• 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**
The cutaneous membrane has two components:

- **Outer epidermis:**
  - Superficial epithelium (epithelial tissues)

- **Inner dermis:**
  - Connective tissues
• 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
Figure 5-1

General Structure of the Integumentary System

- 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 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

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

LM ×150
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 \textit{stratum germinativum} to \textit{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

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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 D$_3$

- Vitamin D$_3$
  - Epidermal cells produce cholecalciferol (vitamin D$_3$):
    - In the presence of UV radiation
  - Liver and kidneys convert vitamin D$_3$ into calcitriol:
    - To aid absorption of calcium and phosphorus
- Insufficient vitamin D$_3$:
  - 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

• 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
Hair Follicles and Hairs

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 Follicles and Hairs

Figure 5-5

Connective tissue sheath
Wall of hair follicle
Cuticle of hair
Cortex of hair
Medulla of hair

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Hair

• Hair Color
  – Produced by melanocytes at the hair papilla
  – Determined by genes
5-7 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
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
Sweat Glands

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
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)
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

- 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.
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 D₃, needed for absorption of calcium and phosphorus.

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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.