5
The Integumentary System

Skin (Integument)
- Consists of three major regions
  1. Epidermis—superficial region
  2. Dermis—middle region
  3. Hypodermis (superficial fascia)—deepest region
    - Subcutaneous layer deep to skin (not technically part of skin)
    - Mostly adipose tissue

Epidermis
- Keratinized stratified squamous epithelium
- Cells of epidermis
  - Keratinocytes—produce fibrous protein keratin
  - Melanocytes
    - 10–25% of cells in lower epidermis
    - Produce pigment melanin
  - Epidermal dendritic (Langerhans) cells—macrophages that help activate immune system
  - Tactile (Merkel) cells—touch receptors

Layers of the Epidermis: Stratum Basale (Basal Layer)
- Deepest epidermal layer firmly attached to the dermis
- Single row of stem cells
- Also called stratum germinativum: cells undergo rapid division
- Journey from basal layer to surface
  - Takes 25–45 days

Layers of the Epidermis: Stratum Spinosum (Prickly Layer)
- Cells contain a weblike system of intermediate prekeratin filaments attached to desmosomes
- Abundant melanin granules and dendritic cells

Layers of the Epidermis: Stratum Granulosum (Granular Layer)
- Thin; three to five cell layers in which the cells flatten
- Keratohyaline and lamellated granules accumulate
Layers of the Epidermis: Stratum Lucidum (Clear Layer)
- In thick skin
- Thin, transparent band superficial to the stratum granulosum
- A few rows of flat, dead keratinocytes

Layers of the Epidermis: Stratum Corneum (Horny Layer)
- 20–30 rows of dead, flat, keratinized membranous sacs
- Three-quarters of the epidermal thickness
- Functions
  - Protects from abrasion and penetration
  - Waterproofs
  - Barrier against biological, chemical, and physical assaults

Dermis
- Strong, flexible connective tissue
- Cells include fibroblasts, macrophages, and occasionally mast cells and white blood cells
- Two layers:
  - Papillary
  - Reticular

Layers of the Dermis: Papillary Layer
- Papillary layer
  - Areolar connective tissue with collagen and elastic fibers and blood vessels
  - Dermal papillae contain:
    - Capillary loops
    - Meissner’s corpuscles
    - Free nerve endings

Layers of the Dermis: Reticular Layer
- Reticular layer
  - ~80% of the thickness of dermis
  - Collagen fibers provide strength and resiliency
  - Elastic fibers provide stretch-recoil properties

Skin Markings: Friction Ridges
- Epidermal ridges lie atop deeper dermal papillary ridges to form friction ridges of fingerprints
Skin Markings: Cleavage Lines
- Collagen fibers arranged in bundles form cleavage (tension) lines
- Incisions made parallel to cleavage lines heal more readily

Skin Color
- Three pigments contribute to skin color:
  1. Melanin
     - Yellow to reddish-brown to black, responsible for dark skin colors
     - Produced in melanocytes; migrates to keratinocytes where it forms “pigment shields” for nuclei
     - Freckles and pigmented moles
     - Local accumulations of melanin
  2. Carotene
     - Yellow to orange, most obvious in the palms and soles
  3. Hemoglobin
     - Responsible for the pinkish hue of skin

Appendages of the Skin
- Derivatives of the epidermis
  - Sweat glands
  - Oil glands
  - Hairs and hair follicles
  - Nails

Sweat Glands
- Two main types of sweat (sudoriferous) glands
  1. Eccrine (merocrine) sweat glands—abundant on palms, soles, and forehead
     - Sweat: 99% water, NaCl, vitamin C, antibodies, dermcidin, metabolic wastes
     - Ducts connect to pores
     - Function in thermoregulation
  2. Apocrine sweat glands—confined to axillary and anogenital areas
     - Sebum: sweat + fatty substances and proteins
     - Ducts connect to hair follicles
• Functional from puberty onward (as sexual scent glands?)
• Specialized apocrine glands
  • Ceruminous glands—in external ear canal; secrete cerumen
  • Mammary glands

Sebaceous (Oil) Glands
• Widely distributed
• Most develop from hair follicles
• Become active at puberty
• Sebum
  • Oily holocrine secretion
  • Bactericidal
  • Softens hair and skin

Hair
• Functions
  • Alerting the body to presence of insects on the skin
  • Guarding the scalp against physical trauma, heat loss, and sunlight
• Distribution
  • Entire surface except palms, soles, lips, nipples, and portions of external genitalia

Hair
• Consists of dead keratinized cells
• Contains hard keratin; more durable than soft keratin of skin
• Hair pigments: melanins (yellow, rust brown, black)
  • Gray/white hair: decreased melanin production, increased air bubbles in shaft

Hair Follicle
• Extends from the epidermal surface into dermis
• Two-layered wall: outer connective tissue root sheath, inner epithelial root sheath
• Hair bulb: expanded deep end

Hair Follicle
• Hair follicle receptor (root hair plexus)
  • Sensory nerve endings around each hair bulb
  • Stimulated by bending a hair
• Arrector pili
  • Smooth muscle attached to follicle
  • Responsible for “goose bumps”

Types of Hair
• Vellus—pale, fine body hair of children and adult females
• Terminal—coarse, long hair of eyebrows, scalp, axillary, and pubic regions (and face and neck of males)

Types of Hair
• Hair Growth
  • Growth phase (weeks to years) followed by regressive stage and resting phase (1–3 months)
  • Growth phase varies (6–10 years in scalp, 3–4 months in eyebrows)

Hair Thinning and Baldness
• Alopecia—hair thinning in both sexes after age 40
• True (frank) baldness
  • Genetically determined and sex-influenced condition
  • Male pattern baldness is caused by follicular response to DHT

Structure of a Nail
• Scalelike modification of the epidermis on the distal, dorsal surface of fingers and toes

Functions of the Integumentary System
1. Protection—three types of barriers
  • Chemical
    • Low pH secretions (acid mantle) and defensins retard bacterial activity

Functions of the Integumentary System
• Physical/mechanical barriers
  • Keratin and glycolipids block most water and water-soluble substances
  • Limited penetration of skin by lipid-soluble substances, plant oleoresins (e.g., poison ivy), organic solvents, salts of heavy metals, some drugs
  • Biological barriers
Dendritic cells, macrophages, and DNA

Functions of the Integumentary System
2. Body temperature regulation
   - ~500 ml/day of routine insensible perspiration (at normal body temperature)
   - At elevated temperature, dilation of dermal vessels and increased sweat gland activity (sensible perspirations) cool the body

3. Cutaneous sensations
   - Temperature, touch, and pain

Functions of the Integumentary System
4. Metabolic functions
   - Synthesis of vitamin D precursor and collagenase
   - Chemical conversion of carcinogens and some hormones

5. Blood reservoir—up to 5% of body’s blood volume

6. Excretion—nitrogenous wastes and salt in sweat

Skin Cancer
- Most skin tumors are benign (do not metastasize)
- Risk factors
  - Overexposure to UV radiation
  - Frequent irritation of the skin
  - Some skin lotions contain enzymes in liposomes that can fix damaged DNA

Skin Cancer
- Three major types:
  - Basal cell carcinoma
    - Least malignant, most common
  - Squamous cell carcinoma
    - Second most common
  - Melanoma
    - Most dangerous

Basal Cell Carcinoma
- Stratum basale cells proliferate and slowly invade dermis and hypodermis
- Cured by surgical excision in 99% of cases
**Squamous Cell Carcinoma**
- Involves keratinocytes of stratum spinosum
- Most common on scalp, ears, lower lip, and hands
- Good prognosis if treated by radiation therapy or removed surgically

**Melanoma**
- Involves melanocytes
- Highly metastatic and resistant to chemotherapy
- Treated by wide surgical excision accompanied by immunotherapy

**Melanoma**
- Characteristics (ABCD rule)
  A: Asymmetry; the two sides of the pigmented area do not match
  B: Border exhibits indentations
  C: Color is black, brown, tan, and sometimes red or blue
  D: Diameter is larger than 6 mm (size of a pencil eraser)

**Burns**
- Heat, electricity, radiation, certain chemicals
  \[ \text{Burn} \]
  (tissue damage, denatured protein, cell death)
  - Immediate threat:
    - Dehydration and electrolyte imbalance, leading to renal shutdown and circulatory shock

**Rule of Nines**
- Used to estimate the volume of fluid loss from burns

**Partial-Thickness Burns**
- First degree
  - Epidermal damage only
    - Localized redness, edema (swelling), and pain
- Second degree
  - Epidermal and upper dermal damage
    - Blisters appear
Full-Thickness Burns
• Third degree
  • Entire thickness of skin damaged
    • Gray-white, cherry red, or black
    • No initial edema or pain (nerve endings destroyed)
  • Skin grafting usually necessary

Severity of Burns
• Critical if:
  • >25% of the body has second-degree burns
  • >10% of the body has third-degree burns
  • Face, hands, or feet bear third-degree burns

Developmental Aspects: Fetal
• Ectoderm → epidermis
• Mesoderm → dermis and hypodermis
• Lanugo coat: covering of delicate hairs in 5th and 6th month
• Vernix caseosa: sebaceous gland secretion; protects skin of fetus

Developmental Aspects: Adolescent to Adult
• Sebaceous gland activity increases
• Effects of cumulative environmental assaults show after age 30
• Scaling and dermatitis become more common

Developmental Aspects: Old Age
• Epidermal replacement slows, skin becomes thin, dry, and itchy
• Subcutaneous fat and elasticity decrease, leading to cold intolerance and wrinkles
• Increased risk of cancer due to decreased numbers of melanocytes and dendritic cells