

Chapter 5 Integumentary Systems
Chapter Outline

Module 5.1 Overview of the Integumentary System (Figures 5.1, 5.2)

A. **Skin structure.** Skin is the largest organ in the body. Skin is more than just an outer covering; it is a complex organ with many vital functions important for homeostasis (**Figure 5.1**).

1. Skin, also known as the **cutaneous membrane**, has two main components:

- a. _____

- b. _____

2. Accessory structures of the skin are embedded in the cutaneous membrane and include _____ glands, _____ glands, _____, and _____.

3. Skin contains sensory receptors and arrector pili muscles, which are small bands of smooth muscle associated with _____.

4. The epidermis is _____ and must rely on the diffusion of oxygen and nutrients from blood vessels in the deeper dermis, which limits its thickness.

5. About 50% of the cells in the epidermis are too far from adequate blood supply to sustain life; the superficial layers are made up entirely of dead cells.

6. The **hypodermis**, also known as the **superficial fascia** or **subcutaneous fat**, is deep to the dermis. Although not part of the skin, it does anchor the skin deeper structures like muscle and bone. The hypodermis is made of loose connective and adipose tissues and has an abundant blood supply.

B. **Functions of the Integumentary System.** The integumentary system has the following functions that are critical for protecting the underlying organs or for maintaining homeostasis (**Figure 5.2**):

1. **Protection.** What does the skin provide protection against? _____

Stratified squamous, keratinized epithelium provides a continuous barrier against invasion. Glands also create a slightly acidic pH, which inhibits pathogen growth. The skin protects against ultraviolet (UV) light; the skin also repels ionic and polar covalent molecules, which is critical to maintain fluid and electrolyte homeostasis.

2. **What is sensation?** _____

Sensory receptors or cellular structures in the skin detect changes in the internal and/or external environment such as heat, cold, and pain.

3. **Describe thermoregulation.** _____

_____ (Figure 5.2)

4. **Explain the sequence of events that occur when the body temperature rises above the normal range, due to weather extremes or abnormal conditions that cause a fever (Figure 5.2a):**

a. _____ :

b. _____ :

c. _____ :

d. _____ :

e. _____ :

5. Explain the sequence of events that occur when the body temperature drops below the normal range due to cold environmental conditions (Figure 5.2b):

- a.

- b.

- c.

- d.

- e.

6. Describe excretion.

7. Skin plays a critical role in **vitamin** ____ **synthesis**. Vitamin D is a hormone that relies on cells found deep in the epidermis for converting vitamin D from an inactive form or precursor, known as cholecalciferol, to its active form, called calcitriol. Vitamin D is required for calcium ion absorption from the small intestine. **Why are calcium ions critical?**

Module 5.2 The Epidermis (Figures 5.3, 5.4)

A. The epidermis is the most superficial layer skin and is composed of several cell-types, the most numerous of which are the_____.

1. **Keratinocytes** make up about 95% of the epidermis. **What two structural features do keratinocytes have that make the epidermis stronger and less susceptible to mechanical trauma?**

a. _____

b. _____

2. Keratinocytes are organized from deep to superficial into five structurally distinct strata (layers). **Identify the layers of the epidermis (Figure 5.3):**

a. **Stratum**_____ (germinativum), is a single layer of stem cells resting on the basement membrane. Being the closest cells to the blood supply in dermis makes these the most metabolically and mitotically active cells in the epidermis. These cells are involved in vitamin _____ synthesis and replacement of dead keratinocytes lost from more superficial layers.

b. **Stratum**_____, the thickest layer, sits on top of the stratum basale so is still close to the blood supply. The cells in this layer are also metabolically and mitotically active.

c. **Stratum**_____ makes up the middle three to five layers of cells filled. Cells have prominent cytoplasmic granules filled with one of the following: _____ or a _____, which are both secreted by exocytosis. The hydrophobic nature of lipids provides a waterproofing that is critical for maintaining internal fluid and electrolyte homeostasis.

d. **Stratum**_____ is a narrow layer of clear dead keratinocytes found only in _____ skin.

e. **Stratum**_____, the outermost layer of the epidermis, consists of several layers of dead flattened keratinocytes with thickened plasma membranes filled mostly with keratin bundles and

little else. These cells are sloughed off or exfoliated mechanically as the _____ holding neighboring cells together are lost.

3. **Keratinocyte life cycle:** the location and functions of the epidermis subjects it to both physical and environmental stress. The stratum corneum is continuously shedding dead cells that must be replaced from the deeper layers to maintain the integrity of the epidermis. The migration from the deepest strata to the stratum corneum takes a cell between _____ days to complete.

B. Besides keratinocytes the following are **Other Cells of the Epidermis (Figure 5.3)**:

1. **Dendritic (Langerhans) cells**, located in the stratum _____, are phagocytes that protect the skin and deeper tissues from pathogens.
2. **Merkel cells**, found scattered throughout the stratum _____, detect light touch and discriminate shapes and textures. They are found in regions that are specialized for touch, such as the fingertips, lips and at the base of hairs.
3. **Melanocytes**, located in the stratum _____, produce _____ which is a protein skin pigment ranging from orange-red to brown-black.

C. **Thick and Thin Skin.** The palms of the hand and the soles of the foot are subjected to a great deal of mechanical stress so these regions of skin have adapted to the added stress. Identify some differences between thick and thin skin **(Figure 5.4)**:

1. _____

_____ **(Figure 5.4a)**
2. _____

_____ **(Figure 5.4b)**

Module 5.3 The Dermis (Figures 5.5, 5.6, 5.7)

A. The dermis is a highly vascular layer deep to the epidermis that serves the following functions: _____, _____

_____, and _____.

The dermis is composed of two distinct layers made up of two types of connective tissue.

B. The _____ **layer**, the thinner most superficial of the two layers, is composed of loose connective tissue. **(Figure 5.5).**

1. **Why are special collagen fibers located at the dermis-epidermal junction that extends into the epidermal basement membrane?** _____

2. The **dermal papillae** are tiny projections found at the surface of the papillary layer where it comes into contact with the epidermis.

a. These contain tiny blood vessels called capillaries arranged in loops that extend up into the most superficial part of the dermal papillae.

What is the function of the loops? _____

b. **Tactile (Meissner) corpuscles**, also found in the dermal papillae, are sensory receptors that respond to light touch stimuli and are more numerous in regions of body where sensation is a primary function such as the skin of the following: _____, _____, _____, and _____.

C. The _____ **layer**, the deep thicker layer that separates the dermis from the hypodermis, is mostly dense irregular connective tissue that consists largely of irregularly arranged collagen bundles as well as elastic fibers, proteoglycans, and lamellated (Pacinian) corpuscles.

1. **What is the function of collagen bundles in the reticular layer?** _____

2. **What purpose do elastic fibers in the reticular layer serve?** _____

3. **Why are proteoglycans present in this layer?** _____

4. **To what sensations do the lamellated (Pacinian) corpuscles respond?**

5. Blood vessels, sweat glands, hairs, sebaceous glands, and adipose tissue are found embedded in the reticular layer.

D. **Skin Markings** are small visible lines in the epidermis created by the interaction between the dermis and epidermis. These are best seen in the thick skin of the palmar surfaces of the _____ and the plantar surface of the _____ (**Figure 5.6**).

1. Dermal ridges are found in these areas where the dermal papillae are more prominent due to the presence of thick collagen bundles. Dermal ridges indent the overlying epidermis to create _____, which enhance the gripping ability of the hands and feet.
2. The reticular layer is also responsible for skin markings associated with tension or lines, cleavage lines, and flexure lines (**Figure 5.7**)

Module 5.4 Skin Pigmentation (Figure 5.8)

A. Skin color, mostly determined by various amounts of the orange-red to black protein pigment _____, is produced by melanocytes in the stratum basale of the epidermis (**Figure 5.8**).

1. Melanin is composed of two molecules of the amino acid tyrosine that are chemically bonded by a series of reactions catalyzed by the enzyme tyrosinase. These reactions occur in a stepwise fashion within a special vesicle called a _____.
2. **What is a primary function of melanin?** _____

3. Melanocytes have several arms or extensions of plasma membrane that are in contact with neighboring keratinocytes in the stratum basale and spinosum.
4. Melanin synthesis increases with exposure to natural or artificial _____, which leads to tanning or darkening of the skin pigmentation. UV radiation has both immediate and delayed effects of skin pigmentation.

a. **What is the immediate response to UV radiation?** _____

b. **What is the delayed effect of UV radiation?** _____

c. The amount of UV radiation melanin can absorb is limited as is the protection it provides.

5. **What is a secondary function of melanin?** _____

6. Skin color depends on the number of melanocytes found in a particular body region leading to uneven distribution of melanin. Fewer melanocytes are found on the palms of the hand and the soles of the feet, for example. The following are common variations of pigmentation:

a. A _____ is small area of increased pigmentation resulting from a local increase in melanin production concentrated in one spot.

b. A _____ or **nevus** is another area of increased pigmentation that is due to a local proliferation of melanocytes instead of an increase in melanin production.

B. Other Pigments That Affect Skin Color: Carotene and Hemoglobin. The following two minor pigments have an effect on skin pigmentation:

1. **Carotene** is a yellow-orange pigment found in food items such as egg yolks and orange vegetables.

a. This lipid-soluble pigment accumulates in the stratum _____.

b. This imparts a slight yellow-orange color that is particularly visible in the stratum _____ of thick skin.

2. **Hemoglobin**, found in red blood cells, is an iron-containing protein that binds to and transports oxygen throughout the body.

- a. Oxygen binds to the iron found in hemoglobin in an oxidation reaction, which is the same reaction that causes iron to rust. Oxidized iron changes color to a bright orange-red, which give blood its characteristic color.
- b. Hemoglobin's affect on skin color is an indirect result of blood flow in the dermis. Light-skinned individuals have little pigment in their epidermis, rendering it somewhat translucent.
- c. The color of blood in the deeper dermis is visible through the epidermis.

C. **Skin Color as a Diagnostic Tool.** Color changes associated with the amount of blood flow in the dermis can be useful in the diagnosis of disease.

1. **Erythema** occurs when the blood flow in the dermis increases, causing a color change that makes the skin more_____. **List some reasons for erythema:** _____

2. **Pallor** occurs when the blood flow in the dermis decreases, resulting in loss of the normal pinkish hue most visible in fair-skinned individuals. The epidermis may take on whitish color of collagen in dermis. **List some reasons for pallor:** _____

3. **Cyanosis, a sign that someone needs immediate attention,** occurs when hemoglobin has less bound oxygen; less oxidized iron reduces the reddish color of blood to a faint_____hue. **List some reasons for cyanosis:** _____

Module 5.5 Accessory Structures of the Integument: Hair, Nails, and Glands (Figures 5.9, 5.10, 5.11)

A. The **accessory structures** or **appendages** of the integument include _____, _____, and _____ that are derived from only epithelium that assist in the overall function of the integumentary system.

B. **Hair** or **pili** are small filamentous structures that protrude from the surface of the skin over the entire body except in the regions with thick skin, the lips, and parts of the external genitalia (**Figure 5.9**).

1. Hair is too sparse to play a significant role in thermoregulation as it does in other mammals. **What are some functions of hair?**

a. Hair provides protection by preventing _____

b. Hair on the head protects _____

c. Hairs are associated with a small sensory neuron that plays a role in

2. **Hair structure:** Hair is composed of two main parts, the _____ and the _____. Both are made up of stratified squamous keratinized epithelial cells in various stages of development, first the shaft followed by the root.

a. **What is the shaft and what composes it?**

b. The **root** is segment of hair that is embedded in the dermis where it is surrounded by a small sensory neuron. The root is indented at its base by a projection of blood vessels from the dermis called a hair

_____.

The root and the hair papilla are collectively known as the **hair**_____.

Many epithelial cells in the root are still alive, having not completed the keratinization process. A small number of

keratinocytes called the _____, found at the base of the root,

actively divide by mitosis.

- c. The root is embedded in the **hair** _____, which is an infolding of the epidermis called the **epithelial root sheath** that extends deep into the dermis or even hypodermis. The epithelial root sheath has an outer component that anchors the follicle to the dermis and an inner component that is anchored tightly to the hair root.
3. A strand of hair has the following three regions on seen observed in a transverse section (Figure 5.9a):
- a. The inner _____, a soft core only found in thick hair like those found on the head, is composed of a soft keratin.
 - b. The middle _____ is highly structured and organized with several layers of keratinocytes containing hard keratin, which provides strength to the strand.
 - c. The outermost _____ consists of a single layer of overlapping keratinocytes containing hard keratin, which provides mechanical strength.
4. Surrounding the epithelial root is a dermal root sheath that consists of connective tissue that supports the follicle and separates it from the dermis.
- a. Small bands of smooth muscle called _____ muscles attach to the dermal root sheath on one end and the dermal papillary layer on the other.
 - b. **What is the function of the arrector pili muscle?** _____

5. **Hair growth** averages between 1-1.5 cm per month but varies between individuals. Growth is not continuous but occurs in a cycle with the following two main phases: first the growth stage, followed by the resting stage.
- a. **Describe the growth stage.** _____

b. **Describe the resting stage.** _____

6. **Hair pigment and texture;** hair color and texture vary with different types of hair. Describe each type:

a. **Lanugo:** _____

b. **Terminal hair:** _____

c. **Vellus hair:** _____

d. Terminal hair replaces much of the vellus hair after puberty, which varies by gender with more hair replacement occurring in males than females.

e. Hair color is largely determined by the melanin produced in the matrix by melanocytes. Melanocytes produce a range of colors from blond hair, which has little melanin, to black hair, which contains a lot of melanin, while red hair has a special reddish pigment containing iron. Melanocytes produce less melanin with aging so hair eventually turns gray or white.

C. **Nails**, hard accessory structures that are located at the ends of the digits, are composed of stratified squamous epithelium filled with hard keratin (**Figure 5.10**).

1. The **nail** _____, the most visible component of the nail, sits on top of an underlying epidermal **nail** _____. The nail plate is divided into the **nail body** and the **nail root**, which lies under the skin where the **nail** _____ actively divides and produces new cells.

2. These folded regions of skin surround and reinforce the nail plate: the proximal nail fold, medial nail fold, and lateral nail fold.

3. Nail growth occurs at the nail matrix where actively dividing cells push neighboring keratinocytes distally, which die once they have completed keratinization and have been cut off from the blood supply. Fingernails grow an average of 0.5 mm per week while toenails grow more slowly.
 4. Nails do not contain melanocytes so are mostly translucent except at a region called the_____. The lunula is half-moon shaped region of the proximal nail plate that represents an accumulation of keratin.
 5. The primary function of nails is protection of the underlying tissue, the distal tips of the fingers and toes, from trauma. Nails can be used as tools, enabling more precise gripping of items when they are picked up.
- D. The skin contains two basic types of **glands** both derived from epithelial cells in the epidermis but located deeper in the dermis: _____
 _____ that produce sweat and _____ that produce oily sebum (**Figure 5.11**).
1. The body has the following four types of **sweat glands** which differ structurally and what products they secrete. Each gland secretes its products from secretory glands by exocytosis, a process called merocrine secretion.
 - a. **Eccrine sweat glands**, the most prevalent type, are simple coiled tubular glands found in the dermis. Sweat, containing mostly water, waste products, and electrolytes, exits from the duct through a **sweat pore** onto the epidermal surface (**Figure 5.11a**). The primary function of sweat from eccrine sweat glands is_____.
 - b. **Apocrine sweat glands**, found in specific regions of the body such as the axillae, anal area, and areola, are large glands that release a protein-rich secretion into a hair follicle. Secretions can become odiferous once skin bacteria metabolize their contents. These glands are influenced by_____ hormones and become active after puberty.
 - c. **Ceruminous glands** are modified apocrine glands that release a thick secretion called_____(ear wax) into hair follicles found in the ears. **What is the function of cerumen?** _____

-
-
- d. **Mammary glands** are highly specialized sweat glands that produce a modified sweat product, milk.
2. **Sebaceous glands** empty into a hair follicle or a small pore that makes and secretes _____ (Figure 5.11b).
 - a. **Where are sebaceous glands located? And what body parts lack them?** _____

 - b. **Describe the composition and release of sebum.** _____

 - c. **What does sebum contain?** _____

 - d. Sebum also inhibits the growth of or kills certain bacteria.

Module 5.6 Pathology of the Skin (Figure 5.12, 5.13, 5.14)

- A. A **wound**, a common skin pathology, is defined as any disruption in the skin's integrity and include the following more specific injuries: lacerations or cuts, burns, and skin cancers.
- B. A **burn** is a wound caused by agents such as heat, extreme cold, electricity, chemicals, and radiation. **Describe the rule of nines and explain why it is used.**

Burns are grouped into the following three classes according to the extent and depth of the tissue damage (Figure 5.12):

1. **First-degree burns**, or superficial burns, are minor wounds that only damage the _____. Skin may develop erythema or a red appearance and some mild pain without any permanent damage.

2. **Second-degree burns**, or partial thickness burns, involve the _____ and part or all of the _____, which can result in pain, blistering, and scarring.
3. **Third-degree burns**, or full thickness burns, are the most damaging wounds, which involve the _____, _____, _____, and potentially even deeper tissue, like muscle or bone.

C. **Skin Cancer: Cancer**, one of the most common diseases in the world, is caused by mutations in the DNA that induce a cell to lose control of the cell cycle (**Figure 5.14**).

1. Unchecked cell division eventually leads to the formation of a large population of undifferentiated cells known as a tumor.
2. Cancerous tumors are able to metastasize where tumor cells spread, through the blood or lymphatic vessels to other tissues and continue to divide.
3. Damage caused by metastatic tumor cells alters the function of the invaded organs.
4. The following three cancers affect the skin and are linked to UV radiation exposure. Other factors that increase the risk for developing cancer include: exposure to cancer-inducing chemicals, toxins, or agents called carcinogens and forms of radiation,
 - a. **Basal cell carcinoma**, the most common of all cancer-types including skin cancer, arises from _____ in the stratum _____ of the epidermis. Skin that is regularly exposed to UV radiation is at risk for developing these tumors that appear as a nodule with a central crater. These tumors rarely metastasize to other tissues so they can be resolved successfully with surgical removal (**Figure 5.14a**).
 - b. **Squamous cell carcinoma**, the second most common skin cancer, is a cancer of the _____ of the stratum _____. Scaly plaques that may ulcerate and bleed are usually found on the head and neck. These tumors are more likely to metastasize than basal cell carcinoma but surgical removal is still useful (**Figure 5.14b**).

- c. **Malignant melanoma** is a cancer of the melanocytes and can be distinguished from other skin cancers and normal moles using the following ABCDE rule (**Figure 5.15c**). **Describe each part of the rule:**

(A): _____

(B): _____

(C): _____

(D): _____

(E): _____

- d. Early detection of melanoma is critical due to its tendency to metastasize to other tissues. These are treated with surgical removal and possibly other options such as radiation therapy and chemotherapy.