Chapter 4 The Structure of Skin

Key Terms

Adipose
Carotene
Dermis
Endocrine glands
Epidermis
Erythema
Exocrine glands
Keratin
Keratinization
Mast cells
Melanin
Nerve endings
Organs
Papillary layer
Reticular layer
Sebaceous glands
Sebum
Subcutaneous
Sudoriferous glands
The Sun Protection Factor (SPF)
Tissues
Trans Epidermal Water Loss
Ultraviolet radiation

Learning Objectives

After completing this chapter, you should be able to:

- Describe each type of tissue and its specialization.
- Identify the main layers of skin and understand their differences.
- List the function of different nerves found in the skin.
- List the function of the different skin glands.
- Explain the causes and types of skin color.
- Understand the difference between UVA, UVB, and UVC.

TISSUE

There are over 100 different types of cells that form the structures of the human body. These cells are organized into tissues. **Tissues** are groups of similar cells that work together to perform a specific function. Two or more types of tissues that are grouped together to form a functional unit are called **organs**. The skin, which includes the hair and nails, is the largest organ of the human body.

Tissue is made up of large groups of cells that are similar in function. There are five types of tissue found in the body.

1. *Connective tissue* supports and protects the organs. It also holds other tissues together. Cartilage, ligaments, and tendons are examples of this type of tissue.
2. *Muscular tissue* gives the ability to move various parts of the body. Movement is caused when muscular tissues contract (shorten) or relax. Muscle tissue also protects delicate internal organs.
3. *Nerve tissue* carries instructions from the brain to the various parts of the body. Nerve tissue cells also send messages to the brain (e.g., touch and sight).
4. *Liquid tissue* carries oxygen and food to other tissue cells and also removes waste from the body. These are individual cells, not linked by connective tissue. Blood and lymph fluid are examples of liquid tissue.
5. *Epithelial* (ep-i-THEEL-ee-ul) *tissue* gives a protective covering to the body and internal organs. Skin is epithelial tissue, as is the lining of the stomach, heart, and lungs. This type of tissue repairs itself very quickly.

Each different type of tissue is made of cells designed to perform a special job. This is called *specialization*. Examples of specialization are seen everywhere in the body. Cells inside the eye are very good at seeing colors but would not work well as muscle cells. Few parts of the body have as many different specialized cells as the skin (Figs. 4-1–4-5)

SKIN

The skin is a thick, tough layer of tissue cells that surrounds the body. Skin acts as a barrier to keep out harmful bacteria, fungi, and viruses. It is the largest body organ in size (three thousand square inches!), but weighs only six pounds. Skin consists of many layers and types of specialized cells as shown in Figures 4-6 and 4-7.

Skin has three main layers:

1. **epidermis** (ep-e-DUR-mis), the outermost layer.
2. **dermis** (DUR-mis), the middle layer.
3. **subcutaneous** (sub-cue-TAY-nee-us) **tissue**, the deepest layer.

Figure 4-1 *Photo of the skin on the back of the hand of a young female, magnified 60 times. Notice the triangular appearance of the major divisions of the skin surface.*
(Courtesy: Gillette Company Research Institute, Rockville, Maryland)

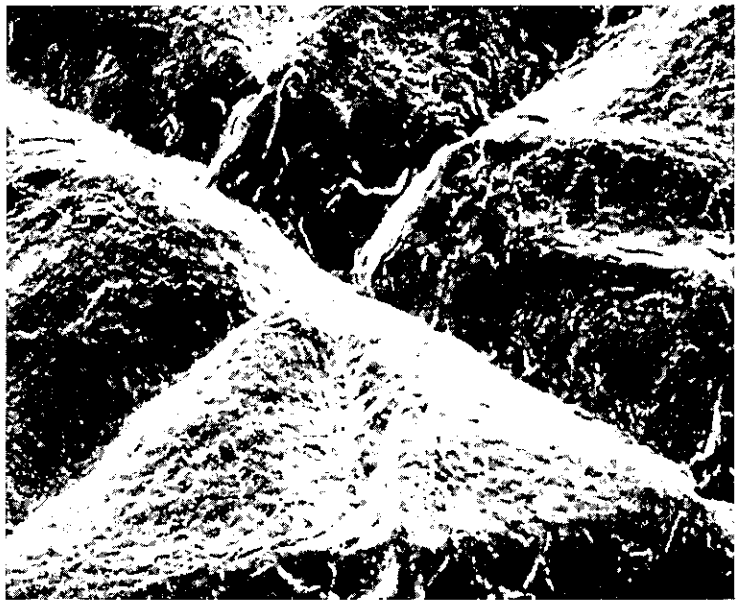

Figure 4-2 *The same skin section magnified 176 times. Notice the edges of the individual stratum corneum cells adhering tightly to the skin.*
(Courtesy: Gillette Company Research Institute, Rockville, Maryland)

Figure 4-3 *Cheek of a young female, magnified 210 times. Notice that the surface looks more plump and more rounded than the back of the hand photos. This probably is the result of more moisture in the skin. Follicle openings can be seen in the center of the photo.*
(Courtesy: Gillette Company Research Institute, Rockville, Maryland)

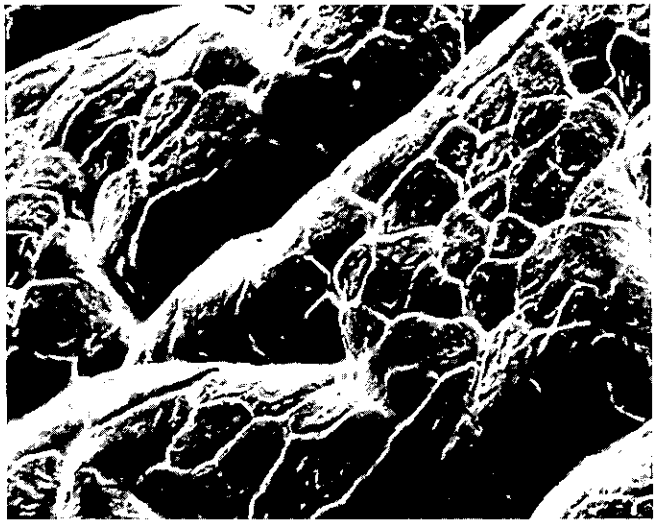

Figure 4-4 *Elbow skin from a young female, magnified 60 times. Notice how the overall architecture of the skin differs from previous skin photos. This indicates that skin from different areas has very different structures.*
(Courtesy: Gillette Company Research Institute, Rockville, Maryland)

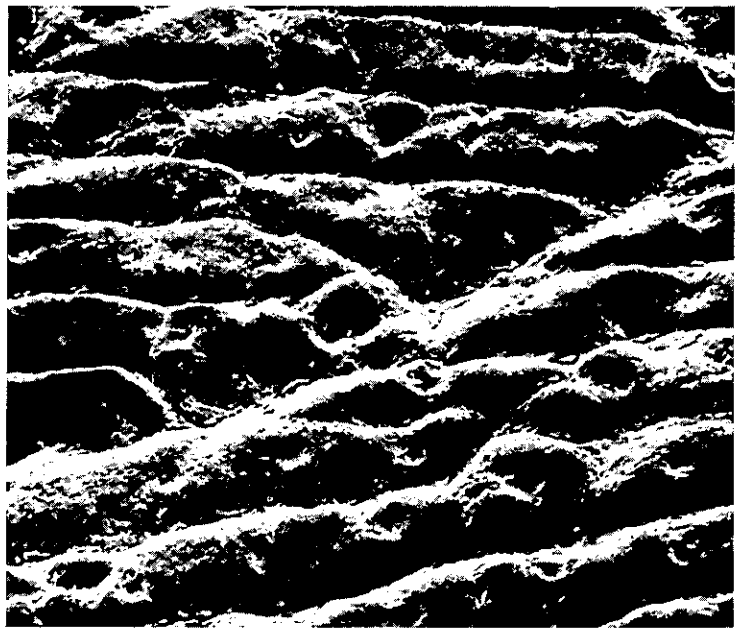

Figure 4-5 *The skin from the palm of the hand, magnified 60 times. Small indentations of ridges are sweat gland openings.*
(Courtesy: Gillette Research Institute, Rockville, Maryland)

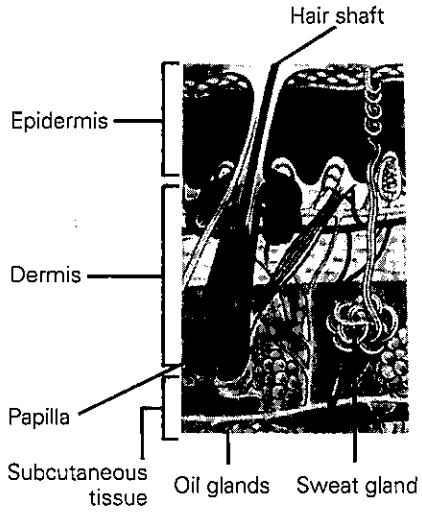

Figure 4-6 *Microscopic section of new skin.*

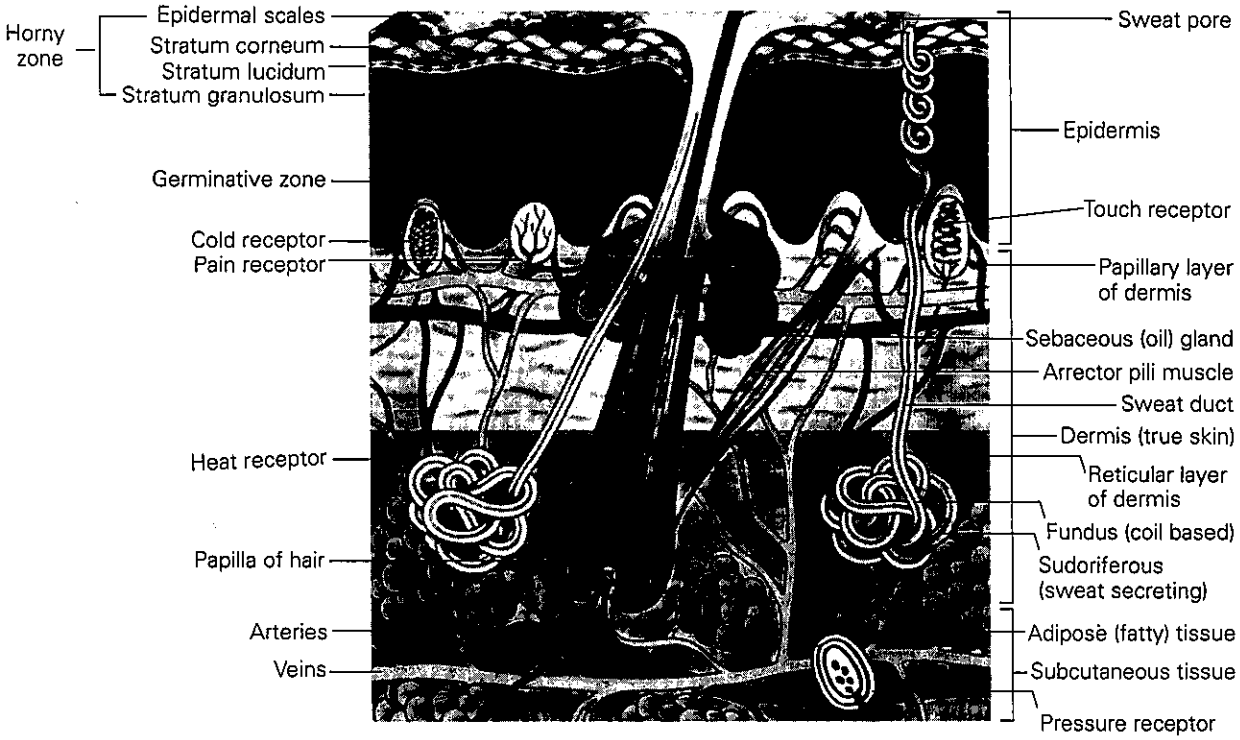

Figure 4-7 *Cross section of the skin.*

Subcutaneous Tissue

Subcutaneous tissue consists mainly of connective tissue, blood veins and arteries, lymph fluid vessels, fat cells, hair papilla, and sensitive nerve endings. Arteries in the subcutaneous tissue supply the upper levels of the skin with food and oxygen.

Veins carry carbon dioxide and waste away from the cells. Since blood vessels do not enter the epidermis, oxygen and nutrients must be fed to the cells from the blood vessels in the subcutaneous layer.

Adipose (AD-I-poce), or **fat tissue,** is found in the subcutaneous layer. It helps give the body smooth curves and contours. Adipose tissue accounts for about 14 percent of the average person's body weight. The fat cells cushion the internal organs from bumps and bangs and can be used for energy. Adipose tissue also helps to insulate the body from extreme cold or heat.

Dermis Tissue

The *dermis* (**DUR**-mis) is the middle layer of skin, located directly above the subcutaneous tissue and below the epidermis.

The dermis layer makes up 90 percent of the skin's dry weight. This tissue collects nutrients from the subcutaneous layer and passes them to the upper layers. In some body locations, like the eyelid, the dermis is very thin. It is several times thicker on the soles of the feet and palms of the hands. This skin layer is made mostly of protein fibers and specialized types of cells.

The strong protein fibers of the dermis are connective tissue. They penetrate into the subcutaneous tissue, tightly bonding the two layers together. The dermis is made up of two layers: the papillary, or superficial layer, and the reticular or deeper layer. The **papillary** (pah-**PIL**-ah-ry) **layer** is the upper layer of the dermis and lies directly below the epidermis. It contains *papillae* (pah-**PIL**-ee), *capillaries* (**KAP**-ih-ler-ees), and *tactile corpuscles* (**TAK**-til **KOR**-pus-els). The lower part of the dermis is called the **reticular layer.** In this layer the protein fibers finely interlace into netlike patterns. Hair follicles grow between spaces in this net. These fibers are made of two types of protein, *collagen* and *elastin*.

Collagen comes from the Greek word meaning "to produce glue." Animal collagen has been used for thousands of years to make strong glues, such as white paper glue. In humans, it makes up about 75 percent of the skin's dry weight. Collagen is to the skin as the frame is to a house or car; it gives strength and support.

Elastin is a unique and very different skin protein. It accounts for only 2 percent of the skin's dry weight, but is still very important. Elastin is much like a rubber band. It can be stretched to twice its length and still bounce back to its original size and shape; likewise, elastin gives skin the ability to stretch while keeping its shape. It acts like the shock absorbers on a car. As skin ages, it contains less elastin, thus becoming less elastic.

Mast cells go unnoticed in the skin until damage occurs. When the skin is cut, burned, or chemically irritated, these unique cells spring into action. First, mast cells release a chemical that stops bleeding. Later, mast cells increase the flow of blood to the injury, thus speeding the healing process. Mast cells also cause redness and swelling in skin after burns or allergic reactions.

Epidermis Tissue

Epidermis tissue is the uppermost layer of skin. The purpose of the epidermal cells is to make the skin resistant to water and to prevent invasion from outside the body (Figs. 4-8 and 4-9). The epidermis is only about fifty cell layers thick and is twenty-five times thinner than the dermis. The epidermis is divided into four layers or *strata* (**STRAT**-uh):

1. *Stratum germinativum* (jur-mi-nah-**TIV**-um) is the basement of the epidermis. It is only one cell layer thick, but from here the rest of the

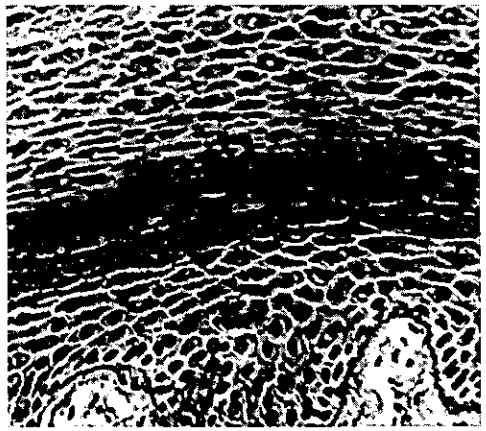

Figure 4-8 *Section of skin showing thickened epidermis on the sole of the foot.*

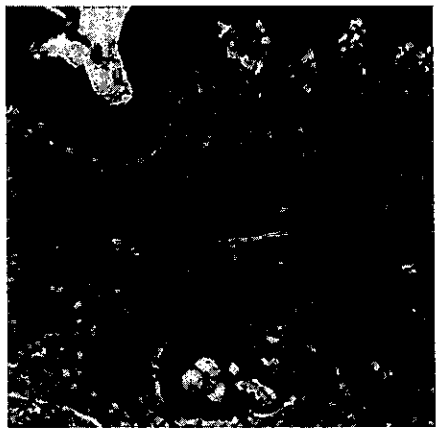

Figure 4-9 *Section of skin showing thinner epidermis on the back of the hand.*

epidermis "germinates" or grows. This single row of cells constantly undergoes mitosis, each cell dividing into two. As these cells multiply, they are pushed toward the surface. This is the beginning of a long, upward journey which eventually brings the cell to the surface of the skin. As these cells are pushed upward, they undergo a remarkable change.

2. *Stratum granulosum* (gran-yoo-LOH-sum) layer contains cells that have become flat and hard. This is the first step in **keratin** formation. Keratin is the water-resistant protein found in the upper layers of the epidermis.

The importance of keratin will be discussed in later chapters. In this stratum, the cells begin to die as their nuclei break down.

3. *Stratum lucidum* (LOO-si-dum) is completely transparent to light. These cells no longer contain a nucleus.
4. *Stratum corneum* (KOHR-nee-um) is about thirty rows thick. The cells in this layer look little like they did in the stratum germinativum. They no longer contain organelles and are completely filled with keratin. The stratum corneum is the barrier that repels heat waves, light, bacteria, and some chemicals. It is important to remember, however, that this barrier is not impenetrable. Many types of chemicals, safe and harmful, can rapidly penetrate this extremely thin cell shield.

As these mature cells reach the surface of the skin, they are continually being shed. In this way, the upper layers of the skin's surface are constantly replaced by cells born in the stratum germinativum.

The epidermis is in a continual state of renewal as the cells are formed, mature, and die. The epidermis completely renews itself every 45 to 75 days. Keratinocytes are formed by mitosis in the basal layer of the epidermis and move upward through the epidermis as they mature in a process called **keratinization**. As newly formed keratinocytes mature, they fill with keratin, move upward, flatten out, lose their nucleus, and die. The cells in the outer most layer of the stratum corneum flake off and are replaced by new cells from below. It is estimated that a new cell takes 28 days to reach the stratum corneum. Every day, the top layer of the stratum corneum is shed as a new replacement layer is formed, by mitosis, in the stratum granulosum below.

SKIN AS A BARRIER

People are often shocked to learn that many harmful chemicals can rapidly penetrate through the skin's pores and enter the bloodstream. In fact, certain chemicals found in professional products can pass through the skin in seconds. For example, hair dyes leave obvious stains. The stain is caused when chemicals become trapped in the cells. However, some of the chemical product may not be trapped and will pass into the blood vessels of the subcutaneous layer.

In most cases, a potentially harmful chemical must first enter your body before it can become a danger. If you keep it off your skin, it can't harm you! Read product labels and instructions. If the manufacturer warns against skin contact, wear gloves and wash your hands after each use!

Prolonged or repeated contact with certain products can have risks ranging from skin rash to long-term health problems. Protect yourself and work wisely to avoid unnecessary problems.

Nerve Endings

The skin contains about one million **nerve endings**. Nerve fibers transmit information from their sensitive ends through the spinal cord instantly to the brain. Nerve endings can pick up a variety of complex sensations. Most of the nerve endings are found in the face, arms, and legs. Only a few are found on the back. They are located on the shoulders and down the sides. Most nerve endings are found in the dermis or upper layers of subcutaneous tissue. Three major kinds of nerves are found in the skin:

1. *Sensory nerves*, which react to sensations such as heat or pressure.
2. *Secretory nerves*, which control the glands of the skin.
3. *Motor nerves*, which cause "gooseflesh" or make the hair shaft "stand on end."

There are several types of *sensory nerve endings*. Each registers a different type of sensation (Fig. 4-10). Some may even transmit more than one type of stimulation. These nerves are sensitive to the following:

- touch
- pressure
- heat
- cold

Pain sensors pick up each of the sensations but only if the stimulation is strong enough. For example, sensory nerve endings make the heat of a blow dryer feel warm on the scalp. However, if you move it too close to the scalp, the temperature

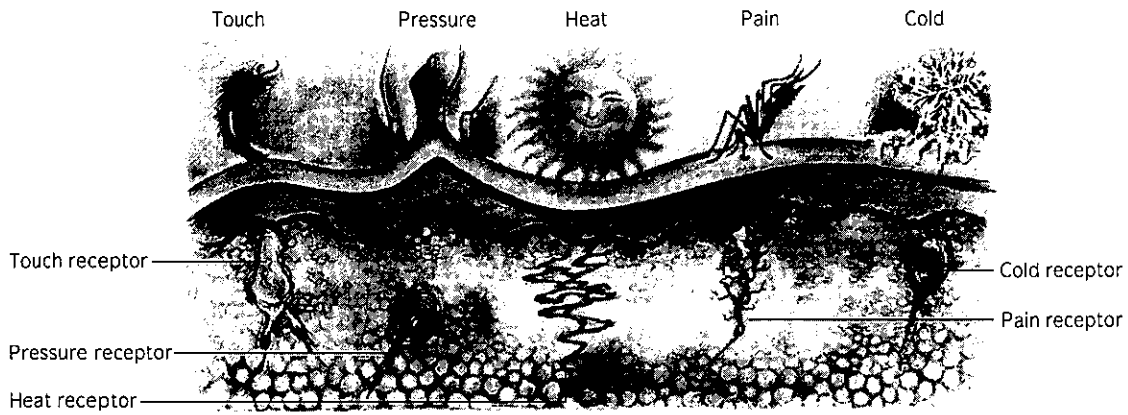

Figure 4-10 *Sensory nerves of the skin.*

skyrockets and triggers the *pain nerve endings*. They send warning messages to the brain that prevent the skin from being harmed. Sensory nerve endings show there is a lot of truth to the phrase, "There's a fine line between pleasure and pain" (Figs. 4-11 and 4-12).

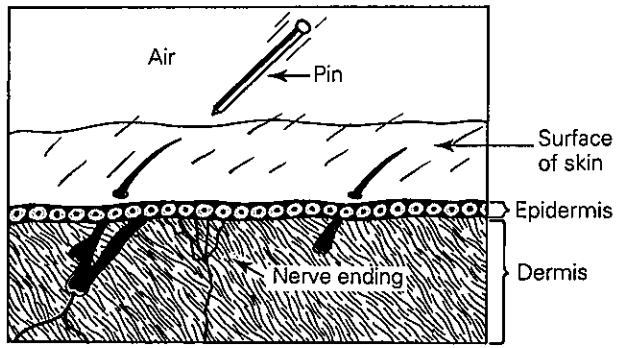

Figure 4-11 *Nerve in skin (non-active).*

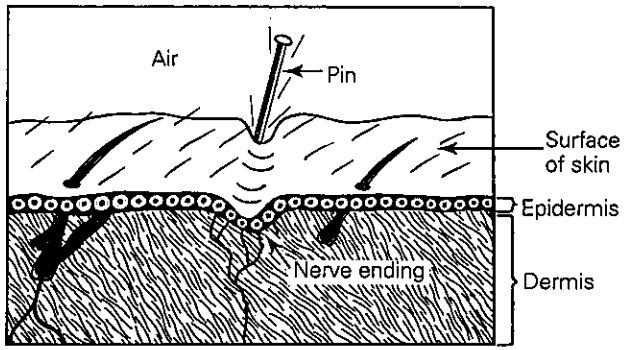

Figure 4-12 *Nerve stimulated to warn brain of injury.*

EXOCRINE GLANDS

Exocrine (EK-suh-krin), or duct **glands**, have canals that lead from the gland to a particular part of the body. There are two exocrine glands in the skin: the **sudoriferous** (soo-dur-IF-ur-us) or sweat glands, and the **sebaceous** (se-BAY-shus) or oil glands.

Secretory nerves control the **sudoriferous** (soo-dur-IF-ur-us) **(sweat) glands** (Fig. 4-13). Some parts of the skin have more than 1,300 sweat glands per square inch. The purpose of these glands is to help the body control its temperature. The sweat glands on the palms and soles also increase the "grip" of the skin

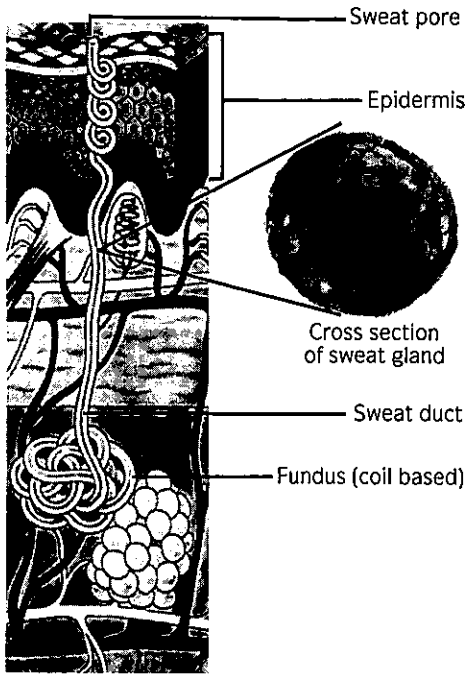

Figure 4-13 *Sweat gland.*

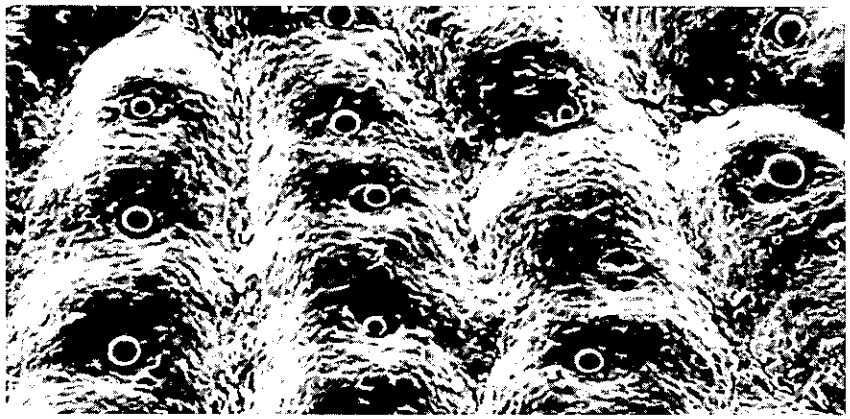

Figure 4-14 *Sweat from pores on palm of hand.*
(Courtesy: Isleworth Laboratory, Unilever Limited, Middlesex, England)

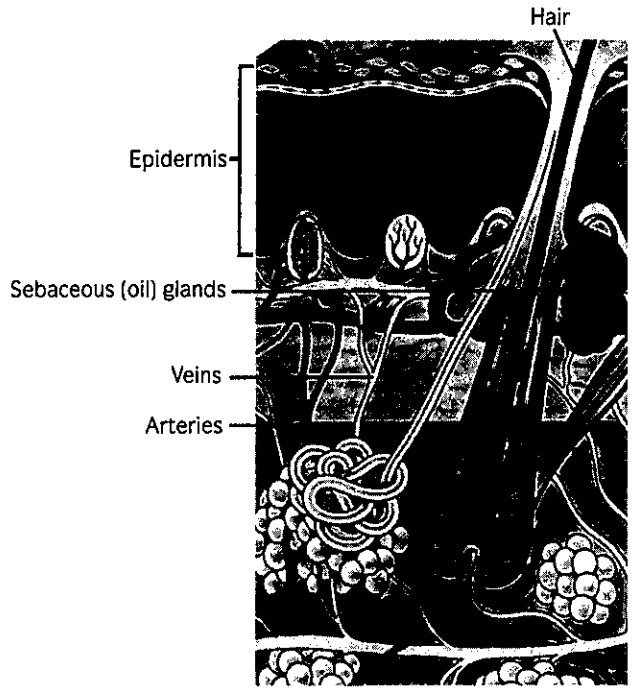

Figure 4-15 *Scalp hair, follicle, and oil glands.*

(Fig. 4-14). Evaporation of sweat has a cooling effect on the body. Sweat usually evaporates quickly, except in the armpits, which is why this area is usually moist. Sweat is odorless when it reaches the skin through the *sweat duct;* however, bacterial action on the sweat produces an offensive "sweaty" odor.

Sebaceous (se-**BAY**-shus) **(oil) glands** are also controlled by the secretory nerves (Fig. 4-15). Usually these glands are found with hair follicles. Great numbers of these oil glands are found on the scalp, face, and upper chest area but never on the soles or palms. The scalp contains as many as 1,900 glands per square inch. Sebaceous glands secrete **sebum** to the hair and skin. *Sebum* is an oily mixture of fatty substances called triglycerides along with various waxes. Many believe that sebum's function is to condition the skin and hair. It also helps the skin to retain moisture (Figs. 4-16 and 4-17).

Because *sebum* is essentially a mixture of natural oils, it reduces friction on the skin and hair. Smoothness and slipperiness of normal skin are due to the oils that coat it. There is no need to be reminded of how rough our hands can feel when the sebum has been removed by constant washing in strong soaps and detergents. The hairstylist should be aware of the role the sebum plays in preserving the natural attractiveness, as well as the essential features, of the skin.

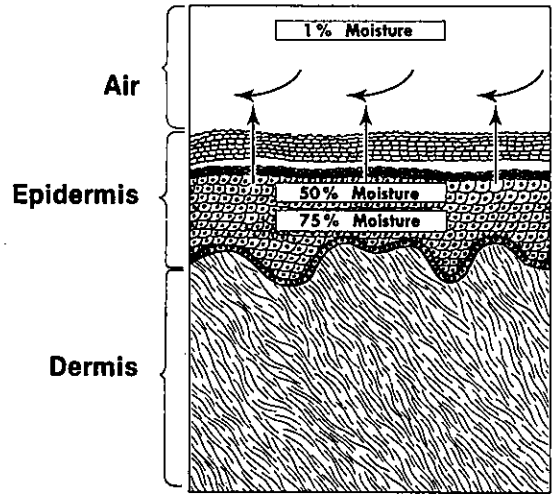

Figure 4-16 *The main function of sebum is to act as a shield that prevents moisture from evaporating from the surface of the skin.*

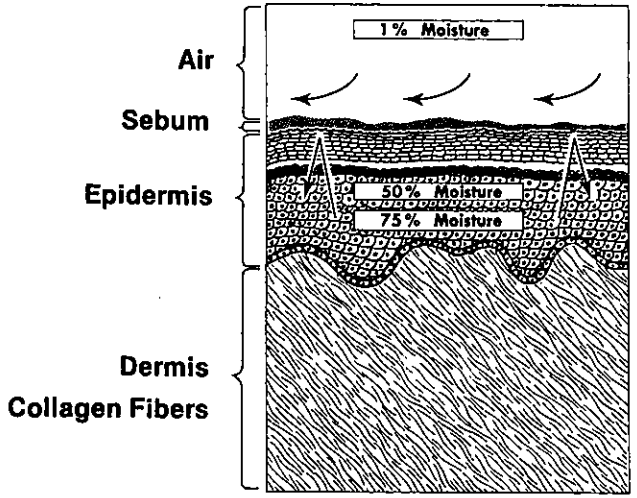

Figure 4-17 *Summer increases the rate of sweating, and this enables the skin to stay naturally moist, preventing drying and chafing.*

Natural oils supply this external lubrication, but more important, internal lubrication is supplied by the normal moisture content of hair and skin.

Most dry skin is a result of damage to the protective layer of lipids and the *Natural Moisturizing Factor* (NMF) within the dermis. The NMF is a mixture of amino acids and salts, such as pyrrolidone carboxylic acid and lactic acid. More than half of our outer skin and about one-tenth of hair consists of water. The dry atmosphere around us poses a constant threat to the maintenance of this high lever of water. The loss of water from the internal structure of the skin to the atmosphere is referred to as **Trans Epidermal Water Loss** (TEWL). Because of the high volume of water in the cells of the skin, when we do lose moisture (for various reasons) the skin shrinks and contracts. This contraction of drying skin can break small blood vessels and cause painful pressure on nerve endings. Dry skin with cracks can easily become infected with bacteria and fungi.

Sebum also possesses powerful bacteria and fungi inhibitors that prevent the mass invasion of the skin and hair by these destructive organisms. When we consider that every object the skin touches provides more chance of attack from hostile bacteria and fungi, we realize just how much we depend on sebum for our survival. The skin would otherwise provide an ideal home for these tiny intruders, as it is warm, moist, and supplied with ample nourishment.

ENDOCRINE GLANDS

Endocrine (EN-duh-krin) **glands** are ductless glands that secrete hormones directly into the bloodstream, which influence the welfare of the entire body.

Skin Color

Human skin can have a surprisingly wide range of colors. Skin can be black, ghost white, red, pink, yellow, brown, olive, and dozens of different shades in between. Three factors determine the color of the skin: the pigment **melanin** (MEL-uh-nin), the pigment **carotene** (KAR-o-teen), and the blood in the capillaries of the dermis.

1. **Melanin** (MEL-uh-nin) is the dark pigment, which gives the skin its brown color and protects it from ultraviolet radiation. Melanin is found chiefly in the stratum germinativum of the epidermis and is contained in organelles called melanosomes. The amino acids tyrosine and cysteine are involved in melanin formation.

Depending upon the amount and type of melanin, skin can range from the palest yellow to the darkest black. An albino is a person whose skin and hair contains no melanin. The result is extremely pale white skin and hair. Sometimes, large pools of melanin collect in the skin and form freckles. Melanin protects sensitive cells from sunburn and tanning beds with ultraviolet rays. An appropriate Sun Protection Factor (SPF) lotion should be used to help the melanin in the skin protect it from burning (Figs. 4-18 and 4-19).

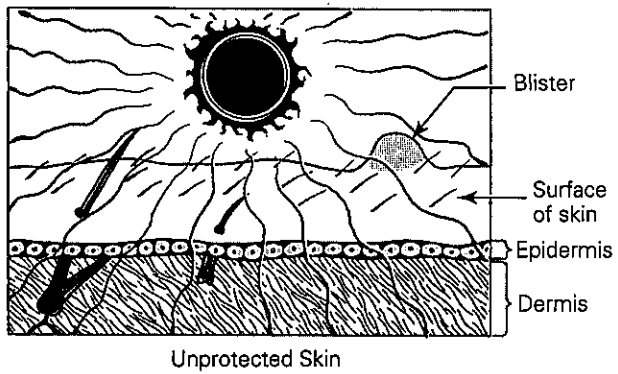

Figure 4-18 *Skin unprotected from the sun's rays.*

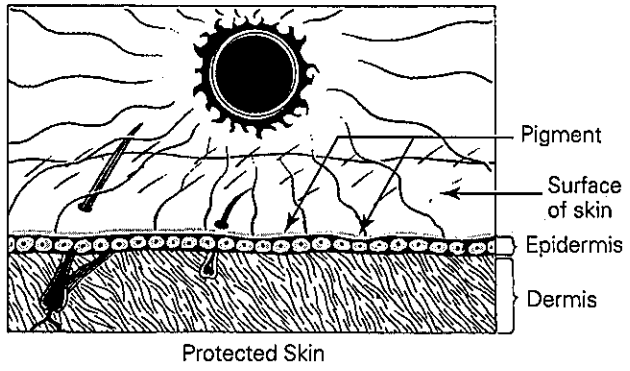

Figure 4-19 *Skin protected from the sun's rays.*

It is also possible for the skin to look blue in color, due to an optical distortion, if melanin is present at lower levels in the skin.

2. **Carotene** (KAR-o-teen) is the pigment that gives yellow skin tones. Carotene is found in the stratum corneum and in the layer of fat just below the skin.

Carotene is similar to the chemical that gives carrots their color. People of Asian origin have higher amounts of carotene in their skin, which accounts for much of the yellowish hue.

3. Blood in the small capillaries located between the dermis and the epidermis and are easily visible and add pink and red tones to the skin. Blushing occurs when these tiny vessels expand and bring the blood closer to the surface. Birthmarks are usually caused in the same way.

ULTRAVIOLET RADIATION AND SUNSCREENS

Over one million new cases of skin cancer are diagnosed each year. It is estimated that one in five Americans will develop skin cancer and 90 percent of those cancers will be the result of exposure to **ultraviolet** (UV) **radiation** from the sun and tanning beds. UV rays penetrate into the dermis and generate free radicals that can alter our DNA, the genetic material of all living cells.

In reasonable amounts, exposure to the sun is beneficial. Natural sunlight has a germicidal effect and produces vitamin D in the skin. UV radiation can be used to treat rickets, psoriasis, and acne. Exposure to UV rays also stimulates the skin's production of melanin, which causes a tan and helps protect the skin from further damage. But deep tanning is another matter, and although a deep tan may look healthy, it is really a sign that the skin is under attack from UV radiation.

Erythema (er-uh-**THEE**-muh), or redness of the skin is an inflammatory response, which appears within six hours of exposure to UV rays. The degree of redness is an indication of the amount of damage done to the skin. With each blistering sunburn, the chance of developing skin cancer is increased by 10 percent. Smoking also increases UV damage because of the formaldehyde produced in cigarette smoke.

Sunlight is a part of the electromagnetic spectrum (Fig. 4-20). *Sunlight* is made up of varying wavelengths of *electromagnetic radiation*. About 35 percent is visible light, 60 percent is *infrared radiation*, and 5 percent is made up of UV rays. UV wavelengths range from 200nm to 400nm and are further divided as follows:

UVC rays (from 200-290 nm) are the most energetic, but are the least penetrating. UVC rays are not a concern because most UVC radiation is blocked by ozone in the atmosphere and never reaches the earth.

UVB rays (from 290-320nm) are often referred to as the burning rays and are the UV radiation wavelengths most responsible for causing erythema and tanning. Erythema is used to measure the effectiveness of sunscreens and indicate the sunscreen's ability to block UVB rays. This measurement is known as the **Sun Protection Factor (SPF)**.

An SPF 2 blocks 50 percent of UVB rays, which allows you to stay in the sun twice as long as you would be able to without any protection. Increasing the SPF increases the protection. An SPF 15 blocks 93.3 percent of UVB and an SPF of 30 blocks 96.9 percent of UVB. But notice that doubling the SPF does not double the protection. In this case, it only increases UVB protection by 3.6 percent; at higher SPFs, the increase is even less. Although doubling the SPF doesn't double the protection, it does greatly increase the potential for sensitivity due to the increase in the concentration of active ingredients. UVB sunscreens include: ethylhexyl methoxycinnamate, octylsalicylate, octylhomosalate, oxybenzone, and titanium dioxide.

UVA rays (from 320-400nm) are the longest wavelengths of ultraviolet radiation and the closest to visible light. UVA is commonly known as "black light." UVA plays only a minor role in erythema and tanning, so although its affects may not be as obvious or acute as UVB, UVA exposure is every bit as damaging. UVA

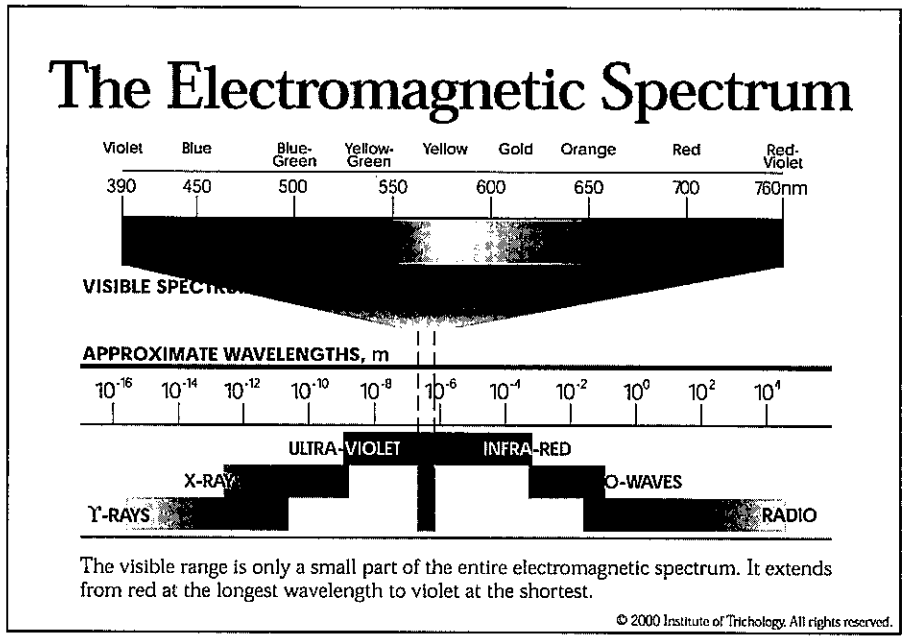

Figure 4-20 *The electromagnetic spectrum.*
(Reprinted with permission of Tri, Institute of Trichology)

wavelengths are the least energetic, but penetrate the deepest. Since UVA penetrates into the dermis, it contributes substantially to chronic sun damage.

Remember that SPFs only indicate protection from UVB rays and do not indicate protection from UVA rays. A sunscreen with a high SPF may provide adequate protection from UVB rays but offer little or no protection from UVA exposure. Make sure the sunscreen you use contains both UVB and UVA protection. Approved UVA sunscreens include: avobenzone (av-oh-Ben-zohn), benzophenone-3 (ben-zo-FEE-nohn), oxybenzone (ok-si-BEN-zohn), octocrylene (ok-tow-KRY-leen), menthyl anthranilate (men-thal an-thra-NY-layt), butyl methoxydibenzoylmethane (BYOO-til meth-ok-si-dy-BEN-zohl-meth-ayn), and zinc oxide (zink OK-syd).

Many sun protection products now claim to use non-chemical sunscreens like titanium dioxide and zinc oxide. Although these inorganic sunscreens are still chemicals, they protect by physically reflecting UV rays. Traditional organic sunscreens protect by chemically absorbing UV rays. Inorganic sunscreens decrease the potential for skin irritation and sensitivity that can be caused by organic sunscreens, especially at the high concentrations required for higher SPFs. There is also some concern about unwanted chemical reactions that may take place on the skin when organic sunscreens absorb UV rays.

Although UV radiation is often referred to as UV light, UV rays are above the visible spectrum of light. UV radiation is invisible and not really light at all.

Since you can't see the UV rays that cause sunburn, it's advisable to protect yourself from the sun even on cloudy days. Although clouds block visible light, they offer little protection from damaging UV rays.

Self-tanning products make it possible to tan safely without the sun. Self-tanners contain the ingredient dihydroxyacetone (dy-hy-drohks-ee-ASS-ah-tohn) that reacts with the proteins on the skin's surface to turn them golden brown and simulate a natural tan.

In order to clear up the confusion about sunscreen products, the Food & Drug Administration (FDA) issued a final ruling regulating the manufacture and labeling of sunscreen products. All sunscreen products must comply with the ruling by January 1, 2003.

1. Although everyone is concerned with both UVB and UVA protection, there is currently no acceptable definition of the term "Broad Spectrum" and no standard test for UVA protection.
2. Consumers who want maximum sun protection often purchase the product with the highest SPF. Most are not aware that SPFs over 30 provide little added protection and greatly increase the dangers associated with such high concentrations of active sunscreen ingredients. The maximum SPF claim allowed on the product label will be SPF30 or SPF30 plus. For maximum protection, apply sunscreen 20 minutes before going out. Apply evenly and generously and reapply every hour.
3. Since there is no official definition of the term "natural" and all sunscreen products contain chemicals, and terms "natural," "non-chemical," and "chemical free" are considered false and misleading and are not approved. Titanium dioxide and zinc oxide are inorganic chemicals.
4. Because all sunscreens allow some UV rays to penetrate the skin, the term "sunblock" is not approved.

Review Questions

1. From where does the skin receive its nourishment?
2. What keeps the dermis from pulling away from the subcutaneous layer?
3. What are the three major parts of the skin?
4. Which protein gives the skin its strength and structure?
5. Which protein gives skin elasticity?
6. Why are mast cells important?
7. Keratin is first formed in which part of the skin?
8. How does a cell in the stratum corneum differ from a cell found in the stratum germinativium?

9. What is the purpose of the sebaceous glands? The sudoriferous gland?
10. What three factors determine a person's skin color?

Discussion Questions

1. If epidermal cells are constantly rising to the surface of the skin and flaking off, why don't scars just "grow" out of the skin?