5 The Integumentary System

PowerPoint® Lecture Outlines
prepared by Alan Magid, Duke University

Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings
Integumentary System Components

- Cutaneous membrane
  - Epidermis
  - Dermis
  - Accessory structures
- Subcutaneous layer (*hypodermis*)
Main Functions of the Integument

- Protection
- Temperature maintenance
- Synthesis and storage of nutrients
- Sensory reception
- Excretion and secretion
Components of the Integumentary System

- Epidermis
  - Hair shaft
  - Pore of sweat gland duct
  - Epidermal ridge
  - Dermal papilla
  - Sebaceous gland
  - Arrector pili muscle
  - Sweat gland duct
  - Touch and pressure receptors
  - Hair follicle

- Dermis
  - Artery
  - Vein
  - Sweat gland
  - Nerve fibers
  - Fat

- Subcutaneous layer (hypodermis)
The Epidermis

- Stratified squamous epithelium
- Several distinct cell layers
  - Thick skin—five layers
    - On palms and soles
  - Thin skin—four layers
    - On rest of body
Integumentary Structure/Function

Cell Layers of The Epidermis

- *Stratum germinativum*
- *Stratum spinosum*
- *Stratum granulosum*
- *Stratum lucidum* (in thick skin)
- *Stratum corneum*
  - Dying superficial layer
  - *Keratin* accumulation
Integumentary Structure/Function

The Structure of the Epidermis

- Surface
- Stratum corneum
- Stratum lucidum
- Stratum granulosum
- Stratum spinosum
- Stratum germinativum
- Basement membrane
- Dermis

Figure 5-2
Cell Layers of The Epidermis

- *Stratum germinativum*
  - Basal layer
  - Stem cells
    - Cell division layer
    - Source of replacement cells
  - *Melanocytes*
    - Synthesize *melanin*
Cell Layers of the Epidermis

- Intermediate strata
  - *Stratum spinosum* (spiny layer)
    - Superficial to stratum germinativum
  - *Stratum granulosum* (grainy layer)
    - Keratin granules in cytoplasm
    - No cell division
  - *Stratum lucidum* (clear layer)
Cell Layers of the Epidermis

- *Stratum corneum*
  - Most superficial layer
  - Flattened (squamous) cells
  - Dead cells
  - Abundant keratin
    - *Keratinized* (also, *cornified*)
    - Tough, water-resistant protein
Sources of Skin Color

- **Melanocytes**
  - Make *melanin*
  - Melanin provides UV protection
  - Gives reddish-brown to brown-black color

- **Carotene**
  - Contributes orange-yellow color
  - Provided from diet

- **Hemoglobin**
  - Blood pigment
Integumentary Structure/Function

Melanocytes

Figure 5-3

- Melanin-containing vesicle
- Melanin pigment
- Melanocyte
- Basement membrane

Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings
Effects of UV Radiation

• Beneficial effect
  • Activates synthesis of vitamin $D_3$

• Harmful effects
  • Sun burn
  • Wrinkles, premature aging
  • Malignant melanoma
  • Basal cell carcinoma
Integumentary Structure/Function

Two Important Types of Skin Cancer

(a) Basal cell carcinoma

Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings

(b) Melanoma

http://drmelton.com/Chicago/skincancerpictures/

Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings
Key Note
The epidermis is a multi-layered, flexible, self-repairing barrier that prevents fluid loss, provides protection from UV radiation, produces vitamin D3, and resists damage from abrasion, chemicals, and pathogens.
Layers of the Dermis

- **Papillary layer**
  - Underlies epidermis
  - Named for *dermal papillae*
  - Loose connective tissue
  - Supports, nourishes epidermis
  - Provides sensory nerves, *lymphatics*, and *capillaries*
Layers of the Dermis

• *Reticular layer*
  • Tough, dense, fibrous layer
  • *Collagen* fibers
    • Limit stretch
  • Elastic fibers
    • Provide flexibility
  • Blends into papillary layer (above)
  • Blends into subcutaneous layer (below)
Other Dermal Components

- Epidermal accessory organs
- Cells of connective tissues proper
- Communication with other organ systems
  - Cardiovascular
  - Lymphatic
  - Nervous
    - Sensation
    - Control of blood flow and secretion
Key Note

The dermis provides mechanical strength, flexibility, and protection for underlying tissues. It is highly vascular and contains a variety of sensory receptors that provide information about the external environment.
The Subcutaneous Layer

- Composed of loose connective tissue
- Stabilizes skin position
  - Loosely attached to dermis
  - Loosely attached to muscle
- Contains many fat cells
  - Provides thermal insulation
  - Cushions underlying organs
- Safely receives *hypodermic* needles
Accessory Structures

- *Hair follicle*
  - A hair
    - *Shaft*
    - *Medulla*
    - *Cortex*
    - *Cuticle*
- *Arrector pili* muscle
  "Goose bumps"
Integumentary Structure/Function

Hair Follicles

Epidermis
Arrector pili muscle
Dermis

Hair shaft
Sebaceous gland

Hair (longitudinal section)
Hair follicle (cross section)
Subcutaneous adipose tissue
Site of cell division and hair production
Hair papilla

Figure 5-5(a)
Integumentary Structure/Function

Hair Follicles

Exposed shaft of hair
Hair shaft
Sebaceous gland
Boundary between hair shaft and hair root
Arrector pili muscle
Hair root
Connective tissue sheath of hair follicle
Site of cell division and hair production
Hair papilla

Figure 5-5(b)
Integumentary Structure/Function

Hair Follicles

- Connective tissue sheath
- Wall of hair follicle
  - Cuticle of hair
  - Cortex of hair
  - Medulla of hair
Accessory Structures

- Hair growth cycle
  - 0.3 mm/day growth rate
  - 2–5 years growth
  - 2–5 years follicle rest
  - Follicle reactivation
  - Old hair shedding
Accessory Structures

- **Sebaceous glands** (oil glands)
  - *Holocrine* gland
  - Oily secretion
    - *Sebum*
    - Hair shaft lubricant
  - *Sebaceous follicle*
    - Skin lubricant
    - Skin waterproofing
The Structure of Sebaceous Glands and Their Relationship to Hair Follicles

- Sebaceous gland
- Hair removed
- Wall of hair follicle
- Basement membrane
- Discharge of sebum
- Breakdown of cell walls
- Mitosis and growth
- Germinative cells

Sebaceous gland

LM × 150

Figure 5-6
Sweat Glands

- **Apocrine**
  - Odorous secretion ("funky")
  - Absent before puberty
  - Present in axilla, areola, groin

- **Merocrine**
  - Watery sweat (~1% NaCl)
  - For heat loss
  - Widely present in skin (up to 500/cm$^2$)
Integumentary Structure/Function

Sweat Glands

Figure 5-7
Key Note

The skin plays a major role in controlling body temperature. It acts as a radiator, with the heat being delivered by the dermal circulation and removed primarily by the evaporation of sweat or perspiration.
Accessory Structures: Nails

- Nail body
  - Dense mass of *keratinized* cells
- Nail bed
- Nail root
- Cuticle (*eponychium*)
- Lunula
Integumentary Structure/Function

The Structure of a Nail

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

Figure 5-8

Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings
Four Stages in Skin Healing

- Inflammation
  - Blood flow increases
  - Phagocytes attracted
- Scab formation
- Cell division and migration
- Scar formation
Bleeding occurs at the site of injury immediately after the injury, and mast cells in the region trigger an inflammatory response.

One week after the injury, the scab has been undermined by epidermal cells migrating over the meshwork produced by fibroblast activity. Phagocytic activity around the site has almost ended, and the fibrin clot is disintegrating.

After several hours, a scab has formed and cells of the stratum germinativum are migrating along the edges of the wound. Phagocytic cells are removing debris, and more of these cells are arriving with the enhanced circulation in the area. Clotting around the edges of the affected area partially isolates the region.

After several weeks, the scab has been shed, and the epidermis is complete. A shallow depression marks the injury site, but fibroblasts in the dermis continue to create scar tissue that will gradually elevate the overlying epidermis.
Bleeding occurs at the site of injury immediately after the injury, and mast cells in the region trigger an inflammatory response.
Bleeding occurs at the site of injury immediately after the injury, and mast cells in the region trigger an inflammatory response.

After several hours, a scab has formed and cells of the stratum germinativum are migrating along the edges of the wound. Phagocytic cells are removing debris, and more of these cells are arriving with the enhanced circulation in the area. Clotting around the edges of the affected area partially isolates the region.
One week after the injury, the scab has been undermined by epidermal cells migrating over the meshwork produced by fibroblast activity. Phagocytic activity around the site has almost ended, and the fibrin clot is disintegrating.
One week after the injury, the scab has been undermined by epidermal cells migrating over the meshwork produced by fibroblast activity. Phagocytic activity around the site has almost ended, and the fibrin clot is disintegrating.

After several weeks, the scab has been shed, and the epidermis is complete. A shallow depression marks the injury site, but fibroblasts in the dermis continue to create scar tissue that will gradually elevate the overlying epidermis.
### Table 5-1  A Common Classification of Burns

<table>
<thead>
<tr>
<th>CLASSIFICATION</th>
<th>DAMAGE REPORT</th>
<th>APPEARANCE AND SENSATION</th>
</tr>
</thead>
</table>
| FIRST-DEGREE BURN    | *Killed:* superficial cells of epidermis  
*Injured:* deeper layers of epidermis, papillary dermis | Inflamed; tender             |
| SECOND-DEGREE BURN   | *Killed:* superficial and deeper cells of epidermis; dermis may be affected  
*Injured:* damage may extend into reticular layer of the dermis, but many accessory structures are unaffected | Blisters; very painful       |
| THIRD-DEGREE BURN    | *Killed:* all epidermal and dermal cells  
*Injured:* hypodermis and deeper tissues and organs | Charred; no sensation at all |

Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings
Aging of the Skin

Major Age-Related Changes

- Injury and infection increase
- Immune cells decrease
- Sun protection diminishes
- Skin becomes dry, scaly
- Hair thins, grays
- Sagging, wrinkles occur
- Heat loss decreases
- Repair slows
The Integumentary System in Perspective

FIGURE 5-10
Functional Relationships Between the Integumentary System and Other Systems
The Skeletal System

- Provides structural support
- Synthesizes vitamin $D_3$, essential for calcium and phosphorus absorption (bone maintenance and growth)
The Muscular System

- Contractions of skeletal muscle pull against skin of face, producing facial expressions important in communication
- Synthesizes vitamin D$_3$, essential for normal calcium absorption (calcium ions play an essential role in muscle contraction)
The Nervous System

- Controls blood flow and sweat gland activity for thermoregulation; stimulates contraction of arrector pili muscles to elevate hairs.
- Receptors in dermis and deep epidermis provide sensations of touch, pressure, vibration, temperature, and pain.
The Endocrine System

- Sex hormones stimulate sebaceous gland activity; male and female sex hormones influence hair growth, distribution of subcutaneous fat, and apocrine sweat gland activity; adrenal hormones alter dermal blood flow and help mobilize lipids from adipocytes.

- Synthesizes vitamin $D_3$, precursor of calcitriol.
The Cardiovascular System

- Provides oxygen and nutrients; delivers hormones and cells of immune system; carries away carbon dioxide, waste products, and toxins; provides heat to maintain normal skin temperature

- Stimulation by mast cells produces localized changes in blood flow and capillary permeability
The Lymphatic System

- Assists in defending the integument by providing additional macrophages and mobilizing lymphocytes
- Provides physical barriers that prevent pathogen entry; macrophages resist infection; mast cells trigger inflammation and initiate the immune response
The Respiratory System

- Provides oxygen and eliminates carbon dioxide
- Hairs guard entrance to nasal cavity
The Digestive System

- Provides nutrients for all cells and lipids for storage by adipocytes
- Synthesizes vitamin $D_3$, needed for absorption of calcium and phosphorus
The Urinary System

- Excretes waste products, maintains normal body fluid pH and ion composition
- Assists in elimination of water and solutes; keratinized epidermis limits fluid loss through skin
The Reproductive System

- Sex hormones affect hair distribution, adipose tissue distribution in subcutaneous layer, and mammary gland development.
- Covers external genitalia; provides sensations that stimulate sexual behaviors; mammary gland secretions provide nourishment for newborn infant.