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MODULE 5.1 OVERVIEW OF THE INTEGUMENTARY SYSTEM

SKIN STRUCTURE

- Skin accounts for 10–15% of an individual's total body weight making it *largest organ* in body; more than just an outer covering; complex organ with many functions important for *homeostasis* (**Figure 5.1**)
- Known as **cutaneous membrane**; has two main components:
  - **Epidermis** – superficial layer that consists of *keratinized stratified squamous epithelium* resting on a basement membrane
  - **Dermis** – deep to epidermis and basement membrane; consists of *loose connective tissue* and *dense irregular connective tissue*

SKIN STRUCTURE

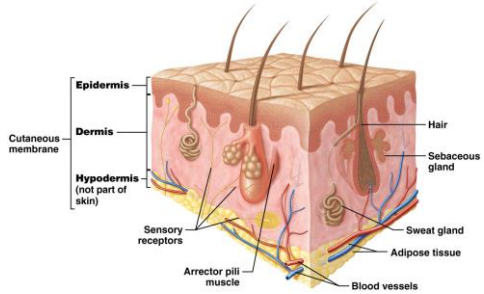


Figure 5.1 Basic anatomy of the skin.

SKIN STRUCTURE

- **Accessory structures** of skin – embedded in cutaneous membrane: *sweat glands*, *sebaceous glands*, *hair*, and *nails*
- Skin contains *sensory receptors* and **arrector pili muscles** (small bands of smooth muscle associated with hair)
- Epidermis is *avascular*:
  - Must rely on diffusion of oxygen and nutrients from blood vessels in deeper dermis; example of **Gradients Core Principle**; limits epidermal thickness
  - About 50% of cells in epidermis are too far from adequate blood supply to sustain life; superficial layers are made up entirely of *dead cells*

SKIN STRUCTURE

- **Hypodermis** – also known as **superficial fascia** or **subcutaneous fat**, is deep to dermis
  - Although *not part of skin*, it does anchor skin to deeper structures like muscle and bone
  - Made of loose connective and adipose tissues; has an abundant blood supply

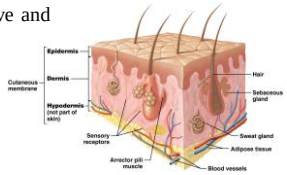


Figure 5.1 Basic anatomy of the skin.

Cellulite

- Term used to describe *dimpled* or "*orange peel*" appearance of skin when collagen bands form around adipose tissue in the *hypodermis*
- Tends to develop in *thighs*, *hips*, and *gluteal area*; influenced by many factors; genetics, gender and amount and distribution of adipose tissue, and age
- Now thought to be *normal condition* (not disorder)
- Little evidence that any "cures" for cellulite work; only proven way to minimize appearance is a *healthy diet* and *regular exercise*; however, even diet and exercise do not generally eliminate it all together

Functions of the Integumentary System

Integumentary system has following functions that are critical for protecting underlying organs or for maintaining homeostasis:

- **Protection** from mechanical trauma, pathogens, and environment is most obvious function:
  - Stratified squamous, keratinized epithelium provides a *durable* but *flexible* surface; protects body from *mechanical trauma* like stretching, pressure, or abrasions
  - Provides a *continuous barrier* to invasion by microorganisms or pathogens that can cause disease
  - Contains cells of immune system that *destroy pathogens* before they invade deeper tissues

Functions of the Integumentary System

- **Protection** (continued):
  - **Glands** secrete a variety of *antimicrobial substances*; sebaceous gland secretions give surface of skin a slightly acidic pH (called **acid mantle**); inhibits growth of many pathogens
  - Provides protection from a number of environmental hazards including *absorption of ultraviolet light* (*UV*) before it damages deeper tissues
  - Skin secretes *hydrophobic lipid-based chemicals*; repel ionic and polar covalent molecules like salt and water; critical for maintaining *water and electrolyte homeostasis* in a wide range of weather conditions

Functions of the Integumentary System

- **Sensation** – process that enables nervous system to *perceive changes* in the body's internal or external surroundings; critical to homeostasis:
  - Skin has numerous *sensory receptors* or cellular structures that detect changes in internal and/or external environment
  - Receptors allow us to detect *potentially harmful stimuli* such as heat, cold, and pain; could lead to tissue damage

Functions of the Integumentary System

- **Thermoregulation** (**Figure 5.2**):
  - Process that relies on negative feedback loops for maintenance of a *stable internal temperature*
  - Example of **Feedback Loops Core Principle**
  - Internal body temperature is determined mostly by *muscle activity* and many chemical reactions involved in *metabolism*

Functions of the Integumentary System

- Sequence of events that occur when body temperature rises above normal range; may be caused by extremes of weather or due to abnormal conditions that cause fever (**Figure 5.2a**):
  - **Sensory receptors** (**thermoreceptors**) in skin detect an increase in temperature in both skin itself and internal body fluids
  - **Control center** in hypothalamus of brain acts as a *thermostat* or **thermoregulatory center**; receives *input* from thermoreceptors; processes and then *responds* to sensory inputs
  - **Control center stimulates sweating**; sweat glands are stimulated to release a watery fluid called **sweat**; water carries a great deal of heat with it when it *evaporates*; provides for an effective cooling mechanism

Functions of the Integumentary System

- Sequence of events that occur when body temperature rises above normal range (continued):
  - **Control center stimulates cutaneous vasodilation**; response triggered by hypothalamus; causes blood vessels in dermis to widen (**dilate**); increased blood flow through dilated vessels increases amount of heat *radiated away* from body into environment; cools body
  - **Body temperature returns to normal range and cooling mechanisms decline by negative feedback**; when thermoreceptors no longer sense body temperatures above normal range they stop sending signals to hypothalamus; ends control center responses; sweating and vasodilation ends

Functions of the Integumentary System

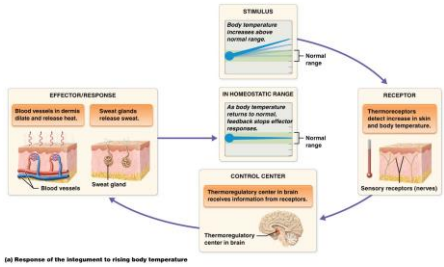


Figure 5.2a Homeostatic regulation of body temperature by integumentary system.

Functions of the Integumentary System

- Sequence of events that occur when body temperature drops below normal range; usually due to cold environmental conditions (**Figure 5.2b**):
  - **Thermoreceptors** detect body temperature drop below normal range; relay information to **thermoregulatory center** in hypothalamus
  - Hypothalamus generates a different response than it does for an increased body temperature; blood vessels in dermis narrow (**vasoconstrict**) reducing amount of blood flow; *limits heat lost* to environment

Functions of the Integumentary System

- Sequence of events that occur when body temperature drops below normal range (continued):
  - Vasoconstriction also *redirects blood flow* to deeper tissues; helps to *conserve heat*
  - When body temperature rises back into normal range, thermoreceptors stop sending information to hypothalamus; response that hypothalamus generated for heat conservation ends; feedback loop is closed

Functions of the Integumentary System

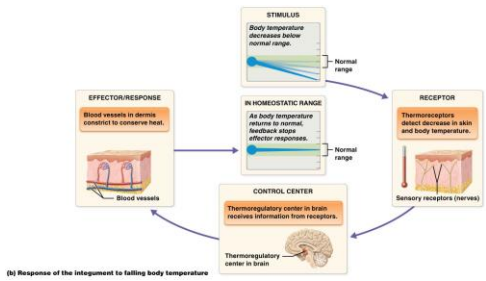


Figure 5.2b Homeostatic regulation of body temperature by integumentary system.

Functions of the Integumentary System

- **Excretion** – process where *waste products* and *toxins* are eliminated from body; most occurs at other organs like *kidneys*; skin and its accessory structures make a small but significant contribution

FUNCTIONS OF THE INTEGUMENTARY SYSTEM

- Skin plays a critical role in **vitamin D synthesis**; cells found deep in epidermis convert vitamin D from an inactive form (**precursor**) to active form:
  - Precursor – modified **cholesterol** molecule; converted to **cholecalciferol** when epidermis is exposed to *UV radiation*
  - Cholecalciferol is *released into blood*; modified first by **liver**, then by **kidneys**, to form **calcitriol** (active form of vitamin D)
  - Vitamin D is required for *calcium ion absorption* from small intestine; calcium ion is critical for *nerve function*, *muscle contraction*, *building* and *maintaining bone tissue*, and many other physiological functions

MODULE 5.2 THE EPIDERMIS

THE EPIDERMIS

- **Epidermis** – most superficial layer; composed of several cell types; most numerous are **keratinocytes**
- Make up about 95% of epidermis; have two structural features that make epidermis *stronger* and <u>less</u> susceptible to *mechanical trauma*:
  - Manufacture **keratin** – *tough fibrous protein* that makes epidermis more resistant to mechanical trauma; demonstrates **Structure-Function Core Principle**
  - Linked to each other by **desmosomes**; makes epidermis stronger

THE EPIDERMIS

- Keratinocytes – organized from deep to superficial into five structurally distinct **strata** (**layers**) (**Figure 5.3**):
  - **Stratum basale** – (**stratum germinativum**) single layer of *stem cells* resting on basement membrane; closest cells to blood supply in dermis; therefore most *metabolically* and *mitotically active* cells in epidermis; involved in vitamin D synthesis and replacement of dead keratinocytes (lost from more superficial layers)
  - **Stratum spinosum** – *thickest layer*, sits on top of stratum basale so still close to blood supply; also metabolically and mitotically active

THE EPIDERMIS

- Five structurally distinct **strata** (continued):
  - **Stratum granulosum**
    - Three to five layers of cells with *prominent cytoplasmic* granules; filled with *keratin bundles* or a *lipid-based substance*; both secreted by exocytosis
    - Hydrophobic nature of lipids provides *waterproofing*; critical for maintaining internal fluid and electrolyte homeostasis; also leads to *isolation* and *death* of cells in this layer and in more superficial layers

THE EPIDERMIS

- Five structurally distinct **strata** (continued):
  - **Stratum lucidum** – narrow layer of *clear*, *dead keratinocytes*; found <u>only</u> in thick skin
  - **Stratum corneum** – outermost layer of epidermis; consists of several layers of *dead flattened keratinocytes* with thickened plasma membranes; filled mostly with *keratin bundles* and little else; *sloughed off* or *exfoliated mechanically* as desmosomes holding neighboring cells together are lost

The Epidermis

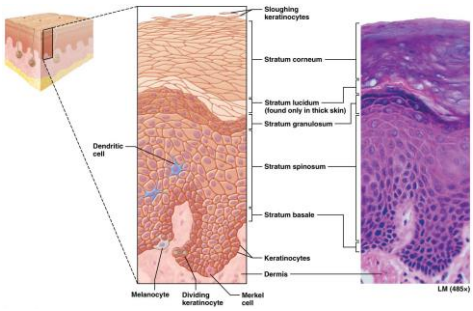


Figure 5.3 Structure of the epidermis.

Topical Medications

- Some medications are *toxic* if swallowed, but *safe* if used **topically** (applied to surface of skin)
- Certain topical *antibiotics* are fairly toxic if taken by mouth, but can be applied to skin with minimal risk of systemic absorption; they are polar molecules that cannot pass through epidermis to reach blood vessels in dermis; allows for *local effect only*
- Nonpolar substances cross epidermis much more easily; provides a *convenient route of administration* for certain medications such as hormones in birth control patches
- Unfortunately, many *poisons* and *toxins* (like **thallium**, a heavy metal) are also nonpolar; cross epidermis with same ease; therefore always good idea to wear gloves when handling chemicals

Study Boost: Remembering the Strata of the Epidermis

Here is a simple trick to remember **strata of epidermis**:

- **"Brilliant Studying Gives Loads of Confidence"**
- If you get confused as to which stratum is superficial and which is deep, think of the "B" in "basale" as standing for "bottom"; it is bottom layer

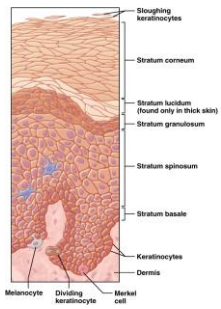


Figure 5.3 Structure of the epidermis.

The Epidermis

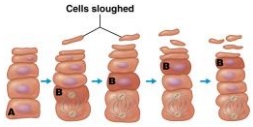
- **Keratinocyte life cycle**: location and functions of epidermis subjects it to both physical and environmental stress; stratum corneum is continuously shedding dead cells that must be replaced to maintain integrity of epidermis:
  - Dead keratinocytes are replaced by *mitosis* of cells in stratum basale and spinosum where blood supply is available for such activities
  - As keratinocytes in deeper strata divide they push cells above them into *more superficial layers*

The Epidermis

- **Keratinocyte life cycle** (continued):
  - Keratinocytes begin life in stratum basale or spinosum; eventually pass through each epidermal layer until shed from stratum corneum
  - Migration from deepest strata to stratum corneum takes a cell between *40–50 days* to complete

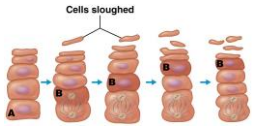
Concept Boost: Understanding Epidermal Growth

- Suppose for simplicity's sake that skin has *one row of cells in each epidermal stratum*, as shown:
  - **Cell A** undergoes mitosis, and one of its two daughter cells (**cell B** in diagram) is now in stratum spinosum
  - Other daughter cell of **cell A** divides again, producing two more daughter cells, one of which pushes **cell B** into stratum granulosum



Concept Boost: Understanding Epidermal Growth

- Suppose for simplicity's sake that skin has *one row of cells in each epidermal stratum*, as shown (continued):
  - **Cell B** is now quite far from blood supply; becomes *coated with lipid-based substance*; causes it to die
  - Stem cells continue to divide, pushing **cell B** *even farther away* from blood supply, into stratum lucidum and then into stratum corneum
  - **Cell B** is now a dead cell filled with keratin; will eventually be *sloughed off skin surface*



Other Cells of the Epidermis

- **Dendritic** (**Langerhans**) **cells** – located in stratum spinosum; *phagocytes* of immune system; protect skin and deeper tissues from pathogens
- **Merkel cells** – oval cells scattered throughout stratum basale; *sensory receptors* associated with small neurons in dermis:
  - Detect *light touch* and discriminate *shapes* and *textures*
  - Found in large numbers in regions that are *specialized for touch*; fingertips, lips, and at base of hairs
- **Melanocytes** – located in stratum basale; *produce* **melanin**; protein skin pigment ranging from orange-red to brown-black

Thick and Think Skin

- As with all structures, form of epidermis in various parts of body differs to match its *function*, in agreement with **Structure-Function Core Principle**
- Palms of hand and sole of foot are subjected to a great deal of mechanical stress, so these regions of skin have adapted; remaining regions of skin are not subjected to as much stress; differences in function and exposure to stress have lead to *thick* and *thin* skin (**Figure 5.4**)

Thick and Think Skin

- **Thick skin**, about as thick as a paper towel, has all five epidermal layers and a very thick stratum corneum; does <u>not</u> have *hair follicles* but contains many *sweat glands* (**Figure 5.4a**)
- Areas of body not subjected to as much mechanical stress are covered with **thin skin**; about as thick as a sheet of printer paper, has <u>only</u> *four layers*; stratum lucidum is missing (**Figure 5.4b**)
  - Each of four layers is thinner than those found in thick skin
  - Numerous *hairs*, *sweat glands*, and *sebaceous glands* present
- **Callus** – additional layers of stratum corneum; form in either thick or thin skin in response to *repetitive pressure*

Thick and Think Skin

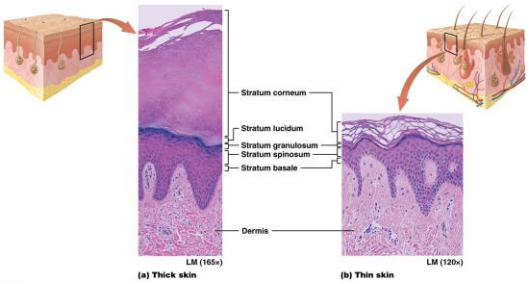


Figure 5.4 Thick and thin skin.

Module 5.3 The Dermis

THE DERMIS

Dermis – highly vascular layer *deep* to epidermis

- Functions:
  - Provides *blood supply* for epidermis
  - Contains *sensory receptors*
  - *Anchors* epidermis in place
- Composed of *two distinct layers* made up of *two types* of connective tissue

THE PAPILLARY LAYER

Papillary layer – thinner most superficial of two layers; composed of *loose connective tissue* (**Figure 5.5**):

- Special collagen fibers are found in this layer at *dermis-epidermal junction*; extends into epidermal basement membrane to *anchor epidermis to dermis*

THE PAPILLARY LAYER

- **Dermal papillae** – *tiny projections* found at surface of papillary layer where it comes into contact with epidermis:
  - Contain tiny blood vessels called **capillaries** arranged in loops; extend up into most *superficial part* of dermal papillae
  - Allow *oxygen* and *nutrients* to diffuse into extracellular fluid of dermis; then into cells of avascular epidermis
  - **Tactile** (**Meissner**) **corpuscles** – also found in dermal papillae; sensory receptors that respond to light touch stimuli; more numerous in regions of body where sensation is a primary function; skin of fingertips, lips, face, and external genitalia

THE RETICULAR LAYER

Reticular layer – deep thicker layer that separates dermis from hypodermis; mostly *dense irregular connective tissue* that consists largely of irregularly arranged collagen bundles:

- *Collagen bundles* strengthen dermis and prevent traumatic injuries from damaging deeper tissues
- *Elastic fibers* allow dermis to return to its original shape and size after *stretching*

THE RETICULAR LAYER

Reticular layer (continued):

- Rich in proteoglycans that draw water into ground substance; keeps skin *firm* and *hydrated*
- **Lamellated** (**Pacinian**) **corpuscles** – found embedded within reticular layer; sensory receptors that respond mainly to changes in *pressure* and *vibration* associated with skin
- *Blood vessels*, *sweat glands*, *hairs*, *sebaceous glands*, and *adipose tissue* are found in reticular layer

THE DERMIS

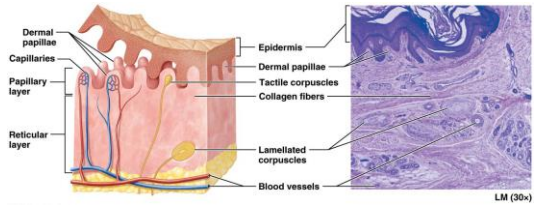


Figure 5.5 Structure of the dermis.

Skin Markings

Skin markings – small *visible lines* in epidermis created by interaction between dermis and epidermis; best seen in thick skin of palmar surfaces of hands and fingers and plantar surface of feet and toes (**Figure 5.6**)

- **Dermal ridges** – found in areas where dermal papillae are more *prominent* due to presence of *thick collagen bundles*
- Dermal ridges *indent overlying epidermis* to create **epidermal ridges**; enhance *gripping ability* of hands and feet:
  - Epidermal ridges occur in characteristic patterns; *loops*, *arches*, and *whorls*; genetically determined and unique to each person
  - *Sweat pores* open along these ridges and leave a thin film or **fingerprint** on things touched with fingers

Skin Markings

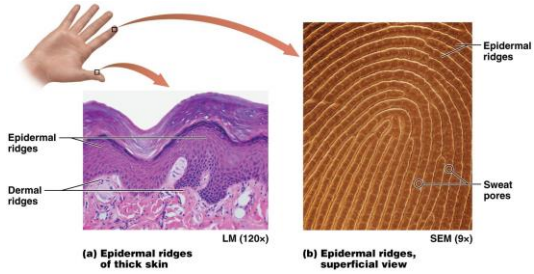


Figure 5.6 Epidermal ridges and fingerprint patterns.

Skin Markings

Skin markings (continued):

- Reticular layer is also responsible for skin markings associated with tension or lines; *cleavage lines* and *flexure lines* (**Figure 5.7**):
  - Gaps found between collagen bundles in dermis create *indentations in epidermis* called **tension** or **cleavage lines**
  - In areas of body, such as surrounding joints, reticular layer is tightly anchored to deeper structures that create deep creases called **flexure lines**

Skin Markings

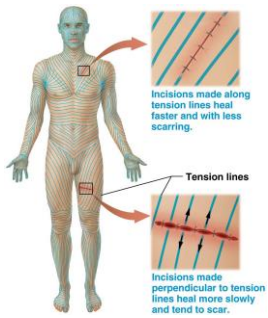


Figure 5.7 Importance of tension lines for surgical incisions.

Skin Wrinkles

- Hallmark of aging; due to age-related *decrease in collagen fibers*, *elastic fibers*, *proteoglycans*, and *adipose tissue* in the dermis
- Reduces skin's *firmness*, *hydration*, and *recoil ability* after stretching; tend to be deeper in areas of repetitive muscle movement (forehead and around eyes and mouth); *UV exposure* and *cigarette smoking* accelerate formation of wrinkles

Skin Wrinkles

- Appearance can be minimized by:
  - **Botox** – bacterial toxin; temporarily paralyzes facial muscles; causes skin to appear smoother
  - **Fillers** – adipose tissue, collagen, and/or proteoglycans are injected into wrinkles
  - **Topical creams** – (especially nonprescription) claim to reduce appearance of wrinkles; little to no effect
- Avoidance of sun, use of sunscreens, maintenance of hydration, and avoidance of smoking can delay appearance of wrinkles

MODULE 5.4 SKIN PIGMENTATION

MELANIN

Skin color – mostly determined by various amounts of orange-red to black protein pigment **melanin**:

- Produced by **melanocytes** in stratum basale of epidermis (**Figure 5.8**)
- Composed of two molecules of amino acid **tyrosine**; chemically bonded by a series of reactions catalyzed by enzyme **tyrosinase**; reactions occur in a stepwise fashion within a special vesicle called a **melanosome**
- Protecting keratinocyte DNA from *mutations induced by UV radiation* is a primary function

MELANIN

Skin color (continued):

- Melanocytes have several extensions of plasma membrane *in contact with keratinocytes* of stratum basale and spinosum
  - Melanosomes migrate to ends of these arms where *released by exocytosis*; absorbed or taken into cytoplasm of surrounding keratinocytes
  - Melanin is transported to *superficial side of nucleus* (faces exterior of body); *shields DNA* of keratinocyte like an umbrella
  - Melanin must be *made continuously* to maintain a consistent skin color as it degrades after a few days

MELANIN

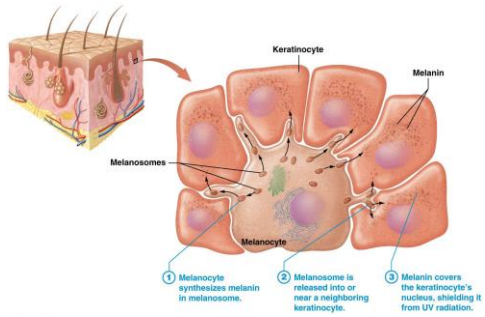


Figure 5.8 Melanocytes and melanin function.

MELANIN

Skin color (continued):

- Melanin synthesis increases with exposure to natural or artificial UV radiation; leads to **tanning** or *darkening of skin pigmentation*; UV radiation has both *immediate* and *delayed* effects on skin pigmentation:
  - Immediate response to UV radiation is *oxidation of melanin* already present in keratinocytes; causes melanin to *quickly darken*
  - UV light causes *DNA damage* in melanocytes; *stimulates melanin production* leading to delayed or secondary effects of UV exposure; appear within 72 hours and *last longer* than melanin oxidation

MELANIN

Skin color (continued):

- Melanin synthesis increases with exposure to natural or artificial UV radiation; leads to **tanning** or *darkening of skin pigmentation*; UV radiation has both *immediate* and *delayed* effects on skin pigmentation (continued):
  - Amount of UV radiation melanin can absorb is limited as is protection it provides
  - People of *all skin pigmentations* can develop **sunburns** and are at risk for skin cancers

MELANIN

Skin color (continued):

- Secondary function of melanin is to *reduce synthesis of vitamin D* in response to UV radiation; leads to less *calcium ion absorption* and maintenance of calcium ion homeostasis within a narrow range:
  - Individuals living in regions exposed to *high amounts of UV radiation* (such as Africa) may have developed darker skin to prevent excess vitamin D production
  - People in areas with *less UV radiation* (such as northern Europe) developed lighter skin so they could synthesize enough vitamin D

MELANIN

Skin color (continued):

- Skin color depends on number of melanocytes found in a particular body region; differences lead to uneven distribution of melanin; fewer melanocytes are found on palms of hand and soles of the feet, for example
- Overall number of melanocytes is *virtually identical* among all individuals, irrespective of skin color; spectrum of human skin tones is due to differences in amount of *tyrosinase activity* and *type* (*color*) *of melanin* produced

MELANIN

Skin color (continued):

- Common variations of pigmentation:
  - **Freckle** – small area of increased *pigmentation*; resulting from increased melanin production in local spot
  - **Mole** or **nevus** – area of increased pigmentation; due to a local *proliferation* of melanocytes, not an increase in melanin production
  - **Albinism** – melanocytes *fail to manufacture* tyrosinase; results in lack of skin pigmentation and greatly increased risk of keratinocyte DNA damage from UV radiation

TANNING AND A "HEALTHY TAN"

- Tanning – $5-billion-a-year business in United States alone; number of salons has soared from 10,000 to 50,000 in last decade; salons promote notion of "healthy tan"
- THERE IS NO SUCH THING AS A HEALTHY TAN!
- UVA and UVB rays are associated with **sunburning**; UVA rays are linked with tanning; led salons to claim that UVA rays are safe and will not damage skin, but mechanism of increased melanin production is same for both types of rays; both *damage DNA equally*, but UVA *ages skin* at much *faster rate*
- ANY amount of tanning *damages melanocytes and other skin elements*, *ages skin prematurely*, and *increases risk of skin cancer*

CAROTENE AND HEMOGLOBIN

Two minor pigments have an effect on skin pigmentation:

- **Carotene** – *yellow-orange pigment* found in food items such as egg yolks and orange vegetables
  - *Lipid-soluble* molecule that accumulates in stratum corneum
  - Imparts a slight yellow-orange color that is particularly visible in stratum corneum of thick skin

CAROTENE AND HEMOGLOBIN

Two minor pigments (continued):

- **Hemoglobin** – found in red blood cells, is an iron-containing protein that binds to and *transports oxygen* throughout body:
  - Oxygen binds to iron in hemoglobin in an oxidation reaction; same reaction that causes iron to rust; oxidized hemoglobin changes color to a bright orange-red; gives blood its characteristic color
  - Hemoglobin's effect on skin color is an indirect result of *blood flow in dermis*; color of blood in deeper dermis is visible through epidermis

Skin Color as a Diagnostic Tool

Color changes associated with *amount of blood flow* in dermis can be useful in diagnosis of disease:

- **Erythema** – occurs when blood flow in dermis increases causing a color change that makes skin *more reddish*
  - Color change is a normal *response to exercise* where blood flow in dermis has increased to maximize heat released to external environment
  - Other conditions that cause erythema include: trauma, fever, and infection

Skin Color as a Diagnostic Tool

Color changes associated with *amount of blood flow* in dermis (continued):

- **Pallor** – occurs when blood flow in dermis decreases; results in loss of *normal pinkish hue*; most visible in pale-skinned individuals; epidermis may take on *whitish color of collagen* in dermis
  - *Normal response* when body is trying to *conserve heat* in a cold environment
  - Can also occur when nervous and endocrine systems alter blood flow to dermis as part of a *flight or fight response*

Skin Color as a Diagnostic Tool

Color changes associated with *amount of blood flow* in dermis (continued):

- **Cyanosis** – sign that someone needs immediate attention; occurs when hemoglobin has very low levels of bound oxygen; blood turns *reddish purple*; skin takes on a faint *bluish hue*; can occur when
  - Someone has *difficulty breathing*
  - *Hemoglobin* or *red cell levels* are low in blood
  - Hemoglobin is *unable to bind to oxygen*

Module 5.5 Accessory Structures of the Integument: Hair, Nails, and Glands

Hair

Accessory structures or **appendages** of integument include *hair*, *nails*, and *glands*; derived from epithelium only; assist in overall function of integumentary system:

- **Hair** (**pili**) – small filamentous structures that protrude from surface of skin over entire body except in regions with thick skin, lips, and parts of external genitalia (**Figure 5.9**)

Hair

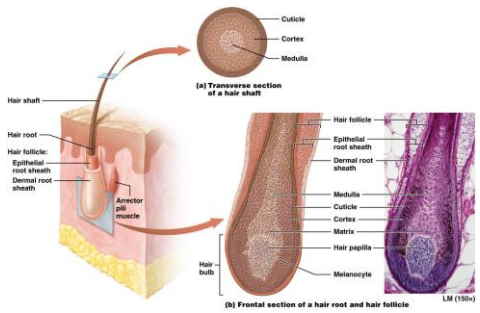


Figure 5.9 Hair structure.

HAIR

- Hair – too sparse in humans to play a significant role in thermoregulation, as it does in other mammals:
  - Does provide *protection* by preventing substances and organisms from external environment from *entering eyes* and *nose*
  - On head, protects underlying skin of scalp from *UV radiation* and *mechanical trauma*
  - Hairs are associated with a *small sensory neuron*; plays a role in detecting *changes in environment*

HAIR STRUCTURE

- **Hair** – composed of two main parts; **shaft** and **root**; both made up of *stratified squamous keratinized epithelial cells* in various stages of development
  - **Shaft**
    - Portion of hair that *projects* from skin's surface
    - Made up of columns of dead keratinized epithelial cells that have *completed keratinization process*

Figure 5.9 Hair structure.

HAIR STRUCTURE

Hair structure (continued):

- **Root**
  - Segment of hair *embedded in dermis*; surrounded by a small sensory neuron
  - Root is indented at its base by a *projection of blood vessels* from dermis called a **hair papilla**
  - Root and hair papilla are collectively known as **hair bulb**
  - Many epithelial cells in root are still alive; have <u>not</u> *completed keratinization process*

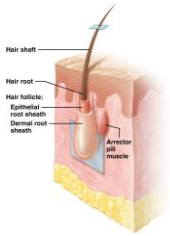


Figure 5.9 Hair structure.

HAIR STRUCTURE

- **Hair structure** (continued):
  - **Matrix** – small number of keratinocytes found at *base of root*; *actively divide*
  - Root is embedded in **hair follicle**; an infolding of epidermis called **epithelial root sheath**; extends deep into dermis or even hypodermis
  - Epithelial root sheath has an outer component that *anchors follicle* to dermis and an inner component that is *anchored tightly to hair root*

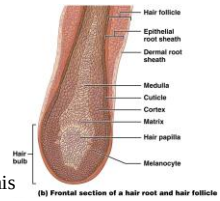


Figure 5.9b Hair structure.

HAIR STRUCTURE

- **Hair structure** (continued):
  - Strand of hair has *three visible regions* in a transverse section:
    - **Inner medulla** – *soft core* <u>only</u> found in thick hair (like on head); composed of a *soft keratin*
    - **Middle cortex** – highly structured and organized with several layers of keratinocytes containing *hard keratin*; provides *strength* to strand
    - **Outermost cuticle** – consists of a single layer of *overlapping keratinocytes* containing *hard keratin*; provides *mechanical strength*

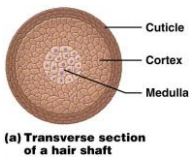


Figure 5.9a Hair structure.

HAIR STRUCTURE

- **Hair structure** (continued):
  - Surrounding epithelial root is a **dermal root sheath**; consists of connective tissue; supports follicle and keeps it separate from dermis
    - Small bands of *smooth muscle* called **arrector pili muscles** attach to dermal root sheath on one end and dermal papillary layer on the other
    - *Contraction* of these tiny muscles causes hair to stand up (**piloerection**); gives skin a dimpled appearance, commonly called "**goosebumps**"

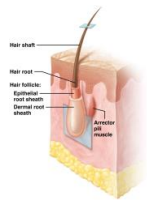


Figure 5.9 Hair structure.

HAIR GROWTH

- **Hair growth** averages between 1–1.5 cm per month; *varies between individuals*; growth is not *continuous* but occurs in a cycle with following *two main phases*:
  - During **growth stage**, *mitosis* occurs in matrix:
    - Cells divide and push cells above them farther away from blood supply where they keratinize and die
    - Stage varies in duration from a month to as long as six years; depends on location of hair

HAIR GROWTH

- **Hair growth** averages between 1–1.5 cm per month; *varies between individuals*; growth is not *continuous* but occurs in a cycle with following *two main phases* (continued):
  - During **resting stage**, mitosis in matrix *ends* as cells *die*:
    - Follicle shortens and hair is pushed toward surface where it remains *dormant* for a month or two
    - *Falls out* on its own or is *pushed out* by a new hair in growth stage

HAIR

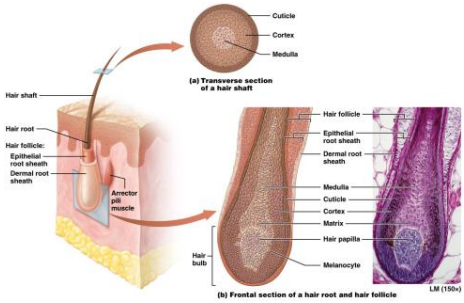


Figure 5.9 Hair structure.

HAIR PIGMENT AND TEXTURE

- Hair color and texture vary with different types of hair:
  - **Lanugo** – *thin, nonpigmented hair* found covering nearly entire body of a fetus; generally fall out around birth; replaced with one of two hair types:
    - **Terminal hair** – *thick, coarse*, and *pigmented hair*; found surrounding eyes and on scalp
    - **Vellus hair** – *thinner nonpigmented hair*; found over remaining regions of body
  - Terminal hair replaces much of vellus hair after *puberty*; varies by *gender* with more hair replacement occurring in males than females

HAIR PIGMENT AND TEXTURE

- Hair color and texture (continued):
  - Hair color is largely determined by melanin produced in matrix by melanocytes; produce a *range of colors*:
    - *Blond hair* has little melanin
    - *Black hair* which contains a lot of melanin
    - *Red hair* has a special *reddish pigment* containing *iron*
  - Melanocytes produce less melanin with *aging* so hair eventually turns gray or white

NAILS

- **Nails** – hard accessory structures that are located at ends of digits; composed of *stratified squamous epithelium* filled with *hard keratin*
- **Nail plate** – most visible component of nail, sits on top of an underlying epidermal **nail bed**; divided into:
  - **Nail body** – *visible portion* of nail plate
  - **Nail root** – portion of plate that lies *under skin*; where **nail matrix** containing *actively dividing cells* is found

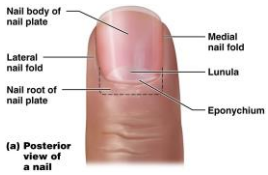


Figure 5.10a Nail structure.

NAILS

- *Folded regions* of skin surround and reinforce nail plate:
  - **Proximal nail fold** – on proximal edge covering nail root; distal edge of this fold is called the **eponychium** (cuticle); consists of only *stratum corneum*
  - **Medial** and **lateral nail folds** – on *medial and lateral edges* of nail plate respectively
  - *Distal or free edge* of nail plate – attached to underlying nail bed by an accumulation of stratum corneum called **hyponychium**

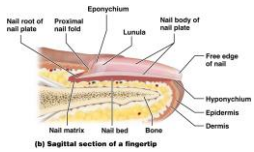


Figure 5.10b Nail structure.

NAILS

- Nail growth occurs at nail matrix; actively dividing cells push neighboring keratinocytes *distally*; die once keratinization is completed and have been cut off from blood supply; grow an average of *0.5 mm per week*; toenails grow more slowly
- Nails do not contain melanocytes; mostly *translucent* except at region called **lunula**; half-moon shaped region of proximal nail plate that represents an *accumulation of keratin*
- Primary function of nails – *protection* of underlying tissue (distal tips of the fingers and toes) from trauma; can be used as *tools*, enabling more precise gripping of items when picked up

GLANDS

Skin contains two basic types of **glands**; both derived from epithelial cells in epidermis but located deeper in dermis

- **Sweat** (**sudoriferous**) **glands** that produce sweat
- **Sebaceous glands** that produce oily **sebum**

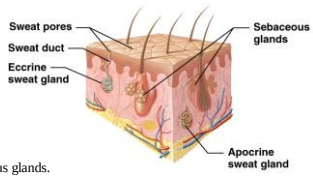


Figure 5.11 Sweat glands and sebaceous glands.

GLANDS

- Four types of **sweat glands**; differ structurally and in products secreted; all secrete products via exocytosis; called **merocrine secretion**:
  - **Eccrine sweat glands** (**Figure 5.11a**):
    - Most prevalent type
    - Simple coiled tubular glands found in dermis
    - Sweat, containing mostly *water*, *waste products*, and *electrolytes*
    - Exits from duct through a **sweat pore** onto *epidermal surface*

GLANDS

- Four types of **sweat glands** (continued):
  - **Apocrine sweat glands** (**Figure 5.11**):
    - Found in specific regions of body such as *axillae*, *anal area*, and *areola*
    - Large glands that release a *protein-rich secretion* into a *hair follicle*
    - Secretions can become *odoriferous* once skin bacteria metabolize their contents
    - Influenced by sex hormones; become active after **puberty**

GLANDS

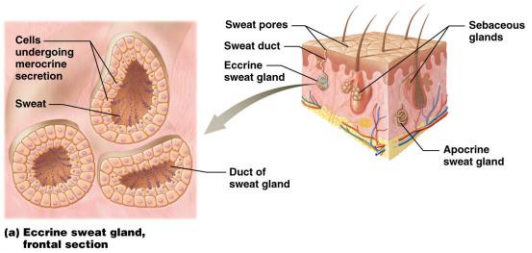


Figure 5.11a Sweat glands and sebaceous glands.

GLANDS

- Four types of **sweat glands** (continued):
  - **Ceruminous glands**:
    - *Modified* apocrine glands
    - Release a thick secretion called **cerumen** (ear wax) into hair follicles found in ear
    - Cerumen *traps incoming particles* along tube leading to tympanic membrane; also *lubricates*
  - **Mammary glands** – highly specialized sweat glands that produce a modified sweat product, **milk**

GLANDS

- **Sebaceous glands** – branched with clusters of secretory cells called **acini** surrounded by small ducts; converge to form a **central duct** that empties into hair follicle or small pore; makes and secretes **sebum** (**Figure 5.11b**):
  - Found everywhere on body except *palms and soles*; greatest number found on *face and scalp*
  - Secretion is influenced by sex hormones; especially male sex hormone (**testosterone**)
  - Dramatic increase in sebum production occurs after puberty; example of **Cell-Cell Communication Core Principle**

GLANDS

- **Sebaceous glands** (continued):
  - **Sebum** – *waxy, oily mixture* of mostly lipids; released by *holocrine secretion*; secretory cells accumulate sebum until cell *ruptures*
  - Contains *cellular fragments* and *debris* in addition to lipids
  - Coats hair, providing it with a *hydrophobic barrier* that inhibits water loss
  - Also *inhibits growth* of or *kills* certain bacteria

GLANDS

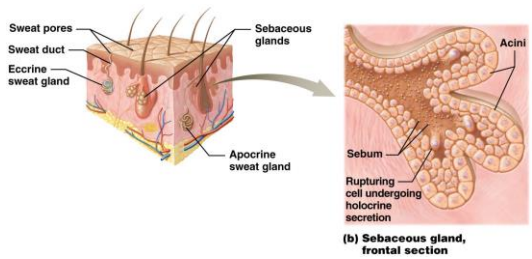


Figure 5.11b Sweat glands and sebaceous glands.

MODULE 5.6 PATHOLOGY OF THE SKIN

ACNE

- ***Acne vulgaris*** – affects **96**% of adolescents and young adults to some degree
- **Cause** – accumulation of sebum and dead cells within sebaceous glands; produces a **comedone** (**blackhead**); occasionally becomes infected by *Propionibacterium acnes*, resulting in inflammation and formation of a **pustule** (**pimple**)
- May be severe and cause *permanent scarring* in some individuals
- Male sex hormones (like **testosterone**) are primary cause; tends to be more pronounced in *males entering puberty*; decreases and may disappear by age 20–25; may persist much longer in some individuals

WOUNDS

- **Wound** – common skin pathology; defined as any *disruption in skin's integrity*; include:
  - **Lacerations** (cuts)
  - **Burns**
  - **Skin cancers**

BURNS

Burn – wound caused by agents such as *heat, extreme cold, electricity, chemicals,* and *radiation*; grouped into three classes according to *extent* and *depth* of tissue damage:

- **First-degree burns** (**superficial burns**)
  - Minor wounds that only *damage epidermis*
  - Skin may develop **erythema** (red appearance) and some mild pain without any *permanent damage*

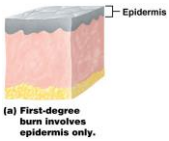


Figure 5.12a The three classes of burns.

BURNS

Burns (continued):

- **Second-degree burns** (**partial thickness burns**)
  - Involve epidermis and *part or all of dermis*
  - Can result in pain, blistering, and *scarring*

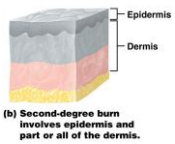


Figure 5.12b The three classes of burns.

BURNS

Burns (continued):

- **Third-degree burns** (**full thickness burns**)
  - Most damaging wounds
  - Involve *epidermis, dermis, hypodermis*; potentially even *deeper tissue*, like muscle or bone
  - Not *generally painful* at first because nerves are destroyed too

Figure 5.12c The three classes of burns.

BURNS

Burns (continued):

- **Third-degree burns** (**full thickness burns**) (continued):
  - Typically result in *major tissue damage* and significant scarring with *loss of hair follicles* and diminished or absent *keratin production*
  - Often problems with **dehydration** due to *massive fluid* loss from swelling; also at great risk for **infection**

Figure 5.12c The three classes of burns.

BURNS

Rule of nines

- Method for estimating how much of body has been affected by a burn
- Body is divided into 11 areas each representing *9% of the total body area*
- Useful clinical tool for grading *extent of burn*; severity and extent of burn is used to direct *treatment options*

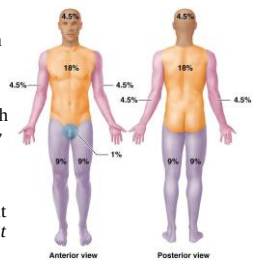


Figure 5.13 Rule of nines: estimating the extent of a burn.

SKIN CANCER

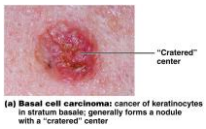
- **Cancer** – one of most common diseases in world; caused by *mutations in DNA* that induce a cell to *lose control* of **cell cycle** (**Figure 5.14**):
  - *Unchecked cell division* eventually leads to formation of a large population of *undifferentiated cells* known as a **tumor**
  - Cancerous tumors are able to **metastasize**; tumor cells *spread* through blood or lymphatic vessels to other tissues and continue to divide
  - Damage caused by metastatic tumor cells *alters function* of invaded organs

SKIN CANCER

- Three cancers affect skin; linked to *UV radiation exposure*; other factors that increase risk for developing cancer include exposure to:
  - Cancer-inducing chemicals, toxins, or agents called **carcinogens**
  - Forms of **radiation**

SKIN CANCER

- **Basal cell carcinoma**
  - Most *common* of all cancer types, including skin cancer
  - Arises from keratinocytes in stratum basale of epidermis
  - Skin that is *regularly exposed* to UV radiation is at risk for developing these tumors
  - Appear as a *nodule* with a *central crater*
  - Rarely metastasize to other tissues
  - Can be resolved successfully with *surgical removal*

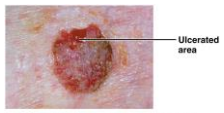


(a) **Basal cell carcinoma:** cancer of keratinocytes in stratum basale; generally forms a nodule with a "cratered" center

Figure 5.14a The three main forms of skin cancer.

SKIN CANCER

- **Squamous cell carcinoma**
  - *Second most common* skin cancer
  - Cancer of keratinocytes of stratum spinosum
  - *Scaly plaques* that may *ulcerate* and *bleed* are usually found on head and neck
  - Tumors are more likely to metastasize than basal cell carcinoma; *surgical removal* is still useful



(b) **Squamous cell carcinoma:** cancer of keratinocytes in stratum spinosum; forms plaques that bleed or ulcerate

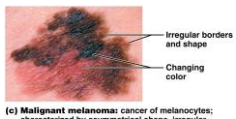
Figure 5.14b The three main forms of skin cancer.

SKIN CANCER

- **Malignant melanoma** – cancer of melanocytes
  - Early detection of melanoma is critical due to its tendency to metastasize
  - "Arms" of cancerous melanocytes extend down into dermis and access *dermal blood vessels*; enables cells to spread to other tissues via bloodstream
  - Treated with *surgical removal* and possibly other options such as *radiation therapy* and *chemotherapy*
  - **Prognosis** depends on size of the tumor, depth to which it extends into dermis, and whether it has metastasized to other tissues

SKIN CANCER

- **Malignant melanoma** can be distinguished from other skin cancers and normal moles using **ABCDE rule**:
  - **(A)**: **A**symmetrical shape (two sides do not match)
  - **(B)**: **B**order irregularity
  - **(C)**: **C**olor, usually blue-black or a variety of colors
  - **(D)**: **D**iameter generally larger than 6 mm (size of a pencil eraser)
  - **(E): E**volving (changing) shape and size



(c) **Malignant melanoma:** cancer of melanocytes; characterized by asymmetrical shape, irregular borders, blue-black color, larger diameter, and evolving nature

Figure 5.14c The three main forms of skin cancer.