INTRODUCTION

• The integumentary system consists of:
  – the skin
  – accessory structures (hair, glands, nails)
• The integumentary system functions to:
  – guard the body’s physical and biochemical integrity
  – maintain a constant body temperature
  – provide sensory information about the surrounding environment

Chapter Overview

• Skin and its accessory structures
  – structure
  – function
  – growth and repair
  – development
  – aging
  – disorders

General Anatomy

• A large organ composed of all 4 tissue types
• 22 square feet
• 1-2 mm thick
• Weight 10 lbs.
Structure of the Skin

- The superficial portion of the skin is the *epidermis* and is composed of epithelial tissue.
- The deeper layer of the skin is the *dermis* and is primarily composed of connective tissue.
- Deep to the dermis is the *subcutaneous layer* or *hypodermis* (*not* a part of the skin).
  - it consists of areolar and adipose tissue.
  - fat storage, an area for blood vessel passage, and an area of pressure-sensing nerve endings.

Overview of Epidermis

- Stratified squamous epithelium
  - avascular (contains no blood vessels)
  - 4 types of cells
  - 4 or 5 distinct strata (layers) of cells

Four Principle Cells of the Epidermis

- **keratinocytes**
  - produce the protein keratin, which helps protect the skin and underlying tissue from heat, microbes, and chemicals, and lamellar granules, which release a waterproof sealant

- **melanocytes**
  - produce the pigment melanin which contributes to skin color and absorbs damaging ultraviolet (UV) light

- **Langerhans cells**
  - participate in immune response

- **Merkel cells**
  - contact a sensory structure called a tactile (Merkel) disc and function in the sensation of touch
Layers of the Epidermis

- There are four or five layers of the epidermis
- From deepest to most superficial the layers are
  - stratum basale (stratum germinativum)
  - stratum spinosum
  - stratum granulosum
  - stratum lucidum (only in palms and soles)
  - stratum corneum

Stratum Basale (stratum germinativum)

- Deepest single layer of epidermis
  - Merkel cells, melanocytes, keratinocytes & stem cells that divide repeatedly
  - keratinocytes have a cytoskeleton of tonofilaments
  - Cells attached to each other & to basement membrane by desmosomes & hemidesmosomes

Stratum Spinosum

- provides strength and flexibility to the skin
  - 8 to 10 cell layers are held together by desmosomes.
  - During slide preparation, cells shrink and appear spiny (where attached to other cells by desmosomes)
- Melanin is taken in by keratinocytes (by phagocytosis) from nearby melanocytes
**Stratum Granulosum**
- Transition between the deeper, metabolically active strata and the dead cells of the more superficial strata
- 3-5 layers of flat dying cells that show nuclear degeneration
  - example of apoptosis
- Contain lamellar granules that release lipid that repels water
- Contain dark-staining keratohyalin granules
  - keratohyalin converts tonofilaments into keratin

**Stratum Lucidum**
- Present only in the fingers tips, palms of the hands, and soles of the feet.
- Three to five layers of clear, flat, dead cells
- Contains precursor of keratin

**Stratum Corneum**
- 25 to 30 layers of flat dead cells filled with keratin and surrounded by lipids
  - continuously shed
- Barrier to light, heat, water, chemicals & bacteria
- Lamellar granules in this layer make it water-repellent
- Constant exposure to friction will cause this layer to increase in depth with the formation of a callus, an abnormal thickening of the epidermis

**Keratinization and Growth of the Epidermis**
- Stem cells divide to produce keratinocytes
- As keratinocytes are pushed up towards the surface, they fill with keratin
  - Keratinization is replacement of cell contents with the protein keratin; occurs as cells move to the skin surface over 2-4 weeks.
- Epidermal growth factor (EGF) and other hormone-like proteins play a role in epidermal growth.
Clinical Application

- **Psoriasis** is a chronic skin disorder characterized by a more rapid division and movement of keratinocytes through the epidermal strata
  - cells shed in 7 to 10 days as flaky silvery scales
  - abnormal keratin produced
- **Skin Grafts**
  - new skin can not regenerate if stratum basale and its stem cells are destroyed
  - autograft: covering of wound with piece of healthy skin from self
  - isograft is from twin
  - autologous skin graft
    - transplantation of patient’s skin after it has grown in culture

Dermis

- Connective tissue layer deep to the epidermis
- Contains hair follicles, glands, nerves & blood vessels
- Two major regions of dermis
  - papillary region
  - reticular region

Dermis - Papillary Region

- Top 20% of dermis
- Areolar connective tissue
  - collagen and elastic fibers provide strength, extensibility (ability to stretch), and elasticity (ability to return to original shape after stretching) to skin.
- Finger like projections are called dermal papillae
  - anchors epidermis to dermis
  - contains capillaries that feed epidermis
  - contains Meissner’s corpuscles (touch) & free nerve endings for sensations of heat, cold, pain, tickle, and itch

Dermis - Reticular Region

- Dense irregular connective tissue
- Contains interlacing collagen and elastic fibers
- Provides strength, extensibility & elasticity to skin
  - stretch marks are dermal tears from extreme stretching
Dermis -- Structure

- Epidermal ridges form in fetus as epidermis conforms to dermal papillae
  - increase friction for better grasping ability
  - provide the basis for fingerprints and footprints
  - fingerprints are left by sweat glands open on ridges

Lines of Cleavage

- Collagen and elastic fibers in the dermis:
  - are arranged in parallel bundles
  - resist force in a specific direction
- Clinical Importance
  - a parallel cut remains shut, heals well
  - a cut across (right angle) pulls open and scars

Skin Color - Clinical Significance

- The color of skin and mucous membranes can provide clues for diagnosing certain problems, such as
  - Jaundice
    - yellowish color to skin and whites of eyes
    - buildup of yellow bilirubin in blood from liver disease
  - Cyanosis
    - bluish color to nail beds and skin
    - hemoglobin depleted of oxygen looks purple-blue
  - Erythema
    - redness of skin due to enlargement of capillaries in dermis
    - during inflammation, infection, allergy or burns

Skin Color Pigments

- The wide variety of colors in skin is due to three pigments - melanin, carotene, and hemoglobin (in blood in capillaries)
- Melanin produced in epidermis by melanocytes
  - UV in sunlight increases melanin production
  - same number of melanocytes in everyone, but differing amounts of pigment produced
  - results vary from yellow to tan to black color
- Carotene
  - yellow-orange pigment (precursor of vitamin A)
- Hemoglobin
  - red, oxygen-carrying pigment in blood cells
  - if other pigments are not present, epidermis is translucent so pinkness will be evident
Skin Color Pigments

- Clinical observations
  - freckles or liver spots = overproduction of melanin
  - Nevus or mole = overgrowth of melanocytes in a patch
  - albinism = inherited lack of tyrosinase; no pigment
  - vitiligo = autoimmune loss of melanocytes in areas of the skin produces white patches

Accessory Structures of Skin

- Develop from the embryonic epidermis
- Cells sink inward during development to form:
  - hair
  - oil glands
  - sweat glands
  - nails

HAIR

- Hairs, or pili, are present on most skin surfaces except the palmar surfaces of the hands and plantar surfaces of the feet
- Hair consists of
  - a shaft above the surface
  - a root that penetrates the dermis and subcutaneous layer
  - a hair follicle
- New hairs develop from cell division of the matrix in the bulb

Structure of Hair

- Shaft -- visible
- Root -- below the surface
- Follicle surrounds root
**Structure of Hair**

- **Shaft** -- visible
  - medulla, cortex & cuticle
  - cross-section round in straight hair
  - cross-section oval in wavy hair
- **Root** -- below the surface
- **Follicle surrounds root**
  - base of follicle is bulb
  - blood vessels
  - germinal cell layer

**Hair Related Structures**

- **Arrector pili**
  - smooth muscle in dermis contracts with cold or fear
  - forms goosebumps as hair is pulled vertically
- **Hair root plexus**
  - detect hair movement
- **Sebaceous (oil) glands**

**Hair Growth**

- The hair growth cycle consists of a growing stage and a resting stage
  - **Growth stage**
    - lasts for 2 to 6 years
    - matrix cells at base of hair root producing length
  - **Resting stage**
    - lasts for 3 months
    - matrix cells inactive & follicle atrophies
- **Old hair falls out as growth stage begins again**
- **Normal hair loss is 70 to 100 hairs per day**
- **Both rate of growth and the replacement cycle can be altered by illness, diet, high fever, surgery, blood loss and severe emotional stress**
- **Chemotherapeutic agents affect the rapidly dividing matrix hair cells resulting in hair loss**
- **Hormones influence the growth and loss of hair**

**Hair Color**

- **Hair color is due primarily to the amount and type of melanin**
  - Dark hair contains true melanin (eumelanin)
  - Blond and red hair contain melanin with iron and sulfur added (pheomelanin)
  - Graying hair is result of decline in melanin production
  - White hair has air bubbles in the medullary shaft
Hair Texture

- Texture – related to differences in cross-sectional shape
  - straight hair is round
  - wavy hair is oval
  - curly hair is relatively flat

Functions of Hair

- Prevents heat loss
- Decreases sunburn
- Eyelashes help protect eyes
- Touch receptors (hair root plexus) senses light touch

Hair Color and Texture

Blond, straight
Black, straight
Red, wavy
Gray, wavy

Glands of the Skin

Specialized exocrine glands found in dermis:
- Sebaceous (oil) glands
- Sudoriferous (sweat) glands
- Ceruminous (wax) glands
- Mammary (milk) glands
Sebaceous (oil) glands

- *Sebaceous (oil) glands* are usually connected to hair follicles; they are absent in the palms and soles
- Secretory portion of gland is located in the dermis
  - produce sebum
    - contains cholesterol, proteins, fats & salts
    - moistens hairs
    - waterproofs and softens the skin
    - inhibits growth of bacteria & fungi (ringworm)
- Acne
  - bacterial inflammation of glands
  - secretions are stimulated by hormones at puberty

Sudoriferous (sweat) glands

- *Eccrine sweat glands* have an extensive distribution most areas of skin
  - ducts terminate at pores at the surface of the epidermis
  - regulate body temperature through evaporation (perspiration)
  - help eliminate wastes such as urea
- *Apocrine sweat glands* are limited in distribution to the skin of the axilla, pubis, and areolae
  - start functioning at puberty
  - duct that opens onto hair follicle
  - secretions are more viscous

Both sweat glands secrete by a merocrine mechanism!

Ceruminous Glands

- *Ceruminous glands* are modified sudoriferous glands that produce a waxy substance called cerumen (ear wax)
  - found in the external auditory canal
  - barrier for entrance of foreign bodies
- An abnormal amount of cerumen can prevent sound waves from reaching the ear drum

Structure of Nails

- Tightly packed keratinized cells
- Nail body
  - visible portion pink due to underlying capillaries
  - free edge appears white
- Nail root
  - buried under skin layers
  - lunula is white due to thickened stratum basale
- Eponychium (cuticle)
  - stratum corneum layer
Nail Growth

• Nail matrix is below nail root -- produces growth
• Cells transformed into tightly packed keratinized cells
• 1 mm per week
• Certain nail conditions may indicate disease

Types of Skin

• Thin skin
  – covers all parts of the body except for palms of the hands and soles of the feet
  – lacks epidermal ridges
  – has a sparser distribution of sensory receptors than thick skin.
• Thick skin (0.6 to 4.5 mm)
  – covers the palms of the hands and soles of the feet
  – features a stratum lucidum and thick epidermal ridges
  – lacks hair follicles, arrector pili muscles, and sebaceous glands, and has more sweat glands than thin skin.

Functions of Skin -- Thermoregulation

• Skin contributes to thermoregulation by
  – perspiration
  – adjusting the flow of blood in the dermis
• Exercise
  – in moderate exercise, more blood brought to surface helps lower temperature
  – with extreme exercise, blood is shunted to muscles and body temperature rises
• Shivering and constriction of surface vessels
  – raise internal body temperature as needed

Functions of Skin

• Blood reservoir
  – extensive network of blood vessels
• Protection - physical, chemical and biological barriers
  – tight cell junctions prevent bacterial invasion
  – lipids released retard evaporation
  – pigment protects somewhat against UV light
  – Langerhans cells alert immune system
• Cutaneous sensations
  – touch, pressure, vibration, tickle, heat, cold, and pain arise in the skin
Functions of Skin

- **Synthesis of Vitamin D**
  - Activation of a precursor molecule in the skin by UV light
  - Necessary vitamin for absorption of calcium from food in the gastrointestinal tract

- **Excretion**
  - 400 mL of water/day, small amounts salt, CO₂, ammonia and urea

Transdermal Drug Administration

- Method of drug passage across the epidermis and into the blood vessels of the dermis
  - Drug absorption is most rapid in areas where skin is thin (scrotum, face and scalp)

- Examples:
  - Nitroglycerin (prevention of chest pain from coronary artery disease)
  - Scopolamine (motion sickness)
  - Estradiol (estrogen replacement therapy)
  - Nicotine (stop smoking alternative)

Epidermal Wound Healing

- Abrasion or minor burn
- Basal cells migrate across the wound
- Contact inhibition with other cells stops migration
- Epidermal growth factor stimulates basal cells to divide and replace the ones that have moved into the wound
- Full thickness of epidermis results from further cell division

Age Related Structural Changes

- Collagen fibers decrease in number & stiffen
- Elastic fibers become less elastic
- Fibroblasts decrease in number
- Decrease in number of melanocytes (gray hair, blotching)
- Decrease in Langerhans cells (decreased immune responsiveness)
- Reduced number and less-efficient phagocytes
Photodamage

- Ultraviolet light (UVA and UVB) both damage the skin
- Acute overexposure causes sunburn
- DNA damage in epidermal cells can lead to skin cancer
- UVA produces oxygen free radicals that damage collagen and elastic fibers and lead to wrinkling of the skin

Skin Cancer

- 1 million cases diagnosed per year
- 3 common forms of skin cancer
  - basal cell carcinoma (rarely metastasize)
  - squamous cell carcinoma (may metastasize)
  - malignant melanomas (metastasize rapidly)
    - most common cancer in young women
    - arise from melanocytes --- life threatening
    - key to treatment is early detection watch for changes in symmetry, border, color and size
    - risks factors include -- skin color, sun exposure, family history, age and immunological status

Burns

- Tissue damage from excessive heat, electricity, radioactivity, or corrosive chemicals that destroys (denatures) proteins in the exposed cells is called a burn.
- Generally, the systemic effects of a burn are a greater threat to life than are the local effects.
- The seriousness of a burn is determined by its depth, extent, and area involved, as well as the person’s age and general health. When the burn area exceeds 70%, over half of the victims die.
- Problems that result
  - shock due to water, plasma and plasma protein loss
  - circulatory & kidney problems from loss of plasma
  - bacterial infection

Types of Burns

- First-degree
  - only epidermis (sunburn)
- Second-degree
  - destroys entire epidermis & part of dermis
  - fluid-filled blisters separate epidermis & dermis
  - accessory structures are not damaged
  - heals without grafting in 3 to 4 weeks & may scar
- Third-degree or full-thickness
  - destroy epidermis, dermis & accessory structures
  - damaged area is numb due to loss of sensory nerves
• Pressure ulcers, also known as *decubitus ulcers* or *bedsores*
  – caused by a constant deficiency of blood to tissues overlying a bony projection that has been subjected to prolonged pressure
  – typically occur between bony projection and hard object such as a bed, cast, or splint
  – the deficiency of blood flow results in tissue ulceration.

• Preventable with proper care