Ingegneria delle tecnologie per la salute

Fondamenti di anatomia e istologia

aa. 2018-19

Lez 10 Apparato tegumentario
INTEGUMENTARY SYSTEM

integumentary system

= refers to skin and its accessory structures responsible for much more than simply human outward appearance: about 16% of body weight, covering an area of 1.5 to 2 m² (= largest organ system in human body).

• skin protects inner organs
INTEGUMENTARY SYSTEM

- **skin** = even not typical, but an organ, made of tissues that work together as a single structure to perform unique and critical functions.
- **integumentary system** = skin + its accessory structures, providing body with overall protection.
- made of multiple layers of cells and tissues, which are held to underlying structures by connective tissue: deeper layer of skin is well vascularized (has numerous blood vessels) and also has numerous sensory, and autonomic and sympathetic nerve fibers ensuring communication to and from brain.
INTEGUMENTARY SYSTEM

Functions of the skin and subcutaneous tissue
- epidermis and dermis
- hypodermis
- thick and thin skin
- skin color
- skin markings

Hair and nails

Cutaneous glands

Skin disorders

Overview

Largest organ (15% of body weight)

Epidermis
- keratinized stratified squamous epithelium

Dermis
- connective tissue layer

Hypodermis

Thickness variable, normally 1-2 mm
- dermis may thicken, up to 6 mm
- stratum corneum layer increased
  - calluses on hands and feet
2 layers: epidermis + dermis
SKIN: histology

**FIGURE 12.1** Thin skin: epidermis and the contents of the dermis. Stain: Masson trichrome (blue stain). Low magnification.
SKIN: histology

**FIGURE 12.2** Skin: epidermis, dermis, and hypodermis in the scalp. Stain: hematoxylin and eosin. Low magnification.
FIGURE 12.3 Hairy thin skin of the scalp: hair follicles and surrounding structures. Stain: hematoxylin and eosin. ×40.
Cells of the Epidermis

- **Stem cells**
  - undifferentiated cells in deepest layers
- **Keratinocytes** - most of the skin cells
- **Melanocytes**
  - synthesize pigment that shield UV
- **Tactile (merkel) cells**
  - receptor cells associated with nerve fibers
- **Dendritic (langerhans) cells**
  - macrophages guard against pathogens
Cell and Layers of the Epidermis

(a) Diagram showing various cells and structures in the epidermis:
- Exfoliating keratinocytes
- Dead keratinocytes
- Living keratinocytes
- Dendritic cell
- Tactile cell
- Stem cell
- Melanocyte
- Sensory nerve ending

(b) Microscopic view of the epidermis layers:
- Friction ridges
- Stratum corneum
- Stratum lucidum
- Stratum granulosum
- Stratum spinosum
- Stratum basale
- Dermis
- Dermal papilla
Epidermis: histology

- composed of keratinized, stratified squamous epithelium, made of 4 or 5 layers of epithelial cells, depending on its location in body. It does not have any blood vessels within it (i.e., it is avascular).
- Skin that has 4 layers of cells = “thin skin” (from deep to superficial, these layers are: stratum basale, stratum spinosum, stratum granulosum, and stratum corneum), most of the skin can be classified as thin skin.
- “Thick skin” found only on palms of hands and soles of feet: has a fifth layer, called stratum lucidum, located between stratum corneum and stratum granulosum.
Epidermis: histology

- Keratinocytes = cells in all of layers (except stratum basale), that manufactures and stores protein keratin [= an intracellular fibrous protein that gives hair, nails, and skin their hardness and water-resistant properties]

- keratinocytes in stratum corneum are dead and regularly slough away, being replaced by cells from the deeper layers
Epidermis: histology, stratum basale

- Also called stratum germinativum, deepest epidermal layer, attaching epidermis to basal lamina, below which lie layers of dermis.

- Cells in stratum basale bond to dermis via intertwining collagen fibers, referred to as basement membrane.

- Finger-like projection, or fold, known as dermal papilla (plural = dermal papillae) is found in superficial portion of dermis.

- Dermal papillae increase strength of connection between epidermis and dermis = greater the folding, stronger the connections made.
Epidermis: histology, stratum basale

- A single layer of cells primarily made of basal cells [= a cuboidal-shaped stem cell that is a precursor of keratinocytes of epidermis]
- All keratinocytes produced from this single layer of cells, constantly going through mitosis to produce new cells: as new cells are formed, existing cells are pushed superficially away from stratum basale
- 2 other cell types found dispersed among basal cells in stratum basale: 1. Merkel cell [= functions as a receptor and is responsible for stimulating sensory nerves that brain perceives as touch, especially abundant on surfaces of hands and feet], 2. melanocyte [produces pigment melanin, giving hair and skin its color, and also helping protect living cells of epidermis from ultraviolet (UV) radiation damage].
- In a growing fetus, fingerprints form where cells of stratum basale meet papillae of underlying dermal layer (papillary layer), resulting in formation of ridges on fingers that can be recognized as fingerprints [= unique to each individual and used for forensic analyses because patterns do not change with growth and aging processes]
Epidermis: histology, stratum basale

- Single layer cells on basement membrane

- **Cell types in this layer**
  - keratinocytes (STEM CELLS)
    - undergo mitosis to replace epidermis
  - melanocytes
    - distribute melanin through cell processes
    - melanin picked up by keratinocytes
  - merkel cells are touch receptors
    - form Merkel disc
Epidermis: histology, stratum spinosum

- spiny in appearance due to protruding cell processes that join cells via a structure called a desmosome, interlocking with each other and strengthen bond between cells [note: “spiny” nature of this layer is an artifact of staining process: unstained epidermis samples do not exhibit this characteristic appearance]
- composed of 8 to 10 layers of keratinocytes, formed as a result of cell division in stratum basale
- interspersed among keratinocytes of this layer is a type of dendritic cell called Langerhans cell, which functions as a macrophage by engulfing bacteria, foreign particles, and damaged cells that occur in this layer.
• Keratinocytes in stratum spinosum begin synthesis of keratin and release a water-repelling glycolipid that helps prevent water loss from body, making skin relatively waterproof.

• As new keratinocytes are produced atop stratum basale, keratinocytes of the stratum spinosum are pushed into the stratum granulosum.
Epidermis: histology, stratum spinosum

• Several layers of keratinocytes
  - appear spiny due to shrinkage during histological preparation
• Contains dendritic (Langerhans) cells
  - macrophages from bone marrow that migrate to the epidermis
  - 800 cells/millimeter²
  - help protect body against pathogens by “presenting” them to the immune system
**Stratum Granulosum** = a grainy appearance due to further changes to keratinocytes as they are pushed from stratum spinosum; cells (3 to 5 layers deep) become flatter, their cell membranes thicken, and they generate large amounts of proteins keratin, which is fibrous, and keratohyalin, which accumulates as lamellar granules within cells. [2 proteins make up bulk of keratinocyte mass in stratum granulosum and give layer its grainy appearance.] The nuclei and other cell organelles disintegrate as cells die, leaving behind keratin, keratohyalin, and cell membranes that will form stratum lucidum, stratum corneum, and accessory structures of hair and nails.
Epidermis: histology, more strata

**Stratum Granulosum**

- 3 to 5 layers Flat keratinocytes
- Contain keratinohyalin granules
  - combine with filaments of cytoskeleton to form keratin
- Produces lipid-filled vesicles that release a glycolipid by exocytosis to waterproof the skin
  - forms a barrier between surface cells and deeper layers of the epidermis
  - cuts off surface strata from nutrient supply
**Stratum Lucidum** = a smooth, seemingly translucent layer of epidermis located just above stratum granulosum and below the stratum corneum. This thin layer of cells is found only in thick skin of the palms, soles, and digits. Keratinocytes that compose stratum lucidum are dead and flattened (cells densely packed with eleiden, a clear protein rich in lipids, derived from keratohyalin, which gives these cells their transparent (i.e., lucid) appearance and provides a barrier to water).
Epidermis: histology, more strata

Stratum Lucidum

- Thin translucent zone seen only in thick skin
- Keratinocytes are packed with eleidin, a precursor to keratin
- Does not stain well
- Cells have no nucleus or organelles
**Epidermis: histology, more strata**

**Stratum Corneum** = the most superficial layer, exposed to outside environment, where increased keratinization (also called cornification) of cells in this layer gives it its name, with usually 15 to 30 layers of cells in stratum corneum, helping prevent penetration of microbes and dehydration of underlying tissues, and providing a mechanical protection against abrasion for more delicate, underlying layers; cells shed periodically and replaced by cells pushed up from stratum granulosum (or stratum lucidum in case of palms and soles of feet): entire layer is replaced during a period of about 4 weeks.
Epidermis: histology, more strata

**Stratum Corneum**

- Up to 30 layers of dead, scaly, keratinized cells
  - surface cells flake off (exfoliate)
FIGURE 12.5 ■ Thick skin: epidermis, dermis, and hypodermis of the palm. Stain: hematoxylin and eosin. ×17.
Epidermis: histology, thick

**FIGURE 12.7** Thick skin: epidermis and superficial cell layers. Stain: hematoxylin and eosin. x40.
FIGURE 12.6 - Thick skin of the palm, superficial cell layers, and melanin pigment. Stain: hematoxylin and eosin. Medium magnification.
Life History of Keratinocytes

• Produced by stem cells in stratum basale
• New cells push others toward surface
  – cells grow flat and fill with vesicles
• Cells filled with keratin
  – forms water barrier
• Cells die and exfoliate
Epidermis

• Keratinized stratified squamous epithelium
• 4 types of cells
  - Keratinocytes - deepest, produce keratin (tough fibrous protein)
  - Melanocytes - make dark skin pigment melanin
  - Merkel cells - associated with sensory nerve endings
  - Langerhans cells - macrophage-like dendritic cells
• Layers (from deep to superficial)
  - Stratum basale or germinativum - single row of cells attached to dermis; youngest cells
  - Stratum spinosum - spinyness is artifactual; tonofilaments (bundles of protein) resist tension
  - Stratum granulosum - layers of flattened keratinocytes producing keratin (hair and nails made of it also)
  - Stratum lucidum (only on palms and soles)
  - Stratum corneum - horny layer (cells dead, many layers thick)

(see figure on next slide)
Epithelium: layers (on left) and cell types (on right)

- **Stratum corneum**: Cells are dead; represented only by flat membranous sacs filled with keratin. Glycolipids in extracellular space.
- **Stratum granulosum**: Cells are flattened; organelles deteriorating; cytoplasm full of lamellated granules (release lipids) and keratohyaline granules.
- **Stratum spinosum**: Cells contain thick bundles of intermediate filaments made of pre-keratin.
- **Stratum basale**: Cells are actively mitotic stem cells; some newly formed cells become part of the more superficial layers.
- **Melanocytes**: Melanin granules
- **Merkel cell**: Sensory nerve ending
- **Langerhans' cell**:
Epidermis
Remember...

- Four basic types of tissue
  - Epithelium - epidermis just discussed
  - Connective tissue - dermis
  - Muscle tissue
  - Nervous tissue
Epidermis and Dermis

- **Epidermis** is avascular (no blood vessels)
- **Dermis** is highly vascular (has blood vessels)
- Epidermis receives nourishment from dermis
- Cells far away from nourishment die
Dermis

- Thick layer under the epidermis
- Contains blood vessels
- Oil glands
- Sweat glands
- Hair follicles
- Fat tissue
- Nerves
- Connective tissue
Dermis: histology

= might be considered “core” of integumentary system (derma- = “skin”), as distinct from the epidermis (epi- = “upon” or “over”) and hypodermis (hypo- = “below”), containing blood and lymph vessels, nerves, and other structures, such as hair follicles and sweat glands, made of 2 layers of connective tissue that compose an interconnected mesh of elastin and collagenous fibers, produced by fibroblasts:
Dermis: histology

1. Papillary Layer
= made of loose, areolar connective tissue, which means collagen and elastin fibers of this layer form a loose mesh, projecting into stratum basale of epidermis to form finger-like dermal papillae, within it are fibroblasts, a small number of fat cells (adipocytes), and an abundance of small blood vessels, in addition, containing phagocytes [defensive cells that help fight bacteria or other infections that have breached the skin] and also lymphatic capillaries, nerve fibers, and touch receptors called the Meissner corpuscles.
Dermis: histology

2. Reticular Layer
= underlying papillary layer, much thicker, composed of dense, irregular connective tissue, well vascularized with a rich sensory and sympathetic nerve supply, appears reticulated (netlike) due to a tight meshwork of fibers (elastin fibers provide some elasticity to skin, enabling movement, and collagen fibers provide structure and tensile strength, with strands of collagen extending into both papillary layer and hypodermis). In addition, collagen binds water to keep skin hydrated.
Dermis

- Strong, flexible connective tissue: your “hide”
- Rich supply of nerves and vessels
- Critical role in temperature regulation (the vessels)
- Thickness = 0.6mm to 3mm
- Composition (collagen, elastic and reticular fibers, Cells: fibroblasts, macrophages, mast cells, WBCs)
- Dermal papillae - extensions of the dermis into the epidermis
  forming the ridges of the fingerprints
- Layers 2 (see next slides)
  - Papillary – areolar connective tissue; includes dermal papillae
  - Reticular – “reticulum” (network) of collagen and reticular fibers
Epidermis and dermis of (a) thick skin and (b) thin skin (which one makes the difference?)
Deeper Layer of the Dermis

Dense connective tissue
- Contains
  • Blood vessels
  • Glands
  • Deep pressure receptors
- Attached to underlying organs by the subcutaneous layer
  • Loose connective tissue
    - Packed with adipose cells
  • Stabilizes position of skin
Fingerprints

Opening of sweat gland ducts

Epidermal ridge
Fingerprints

Fingerprints, palmprints, footprints

• Dermal papillae lie atop dermal ridges
• Elevate the overlying epidermis into epidermal ridges
• Are “sweat films” because of sweat pores
• Genetically determined

Flexion creases

• Deep dermis, from continual folding

Fibers

• Collagen: strength and resilience
• Elastic fibers: stretch–recoil
  - Striae: stretch marks
• Tension lines (or lines of cleavage)
  - The direction the bundles of fibers are directed

The dermis is the receptive site for the pigment of tattoos
Hypodermis: histology

(Also called subcutaneous layer or superficial fascia), layer directly below dermis, serving to connect skin to the underlying fascia (fibrous tissue) of the bones and muscles. It is not strictly a part of the skin, although border between hypodermis and dermis can be difficult to distinguish: consists of well vascularized, loose, areolar connective tissue and adipose tissue, which functions as a mode of fat storage and provides insulation and cushioning for integument.
Hypodermis

- Subcutaneous tissue/ superficial fascia
- Mostly adipose
- Functions
  - energy reservoir
  - thermal insulation
- Hypodermic injections (subQ)
  - highly vascular
Hypodermis

- “Hypodermis” (Gk) = below the skin
- “Subcutaneous” (Latin) = below the skin
- Also called “superficial fascia”
  “fascia” (Latin) = band; in anatomy: sheet of connective tissue
- Fatty tissue which stores fat and anchors skin (areolar tissue and adipose cells)
- Different patterns of accumulation (male/female)
Pigmentation

- Color of skin is influenced by a number of pigments, including melanin, carotene, and hemoglobin.
- Melanin is produced by cells called melanocytes, which are found scattered throughout stratum basale of epidermis and is transferred into keratinocytes via a cellular vesicle called a melanosome.
Melanin occurs in 2 primary forms: eumelanin exists as black and brown, whereas pheomelanin provides a red color.

Dark-skinned individuals produce more melanin than those with pale skin. Exposure to sun UV rays causes melanin to be manufactured and built up in keratinocytes, as sun exposure stimulates keratinocytes to secrete chemicals that stimulate melanocytes: accumulation of melanin in keratinocytes results in the darkening of the skin.

This increased melanin accumulation protects DNA of epidermal cells from UV ray damage and the breakdown of folic acid, a nutrient necessary for our health and well-being. In contrast, too much melanin can interfere with production of vitamin D, an important nutrient involved in calcium absorption. Thus, amount of melanin present in skin is dependent on a balance between available sunlight and folic acid destruction, and protection from UV radiation and vitamin D production.
Pigmentation

- It requires about 10 days after initial sun exposure for melanin synthesis to peak, which is why pale-skinned individuals tend to suffer sunburns of epidermis initially. Dark-skinned individuals can also get sunburns, but are more protected than are pale-skinned individuals. Melanosomes are temporary structures that are eventually destroyed by fusion with lysosomes; this fact, along with melanin-filled keratinocytes in stratum corneum sloughing off, makes tanning impermanent.

- Too much sun exposure can eventually lead to wrinkling (rughe) due to the destruction of the cellular structure of skin, and in severe cases, can cause sufficient DNA damage to result in skin cancer. When there is an irregular accumulation of melanocytes in the skin, freckles (lentigini) appear. Moles are larger masses of melanocytes, and although most are benign, they should be monitored for changes that might indicate presence of cancer.
Pigmentation

Moles range from benign accumulations of melanocytes to melanomas.
Skin color

Three skin pigments

Melanin: the most important
Carotene: from carrots and yellow vegies
Hemoglobin: the pink of light skin

Melanin in granules passes from melanocytes (same number in all ethnic groups) to keratinocytes in stratum basale

Digested by lysosomes

Variations in color

Protection from UV light vs vitamin D?
Skin color

- Hemoglobin = red pigment of red blood cells
- Carotene = yellow pigment
  - concentrates in stratum corneum and fat
- Melanin = yellow, brown, and black hues
  - pigment synthesis stimulated by UV radiation
Abnormal Skin Colors 1

- **Cyanosis** = blueness from deficiency of oxygen in the circulating blood (cold weather)
- **Erythema** = redness due to dilated cutaneous vessels (anger, sunburn, embarrassment)
- **Jaundice** = yellowing of skin and sclera due to excess of bilirubin in blood (liver disease)
Abnormal Skin Colors 2

- Bronzing = golden-brown color of Addison disease (deficiency of glucocorticoid hormone)
- Pallor = pale color from lack of blood flow
- Albinism = a genetic lack of melanin
- Hematoma = a bruise (visible clotted blood)
Skin Markings

• Hemangiomas (birthmarks)
  - discolored skin caused by benign tumors of dermal blood capillaries (strawberry birthmarks disappear in childhood -- port wine birthmarks last for life)

• Freckles and moles = aggregations of melanocytes
  - freckles are flat; moles are elevated

• Friction ridges leave oily fingerprints on touched surfaces
  - unique pattern formed during fetal development

• Flexion creases form after birth by repeated closing of the hand

• Flexion lines form in wrist and elbow areas
Accessory Structures of the Skin

- Include hair, nails, sweat glands, and sebaceous glands.
- These structures embryologically originate from epidermis and can extend down through dermis into hypodermis.
Accessory Structures of the Skin

hair, nails, sweat glands, and sebaceous glands
Hair

= keratinous filament growing out of epidermis, primarily made of dead, keratinized cells
Strands of hair originate in an epidermal penetration of dermis called hair follicle; hair shaft is the part of hair not anchored to follicle, and much of this is exposed at skin’s surface; rest of hair, which is anchored in follicle, lies below surface of skin and is referred to as hair root; hair root ends deep in dermis at hair bulb, and includes a layer of mitotically active basal cells called hair matrix; hair bulb surrounds hair papilla, which is made of connective tissue and contains blood capillaries and nerve endings from dermis.
Characteristics and structure of hair

• Hair (composed of hard keratin)
  - disulfide bridges between molecules

• Hair found almost everywhere
  - differences between sexes or individuals is difference in texture and color of hair

• 3 different body hair types
  - lanugo -- fine, unpigmented fetal hair
  - vellus -- fine, unpigmented hair of children and women
  - terminal hair -- coarse, long, pigmented hair of scalp

• Hair is filament of keratinized cells
  - shaft = above skin; root = within follicle
  - in cross section: medulla, cortex and cuticle

• Follicle is oblique tube within the skin
  - bulb is where hair originates
  - vascular tissue (papilla) in bulb provides nutrients

• Texture and shape of hair
  - straight hair = round, wavy = oval

• Hair color = pigment in cells of cortex
Characteristics and structure of follicle

- Epithelial root sheath
- Connective tissue root sheath
- Hair receptors entwine each follicle
- Piloerector muscle
  - goose bumps
Hair and hair follicles: complex
Derived from epidermis and dermis
Everywhere but palms, soles, nipples, parts of genitalia

*“arrector pili” is smooth muscle

Hair bulb: epithelial cells surrounding papilla

Hair papilla is connective tissue
Hair

- just as basal layer of epidermis forms layers of epidermis that get pushed to surface as dead skin on surface sheds, basal cells of hair bulb divide and push cells outward in the hair root and shaft as the hair grows.
- **medulla** forms the central core of hair, which is surrounded by cortex, a layer of compressed, keratinized cells that is covered by an outer layer of very hard, keratinized cells known as the cuticle.
- these layers are depicted in a longitudinal cross-section of the hair follicle, although not all hair has a medullary layer [hair texture (straight, curly) is determined by the shape and structure of the cortex, and to the extent that it is present, the medulla. The shape and structure of these layers are, in turn, determined by the shape of the hair follicle].
- hair growth begins with production of keratinocytes by basal cells of hair bulb: as new cells are deposited at hair bulb, hair shaft is pushed through the follicle toward surface: keratinization is completed as cells are pushed to skin surface to form shaft of hair that is externally visible [external hair is completely dead and composed entirely of keratin, for this reason, hair does not have sensation, and furthermore, hair can be cut or shaved without damaging hair structure because cut is superficial]
Hair

wall of hair follicle = made of 3 concentric layers of cells:

1. **cells of the internal root sheath** surround the root of the growing hair and extend just up to the hair shaft: they are derived from the basal cells of the hair matrix.

2. **external root sheath**, which is an extension of the epidermis, encloses the hair root: it is made of basal cells at the base of the hair root and tends to be more keratinous in the upper regions.

3. **glassy membrane** = thick, clear connective tissue sheath covering the hair root, connecting it to the tissue of the dermis.
Hair: histology

**FIGURE 12.4** Hair follicle: bulb of the hair follicle, sweat gland, sebaceous gland, and arrector pili muscle. Stain: hematoxylin and eosin. Medium magnification.
Hair functions

- variety of functions, including protection, sensory input, thermoregulation, and communication [for example, hair on head protects skull from sun; hair in the nose and ears, and around the eyes (eyelashes) defends the body by trapping and excluding dust particles that may contain allergens and microbes; hair of the eyebrows prevents sweat and other particles from dripping into and bothering the eyes].

- Hair also has a sensory function due to sensory innervation by a hair root plexus surrounding the base of each hair follicle [extremely sensitive to air movement or other disturbances in the environment, much more so than the skin surface; also useful for the detection of the presence of insects or other potentially damaging substances on the skin surface].

- Each hair root is connected to a smooth muscle called the arrector pili that contracts in response to nerve signals from the sympathetic nervous system, making the external hair shaft “stand up” [primary purpose for this is to trap a layer of air to add insulation: visible in humans as goose bumps and even more obvious in animals, such as when a frightened cat raises its fur; much more obvious in organisms with a heavier coat than most humans, such as dogs and cats].
Hair functions

• Body hair (too thin to provide warmth)
  - alert us to parasites crawling on skin

• Scalp hair
  - heat retention and sunburn cover

• Beard, pubic and axillary hair indicate sexual maturity and help distribute sexual scents

• Guard hairs and eyelashes
  - prevent foreign objects from getting into nostrils, ear canals or eyes

• Expression of emotions with eyebrows
Hair grows and is eventually shed and replaced by new hair. This occurs in 3 phases:

1. **anagen phase** = during which cells divide rapidly at the root of the hair, pushing the hair shaft up and out: length of this phase is measured in yrs, typically from 2 to 7 yrs.

2. **catagen phase** = lasts only 2 to 3 weeks, and marks a transition from the hair follicle’s active growth.

3. **telogen phase** = hair follicle is at rest and no new growth occurs: at the end of this phase, which lasts about 2 to 4 months, another anagen phase begins. The basal cells in the hair matrix then produce a new hair follicle, which pushes the old hair out as the growth cycle repeats itself.

Hair typically grows at the rate of 0.3 mm per day during the anagen phase. On average, 50 hairs are lost and replaced per day. Hair loss occurs if there is more hair shed than what is replaced and can happen due to hormonal or dietary changes. Hair loss can also result from the aging process, or the influence of hormones.
Hair Growth

- **Hair cycle = 3 repeating cycles**
  - anagen is growth stage (90% of scalp follicles)
    - lasts 6-8 years in young adult
  - catagen is shrinking follicle (lasts 2-3 weeks)
  - telogen is resting stage (lasts 1-3 months)

- **Thinning or baldness = alopecia**

- **Pattern baldness = genetic and hormonal**
  - sex-influenced trait (dominant in males, recessive in females); expressed only with high testosterone levels

- **Hirsutism = excessive hair growth**
  - hormone imbalance (ovary or adrenal cortex problem)
Hair Color

Similar to the skin, hair gets its color from the pigment melanin, produced by melanocytes in the hair papilla. Different hair color results from differences in the type of melanin, which is genetically determined. As a person ages, the melanin production decreases, and hair tends to lose its color and becomes gray and/or white.

Basis of Hair Color and Texture
Hair Color

Brunette

Eumelanin pigment colors brown and black hair.
Blonde hair contain pheomelanin pigment, but little eumelanin.
Hair Color

Red

Red hair contains little eumelanin but lots of pheomelanin.
White hair = air in medulla and lack of pigment in cortex. Gray hair is a mixture of white and pigmented hairs.
Nails

- **nail bed** = specialized structure of epidermis that is found at tips of fingers and toes.
- **nail body** is formed on the nail bed, and protects the tips of our fingers and toes as they are the farthest extremities and the parts of the body that experience the maximum mechanical stress; in addition, the nail body forms a back-support for picking up small objects with the fingers; it is composed of densely packed dead keratinocytes.

The epidermis in this part of the body has evolved a specialized structure upon which nails can form. The nail body forms at the **nail root**, which has a matrix of proliferating cells from the stratum basale that enables the nail to grow continuously. The lateral nail fold overlaps the nail on the sides, helping to anchor the nail body. The nail fold that meets the proximal end of the nail body forms the **nail cuticle**, also called the **eponychium**. The nail bed is rich in blood vessels, making it appear pink, except at the base, where a thick layer of epithelium over the nail matrix forms a crescent-shaped region called the **lunula** (the “little moon”). The area beneath the free edge of the nail, furthest from the cuticle, is called the **hyponychium**. [consists of a thickened layer of stratum corneum].

![Nail Diagram]

**Diagram Notes:**
- Free edge
- Nail
- Lateral nail fold
- Lunula
- Eponychium
- Proximal nail fold
- Eponychium
- Proximal nail fold
- Epidermis
- Dermis
- Phalanx
- Hyponychium
- Nail root
- Lunula
- Nail body
Nails

- Of hard keratin
- Corresponds to hooves and claws
- Grows from nail matrix
Nail Structure

- Nail body
- Free edge
- Nail root
  - Matrix
- Lunula (moon)
Nail

- Derivative of stratum corneum
  - densely packed cells filled with hard keratin
- Flat nails allow for fleshy, sensitive fingertips
- Growth rate is 1 mm per week
  - new cells added by mitosis in the nail matrix
  - nail plate is visible part of nail
    - medical diagnosis of iron deficiency = concave nails
Cutaneous Glands

(a) Apocrine gland

(b) Merocrine gland

(c) Sebaceous gland
Sweat Glands

When the body becomes warm, sudoriferous glands produce sweat to cool the body.

- Sweat glands develop from epidermal projections into the dermis and are classified as merocrine glands; that is, the secretions are excreted by exocytosis through a duct without affecting the cells of the gland.

- There are 2 types of sweat glands, each secreting slightly different products:
1. **eccrine sweat gland** is type of gland that produces a hypotonic sweat for thermoregulation. These glands are found all over the skin’s surface, but are especially abundant on the palms of the hand, the soles of the feet, and the forehead. They are coiled glands lying deep in the dermis, with the duct rising up to a pore on the skin surface, where the sweat is released. This type of sweat, released by exocytosis, is hypotonic and composed mostly of water, with some salt, antibodies, traces of metabolic waste, and dermicidin, an antimicrobial peptide. Eccrine glands are a primary component of thermoregulation in humans and thus help to maintain homeostasis.
2. **apocrine sweat gland** is usually associated with hair follicles in densely hairy areas, such as armpits and genital regions. Apocrine sweat glands are larger than eccrine sweat glands and lie deeper in dermis, sometimes even reaching hypodermis, with duct normally emptying into hair follicle. In addition to water and salts, apocrine sweat includes organic compounds that make the sweat thicker and subject to bacterial decomposition and subsequent smell. The release of this sweat is under both nervous and hormonal control, and plays a role in the poorly understood human pheromone response. [Most commercial antiperspirants use an aluminum-based compound as their primary active ingredient to stop sweat. When the antiperspirant enters the sweat gland duct, the aluminum-based compounds precipitate due to a change in pH and form a physical block in the duct, which prevents sweat from coming out of the pore].
Sweat Glands

- Filtrate of plasma and some waste products
  - 500 ml of insensible perspiration/day
  - sweating with visible wetness is diaphoresis
- Merocrine glands is simple tubular gland
  - millions of them help cool the body
- Apocrine glands produce sweat containing fatty acids
  - found only near hair follicles and respond to stress and sex
  - bromhidrosis is body odor produced by bacterial action on fatty acids
Sweat Glands

- Entire skin surface except nipples and part of external genitalia
- Prevent overheating
- 500 cc to 12 l/day! (is mostly water)
- Humans most efficient (only mammals have)
- Produced in response to stress as well as heat
Sweat Glands

- **Eccrine or merocrine**
  - Most numerous
  - True sweat: 99% water, some salts, traces of waste
  - Open through pores

- **Apocrine**
  - Axillary, anal and genital areas only
  - Ducts open into hair follicles
  - The organic molecules in it decompose with time – odor

- **Modified apocrine glands**
  - Ceruminous – secrete earwax
  - Mammary – secrete milk
Ceruminous Glands

- Found only in external ear canal
- Their secretion combines with sebum to produce earwax
  - waterproof keeps eardrum flexible
  - bitterness repels mites and other pests
Apocrine sweat gland: histology

**FIGURE 12.8** Apocrine sweat gland: secretory and excretory portions of the sweat gland. Stain: hematoxylin and eosin. Medium magnification.
Eccrine sweat gland: histology

FIGURE 12.9  Cross section and three-dimensional appearance of an eccrine sweat gland. Stain: hematoxylin and eosin. Low magnification.
Sebaceous Glands

= a type of oil gland that is found all over the body and helps to lubricate and waterproof skin and hair. Most sebaceous glands are associated with hair follicles. They generate and excrete sebum, a mixture of lipids, onto skin surface, thereby naturally lubricating the dry and dead layer of keratinized cells of the stratum corneum, keeping it pliable. The fatty acids of sebum also have antibacterial properties, and prevent water loss from the skin in low-humidity environments. The secretion of sebum is stimulated by hormones, many of which do not become active until puberty. Thus, sebaceous glands are relatively inactive during childhood.

- Oily secretion called sebum that contains broken-down cells
  - lanolin in skin creams is sheep sebum
- Flask-shaped gland with duct that opens into hair follicle
- Entire body except palms and soles
- Produce sebum by holocrine secretion
- Oils and lubricates

(a) Sectioned sebaceous gland
Functions of Integumentary System

The skin and accessory structures perform a variety of essential functions, such as:

- protecting the body from invasion by microorganisms, chemicals, and other environmental factors;
- preventing dehydration;
- acting as a sensory organ;
- modulating body temperature and electrolyte balance;
- and synthesizing vitamin D.

The underlying hypodermis has important roles in storing fats, forming a “cushion” over underlying structures, and providing insulation from cold temperatures.
Functions of Integumentary System

- Resistance to trauma and infection
  - packed with keratin and linked by desmosomes
  - acid mantle (pH 4-6)
- Barrier to ultraviolet light
- Vitamin D synthesis
- Sensory receptors
- Thermoreceptors through sweating
- Nonverbal communication
Protection

The skin protects the rest of the body from the basic elements of nature such as wind, water, and UV sunlight. It acts as a protective barrier against water loss, due to the presence of layers of keratin and glycolipids in the stratum corneum. It also is the first line of defense against abrasive activity due to contact with grit, microbes, or harmful chemicals. Sweat excreted from sweat glands deters microbes from over-colonizing the skin surface by generating dermicidin, which has antibiotic properties.
Sensory Function

- Feeling an ant crawling on skin, allowing to flick it off before it bites, is because the skin, and especially the hairs projecting from hair follicles in the skin, can sense changes in the environment. The hair root plexus surrounding the base of the hair follicle senses a disturbance, and then transmits the information to the central nervous system (brain and spinal cord), which can then respond by activating the skeletal muscles of your eyes to see the ant and the skeletal muscles of the body to act against the ant.

- The skin acts as a sense organ because the epidermis, dermis, and the hypodermis contain specialized sensory nerve structures that detect touch, surface temperature, and pain. These receptors are more concentrated on the tips of the fingers, which are most sensitive to touch, especially the Meissner corpuscle (tactile corpuscle), which responds to light touch, and the Pacinian corpuscle (lamellated corpuscle), which responds to vibration. Merkel cells, seen scattered in the stratum basale, are also touch receptors. In addition to these specialized receptors, there are sensory nerves connected to each hair follicle, pain and temperature receptors scattered throughout the skin, and motor nerves innervate the arrector pili muscles and glands. This rich innervation helps us sense our environment and react accordingly.
Sensory Function: histology

FIGURE 12.11 Pacinian corpuscles in the dermis of thick skin (transverse and longitudinal sections). Stain: hematoxylin and eosin. High magnification.
Thermoregulation

- Skin helps regulate body temperature through its tight association with sympathetic nervous system, division of nervous system involved in our fight-or-flight responses. The sympathetic nervous system is continuously monitoring body temperature and initiating appropriate motor responses. Recall that sweat glands, accessory structures to the skin, secrete water, salt, and other substances to cool the body when it becomes warm. Even when the body does not appear to be noticeably sweating, approximately 500 mL of sweat (insensible perspiration) are secreted a day.

- If the body becomes excessively warm due to high temperatures, vigorous activity, or a combination of the two, sweat glands will be stimulated by sympathetic nervous system to produce large amounts of sweat, as much as 0.7 to 1.5 L per hour for an active person. When the sweat evaporates from skin surface, body is cooled as body heat is dissipated. In addition to sweating, arterioles in dermis dilate so that excess heat carried by blood can dissipate through the skin and into the surrounding environment. This accounts for skin redness that many people experience when exercising. When body temperatures drop, arterioles constrict to minimize heat loss, particularly in ends of digits and tip of nose. This reduced circulation can result in the skin taking on a whitish hue. Although temperature of the skin drops as a result, passive heat loss is prevented, and internal organs and structures remain warm. If the temperature of the skin drops too much (such as environmental temperatures below freezing), the conservation of body core heat can result in the skin actually freezing, a condition called frostbite.
Thermoregulation = during strenuous physical activities, dermal blood vessels dilate and sweat secretion increases. These mechanisms prevent the body from overheating. In contrast, the dermal blood vessels constrict to minimize heat loss in response to low temperatures.
Vitamin D Synthesis

- The epidermal layer of human skin synthesizes vitamin D when exposed to UV radiation. In the presence of sunlight, a form of vitamin D called cholecalciferol is synthesized from a derivative of the steroid cholesterol in the skin; liver converts cholecalciferol to calcidiol, which is then converted to calcitriol (active chemical form of D vitamin) in kidneys.

- Vitamin D is essential for normal absorption of calcium and phosphorous, which are required for healthy bones. The absence of sun exposure can lead to a lack of vitamin D in the body, leading to a condition called rickets, a painful condition in children where the bones are misshapen due to a lack of calcium, causing bowleggedness. Elderly individuals who suffer from vitamin D deficiency can develop a condition called osteomalacia, a softening of the bones. In present day society, vitamin D is added as a supplement to many foods, including milk and orange juice, compensating for the need for sun exposure.

- In addition to its essential role in bone health, vitamin D is essential for general immunity against bacterial, viral, and fungal infections. Recent studies are also finding a link between insufficient vitamin D and cancer.
thank you for the attention!

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