Chapter 2
The Integumentary System

Learning Objectives
When you complete the instruction in this chapter, you will be able to:

- Explain the integumentary system.
- Describe the two layers of the skin.
- Discuss the integumentary appendages.
- Determine the different types of glands.
- Identify the special sense organs.
- Define the components of each special sense organ.
Introduction

In this chapter you’ll learn about the layers of the skin, as well as the appendages that grow from the skin—the hair and nails. You’ll also read more about the glands.

As you read these chapters about the body systems, you’ll encounter many new terms. But don’t feel overwhelmed! There are examples and illustrations throughout the text designed to help you remember these terms, and your flashcards will be a great tool, as well. You’ll learn about how to relate what you study to the real world, and you’ll find the chapters full of a lot of hints and pneumonic devices to help you remember the various muscles, bones, glands, veins and arteries, among other items, in our bodies. Also, Practice Exercises will reinforce what you learn. Keep in mind that these body systems build upon one another, so what you learn in one chapter will help you as you study the next chapter—you’ll begin to recognize many of the terms you see.

Now, let’s begin our discussion of the body systems with an introduction to the integumentary system.

Introduction to the Integumentary System

The integumentary system is made of the skin, which is known as the integument; appendages that grow from the skin, such as hair and nails; and the glands the skin contains. The integumentary system is the largest organ system in the body, covering nearly 22 square feet of surface area. The function of this system is to protect the body from things such as heat, cold, harmful chemicals and bacteria.

The skin, or integument, is a sense organ because the sensory neurons are concentrated and because the skin functions as a receptor. It senses items such as changes in temperature, touch or pain. To understand its importance, remember that loss of enough of the integument can result in death. For example, if a burn injury is so severe that a great deal of the integument is destroyed, a person will die.

The Skinny on the Skin

The skin is composed of two layers of tissue. They are:

- the epidermis
- the dermis
The following table lists the components of each layer of skin. The skin also includes **appendages**, which are structures arising from the skin.

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### The Epidermis

The **epidermis** is the superficial surface of the skin, and it is made up of stratified squamous epithelium. It is thicker on the palms of the hand and the soles of the feet. This skin layer is **avascular**; there is no blood supply. The epidermis continually forms new cells in its deepest layer and sheds dead cells at its surface. Millions of dead squamous cells are shed, or **desquamated**, every day. You learned this in a previous chapter.

The epidermal cells are produced in the deepest epidermal layer, the **stratum germinativum**. This is the layer that produces the epidermal epithelial cells through simple cell division. This basal layer of the epidermis is a single row of columnar cells resting on a basement membrane. Just below the basement membrane is the dermis.

Like bubbles rising to the top of a boiling pot of water, the squamous cells formed in the stratum germinativum rise to the top of the skin, where they are shed.

The strata of the epidermis contain specialized cells that add color to the skin and the iris in the eye. The cells are called **melanocytes** because they contain the pigment **melanin**. The color of skin depends on the number of melanocytes and the depth at which they lie. Melanin causes skin color to vary from the complete absence of color, called **albinism**, to very dark skin.
Let’s pause for a moment and apply your new knowledge of melanocytes. Surely, you’ve heard the warnings. And hopefully you’ve listened. Lather on the sunscreen because our sun is causing some serious damage to exposed skin. But what exactly is damaged?

Well, those melanocytes are where melanoma, or skin cancer, begins. There are several signs of skin cancer, including any change in a mole, a new growth on the skin or the spread of pigmentation beyond its border. The best ways to lower the risk of skin cancer are to avoid intense sunlight for long periods of time and to practice sun safety, such as wearing sunscreen or staying out of the sun from 10 a.m. to 4 p.m. So do what it takes to protect those melanocytes! Now, let’s continue our discussion of the epidermis.

Just superficial to the stratum germinativum is the **stratum spinosum**. The cells in this layer are shaped like polygons and are prickly in nature.

Next, you’ll find the **stratum granulosum**. The cells in this layer change in shape from plump to flattened as they move closer to the surface of the skin.

The stratum granulosum is three to five cells thick. It is here that the cells contain granules of substance called **keratohyalin**. This is the layer where the cells begin to harden, a process called **cornification**.

Keratohyalin makes a dry, tough protein called **keratin**. You learned about keratinized and nonkeratinized tissue previously in this course. Cornification is the process of drying out the epidermal cells and replacing them with keratin. This process kills the epidermal cells. However, these keratinized, dead epidermal cells form a waterproof layer that protects the body from losing body water and prevents foreign materials such as toxins and bacteria from entering the body.

The **stratum lucidum** is a layer of flat, clear cells that lie on top of the stratum granulosum. The most superficial layer is the **stratum corneum**, also called the **horny layer**. By this time, the epidermal cells are no longer living. The cells are fully keratinized at the surface. In areas where the skin has extra wear, like the palms of the hands and the soles of the feet, the strata lucidum and corneum are thicker, to protect the underlying tissues.

![Figure 2-2: Layers of the dermis](image)

**The Dermis**

The **dermis** is the layer of the skin that lies beneath the epidermis. It is a layer of connective tissue that is tough and flexible. For example, the leather in leather gloves is dermal tissue. The dermis is thick over the palms and soles, thinner in your inner wrist and very thin in the eyelids. Rub the skin of your eyelid, wrist and palm to see the difference in toughness and flexibility in the skin, depending on the thickness of this layer.

Unlike the epidermis, the dermis has a generous supply of blood vessels, nerve endings, collagen and elastic fibers and smooth muscles.

The dermis contains two layers:
- The papillary layer
- The reticular layer
These two layers are very much alike since they are connective tissue. They only differ by how closely the collagenous and elastic fibers are matted and by the vessels, nerves and other skin organs they contain. The dermis changes gradually from one layer to another; there is no sharp border.

The papillary layer is the superficial layer that lies just below the epidermis. The connective tissue fibers are very tightly matted in this part of the dermis. This layer has finger-like projections extending into the epidermis. These projections are called dermal papillae. The dermal papillae are vascular, meaning that they have a blood supply. It is this blood supply that helps to regulate body temperature because it lets heat reach the skin surface. The papillae contain many nerve endings for pain and touch.

The reticular layer is the deep layer of the dermis. Its connective tissue fibers are loosely matted, like felt. Hair follicles, sweat glands and oil glands reach as deep as the reticular layer.

Scattered throughout the dermis are phagocytes, which are cells that help fight infection by eating dead bacteria and debris. The dermis of the scrotum, nipples, foreskin and perianal area also contain smooth muscle, which causes skin wrinkling when they contract.

The Areolar Subcutaneous Tissue
Below the dermis is a layer of loose areolar connective tissue. The transition from the skin to the loose subcutaneous tissue below is a gradual one. The subcutaneous tissue is very loose and contains many fat cells. It allows the skin to move over the surface of the body when you push it back and forth. Another name for this layer is superficial fascia. This layer separates easily at surgery. Subcutaneous injections spread in this loose tissue without making much of a lump.

All About Integumentary Appendages

There are two appendages that develop from the skin: the hair and nails. Because they are developed from the skin, they are often abnormal when disease is present.

Hair

Hair grows from the epidermal layer all over the body. Some areas are hairier than others. The texture and color depend on the area of the body, gender, age, health and heredity.

Hair patterns are different in males and females. For example, the distribution of pubic hair is triangular in females and diamond shaped in males. Balding over the temples is more common in males, a characteristic called male pattern baldness.

Hair is a horny, elastic thread that develops from the epidermis but extends into the dermis. Hair has three layers of tissue:

- The cuticle
- The cortex
- The medulla
The **cuticle** is a thin layer of cells that overlap like fish scales on the surface of the hair. The **cortex** is the horny tissue arranged in a number of layers. This is the layer that contains the pigment that determines hair color. The **medulla** is the central axis. It is only present in thick hairs.

The hair grows from an envelope called the **follicle**. The follicle extends into the dermis from the epidermis. At the base of the follicle, the **hair bulb** gives rise to the hair from germinal epithelial cells. The hair grows like a flower grows from a bulb planted in the ground. The part of the hair thread inside the follicle is called the **root**. The part of the hair that emerges from the follicle, like a flower emerging from the ground, is called the **hair shaft**.

Like the skin, this appendage is mostly dead, keratinized cells. When there is separation of the cortical and medullary layers in thick hairs, the hair shaft splits. This won’t occur in fine hair, where there is no medullary layer, or in recently cut hair, where the damaged, separated cells are cut off.

Consider this example. Most of us probably get our hair cut every six to eight weeks. While it’s true that our hair is getting long and needs that trim every so often, many of us get haircuts to avoid split ends. After all, hair looks healthier when the damaged, separated cells are cut off.

The hair follicles have small, smooth muscles that connect to the dermal papillae. These muscles are called **arrector pili**. When they contract, they pull the follicle and make the hair stand on end. This is what causes goose bumps in your skin. This function is not very helpful anymore in humans because we no longer use hair to keep us warm, like a fox does in the snow. And we don’t scare away our enemies when our hair stands on end, like a porcupine does. However, we still feel this physiologic mechanism in action when it is cold or when we are scared.

Hair texture can depend on the shape of the shaft. Round hair shafts don’t curl; flat shafts do. The amount and distribution of hair depends on hormones and gender. Hair is a secondary sex characteristic. The pattern of hair in the male is different from that in the female, unless abnormal hormones are produced. For example, an ovarian tumor may produce excess male hormones in a woman, causing an increase in facial hair or male pattern baldness in the scalp. **Cirrhosis**, or hardening of the liver, prevents the liver from destroying the small amount of female hormone that males have normally, leading to a loss of chest hair in a man.
Nails

Fingernails and toenails are other horny, scale-like appendages that the epidermis produces. They are like hooves and claws in other animals. The nail body is the part that attaches firmly to the skin and that the skin does not cover. The nail root is embedded in a fold of skin. The nail bed is the skin under the nail.

Healthy nails are essentially colorless. The color of a healthy nail depends on the blood supply to the nail bed. Squeeze your thumbnail and then let go quickly. You will see that the nail bed is white, quickly filling in with pink as the blood vessels of the nail bed fill with blood. When the oxygen level of blood is very low, the resulting cyanosis will color the nail bed blue. In an emergency, a simple way to see if there is blood flow or cyanosis is to squeeze the thumbnail to see how fast the blood returns and how pink it is.

And here’s another real-world example involving blood supply to the nail bed. Have you ever been admitted to the hospital for surgery? If so, and if you arrived at the hospital with nail polish on your fingernails and toenails, you likely were asked to remove it before you underwent the surgical procedure. This is because, during surgery, those attending to you want to be able to see if there is blood flow by squeezing your nails, just as we described. This is impossible to do if someone is wearing nail polish, and this is why it’s common for surgical patients to be asked to remove the polish.

Getting to Know the Glands

You studied glands previously in this course, but now it’s time for a bit more information. There are a number of glands that develop in the skin. Glands are classified as to how they secrete the material the gland produces. Glands in the integumentary system are exocrine glands. You’ll recall that exocrine glands secrete their product through a duct directly outside the gland, not into the bloodstream.

Sudoriferous Glands

The sudoriferous glands produce sweat. They open to the surface through openings in the epidermis called pores. Generally, these exocrine glands can be further classified by the type of secretion they produce as either eccrine or apocrine glands.

Eccrine sudoriferous glands secrete water that contains sodium chloride, or salt and urea. Apocrine sudoriferous glands begin to function at puberty, are larger and make thicker secretions than eccrine glands. They are localized in and around the axillae, or armpits, and the genitals. The secretions of the apocrine glands contain protein along with sweat. The protein can support bacterial growth, which leads to changes in sweat odor at puberty.

Sweat glands are an important factor in body temperature regulation. Sweat is produced when it is hot. The evaporation of this fluid cools the body surface, allowing heat to escape through the skin. This physiologic mechanism responds to increases in body temperature or temperature outside the body. Just as heat is used to make steam from water, heat is used up evaporating sweat from the surface of the skin. However, when this happens, salt is lost. This can lead to an imbalance in the body salt balance, causing dehydration or heat stroke.
Ceruminous Glands

Ceruminous glands are modified sweat glands located in the ear canal. The ducts open to the skin surface or into a hair follicle. These are also apocrine glands. They produce a very thick material called cerumen that contains sweat, sebum and desquamated epithelial cells. Cerumen is usually called ear wax.

Did your mother ever tell you never to clean your ears with anything smaller than your elbow? Well, in a way, she was right. While many parents use Q-tips to clean the ears of their children, it’s now believed this isn’t the best solution. Q-tips often push skin and cerumen toward the eardrum, clogging it further, and Q-tips even can easily puncture the eardrum if they are pushed too far into the ear canal.

So what’s a mom to do? Well, the ear actually is self cleaning. Most of the cerumen works its way out of the ear canal on its own! Therefore, most doctors recommend that you simply wipe the outside of the child’s ears with a warm, wet washcloth.

Sebaceous Glands

The sebaceous glands, or oil glands, are exocrine glands that produce sebum. Sebum is a mixture of lipids and cellular debris. These are the glands that keep the skin from being too dry. They also can make the skin very oily. They usually empty into a hair follicle, but their ducts can also open directly to the skin surface.

When the duct of a sebaceous gland is blocked, it swells to form a cyst filled with sebum, called a sebaceous cyst. This cyst is found as a round firm mass under the skin.

Sebaceous glands increase their output when there is an increase in male hormones. For example, during puberty, an increase in male hormone raises the oily secretions in the skin. Blocked ducts and infection complicate this oiliness, leading to acne. Endocrine conditions can also affect the output of these exocrine glands; hyperadrenalism, increased secretion of the adrenal gland, can lead to acne in an adult.
Meibomian Glands
The meibomian glands are sebaceous glands in the eyelids. The oily secretions form a seal at the corners of the eyes to keep the eyes watertight when they are closed and prevent leaking of tears when they are open. When these secretions are dry, they are sometimes called sleepy seeds.

Mammary Glands
Mammary glands are sweat glands that have been modified to produce milk. They develop at puberty behind the nipples. We will look at the anatomy and physiology of these exocrine glands of the skin in a later chapter.

Vernix Caseosa
The vernix caseosa is a waterproofing material that the sebaceous glands secrete to cover the fetal skin inside the uterus. At birth, it is seen as a white material covering the skin. It is washed off after the birth. Also, the accumulation of the white material, spots called milia, in the sebaceous glands on the baby’s face is usually gone by the time a baby is a month old.

Practice Exercise 2-1
For questions 1 through 20, select the best answer from the choices provided.

1. The _____ system includes the skin, hair and nails.
   a. special sense
   b. integumentary
   c. surface
   d. muscular

2. The purpose of the integumentary system is to _____.
   a. transmit information to the nervous system
   b. protect the body from the elements, pathogens and poisons
   c. hold the body’s organs in place
   d. protect the organ systems from UV rays

3. The integument contains a large concentration of sensory neurons. For this reason, it is considered a _____.
   a. sense organ
   b. part of the nervous system
   c. nerve impulse transmitter
   d. light receptor

4. The _____ is the superficial layer of the skin and contains five strata, while the _____ lies beneath this layer and is made up of two layers.
   a. dermis, epidermis
   b. integument, epidermis
   c. epidermis, dermis
   d. stratum germinativum, stratum corneum
5. The epidermis is made up of _____; while the dermis contains _____.
   a. stratified squamous cells; connective tissue, blood vessels, nerve endings, collagen fibers, elastic fibers and smooth muscles
   b. four strata of dead cells; living tissue
   c. connective tissue, blood vessels, nerve endings, collagen fibers, elastic fibers and smooth muscles; stratified squamous cells
   d. specialized cells that provide pigment to the skin and iris of the eye; only clear cells

6. The _____ is the deepest strata of the _____. and produces epithelial, or squamous, cells.
   a. stratum lucidum, epidermis
   b. stratum germinativum, epidermis
   c. papillary layer, dermis
   d. reticular layer, epidermis

7. In the ____, cells begin to flatten and harden. This process is called _____.
   a. stratum corneum, stratification
   b. stratum lucidum, keratinization
   c. papillary layer, temperature regulation
   d. stratum granulosum, cornification

8. At the ____ layer, cells are fully keratinized and are no longer living. This layer is also called the _____.
   a. papillary, reticular layer
   b. subcutaneous tissue, dermis
   c. stratum corneum, horny layer
   d. stratum granulosum, keratin layer

9. The ____ has very tightly matted collagenous and elastic fibers and has finger-like projections called ____, which help to regulate body temperature.
   a. papillary layer, dermal papillae
   b. reticular layer, sweat glands
   c. papillary layer, phagocytes
   d. reticular layer, dermal papillae

10. Loosely matted connective tissue, hair follicles, ____ and oil glands lie in the ____ layer of the dermis.
    a. sebaceous glands, reticular
    b. sweat glands, papillary
    c. smooth muscle, papillary
    d. sudoriferous glands, reticular
11. Hair is made up of a ____—a thin layer of cells on the surface, a(n) ____—the layer that contains pigment and a(n) ____—the central axis.
   a. horny, elastic thread, cuticle, follicle
   b. hair shaft, follicle, cuticle
   c. cuticle, hair bulb, arrector pili
   d. cuticle, cortex, medulla

12. ____ is an integumentary appendage that can help medical professionals determine blood flow—it is composed of a(n) ____ , a(n) ____ and a ____.
   a. Hair, cuticle, hair bulb, medulla
   b. Sweat gland, eccrine gland, apocrine gland, cerumen
   c. A nail, bed, body, root
   d. A fingernail, epidermis, nail, cuticle

13. Sudoriferous glands are ____ glands because they secrete sweat through pores on the skin.
   a. exocrine
   b. sweat
   c. eccrine
   d. apocrine

14. The ____ glands produce protein with sweat, which is the culprit behind sweat odor during puberty.
   a. sudoriferous
   b. eccrine sudoriferous
   c. apocrine sudoriferous
   d. sebaceous

15. ____ glands are important in helping the body regulate temperature.
   a. Sebaceous
   b. Ceruminous
   c. Sudoriferous
   d. Meibomian

16. The sebaceous glands secrete sebum—a mixture of lipids and cellular debris—usually through ____.
   a. exocrine glands
   b. acne
   c. sweat glands
   d. hair follicles
17. The function of the sebaceous glands is to _____.
   a. expel cellular debris from the skin
   b. prevent skin from becoming too dry
   c. create sebaceous cysts
   d. keep the scalp lubricated

18. Another function of the sebaceous glands is to _____.
   a. waterproof the skin
   b. release male hormones
   c. cover the fetus’s body with a waterproofing substance
   d. produce milia in the sebaceous glands on infants’ skin

19. Like some sudoriferous glands, ceruminous glands are ____—they are larger glands that produce a thick substance called cerumen.
   a. sebaceous
   b. apocrine
   c. eccrine
   d. exocrine

20. Mammary glands are ____ that have been modified to produce milk.
   a. breast tissues
   b. sebaceous glands
   c. endocrine glands
   d. sudoriferous glands

**Review Practice Exercise 2-1**

Check your answers with the Answer Key at the back of this book. Correct any mistakes you have made.
**Special Sense Organs**

You already know that the skin is a sense organ. But did you know there are other sense organs in our bodies? Well, there are four *special sense organs* that have very specific anatomy and function. They include:

- The eye (vision)
- The ear (hearing and balance)
- The nose (smell)
- The tongue (taste)

These sensory receptors are so complex that they are considered organs in their own right. Sometimes these organs are grouped with the neurological system because all of the sensory input from these special sense organs is integrated with the sensory input from the peripheral nervous system, which we’ll discuss later in this text. At other times, these organs are discussed with the integumentary system because they are sense organs, like the skin.

In this text, we’ll mainly talk about these organs as part of the integumentary system. However, because they’ll be discussed again briefly in the chapter about the nervous system, the flashcards pertaining to the sense organs will be included with the nervous system flashcards.

**Seeing is Believing**

The *eye* is nearly spherical, which is why it is often called the *globe*, or *orbit*. When your eyes are open you can only see a part of the eye’s anterior surface. The eye sits in the *orbital fossa*, or *eye socket*, in the skull. This protects the eye from crushing, since the eye is delicate, like a soft-boiled egg.

Structures that protect, lubricate and move the eye surround it. The *eyelids*, flaps of tissue that join at either side of the eye, cover the eye. The angles that the eyelids form are called the *medial* and *lateral canthi*. *Eyelashes* are hairs that grow from the eyelids. They protect the eye from debris and warn you if something gets too close to your eyes. It is an involuntary eye reflex for the eye to blink if something comes near it. The eye also blinks when you sneeze.

Meibomian glands are sebaceous glands adjacent to the eyelash follicles. You read about these glands a moment ago. These meibomian help lubricate the eyelids. When the secretion dries, it is called sleepy seeds. Sweat glands in the eyelids are called *ciliary glands*. The *conunctiva* is a membrane that lines the inner surface of the eyelids and reflects backward to cover the anterior surface of the eye, fusing with the epithelium covering the cornea in front of the pupil. The conjunctiva is a mucous membrane that secretes mucus to keep the eyeball moist. It is essential that the eyeball stay moist if it is to function properly.

The *lacrimal glands* are located superiorly and laterally to each eye. They produce *tears*, a salty fluid that flows over the anterior surface of the eyeball. As tears bathe the eyeball, they are absorbed in the *lacrimal duct*—tubes that lie in the medial portion of the orbital cavity. The lacrimal ducts drain into the *lacrimal sac* and through the *nasolacrimal duct* into the nose. Tears contain antibodies and *lysozyme*, which is an enzyme that fights bacteria.
The Globe

The globe of the eye is a hollow ball. There are three layers in the wall of the globe, and the globe is filled with liquid, like a water balloon. The eye operates like a simple camera. There is a lens in the front to focus the eye, with fluid lying in front of the lens and filling the inside of the eye behind the lens.

Sclera

The most superficial layer of the globe is a relatively thick white layer of fibrous connective tissue called the sclera. The sclera is the white of the eye. The cornea is the portion of the sclera that is transparent, allowing light to enter the eye.

The cornea is quite remarkable. Not only does it have an unusually high number of sensory nerve fibers, but it also is avascular. The great number of nerve fibers means that the cornea is extremely sensitive to even the slightest touch, giving the eye extra protection from trauma. With even the slightest touch, the eyelids blink and tearing increases to protect and wash the eye. If you wear contacts, you can attest to this! Many people find putting contacts in their eyes to be difficult because the eyelids automatically try to blink when the lens touches the cornea.
Because the cornea is avascular, the immune system can’t reject a corneal transplant, and surgery involving the cornea is not very bloody. Furthermore, the cornea heals itself better than almost any other tissue in the body.

**Choroid**

The middle layer of the globe is called the choroid. This is a very vascular layer that is pigmented. Like blackout shades over a window, the pigment in the choroid keeps light from reflecting back and forth in the eye so that light rays remain organized when they enter the eye.

The choroid forms the ciliary body, a muscle attached to the rim of the perimeter of the lens. The ciliary body helps the lens change shape for focusing. As the choroid continues over the anterior surface of the globe, it forms the iris.

The iris contains pigment, which gives eyes their color. The depth of the pigment is what determines whether eyes are very dark or very light. The hole in the center of the iris is called the pupil. The smooth muscles of the iris open and close the pupil like a camera shutter. These muscles are arranged in two rows, a circular row that constricts the pupil and a radial row that dilates the pupil.

The only item that the eye actually sees is light. In a dark room, the pupil dilates to allow more light in, since light is the only information the eye understands. When light is bright, the pupil constricts, limiting the amount of light so that the eye is better able to see. This is why it is easier to see a star in a night sky than it is to see an airplane far off in the sky on a sunny day. At night, the only information entering the eye is the light from the star. In the bright daylight, all of the light from the sky is information, overwhelming the tiny dot that is the airplane. It is for this reason that many people who use computer terminals prefer light letters on a dark background. That way, they only see the letters they want to read.

**Retina**

The deepest layer of the globe is the thin retina. The retina covers the inside surface of the globe, ending at the ciliary body. The posterior wall of the retina is called the fundus. The retina contains the specialized vision receptor cells called rods and cones. These are photoreceptors, or light receivers, that only respond to light. The photoreceptor cells are connected to bipolar cells.

Bipolar cells lie between the photoreceptor cells and ganglion cells. The axons of the ganglion cells form a bundle called the optic nerve. The entire retina is covered with photoreceptor cells except for one spot, the area where the optic nerve leaves the globe. This part of the retina is called the optic disk. Since the optic disk has no cones or rods, it is a blind spot.

Different parts of the retina see different items. There are more rod cells near the outer border of the retina and fewer rod cells near the center. Because they are at the edge, rod cells provide peripheral vision. They also let us see in the dark, since rod cells don’t need a lot of light to be stimulated and basically respond to the colors black and white.

Cones are color receptors. Cones are more common near the center of the retina and occur less frequently in the periphery. In fact, just next to the blind spot is a tiny area called the fovea centralis that contains cones but no rods. This is why the fovea centralis is the part of the retina with the best visual acuity, or vision sharpness, and the sharpest focus.
Different cones contain different pigments. Depending on the pigment they contain, cones are more sensitive to red, blue or green—the three colors that cones recognize best. Cones recognize color when light energy breaks down the pigment in the cone into its component parts.

The ability to see color depends on the presence of cones of all three types. The absence of red or green color receptors can cause **color blindness**. Color blindness usually occurs in males more often than in females.

### The Lens

The **lens** focuses the incoming light onto the retina. Because the lens curves outward on its anterior and posterior surface, it is a biconvex lens. The ciliary body holds the lens in place. If the lens is injured through trauma or radiation, it can form a cataract. A **cataract** is a clouding of the lens, slowly causing blindness because the lens no longer transmits light.

The inside of the globe is filled with fluid. The space between the lens and the cornea is filled with **aqueous humor**, a water-like liquid. The remainder of the globe, posterior to the lens, is filled with a viscous jelly called the **vitreous humor**, or **vitreous body**. The aqueous and vitreous humors maintain pressure inside the eye so that the eye doesn't slowly collapse like a balloon losing air. Since the cornea is avascular, the aqueous humor keeps it nourished and then is reabsorbed into the blood stream through the **canal of Schlemm** at the boundary of the cornea. When this reabsorption is blocked, the aqueous humor increases, causing increased intraocular, or inner eye, pressure. This condition is called **glaucoma**.

### Optic Nerves

The **optic nerves** exit posteriorly from the orbit and go through the **orbital fissure** into the brain. At the base of the brain, the fibers crisscross at the **optic chiasm**. The fibers from the medial side of each eye cross over to the opposite side of the brain. After this crossover, the fiber tracts are called the **optic tracts** and travel to the thalamus. After synapsing here, the fibers leaving the thalamus are called the **optic radiation**, and these fibers run to the occipital lobe.

Because of crossover of fibers, each side of the brain receives fibers from the lateral side of the same side, or **ipsilateral**, eye and the medial side of the opposite, or **contralateral**, eye. That way, images from the left side of the field of vision go to the right brain and images from the right field of vision go to the left brain. Both of these **visual fields** (the space within which objects are visible to the immobile eyes at a given time) overlap. In other words, your left eye can see many of the things your right eye can see. This is because your eyes are facing straight ahead. This is called **binocular vision**.

### Globe Muscles

There are six skeletal muscles that move the eye. The **rectus muscles** originate from the posterior wall of the orbit. They are named for their insertion on the globe and the resulting direction that they move the eye. For example, the **lateral rectus** muscle inserts on the lateral surface of the globe and pulls the eye laterally.
In the same manner, the superior, medial and inferior rectus muscles insert on the superior, medial and inferior surfaces of the globe, respectively, and pull the eye in their own directions.

The superior and inferior oblique muscles rotate the eye. The superior oblique muscle is hooked up to a pulley called the trochlea, which is like a cord that pulls drapes, and it rotates the eye clockwise. The inferior oblique muscle rotates the eye counterclockwise.

**Eye Physiology**

You can focus a camera by changing the distance between the lens and the photographic surface, or you can change the focus by changing the thickness of the lens. This is because the thickness of the lens determines how light is bent. The best focus or sharpest acuity comes from focusing the light beam right at the photographic plate. In the case of the eye, the light must focus on the retinal surface for the best visual acuity.

**Focus, or Refraction**

Obviously, it would be difficult to change the distance between the lens and the retina quickly. Therefore, the eye focuses light by changing the shape of the lens. The ciliary body contracts, and this makes the lens fatter or more convex. This allows the lens to focus light from closer objects on the retina. Farther objects require less bending of light to focus on the retina, so the ciliary body relaxes, allowing the lens to become flatter.

**Accommodation** is the normal process of contracting the lens to focus on close objects. A normal eye has no trouble accommodating near and far objects. A normal eye is emmetropic—that is, it sees the true image.

Now let’s apply what you’ve learned about vision to a few common problems that people experience with their eyes. Vision problems occur if the eye changes shape over time, changing the distance between the lens and the retina. The lens has no way of knowing that the retinal distance changed, so it has trouble accommodating or bending light to the right distance. Near-sighted people have myopia. They have no trouble accommodating close objects, but since the eyeball is elongated, focus of far objects occurs in front of the retina. Far-sighted people have hyperopia. In these people, the eyeball has become foreshortened, and the lens is focusing near objects behind the retina.

**Presbyopia** occurs with older age. You can accommodate near objects by moving them away from your eyes slightly, just as you do when you hold a book further from your face. Eventually, you run out of arm, and you need to get reading glasses. Presbyopia usually begins when people are in their 40s. Lastly, macular degeneration is a common eye disease that causes deterioration of the macula, which is the central area of the retina. This eye problem results in blind spots and distorted vision.

**Accommodation**

Even when the eye focuses properly, visual acuity troubles occur if there are problems with the muscles moving the eyes. Even though the lens may accommodate near objects correctly, the eyes also have to move together to see things that are close. This is called convergence.

Convergence relies on cranial nerves III, IV and VI. At the same time, the pupils constrict during close vision, narrowing our field of view and focusing more on the cones. This combination of lens accommodation, globe convergence and pupillary constriction is called the accommodation-pupillary reflex.
The pupils also constrict if they are exposed suddenly to bright light. This reflex is called the **photopupillary reflex**. If you have a cat at home, you’ve probably noticed that his pupils are noticeably smaller in the brightness of day but become large under the darkness of night. Because a cat’s pupils react so clearly to light and darkness, it’s easy to see the photopupillary reflex in this animal.

Another way to see this reflex in action is to go into your bathroom while the light is off. Look into the mirror at your eyes and then turn on the light. If you’re looking at your eyes in the mirror as the room suddenly changes from light to dark, you’ll be able to see your pupils constrict.

The photopupillary reflex is a very basic test of brain function. If the pupils don’t constrict when light is shined in the eye, the pupils are said to be nonreactive. This is seen in brain death.

**Heard It Through the Grapevine**

The **ear** is a special sense organ that hears sound and helps us maintain our balance. At first glance, this seems like an unusual combination of functions for one sense organ. But the similarities between these two senses become clearer when you realize that sound is a **pressure wave**. In other words, sound causes motion in the materials through which it passes. If you have any doubts about this, turn up the stereo volume. You can feel the motion that the vibration of the sound pressure wave causes!

In the same way, our body maintains its balance by being aware of motion. When you ride in a roller coaster and the car turns to the left, your body leans to the right to help maintain its balance. Therefore, the ear is a special sense organ that detects motion, whether it is from the motion of sound waves or the motion of your body.

The ear is divided into three different parts:

- The external, or outer ear
- The middle ear
- The internal, or inner ear

![Figure 2-8: Gross and microscopic anatomy of the ear]
External, or Outer, Ear
What most people think of as the ear is actually the external ear: the pinna and the external auditory canal.

The pinna is the fleshy, cartilage-containing structure that sticks out from the side of your head. Its funnel shape suggests that it is used to collect sound waves, and this is true in many other species, like bats, as well. The pinna is also called the auricle.

The external auditory canal is a canal through the temporal bone leading from the pinna to the eardrum, which is a diaphragm covering the inner border of the external ear. Skin covers the pinna and the external auditory canal. Because of this, the pinna and canal contain ceruminous glands. These glands secrete a yellow, waxy substance called cerumen, or ear wax, which you read about previously in this text. The auditory canal is surrounded by temporal bone, which contains the mastoid ear cells at this level. The external auditory canal ends at the tympanic membrane, or eardrum. It is called the tympanic membrane because it vibrates like a drum skin when the pressure waves of sound hit it.

Middle Ear
The middle ear is also called the tympanic cavity. It is a small cavity in the temporal bone that lies between the external ear and the inner ear. Its lateral surface is the tympanic membrane. Its medial surface is bone containing two more membrane-covered foramina—the oval and round windows. A tube called the Eustachian (Auditory) tube runs from the floor of the tympanic cavity. It runs downward, then medially to connect with the pharynx. In other words, the tympanic membrane connects directly to the air outside your body through the external auditory canal and to the air in your throat through the Eustachian tube.

Air pressure on either side of the tympanic membrane has to be equal for the tympanic membrane to vibrate when sound waves hit it. Like any other diaphragm or membrane, when pressure is higher on one side of the membrane, it causes the membrane to bulge away from the side of higher pressure. Since the Eustachian tube is usually closed, any changes in air pressure can cause the tympanic membrane to bulge.

Let’s take a quick break and talk about how changes in air pressure impact you. If you’ve ever ridden in an airplane, taken an elevator to the top of a skyscraper or driven into the mountains, you’ve likely felt the urge to pop your ears. So, what causes this urge? Well, you just learned that the Eustachian tube is usually closed and that changes in air pressure cause the tympanic membrane to bulge. When this membrane bulges, the body must find a way to equalize the pressure between the outer ear and the middle ear. To do this, the Eustachian tube opens and closes, and this is the pop you feel in your ears on the airplane, in the elevator and in the car.

Before we move on, take a look at another quick real-world application of this information. For those of you who have children, you likely were sent home from the hospital armed with the advice of countless nurses, doctors, midwives, relatives and friends. Amid this advice, you probably were cautioned against feeding your baby while he or she is lying down because it can increase the risk of ear infections. But why?
Well, when a baby is fed while he’s lying down, the milk can pool in the mouth and enter the Eustachian tubes. Babies and young children are more prone to ear infections when this happens because their Eustachian tubes are underdeveloped and clog with fluid easily. (Didn’t you ever wonder why you almost never get ear infections as an adult?) Therefore, many experts recommend that babies be fed sitting up rather than lying down.

Now, on with our discussion of the middle ear!

There are three bones, or ossicles, in the tympanic cavity that link the tympanic membrane and the oval window. These three bones are named for their shapes: malleus, or hammer; incus, or anvil; and stapes, or stirrup.

The malleus is attached to the tympanic membrane. Vibrations of the tympanic membrane cause the malleus to move, passing vibrations to the incus. The incus transmits these same vibrations to the stapes, which causes the oval window to vibrate. The oval window passes the pressure wave on to the fluid in the inner ear. Think about how sound can vibrate a solid object like a wall and how you can feel that vibration of the wall with your hand. Well, the same sound waves cause vibrations in the tympanic membrane, which are transmitted through these three bones to the internal ear.

**Internal Ear**

The inner ear is called the labyrinth because it is made up of catacomb-like chambers deep within the temporal bone. Bone surrounds the labyrinth completely, and this protects it from damage and from vibrations other than those coming from the external ear.

The labyrinth is filled with a fluid called perilymph. Traversing the perilymph is a network of membranes lining the labyrinth; these membranes also form small sacs containing a fluid called endolymph. There are three structures that make up the labyrinth:

- Cochlea
- Vestibule
- Semicircular canals

The labyrinth overall is shaped something like a snail that has three circular antennas. The coiled shell of the snail is the cochlea. The body of the snail coming out of the shell is the vestibule, and the three circular antennae are the semicircular canals.

The cochlea is the part of the internal ear that contains the afferent nerve fibers for hearing. The semicircular canals and the vestibule are the parts of the inner ear that have receptors for balance.

**Cochlea**

Running down the center of the spiral cochlea is a structure called the organ of Corti, which contains the sensory receptors for hearing, the hair cells. The tectorial membrane separates the organ of Corti from the perilymph. This membrane divides the spiral of the cochlea into sections, like membranes in grapefruit divide the pulp into sections. The vibrations coming from the oval window allow the fluid in the internal ear to form wave-like pulses, which cause the tectorial membrane to vibrate. This causes the hair cells to move and become stimulated.

High-pitched sound waves stimulate the part of the cochlea close to the oval window. Sounds with lower pitch stimulate the part of the cochlea farthest away from the oval window. The hair cells transmit nerve impulses along the cochlear nerve, a division of the vestibulocochlear cranial nerve. The impulses are sent to the auditory cortex of the temporal lobe.
Vestibule

The vestibule lies between the cochlea and the semicircular canals. It contains sacs called maculae, which the labyrinth membranes form. The maculae detect the position of the head relative to gravity when the body is still. Because the body is at rest and not moving, this sense is called static equilibrium. This is how we know which way is up or down. Usually our eyes can tell us which way is up or down, but when we can’t tell by looking, or when it is dark, the maculae tell us if we are right side up.

The macula is a collection of specialized hair cells, the hairs being embedded in a ball of gel that contains otoliths. Otoliths are stones made of calcium salts that roll, like marbles in a box, when the head moves. The rolling of the otoliths pulls the hair cells to one side, which stimulates them. The membranous sacs are filled with endolymph in which otoliths and gelatin float. Impulses are sent along the vestibular nerve, the second branch of the vestibulocochlear cranial nerve. This information, though, is sent to the cerebellum, which is responsible for integrating equilibrium information.

Semicircular Canals

The semicircular canals, along with the vestibule, form what is called the vestibular apparatus since they are both concerned with equilibrium. Although the vestibule monitors equilibrium when the body is not moving, the semicircular canals contain the sensory receptors for equilibrium when the body is moving. This is called dynamic equilibrium.

Before you continue your studies of the semicircular canals, let’s talk a bit more about equilibrium. Have you ever gotten motion sickness on a boat, plane or rollercoaster? Why does this happen? Well, remember those hair cells you read about a moment ago? When the hair cells are stimulated, they send impulses to the brain. If the hair cells send messages to the brain that don’t match what the eyes see, we start to feel a little sick, and it can make us stagger. If you’re on a boat that’s encountered some rough waters, what your eyes see and what your body feels are at odds. Your equilibrium is skewed, and motion sickness results.

Now, let’s further discuss the semicircular canals.

The orientation of the semicircular canals is in three planes: a transverse plane, a sagittal plane and a coronal plane. This way, the semicircular canals can monitor motion and orientation of the body in all three planes at once. Each semicircular canal has a receptor at its connection to the vestibule called the crista ampullaris. The junction contains a gelatin cup called a cupula. A tuft of hair cells is embedded in each cup, and the nerve fibers run from the hair cells across the vestibule to join the vestibular nerve, along with the fibers from the maculae of the vestibule.

The hair cells are stimulated because the endolymph in the semicircular canals is sluggish. When you turn your head rapidly, the endolymph pushes in the opposite direction, against the cupula, which stimulates the hair cells. When you stop turning abruptly, the endolymph quickly rotates in the opposite direction, stimulating the hair cells again. The nerve impulses that are generated transmit to the vestibular nerve and on to the cerebellum.

Think of this like moving a bowl of water. If you move the bowl back and forth rapidly, the water will slosh back and forth, usually in a direction opposite of the way you move. However, if you move the bowl slowly and continuously, the water stops sloshing. The semicircular canals react to sudden rapid turning motions in the same way, which is why you get dizzy when you turn. But these canals don’t react to slow or constant motion, just like the bowl of water.
Stop and Smell the Roses

The olfactory nerves are specialized sense receptors for smell. They are located in the roof of the nasal cavity. This is why you sniff when you want to smell something. The olfactory nerve is the first cranial nerve and lies just along the inferior surface of the frontal lobe, just inside the base of the skull from the nasal cavity.

The tip of cranial nerve I lies over the ethmoid bone. There are many tiny holes in this area of the ethmoid bone—an area called the cribriform plate. The olfactory receptor cells extend through these little holes and through the nasal mucosa into the nasal cavity. These specialized afferent neurons have long cilia extending from them that wave in the breeze as air comes through the nasal cavity. They are not stimulated by motion but by chemicals dissolved in the nasal mucus. They travel along the olfactory nerve to the olfactory cerebral cortex.

Since emotion and memory are connected, smells can be remembered for a long time and recalled easily. They are also usually associated with emotion. For example, who hasn’t responded to the smell of popcorn when you encounter it unexpectedly? On the other hand, even the cutest newborn baby loses its cuteness when the smell from its diaper is noticed.

It only takes a few molecules to stimulate the olfactory receptor cells, which is why you can smell something long before you are near it. If the cells are stimulated enough, they eventually stop reacting to a smell, which is why you can adjust to an unpleasant smell if you encounter it often enough.

On the Tip of Your Tongue

Everyone knows what taste is, but there’s some disagreement as to what it means. That is because it is a matter of interpretation. Just like taste in clothing or movies, tasting anything in your mouth relies not only on the neurological sensation of taste but your emotional reaction to that sensation. The specialized sensory receptors for taste are called taste buds, and they are located in the tongue mucosa.

The dorsal surface of the tongue is covered with many papillae, or bud-like projections, that give the tongue its velvety feel. Filiform papillae cover most of the dorsal tongue and are pointed. Fungiform papillae are larger and rounded, and these are the little bumps scattered widely over the tongue. Posteriorly in the tongue there are very large papillae called the circumvallate papillae. The taste buds are the little pockets found on the fungiform papillae and the stalks of the circumvallate papillae.

Within each taste bud are cells called gustatory cells that chemicals in the saliva stimulate. The tips of the gustatory cells extend through a hole at the surface of the taste bud called a taste pore. When gustatory cells are stimulated, their impulses are transmitted along a cranial nerve to the gustatory cortex. The facial cranial nerve receives impulses from the anterior portion of the tongue; cranial nerves IX and X receive impulses from the posterior part of the tongue.
There are five taste sensations:

- Sweet
- Sour
- Bitter
- Salty
- Umami

These five groups of taste sensations help us recognize the types of chemicals that occur in food groups. Sweet sensations recognize carbohydrates. Salt sensations recognize various minerals and proteins. Sour sensations recognize acid found in citrus fruits and tomatoes. Bitter sensations help us determine if toxic chemicals are present in the foods we eat. And umami sensations help us recognize meat or other high-protein foods.
Taste and smell are very closely related, as they both occur in the front of the face. In fact, the odor of objects often overwhelms their taste. Have you ever wondered why, when you have a cold, food doesn’t have much taste? Well, it’s because the olfactory receptors can’t smell food. Also consider that if an unusual smell is passed on to a food that otherwise tastes the same, we won’t eat it. For example, you are much more aware of sour milk because of its smell rather than its taste.

Both the olfactory receptors and gustatory receptors are chemoreceptors; that is, they respond to chemicals. The hair cells for hearing and equilibrium respond to motor stimuli or pressure. And the rods and cones in the eye respond to light waves.

**Practice Exercise 2-2**

For questions 1 through 20, select the best answer from the choices provided.

1. **The purpose of the special sense organs is to _____.**
   a. keep the body in homeostasis
   b. relay sensory input through the peripheral nervous system
   c. protect the body from outside elements, pathogens and poisons
   d. transmit nerve impulses from the skin to the brain

2. **The special sense organs include the _____.**
   a. eye, nose, skin and mouth
   b. ear, eye, nose, skin and tongue
   c. ear, eye, mouth and nose
   d. ear, eye, nose and tongue

3. **The eye lies in the ____ in the skull, which protects it from harm.**
   a. orbital fossa
   b. globe
   c. lateral canthus
   d. conjunctiva

4. **The orbit is kept moist by _____.**
   a. secretions from the sweat glands in the eye, called ciliary glands
   b. mucous secreted by the conjunctiva
   c. the tears produced by the lacrimal glands
   d. a thick, white layer of fibrous connective tissue called the sclera

5. **Tears contain _____, which is an enzyme that fights bacteria.**
   a. sclera
   b. choroid
   c. lysozyme
   d. salt
6. The layers of the orbit, from outside to inside, are the _____.
   a. sclera, choroid and retina
   b. lens, fluid and retina
   c. cornea, ciliary body and fundus
   d. lens, photoreceptor cells and vitreous body

7. The part of the eye called the fovea centralis provides the best visual acuity because it _____.
   a. has no cones or rods
   b. contains rods but no cones
   c. contains cones but no rods
   d. is the only area that contains both cones and rods

8. Color blindness results from _____.
   a. having an overly large optical disk
   b. a lack of red, blue or green cones
   c. photoreceptor cells that can’t convert light to color
   d. an absence of red or green color receptors

9. Both aqueous humor and vitreous humor regulate pressure inside the orbit. ____ causes too much pressure inside the orbit, leading to glaucoma.
   a. The inability to reabsorb vitreous humor
   b. Overproduction of vitreous humor
   c. A blocked canal of Schlemm
   d. Overproduction of aqueous humor

10. Accommodation is the process of contracting the lens to _____.
    a. focus on an object
    b. protect the eye from bright light
    c. provide color vision
    d. read small print

11. When the eyes move together to see things that are close, this is called _____.
    a. accommodation
    b. emmetropic response
    c. presbyopia
    d. convergence

12. The pupils constrict if they are exposed suddenly to bright light. This function is called the ____ reflex.
    a. accommodation-pupillary
    b. photopupillary
    c. myopic
    d. accommodation
13. **The ear has two functions—to hear sound and to** _____.
   a. transmit sound to the brain
   b. maintain homeostasis within the skull
   c. maintain balance
   d. protect the brain from pressure waves

14. **With both sound waves and the position of the body, the ear is detecting** _____.
   a. motion
   b. pressure
   c. sound
   d. waves

15. **The external ear contains the** _____.
   a. external auditory canal
   b. skin and cartilage that surround the ear canal
   c. ear pinna
   d. pinna, a canal that leads to the tympanic membrane and ceruminous glands

16. **The middle ear is a collection of bones and the eustachian tube, which work together to** _____.
   a. keep the auditory canal clear of fluids
   b. transmit sound waves to the inner ear
   c. keep air pressure balanced in the inner ear
   d. maintain balance

17. **The inner ear is a complex labyrinth filled with** _____.
   a. perilymph
   b. ossicles
   c. lymph
   d. tubes

18. **Odors reach the brain by** _____.
   a. smells stimulating the cilia in the nasal cavity. The cilia then transmit the odor along the inferior surface of the frontal lobe just inside the base of the skull from the nasal cavity
   b. entering the nasal cavity, causing a chemical reaction in the mucous. These chemicals then travel along the olfactory nerve to the olfactory cerebral cortex
   c. olfactory receptor cells that extend from the cribriform plate in the ethmoid bone. The cells react to the chemicals that mucous in the nasal cavity creates from odor molecules. This information then travels along the olfactory nerve to the olfactory cerebral cortex
   d. odor molecules that enter the ethmoid bone and stimulate the cribriform plate. The information gathered by the afferent neurons in the ethmoid bone then travels along the olfactory nerve to the olfactory cerebral cortex
19. All sensory organs have specialized sensory receptors: the nose has olfactory nerves, while the tongue has _____.
   a. gustatory cells
   b. gustatory nerves
   c. filiform papillae
   d. taste buds

20. The five taste sensations found in the taste pores help us _____.
   a. maintain a healthy balance of sweet, sour, salty, high-protein and bitter foods
   b. smell and taste food
   c. recognize the types of chemicals that foods contain
   d. determine if something is poisonous

**Review Practice Exercise 2-2**

Check your answers with the Answer Key at the back of this book. Correct any mistakes you have made.

**Summary**

You’re already finished with your first body system chapter! You studied the integumentary system. This system is made of the skin, which is known as the integument; appendages that grow from the skin, such as hair and nails; and the glands the skin contains. The epidermis is the superficial surface of the skin, and the dermis is the layer of skin that lies below the epidermis. There are two appendages that develop from the skin: the hair and nails.

This chapter explained sudoriferous glands, ceruminous glands and sebaceous glands, as well as two types of sebaceous glands: mammary and meibomian glands.

In addition, you read about the four special sense organs—the eyes, ears, nose and tongue. The eye is responsible for sight, while the ear hears sound and helps us maintain our balance. The olfactory nerves in the nose are specialized sense receptors for smell. The specialized sensory receptors for taste are called taste buds, and within each taste bud are cells called gustatory cells. The five types of taste sensations are sweet, sour, bitter, salty and umami.

Now that you know all about the skin, it’s time to study what’s underneath it. In the next chapter you’ll read about the musculoskeletal system.
Clinical-Pathologic Conference #1

Doctors from different specialties meet at regular intervals to compare symptoms, findings, test results, responses to treatment and outcomes with what pathologists find at autopsy or after surgery. From these meetings, they learn about disease: what it looks like, how tissue changes with disease and treatment, how to tell disease from normal differences from person to person.

The way to tell skin disease is to look at the following factors:

**Color:** Skin color depends on the quantity of melanin and quality of blood circulation.

- Bruises are a result of bleeding into the skin. Ecchymosis (*eck-ee-moe-sis*) is the medical term for bruise. Pinpoint areas of “bruising” occur when blood vessels break. They are called petechiae (*pah-teke-ee-ee*). They can be seen on the nose of a chronic alcoholic. They can be seen in many other conditions, including leukemia.

- Injury to the skin causes it to turn red if the injury is mild and blood flow increases. This redness is called erythema. Pallor is the paleness that occurs when injury results in decreased blood flow. When there is a decrease in oxygen levels in the blood, the bluish discoloration is called cyanosis.

- Decreased hemoglobin in the blood makes skin, and especially mucous membranes, pale. Shock is a condition where the blood pressure is very low. This decreased flow causes pallor.

- Other pigments can be seen in the skin. When there is liver or gallbladder disease, backup of the pigment bilirubin makes skin yellow. Bilirubin may be elevated in pancreatic carcinoma and in blood-forming disease. It can be a normal variant in newborns. This is called jaundice. Jaundice can be caused by endogenous pigment, like bilirubin, or by exogenous pigment, like carotene from eating too many carrots. (This usually occurs when you try out your new juicer and get carried away. Try celery. It won’t make you green.)

- Burns can change the color of skin. If the layer containing melanocytes is destroyed, the new skin that grows back will not have very much pigment. It will appear lighter than the original skin. New skin regrowth is pinker at first because blood vessels are so near the surface; then the epidermis cornifies and darkens it. Burns are classified by the layers of skin that are destroyed. In the past, burns were defined by degrees: first degree, second degree and third degree.

- Superficial Burns (first-degree) damage only the epidermis. Like a mild sunburn, they don’t form blisters and will heal in a few days. They can be very painful. Since the blood supply is intact and increased to help heal the area, superficial burns have lots of erythema.

- Deep Burns (second-degree) damage the epidermis and the papillary layer of the dermis. Blisters form; they are painful. The amount of erythema depends on the blood flow. The top of a blister is pallid since it is separated from the blood supply below. However, the skin can grow again since there are still epithelial cells present in the dermis, along with a blood supply.
Full-Thickness Burns (third-degree) involve all layers of the skin, a full-thickness burn. The “skin” is pallid to charred. There is no pain since the nerve ending for pain in the dermis is now destroyed. No epithelial cells can grow since all the epithelial cells are destroyed. Skin grafts are used to regrow skin in full-thickness burns.

Texture: This depends on the amount of keratinization in the epidermis and thickness of all layers. Skin disease is usually “wet” or “dry” when compared to normal skin. When keratinization is increased, the lesion is drier. When it is decreased or the epidermis is eroded, the lesion is wetter than normal skin.

Diabetics have moister skin, with frequent upper body sweating, or cold sweating when they are in insulin shock. Ringworm is caused by fungal infection. Dry, scaly, ring-like patches appear on the skin. There are many related infections, usually named by where they occur in the body. For example, tinea capitis (cradle cap) occurs on the scalp. Tinea cruris occurs in the folds of the groin.

Infection often leads to open sores. The erosion of the epidermis leads to a “wet” sore. When a person is immobilized for a long time, the pressure of underlying bones decreases circulation to the skin, causing a breakdown of tissue, and open sores, skin ulcerations, develop. These ulcers are called decubitus ulcers, since they are caused by lying too much on one body part.

Skin allergies and infections can look a lot alike. They cause redness, scaliness, blisters, areas that are weepy or wet. Sometimes the pattern of a rash or type of blister can help you tell one from another. For example, chicken pox forms scabs over its blisters very early on. Measles is a lot redder than most infections and has characteristic spread patterns.

Nodules under the skin can be focal abscesses, like carbuncles or furuncles, but they can also be signs of systemic disease, like neurofibromatosis, which forms fibrous masses in the skin.

Sensation: What the skin feels like changes with disease.

Some diseases cause itching, called pruritus. This may be an early sign of liver disease or medication overdose.

Extreme sensations of hot or cold can be felt in conditions like Raynaud’s phenomenon and menopause.

Appendages: The nails and hair may have local disease or show signs of systemic disease.

Loss of hair is normal at times, but the pattern of hair loss may indicate serious disease in other systems. Alopecia—progressive, near-total hair loss—can be seen in major illness or secondary to cancer chemotherapy. Many times, no definite cause is found. This is different from male pattern baldness, which is common in many adult males and is due to family traits and male hormone.

Too much hair is called hypertrichosis. Most often, increased hairiness is a normal variant, a familial trait. Sometimes it is a sign of hormonal imbalance in endocrine disease.

Nails can develop onycholysis, a nail lifting off the nail bed as a result of allergy or secondary to infection. It is becoming a common reaction to acrylic artificial nails.