20B Objectives

- Describe the functions of the integumentary system
- List and describe the layers of the skin
- Describe human hair and nails
- Compare and contrast sebaceous and sweat glands

20B—The Integumentary System

Approximately 1.8 m^2 (about 19 ft^2 or 2800 $in.^2$) of skin covers the body. Although the thickness varies, it averages 3.2 mm (0.125 in.). Few people think much about their skin except for the portion that is visible in the mirror each day. However, this large but thin system and its associated structures are vital in maintaining homeostasis. If large portions of the skin are lost or damaged, due to extensive burns, they must be replaced with either skin grafts from unburned areas or artificial skin. Even so, the body struggles to survive.

20B-1 The Functions of the Skin

The skin has six major functions.

✦ *Protection.* The skin does not permit significant amounts of substances like water and air to enter or exit the body. Bacteria, viruses, and many common chemicals that humans constantly touch would be very harmful if they penetrated into the tissues of the body. Skin is an effective barrier to most of them.
✦ *Sensation.* The skin contains nerve receptors for touch, pressure, temperature, and pain. The various kinds of receptors are unevenly distributed throughout the skin, which accounts for the extreme sensitivity of the fingertips in comparison with the back of the elbow, which is not nearly as sensitive.
✦ *Temperature regulation.* The amount of blood being carried to the surface of skin is regulated to control the amount of heat lost to the environment. The flush of pink after physical exercise is caused by large amounts of warm blood coming to the surface for cooling. The skin turns pale when the body is cold because blood is being withheld from the skin to conserve body heat. However, when the skin is very cold, blood is sent to it to prevent it from being damaged. Rosy cheeks and red ears after outdoor winter activities demonstrate this function quite vividly. If the body generates excessive heat, the skin secretes large amounts of sweat. Evaporation of sweat cools the skin's surface and thereby cools the blood in the skin's blood vessels.
✦ *Excretion.* Small amounts of body wastes are excreted with sweat.
✦ *Vitamin D manufacture.* The skin produces small amounts of vitamin D.
✦ *Absorption.* The skin can absorb some chemicals, a few drugs, and a small amount of oxygen.

20B-2 The Layers of the Skin

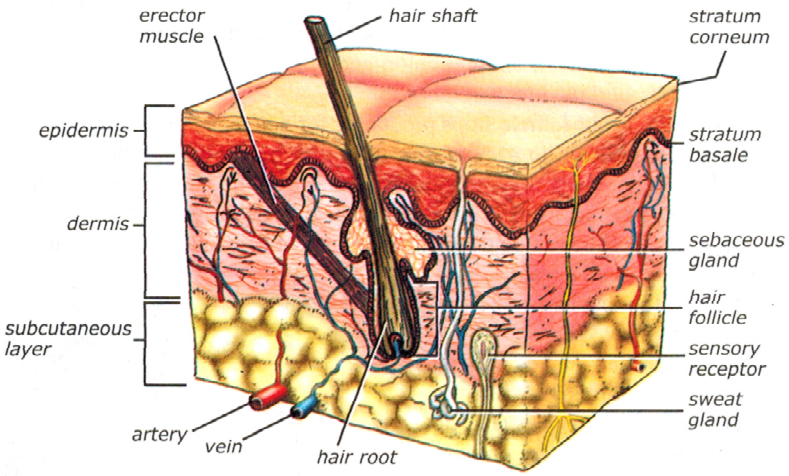
The most superficial layer of the skin is the **epidermis**. The epidermis is made entirely of layers of epithelial cells. The deepest layer of the epidermis is called the *stratum basale* (also called *stratum germinativum*). This single cell layer carries on cell division, producing new cells. These new cells are constantly being forced more superficially as more cells are produced by the stratum basale. The older cells of the epidermis fill with a waxy protein called *keratin* and die. These dead cells form the outer layers of the epidermis, called the *horny layer* or *stratum corneum*. This layer is constantly being sloughed off, and about every twenty-five days (fewer days for some people and some areas of the body), a completely new epidermis covers the body.

The next deeper layer of the skin is much thicker and is called the **dermis**. The dermis is composed primarily of connective tissues. The blood vessels, nerve endings, sweat glands, hair follicles, and oil glands are contained within this layer.

The **subcutaneous*** (SUB kyoo TAY nee us) **layer** is not actually a part of the skin. It is the portion of the integumentary system that attaches the dermis to the underlying muscles and is composed of connective tissues. The fat deposits found in this layer serve to insulate, cushion, and smooth the contours of the body.

Many of the fibers in the connective tissues of the dermis and subcutaneous layers are elastic. Just as a rubber band loses some of its elasticity when it is old, so the elastic fibers of the skin lose some of their elasticity with age. Hence, the skin sags and wrinkles. Surgical facelift procedures often separate the skin from the subcutaneous layer, remove some of the fat tissue, surgically tighten the muscles, and pull the skin taut. Any excess skin is removed and the patient has a less wrinkled face. Unfortunately the results are only temporary and the wrinkles eventually return.

20B.1
Much of the difference between young and old skin is the elasticity of subcutaneous fibers.

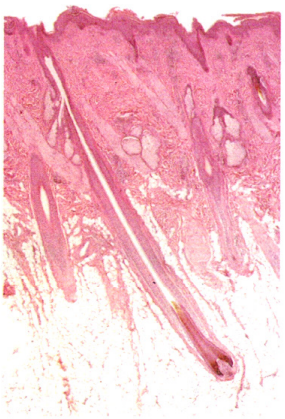


20B.2
A cross section of human skin

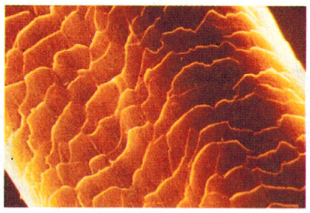
subcutaneous: sub- (under) -cuta- (skin)

Skin Diseases and Disorders

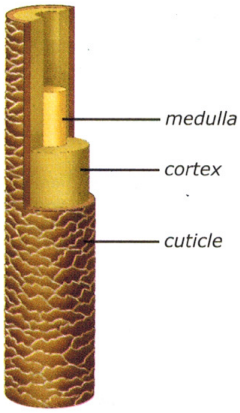
- *Acne:* an inflammation of sebaceous glands caused by a blockage of the pore, resulting in the accumulation of oil and white blood cells within the gland. The causes of acne are not completely understood, but cleanliness, bacteria, diet, and heredity are involved.
- *Blisters:* a collection of watery fluid under the epidermis. There are various causes. If they result from ill-fitting shoes, the friction causes the epidermis to separate from the dermis and extracellular fluid collects in the space. This forms the familiar heel blister. If the skin is severely pinched, the force of the pinch can separate the two layers. Blood may fill the space and cause a "blood blister" to develop.
- *Boils:* rounded, painful inflammation resulting from a localized bacterial infection of a hair follicle.
- *Burns: First-degree* burns involve damage to the outer epidermal layers only. Cold water on the area, followed by an ointment, is usually the recommended first aid. Mild sunburns are first degree burns. *Second-degree* burns involve damage to all the epidermal layers and some of the dermis. Cold water and covering with gauze is usually recommended. Severe sunburns can result in second-degree burns. *Third-degree* burns involve tissue damage to all the dermis and often into the subcutaneous layer. The area should be covered with a moist, sterile cloth until medical attention can be obtained. Ointments and other medications should not be used on a second or third degree burn unless prescribed by a physician.
- *Calluses, corns:* thickened layers of epidermis caused by pressure and friction.
- *Psoriasis:* red scaly patches of skin where epidermal cells have fallen off too rapidly. The exact causes of psoriasis are unknown, although most researchers believe that it results from a malfunction of the immune system and enzymes that regulate skin cell division.
- *Ringworm:* a fungal infection of the skin that appears as a white circle under the skin.
- *Shingles:* an area of soreness, followed by blisters, caused by the chicken pox virus.
- *Warts:* layers of hard, dead cells resulting from a localized viral infection.



20B.3
A light micrograph of a hair follicle. As the epidermal cells at the base of the follicle reproduce, they move upward, lengthening the hair shaft.



20B.4
SEM of human hair showing the overlapping scales of the cuticle



20B.5
Human hair shaft showing the cuticle, cortex, and medulla

20B-3 Hair and Nails

Hairs are located on all of the body except the palms of the hands and the soles of the feet. Different body regions, however, have different types of hair. The root of a hair lies in a hair **follicle*** (FAHL ih kul) located in the dermis or occasionally as deep as the subcutaneous layers. Hair cells are produced at the bottom of the hair follicle and are then filled with keratin and pigments. As the follicle produces more cells, the dead cells are pushed upward and out of the follicle.

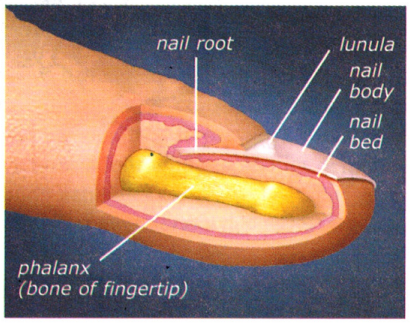
The **shaft** is the visible portion and is actually a collection of these dead protein-filled cells. It is composed of an outer *cuticle*, a thick middle layer—the *cortex*—where the pigment is located, and an inner core called the *medulla*. Since the shaft of the hair is dead, cutting the hair does not cause it to grow faster or coarser.

Scalp hair grows about 1.3 cm (0.5 in.) per month. Diet, hormones, general health, and age can all affect growth. If the follicle opening is elliptical, the hair is kinky. Round follicles produce straight hair. There are varying degrees in between. Straightness, texture, color, and other hair characteristics are all inherited traits.

Periodically a hair follicle stops producing for a time, and the hair falls out; however, it may begin to grow again. Diet, chemicals, fever, emotions, and other factors can temporarily shut down large numbers of hair follicles. Baldness, on the other hand, is an inherited trait. When the genes direct the hair to stop growing, little can be done either to prevent hair follicles from shutting down or to start them again.

Attached to most hair follicles is an *erector muscle*. When the muscle contracts, the hair stands on end, and gooseflesh forms. Temperature, as well as emotions such as fear, can trigger contraction of these muscles.

The nails of the fingers and toes are very similar to hair since they develop from the skin and the visible portion is composed of dead cells filled with protein. Whereas fingernails are replaced about every six months, toenails may require a year.



20B.6
Fingernail anatomy

20B-4 Skin Glands

The skin contains two kinds of **exocrine* glands**. Exocrine glands release secretions through ducts, in this case to the surface of the skin.

Sebaceous (sih BAY shus) **glands** produce **sebum*** (SEE bum), or oil, and are usually connected to hair follicles by ducts. There are also some sebaceous glands that do not accompany hair follicles, especially if there is only a small amount of hair in that area. The sebum helps keep the hair and skin soft and reduces water loss. Sebaceous glands are concentrated on the scalp, face, and forehead; none are located on the palms or soles of the feet.

The amount of sebum produced by sebaceous glands is inherited. Very oily skin often requires the use of special oil solvents. However, removal of too much sebum by detergents or oil-dissolving soaps can cause skin to become dry and cracked and can cause hair to become brittle and to develop split ends. Frequent washing may require the use of conditioners and lotions in order to keep hair and skin supple.

follicle: (L. FOLLICULUS, little bag)

exocrine: exo- (out) + -crine (Gk. KRINEIN, to separate)

sebum: (L. SEBUM, tallow)

There are approximately 150–300 **sweat glands** per square centimeter of skin (1 cm^2 = 0.155 $in.^2$). These tube-shaped glands produce *perspiration*, a substance that is about 99% water. Half of the other 1% is salts (primarily sodium chloride), and half is organic substances, including sugars, amino acids, and urea. Sweat production has two primary functions: elimination of waste and temperature control.

If a person's kidneys fail, the skin attempts to rid the body of wastes like urea and uric acid. This activity produces an unusual body odor. Skin is a poor excretory organ, though, and a person with kidney failure who does not receive medical treatment will soon die.

Normally, the entire body sweats constantly and excretes about 237 mL (0.5 pint) of water daily, even if a person remains in a comfortable room and does no strenuous activity. Because this amount evaporates quickly, this perspiration goes unnoticed. On a hot day with strenuous activity a person can lose almost 7.6 L (2 gal) of water.

Sweat itself does not have an odor, but odors are released when sweat combines with substances on the skin and with the waste products of bacteria growing on the dead skin cells that collect on hair and clothing. Washing with warm water to remove the sloughed-off epidermal cells and bacteria and wearing clean clothing minimize body odor resulting from perspiration. Antiperspirants contain chemicals that inhibit the sweat glands. Deodorants are usually perfumes to cover body odor, often with a little antibacterial substance.

Skin Color and Genetics

The pink color of a person's skin is his blood showing through; other colors are the result of pigments. **Melanocytes*** are cells in the stratum basale of the epidermis that produce **melanin**, the brown, black, or yellow pigment that colors the skin. All humans have approximately the same number of melanocytes in their skin. It is the amount of melanin produced that is genetically and environmentally controlled. Exposure to UV light causes melanocytes to produce more melanocytes; however, they can produce no more than is genetically programmed for that individual.

Ultraviolet radiation (one of the forms of radiation from the sun) stimulates melanocytes to produce melanin. When the melanin enters the layers of the epidermis, it causes the skin to appear darker. Melanin in the upper horny layers of the epidermis absorbs ultraviolet radiation before it penetrates and damages or kills skin cells. Thus a person who has inherited many melanocytes that produce dark melanin has a darker skin color and can withstand more of the sun's harmful ultraviolet rays without skin damage than a person with fair skin can.

Many people have the idea that sunbathing is good and that a deep tan is an indication of good health. Both ideas are in error. A person with a tan can be very ill, and a fair-skinned person, one with minimal ability to produce melanin and who cannot tan, can be in excellent physical condition. When sunbathing to obtain a tan, one actually forces his body to put up a screen against excessive exposure to the sun.

Excessive sunbathing damages or kills skin cells by exposing them to the mutation-inducing ultraviolet rays of the sun. These cells must then be replaced at a rate faster than normal, and the skin consequently ages prematurely. Ultraviolet radiation from the sun can also cause the mutations that cause skin cancer. Tans may be fashionable, but if a person has to work at one, he will be better off to be out of fashion.

What about skin color and the different races seen today? Actually the classification of humans into races is a device that man has created. In reality there is only one race of humans. In Acts 17:26 Paul states, "And [God] hath made of one blood all nations of men for to dwell on the face of the earth." As discussed in the previous paragraphs, all humans have the same number of melanocytes. The Bible states that all humans are descendants of Adam and Eve. How then can all of the various skin colors be accounted for?

Chapter 6 discusses the concept that some traits are controlled by more than one gene. Skin color is one such trait. To help understand how various skin colors could come from Adam and Eve, a model can be devised using the genetic concepts already studied. The model will assume that skin color is controlled by three genes, A, B, and C. The dominant alleles result in dark skin color while the recessive alleles result in light skin color. A genotype of *AABBCC* would be the darkest and *aabbcc* would be the lightest; *AaBbCc* would result in a medium skin color. The model will also assume that both Adam and Eve had medium skin color. A Punnett square will predict the possible genotypes and phenotypes of their offspring.

This model predicts that many skin color genotypes and phenotypes are possible from one set of parents. Considering that pre-Flood life spans were routinely three hundred to four

* **melanocyte:** melan- or melano- (Gk. MELAS, black) + -cyte (cell)

hundred years and that families were probably quite large, it is very possible that all of the genotypes could be produced within one family unit. It is also possible that Noah's family members expressed various skin colors. Does this model scientifically prove that all humans came from Adam and Eve? No, biblical worldview Christians accept Adam and Eve as mankind's ancestors because it is recorded in the Bible—the inspired Word of God. However, this model does use the scientifically accepted knowledge of genetics to construct a model that fits within the biblical framework.

	ABC	ABc	AbC	Abc	aBC	aBc	abC	abc
ABC	AABBCC (6)	AABBCc (5)	AABbCC (5)	AABbCc (4)	AaBBCC (5)	AaBBCc (4)	AaBbCC (4)	AaBbCc (3)
ABc	AABBCc (5)	AABBcc (4)	AABbCc (4)	AABbcc (3)	AaBBCc (4)	AaBBcc (3)	AaBbCc (3)	AaBbcc (2)
AbC	AABbCC (5)	AABbCc (4)	AabbCC (4)	AabbCc (3)	AaBbCC (4)	AaBbCc (3)	AabbCC (3)	AabbCc (2)
Abc	AABbCc (4)	AABbcc (3)	AabbCc (3)	Aabbcc (2)	AaBbCc (3)	AaBbcc (2)	AabbCc (2)	Aabbcc (1)
aBC	AaBBCC (5)	AaBBCc (4)	AaBbCC (4)	AaBbCc (3)	aaBBCC (4)	aaBBCc (3)	aaBbCC (3)	aaBbCc (2)
aBc	AaBBCc (4)	AaBBcc (3)	AaBbCc (3)	AaBbcc (2)	aaBBCc (3)	aaBBcc (2)	aaBbCc (2)	aaBbcc (1)
abC	AaBbCC (4)	AaBbCc (3)	AabbCC (3)	AabbCc (2)	aaBbCC (3)	aaBbCc (2)	aabbCC (2)	aabbCc (1)
abc	AaBbCc (3)	AaBbcc (2)	AabbCc (2)	Aabbcc (1)	aaBbCc (2)	aaBbcc (1)	aabbCc (1)	aabbcc (0)

In this model, it is the number of dominant alleles (noted in parentheses) rather than which allele is dominant that determines skin color. Therefore, those individuals with six dominant alleles have the darkest skin color and those with no dominant alleles have the lightest color.

According to a biblical worldview, all of the variations in skin color came from the gene pool of Adam and Eve.

The Integumentary System

1. List and describe the six major functions of the skin.
2. From the outer layer to the inner layer, list the three major layers of the human skin and the type of cells each is made up of.
3. What causes the outer layer of skin cells to die?
4. Describe how a human hair grows.
5. What is an exocrine gland?
6. List the two types of exocrine glands in the skin and the function of each gland.