Introduction to the Integumentary System

• The integument is the largest system of the body
  – 16% of body weight
  – 1.5 to 2 m² in area
  – The integument is made up of two parts:
    • Cutaneous membrane (skin)
    • Accessory structures
Introduction to the Integumentary System

• The cutaneous membrane has two components
  – Outer *epidermis*:
    • Superficial epithelium (epithelial tissues)
  – Inner *dermis*:
    • Connective tissues
Introduction to the Integumentary System

- Accessory Structures
  - Originate in the dermis
  - Extend through the epidermis to the skin surface:
    - Hair
    - Nails
    - Multicellular exocrine glands
Introduction to the Integumentary System

• **Subcutaneous Layer** (Superficial Fascia or Hypodermis)
  – Loose connective tissue
  – Below the dermis
  – Location of hypodermic injections
General Structure of the Integumentary System

Figure 5-1

- Epidermis
- Dermis
- Subcutaneous layer (hypodermis)
  - 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
  - Artery
  - Vein
  - Sweat gland
  - Nerve fibers
  - Fat

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Introduction to the Integumentary System

• Functions of Skin
  – **Protects** underlying tissues and organs
  – **Maintains** body temperature (insulation and evaporation)
  – **Synthesizes** vitamin $D_3$
  – **Stores** lipids
  – **Detects** touch, pressure, pain, and temperature
  – **Excretes** salts, water, and organic wastes (glands)
5-1 The epidermis is composed of strata (layers) with various functions
Epidermis

- Epidermis is
  - Avascular stratified squamous epithelium:
    - Nutrients and oxygen diffuse from capillaries in the dermis
Epidermis

• Thin Skin
  – Covers most of the body
  – Has four layers of keratinocytes

• Thick Skin
  – Covers the palms of the hands and soles of the feet
  – Has five layers of keratinocytes
Structure of the Epidermis

Figure 5-2
Epidermis

• Structures of the Epidermis
  – The five **strata** of keratinocytes in thick skin
  – From basal lamina to free surface:
    • Stratum germinativum
    • Stratum spinosum
    • Stratum granulosum
    • Stratum lucidum
    • Stratum corneum
Stratum Germinativum

• The “germinative layer”
  – Has many germinative (stem) cells or **basal cells**
  – Is attached to basal lamina by hemidesmosomes
  – Forms a strong bond between epidermis and dermis
  – Forms **epidermal ridges** (e.g., fingerprints)
  – **Dermal papillae** (tiny mounds):
    • Increase the area of basal lamina
    • Strengthen attachment between epidermis and dermis
Intermediate Strata

• **Stratum Spinosum**
  - The “spiny layer”:
    - Produced by division of stratum germinativum
    - Eight to ten layers of keratinocytes bound by desmosomes
    - Cells shrink until cytoskeletons stick out (spiny)
Intermediate Strata

- **Stratum Granulosum**
  - The “grainy layer”
  - Stops dividing, starts producing

- **Stratum Lucidum**
  - The “clear layer”:
    - Found only in thick skin
    - Covers stratum granulosum
Stratum Corneum

• The “Horn Layer”
  – Exposed surface of skin
  – 15 to 30 layers of keratinized cells
  – Water resistant
  – Shed and replaced every 2 weeks
Epidermis

• **Keratinization**
  – The formation of a layer of dead, protective cells filled with keratin
  – Occurs on all exposed skin surfaces except eyes
  – Skin life cycle
  – It takes 2 to 4 weeks for a cell to move from *stratum germinativum* to *stratum corneum*
5-2 Factors influencing skin color are epidermal pigmentation and dermal circulation
The Role of Pigmentation

- Two pigments
  - **Carotene:**
    - Orange-yellow pigment
    - Found in orange vegetables
    - Accumulates in epidermal cells and fatty tissues of the dermis
    - Can be converted to vitamin A
  - **Melanin:**
    - Yellow-brown or black pigment
    - Produced by *melanocytes* in stratum germinativum
    - Stored in transport vesicles (*melanosomes*)
    - Transferred to keratinocytes
- Blood circulation (red blood cells)
Figure 5-3
Melanocytes

Figure 5-3

(b)

Melanosome
Melanin pigment
Melanocyte
Basement membrane
Skin Color

• Function of Melanocytes
  – Melanin protects skin from sun damage
  – Ultraviolet (UV) radiation
    • Causes DNA mutations and burns that lead to cancer and wrinkles
  – Skin color depends on melanin production, not on the number of melanocytes
Skin Color

• Capillaries and Skin Color
  – Oxygenated red blood contributes to skin color:
    • Blood vessels dilate from heat, skin reddens
    • Blood flow decreases, skin pales
  – Cyanosis:
    • Bluish skin tint
    • Caused by severe reduction in blood flow or oxygenation
5-3 Sunlight has detrimental and beneficial effects on the skin
The Epidermis and Vitamin D₃

• Vitamin D₃
  – Epidermal cells produce cholecalciferol (vitamin D₃):
    • In the presence of UV radiation
  – Liver and kidneys convert vitamin D₃ into calcitriol:
    • To aid absorption of calcium and phosphorus
  – Insufficient vitamin D₃:
    • Can cause rickets
Types of Skin Cancer

(a) Basal cell carcinoma

(b) Melanoma

Figure 5-4
5-4 The dermis is the tissue layer that supports the epidermis.
• The Dermis
  – Is located between epidermis and subcutaneous layer
  – Anchors epidermal accessory structures (hair follicles, sweat glands):
    – Has two components
      • Outer papillary layer
      • Deep reticular layer
The Dermis

• The Papillary Layer
  – Consists of areolar tissue
  – Contains smaller capillaries, lymphatics, and sensory neurons
  – Has dermal papillae projecting between epidermal ridges

• The Reticular Layer
  – Consists of dense irregular connective tissue
  – Contains larger blood vessels, lymph vessels, and nerve fibers
  – Contains collagen and elastic fibers
  – Contains connective tissue proper
The hypodermis is tissue that connects the dermis to underlying tissues
The Hypodermis

- The **subcutaneous layer** or hypodermis
  - Lies below the integument
  - Stabilizes the skin
  - Allows separate movement
  - Is made of elastic areolar and adipose tissues
  - Is connected to the reticular layer of integument by connective tissue fibers
  - Has few capillaries and no vital organs
  - Is the site of **subcutaneous injections** using hypodermic needles
The Hypodermis

• Deposits of subcutaneous fat
  – Have distribution patterns determined by hormones
  – Are reduced by cosmetic liposuction (lipoplasty)
General Structure of the Integumentary System

Figure 5-1
5-6 Hair is composed of keratinized dead cells that have been pushed to the surface
Hair

• Hair, hair follicles, sebaceous glands, sweat glands, and nails
  – Are integumentary accessory structures
  – Are located in dermis
  – Project through the skin surface
Hair

• The human body is covered with hair, except
  – Palms
  – Soles
  – Lips
  – Portions of external genitalia

• Functions of Hair
  – Protects and insulates
  – Guards openings against particles and insects
  – Is sensitive to very light touch
Figure 5-5
Hair Follicles and Hairs

Figure 5-5

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

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Hair

- Hair Color
  - Produced by melanocytes at the hair papilla
  - Determined by genes
Sebaceous glands and sweat glands are exocrine glands found in the skin.
Exocrine Glands in Skin

- **Sebaceous Glands** (Oil Glands)
  - Holocrine glands
  - Secrete **sebum**

- **Sweat Glands**
  - Two types: apocrine glands and merocrine (eccrine) glands
  - Watery secretions
Sebaceous Glands and Sweat Glands

• Sebaceous (Oil) Glands
  – Simple branched alveolar glands:
    • Associated with hair follicles
  – Sebaceous follicles:
    • Discharge directly onto skin surface
    • Sebum:
      – contains lipids and other ingredients
      – lubricates and protects the epidermis
      – inhibits bacteria
Sebaceous Glands and Sebaceous Follicles

Figure 5-6

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

Sebaceous gland  LM × 150
Sweat Glands

• Apocrine sweat glands
  – Found in armpits, around nipples, and groin
  – Secrete products into hair follicles
  – Produce sticky, cloudy secretions
  – Break down and cause odors
  – Surrounded by myoepithelial cells:
    • Squeeze apocrine gland secretions onto skin surface
    • In response to hormonal or nervous signal
Figure 5-7
Sweat Glands

- **Merocrine (Eccrine) Sweat Glands**
  - Widely distributed on body surface
  - Especially on palms and soles
  - Discharge directly onto skin surface
  - Sensible perspiration
  - Water, salts, and organic compounds
  - Functions of merocrine sweat gland activity:
    - Cools skin
    - Excretes water and electrolytes
    - Flushes microorganisms and harmful chemicals from skin
5-8 Nails are keratinized epidermal cells that protect the tips of fingers and toes.
Nails

• Nails protect fingers and toes
  – Made of dead cells packed with keratin
  – Metabolic disorders can change nail structure

• Nail production
  – Occurs in a deep epidermal fold near the bone called the nail root
The Structure of a Nail

Figure 5-8

- Free edge
- Nail body
- Nail root (site of growth)
- Cuticle (eponychium)
- Lunula
- Nail bed
- Epidermis
- Dermis
- Bone of fingertip
Several steps are involved in repairing the integument following an injury.
Repair of Skin Injuries

Figure 5-9
Repair of Skin Injuries

Figure 5-9
<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&lt;br&gt;<em>Injured:</em> deeper layers of epidermis, papillary dermis</td>
<td>Inflamed; tender</td>
</tr>
<tr>
<td>Second-Degree Burn</td>
<td><em>Killed:</em> superficial and deeper cells of epidermis; dermis may be affected&lt;br&gt;<em>Injured:</em> damage may extend into reticular layer of the dermis, but many accessory structures are unaffected</td>
<td>Blisters; very painful</td>
</tr>
<tr>
<td>Third-Degree Burn</td>
<td><em>Killed:</em> all epidermal and dermal cells&lt;br&gt;<em>Injured:</em> hypodermis and deeper tissues and organs</td>
<td>Charred; no sensation at all</td>
</tr>
</tbody>
</table>
5-10 Effects of aging include dermal thinning, wrinkling, and reduced melanocyte activity
Effects of Aging

- Skin injuries and infections become more common.
- The sensitivity of the immune system is reduced.
- Muscles become weaker, and bone strength decreases.
- Sensitivity to sun exposure increases.
- The skin becomes dry and often scaly.
Effects of Aging

• Hair thins and changes color.
• Sagging and wrinkling of the skin occur.
• The ability to lose heat decreases.
• Skin repairs proceed relatively slowly.
5-11 The integumentary system provides protection for all other body systems
Importance of the Integumentary System

- Protects and interacts with all organ systems
- Changes in skin appearance are used to diagnose disorders in other systems
The Integumentary System in Perspective

Functional Relationships Between the Integumentary System and Other Systems
The Skeletal System

- The Skeletal System provides structural support.

- The Integumentary System synthesizes vitamin D₃, essential for calcium and phosphorus absorption (bone maintenance and growth).
The Muscular System

- The Muscular System’s facial muscles pull against skin of face, producing expressions important in communication.

- The Integumentary System synthesizes vitamin D₃, essential for normal calcium absorption (calcium ions play an essential role in muscle contraction).

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The Nervous System

- The Nervous System controls blood flow and sweat gland activity for thermoregulation; stimulates contraction of arrector pili muscles to elevate hairs.

- The Integumentary System’s receptors in dermis and deep epidermis provide sensations of touch, pressure, vibration, temperature, and pain.
The Endocrine System includes the sex hormones that stimulate sebaceous and apocrine gland activity, and develop secondary sexual characteristics; suprarenal hormones alter blood flow to skin and mobilize lipids from fat cells.

The Integumentary System synthesizes vitamin D₃, precursor of calcitriol, a hormone produced by the kidneys.
The Cardiovascular System

- 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

- The Integumentary System’s mast cells produce localized changes in blood flow and capillary permeability
The Lymphatic System

- The Lymphoid System assists in defending the integument by providing additional macrophages and mobilizing lymphocytes

- The Integumentary System provides physical barriers that prevent pathogen entry; macrophages resist infection; mast cells trigger inflammation and initiate the immune response

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The Respiratory System

- The Respiratory System provides oxygen and eliminates carbon dioxide
- The Integumentary System’s hairs guard entrance to nasal cavity
The Digestive System

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

- The Urinary System excretes waste products, maintains normal body fluid pH and ion composition.
- The Integumentary System assists in elimination of water and solutes; keratinized epidermis limits fluid loss through skin.
The Reproductive System

- The Reproductive System’s sex hormones affect hair distribution, adipose tissue distribution in subcutaneous layer, and mammary gland development.

- The Integumentary System covers external genitalia; provides sensations that stimulate sexual behaviors; mammary gland secretions provide nourishment for newborn infant.