Chapter 5

The Integumentary System

An Introduction to the Integumentary System

- The **Integument**
  - Is the largest system of the body
    - Sixteen percent of body weight
    - 1.5 to 2 m^2 in area
    - The integument is made up of two parts
      1. **Cutaneous membrane** (skin)
      2. **Accessory structures**

An Introduction to the Integumentary System

- Two Components of the Cutaneous Membrane
  1. Outer **epidermis**
     - Superficial epithelium (epithelial tissues)
  2. Inner **dermis**
     - Connective tissues

An Introduction to the Integumentary System

- **Accessory Structures**
  - Originate in the dermis
  - Extend through the epidermis to skin surface
    - Hair
    - Nails
    - Multicellular exocrine glands

An Introduction to the Integumentary System

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

An Introduction to the Integumentary System

- **Hypodermis** (Superficial Fascia or *Subcutaneous Layer*)
  - Loose connective tissue
  - Below the dermis
  - Location of hypodermic injections

An Introduction to the Integumentary System

- Functions of Skin
  - *Protection* of underlying tissues and organs
  - *Excretion* of salts, water, and organic wastes (glands)
  - *Maintenance* of body temperature (insulation and evaporation)
  - *Production* of melanin

An Introduction to the Integumentary System

- Functions of Skin
  - *Production* of keratin
  - *Synthesis* of vitamin D_3
  - *Storage* of lipids
  - *Detection* of touch, pressure, pain, and temperature

5-1 Epidermis

- The Epidermis
  - Is avascular stratified squamous epithelium
    - Nutrients and oxygen diffuse from capillaries in the dermis

5-1 Epidermis

- Cells of the Epidermis
  - **Keratinocytes**
    - Contain large amounts of keratin
    - Are the most abundant cells in the epidermis

5-1 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

5-1 Epidermis

- Structures of the Epidermis
  - The five *strata* of keratinocytes in thick skin
  - From basal lamina to free surface
    1. **Stratum basale**
    2. **Stratum spinosum**
    3. **Stratum granulosum**
    4. **Stratum lucidum**

5. **Stratum corneum**

5-1 Epidermis

- **Stratum Basale**
  - Is attached to basement membrane by hemidesmosomes
  - Forms a strong bond between epidermis and dermis
  - Forms **epidermal ridges** (basis of fingerprints)
  - **Dermal papillae** (tiny mounds)
    - Increase the area of basement membrane
    - Strengthen attachment between epidermis and dermis
  - Has many **basal cells**, or *germinative cells*

5-1 Epidermis

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

5-1 Epidermis

- **Stratum Spinosum** — the “spiny layer”
  - Produced by division of stratum basale
  - 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

5-1 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

5-1 Epidermis

- Cells of Stratum Granulosum
  - Produce protein fibers

- Dehydrate and die
- Create tightly interlocked layer of keratin surrounded by keratohyalin

5-1 Epidermis

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

5-1 Epidermis

- **Stratum Corneum** — the “horn layer”
  - Exposed surface of skin
  - 15 to 30 layers of keratinized cells
  - Water resistant
  - Shed and replaced every two weeks

5-1 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 7 to 10 days for a cell to move from stratum basale to stratum corneum

5-1 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])

5-1 Epidermis

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

5-2 Skin Color

- Skin Color Is Influenced by Two Pigments
  1. **Carotene**

2. **Melanin**
   - Blood circulation (red blood cells)

5-2 Skin Color

- **Carotene**
  - Orange-yellow pigment
  - Found in orange vegetables
  - Accumulates in epidermal cells and fatty tissues of the dermis
  - Can be converted to vitamin A

5-2 Skin Color

- Melanin
  - Yellow-brown or black pigment
  - Produced by **melanocytes** in stratum basale
  - Stored in transport vesicles (*melanosomes*)
  - Transferred to keratinocytes

5-2 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

5-2 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

5-2 Skin Color

- Illness and Skin Color
  - *Jaundice*
    - Buildup of bile produced by liver
    - Yellow color
  - Pituitary tumor
    - Excess MSH

5-2 Skin Color

- Illness and Skin Color (cont.)
  - *Addison's disease*
    - A disease of the pituitary gland
    - Skin darkening
  - *Vitiligo*
    - Loss of melanocytes
    - Loss of color

5-3 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**
    - Aids absorption of calcium and phosphorus
  - Insufficient vitamin D_3
    - Can cause *rickets*

5-4 Epidermal Growth Factor (EGF)

- **Epidermal Growth Factor** (**EGF**)
  - Powerful peptide growth factor
  - Produced by glands (salivary and duodenum)
  - Used in laboratories to grow skin grafts
- Functions of EGF
  - Promotes division of germinative cells
  - Accelerates keratin production
  - Stimulates epidermal repair
  - Stimulates glandular secretion

5-5 The Dermis

- The Dermis
  - Located between epidermis and subcutaneous layer
  - Anchors epidermal accessory structures (hair follicles, sweat glands)
  - Two components
    - Outer papillary layer
    - Deep reticular layer

5-5 The Dermis

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

5-5 The Dermis

- The Reticular Layer
  - Consists of dense irregular connective tissue
  - Contains larger blood vessels, lymphatic vessels, and nerve fibers
  - Contains collagen and elastic fibers
  - Contains connective tissue proper

5-5 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

5-5 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

5-5 The Dermis

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

5-5 The Dermis

- Skin Damage
  - Stretch marks
    - Thickened tissue resulting from excessive stretching of skin due to:
      - Pregnancy
      - Weight gain

5-5 The Dermis

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

5-5 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

5-5 The Dermis

- Innervation of the Skin
  - Nerve fibers in skin control:
    - Blood flow
    - Gland secretions
    - Sensory receptors
      - Light touch—*tactile corpuscles*, located in dermal papillae
      - Deep pressure and vibration—*lamellated corpuscles*, in the reticular layer

5-6 The Hypodermis

- The **Hypodermis** (Subcutaneous Layer)
  - Lies below the integument
  - Stabilizes the skin
  - Allows separate movement
  - Made of elastic areolar and adipose tissues
  - Connected to the reticular layer of integument by connective tissue fibers
  - Few capillaries and no vital organs
  - The site of subcutaneous injections using hypodermic needles

5-6 The Hypodermis

- Deposits of Subcutaneous Fat

- Distribution patterns determined by hormones
- Reduced by cosmetic **liposuction** (**lipoplasty**)

5-7 Hair

- Hair, Hair Follicles, Sebaceous Glands, Sweat Glands, and Nails
  - Integumentary accessory structures
  - Derived from embryonic epidermis
  - Located in dermis
  - Project through the skin surface
-

5-7 Hair

- Human Body
  - The human body is covered with hair, *except*:
    - Palms
    - Soles
    - Lips
    - Portions of external genitalia

5-7 Hair

- Functions of Hair
  - Protects and insulates
  - Guards openings against particles and insects
  - Is sensitive to very light touch

5-7 Hair

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

5-7 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

5-7 Hair

- 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

5-7 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

5-7 Hair

- Hair Shaft Structure
  - Medulla
    - The central core
  - Cortex
    - The middle layer
  - Cuticle
    - The surface layer

5-7 Hair

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

5-7 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

5-7 Hair

- Hair Growth Cycle
    - Growing hair
        - Is firmly attached to matrix
        - Club hair
            - Is not growing
            - Is attached to an inactive follicle

5-7 Hair

- Hair Growth Cycle
    - New hair growth cycle
        - Follicle becomes active
        - Produces new hair
        - Club hair is shed

5-7 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

5-7 Hair

- Hair Color
    - Produced by melanocytes at the hair papilla
    - Determined by genes

5-8 Sebaceous Glands and Sweat Glands

- Exocrine Glands in Skin
    - Sebaceous Glands (oil glands)
        - Holocrine glands
        - Secrete sebum
    - Two Types of **Sweat Glands**
        - Apocrine glands
        - Merocrine (eccrine) glands
            - Watery secretions

5-8 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

5-8 Sebaceous Glands and 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

5-8 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

5-8 Sebaceous Glands and Sweat Glands

- Merocrine (Eccrine) Sweat Glands (cont.)
  - 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 Sebaceous Glands and Sweat Glands

- Other Integumentary Glands
  - Mammary glands
    - Produce milk
  - Ceruminous glands

        - Produce **cerumen** (earwax)
        - Protect the eardrum

5-8 Sebaceous Glands and Sweat Glands

- Control of Glands
    - Autonomic nervous system (ANS)
        - Controls sebaceous and apocrine sweat glands
        - Works simultaneously over entire body
    - Merocrine sweat glands
        - Controlled independently
        - Sweating occurs locally
    - Thermoregulation
        - The main function of sensible perspiration
        - Works with cardiovascular system
        - Regulates body temperature

5-9 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**

5-9 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**

5-9 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

5-10 Repair of the Integument

- Repair of the Integument Following an Injury
  - 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**

5-10 Repair of the Integument

- Repair of the Integument Following an Injury
  - Fibroblasts produce **scar tissue**
    - Inflammation decreases, clot disintegrates
    - Fibroblasts strengthen scar tissue
    - A raised **keloid** may form

5-11 Effects of Aging on the Integumentary System

- Effects of Aging
  - Epidermal thinning
  - Decreased numbers of dendritic (Langerhans) cells
  - Decreased vitamin D_3 production
  - Decreased melanocyte activity
  - Decreased glandular activity (sweat and oil glands)

5-11 Effects of Aging on the Integumentary System

- Effects of Aging
  - Reduced blood supply
  - Decreased function of hair follicles
  - Reduction of elastic fibers
  - Decreased hormone levels
  - Slower repair rate

5-11 Importance of the Integumentary System

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