Chapter 5

The Integumentary System

PowerPoint® Lecture Slides
prepared by Jason LaPres
Lone Star College - North Harris

Copyright © 2009 Pearson Education, Inc., publishing as Pearson Benjamin Cummings
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 skin surface
    - Hair
    - Nails
    - Multicellular exocrine glands
Introduction to the Integumentary System

- Connections
  - Cardiovascular system
    - Blood vessels in the dermis
  - Nervous system
    - Sensory receptors for pain, touch, and temperature
Introduction to the Integumentary System

- **Subcutaneous layer** *(superficial fascia or hypodermis)*
  - Loose connective tissue
  - Below the dermis
  - Location of hypodermic injections
Figure 5–1 The Components of the Integumentary System.
Functions of Skin

- **Protects** underlying tissues and organs
- **Excretes** salts, water, and organic wastes (glands)
- **Maintains** body temperature (insulation and evaporation)
- **Synthesizes** vitamin D₃
- **Stores** lipids
- **Detects** touch, pressure, pain, and temperature
Epidermis

Epidermis is

- Avascular stratified squamous epithelium
  - Nutrients and oxygen diffuse from capillaries in the dermis
Figure 5–2 The Basic Organization of the Epidermis.
Epidermis

- Cells of the Epidermis
  - Keratinocytes
    - Contain large amounts of keratin
    - The most abundant cells in the epidermis
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
Figure 5–2 The Basic Organization of the Epidermis.
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
Figure 5–3 The Structure of the Epidermis.
Epidermis

- **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
Figure 5–4 The Epidermal Ridges of Thick Skin.
Epidermis

- Specialized Cells of Stratum Germinativum
  - **Merkel cells**
    - Found in hairless skin
    - Respond to touch (trigger nervous system)
  - **Melanocytes**
    - Contain the pigment melanin
    - Scattered throughout stratum germinativum
Epidermis

- **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)
  - Continue to divide, increasing thickness of epithelium
  - Contain dendritic (Langerhans) cells, active in immune response
Epidermis

- **Stratum Granulosum**
  - The “grainy layer”
  - Stops dividing, starts producing
    - **Keratin:**
      - a tough, fibrous protein
      - makes up hair and nails
    - **Keratohyalin:**
      - dense granules
      - cross-link keratin fibers
Epidermis

- **Cells of Stratum Granulosum**
  - Produce protein fibers
  - Dehydrate and die
  - Create tightly interlocked layer of keratin surrounded by keratoxyalin
Epidermis

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

- **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 15–30 days for a cell to move from stratum germinativum to stratum corneum
Epidermis

- Perspiration
  - Insensible perspiration
    - Interstitial fluid lost by evaporation through the stratum corneum
  - Sensible perspiration
    - Water excreted by sweat glands
  - Dehydration results:
    - from damage to stratum corneum (e.g., burns and blisters [insensible perspiration])
    - from immersion in hypertonic solution (e.g., seawater [osmosis])
Epidermis

- **Hydration**
  - Results from immersion in hypotonic solution (e.g., freshwater [osmosis])
  - Causes swelling of epithelial cells, evident on the palms and soles
Skin Color

- Skin color is influenced by
  - 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 5–5a Melanocytes.
Figure 5–5b Melanocytes.
Skin Color

(a) Basal cell carcinoma

(b) Melanoma

Figure 5–6 Skin Cancers.
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 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
Skin Color

- Illness and Skin Color
  - Jaundice
    - Buildup of bile produced by liver
    - Yellow color
  - Addison disease
    - A disease of the pituitary gland
    - Skin darkening
  - Vitiligo
    - Loss of melanocytes
    - Loss of color
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
Figure 5–7 Rickets.
Epidermal Growth Factor (EGF)

- Is a powerful peptide growth factor
- Is produced by glands (salivary and duodenum)
- Is used in laboratories to grow skin grafts

Functions of EGF

- Promotes division of germinative cells
- Accelerates keratin production
- Stimulates epidermal repair
- Stimulates glandular secretion
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 Dermis

- **Dermatitis**
  - An inflammation of the papillary layer
  - Caused by infection, radiation, mechanical irritation, or chemicals (e.g., poison ivy)
  - Characterized by itch or pain
The Dermis

- Dermal Strength and Elasticity
  - Presence of two types of fibers
    - **Collagen fibers:**
      - very strong, resist stretching but bend easily
      - provide flexibility
    - **Elastic fibers:**
      - permit stretching and then recoil to original length
      - limit the flexibility of collagen fibers to prevent damage to tissue
  - **Skin turgor:**
    - Properties of flexibility and resilience
The Dermis

- **Skin Damage**
  - Sagging and wrinkles (reduced skin elasticity) are caused by
    - Dehydration
    - Age
    - Hormonal changes
    - UV exposure

- **Stretch Marks**
  - Thickened tissue resulting from excessive stretching of skin due to:
    - pregnancy
    - weight gain
The Dermis

- **Lines of Cleavage**
  - Collagen and elastic fibers in the dermis
    - Are arranged in parallel bundles
    - Resist force in a specific direction
  - **Lines of cleavage** establish important patterns
    - A parallel cut remains shut, heals well
    - A cut across (right angle) pulls open and scars
The Dermis

Figure 5–8 Lines of Cleavage of the Skin.
The Dermis

- The Dermal Blood Supply
  - Cutaneous plexus
    - A network of arteries along the reticular layer
  - Papillary plexus
    - Capillary network from small arteries in papillary layer
  - Venous plexus
    - Capillary return deep to the papillary plexus
- Contusion
  - Damage to blood vessels resulting in “black–and–blue” bruising
The Dermis

Figure 5–9 Dermal Circulation.
Innervation of the Skin

- Nerve fibers in skin control
  - Blood flow
  - Gland secretions
  - Sensory receptors
- **Tactile discs** monitor Merkel cells
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)
Hair

- Hair, hair follicles, sebaceous glands, sweat glands, and nails
  - Are integumentary accessory structures
  - Are derived from embryonic epidermis
  - 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

- The Hair Follicle
  - Is located deep in dermis
  - Produces nonliving hairs
  - Is wrapped in a dense connective tissue sheath
  - Base is surrounded by sensory nerves (root hair plexus)
Hair

- Accessory Structures of Hair
  - **Arrector pili**
    - Involuntary smooth muscle
    - Causes hairs to stand up
    - Produces “goose bumps”
  - **Sebaceous glands**
    - Lubricate the hair
    - Control bacteria
Regions of the Hair

- **Hair root**
  - Lower part of the hair
  - Attached to the integument

- **Hair shaft**
  - Upper part of the hair
  - Not attached to the integument
Figure 5–10 Hair Follicles and Hairs.
Hair

Figure 5–10 Hair Follicles and Hairs.

(d) Cross-Section Through a Hair Follicle

Connective tissue sheath
Glassy membrane
Cortex of hair
Medulla of hair
Cuticle of hair
Internal root sheath
External root sheath
Figure 5–10 Hair Follicles and Hairs.
Figure 5–10 Hair Follicles and Hairs.
Hair

- Hair Production
  - Begins at the base of a hair follicle, deep in the dermis
    - The *hair papilla* contains capillaries and nerves
    - The *hair bulb* produces *hair matrix*:
      - a layer of dividing basal cells
      - produces hair structure
      - pushes hair up and out of skin
Hair Shaft Structure

- **Medulla**
  - The central core

- **Cortex**
  - The middle layer

- **Cuticle**
  - The surface layer
Hair

- Keratin
  - As hair is produced, it is **keratinized**
    - Medulla contains flexible **soft keratin**
    - Cortex and cuticle contain stiff **hard keratin**
Hair

- Layers in the Follicle
  - **Internal root sheath**
    - The inner layer
    - Contacts the cuticle in lower hair root
  - **External root sheath**
    - Extends from skin surface to hair matrix
  - **Glassy membrane**
    - A dense connective tissue sheath
    - Contacts connective tissues of dermis
Hair Growth Cycle

Growing hair

- Is firmly attached to matrix

Club hair:
  - is not growing
  - is attached to an inactive follicle

New hair growth cycle:
  - follicle becomes active
  - produces new hair
  - club hair is shed
Hair

- Types of Hairs
  - Vellus hairs
    - Soft, fine
    - Cover body surface
  - Terminal hairs
    - Heavy, pigmented
    - Head, eyebrows, and eyelashes
    - Other parts of body after puberty
Hair

- Hair Color
  - Produced by melanocytes at the hair papilla
  - Determined by genes
Sebaceous Glands and Sweat Glands

- 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

- **Types of 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
Figure 5–11 The Structure of Sebaceous Glands and Sebaceous Follicles.
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
Sebaceous Glands and Sweat Glands

Figure 5–12a Sweat Glands.
Sebaceous Glands and Sweat Glands

- Merocrine (Eccrine) sweat glands
  - Widely distributed on body surface
  - Especially on palms and soles
  - Coiled, tubular glands
  - 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
Figure 5–12b Sweat Glands.
Other Integumentary Glands

- **Mammary glands**
  - Produce milk

- **Ceruminous glands**
  - Produce **cerumen** (earwax)
  - Protect the eardrum
Control of Glandular Secretions

- **Control of Glands**
  - Autonomic nervous system
    - Controls sebaceous and apocrine sweat glands
    - Works simultaneously over entire body
  - Merocrine sweat glands
    - Are controlled independently
    - Sweating occurs locally

- **Thermoregulation**
  - Is the main function of sensible perspiration
  - Works with cardiovascular system
  - Regulates body temperature
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
Nails

- Structure of a Nail
  - Nail body
    - The visible portion of the nail
    - Covers the nail bed
  - Lunula
    - The pale crescent at the base of the nail
  - Sides of nails
    - Lie in lateral nail grooves
    - Surrounded by lateral nail folds
Nails

- Structure of a Nail
  - Skin beneath the distal **free edge** of the nail
    - Is the **hyponychium** (onyx = nail)
  - Visible nail emerges
    - From the **eponychium** (cuticle)
    - At the tip of the **proximal nail fold**
Figure 5–13 The Structure of a Nail.
Figure 5–13 The Structure of a Nail.
Repair of the Integument

- Bleeding occurs
- Mast cells trigger inflammatory response
- A scab stabilizes and protects the area
- Germinative cells migrate around the wound
- Macrophages clean the area
- Fibroblasts and endothelial cells move in, producing granulation tissue
Repair of the Integument

STEP 1
Bleeding occurs at the site of injury immediately after the injury, and mast cells in the region trigger an inflammatory response.

STEP 2
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 via the enhanced circulation in the area. Clotting around the edges of the affected area partially isolates the region.

Figure 5–14 Repair of Injury to the Integument.
STEP 3
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.

STEP 4
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.

Figure 5–14 Repair of Injury to the Integument.
Repair of the Integument

- Fibroblasts produce **scar tissue**
  - Inflammation decreases, clot disintegrates
  - Fibroblasts strengthen scar tissue
  - A raised **keloid** may form
Figure 5–15 A Keloid.
Figure 5–17 A Quick Method of Estimating the Percentage of Surface Area Affected by Burns.
Effects of Aging

- Effects of aging include
  - Epidermal thinning
  - Decreased numbers of dendritic (Langerhans) cells
  - Decreased vitamin D$_3$ production
  - Decreased melanocyte activity
  - Decreased glandular activity (sweat and oil glands)
Effects of Aging

- Effects of aging include
  - Reduced blood supply
  - Decreased function of hair follicles
  - Reduction of elastic fibers
  - Decreased hormone levels
  - Slower repair rate
Importance of the Integumentary System

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

Figure 5–16 The Integumentary System in Perspective.

THE INTEGUMENTARY SYSTEM IN PERSPECTIVE

Skeletal System
- Provides structural support
- Synthesizes vitamin D₃ essential for calcium and phosphorus absorption (bone maintenance and growth)

Muscular System
- Contractions of skeletal muscles pull against skin of face, producing facial expressions important in communication
- Synthesizes vitamin D₃, essential for normal calcium absorption (calcium ions play an essential role in muscle contraction)

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 INTEGUMENTARY SYSTEM IN PERSPECTIVE**

**Endocrine System**
- Sex hormones stimulate sebaceous gland activity; male and female sex hormones influence growth, distribution of subcutaneous fat, and apocrine sweat gland activity; suprarenal hormones alter dermal blood flow and help mobilize lipids from adipocytes
- Synthesizes vitamin D₃, precursor of calcitriol

**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 of mast cells produces localized changes in blood flow and capillary permeability

Figure 5–16 The Integumentary System in Perspective.
Importance of the Integumentary System

Figure 5–16 The Integumentary System in Perspective.

THE INTEGUMENTARY SYSTEM IN PERSPECTIVE

Lymphoid System
- Assists in defending the integument by providing additional macrophages and mobilizing lymphocytes
- Provides physical barriers that prevent entry of pathogens; dendritic (Langerhans) cells and macrophages resist infection; mast cells trigger inflammation and initiate the immune response

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

Digestive System
- Provides nutrients for all cells and lipids for storage by adipocytes
- Synthesizes vitamin D₃, needed for absorption of calcium and phosphorus
The Integumentary System in Perspective

**Urinary System**
- Excretes waste products; maintains normal pH and ion composition of body fluids
- Assists in excretion of water and solutes; keratinized epidermis limits fluid loss through skin

**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

Figure 5–16 The Integumentary System in Perspective.