Skin and Body Membranes

Your Goals

After completing this chapter, you will have a working knowledge of the functions of the skin and body membranes system and will have mastered the objectives listed below.

Function Preview

- Body membranes line or cover, protect, and lubricate body surfaces.
- As the outermost boundary of the body, the skin protects against injuries of many types.

Objective Checklist

CLASSIFICATION OF BODY MEMBRANES (pp. 96–98)

- List the general functions of each membrane type—cutaneous, mucous, serous, and synovial—and give its location in the body.
- Compare the structure (tissue makeup) of the major membrane types.

INTEGUMENTARY SYSTEM (SKIN) (pp. 98–111)

- List several important functions of the integumentary system and explain how these functions are accomplished.
- When provided with a model or diagram of the skin, recognize and name the following skin structures: epidermis, dermis (papillary and reticular layers), hair and hair follicle, sebaceous gland, and sweat gland.
- Name the layers of the epidermis and describe the characteristics of each.
- Describe the distribution and function of the epidermal derivatives—sebaceous glands, sweat glands, and hair.
- Name the factors that determine skin color and describe the function of melanin.
- Differentiate between first-, second-, and third-degree burns.
- Explain the importance of the "rule of nines."
- Summarize the characteristics of basal cell carcinoma, squamous cell carcinoma, and malignant melanoma.

DEVELOPMENTAL ASPECTS OF SKIN AND BODY MEMBRANES (p. 111)

- List several examples of integumentary system aging.

Body membranes, which cover surfaces, line body cavities, and form protective (and often lubricating) sheets around organs, fall into two major groups. There are (1) *epithelial membranes,* which include the cutaneous, mucous, and serous membranes, and (2) *connective tissue membranes,* represented by synovial membranes. The cutaneous membrane, generally called the skin or integumentary system, will receive most of our attention in this chapter, but first we will consider the other body membranes.

Classification of Body Membranes

The two major categories of body membranes—epithelial and connective tissue—are classified in part according to their tissue makeup.

Epithelial Membranes

The **epithelial membranes** include the cutaneous membrane (skin), the mucous membranes, and the serous membranes (Figure 4.1). However, calling these membranes "epithelial" is not only misleading but also inaccurate. Although they all *do* contain an epithelial sheet, it is always combined with an underlying layer of connective tissue. Hence these membranes are actually simple organs. Since the skin will be discussed in some detail shortly, it will be listed here solely as a subcategory of the epithelial membranes.

Cutaneous Membrane

The **cutaneous** (ku-ta′ne-us) **membrane** is your skin. Its superficial epidermis is composed of a keratinizing stratified squamous epithelium. The underlying dermis is mostly dense (fibrous) connective tissue. Unlike the other epithelial membranes, the cutaneous membrane is exposed to air and is a *dry* membrane.

Mucous Membranes

A **mucous membrane (mucosa)** is composed of epithelium (the type varies with the site) resting on a loose connective tissue membrane called a *lamina propria.* This membrane type lines all body cavities that open to the exterior, such as those of the hollow organs of the respiratory, digestive, urinary, and reproductive tracts (Figure 4.1b). Notice that the term *mucosa* refers only to the location of the epithelial membranes, *not* their cell makeup, which varies. However, most mucosae contain either stratified squamous epithelium (as in the mouth and esophagus) or simple columnar epithelium (as in the rest of the digestive tract). In all cases, they are "wet," or moist membranes that are almost continuously bathed in secretions, or in the case of the urinary mucosae, urine.

The epithelium of mucosae is often adapted for absorption or secretion. Although many mucosae secrete mucus, this is not a requirement. The mucosae of the respiratory and digestive tracts secrete large amounts of protective, lubricating mucus; that of the urinary tract does not.

Serous Membranes

A **serous membrane (serosa)** is composed of a layer of simple squamous epithelium resting on a thin layer of areolar connective tissue. In contrast to mucous membranes, which line open body cavities, serous membranes line body cavities that are closed to the exterior (except for the dorsal body cavity and joint cavities).

Serous membranes occur in pairs. The *parietal* (pah-ri′e-tal: *parie* = wall) *layer* lines a specific portion of the wall of the ventral body cavity. It folds in on itself to form the *visceral* (vis′er-al) *layer,* which covers the outside of the organs in that cavity.

You can visualize the relationship between the serosal layers by pushing your fist into a limp balloon (Figure 4.1d). The part of the balloon that clings closely to your fist can be compared to the visceral serosa clinging to the organ's external surface. The outer wall of the balloon represents the parietal serosa that lines the walls of the cavity and that, unlike the balloon, is never exposed but is always fused to the cavity wall. In the body, the serous layers are separated not by air but by a thin, clear fluid, called **serous fluid,** which is secreted by both membranes. Although there is a potential space between the two membranes, they tend to lie very close to each other.

The serous fluid allows the organs to slide easily across the cavity walls and one another without

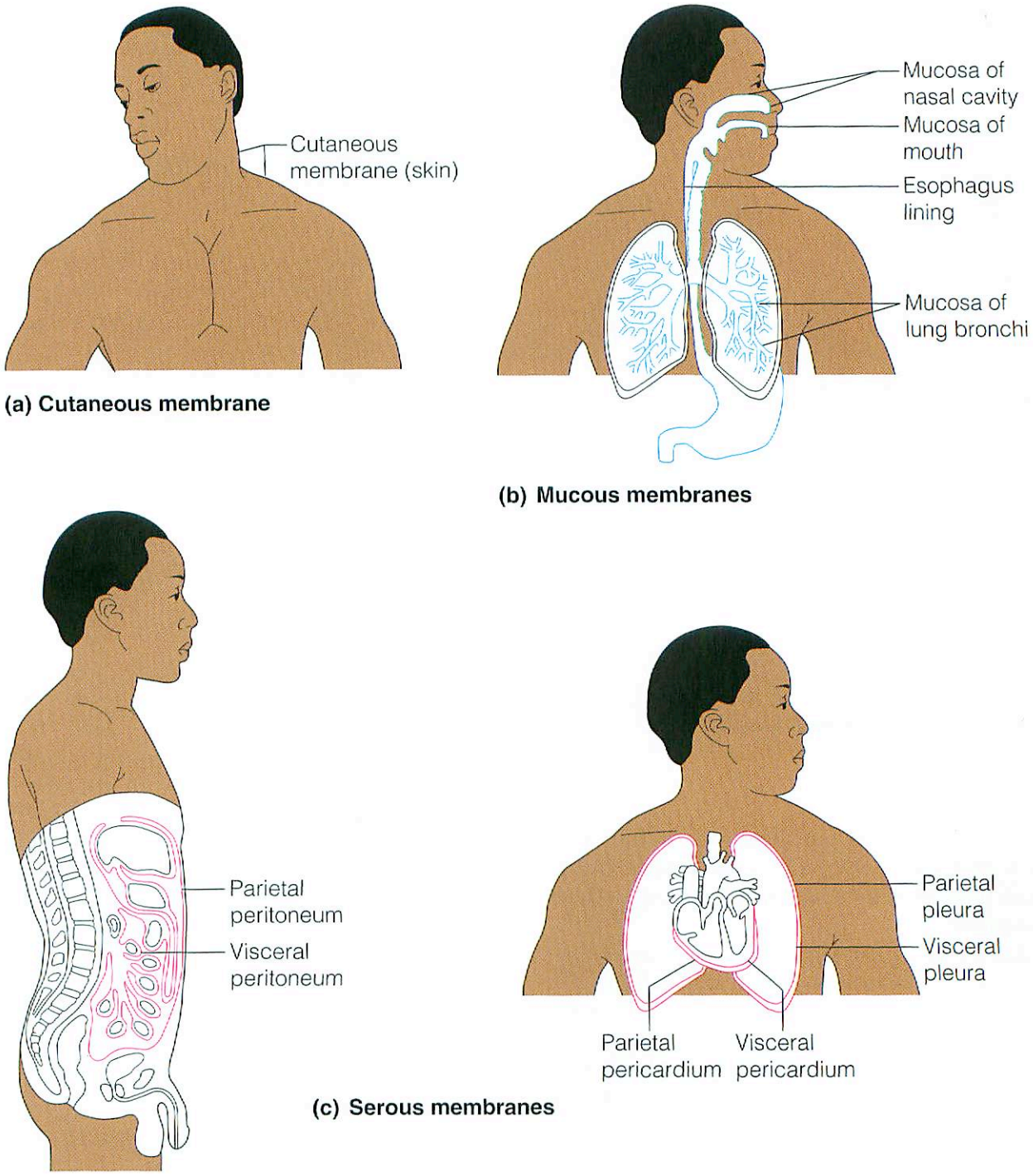


Figure 4.1 Classes of epithelial membranes. **(a)** Cutaneous membrane, or skin. **(b)** Mucous membranes (blue) line body cavities that are open to the exterior. **(c)** Serous membranes (shown in red) line ventral body cavities that are closed to the exterior. **(d)** A fist thrust into a flaccid balloon demonstrates the relationship between the parietal and visceral serous membrane layers.

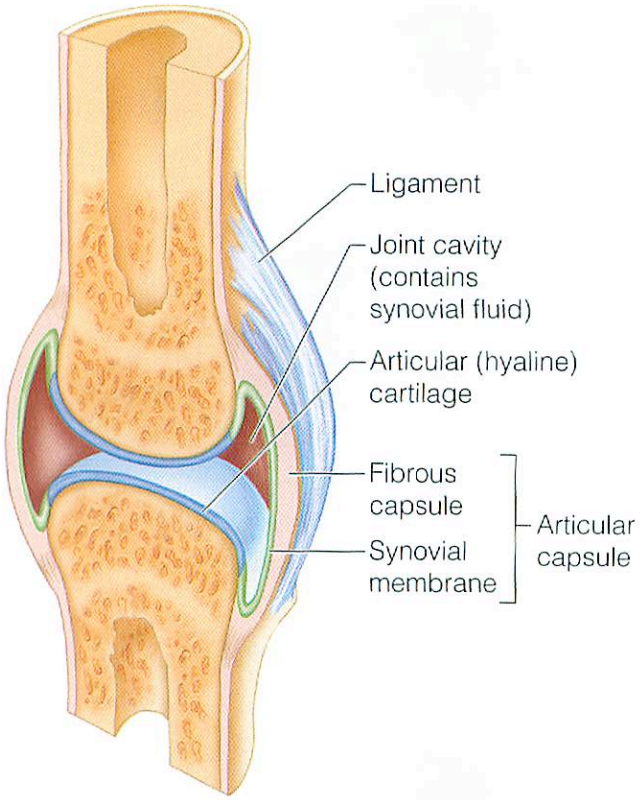


Figure 4.2 A typical synovial joint.

friction as they carry out their routine functions. This is extremely important when mobile organs such as the pumping heart and a churning stomach are involved.

The specific names of the serous membranes depend on their locations. The serosa lining the abdominal cavity and covering its organs is the **peritoneum** (per″ĭ-to-ne′um). In the thorax, serous membranes isolate the lungs and heart from one another. That surrounding the lungs (Figure 4.1c) is the **pleura** (ploo′rah); that around the heart is the **pericardium** (per″ĭ-kar′de-um).

Connective Tissue Membranes

Synovial (sĭ-no′ve-al) **membranes** are composed of soft areolar connective tissue and contain no epithelial cells at all. These membranes line the fibrous capsules surrounding joints (Figure 4.2), where they provide a smooth surface and secrete a lubricating fluid. They also line small sacs of connective tissue called *bursae* (ber′se) and the tube-like *tendon sheaths*. Both of these structures cushion organs moving against each other during muscle activity—such as the movement of a tendon across a bone's surface.

Integumentary System (Skin)

Would you be enticed by an advertisement for a coat that is waterproof, stretchable, washable, and permanent-press, that invisibly repairs small cuts, rips, and burns, and that is guaranteed to last a lifetime with reasonable care? Sounds too good to be true, but you already have such a coat—your *cutaneous membrane*, or **skin.** The skin and its derivatives (sweat and oil glands, hairs, and nails) serve a number of functions, mostly protective. Together, these organs are called the **integumentary** (in-teg″u-men′ta-re) **system.**

Basic Skin Functions

Also called the **integument** (in-teg′u-ment), which simply means "covering," the skin is much more than an external body covering. It is absolutely essential because it keeps water and other precious molecules in the body. It also keeps water (and other things) out. (This is why one can swim for hours without becoming waterlogged.) Structurally, the skin is a marvel. It is pliable yet tough, which allows it to take constant punishment from external agents. Without our skin, we would quickly fall prey to bacteria and perish from water and heat loss.

The skin has many functions; most, but not all, are protective (Table 4.1). It insulates and cushions the deeper body organs and protects the entire body from mechanical damage (bumps and cuts), chemical damage (such as from acids and bases), thermal damage (heat and cold), ultraviolet radiation (in sunlight), and bacteria. The uppermost layer of the skin is full of keratin and *cornified,* or hardened, in order to prevent water loss from the body surface.

The skin's rich capillary network and sweat glands (both controlled by the nervous system) play an important role in regulating heat loss from the body surface. The skin acts as a mini-excretory system; urea, salts, and water are lost when we sweat. The skin also manufactures several proteins important to immunity and synthesizes vitamin D.

Table 4.1 Functions of the Skin

Functions	How accomplished
Protects deeper tissues from	
• Mechanical damage (bumps)	Physical barrier contains keratin, which toughens cells, and pressure receptors, which alert the nervous system to possible damage.
• Chemical damage (acids and bases)	Has relatively impermeable keratinized cells; contains pain receptors, which alert the nervous system to possible damage.
• Bacterial damage	Has an unbroken surface and "acid mantle" (skin secretions are acidic, and thus inhibit bacteria). Phagocytes ingest foreign substances and pathogens, preventing them from penetrating into deeper body tissues.
• Ultraviolet radiation (damaging effects of sunlight)	Melanin produced by melanocytes offers protection.
• Thermal (heat or cold) damage	Contains heat/cold/pain receptors.
• Desiccation (drying out)	Contains waterproofing substances including keratin.
Aids in body heat loss or heat retention (controlled by the nervous system)	Heat loss: By activating sweat glands and allowing blood to flush into skin capillary beds. Heat retention: By not allowing blood to flush into skin capillary beds.
Aids in excretion of urea and uric acid	Contained in perspiration produced by sweat glands.
Synthesizes vitamin D	Modified cholesterol molecules in skin converted to vitamin D by sunlight.

(Modified cholesterol molecules located in the skin are converted to vitamin D by sunlight.) Finally, the *cutaneous sensory receptors*, which are actually part of the nervous system, are located in the skin. These tiny sensors, which include touch, pressure, temperature, and pain receptors, provide us with a great deal of information about our external environment. They alert us to bumps and the presence of tissue-damaging factors as well as to the feel of wind in our hair and a caress.

Structure of the Skin

The skin is composed of two kinds of tissue. The outer **epidermis** (ep″ĭ-der′mis) is made up of stratified squamous epithelium that is capable of **keratinizing** (ker′ah-tin-īz-ing), or becoming hard and tough. The underlying **dermis** is made up of dense connective tissue. The epidermis and dermis are firmly connected. However, a burn or friction (e.g., the rubbing of a poorly fitting shoe) may cause them to separate, which results in a *blister*.

Deep to the dermis is the **subcutaneous tissue,** or **hypodermis,** which essentially is adipose tissue. It is not considered part of the skin, but it does anchor the skin to underlying organs. Subcutaneous tissue serves as a shock absorber and insulates the deeper tissues from extreme temperature changes occurring outside the body. It is also responsible for the curves that are more a part of a woman's anatomy than a man's. The main skin areas and structures are described next. As you read, locate the described areas or structures on Figures 4.3 and 4.4.

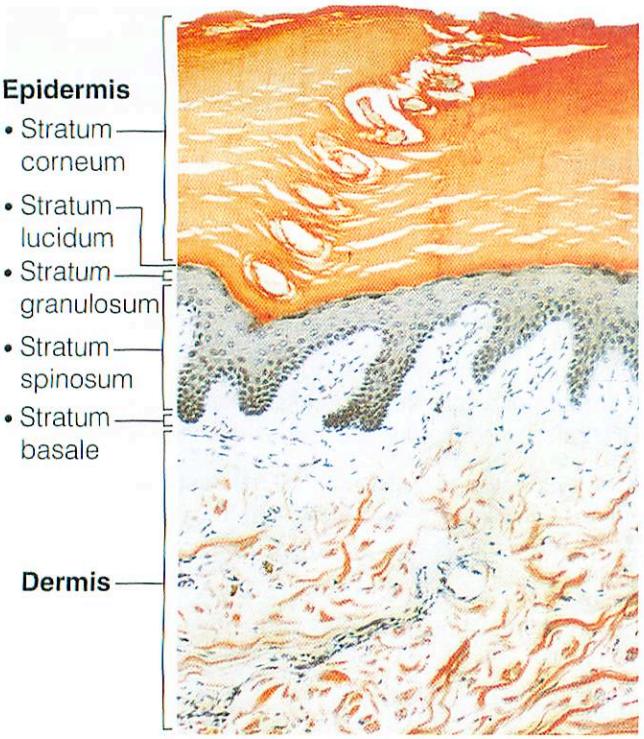


Figure 4.3 The epidermis of thick skin. This photomicrograph is magnified 150×. From *Gray's Anatomy,* Henry Gray. Churchill Livingstone, UK.

Epidermis

The epidermis is composed of five zones or layers called *strata*. From the inside out these are the stratum basale, spinosum, granulosum, lucidum, and corneum (see Figure 4.3).

Like all epithelial tissues, the epidermis is *avascular;* that is, it has no blood supply of its own. This explains why a man can shave daily and not bleed even though he is cutting off many cell layers each time he shaves.

Most cells of the epidermis are **keratinocytes** (keratin cells), which produce keratin, the fibrous protein that makes the epidermis a tough protective layer. The deepest cell layer of the epidermis, the **stratum basale** (stra'tum bă-sah'le), lies closest to the dermis and contains the only epidermal cells that receive adequate nourishment via diffusion of nutrients from the dermis. These cells are constantly undergoing cell division, and millions of new cells are produced daily; hence its alternate name, *stratum germinativum*. The daughter cells are pushed upward, away from the source of nutrition, to become part of the epidermal layers closer to the skin surface. They move away from the dermis and become part of the more superficial layers, the **stratum spinosum** and then the **stratum granulosum.** Then they become flatter, increasingly full of keratin (keratinized), and finally die, forming the clear **stratum lucidum** (lu'sidum). This latter epidermal layer occurs only where the skin is hairless and extra thick, that is, on the palms of the hands and soles of the feet. The combination of accumulating water-repellent keratin inside them and their increasing distance from the blood supply (in the dermis) effectively dooms the stratum lucidum cells and the more superficial epidermal cells because they are unable to get adequate nutrients and oxygen.

The outermost layer, the **stratum corneum** (kor'ne-um), is 20 to 30 cell layers thick. It accounts for about three-quarters of the epidermal thickness. The shinglelike dead cell remnants, completely filled with keratin, are referred to as *cornified* or *horny cells* (*cornu* = horn). The common saying "Beauty is only skin deep" is especially interesting in light of the fact that nearly everything we see when we look at someone is dead! Keratin is an exceptionally tough protein. Its abundance in the stratum corneum allows that layer to provide a durable "overcoat" for the body, which protects deeper cells from the hostile external environment (air) and from water loss and helps the body resist biological, chemical, and physical assaults. The stratum corneum rubs and flakes off slowly and steadily and is replaced by cells produced by the division of the deeper stratum basale cells. Indeed, we have a totally "new" epidermis every 25 to 45 days.

Melanin (mel'ah-nin), a pigment that ranges in color from yellow to brown to black, is produced by special cells called **melanocytes** (mel'ah-no-sītz), found chiefly in the stratum basale. When the skin is exposed to sunlight, which stimulates the melanocytes to produce more of the melanin pigment, tanning occurs. The stratum basale cells phagocytize (eat) the pigment, and as it accumulates within them, the melanin forms a protective pigment "umbrella" over the superficial, or "sunny," side of their nuclei that shields their genetic material (DNA) from the damaging effects of ultraviolet radiation in sunlight. *Freckles* and *moles* are seen where melanin is concentrated in one spot.

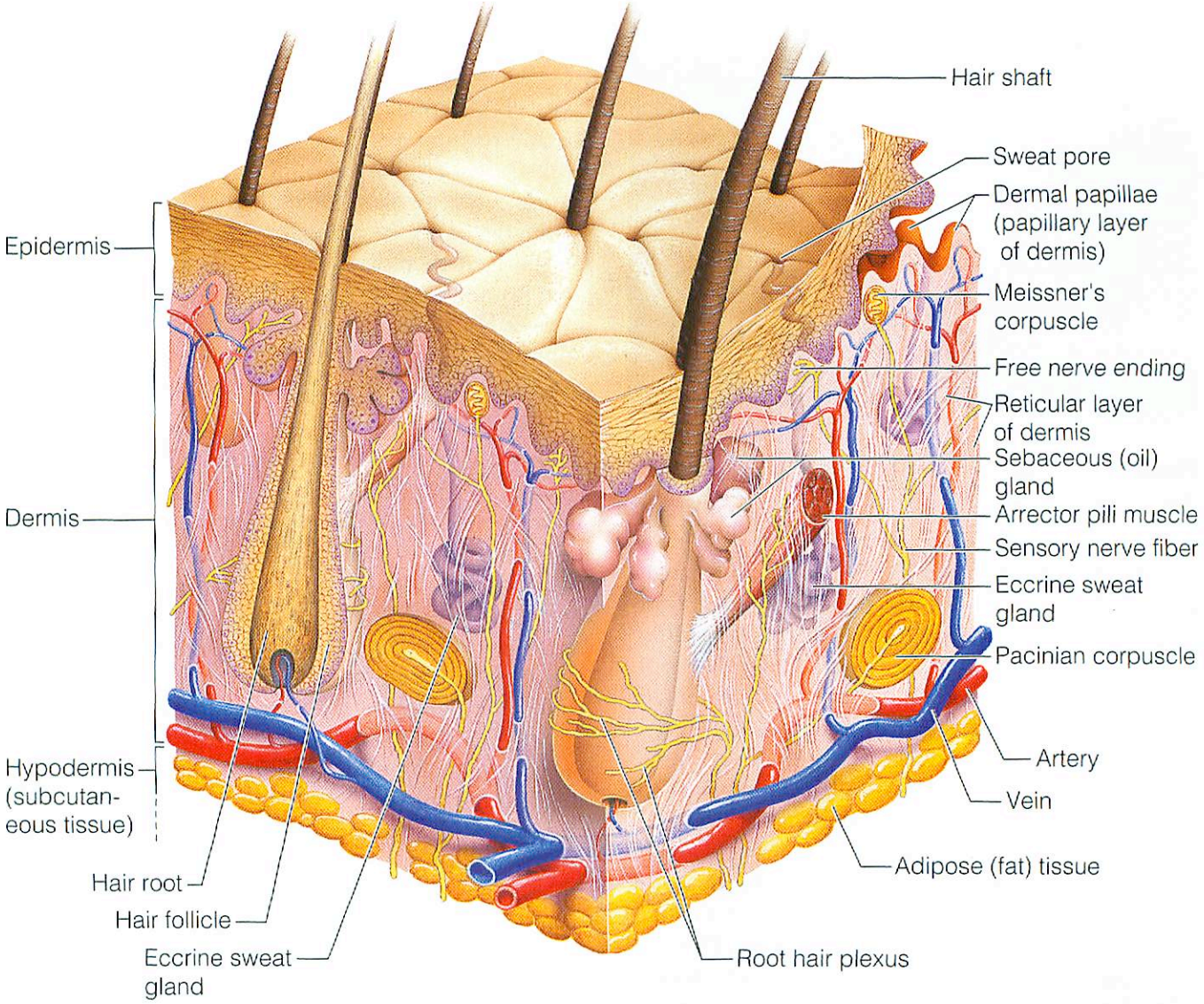


Figure 4.4 Skin structure. Three-dimensional view of the skin and underlying subcutaneous tissue.

HOMEOSTATIC IMBALANCE Despite melanin's protective effects, excessive sun exposure eventually damages the skin. It causes the elastic fibers to clump, leading to leathery skin. It also depresses the immune system. This may help to explain why many people infected with the *herpes simplex*, or *cold sore*, virus are more likely to have an eruption after sunbathing. Overexposure to the sun can also alter the DNA of skin cells and in this way lead to skin cancer. Black people seldom have skin cancer, attesting to melanin's amazing effectiveness as a natural sunscreen. ▲

Dermis

The dermis is your "hide." It is a strong, stretchy envelope that helps to hold the body together. When you purchase leather goods (bags, belts, shoes, and the like), you are buying the treated dermis of animals.

The dense (fibrous) connective tissue making up the dermis consists of two major regions—the *papillary* and the *reticular* areas. Like the epidermis, the dermis varies in thickness. For example, it is particularly thick on the palms of the hands and soles of the feet but is quite thin on the eyelids.

Figure 4.5 Photograph of a deep (stage III) decubitus ulcer.

The **papillary layer** is the upper dermal region. It is uneven and has fingerlike projections from its superior surface, called **dermal papillae** (pah-pil′e; *papill* = nipple), which indent the epidermis above. Many of the dermal papillae contain capillary loops, which furnish nutrients to the epidermis. Others house pain receptors (free nerve endings) and touch receptors called *Meissner's corpuscles* (mīs′nerz kor′puh-sulz). On the palms of the hands and soles of the feet, the papillae are arranged in definite patterns that form looped and whorled ridges on the epidermal surface that increase friction and enhance the gripping ability of the fingers and feet. Papillary patterns are genetically determined. The ridges of the fingertips are well provided with sweat pores and leave unique, identifying films of sweat called *fingerprints* on almost anything they touch.

The **reticular layer** is the deepest skin layer. It contains blood vessels, sweat and oil glands, and deep pressure receptors called *Pacinian* (pah-sin′e-an) *corpuscles* (see Figure 4.4). Many phagocytes are found here (and in fact, throughout the dermis). They act to prevent bacteria that have managed to get through the epidermis from penetrating any deeper into the body.

Both *collagen* and *elastic fibers* are found throughout the dermis. Collagen fibers are responsible for the toughness of the dermis. Collagen fibers also attract and bind water and thus help to keep the skin hydrated. Elastic fibers give the skin its elasticity when we are young. As we age, the number of collagen and elastic fibers decreases, and the subcutaneous tissue loses fat. As a result, the skin becomes less elastic and begins to sag and wrinkle.

The dermis is abundantly supplied with blood vessels that play a role in maintaining body temperature homeostasis. When body temperature is high, the capillaries of the dermis become engorged, or swollen, with heated blood, and the skin becomes reddened and warm. This allows body heat to radiate from the skin surface. If the environment is cool and body heat must be conserved, blood bypasses the dermis capillaries temporarily, allowing internal body temperature to stay high.

HOMEOSTATIC IMBALANCE Any restriction of the normal blood supply to the skin results in cell death and, if severe or prolonged enough, skin ulcers. *Decubitus* (de-ku′bĭ-tus) *ulcers* (bedsores) occur in bedridden patients who are not turned regularly or who are dragged or pulled across the bed repeatedly. The weight of the body puts pressure on the skin, especially over bony projections. Because this restricts the blood supply, the skin becomes pale or blanched at pressure points. At first, the skin reddens when pressure is released, but if the situation is not corrected, the cells begin to die, and typically small cracks or breaks in the skin appear at compressed sites. Permanent damage to the superficial blood vessels and tissue eventually results in degeneration and ulceration of the skin (Figure 4.5). ▲

The dermis also has a rich nerve supply. As mentioned earlier, many of the nerve endings have specialized receptor end-organs that send messages to the central nervous system for interpretation when they are stimulated by environmental factors (pressure, temperature, and the like). These cutaneous receptors are discussed in more detail in Chapter 7.

Skin Color

Three pigments contribute to skin color:

1. The amount and kind (yellow, reddish brown, or black) of melanin in the epidermis.
2. The amount of carotene deposited in the stratum corneum and subcutaneous tissue. (Carotene is an orange-yellow pigment found in abundant amounts in carrots and other orange, deep yellow, or leafy green vegetables.) The skin tends to take on a yellow-orange cast when large amounts of carotene-rich foods are eaten.

3. The amount of oxygen bound to hemoglobin (pigment in red blood cells) in the dermal blood vessels.

People who produce a lot of melanin have brown-toned skin. In light-skinned (Caucasian) people, who have less melanin, the crimson color of oxygen-rich hemoglobin in the dermal blood supply flushes through the transparent cell layers above and gives the skin a rosy glow.

HOMEOSTATIC IMBALANCE When hemoglobin is poorly oxygenated, both the blood and the skin of Caucasians appear blue, a condition called *cyanosis* (si″ah-no′sis). Cyanosis is common during heart failure and severe breathing disorders. In black people, the skin does not appear cyanotic because of the masking effects of melanin, but cyanosis is apparent in their mucous membranes and nail beds. ▲

Skin color is also influenced by emotional stimuli, and many alterations in skin color signal certain disease states:

- *Redness,* or *erythema* (er″ĭ-the′mah): Reddened skin may indicate embarrassment (blushing), fever, hypertension, inflammation, or allergy.
- *Pallor,* or *blanching:* Under certain types of emotional stress (fear, anger, and others), some people become pale. Pale skin may also signify anemia, low blood pressure, or impaired blood flow into the area.
- *Jaundice* (jon′dis) or a *yellow cast:* An abnormal yellow skin tone usually signifies a liver disorder in which excess bile pigments are absorbed into the blood, circulated throughout the body, and deposited in body tissues.
- *Bruises* or *black-and-blue marks:* Black-and-blue marks reveal sites where blood has escaped from the circulation and has clotted in the tissue spaces. Such clotted blood masses are called *hematomas.* An unusual tendency to bruising may signify a deficiency of vitamin C in the diet or hemophilia (bleeder's disease).

Appendages of the Skin

The **skin appendages** include cutaneous glands, hairs and hair follicles, and nails. Each of these appendages arises from the epidermis and plays a unique role in maintaining body homeostasis.

Cutaneous Glands

The cutaneous glands are all **exocrine glands** that release their secretions to the skin surface via ducts. They fall into two groups: *sebaceous glands* and *sweat glands.* As these glands are formed by the cells of the stratum basale, they push into the deeper skin regions and ultimately reside almost entirely in the dermis.

Sebaceous (Oil) Glands The **sebaceous** (seh-ba′-shus) **glands,** or oil glands, are found all over the skin, except on the palms of the hands and the soles of the feet. Their ducts usually empty into a hair follicle (see Figures 4.4 and 4.6), but some open directly onto the skin surface.

The product of the sebaceous glands, **sebum** (se′bum; *seb* = grease), is a mixture of oily substances and fragmented cells. Sebum is a lubricant that keeps the skin soft and moist and prevents the hair from becoming brittle. Sebum also contains chemicals that *kill* bacteria, so it is important in preventing the bacteria present on the skin surface from invading the deeper skin regions. The sebaceous glands become very active when male sex hormones are produced in increased amounts (in both sexes) during adolescence. Thus, the skin tends to become oilier during this period of life.

HOMEOSTATIC IMBALANCE If a sebaceous gland's duct becomes blocked by sebum, a *whitehead* appears on the skin surface. If the accumulated material oxidizes and dries, it darkens, forming a *blackhead. Acne* is an active infection of the sebaceous glands accompanied by "pimples" on the skin. It can be mild or extremely severe, leading to permanent scarring. *Seborrhea* (seb″o-re′ah), known as "cradle cap" in infants, is caused by overactivity of the sebaceous glands. It begins on the scalp as pink, raised lesions that gradually form a yellow to brown crust that sloughs off as oily dandruff. Careful washing to remove the excessive oil often helps. ▲

Sweat Glands **Sweat glands,** also called **sudoriferous** (su″do-rif′er-us; *sudor* = sweat) **glands,** are widely distributed in the skin. Their number is staggering—more than 2.5 million per person. There are two types of sweat glands, *eccrine* and *apocrine.*

The **eccrine** (ek′rin) **glands** are far more numerous and are found all over the body. They produce **sweat,** a clear secretion that is primarily

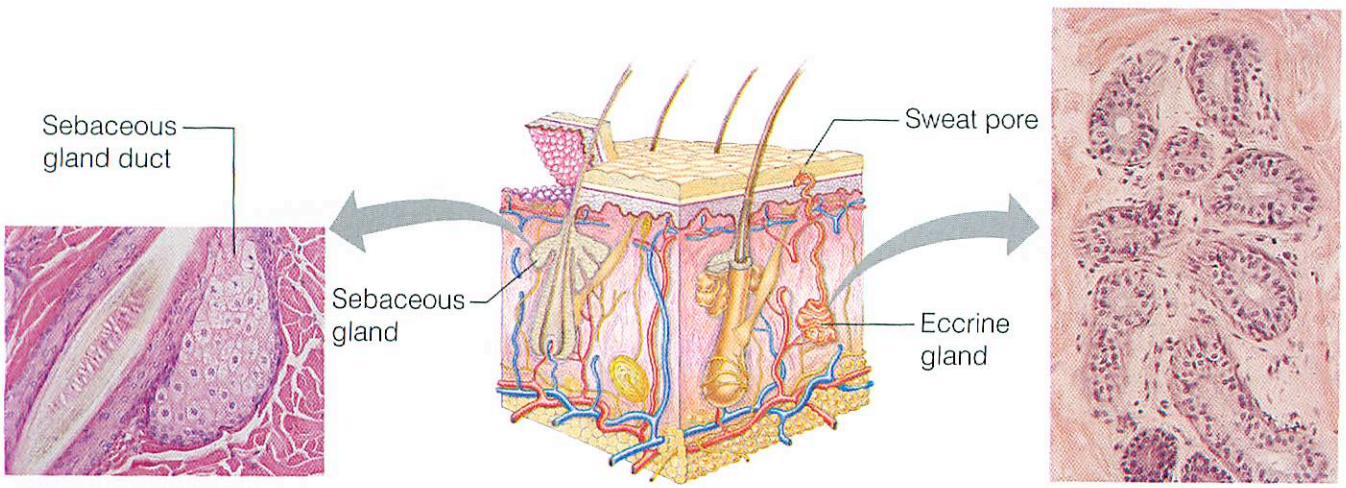


Figure 4.6 Cutaneous glands. (a) Photomicrograph of a sebaceous gland (104×). **(b)** Photomicrograph of eccrine sweat glands (148×).

water plus some salts (sodium chloride), vitamin C, traces of metabolic wastes (ammonia, urea, uric acid), and lactic acid (the chemical that attracts mosquitoes). Sweat is acidic (pH from 4 to 6), a characteristic that inhibits the growth of bacteria, which are always present on the skin surface. Typically, sweat reaches the skin surface via a duct that opens externally as a funnel-shaped **pore** (see Figures 4.4 and 4.6). Notice, however, that the facial "pores" commonly referred to when we talk about our complexion are *not* these sweat pores, but the external outlets of hair follicles.

The eccrine sweat glands are an important and highly efficient part of the body's heat-regulating equipment. They are supplied with nerve endings that cause them to secrete sweat when the external temperature or body temperature is high. When sweat evaporates off the skin surface, it carries large amounts of body heat with it. On a hot day, it is possible to lose up to 7 liters of body water in this way. The heat-regulating functions of the body are important—if internal temperature changes more than a few degrees from the normal 98.2°F, life-threatening changes occur in the body. Body temperature regulation is discussed in more detail in Chapter 14.

Apocrine (ap′o-krin) **sweat glands** are largely confined to the axillary and genital areas of the body. They are usually larger than eccrine glands, and their ducts empty into hair follicles. Their secretion contains fatty acids and proteins, as well as all the substances present in eccrine secretion; consequently, it may have a milky or yellowish color. The secretion is odorless, but when bacteria that live on the skin use its proteins and fats as a source of nutrients for their growth, it takes on a musky, unpleasant odor.

Apocrine glands begin to function during puberty under the influence of androgens. Although their secretion is produced almost continuously, apocrine glands play a minimal role in thermoregulation. Their precise function is not yet known, but they are activated by nerve fibers during pain and stress and during sexual foreplay.

Hairs and Hair Follicles

There are millions of **hairs** scattered all over the body. But, other than serving a few minor protective functions—such as guarding the head against bumps, shielding the eyes (via eyelashes), and helping to keep foreign particles out of the respiratory tract (via nose hairs)—our body hair has lost much of its usefulness. Hairs served early humans (and still serve hairy animals) by providing insulation in cold weather, but now we have other means of keeping warm.

A hair, produced by a *hair follicle*, is a flexible epithelial structure. That part of the hair enclosed in the follicle is called the **root.** The part projecting from the surface of the scalp or skin is called the **shaft** (see Figure 4.7). A hair is formed by division

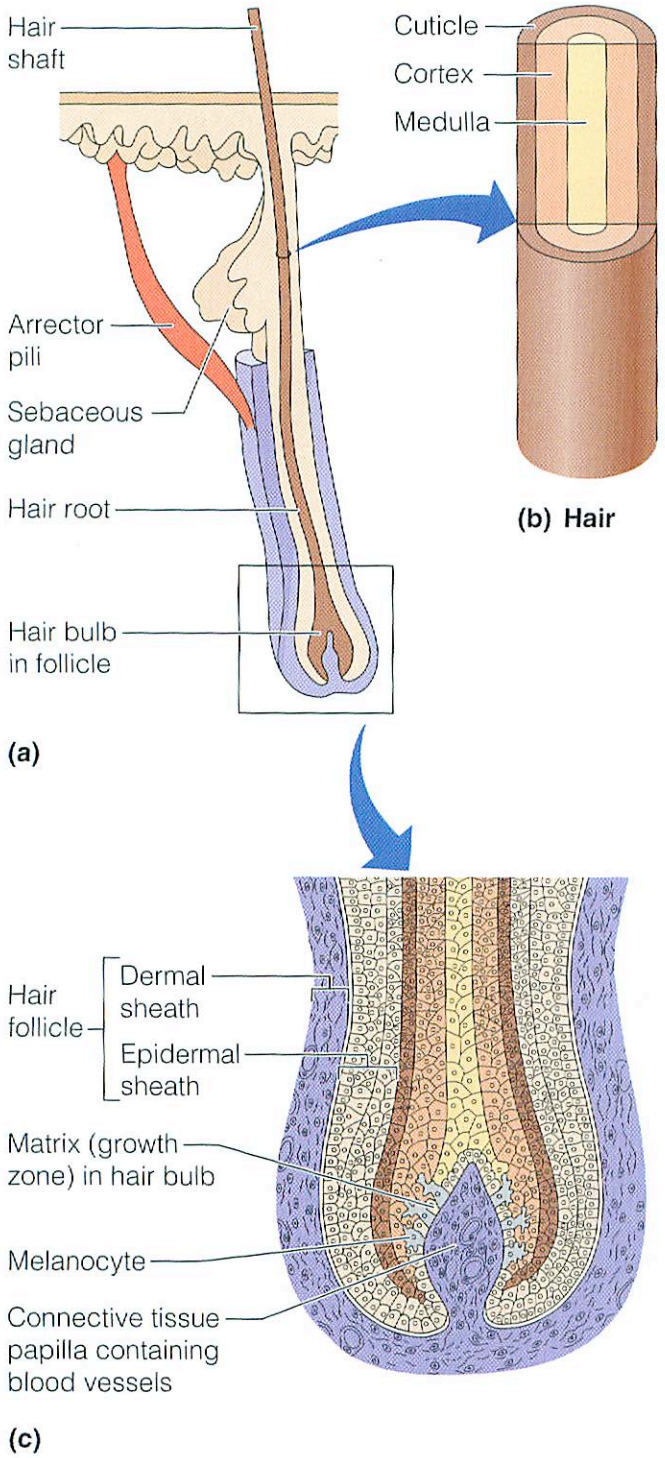


Figure 4.7 Structure of a hair and hair follicle. (a) Longitudinal section of a hair within its follicle. **(b)** Enlarged longitudinal section of a hair. **(c)** Enlarged longitudinal view of the expanded hair bulb in the follicle showing the matrix, the region of actively dividing epithelial cells that produces the hair.

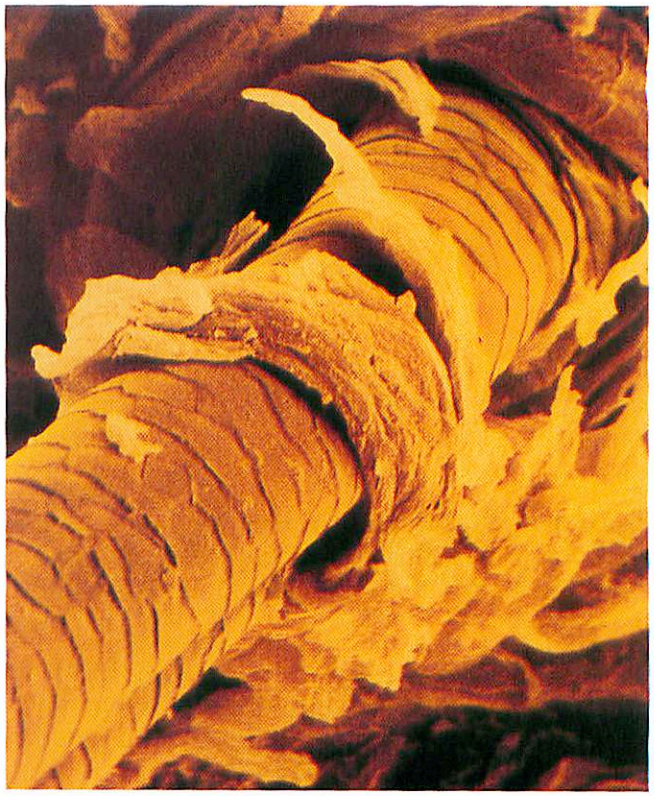


Figure 4.8 Scanning electron micrograph showing a hair shaft emerging from a follicle at the skin surface. Notice how the scalelike cells of the cuticle overlap one another (1500×).

of the well-nourished stratum basale epithelial cells in the growth zone, or **hair bulb matrix,** at the inferior end of the follicle. As the daughter cells are pushed farther away from the growing region, they become keratinized and die. Thus the bulk of the hair shaft, like the bulk of the epidermis, is dead material and almost entirely protein.

Each hair consists of a central core called the *medulla* (me-dul'ah) surrounded by a bulky *cortex* layer. The cortex is, in turn, enclosed by an outermost *cuticle* formed by a single layer of cells that overlap one another like shingles on a roof. This arrangement of the cuticle cells helps to keep the hairs apart and keeps them from matting (see Figures 4.7b and 4.8). The cuticle is the most heavily keratinized region; it provides strength and helps keep the inner hair layers tightly compacted. Because it is most subject to abrasion, the cuticle tends to wear away at the tip of the shaft, allowing the keratin fibrils in the inner hair regions to frizz out, a phenomenon called "split ends." Hair pigment is

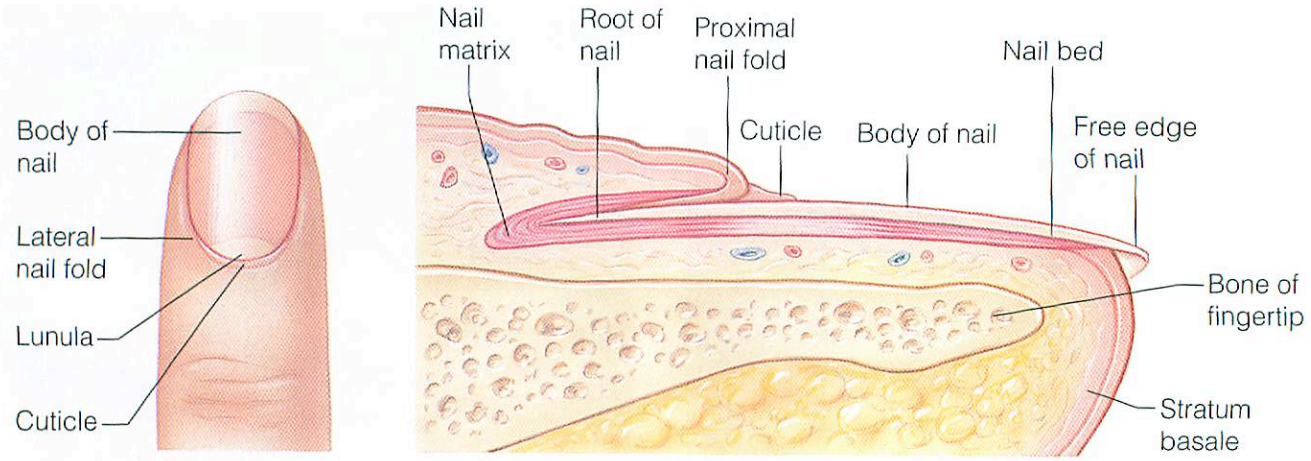


Figure 4.9 Structure of a nail. Surface view (left) and longitudinal section of the distal part of a finger (right), showing nail parts and the nail matrix that forms the nail.

made by melanocytes in the hair bulb, and varying amounts of different types of melanin (yellow, rust, brown, and black) combine to produce *all* varieties of hair color from pale blond to pitch black.

Hairs come in a variety of sizes and shapes. They are short and stiff in the eyebrows, long and flexible on the head, and usually nearly invisible almost everywhere else. When the hair shaft is oval, hair is smooth and silky and the person has wavy hair. When the shaft is flat and ribbonlike, the hair is curly or kinky. If it is perfectly round, the hair is straight and tends to be coarse. Hairs are found all over the body surface except the palms of the hands, soles of the feet, nipples, and lips. Humans are born with as many hair follicles as they will ever have, and hairs are among the fastest growing tissues in the body. Hormones account for the development of "hairy" regions—the scalp and, in the adult, the pubic and axillary (armpit) areas.

Hair follicles are actually compound structures. The inner *epidermal sheath* is composed of epithelial tissue and forms the hair. The outer *dermal sheath* is actually dermal connective tissue. This dermal layer supplies blood vessels to the epidermal portion and reinforces it. Its nipplelike papilla provides the blood supply to the matrix in the hair bulb.

Look carefully at the structure of the hair follicle at the front corner of Figure 4.4. Notice that it is slanted. Small bands of smooth muscle cells—**arrector pili** (ah-rek'tor pi'li)—connect each side of the hair follicle to the dermal tissue. When these muscles contract (as when we are cold or frightened), the hair is pulled upright, dimpling the skin surface with "goose bumps." This action helps keep animals warm in winter by adding a layer of insulating air to the fur. It is especially dramatic in a scared cat, whose fur actually stands on end to make it look larger to scare off its enemy. However, this "hair-raising" phenomenon is not very useful to human beings.

Nails

A **nail** is a scalelike modification of the epidermis that corresponds to the hoof or claw of other animals. Each nail has a *free edge*, a *body* (visible attached portion), and a *root* (embedded in the skin). The borders of the nail are overlapped by skin folds, called *nail folds*. The thick proximal nail fold is commonly called the *cuticle* (Figure 4.9).

The stratum basale of the epidermis extends beneath the nail as the *nail bed*. Its thickened proximal area, called the *nail matrix*, is responsible for nail growth. As the nail cells are produced by the matrix, they become heavily keratinized and die. Thus, nails, like hairs, are mostly nonliving material.

Nails are transparent and nearly colorless, but they look pink because of the rich blood supply in the underlying dermis. The exception to this is the region over the thickened nail matrix that appears as a white crescent and is called the *lunula* (loo'nyu-luh). As noted earlier, when the supply of oxygen in the blood is low, the nail beds take on a cyanotic (blue) cast.

(a) (b) (c)

Figure 4.10 Cutaneous lesions. (a) Cold sores. **(b)** Impetigo. **(c)** Psoriasis.

Homeostatic Imbalances of Skin

HOMEOSTATIC IMBALANCE It is difficult to scoff at anything that goes wrong with the skin because, when it rebels, it is quite a visible revolution. Loss of homeostasis in body cells and organs can reveal itself on the skin in ways that are sometimes almost unbelievable. The skin can develop more than 1000 different ailments. The most common skin disorders result from allergies or bacterial, viral, or fungal infections. Less common, but far more damaging, are burns and skin cancers. A number of the homeostatic imbalances of the skin are summarized briefly in the sections just below.

Infections and Allergies

- **Athlete's foot.** An itchy, red, peeling condition of the skin between the toes, resulting from fungus infection. Also called *tinea pedis*.
- **Boils and carbuncles** (kar'bun-kulz). Inflammation of hair follicles and sebaceous glands, common on the dorsal neck. Carbuncles are composite boils typically caused by bacterial infection (often *Staphylococcus aureus*).
- **Cold sores** (fever blisters). Small fluid-filled blisters that itch and sting, caused by a herpes simplex infection. The virus localizes in a cutaneous nerve, where it remains dormant until activated by emotional upset, fever, or UV radiation. Cold sores usually occur around the lips and in the oral mucosa of the mouth (see Figure 4.10a).
- **Contact dermatitis.** Itching, redness, and swelling of the skin, progressing to blistering. Caused by exposure of the skin to chemicals (e.g., those in poison ivy) that provoke allergic responses in sensitive individuals.
- **Impetigo** (im-peh-ti'go; *impet* = an attack). Pink, water-filled, raised lesions (commonly around the mouth and nose) that develop a yellow crust and eventually rupture (Figure 4.10b). Caused by a highly contagious staphylococcus infection; common in elementary school–aged children.
- **Psoriasis** (so-ri'ah-sis). A chronic condition, characterized by reddened epidermal lesions covered with dry, silvery scales (Figure 4.10c). When severe, may be disfiguring. Its cause is unknown; may be hereditary in some cases. Attacks often triggered by trauma, infection, hormonal changes, and stress.

Burns

The skin is only about as thick as a paper towel—not too impressive as organ systems go. And yet, when it is severely damaged, nearly every body system suffers. Metabolism accelerates or may be impaired, changes in the immune system occur, and the cardiovascular system may falter. Such severe damage can be caused by burns. A **burn** is tissue damage and cell death caused by intense heat, electricity, UV radiation (sunburn), or certain chemicals (such as acids).

There are few threats to skin more serious than burns. When the skin is burned and its cells are

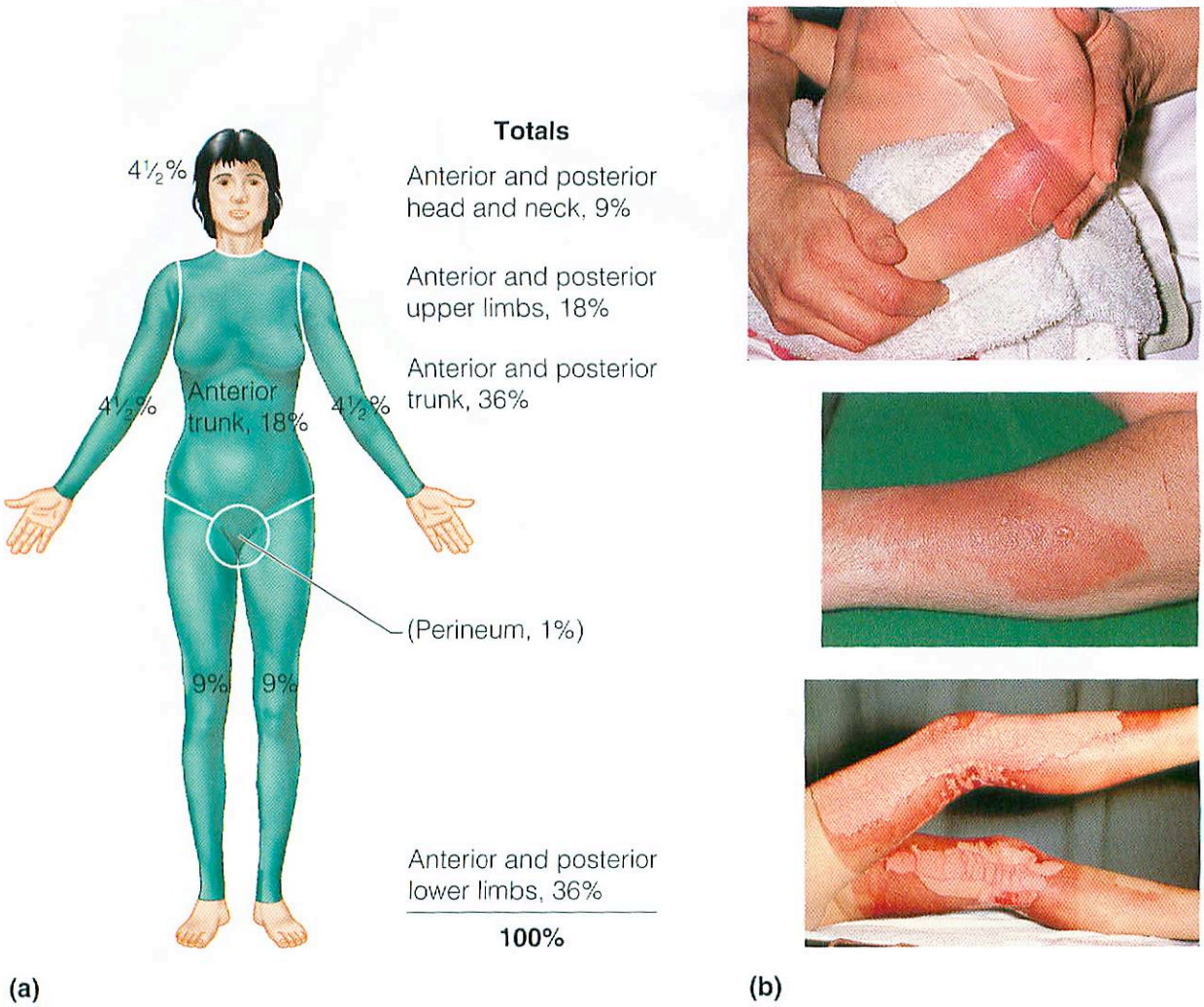


Figure 4.11 **Burns. (a)** Estimating the extent of burns using the rule of nines. The surface areas for the anterior body surface are indicated on the human figure. Total surface area (anterior and posterior body surfaces) is tabulated to the right of the figure. **(b)** Burns of increasing severity, from top to bottom: first-degree, second-degree, third-degree.

destroyed, two life-threatening problems result. First, the body loses its precious supply of fluids containing proteins and electrolytes as these seep from the burned surfaces. Dehydration and electrolyte imbalance follow and can lead to a shutdown of the kidneys and *circulatory shock* (inadequate circulation of blood caused by low blood volume). To save the patient, the lost fluids must be replaced immediately.

The volume of fluid lost can be estimated indirectly by determining how much of the body surface is burned (extent of burns), using the **rule of nines.** This method divides the body into 11 areas, each accounting for 9 percent of the total body surface area, plus an additional area surrounding the genitals (the perineum) representing 1 percent of body surface area (Figure 4.11a). Later, infection becomes the most important threat and is the leading cause of death in burn victims. Burned skin is sterile for about 24 hours. But after that, pathogens (path'o-jenz) such as bacteria and fungi easily invade areas where the skin has been destroyed and multiply rapidly in the nutrient-rich environment of dead tissues. To make matters worse, the patient's immune system becomes depressed within one to two days after severe burn injury.

Burns are classified according to their severity (depth) as first-, second-, or third-degree burns

(a) (b) (c)

Figure 4.12 Photographs of skin cancers. (a) Basal cell carcinoma. **(b)** Squamous cell carcinoma. **(c)** Melanoma.

(Figure 4.11b). In **first-degree burns,** only the epidermis is damaged. The area becomes red and swollen. Except for temporary discomfort, first-degree burns are not usually serious and generally heal in two to three days without any special attention. Sunburn is usually a first-degree burn. **Second-degree burns** involve injury to the epidermis and the upper region of the dermis. The skin is red and painful and *blisters* appear. Because sufficient numbers of epithelial cells are still present, regrowth (regeneration) of the epithelium can occur. Ordinarily, no permanent scars result if care is taken to prevent infection. First- and second-degree burns are referred to as **partial-thickness burns.**

Third-degree burns destroy the entire thickness of the skin, so these burns are also called **full-thickness burns.** The burned area appears blanched (gray-white) or blackened, and since the nerve endings in the area are destroyed, the burned area is not painful. In third-degree burns, regeneration is not possible, and skin grafting must be done to cover the underlying exposed tissues.

In general, burns are considered *critical* if any of the following conditions exists:

1. Over 25 percent of the body has second-degree burns,
2. Over 10 percent of the body has third-degree burns, or
3. There are third-degree burns of the face, hands, or feet.

Facial burns are dangerous because of the possibility of burned respiratory passageways, which can swell and cause suffocation. Joint injuries are troublesome because the scar tissue that eventually forms can severely limit joint mobility.

Skin Cancer

Numerous types of tumors arise in the skin. Most skin tumors are benign and do not spread (metastasize) to other body areas. (A wart, a neoplasm caused by a virus, is one such example.) However, some skin tumors are malignant, or cancerous, and they tend to invade other body areas. Indeed, skin cancer is the single most common type of cancer in humans. The cause of most skin cancers is not known, but the most important risk factor is overexposure to ultraviolet radiation in sunlight. Frequent irritation of the skin by infections, chemicals, or physical trauma also seems to be a predisposing factor.

Basal Cell Carcinoma **Basal cell carcinoma** (kar″sĭ-no′mah) is the least malignant and most common skin cancer. Cells of the stratum basale, altered so that they cannot form keratin, no longer honor the boundary between epidermis and dermis. They proliferate, invading the dermis and subcutaneous tissue. The cancer lesions occur most often on sun-exposed areas of the face and appear as shiny, dome-shaped nodules that later develop a central ulcer with a "pearly" beaded edge (Figure 4.12a). Basal cell carcinoma is relatively slow-growing, and metastasis seldom occurs before it is noticed. Full cure is the rule in 99 percent of cases where the lesion is removed surgically.

Squamous Cell Carcinoma **Squamous cell carcinoma** arises from the cells of the stratum spinosum. The lesion appears as a scaly, reddened papule

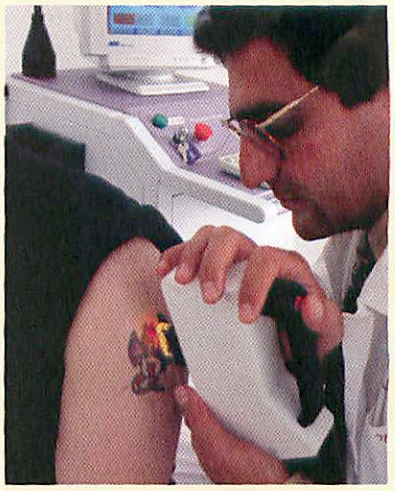
A Closer Look

Tattoos

Tattoos are made by using a needle to deposit pigment within the dermis. Tattooing is an ancient practice, believed to have originated around 10,000 years ago. These days, tattoos are symbols of club membership for some males (street gangs, the military, fraternities); other people view them as symbols of individuality. In recent years, females have increasingly *acquired* tattoos as a means of expression and for cosmetic purposes; permanent eyeliner and tattooed liplines now account for over 125,000 tattoos a year.

But what if a tattoo becomes unfashionable or the pigment migrates? Until recently, once you had one, you were essentially stuck with it, because attempts at removal—dermabrasion, cryosurgery (freezing), or applying caustic chemicals—left nasty scars. Using new laser-based technologies, dermatologists have no problem destroying the black or blue pigments in tattoos applied a generation ago, but newer, multicolored tattoos pose a larger problem. The multitude of pigments in tattoos today require that several different lasers be used over seven to nine treatments spaced about a month apart, at a cost in pain roughly equal to getting tattooed in the first place.

Tattoos present some other risks. Even though the FDA has some regulations concerning the composition of tattoo pigments, their safety is not well established. Statutory regulations vary widely (from none to complete prohibition) from state to state. Still, in each case, needles are used and bleeding occurs, and practitioners' competence varies significantly. If strict sterile procedures are not adhered to, tattooing can spread infections such as *hepatitis*. The risk of being infected by hepatitis C, a chronic liver condition, is nine times higher in people who have been tattooed than in those who have not. Even with the new lasers, is it worth the risk?



Removing an unwanted tattoo can be costly. This tattoo is being removed by a laser.

(small, rounded elevation) that gradually forms a shallow ulcer with a firm, raised border (Figure 4.12b). This variety of skin cancer appears most often on the scalp, ears, dorsum of the hands, and lower lip. It grows rapidly and metastasizes to adjacent lymph nodes if not removed. This epidermal cancer is also believed to be sun-induced. If it is caught early and removed surgically or by radiation therapy, the chance of complete cure is good.

Malignant Melanoma **Malignant melanoma** (mel"ah-no'mah) is a cancer of melanocytes. It accounts for only about 5 percent of skin cancers, but its incidence is increasing rapidly and it is often deadly. Melanoma can begin wherever there is pigment; most such cancers appear spontaneously, but some develop from pigmented moles. It usually appears as a spreading brown to black patch (Figure 4.12c) that metastasizes rapidly to sur-

rounding lymph and blood vessels. The chance for survival is about 50 percent, and early detection helps. The American Cancer Society suggests that sun worshippers periodically examine their skin for new moles or pigmented spots and apply the **ABCD rule** for recognizing melanoma:

(A) Asymmetry: the two sides of the pigmented spot or mole do not match.

(B) Border irregularity: the borders of the lesion are not smooth but exhibit indentations.

(C) Color: the pigmented spot contains areas of different colors (blacks, browns, tans, and sometimes blues and reds).

(D) Diameter: the spot is larger than 6 mm in diameter (the size of a pencil eraser).

The usual therapy for malignant melanoma is wide surgical excision along with immunotherapy. ▲

Developmental Aspects of Skin and Body Membranes

During the fifth and sixth months of fetal development, the soon-to-be-born infant is covered with a downy type of hair called *lanugo* (lah-noo′go), but this hairy cloak has usually been shed by birth. When a baby is born, its skin is covered with *vernix caseosa* (ver′niks kah-se-o′sah). This white, cheesy-looking substance, produced by the sebaceous glands, protects the baby's skin while it is floating in its water-filled sac inside the mother. The newborn's skin is very thin, and blood vessels can easily be seen through it. Commonly, there are accumulations in the sebaceous glands, which appear as small white spots called *milia* (mil′e-ah), on the baby's nose and forehead. These normally disappear by the third week after birth. As the baby grows, its skin becomes thicker and moist, and more subcutaneous fat is deposited.

During adolescence, the skin and hair become more oily as sebaceous glands are activated, and acne may appear. Acne usually subsides in early adulthood, and the skin reaches its optimal appearance when we are in our 20s and 30s. Then visible changes in the skin begin to appear as it is continually assaulted by abrasion, chemicals, wind, sun, and other irritants and as its pores become clogged with air pollutants and bacteria. As a result, pimples, scales, and various kinds of *dermatitis* (der″mah-ti′tis), or skin inflammation, become more common.

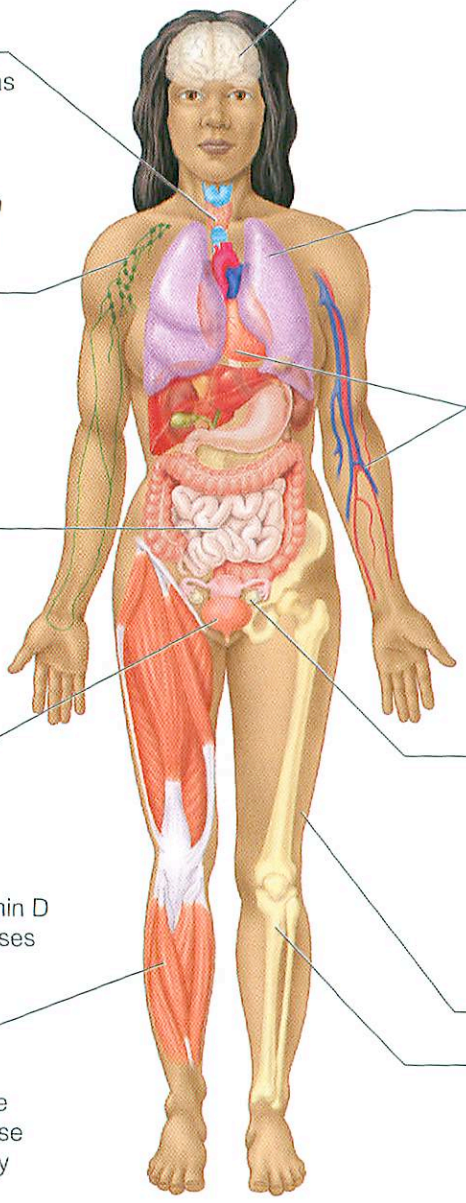
During old age, the amount of subcutaneous tissue decreases, leading to the intolerance to cold so common in the elderly. The skin also becomes drier (because of decreased oil production and declining numbers of collagen fibers), and as a result, it may become itchy and bothersome. *Thinning of* the skin, another result of the aging process, makes it more susceptible to bruising and other types of injuries. The decreasing elasticity of the skin, along with the loss of subcutaneous fat, allows bags to form under our eyes, and our jowls begin to sag. This loss of elasticity is speeded up by sunlight, so one of the best things you can do for your skin is to shield it from the sun by wearing sunscreens and protective clothing. In doing so, you will also be decreasing the chance of skin cancer. Although there is no way to avoid the aging of the skin, good nutrition, plenty of fluids, and cleanliness help delay the process.

Hair loses its luster as we age, and by age 50 the number of hair follicles has dropped by one-third and continues to decline, resulting in hair thinning and some degree of baldness, or *alopecia* (al″o-pe′she-ah), in most people. Many men become obviously bald as they age, a phenomenon called *male pattern baldness*. A bald man is not really hairless—he does have hairs in the bald area. But because those hair follicles have begun to degenerate, the hairs are colorless and very tiny (and may not even emerge from the follicle). Such hairs are called *vellus* (*vell* = wool) hairs. Another phenomenon of aging is graying hair. Like balding, this is usually genetically controlled by a "delayed-action" gene. Once the gene takes effect, the amount of melanin deposited in the hair decreases or becomes entirely absent, which results in gray-to-white hair.

HOMEOSTATIC IMBALANCE Certain events can cause hair to gray or fall out prematurely. For example, many people have claimed that they turned gray nearly overnight because of some emotional crisis in their life. In addition, we know that anxiety, protein-deficient diets, therapy with certain chemicals (chemotherapy), radiation, excessive vitamin A, and certain fungal diseases (ringworm) can cause both graying and hair loss. However, when the cause of these conditions is not genetic, hair loss is usually not permanent. ▲

Systems in Sync

Homeostatic Relationships between the *Integumentary System* and Other Body Systems



Nervous System
- Skin protects nervous system organs; cutaneous sensory receptors located in skin
- Nervous system regulates diameter of blood vessels in skin; activates sweat glands, contributing to thermoregulation; interprets cutaneous sensation; activates arrector pili muscles

Endocrine System
- Skin protects endocrine organs
- Androgens produced by the endocrine system activate sebaceous glands and help regulate hair growth; estrogen helps maintain skin hydration

Respiratory System
- Skin protects respiratory organs
- Respiratory system furnishes oxygen to skin cells and removes carbon dioxide via gas exchange with blood

Lymphatic System/Immunity
- Skin protects lymphatic organs; prevents pathogen invasion
- Lymphatic system prevents edema by picking up excessive leaked fluid; immune system protects skin cells

Cardiovascular System
- Skin protects cardiovascular organs; prevents fluid loss from body surface; serves as blood reservoir
- Cardiovascular system transports oxygen and nutrients to skin and removes wastes from skin; provides substances needed by skin glands to make their secretions

Digestive System
- Skin protects digestive organs; provides vitamin D needed for calcium absorption
- Digestive system provides needed nutrients for the skin

Reproductive System
- Skin protects reproductive organs; highly modified sweat glands (mammary glands) produce milk. During pregnancy, skin stretches to accommodate growing fetus; changes in skin pigmentation may occur

Urinary System
- Skin protects urinary organs; excretes salts and some nitrogenous wastes in sweat
- Urinary system activates vitamin D made by keratinocytes; disposes of nitrogenous wastes of skin metabolism

Integumentary System (Skin)

Muscular System
- Skin protects muscles
- Active muscles generate large amounts of heat which increase blood flow to the skin and may promote activation of sweat glands of skin

Skeletal System
- Skin protects bones; skin synthesizes vitamin D bones need for normal calcium absorption and deposit of bone (calcium) salts which make bones hard
- Skeletal system provides support for the skin

Summary

Media study tools that could provide you with additional help in reviewing specific key topics of Chapter 4 are referenced below.

IP = *Interactive Physiology;* WEB = *A&P Place website.*

CLASSIFICATION OF BODY MEMBRANES (pp. 96–98)

1. Epithelial: Simple organs, epithelium and connective tissue components.
   a. Cutaneous (the skin): epidermis (stratified squamous epithelium) underlain by the dermis (dense connective tissue); protects body surface.
   b. Mucous: epithelial sheet underlain by a lamina propria (areolar connective tissue); lines body cavities open to the exterior.
   c. Serous: simple squamous epithelium resting on a scant connective tissue layer; lines the ventral body cavity.
2. Connective tissue: Synovial; lines joint cavities.

INTEGUMENTARY SYSTEM (SKIN) (pp. 98–111)

1. Skin functions include protection of the deeper tissue from chemicals, bacteria, bumps, and drying; regulation of body temperature through radiation and sweating; and synthesis of defensive proteins and vitamin D. The cutaneous sensory receptors are located in the skin.
2. The epidermis, the more superficial part of the skin, is formed of stratified squamous keratinizing epithelium and is avascular. Moving from its superficial to deep region, its layers are the stratum corneum, stratum lucidum (in thick skin only), stratum granulosum, stratum spinosum, and stratum basale. Cells at its surface are dead and continually flake off. They are replaced by division of cells in the basal cell layer. As the cells move away from the basal layer, they accumulate keratin and die. Melanin, a pigment produced by melanocytes, protects the nuclei of epithelial cells from the damaging rays of the sun.
3. The dermis is composed of dense connective tissue. It is the site of blood vessels, nerves, and epidermal appendages. It has two regions, the papillary and reticular layers. The papillary layer has ridges, which produce fingerprints.
4. Skin appendages are formed from the epidermis but reside in the dermis.
   a. Sebaceous glands produce an oily product (sebum), usually ducted into a hair follicle. Sebum keeps the skin and hair soft and contains bacteria-killing chemicals.
   b. Sweat (sudoriferous) glands, under the control of the nervous system, produce sweat, which is ducted to the epithelial surface. These glands are part of the body's heat-regulating apparatus. There are two types: eccrine (the most numerous) and apocrine (their product includes fatty acids and proteins, which skin bacteria metabolize).
   c. A hair is primarily dead keratinized cells and is produced by the hair bulb. The root is enclosed in a sheath, the hair follicle.
   d. Nails are hornlike derivatives of the epidermis. Like hair, nails are primarily dead keratinized cells.

   WEB Exercise: Chapter 4, Structure of the Skin.
5. Most minor afflictions of the skin result from infections or allergic responses; more serious are burns and skin cancer. Because they interfere with skin's protective functions, burns represent a major threat to the body.

   WEB Exercise: Chapter 4, Integumentary I Case Study.
   a. Burns result in loss of body fluids and invasion of bacteria. The extent of burns is assessed by the "rule of nines." The severity (depth) of burns is described as first-degree (epidermal damage only), second-degree (epidermal and some dermal injury), and third-degree (epidermis and dermis totally destroyed). Third-degree burns require skin grafting.
   b. The most common cause of skin cancer is exposure to ultraviolet radiation. Cure of basal cell carcinoma and squamous cell carcinoma is complete if they are removed before metastasis. Malignant melanoma, a cancer of melanocytes, is still fairly rare but is fatal in about half the cases.

   WEB Exercise: Chapter 4, Integumentary II Case Study; At the Clinic: Integumentary.

DEVELOPMENTAL ASPECTS OF SKIN AND BODY MEMBRANES (p. 111)

1. The skin is thick, resilient, and well hydrated in youth but loses its elasticity and thins as aging occurs. Skin cancer is a major threat to skin exposed to excessive sunlight.
2. Balding and/or graying occurs with aging. Both are genetically determined, but other factors (drugs, emotional stress, and so on) can result in either.

Review Questions

MULTIPLE CHOICE

1. Select the one false statement about mucous and serous membranes.
   a. The epithelial type is the same in all serous membranes, but there are different epithelial types in different mucous membranes.

b. Serous membranes line closed body cavities, while mucous membranes line body cavities open to the outside.
c. Serous membranes always produce serous fluid, and mucous membranes always secrete mucus.
d. Both membranes contain an epithelium plus a layer of loose connective tissue.

2. Serous membranes:
a. line the mouth
b. have parietal and visceral layers
c. consist of epidermis and dermis
d. have a connective tissue layer called the lamina propria
e. secrete a lubricating fluid

3. Which is *not* a component of sweat?
a. Water **d.** Ammonia
b. Sodium chloride **e.** Vitamin D
c. Sebum

4. Which structure is *not* associated with a hair?
a. Shaft **d.** Matrix
b. Cortex **e.** Cuticle
c. Lunula

5. In investigating the cause of thinning hair, which of the following questions needs to be asked?
a. Is the diet deficient in proteins?
b. Is the person taking megadoses of vitamin C?
c. Has the person been exposed to excessive radiation?
d. Has the person recently suffered severe emotional trauma?

6. Which structure is *not* associated with a nail?
a. Nail bed **c.** Nail folds
b. Lunula **d.** Nail follicle

7. Which one of the following is *not* associated with the production of perspiration?
a. Sweat glands **d.** Eccrine gland
b. Sweat pores **e.** Apocrine gland
c. Arrector pili

SHORT ANSWER ESSAY

1. What is the name of the connective tissue membrane found lining joint cavities?

2. What primary tissues are destroyed when the skin is damaged?

3. From what types of damage does the skin protect the body?

4. Explain why we become tanned after sitting in the sun.

5. What is a decubitus ulcer? Why does it occur?

6. Name two different categories of skin secretions and the glands that manufacture them.

7. How does the skin help to regulate body temperature?

8. What is a blackhead?

9. What are arrector pili? What do they do?

10. What are the life-threatening consequences of severe burns?

11. Distinguish between first-, second-, and third-degree burns.

12. Why does hair turn gray?

13. Name three changes that occur in the skin as one ages.

14. Is a bald man really hairless? Explain.

AT THE CLINIC

1. A nurse tells a doctor that a patient is *cyanotic*. What is cyanosis? What does its presence indicate?

2. Both newborn infants and aged individuals have very little subcutaneous tissue. How does this affect their sensitivity to cold environmental temperature?

3. A 40-year-old beachboy is complaining to you that his suntan made him popular when he was young, but now his face is all wrinkled, and he has several darkly pigmented moles that are growing rapidly and are as big as large coins. He shows you the moles, and immediately you think "ABCD." What does that mean, and why should he be concerned?

4. Martha, the mother of a 13-month-old infant, brings her child to the clinic because his skin has turned orange. Why does the pediatrician inquire about the child's diet?

5. If the water of a swimming pool is hypotonic to our cells and body fluids (and it is), then why do we not swell and pop when we go for a swim?

6. Mr. Bellazono, a fisherman in his late 60s, comes to the clinic to complain of small ulcers on both forearms as well as on his face and ears. Although he has had them for several years, he has not had any other problems. What is the likely diagnosis, and what is the likely cause?