CHAPTER 5

The Integumentary System
Chapter 5 Learning Outcomes

• 5-1
  • Describe the main structural features of the epidermis, and explain the functional significance of each.

• 5-2
  • Explain what accounts for individual differences in skin color, and discuss the response of melanocytes to sunlight exposure.

• 5-3
  • Describe the interaction between sunlight and vitamin D₃ production.

• 5-4
  • Describe the structure and functions of the dermis.

• 5-5
  • Describe the structure and functions of the hypodermis.
Chapter 5 Learning Outcomes

• 5-6
  • Describe the mechanisms that produce hair and the structural basis for hair texture and color.

• 5-7
  • Discuss the various kinds of glands in the skin, and list the secretions of those glands.

• 5-8
  • Describe the anatomical structure of nails, and explain how they are formed.

• 5-9
  • Explain how the skin responds to injury and repairs itself.

• 5-10
  • Summarize the effects of aging on the skin.
General Structure of the Integument (Introduction)

- **Cutaneous membrane** is skin
- Two layers of skin
  1. **Epidermis** (superficial)
  2. **Dermis** (deep)
- **Accessory structures**
  - Hair, nails, and some exocrine glands
- **Hypodermis** or subcutaneous layer
  - Deep to the dermis
Figure 5-1 The General Structure of the Integumentary System.

**Cutaneous Membrane**
- Epidermis
- Papillary layer
- Reticular layer

**Dermis**

**Hypodermis**

**Accessory Structures**
- Hair shaft
- Pore of sweat gland duct
- Touch receptor
- Sebaceous gland
- Arrector pili muscle
- Sweat gland duct
- Hair follicle
- Pressure receptor
- Nerve fibers
- Sweat gland
- Artery
- Vein
- Cutaneous plexus
- Fat
Five General Functions of the Integument (Introduction)

1. Protection
   - Skin covers underlying tissues and prevents fluid loss

2. Temperature maintenance
   - Skin regulates heat exchange with the environment

3. Synthesis and storage of nutrients
   - Epidermis synthesizes vitamin D$_3$
   - Dermis stores lipids in adipose tissue
Five General Functions of the Integument (Introduction)

4. Sensory reception
   - Receptors for pain, pressure, touch, and temperature detect stimuli and send information to nervous system

5. Excretion and secretion
   - Glands excrete salts, water, and organic wastes
   - Specialized mammary glands secrete milk
Checkpoint (Introduction)

1. List the general functions of the integumentary system.
The Epidermis (5-1)

- Is stratified squamous epithelium
  - **Thick skin** has five layers
  - **Thin skin** has four layers
  - Layers are called **strata**, from deep to superficial
    - Stratum basale
    - Three intermediate layers
      - Stratum spinosum, stratum granulosum, and stratum lucidum
    - Stratum corneum
Figure 5-2 The Structure of the Epidermis.

Surface

Stratum corneum

Stratum lucidum

Stratum granulosum

Stratum spinosum

Stratum basale

Basement membrane

Dermis

Thick skin

LM x 210
Stratum Basale (5-1)

- Also called stratum germinativum
  - Attached to basement membrane by hemidesmosomes
- Forms **epidermal ridges** down into dermis
- Dermis has dermal papillae up into epidermis
- Epidermis is avascular
  - Ridges and papillae increase surface area for diffusion between dermis and epidermis
Intermediate Strata (5-1)

- **Stratum spinosum** is the result of stem cell division

- **Stratum granulosum** cells make a lot of **keratin**
  - A protein that provides water resistance and the foundation for hair and nails

- **Stratum lucidum** cells are densely packed into a highly keratinized layer
Stratum Corneum (5-1)

• Contains 15–30 layers of *keratinized* or *cornified* dead cells

• Cells are connected via desmosomes and are therefore shed in large groups
2. Identify the five layers of the epidermis.

3. Dandruff is caused by excessive shedding of cells from the outer layer of skin in the scalp. Thus, dandruff is composed of cells from which epidermal layer?

4. Some criminals sand their fingertips to avoid leaving recognizable fingerprints. Would this practice permanently remove fingerprints? Why or why not?
Skin Color (5-2)

• Role of pigmentation

• **Carotene** is orange-yellow, accumulates in epidermis, and comes from orange-colored foods

• **Melanin** is brown, yellow-brown, or black, produced by **melanocytes** near stratum basale cells, absorbs **ultraviolet (UV) radiation** protecting deeper layers
Figure 5-3 Melanocytes.

Melanocytes in stratum basale
Melanin pigment
Basement membrane

Melanosomes
Melanin pigment
Melanocyte
Basement membrane
Skin Color (5-2)

- Role of dermal circulation
  - Oxygenated blood is bright red resulting in a flushed, red skin color when dermal blood vessels dilate
  - Short-term paling of the skin occurs with vasoconstriction
  - **Cyanosis**, a bluish coloration, occurs when blood oxygen supplies are diminished
5. Name the two pigments in the epidermis.

6. Why does exposure to sunlight or sunlamps darken skin?

7. Why does the skin of a fair-skinned person appear red during exercise in hot weather?
Beneficial Effects of Sunlight on Skin (5-3)

- **Vitamin D₃** is derived from:
  - A cholesterol-related steroid in the epidermis when exposed to sunlight

- **Vitamin D₃** is modified by:
  - The liver and the kidneys into calcitriol, essential for calcium and phosphorus absorption in the small intestine
Detrimental Effects of Sunlight on Skin (5-3)

• Skin cancers
  • **Basal cell carcinoma** is most common
    • Originating in stratum basale
  • **Squamous cell carcinoma** found in more superficial layers
  • **Malignant melanoma** is most dangerous
    • Usually begins from a mole, and can metastasize through the lymphatic system
Figure 5-4 Skin Cancers.

a Basal cell carcinoma

b Melanoma
8. Explain the relationship between sunlight exposure and vitamin D₃ synthesis.

9. What is the most common skin cancer?
The Dermal Papillary Layer (5-4)

• Named for the dermal papillae
• Just deep to, and projects up into, the epidermis
• Contains capillaries and nerves supplying the epidermis
The Dermal Reticular Layer (5-4)

- Interwoven meshwork of dense, irregular connective tissue
  - As well as mixed in cells of connective tissue proper
- Elastic and collagen fibers are present
  - Combine to establish the right balance of flexibility and stability
- Collagen fibers extend from up into the dermal papillae
  - Down into the hypodermis
The Dermal Reticular Layer (5-4)

- Hair follicles and sweat glands derived from epidermis
  - Extend down into the dermis
- Cutaneous plexus—blood vessels from the hypodermis—extends up into the reticular layer
- Blood vessels, lymphatics, and nerves
  - Supply nutrients, eliminate wastes, control secretions, and respond to stimuli
Figure 5-1 The General Structure of the Integumentary System.

- **Cutaneous Membrane**
  - Epidermis
  - Papillary layer
  - Reticular layer

- **Dermis**

- **Hypodermis**

- **Accessory Structures**
  - Hair shaft
  - Pore of sweat gland duct
  - Touch receptor
  - Sebaceous gland
  - Arrector pili muscle
  - Sweat gland duct
  - Hair follicle
  - Pressure receptor
  - Nerve fibers
  - Sweat gland
  - Artery
  - Vein
  - Cutaneous plexus
  - Fat
10. Describe the location of the dermis.

11. Where are the capillaries that supply the epidermis located?
The Hypodermis (5-5)

- Also called the subcutaneous layer
  - Deep to the dermis without a clear line separating them
- Not actually part of the integument
  - But stabilizes the skin to underlying tissues
- Made of areolar tissue with many adipose cells
- No vital organs in area make it an ideal site for subcutaneous injections
13. List the two terms for the tissue that connects the dermis to underlying tissues.

14. Describe the hypodermis.
Hair and Hair Follicles (5-6)

• Are accessory organs of the integumentary system

• Hairs are nonliving structures
  • Project above the skin surface everywhere except:
    • The soles of the feet, palms of the hands, sides of the fingers and toes, the lips, and portions of the external genitalia
Hair and Hair Follicles (5-6)

- Epidermal layers invaginate into the dermis to form **hair follicles**
- Epithelium at the base of follicle caps over the **hair papilla**
  - Connective tissue that contains capillaries and nerves
- Epithelial stem cells divide to form **hair matrix** surrounding the papilla
Hair and Hair Follicles (5-6)

- **Hair matrix** grows, making hair longer, and cells become keratinized and die

- Halfway to skin surface, it becomes the **hair root**
  - Above the surface it is called the **hair shaft**

- Shaft has three layers of dead cells
  - From outer to inner: **cuticle, cortex, and medulla**
Functions of Hair (5-6)

- Protects the scalp
- Prevents entry of foreign particles into nose, eyes, and ears
- Prevents injury via sensory perception
- Expresses emotional state by hair standing up, due to contraction of arrector pili muscle
Hair Color (5-6)

• Differences due to type and amount of melanin from melanocytes

• Aging results in less pigment production
  • Causing gray or white hair
In this section of skin of the scalp, notice that the two hair follicles extend into the hypodermis.
Figure 5-5b Hair Follicles and Hairs.

This drawing shows a longitudinal section of a single hair follicle and hair.

- Hair shaft
- Sebaceous gland
- Arrector pili muscle
- Hair root
- Connective tissue sheath
- Hair matrix
- Hair papilla
- Boundary between hair shaft and hair root

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This cross section through a hair follicle was taken at the boundary between the hair shaft and hair root.
14. Describe a typical strand of hair.

15. What happens when the arrector pili muscle contracts?

16. If a burn on the forearm destroys the epidermis and the deep dermis and then heals, will hair grow again in the affected area?
Sebaceous Glands of the Skin (5-7)

- Secrete oily sebum into the hair follicle

- **Sebaceous follicles** secrete sebum directly onto:
  - Skin of face, back, chest, nipples, and external genitalia

- Sebaceous glands are sensitive to hormonal changes
  - Inflamed glands can result in **acne**
Figure 5-6  Sebaceous Glands and Their Relationship to Hair Follicles.

- Sebaceous follicle
- Sebaceous gland
- Epidermis
- Dermis
- Hypodermis
- Hair removed
- Wall of hair follicle
- Basement membrane
- Discharge of sebum
- Breakdown of cell membranes
- Mitosis and growth
- Basal cells
- Sebaceous gland (LM x 150)
Sweat Glands (5-7)

• Also called *sudoriferous glands*

• Include two types

  1. *Apocrine sweat glands*

  2. *Merocrine sweat glands*
Apocrine Sweat Glands (5-7)

- Become active at puberty
- Secrete sticky, cloudy sweat into hair follicles in armpits, around nipples, and in the pubic region
- Sweat is food source for bacteria on skin, increasing odor
Merocrine Sweat Glands (5-7)

- Also called *eccrine sweat glands*
- Very numerous with high numbers on soles and palms
- Coiled tubular structure secretes watery perspiration directly onto surface of skin
- Sweat also contains electrolytes, urea, and organic nutrients
  - Sodium chloride gives it the salty taste
- Function is to cool body through evaporation
Modified Sweat Glands (5-7)

- Mammary glands
  - Secrete milk

- Ceruminous glands
  - Secrete a waxy substance that combines with sebaceous oils to form earwax
17. Identify two types of exocrine glands found in the skin.
18. What are the functions of sebaceous secretions?
19. Deodorants are used to mask the effects of secretions from which type of skin gland?
Nails (5-8)

- Protect tips of fingers and toes

- Visible **nail body**
  - Made of dense, keratinized cells recessed under surrounding epithelium

- **Nail bed**
  - Deeper level of epithelium covered by nail body
Nails (5-8)

- **Nail root**
  - Where the nail is produced
  - Covered by the *cuticle*

- **Lunula**
  - Pale crescent near root
Figure 5-8 The Structure of a Nail.

- Free edge
- Nail body
- Nail root (site of growth)
- Cuticle (eponychium)
- Lunula
- Nailbed
- Epidermis
- Dermis
- Bone of fingertip

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20. What substance makes nails hard?

21. Where does nail growth occur?
Repair of the Integument (5-9)

- Skin regeneration occurs because:
  - Stem cells of epithelium and connective tissue undergo cell division
    - Replacing lost or damaged tissue

- Four steps of skin repair
  1. Scab formation
  2. Tissue granulation
  3. Scab removal
  4. Scar formation
Scab formation

- A blood clot that forms on the surface
- Is a temporary "patch" and can help prevent additional microbes from invading the injury

Granulation tissue

- Is formed from the combination of the fibrin blood clot, fibroblasts, and capillaries
- Macrophages clean up debris
Repair of the Integument (5-9)

- Clot removal and a decline of capillaries
  - **Scar** is formed from remaining meshwork of collagen fibers
  - Degree of scar dependent on severity and location of injury and age of patient
  - **Keloid scars** are thicker, raised, smooth, and shiny epidermal surface
Figure 5-9 Events in Skin Repair.

1. Epidermis
   - Dermis
   - Mast cells

2. Migrating epithelial cells
   - Macrophages and fibroblasts
   - Granulation tissue

3. Fibroblasts

4. Scar tissue
Effects of Burns (5-9)

- Can be caused by chemicals, heat, radiation, and electrical shock
- Severity depends on depth into the tissues, and the total area affected
<table>
<thead>
<tr>
<th>Classification</th>
<th>Damage Report</th>
<th>Appearance and Sensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-Degree Burn</td>
<td><em>Killed:</em> superficial cells of epidermis</td>
<td>Inflamed; tender</td>
</tr>
<tr>
<td>(partial-thickness burn)</td>
<td><em>Injured:</em> deeper layers of epidermis, papillary dermis</td>
<td></td>
</tr>
<tr>
<td>Second-Degree Burn</td>
<td><em>Killed:</em> superficial and deeper cells of epidermis; dermis may be affected</td>
<td>Blisters; very painful</td>
</tr>
<tr>
<td>(partial-thickness burn)</td>
<td><em>Injured:</em> damage may extend into reticular layer of the dermis, but many</td>
<td></td>
</tr>
<tr>
<td></td>
<td>accessory structures (hair follicles and glands) are unaffected</td>
<td></td>
</tr>
<tr>
<td>Third-Degree Burn</td>
<td><em>Killed:</em> all epidermal and dermal cells</td>
<td>Charred; no sensation at all due to damage to sensory nerves</td>
</tr>
<tr>
<td>(full-thickness burn)</td>
<td><em>Injured:</em> hypodermis and deeper tissues and organs</td>
<td></td>
</tr>
</tbody>
</table>
22. What term describes the combination of fibrin clots, fibroblasts, and the extensive network of capillaries in healing tissue?

23. Why can skin regenerate effectively even after considerable damage has occurred?
Effects of Aging on the Integument (5-10)

• Skin injuries and infections are more common
  • Likely due to a thinning of the epidermis

• Sensitivity of immune system is reduced
  • Mainly due to a decrease of macrophages residing in the skin

• Muscles become weaker and bone strength decreases
  • Due to a decline in vitamin D₃
Effects of Aging on the Integument (5-10)

• Sensitivity to sun exposure increases
  • Due to lower amount of melanin production

• Skin becomes dryer and flakier
  • Due to reduction in glandular secretions

• Hair thins and loses color
  • Due to low-functioning follicles and decreased melanocyte activity
Effects of Aging on the Integument (5-10)

- Sagging and wrinkling of the skin occurs
  - Due to decrease in elastic network, more noticeable when skin has been exposed to a lot of sunlight

- Ability to lose heat is reduced
  - Due to reduced dermal blood supply and less active sweat glands

- Skin repairs more slowly
  - Due to slower stem cell division, increasing the threat of infection in cuts
The integumentary system provides mechanical protection against environmental hazards. It forms the external surface of the body and provides protection from dehydration, environmental chemicals, and external forces. The integument (skin) is separated and insulated from the rest of the body by the hypodermis layer, but it is interconnected with the rest of the body by an extensive circulatory network of blood and lymphatic vessels. As a result, although the protective mechanical functions of the skin can be discussed independently, its physiological activities are always closely integrated with those of other systems.
24. Older individuals do not tolerate summer heat as well as they did when they were young, and they are more prone to heat-related illnesses. What accounts for these changes?

25. Why does hair turn gray or white with age?