a slight fever should not be reduced (with medication or cold baths) because it may be part of a normal immune response. A high or prolonged fever, however, requires medical attention.

erythema (er´´ĭ-the´mah) Reddening of the skin due to dilation of dermal blood vessels in response to injury or inflammation.
herpes (her´pēz) Infectious disease of the skin, usually caused by the herpes simplex virus and characterized by recurring formations of small clusters of vesicles.
impetigo (im´´pĕ-ti´go) Contagious disease of bacterial origin, characterized by pustules that rupture and become covered with loosely held crusts.
keloid (ke´loid) Elevated, enlarging fibrous scar usually initiated by an injury.
mole (mōl) Fleshy skin tumor (nevus) that is usually pigmented; colors range from brown to black.
pediculosis (pĕ-dik´´u-lo´sis) Disease produced by an infestation of lice.
pruritus (proo-ri´tus) Itching of the skin.
psoriasis (so-ri´ah-sis) Chronic skin disease characterized by red patches covered with silvery scales.
pustule (pus´tūl) Elevated, pus-filled area on the skin.
scabies (ska´bēz) Disease resulting from an infestation of mites.
seborrhea (seb´´o-re´ah) Hyperactivity of the sebaceous glands, causing greasy skin and dandruff.
ulcer (ul´ser) Open sore.
urticaria (ur´´tĭ-ka´re-ah) Allergic reaction of the skin that produces reddish, elevated patches (hives).
wart (wort) Flesh-colored, raised area caused by a viral infection.

Organization

INTEGUMENTARY SYSTEM

The skin provides protection, contains sensory organs, and helps control body temperature.

Skeletal System

Vitamin D activated by the skin helps provide calcium for bone matrix.

Lymphatic System

The skin provides an important first line of defense for the immune system.

Muscular System

Involuntary muscle contractions (shivering) work with the skin to control body temperature. Muscles act on facial skin to create expressions.

Digestive System

Excess calories may be stored as subcutaneous fat. Vitamin D activated by the skin stimulates dietary calcium absorption.

Nervous System

Sensory receptors provide information about the outside world to the nervous system. Nerves control the activity of sweat glands.

Respiratory System

Stimulation of skin receptors may alter respiratory rate.

Endocrine System

Hormones help to increase skin blood flow during exercise. Other hormones stimulate either the synthesis or the decomposition of subcutaneous fat.

Urinary System

The kidneys help compensate for water and electrolytes lost in sweat.

Cardiovascular System

Skin blood vessels play a role in regulating body temperature.

Reproductive System

Sensory receptors play an important role in sexual activity and in the suckling reflex.

Clinical Connection

When skin must heal from a severe ulcer, differentiated cells can *de*differentiate, reverting to stem cells that can help to fill in destroyed tissue. Researchers treated eight patients with leg ulcers with epidermal growth factor, and compared stem cells in their skin to those of seven patients with leg ulcers who had not received the treatment. They detected the stem cells by staining the cells for varieties of integrin and keratin proteins unique to skin stem cells. In the patients who were not treated with the growth factor, scattered stem cells appeared in one layer at the bottom of the basement membrane. However, in the patients who had been treated, stem cells were considerably more abundant, grouped into "stem cell islands" that traverse more than one layer, particularly where the epidermis dips down into the region of the dermis. In areas of healthy skin in all the patients, stem cells were quite scarce, appearing in hair follicles and near the basement membrane. The researchers think that the new stem cells arise from differentiated cells losing their specialization, rather than from stem cells proliferating. Discovering how skin stem cells function can lead to new ways to treat burns.

SUMMARY OUTLINE

6.1 Introduction (p. 113)

Organs, such as membranes, are composed of two or more kinds of tissues. The skin is an organ. Together with its accessory organs, it constitutes the integumentary system.

6.2 Types of Membranes (p. 113)

1. Serous membranes
   a. Serous membranes line body cavities that lack openings to the outside.
   b. Cells of serous membranes secrete watery serous fluid that lubricates membrane surfaces.
2. Mucous membranes
   a. Mucous membranes line cavities and tubes that open to the outside of the body.
   b. Cells of mucous membranes secrete mucus.
3. Synovial membranes
   a. Synovial membranes line joint cavities.
   b. They secrete synovial fluid that lubricates the ends of the bones at joints.
4. The cutaneous membrane is the external body covering commonly called the skin.

6.3 Skin and Its Tissues (p. 113)

Skin is a protective covering, helps regulate body temperature, retards water loss, houses sensory receptors, synthesizes various biochemicals, and excretes wastes. It is composed of an epidermis and a dermis separated by a basement membrane.

1. Epidermis
   a. The deepest layer of the epidermis, called the stratum basale, contains cells that divide.
   b. Epidermal cells undergo keratinization as they mature and are pushed toward the surface.
   c. The outermost layer, called the stratum corneum, is composed of dead epidermal cells.
   d. The epidermis protects underlying tissues against water loss, mechanical injury, and the effects of harmful chemicals.
   e. Melanin protects underlying cells from the effects of ultraviolet light.
   f. Melanocytes transfer melanin to nearby epidermal cells.
2. Skin color
   a. All people have about the same concentration of melanocytes.
   b. Skin color is due largely to the amount of melanin and the distribution and size of the pigment granules in the epidermis.
   c. Environmental and physiological factors, as well as genes, influence skin color.
3. Dermis
   a. The dermis binds the epidermis to underlying tissues.
   b. Dermal blood vessels supply nutrients to all skin cells and help regulate body temperature.
   c. Nerve fibers are scattered throughout the dermis.
      (1) Some dermal nerve fibers carry impulses to muscles and glands of the skin.
      (2) Other dermal nerve fibers are associated with sensory receptors in the skin, and carry impulses to the brain and spinal cord.
   d. The dermis also contains hair follicles, sebaceous glands, and sweat glands.
4. Subcutaneous layer
   a. The subcutaneous layer beneath the dermis consists of loose connective and adipose tissues.
   b. Adipose tissue helps conserve body heat.
   c. The subcutaneous layer contains blood vessels that supply the skin and underlying adipose tissue.

6.4 Accessory Organs of the Skin (p. 117)

1. Hair follicles
   a. Each hair develops from epidermal cells at the base of a tubelike hair follicle.
   b. As newly formed cells develop and grow, older cells are pushed toward the surface and undergo keratinization.
   c. A bundle of smooth muscle cells is attached to each hair follicle.
   d. Hair color is determined by genes that direct the amount of melanin that melanocytes associated with hair follicles produce.
2. Sebaceous glands
   a. Sebaceous glands are usually associated with hair follicles.
   b. Sebaceous glands secrete sebum, which helps keep the skin and hair soft and waterproof.
3. Nails
   a. Nails are protective covers on the ends of fingers and toes.
   b. Specialized epidermal cells that are keratinized make up nails.
   c. The keratin of nails is harder than that produced by the skin's epidermal cells.
4. Sweat glands
   a. Each sweat gland is a coiled tube.
   b. Sweat is primarily water but also contains salts and waste products.
   c. Eccrine sweat glands respond to elevated body temperature, whereas apocrine glands respond to emotional stress.