

## The Integumentary System

The integumentary system is made up of the skin, hair, nails, sweat glands, and sebaceous glands. The skin is the largest organ in the body. It makes up 12-15% of body weight and has an entire surface area between 1-2 meters. Our skin is our first barrier against infectious disease and prevents fluid loss from our organs, which allows our body to maintain homeostasis. The skin is such an important organ that even moderate burns on more than 30% of the skin can be life-threatening due to fluid loss and infection.

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## Functions of the Skin

The skin performs a variety of functions that are crucial to human survival.

Skin Functions	Actions
<b>Protection</b>	<ul style="list-style-type: none"> <li>Prevents microorganisms, as well as many harmful chemicals, from invading the body</li> <li>Secretes a residue, or surface film, that helps block toxins and inhibit bacterial and fungal growth</li> <li>Absorbs the force of injuries, protecting delicate underlying structures</li> </ul>
<b>Barrier</b>	<ul style="list-style-type: none"> <li>Keeps the body from absorbing excess water, such as when swimming or bathing</li> <li>Prevents dehydration by regulating the volume and content of fluid lost from the body</li> <li>Blocks ultraviolet (UV) radiation, keeping it from reaching deeper issue layers</li> </ul>
<b>Vitamin D production</b>	<ul style="list-style-type: none"> <li>Initiates the production of vitamin D when exposed to ultraviolet light</li> </ul>
<b>Sensory perception</b>	<ul style="list-style-type: none"> <li>Contains millions of sensory nerve fibers, allowing for perception of temperature, touch, pressure, pain, and vibration</li> </ul>
<b>Thermoregulation</b>	<ul style="list-style-type: none"> <li>Contains nerves that cause blood vessels in the skin to dilate or constrict to regulate heat loss</li> <li>When chilled, the skin retains heat by constricting blood vessels; this reduces blood flow through the skin and conserves heat</li> <li>When overheated, the blood vessels in the skin dilate; this increases the flow of blood and increases heat loss</li> <li>If the body is still overheated, the brain stimulates sweating; as sweat evaporates, cooling occurs (For more information on thermoregulation, see Chapter 21, <i>Nutrition &amp; Metabolism</i>)</li> </ul>

## Structure of the Skin

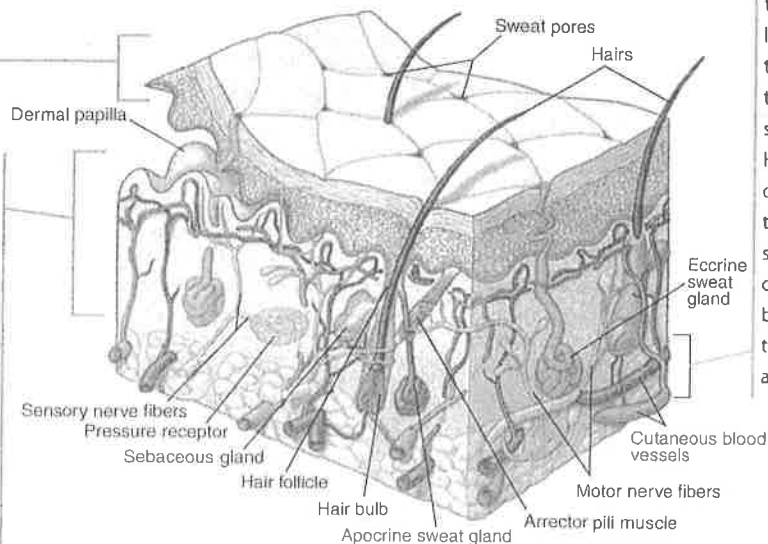
The skin, also called the **cutaneous membrane**, consists of two layers: the epidermis and the dermis.

The **epidermis**—the outermost layer—consists of stratified squamous epithelial tissue. It contains no blood vessels; instead, it obtains oxygen and nutrients by diffusion from the dermal layer beneath it.

The **dermis**—the inner, deeper layer—is composed of connective tissue. It contains primarily collagen fibers (which strengthen the tissue), but it also contains elastin fibers (which provide elasticity) and reticular fibers (which bind the collagen and elastin fibers together).

The dermis contains an abundance of blood vessels in addition to sweat glands, sebaceous glands, and nerve endings. Hair follicles are also embedded in the dermis. Finger-like projections, called **papillae**, extend upward from the dermis. These projections interlock with downward waves on the bottom of the epidermis, effectively binding the two

Beneath the skin is a layer of subcutaneous tissue called the **hypodermis**. Made of loose connective (areolar) tissue and adipose tissue, the hypodermis binds the skin to the underlying tissue. Hypodermis that's composed mostly of adipose tissue is called subcutaneous fat. This layer of fat helps insulate the body from outside temperature changes; it also acts as an energy reservoir.



## The Layers of the Skin

The skin is separated into three main layers called the epidermis, dermis, and hypodermis.

### The Epidermis

The epidermis is the outermost layer of the skin. There are four types of cells that make up the epidermis: melanocytes that produce melanin (influences skin color), keratinocytes that produce keratin, Merkel's cells that function in touch, and Langerhans' cells that function in immunity. There are a few layers, called strata, that make up the epidermis. The epidermis is avascular and all nutrients for the living cells of the epidermis diffuse from the basement membrane of the dermis below it. From the bottom layer to the outermost layer the strata include:

- **Stratum basale** – a layer of single cells that lays on the basement membrane of the dermis. These cells continuously divide and push up towards the surface of the skin.
- **Stratum spinosum** – These cells are “spiny” as the name denotes. They have been pushed out from the stratum basale and the spines interlock together to form a support layer.
- **Stratum granulosum** – The cells of this layer are still living, but none of the nutrients reach them. These cells begin producing keratin and the cells begin to die. Eventually, the keratin protein produced will make up the majority of the dead cells in the next two layers.
- **Stratum lucidum** – This layer of dead keratinized cells is only found in areas where skin is thick, such as the soles of the feet, and is not found in thin skin areas, such as the forearm.
- **Stratum corneum** – This is the outer layer that we see and is made up of layers of dead keratinized cells. This layer is tightly bound together, and the keratin protects the underlying cells from fluid loss while keeping the skin elastic. In a process called desquamation, cells of the stratum corneum are sloughed off. Cells from the epidermis are completely shed every 35-45 days, so essentially you have completely new skin every month and a half!

### Layers of the Epidermis

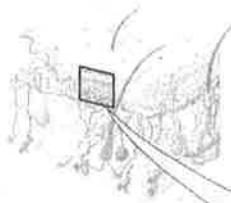
The epidermis consists of four or five layers, with the extra layer being present in areas receiving a lot of wear and tear, like the soles of the feet. During the course of life, the cells of the outer layer of the epidermis are sloughed off; this means that the skin must continually renew itself by replacing the sloughed off cells with new ones.

Those new cells are created in the lowest level of the epidermis. Once formed, they pass through the layers above, undergoing changes along the way, until they reach the skin's surface. Here's what happens:

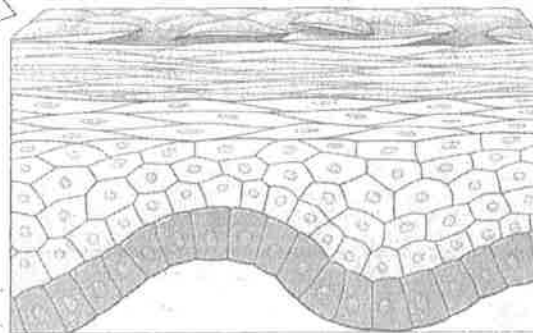
#### FAST FACT

The average person sheds more than 1 pound (0.5 kg) of skin every year. In fact, the outer layer of the epidermis is completely replaced every month.

ANIMATION



**1** The **stratum basale**, or basal layer—also called the **stratum germinativum**—is the innermost layer. It consists of a layer of columnar stem cells. These stem cells continually undergo mitosis, producing new skin cells. As new cells are produced, they push the older cells upward, toward the skin's surface.



**2** As the cells are pushed upward, they stop dividing and instead produce **keratin**, a tough, fibrous protein. The keratin replaces the cytoplasm and nucleus in each cell. The cells flatten, and as they move further away from their blood supply, they die.

**3** By the time the cells reach the outermost layer—called the **stratum corneum**—all that's left of the dead cells is their keratin. The newly arriving flattened cells—called **keratinocytes**—replace the dead cells that flake away with daily wear.

The stratum corneum actually consists of up to 30 layers of dead, flat keratin-coated cells. This makes the skin's surface durable and resistant to abrasions. It's also an effective barrier, preventing water from entering the body from the outside while still allowing for evaporation.

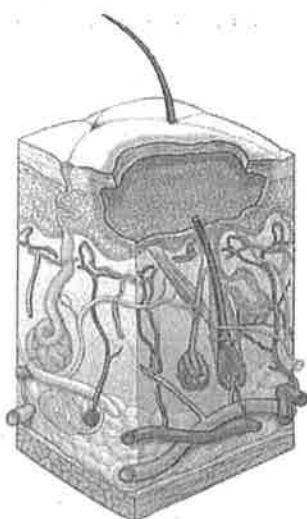
## Life lesson: Burns

Burns can be caused by fire, hot water, steam, electricity, chemicals, and sunlight. Considering the skin's crucial role in protecting against infection, controlling fluid loss, and thermoregulation, it's easy to understand the seriousness of severe or extensive burns. In fact, following a serious burn, a patient may lose as much as 75% of his circulating fluid volume in the first few hours, placing that person at risk for circulatory collapse and cardiac arrest. Another complication of burns is the development of eschar—the dead tissue resulting from a burn. Besides secreting toxins and promoting bacterial growth, eschar can restrict circulation.

Burns are classified according to their depth: in other words, the number of tissue layers affected by the burn.

### Burn Classifications

#### First-degree burn



##### Partial-thickness burn: superficial

- Involves only the epidermis
- Causes redness, slight swelling, and pain
- Often results from sunlight (sunburn)

#### Second-degree burn



##### Partial-thickness burn: deep

- Involves the epidermis as well as part of the dermis
- Results in blisters, severe pain, and swelling
- May result in scarring
- May appear red, white, or tan

#### Third-degree burn



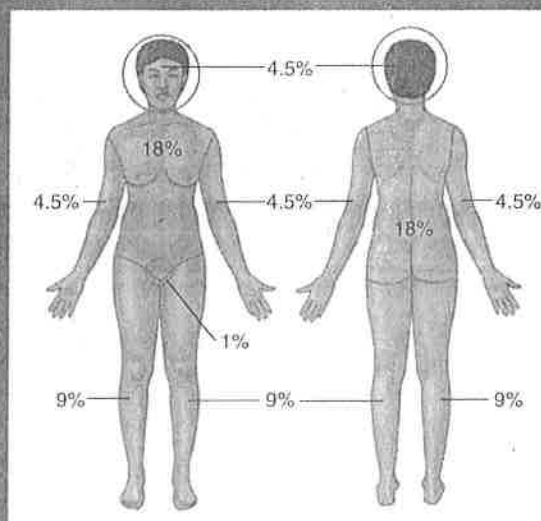
##### Full-thickness burn

- Extends through the epidermis and dermis and into the subcutaneous layer
- May not be painful initially because of the destruction of nerve endings
- May appear white or black and leathery
- Often requires skin grafts

### Rule of Nines

Another aspect of burn treatment involves estimating the percentage of body surface area (BSA) affected. A commonly used method, called the Rule of Nines, divides the body into 11 areas of 9%. By adding the corresponding percentages for each body section burned, it's possible to arrive at a quick and accurate estimate of the extent of the burn.

The Rule of Nines isn't accurate in children, however, because a child's BSA differs from that of an adult. For example, a burn to half the head accounts for 9 1/2% BSA in a newborn, 6 1/2% in a child age 1 to 4 years, and 3 1/2% in an adult. A table called the Lund-Browder chart—which adjusts the surface area of certain body regions according to age—is used to determine burn size in infants and children.

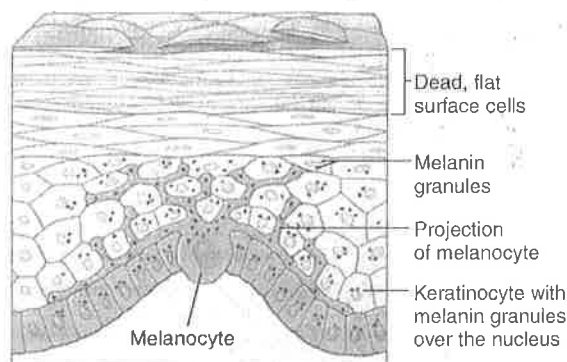


# Skin Color

Scattered throughout the basal layer of the epidermis are cells called **melanocytes**. These special cells produce a substance called **melanin**, which accumulates in the cells of the epidermis. There are two types of melanin: a reddish *pheomelanin* and a brown-black *eumelanin*.

A person's skin color is determined by the amount, and type, of melanin—not the number of melanocytes. (In fact, persons of all races have about the same number of melanocytes. The cells in dark-skinned people produce more melanin, and the melanin is broken down more slowly.)

- Melanocytes, which have long projections reaching between cells, release melanin.
- The keratinocytes then bring the melanin into their cells.
- The melanin forms a cap over the top of the cell nucleus to protect it from exposure to the harmful ultraviolet rays of the sun.
- Prolonged exposure to sunlight stimulates the cells to secrete more melanin. This protects the cell's nucleus and also darkens the skin.



## FAST FACT

When ultraviolet radiation reaches the nucleus of the cell, it damages the cell's DNA and can lead to skin cancer.

## The Body AT WORK

Variations in skin tone normally occur. Melanin is not evenly distributed throughout the body: the palms and soles have less melanin than the backs of the hands and the tops of the feet. Melanin can also concentrate in certain areas, such as freckles and moles. A yellow pigment called *carotene* is also stored in skin tissue. Eating large quantities of foods containing carotene (such as carrots) can give the skin a yellow tint.

## Abnormal Changes in Skin Color

Condition	Skin Tone	Cause
Cyanosis	Blue tint	A deficiency of oxygen in circulating blood
Jaundice	Yellow discoloration of skin and the whites of the eyes	Impaired liver function (such as from hepatitis or liver disease) that allows bile to accumulate, which stains the skin
Bronzing	A golden brown skin color	A deficiency of hormones from the adrenal gland, such as occurs with Addison disease
Albinism	Extremely pale skin, white hair, and pink eyes	A genetic lack of melanin
Erythema	Abnormal redness	Increased blood flow in dilated blood vessels close to the skin's surface; may result from heat, exercise, sunburn, or emotions such as embarrassment or anger
Pallor	Pale skin	Decreased blood flow, such as occurs from cold temperatures, fear or emotional stress, or low blood pressure
Bruise (hematoma)	Bluish, black, or yellowish mark on the skin	The breakdown of clotted blood under the skin

## *Life lesson: Skin cancer*

Skin cancer is the most common form of cancer, with more than 800,000 new cases being reported in the United States each year. These cancers result from changes in epidermal cells. There are three types of skin cancer:



- **Basal cell carcinoma**

- The most common type
- Seldom metastasizes, so is the least dangerous
- Arises from the cells of the stratum basale, typically on the nose or face
- Lesion first appears as a small, shiny bump; as it enlarges, it often develops a central depression and a beaded, "pearly" edge



- **Squamous cell carcinoma**

- Arises in the epidermis and is slow growing
- Often occurs on the scalp, forehead, backs of the hands, and top of the ears
- Has a raised, red, scaly appearance
- Some forms may metastasize



- **Malignant melanoma**

- Most deadly of all skin cancers
- Sometimes develops from melanocytes of a preexisting mole
- Metastasizes quickly and is often fatal when not treated early
- Risk is greatest in individuals who had severe sunburns as children



# Appendages of the Skin

The appendages of the skin are hair, nails, and glands.

## Hair

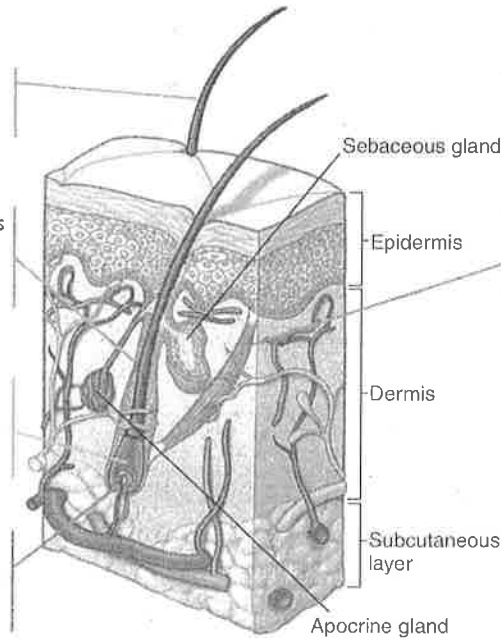
Hair occurs everywhere on the body except for a few locations: the palms and soles, lips, nipples, and some areas of the genitals. In some locations, hair has a protective role: the eyelashes and eyebrows keep perspiration out of the eyes; hair in the nostrils filters out dust; and the hair on the head provides insulation against heat and cold. The rest of the body's hair doesn't have a known function.

The **shaft** is the part of the hair that extends above the skin's surface.

Each hair lies within a sheath of epidermis called a **hair follicle**. Hair follicles have a rich nerve and blood supply.

Buried in the dermis is the hair **bulb** or **root**; this is the lowest part of the hair and is where growth occurs.

At the base of the hair is a cluster of connective tissue and blood vessels called the **papilla** that nourishes each hair.



Attached to each hair follicle is a small bundle of smooth muscle called the **arrector pili** muscle. Cold temperatures, or emotions such as fear, cause the muscle to contract. When it does, the hair becomes more upright, sometimes called "standing on end."

## Hair Color and Texture

Hair obtains its color from melanin. The two types of melanin (eumelanin and pheomelanin) give rise to the various shades of hair. Darker hair has a greater concentration of eumelanin. Blond hair contains mostly pheomelanin, while red hair contains a mixture of the two. Gray and white hair result from a lack of melanin.

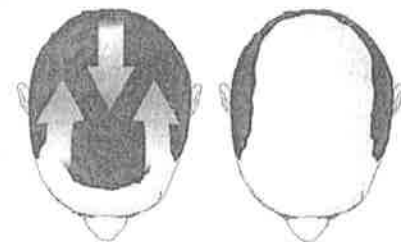
The shape of the hair shaft determines whether it's straight or curly. A round shaft produces straight hair, while an oval shaft produces curly hair.

## Hair Growth and Loss

Hair grows from the base. New cells causing hair growth arise in an area above the papilla. Once formed, these new cells produce keratin and then die. As more cells are formed beneath them, the older cells are pushed toward the surface of the skin; this causes the hair to lengthen. All the cells of the hair—other than the cells just above the papilla—are dead, flattened cells filled with keratin.

Hair has a limited lifespan. Typically, the hair on the head lives between 2 and 6 years. After that it falls out, and after a resting phase, it's replaced by new hair.

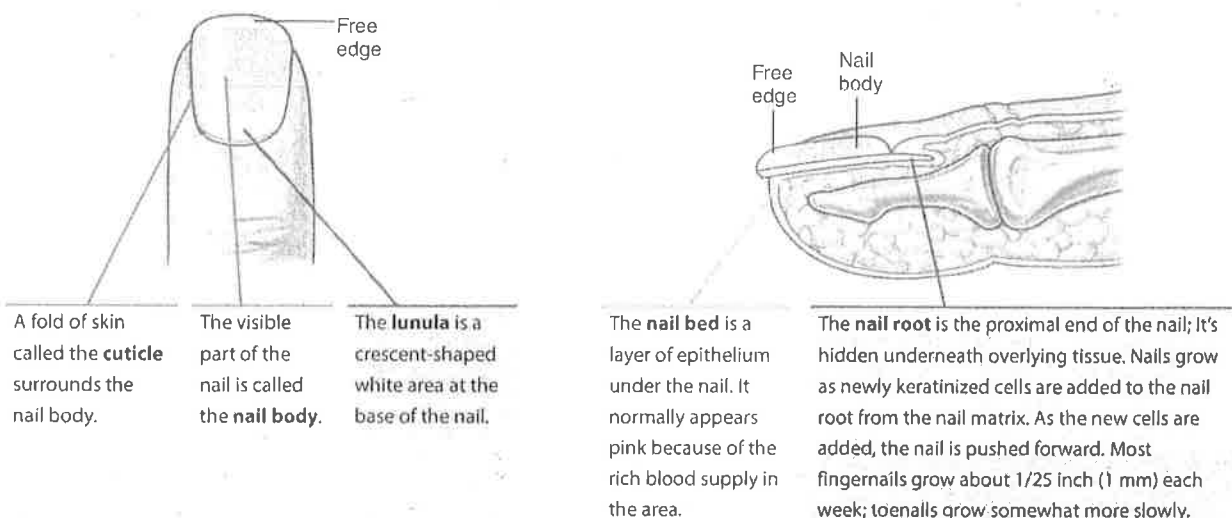
Excessive hair loss is called **alopecia**. Alopecia may result from disease, poor nutrition, chemotherapy, or even emotional distress. A common cause of alopecia is aging. Some men exhibit what's known as **male pattern baldness**. This type of hair loss occurs only in individuals who have inherited a specific gene and who have high levels of testosterone, which is why it typically occurs in men.



In male pattern baldness, hair recedes in an M shape. Eventually the bald patch on the crown meets the two points of the M, creating a horseshoe shape.

## Nails

Nails consist of densely packed, heavily keratinized epithelial cells.



The shape and color of nails can provide clues about underlying disorders.

### Abnormal Nail Changes

<b>Clubbing</b>	Long-term oxygen deficiency, usually due to lung disease (This causes the distal ends of the fingers to enlarge, making it look like a drumstick when viewed from above. At the same time the nail bed softens, causing the nail to angle downward, giving it a beaked appearance when viewed from the side.)
<b>Cyanosis</b>	Often is the first sign of oxygen deficiency
<b>Flattened or concave nail beds</b>	May indicate an iron deficiency
<b>Dark lines beneath the nail</b>	May indicate melanoma in lighter-skinned individuals, although such lines may be normal in individuals with dark skin
<b>White nails</b>	May occur in liver diseases such as hepatitis
<b>Yellowish, thickened, slow-growing nails</b>	Often occur in individuals with lung diseases such as emphysema
<b>Pale nail beds</b>	May be a sign of anemia

## Life lesson: Changes with aging

The integumentary system may be one of the first body systems to visibly reflect signs of aging. Here are some common results of aging:

- The amount of fat in subcutaneous tissue declines, the dermis thins, the amount of collagen and elastin decreases, and skin cell replacement slows, all leading to wrinkles around the eyes, nose, and mouth.
- Skin cell replacement slows, leading to delayed wound healing and an increased risk for infection.
- The number, and output, of sweat glands declines, making it difficult for elderly individuals to maintain their body temperature.
- Overall melanocyte production slows, increasing sun sensitivity, while the proliferation of melanocytes increases in localized areas, causing brown spots to develop on the skin.
- The pigment in hair decreases, leading to thinning and graying hair.

## Glands

The glands associated with the skin include sweat glands, sebaceous glands, and ceruminous glands.

### Sweat Glands

These are the most numerous of the skin glands.

**FACT**  
The skin of an adult contains 3 to 4 million sweat glands.

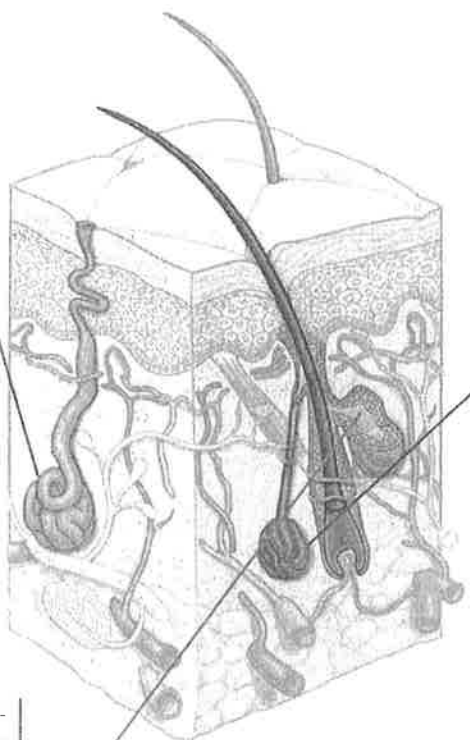
### The Body AT WORK

Every day, the body loses about 500 ml of insensible perspiration: perspiration that doesn't make the skin feel damp. Perspiration increases dramatically from heat or exercise. In fact, the body can lose as much as a liter of perspiration an hour from intense exercise or extreme heat. If the fluid isn't replaced, dehydration or even circulatory shock may result.

There are two types of sweat glands: **eccrine glands** and **apocrine glands**.

#### Eccrine glands

- Contain a duct that leads from a secretory portion (consisting of a twisted coil in the dermis), through the dermis and epidermis, and onto the skin's surface
- Are widespread throughout the body, but are especially abundant on the palms, soles, forehead, and upper torso
- Produce a transparent, watery fluid called *sweat*, which contains potassium, ammonia, lactic acid, uric acid, and other wastes
- Sweat plays a chief role in helping the body maintain a constant core temperature and also helps the body eliminate wastes



#### Apocrine glands

- Contain a duct that leads to a hair follicle (as opposed to opening onto the skin's surface)
- Are located mainly in the axillary and anogenital (groin) regions
- Are scent glands that respond to stress and sexual stimulation
- Begin to function at puberty
- Sweat produced by these glands does not have a strong odor unless it accumulates on the skin; when this occurs, bacteria begins to degrade substances in the sweat, resulting in body odor

### Sebaceous Glands

Sebaceous glands, which open into a hair follicle, secrete an oily substance called sebum. Sebum helps keep the skin and hair from drying out and becoming brittle. Sebum has a mild antibacterial and antifungal effect. Under the influence of sex hormones, sebum production increases during adolescence. When excess sebum accumulates in the gland ducts, pimples and blackheads can form. (When the accumulated sebum is exposed to air, it darkens, forming a blackhead. A pustule results if the area becomes infected by bacteria.)

### Ceruminous Glands

**Ceruminous glands**, which exist in the external ear canal, secrete a waxy substance called **cerumen**, or ear wax. Cerumen helps keep the ear canal from drying out. However, excess cerumen can accumulate in the ear canal and harden, diminishing hearing.