

# Chapter 05

## APR Enhanced Lecture Slides

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# Chapter 5

# Integumentary System

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# 5.1 Functions of the Integumentary System

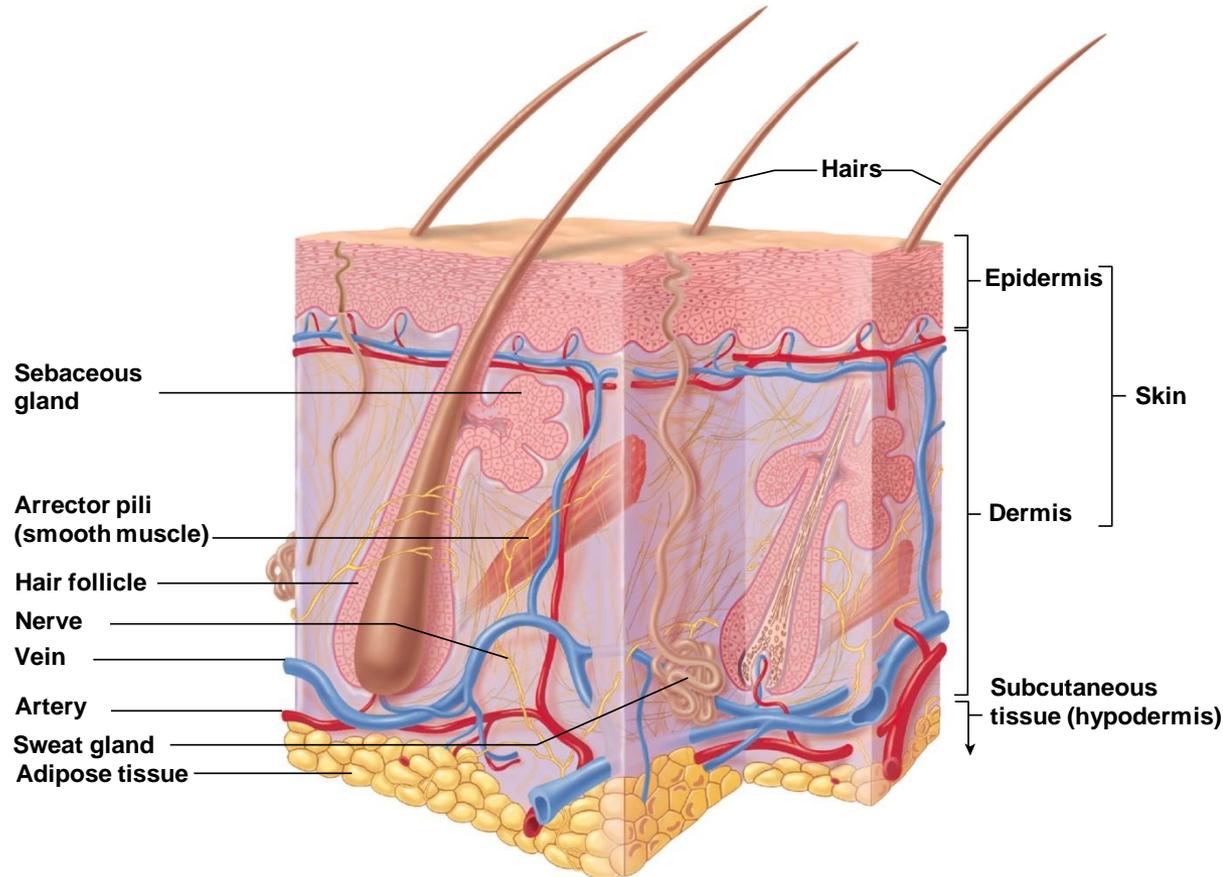
- Structures that are part of the integument

- Skin
- Hair
- Nails
- Glands

- Overview of Functions

- Protection
- Sensation
- Temperature regulation
- Vitamin D production
- Excretion
- Immunity

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# Skin of Finger



Epidermis



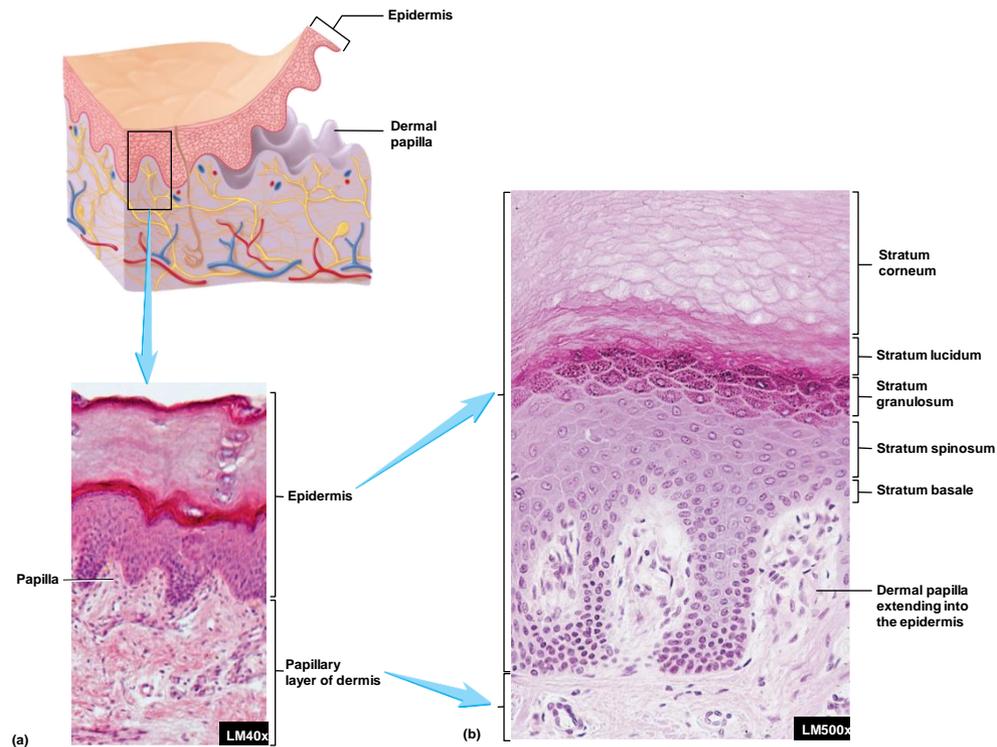
Dermis



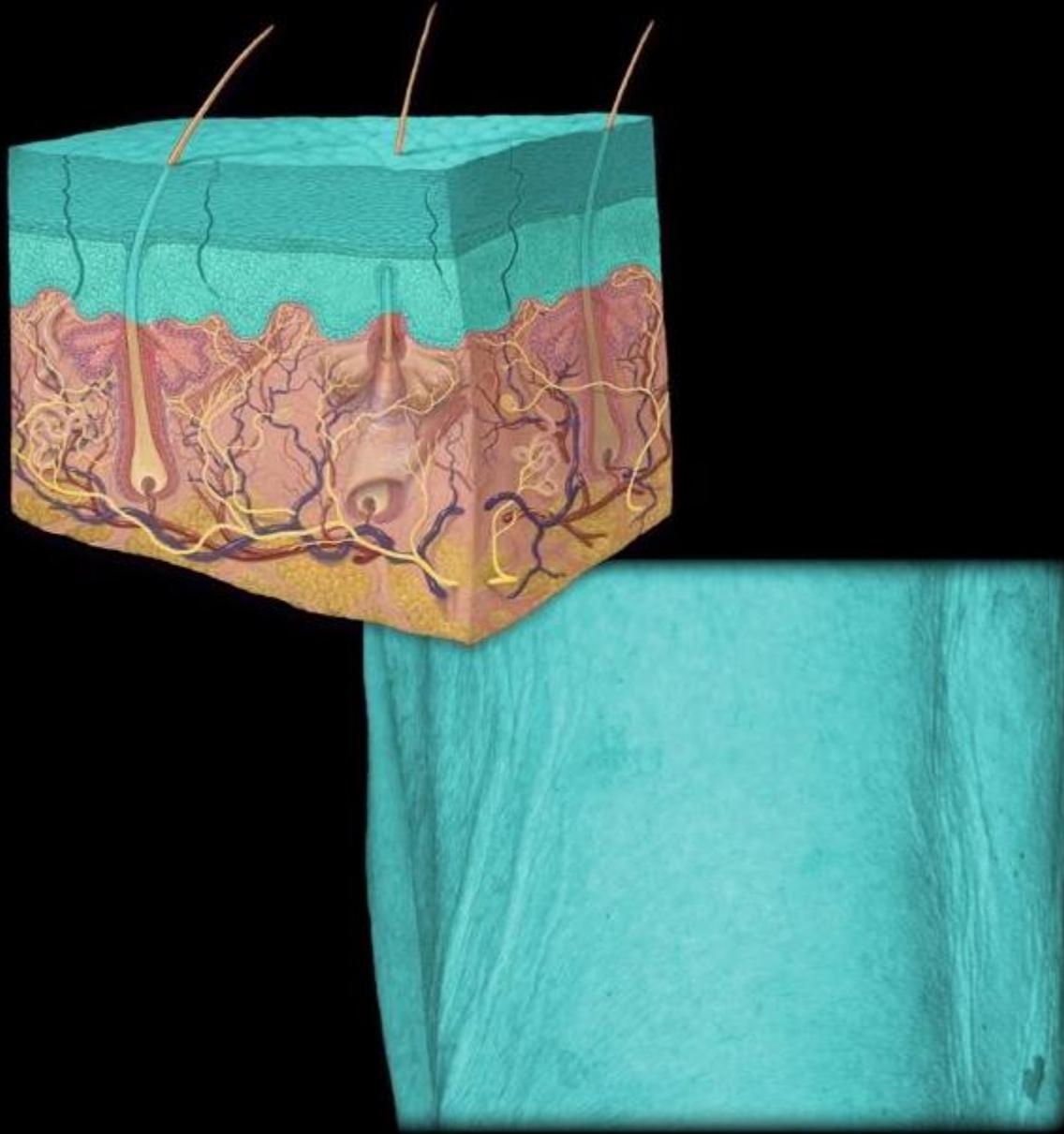
# 5.2 Skin

- **Epidermis:** Superficial layer of epithelial tissue.
- **Dermis:** Deep layer of connective tissue.
  - Structural strength
- **Subcutaneous tissue**
  - Not part of skin
  - Loose connective tissue that connects skin to underlying structures

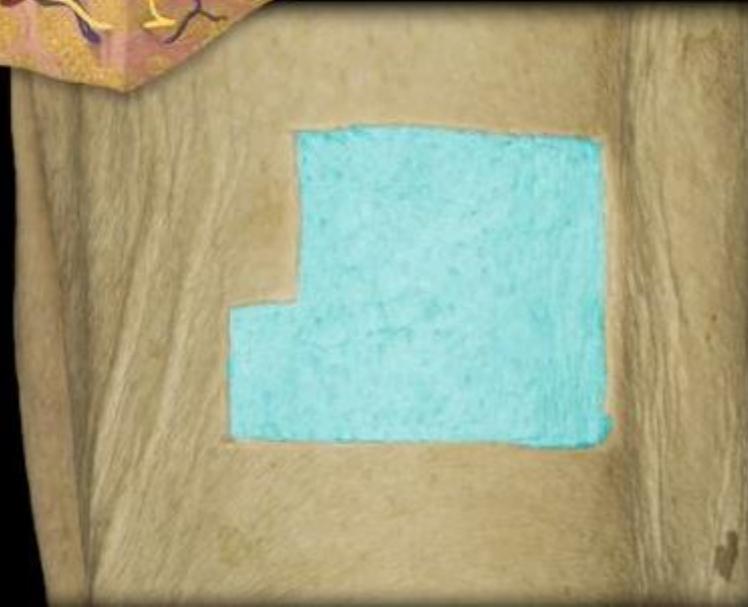
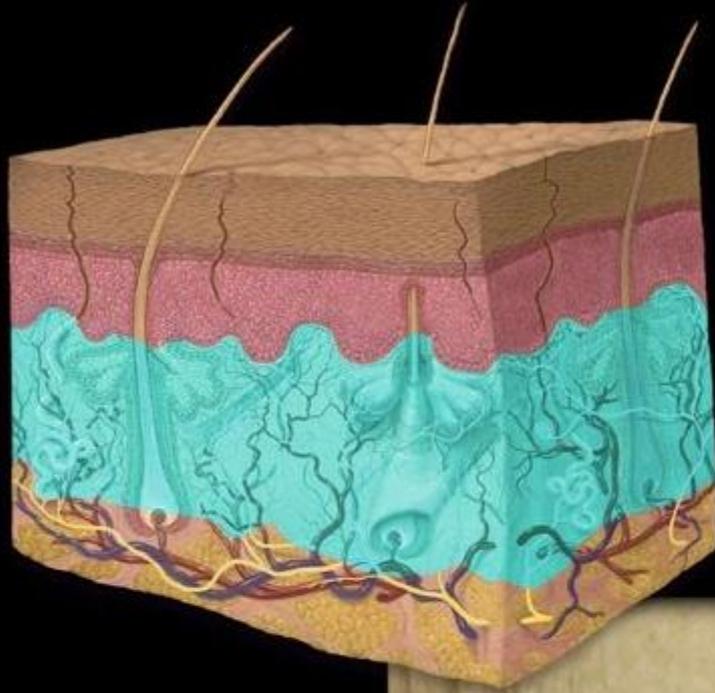
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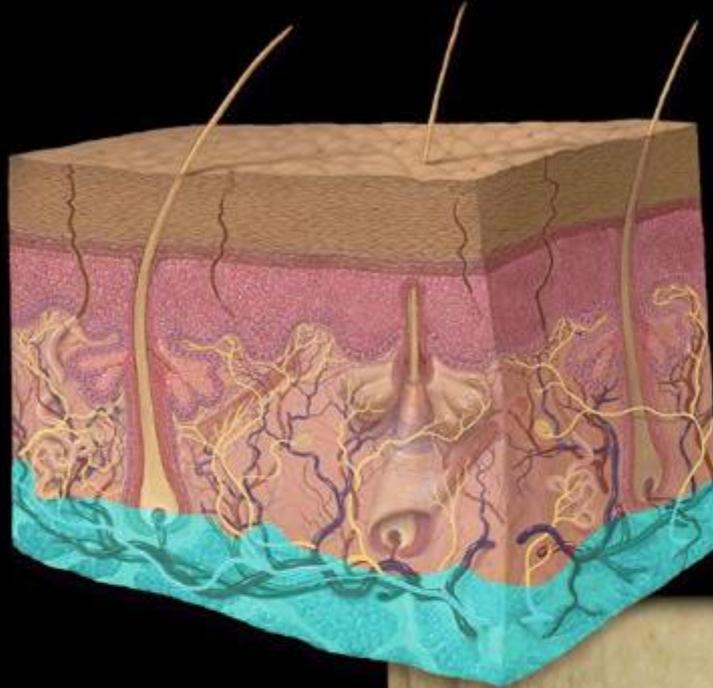
# Epidermis



# Dermis

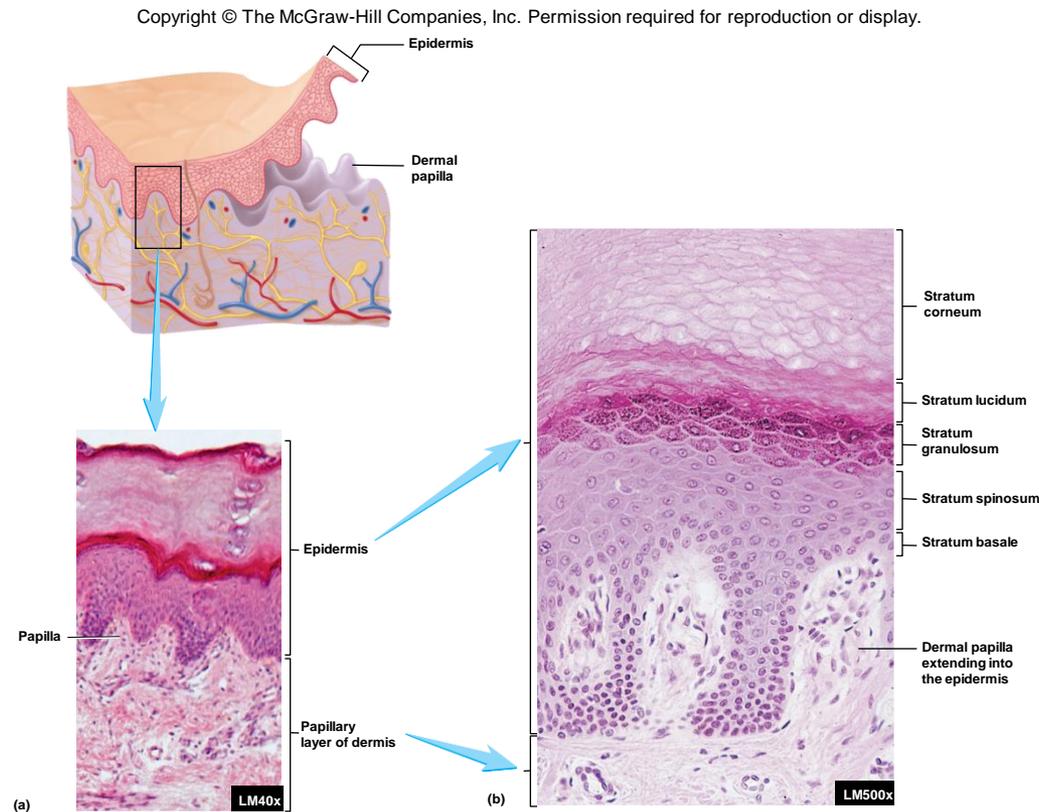


# Subcutaneous Layer

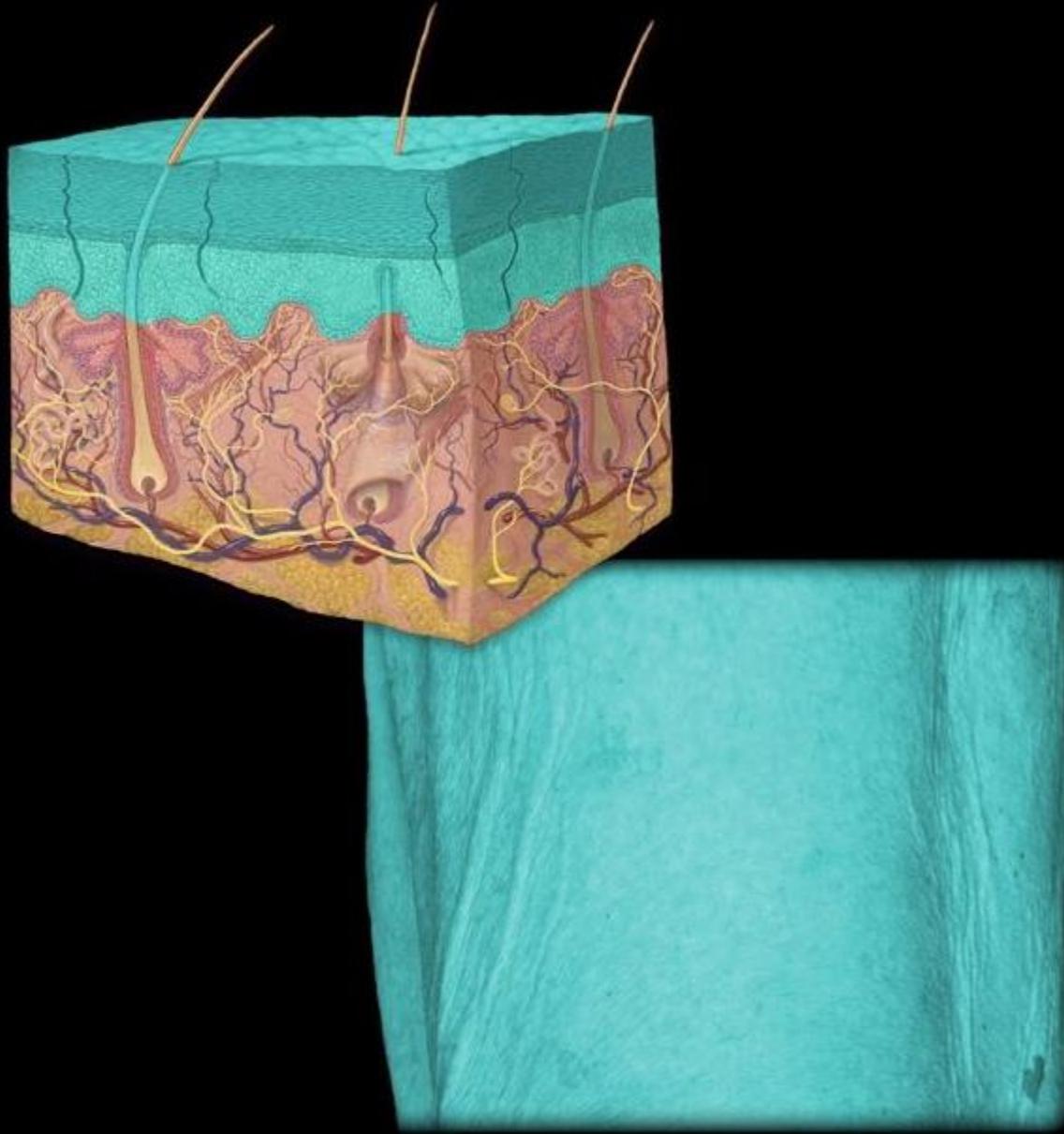


# Epidermis

- Avascular; nourished by diffusion from capillaries of the papillary layer of the dermis
- Composed of cells arranged into layers or strata.
- Separated from dermis by basement membrane



# Epidermis



# Epidermal Cells

- **Cell types**
  - **Keratinocytes**: most cells. Produce keratin for strength
  - **Melanocytes**: contribute to skin color. Melanin produced by these cells then transferred to keratinocytes. Same number of melanocytes in all people.
  - **Langerhans' cells**: part of the immune system
  - **Merkel's cells**: detect light, touch, and superficial pressure
- **Desquamate**: cells of the deeper layers undergo mitosis; as they move toward the surface, older cells slough off
- **Keratinization**: as cells move outward through the layers they fill with keratin, die, and serve as a layer that resists abrasion and forms permeability layer

# Epidermal Strata

- **Stratum basale (germinativum)**
  - Deepest portion of epidermis and single layer. High mitotic activity and cells become **keratinized**
- **Stratum spinosum**
  - Limited cell division. Desmosomes. Lamellar bodies and additional keratin fibers
- **Stratum granulosum**
  - Contains keratohyalin. In superficial layers nucleus and other organelles **degenerate** and cell dies
- **Stratum lucidum**
  - Thin, clear zone. Found only in palms and soles
- **Stratum corneum**
  - Most superficial and consists of cornified cells

# Thick Skin Low Magnification



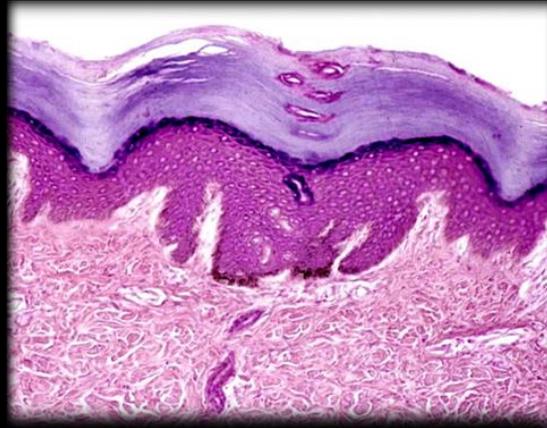
Epidermis



Dermis



Dermal papillae



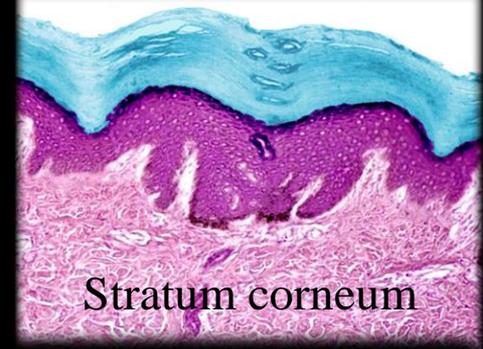
Stratum corneum



Duct of merocrine sweat gland



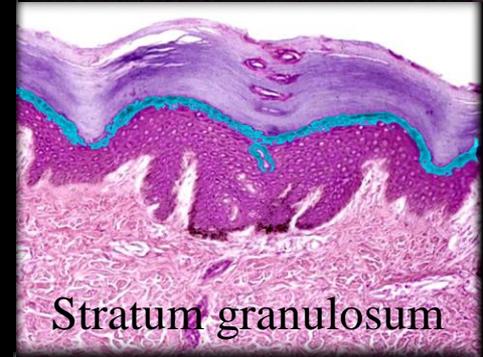
Stratum basale



Stratum lucidum

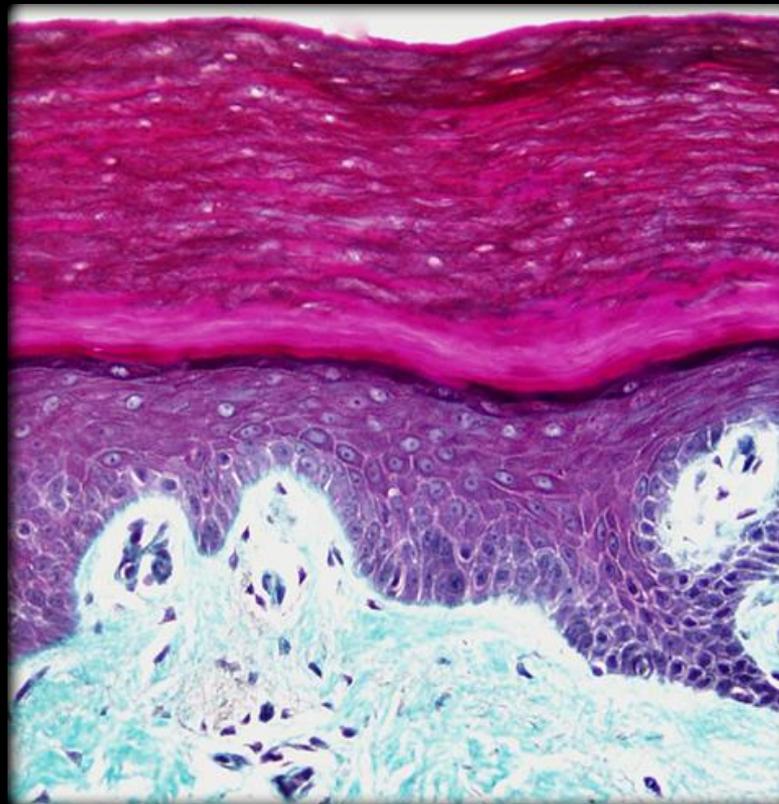
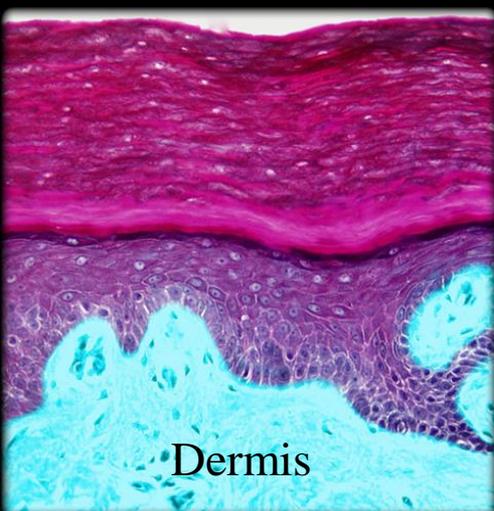
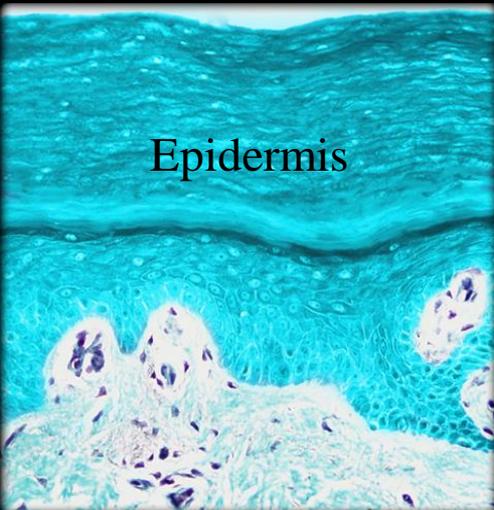


Stratum granulosum



Stratum spinosum

# Thick Skin High Magnification



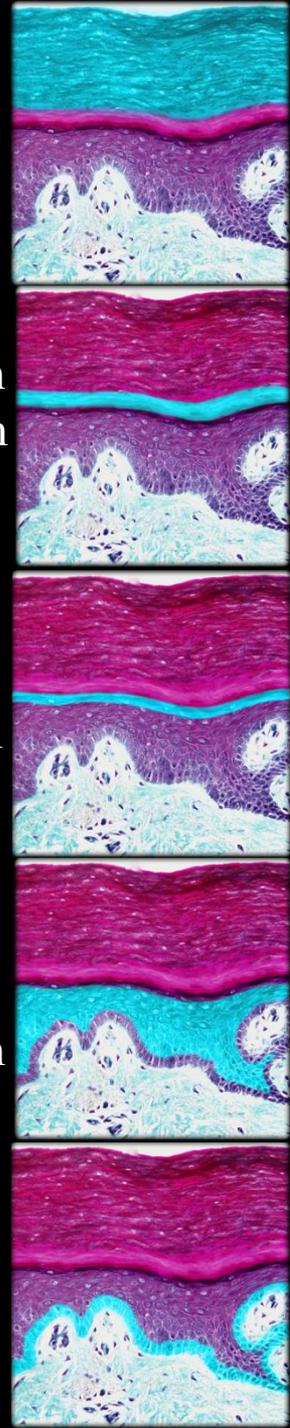
Stratum  
corneum

Stratum  
lucidum

Stratum  
granulosum

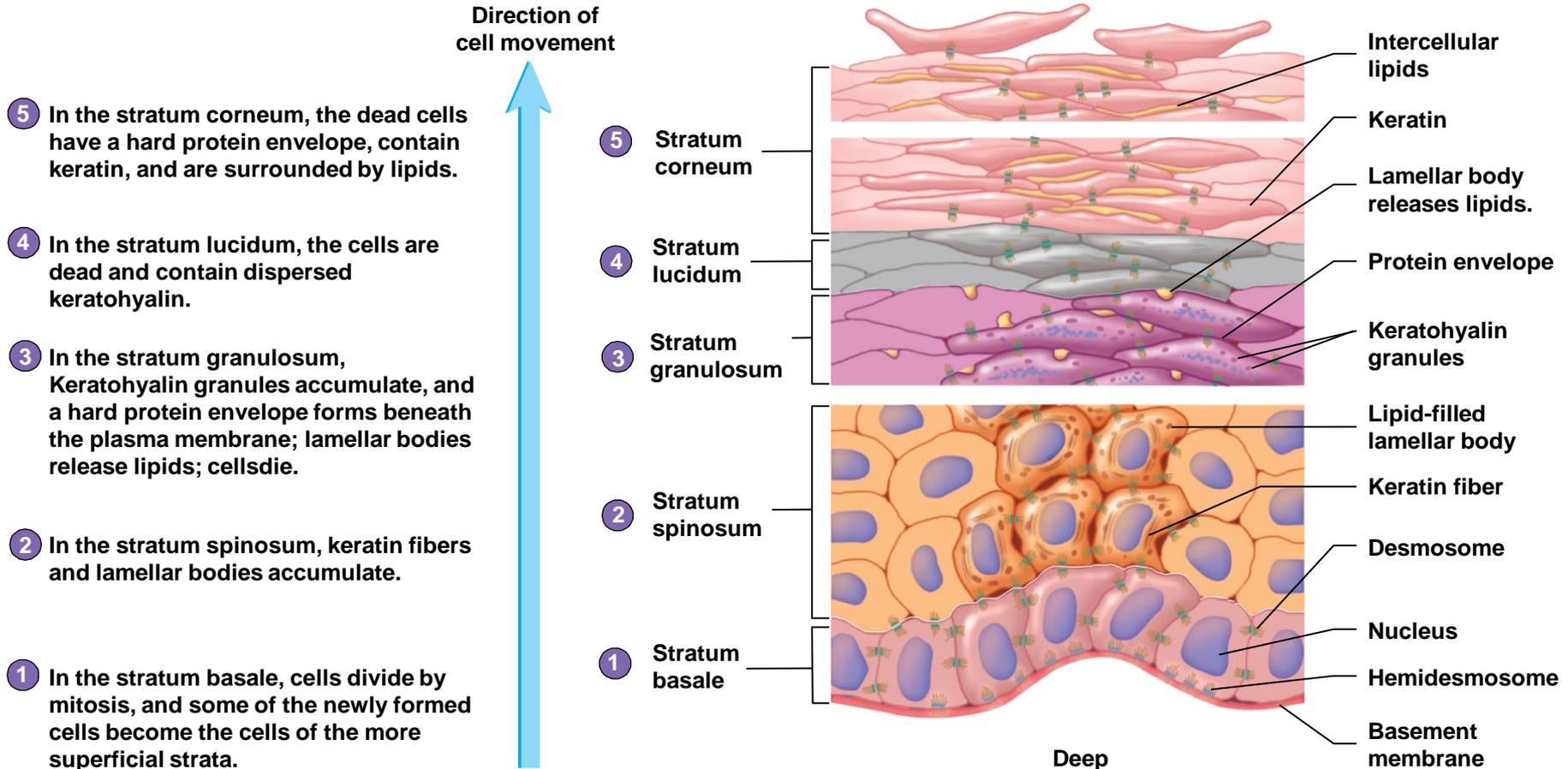
Stratum  
spinosum

Stratum  
basale



# Epidermal Layers and Keratinization

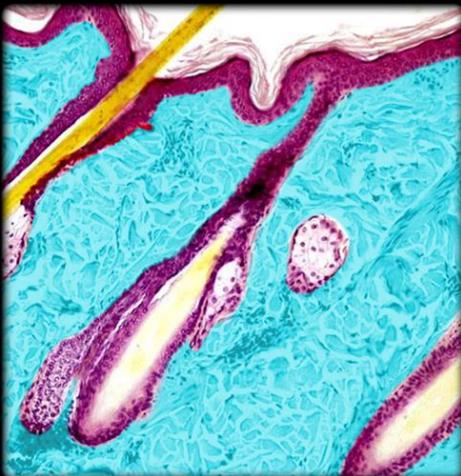
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# Thin Skin

## Low Magnification

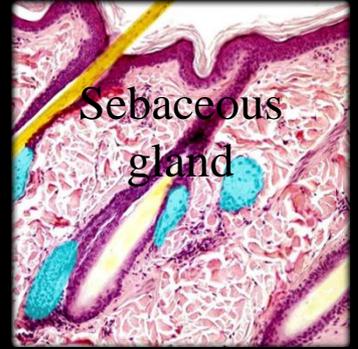
Epidermis



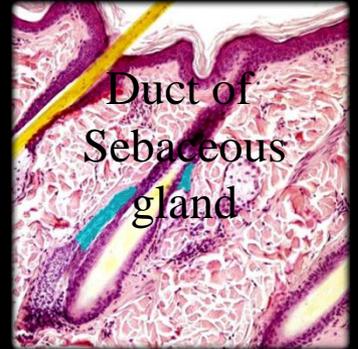
Dermis



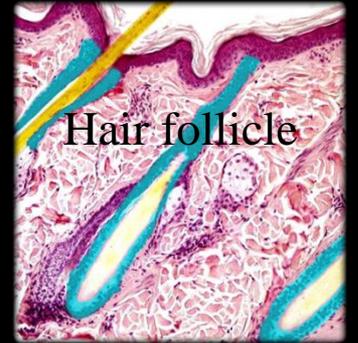
Hair



Sebaceous gland



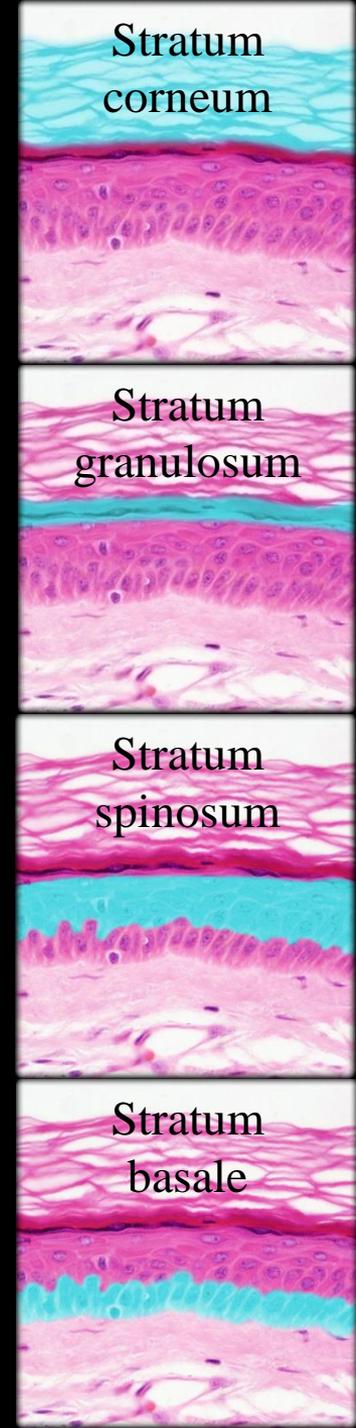
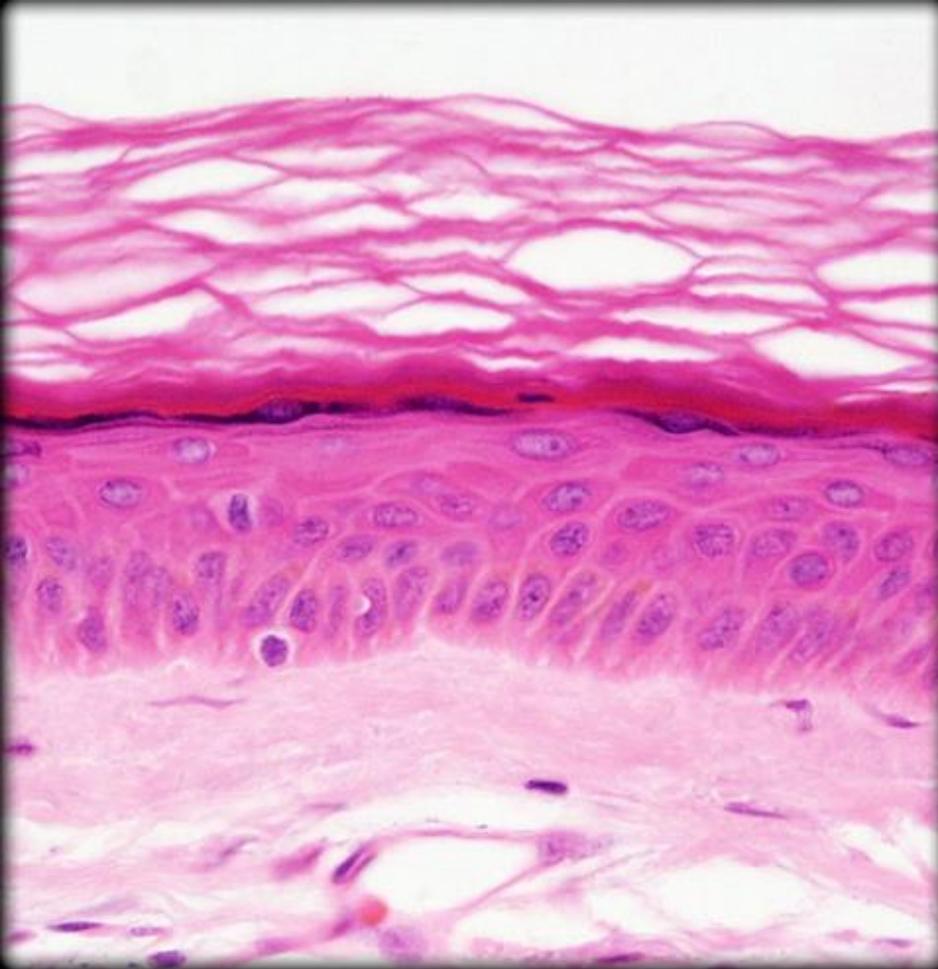
Duct of Sebaceous gland



Hair follicle

# Thin Skin

## High Magnification



**TABLE 5.1** Comparison of the Skin (Epidermis and Dermis) and Subcutaneous Tissue

Part	Structure	Function
<b>Epidermis</b>	Superficial part of skin; stratified squamous epithelium; composed of four or five strata	Prevents water loss and the entry of chemicals and microorganisms; protects against abrasion and ultraviolet light; produces vitamin D; gives rise to hair, nails, and glands
Stratum corneum	Most superficial stratum of the epidermis; 25 or more layers of dead squamous cells	Provides structural strength due to keratin within cells; prevents water loss due to lipids surrounding cells; sloughing off of most superficial cells resists abrasion
Stratum lucidum	Three to five layers of dead cells; appears transparent; present in thick skin, absent in most thin skin	Disperses keratohyalin around keratin fibers
Stratum granulosum	Two to five layers of flattened, diamond-shaped cells	Produces keratohyalin granules; lamellar bodies release lipids from cells; cells die
Stratum spinosum	A total of 8–10 layers of many-sided cells	Produces keratin fibers; lamellar bodies form inside keratinocytes
Stratum basale	Deepest stratum of the epidermis; single layer of cuboidal or columnar cells; basement membrane of the epidermis attaches to the dermis	Produces cells of the most superficial strata; melanocytes produce and contribute melanin, which protects against ultraviolet light
<b>Dermis</b>	Deep part of skin; connective tissue composed of two layers	Is responsible for the structural strength and flexibility of the skin; the epidermis exchanges gases, nutrients, and waste products with blood vessels in the dermis
Papillary layer	Papillae project toward the epidermis; loose connective tissue	Brings blood vessels close to the epidermis; dermal papillae form fingerprints and footprints
Reticular layer	Mat of collagen and elastic fibers; dense irregular connective tissue	Is the main fibrous layer of the dermis; strong in many directions; forms cleavage lines
<b>Subcutaneous tissue</b>	Not part of the skin; loose connective tissue with abundant deposits of adipose tissue	Attaches the dermis to underlying structures; adipose tissue provides energy storage, insulation, and padding; blood vessels and nerves from the subcutaneous tissue supply the dermis

# Thick and Thin Skin

- Thick skin
  - Has all 5 epithelial strata
  - Found in areas subject to pressure or friction
    - Palms of hands, fingertips, soles of feet
  - Fingerprints and footprints. Papillae of underlying dermis in parallel rows
- Thin skin
  - More flexible than thick skin
  - Covers rest of body
  - Hair grows here
- **Callus**. Increase in number of layers in stratum corneum. When this occurs over a bony prominence, a **corn** forms.

# Thick Skin



# Thin Skin



# Skin Color

Determined by 3 factors: pigments, blood circulating through the skin, thickness of stratum corneum

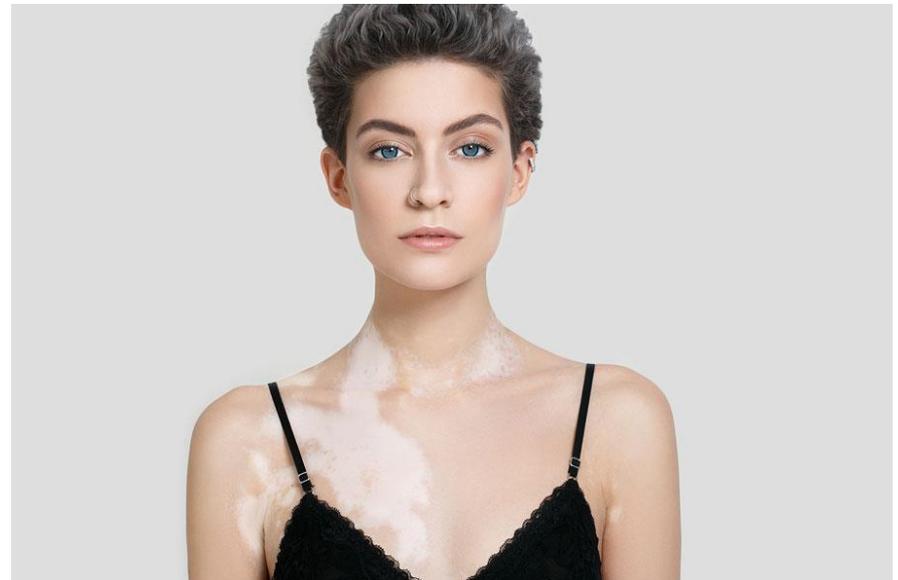
- Pigments

- **Melanin**: provides for protection against UV light. Group of chemicals derived from aa tyrosine. Colored brown to black, may be yellowish or reddish
  - **Melanocytes**. processes extend between keratinocytes.
  - **Albinism**: deficiency or absence of pigment. Production determined by genetics, hormones, exposure to light
- **Carotene**: yellow pigment. From vegetables. Accumulates in stratum corneum, in adipose cells of dermis, and in Subcutaneous tissue.
- **Lycopene**: Lycopopenia is a benign clinical entity characterized by yellowish orange pigmentation of the skin. It is caused by the deposition of lycopene. The deposits occur mainly in the stratum corneum, which has a high lipid content and hence an affinity for lycopene

- **Tinea Virsicolor:**  
Tinea versicolor is caused by an overgrowth of yeast on the skin. It most often affects teens and young adults. The condition isn't contagious



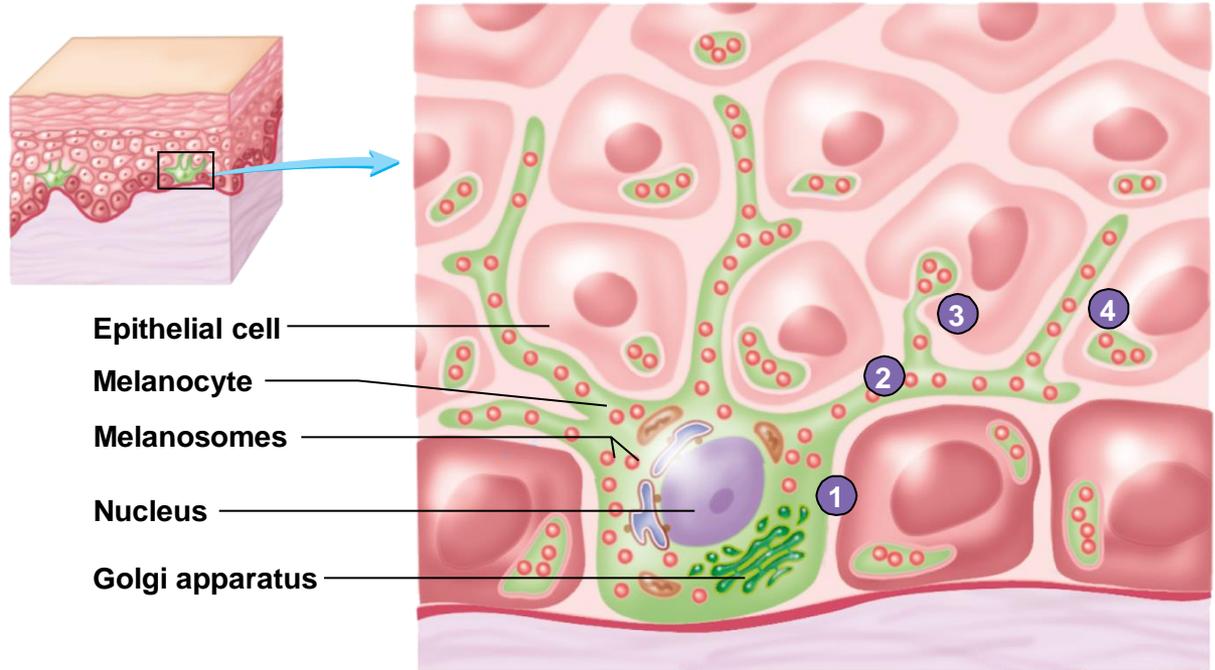
- **Vitiligo:** a skin condition whose exact cause is unknown. Patches of skin lose their pigmentation when the 'melanocytes' are attacked and destroyed. It may affect the skin, mucous membranes, eyes, inner ear or hairs leaving white patches.



# Skin Color

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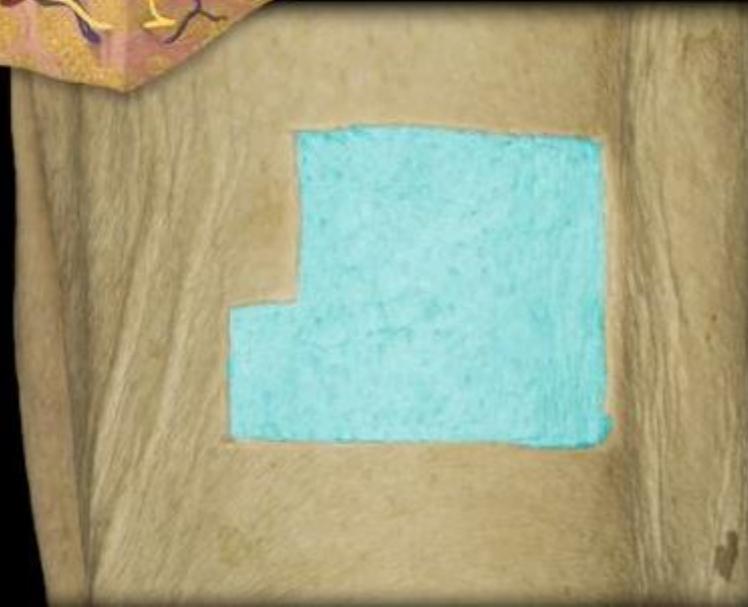
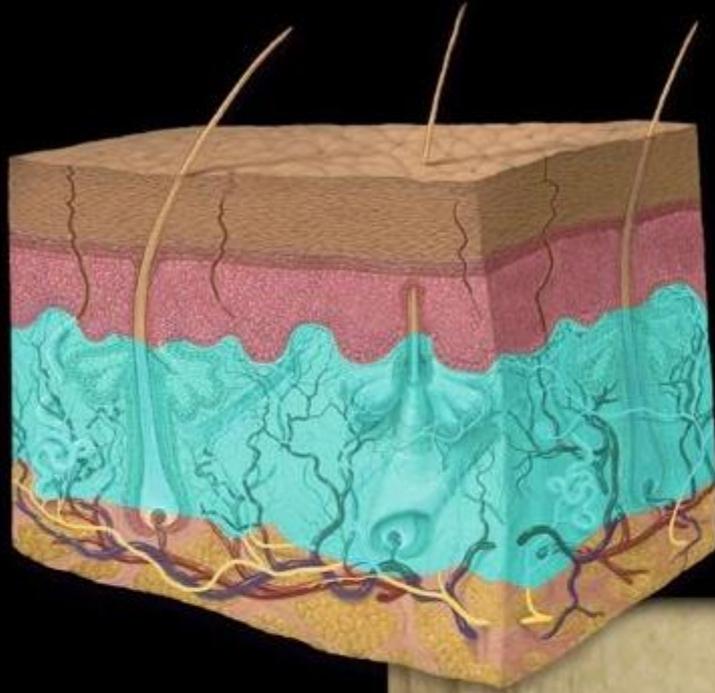
- 1 Melanosomes are produced by the Golgi apparatus of the melanocyte.
- 2 Melanosomes move into melanocyte cell processes.
- 3 Epithelial cells phagocytize the tips of the melanocyte cell processes.
- 4 The melanosomes, which were produced inside the melanocytes, have been transferred to epithelial cells and are now inside them.



# Skin Color

- Blood circulating through the skin
  - Imparts reddish hue and increases during blushing, anger, inflammation
  - **Cyanosis**: blue color caused by decrease in blood oxygen content
- Thickness of stratum corneum
  - Thicker areas can be yellowish

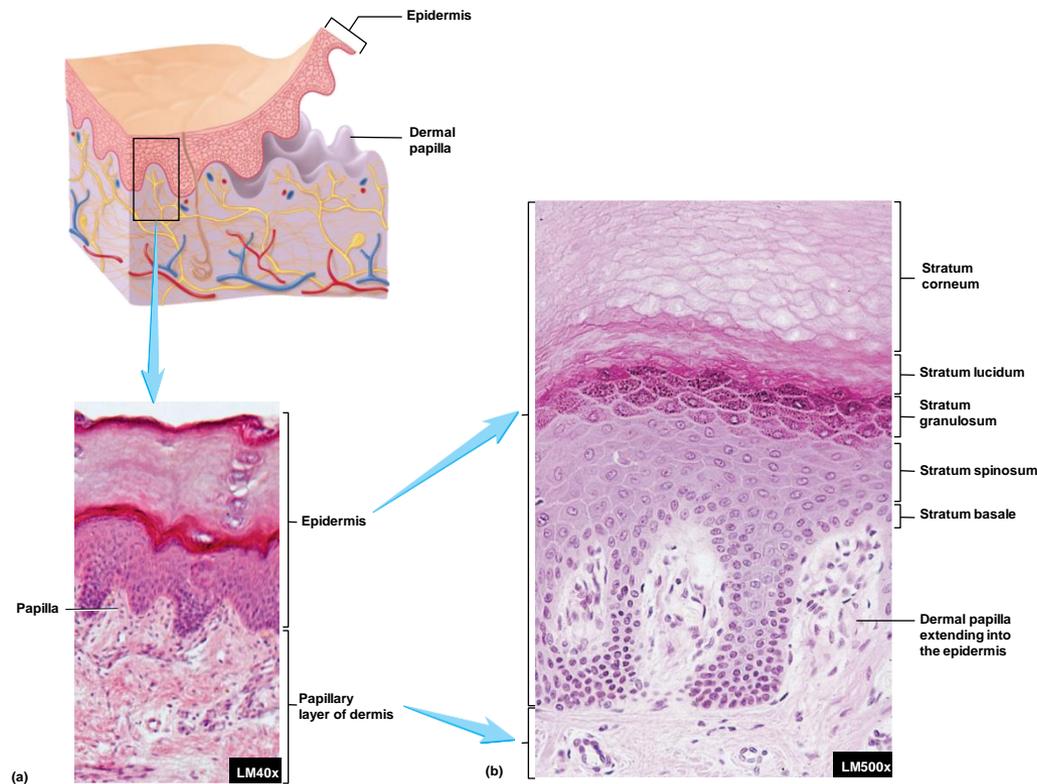
# Dermis



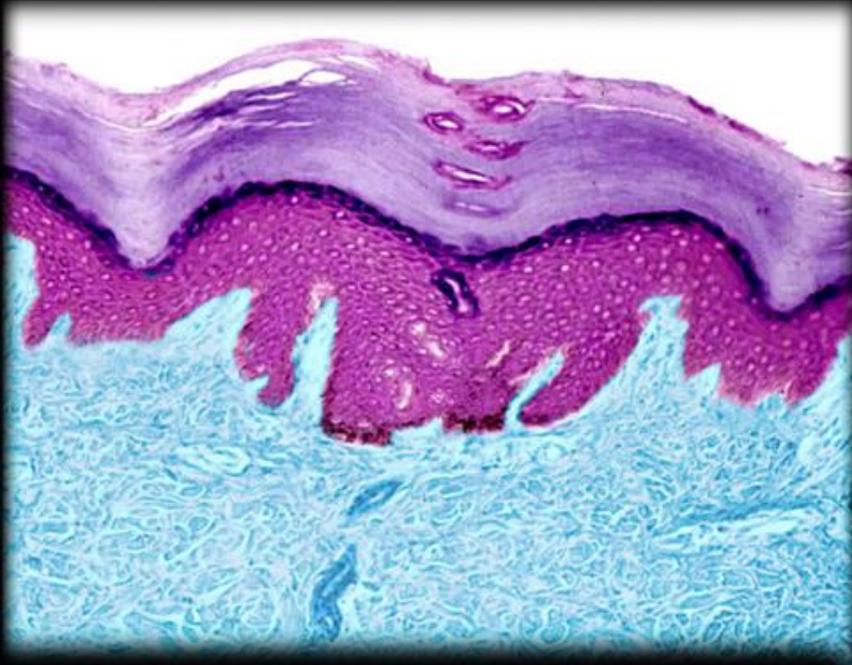
# Dermis

- Gives structural strength. C.T. with many fibers, fibroblasts, macrophages. Some adipocytes and blood vessels.
- Contains nerves, blood vessels, hair follicles, smooth muscles, glands, and lymphatic vessels.
- Sensory functions: pain, itch, tickle, temperature, touch, pressure, two-point discrimination.

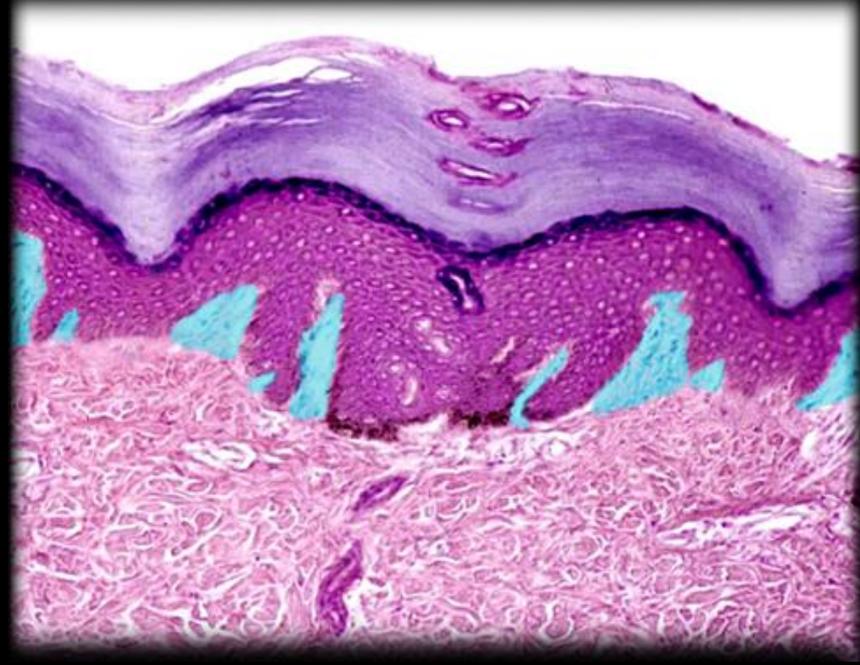
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# Dermis and Dermal Papillae



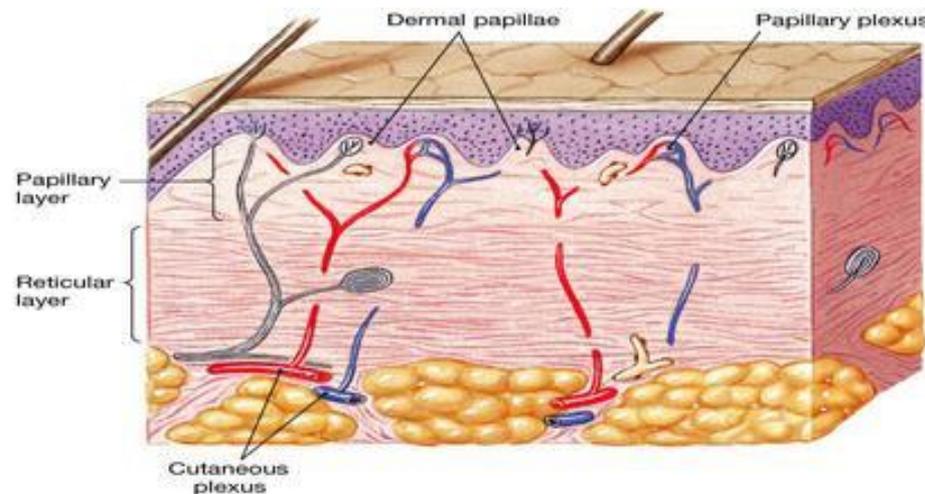
Dermis



Dermal papillae

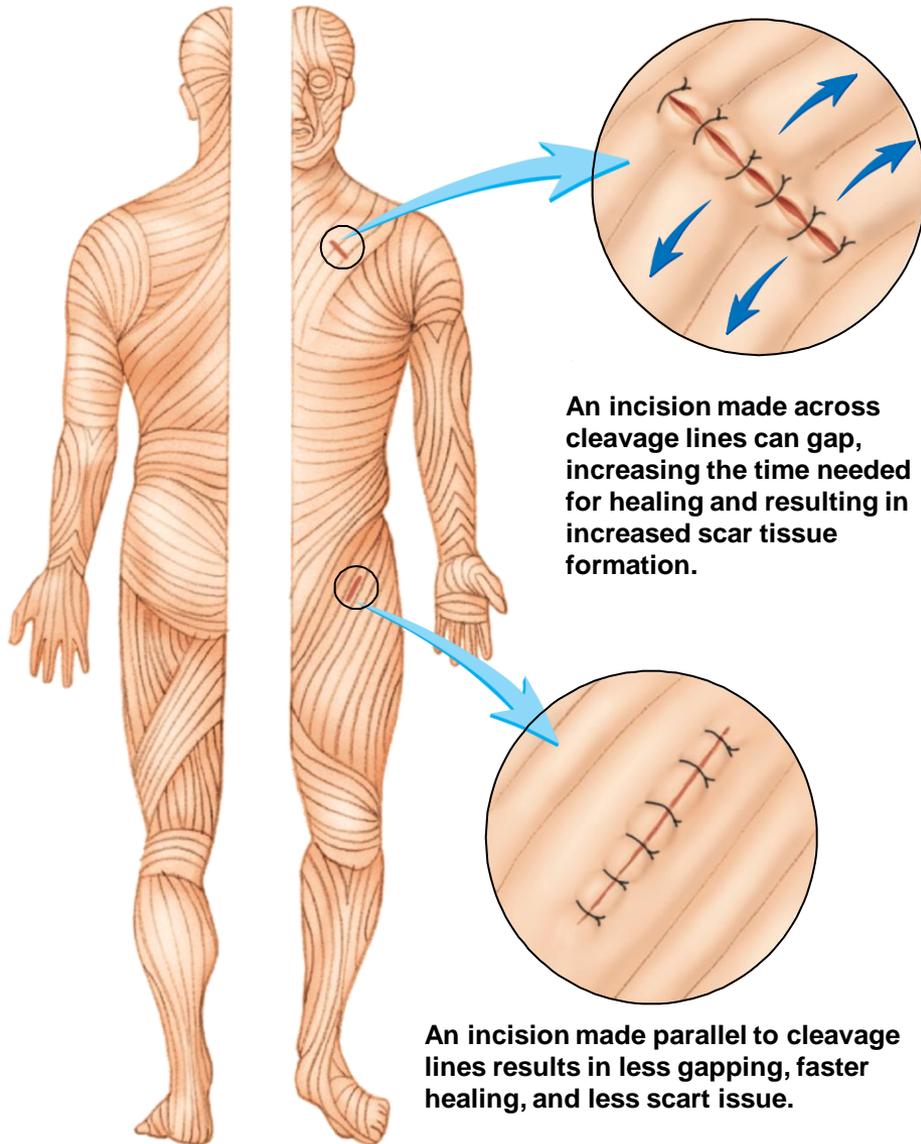
# Two Layers of the Dermis

- Two layers variable in thickness
  - **Papillary**. Superficial (outer) 1/5. Areolar with lots of elastic fibers. Dermal papillae, capillary beds. Fingerprints. Whorls of ridges. Touch receptors (Meissner's), free nerve endings sensing pain
  - **Reticular**: Deep (inner) 4/5. Dense irregular C.T. Collagen and elastic fibers. In the figure see: some adipose, hair follicles, nerves, oil glands, ducts of sweat glands, heat sensors.



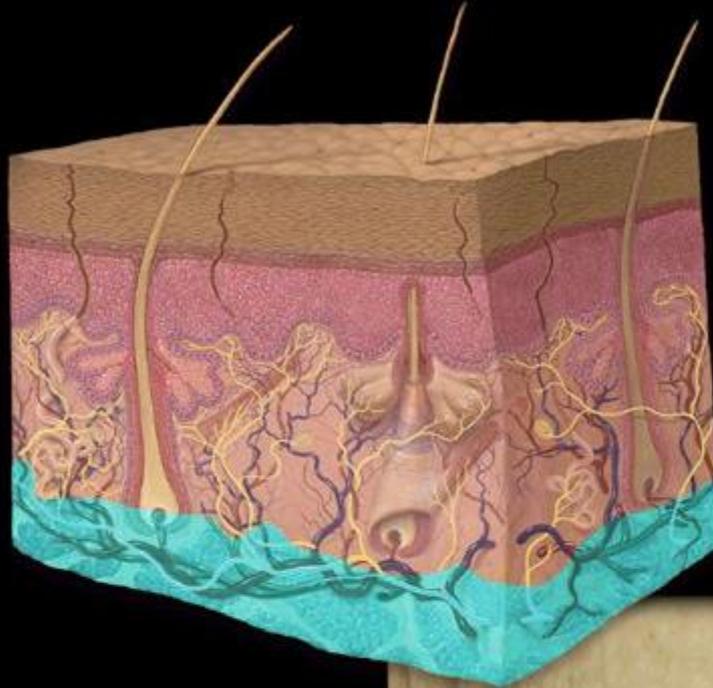
# Cleavage (Tension) Lines and Striae

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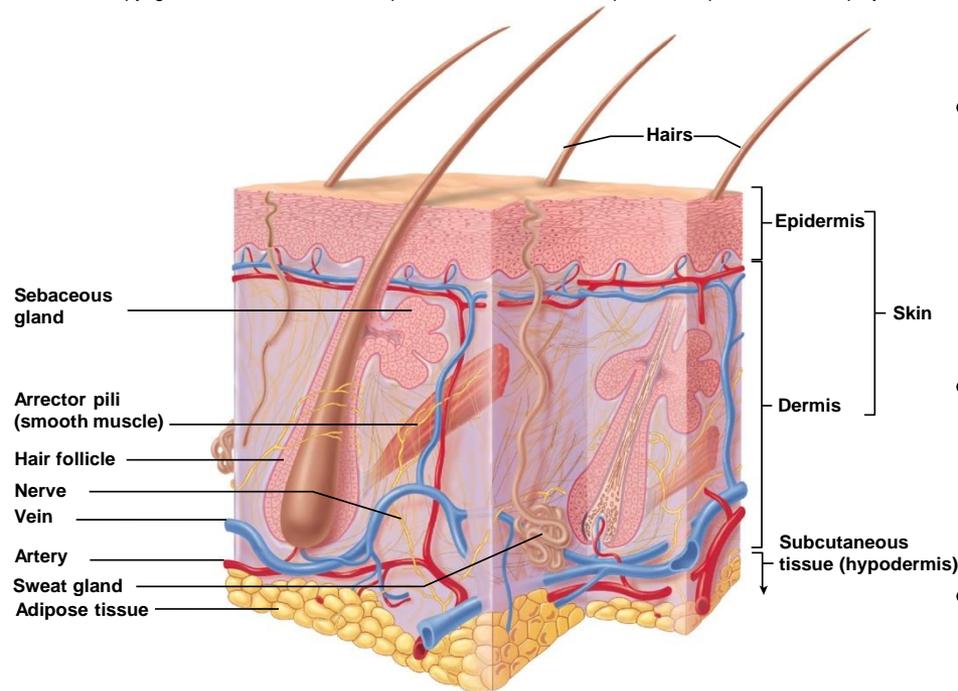
- **Cleavage (tension) lines:** elastic and collagen fibers oriented in some directions more than in others
- Important in surgery
  - If incision parallel to lines, there is less gapping, faster healing, less scar tissue
- If skin is overstretched, **striae** (stretch marks) occur
  - striae gravidarum

# Subcutaneous Layer



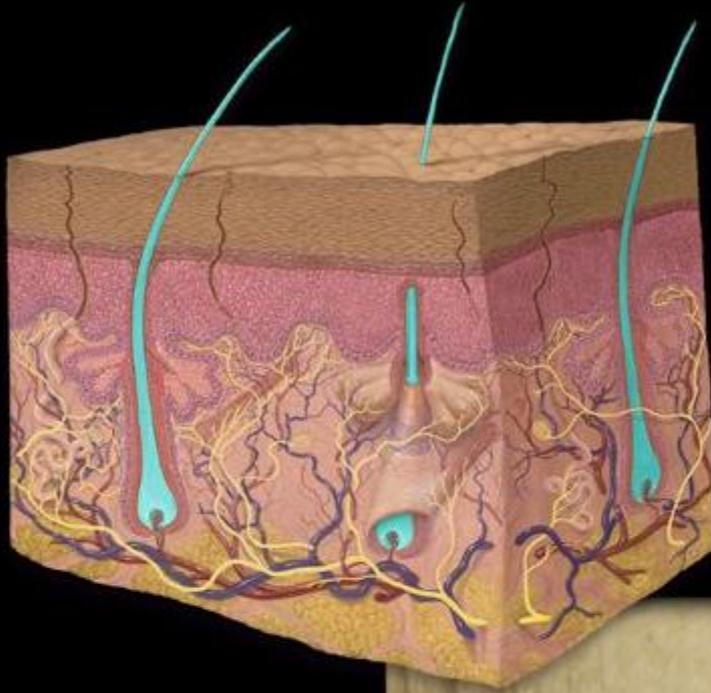
# 5.3 Subcutaneous tissue

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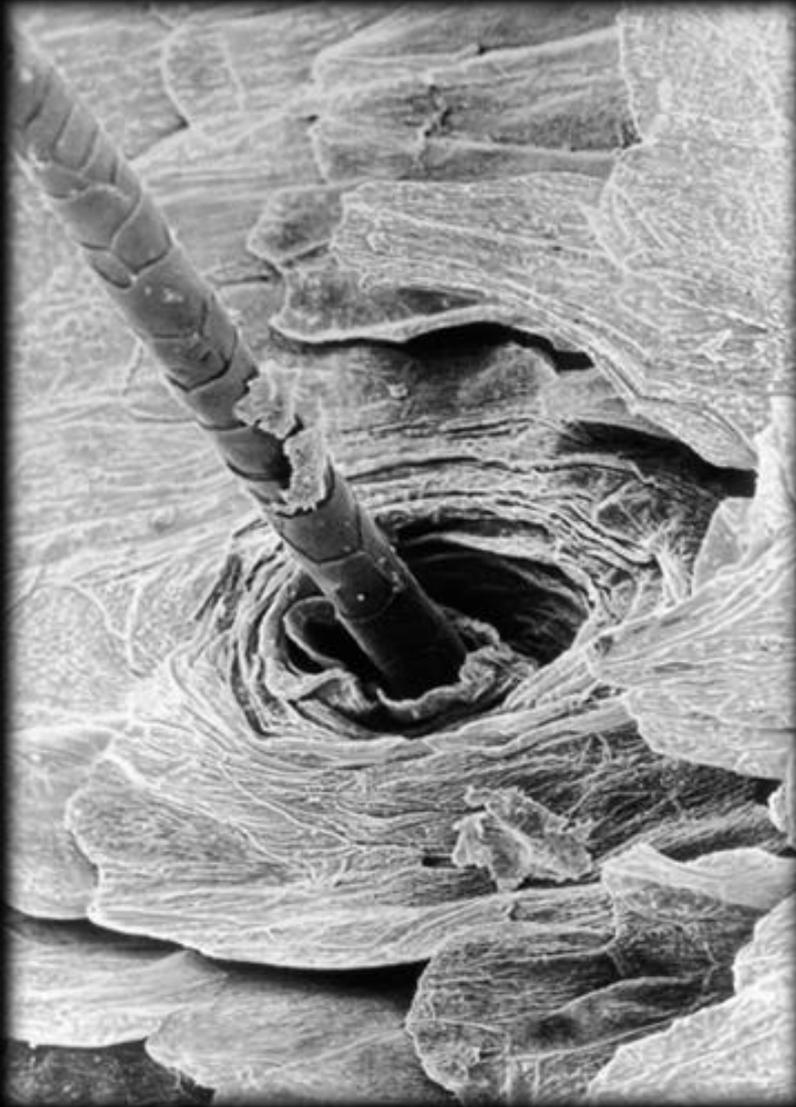
- Deep to skin
- Consists of loose connective tissue with collagen and elastic fibers
- Types of cells
  - Fibroblasts
  - Adipose cells
  - Macrophages
- Also called
  - Hypodermis
  - Superficial fascia (loose areolar)
- Contains about one-half of body's adipose tissue. Functions as
  - Energy source
  - Insulation
  - Padding

# Hair

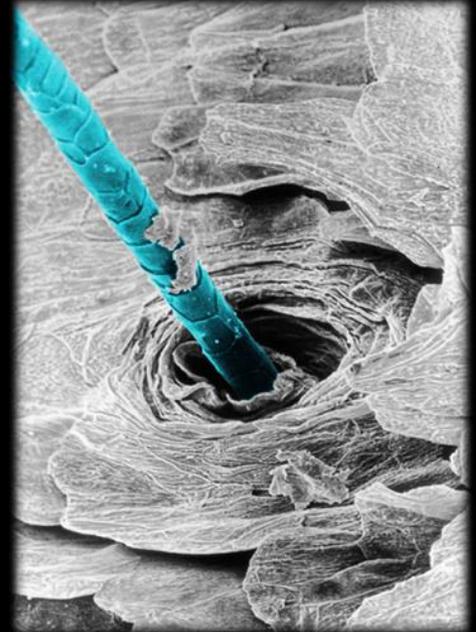




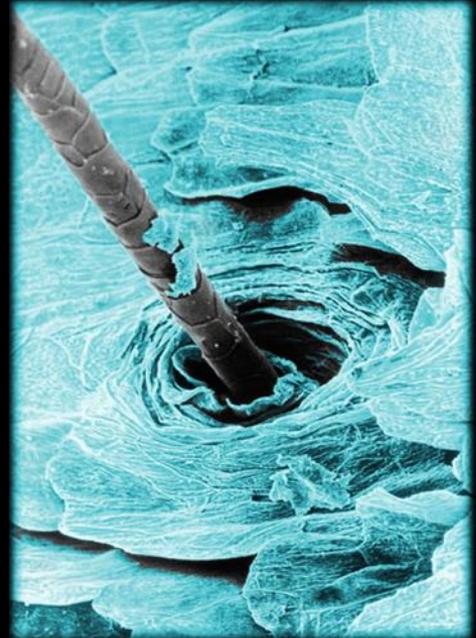
# Hair



Hair shaft

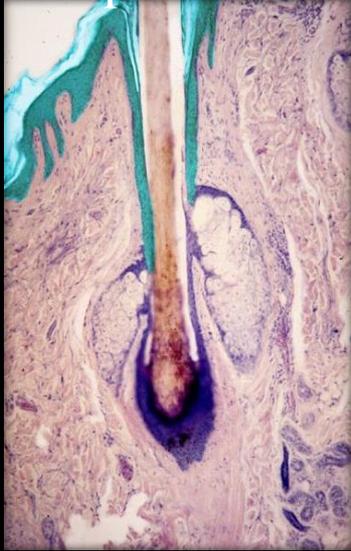


Keratinocytes



# Histology of Hair Follicle

Epidermis



Hair



Hair follicle



Sebaceous gland

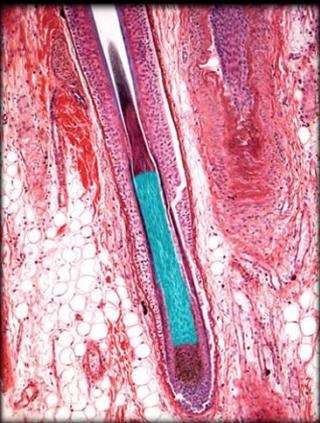


# Hair Follicle

## Medium Magnification



Cortex  
of hair



Differentiation  
zone of hair



Hair matrix



Connective  
tissue  
sheath



Glassy  
membrane



External  
root  
sheath



Internal  
root  
sheath



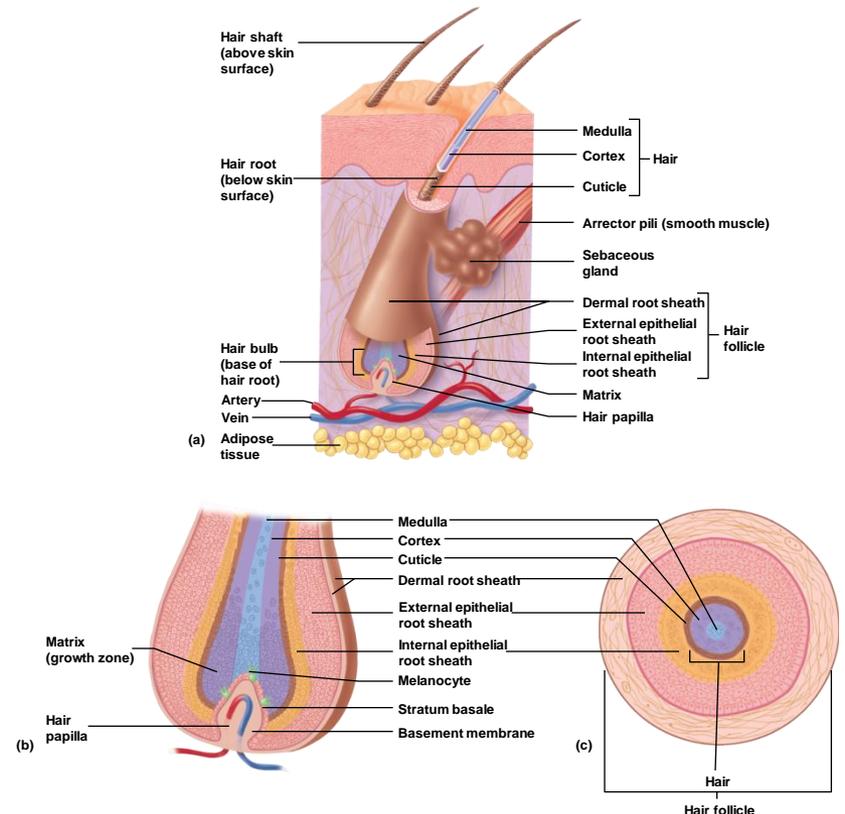
# Hair Structure

- Hair follicle
  - Dermal root sheath: part of dermis that surrounds the epithelial root sheath
  - Epithelial root sheath with internal and external parts.
    - **Internal part contains stratum basale that may remain after injury and supply a source of new epidermis**
    - **When hairs are pulled out, internal part comes out and is visible as white bulb**

- Hair bulb

- Internal matrix is source of hair
- Dermis projects into bulb and is blood supply

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# Hair Follicle High Magnification



Dermis



Internal  
root  
sheath

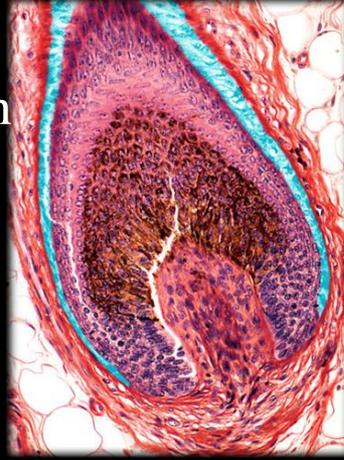


Connective  
tissue  
sheath

Hair  
matrix



External  
root sheath



Glassy  
membrane

Dermal  
papilla

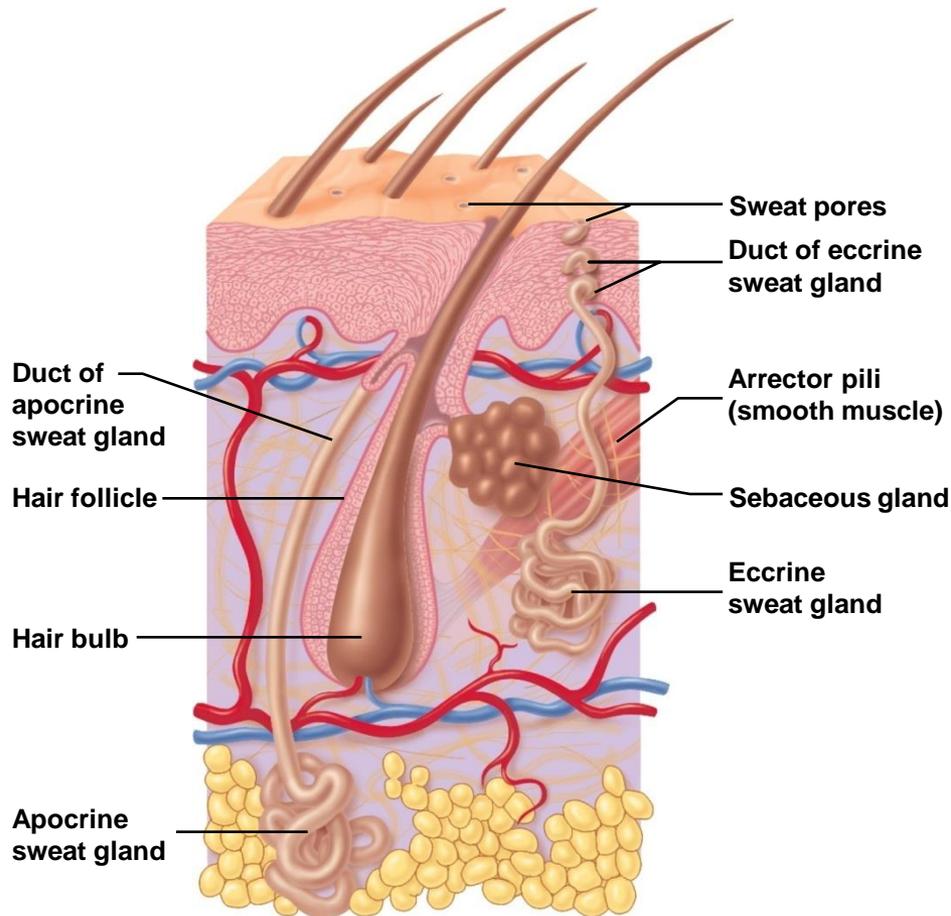


# Hair Structure

- Hair Growth
  - Cycles
    - Growth and resting stages
      - **Growth: cells added at base and hair elongates. Average rate is 0.3 mm/day**
      - **Rest: follicle shortens and holds hair in place. Rest, then hair falls out of follicle. New hair begins.**
    - Regular hair loss means hair is being replaced.
    - Permanent hair loss: **pattern baldness** most common cause
- Hair Color. Caused by varying amounts and types of melanin. Melanin can be black-brown and red
- Muscles. **Arrector pili.** Type of smooth muscle.
  - Muscle contraction causes hair to “stand on end”
  - Skin pushed up by movement of hair follicle

# Accessory Skin Structures: Glands

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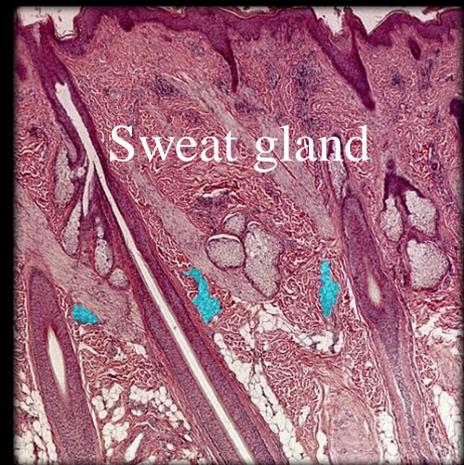
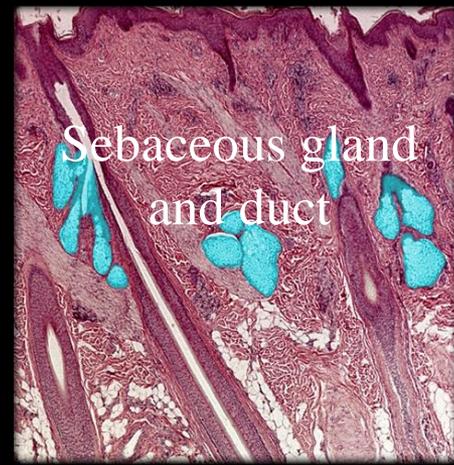
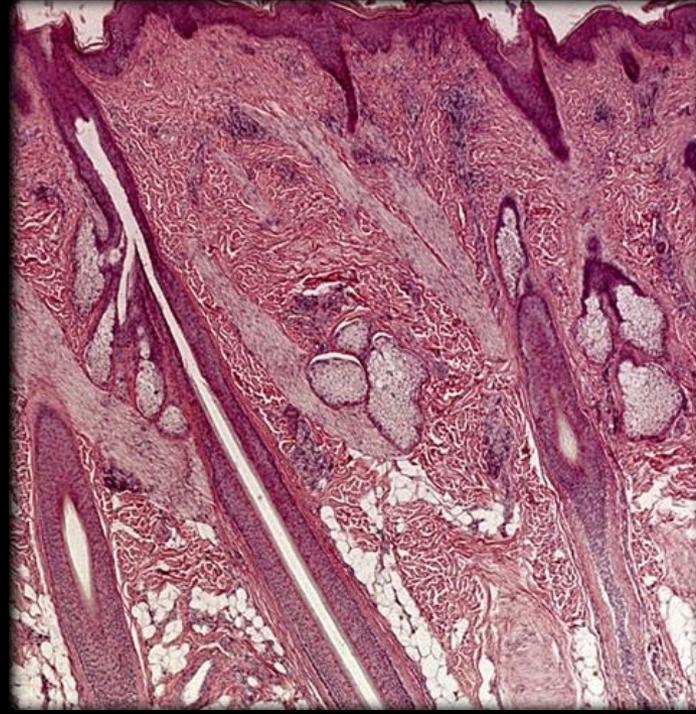
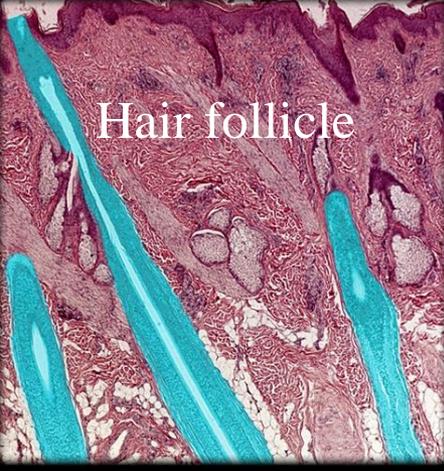
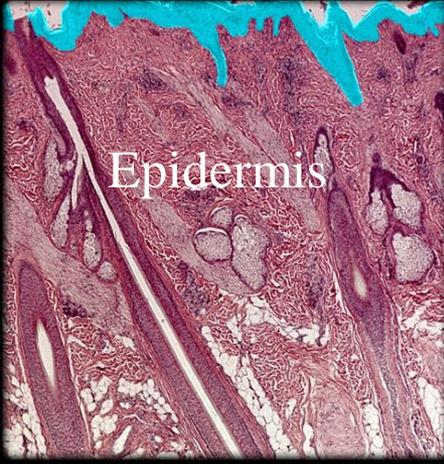


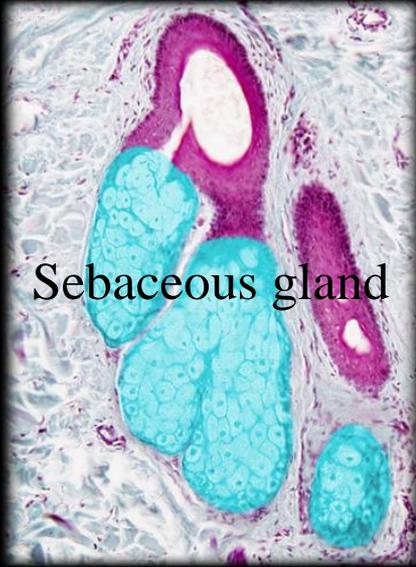
- **Sebaceous Glands**

- Holocrine (death of secretory cells)
- Oily secretion
- Prevents drying and may inhibit bacteria
- Most empty into hair follicle
  - Exceptions: lips, meibomian glands of eyelids, genitalia

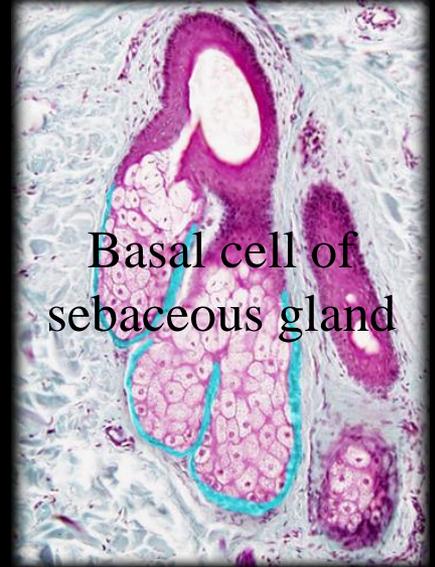
# Sebaceous Gland

## Low Magnification

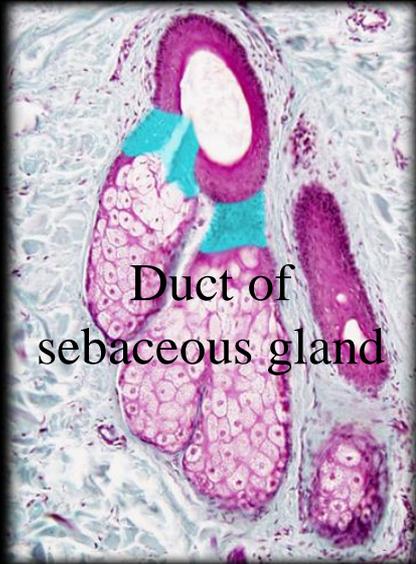




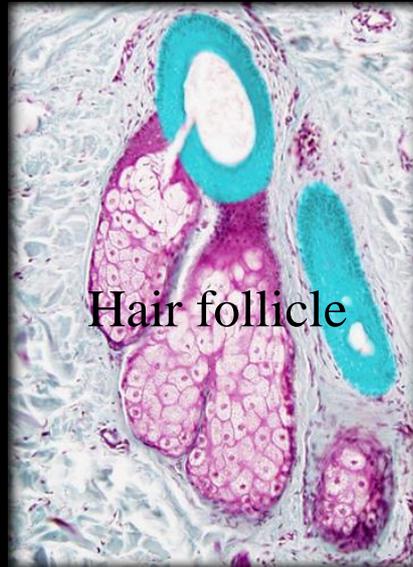
Sebaceous gland



Basal cell of sebaceous gland



Duct of sebaceous gland



Hair follicle



Secretory cells

Sebaceous Gland

High Magnification

# Accessory Skin Structures: Glands

- **Sweat (Sudoriferous) Glands**

- Two types traditionally called apocrine and merocrine, but apocrine may secrete in a merocrine or holocrine fashion.

- **Merocrine** or **eccrine**. Most common.

- Simple coiled tubular glands.

- Open directly onto surface of skin. Have own pores.

- Coiled part in dermis, duct exiting through epidermis.

- Produce isotonic fluid (water and NaCl, but also excretory because sweat includes ammonia, urea, uric acid and lactic acid). As fluid moves through duct, NaCl is moved by active transport back into the body. Final product is hyposmotic (hypertonic). Sweat.

- Numerous in palms and soles. Absent from margin of lips, labia minora, tips of penis, and clitoris.

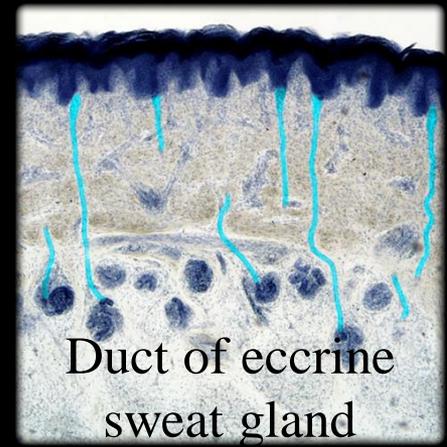
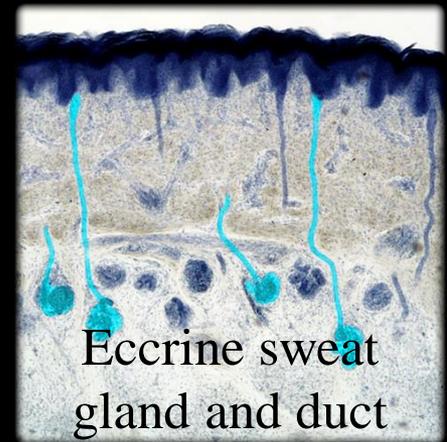
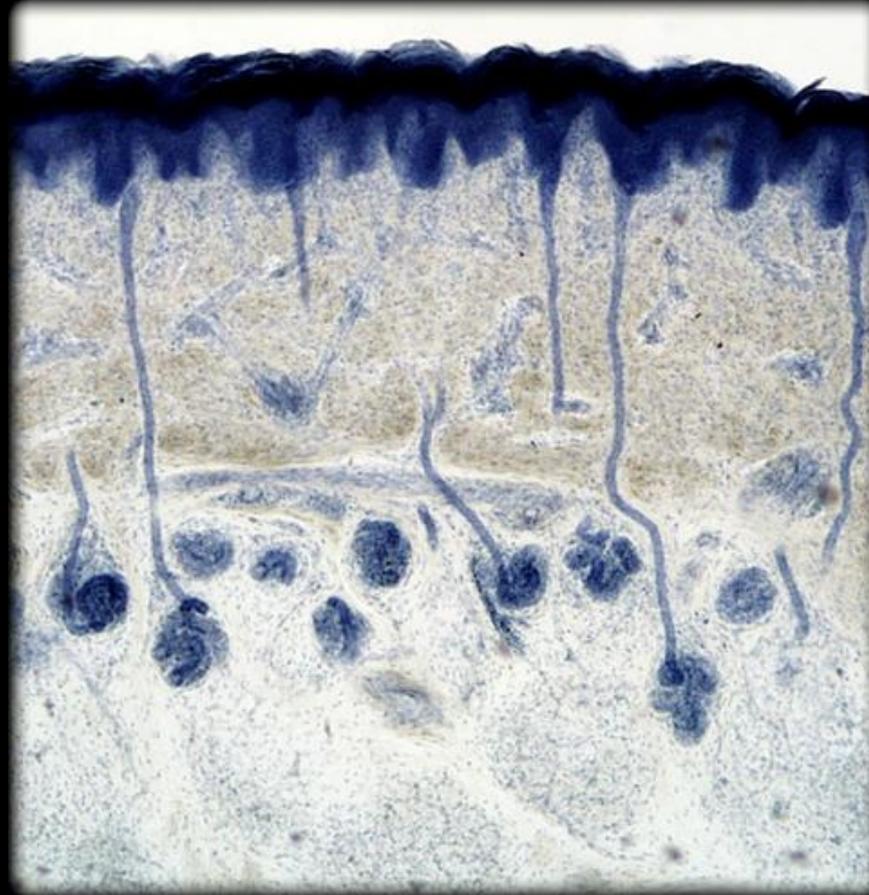
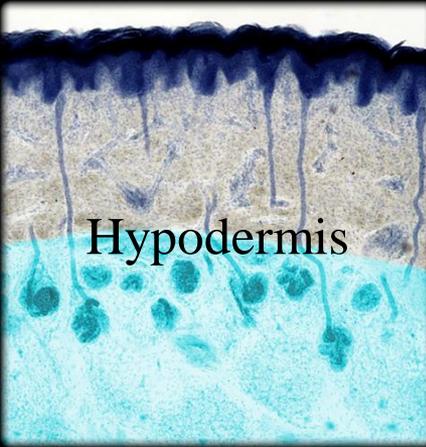
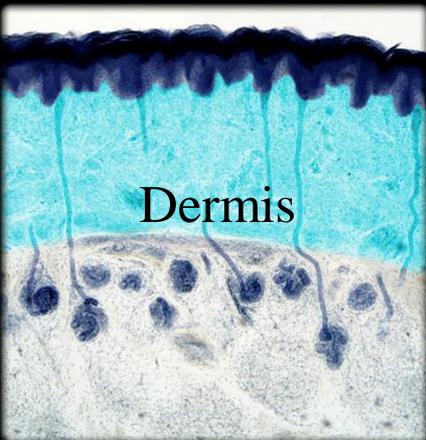
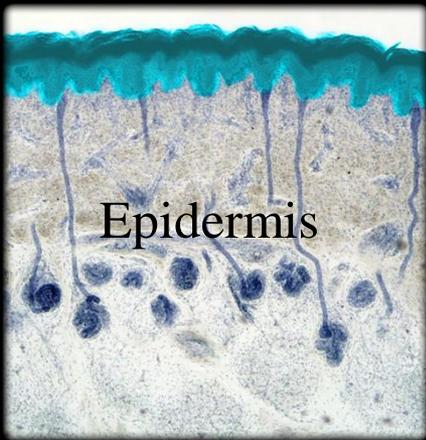
- **Apocrine**. Active at puberty.

- Compound coiled tubular, usually open into hair follicles superficial to opening of sebaceous gland.

- Secretion: organic compounds that are odorless but, when acted upon by bacteria, may become odiferous.

- Found in axillae, genitalia (external labia, scrotum), around anus.

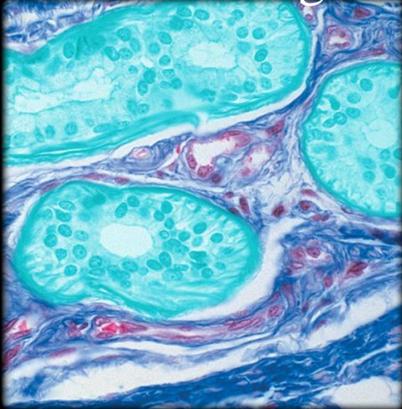
# Merocrine (Eccrine) Sweat Gland Low Magnification



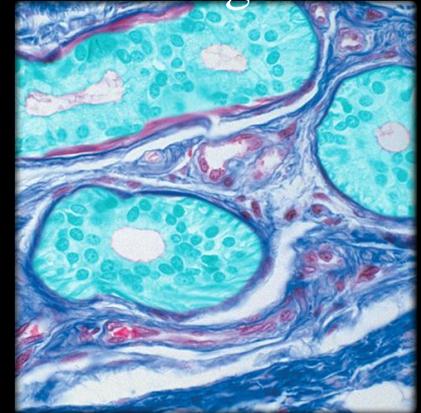
# Merocrine (Eccrine) Sweat Gland

## High Magnification

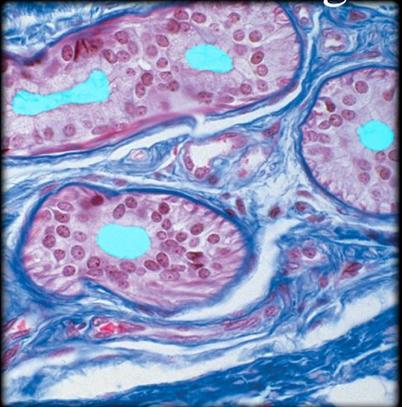
Eccrine sweat gland



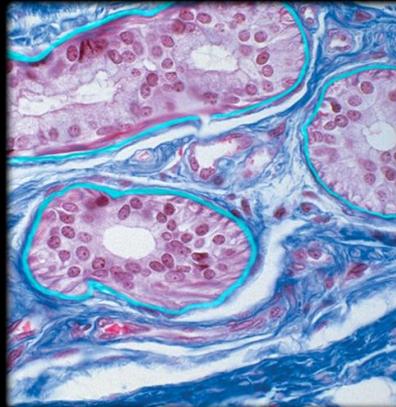
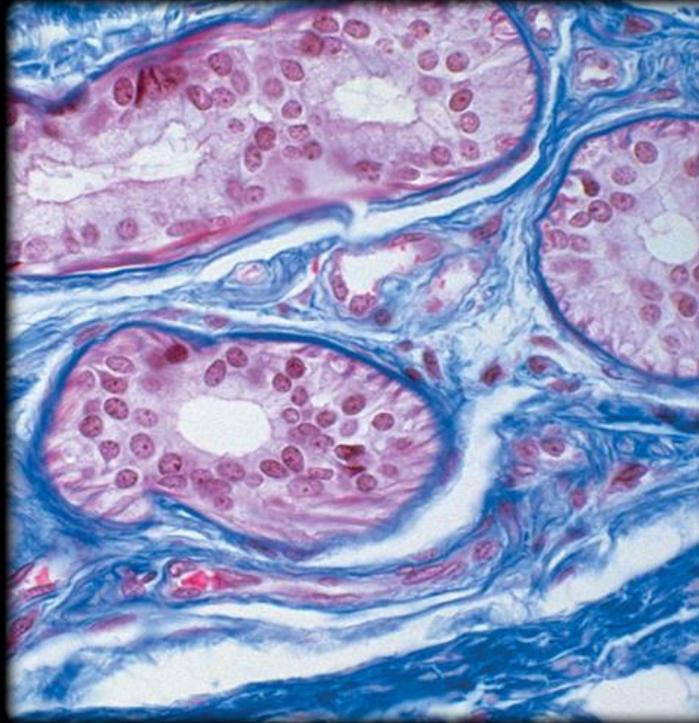
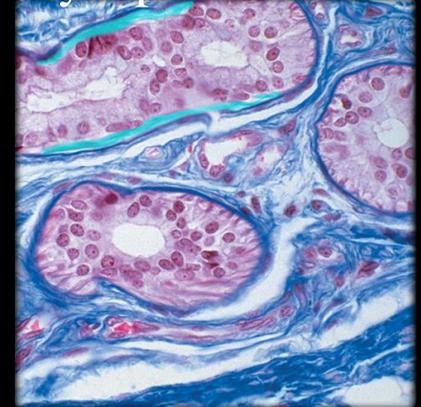
Epithelial cells of sweat gland



Lumen of sweat gland



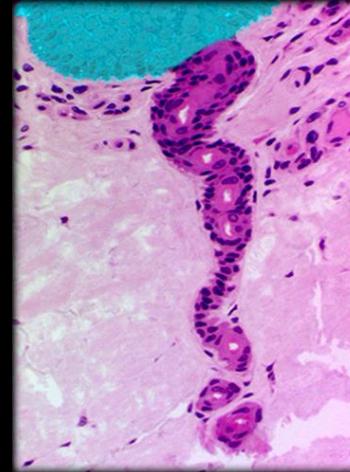
Myoepithelial cells



Basal lamina of eccrine sweat gland

# Duct of Sweat Gland

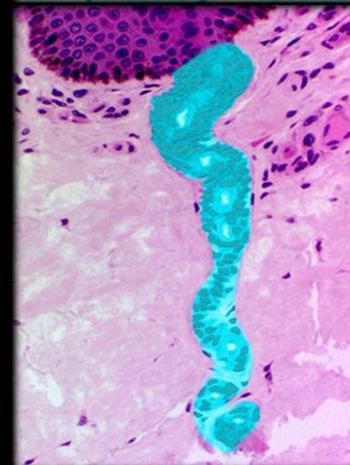
## High Magnification



Epidermis



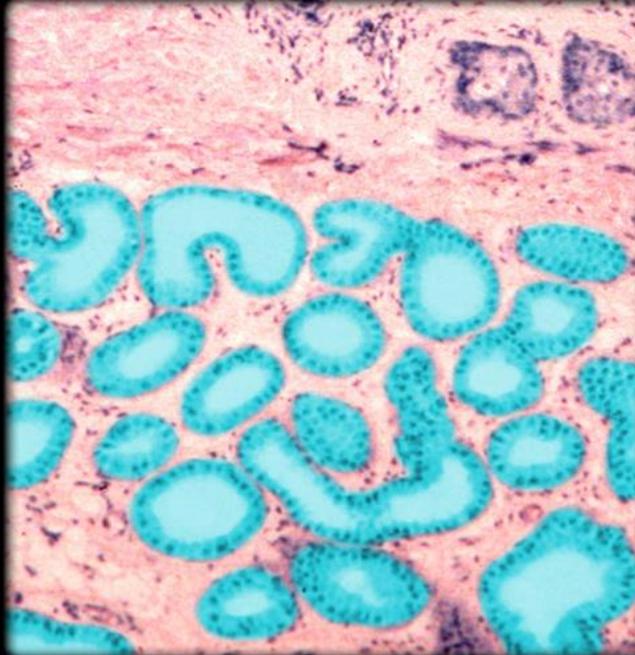
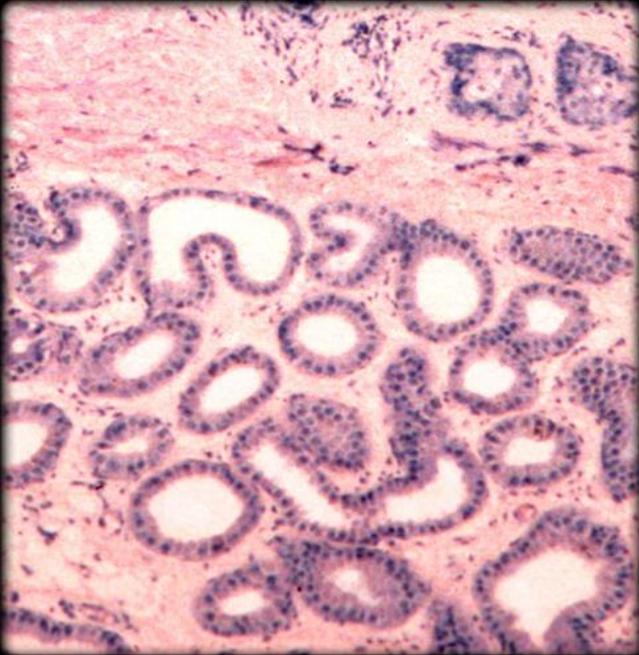
Dermis



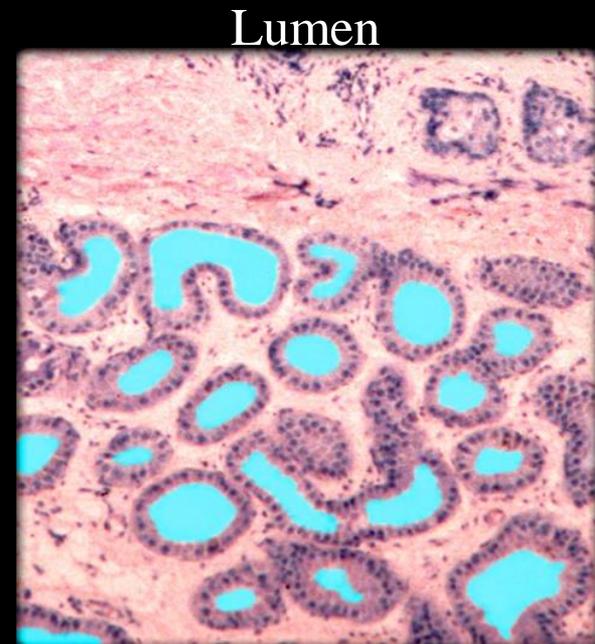
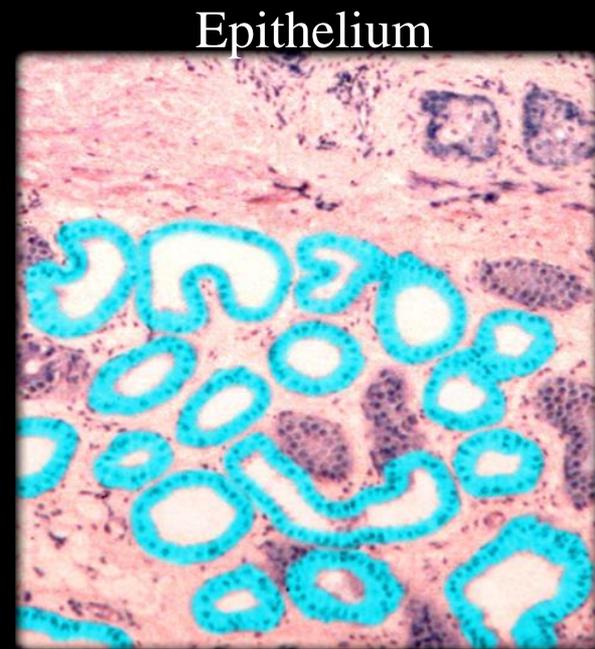
Duct of sweat gland

# Apocrine Sweat Gland

## Low Magnification

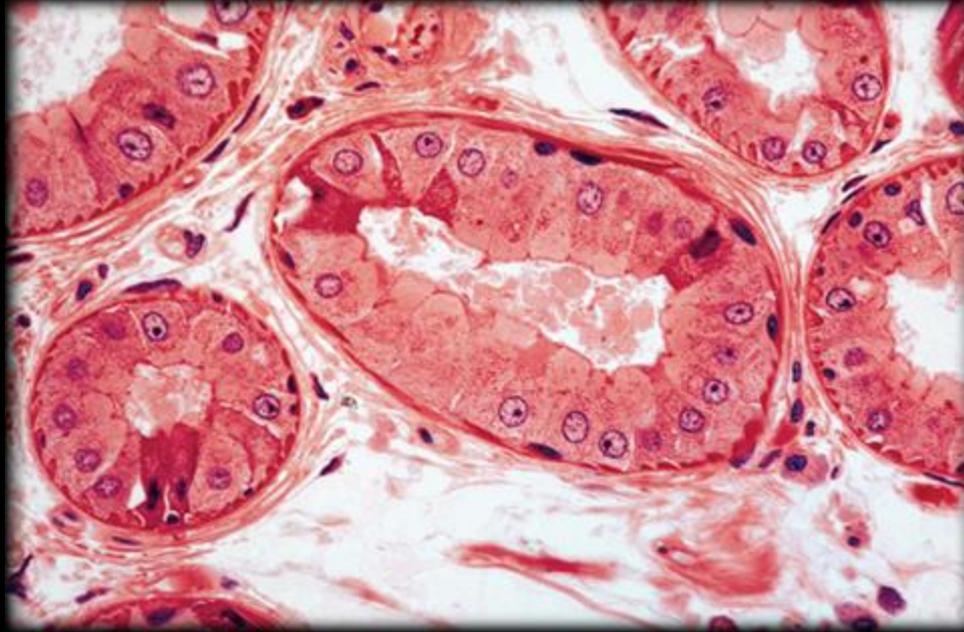


Apocrine sweat gland



# Apocrine Sweat Gland

## High Magnification

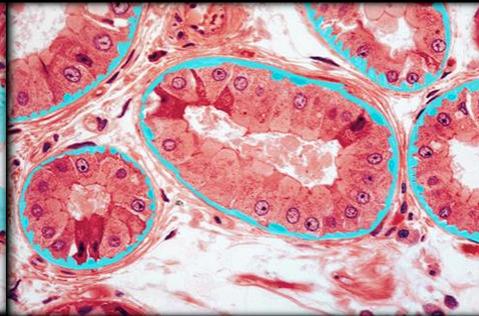
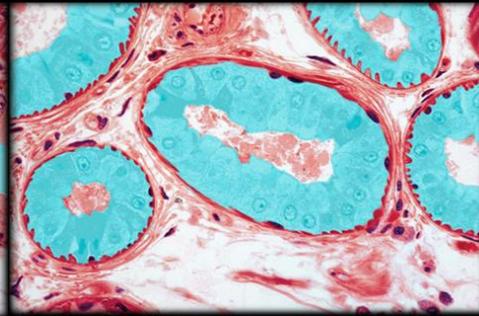
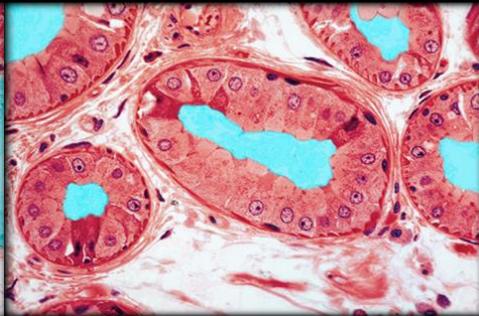
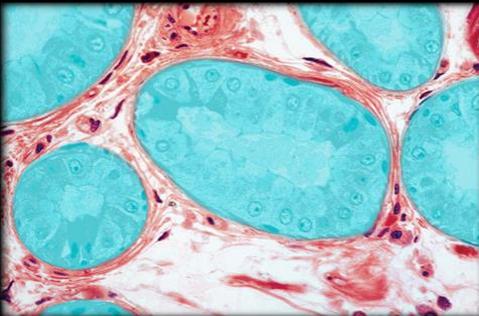


Apocrine sweat gland

Lumen

Epithelial cells

Myoepithelial cells



# Accessory Skin Structures: Glands

- **Ceruminous glands:** modified merocrine sweat glands, external auditory meatus.
  - Earwax (cerumen). Composed of a combination of sebum and secretion from ceruminous.
  - Function- In combination with hairs, prevent dirt and insects from entry. Also keep eardrum supple.
- **Mammary glands:** modified apocrine sweat glands. Covered with reproductive chapter.

# Accessory Skin Structures: Nails

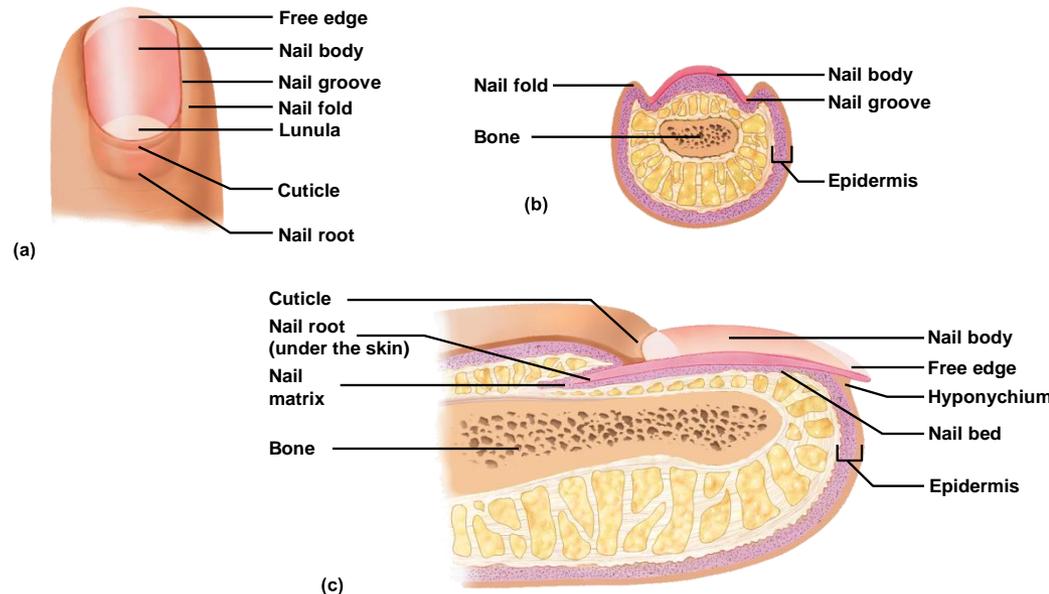
- Anatomy

- **Nail body**: stratum corneum
- **Eponychium** or **cuticle** is corneum superficial to nail body, **hyponychium** is corneum beneath the free edge
- **Matrix** and **nail bed**: cells that give rise to the nail
- **Nail root**: extends

- Growth

- Grow continuously unlike hair
- Fingernails grow 0.5-1.2 mm/day; faster than toenails

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# Nails



Free edge

Nail body

Eponychium



Nail root

Nail matrix



# 5.5 Physiology of the Integumentary System

- Protection
  - Against abrasion, sloughing off of bacteria as desquamation occurs.
  - Against microorganisms and other foreign substances. Glandular secretions bacteriostatic and skin contains cells of the immune system.
  - Melanin against UV radiation.
  - Hair on head is insulator and protection against light, and from abrasion. Eyebrows keep sweat out of the eyes; eyelashes protect eyes from foreign objects. Hair in nose and ear against dust, bugs, etc.
  - Nails protect ends of digits, self defense.
  - Acts as barrier to diffusion of water.

# Physiology of the Integumentary System

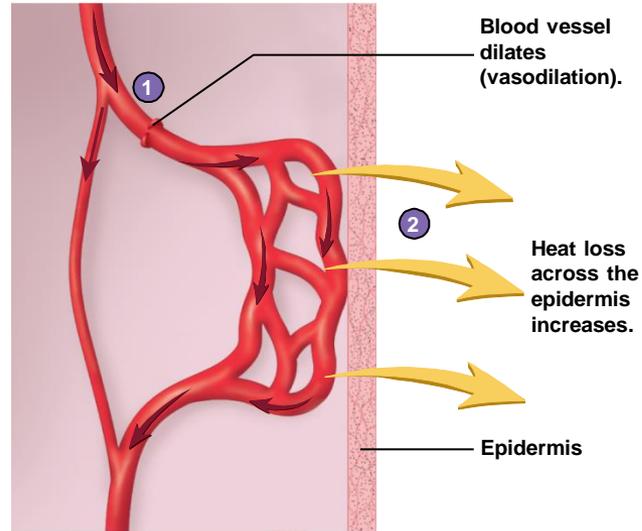
- **Sensation:** Pressure, temperature, pain, heat, cold, touch, movement of hairs.
- **Temperature Regulation:** sweating and radiation.
  - Sweat causes evaporative cooling.
  - Arterioles in dermis change diameter as temperature changes. More or less blood flows through the dermis.

# Physiology of the Integumentary System

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- 1 Blood vessel dilation results in increased blood flow toward the surface of the skin.

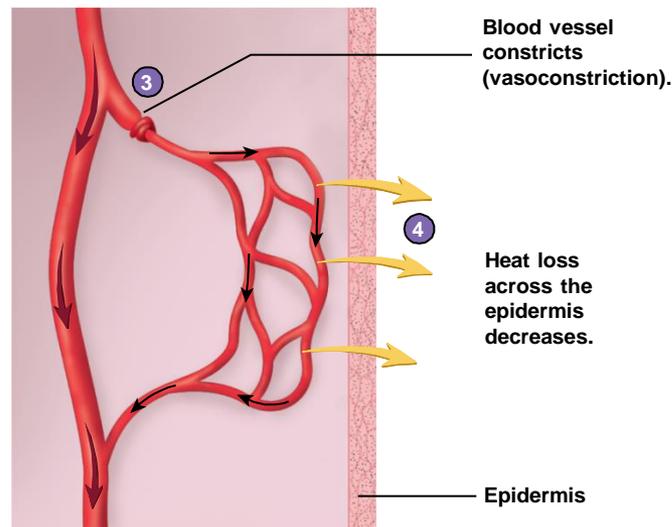
- 2 Increased blood flow beneath the epidermis results in increased heat loss (gold arrows).



(a)

- 3 Blood vessel constriction results in decreased blood flow toward the surface of the skin.

- 4 Decreased blood flow beneath the epidermis results in decreased heat loss.



(b)

# Physiology of the Integumentary System

- **Vitamin D Production**

- Begins in skin; aids in  $\text{Ca}^{2+}$  absorption.
- Vitamin D (calcitriol): hormone.
  - Stimulates uptake of  $\text{Ca}^{2+}$  and  $\text{PO}_4^{2-}$  from intestines
  - Promotes  $\text{Ca}^{2+}$  and  $\text{PO}_4^{2-}$  release from bones
  - Reduces  $\text{Ca}^{2+}$  loss from kidneys.
  - Increases blood  $\text{Ca}^{2+}$  levels.
- Functions of  $\text{Ca}^{2+}$ 
  - bone formation, growth, repair
  - clotting
  - nerve and muscle function.
- 7-dehydrocholesterol converts to cholecalciferol when exposed to UV radiation. Cholecalciferol released to blood and modified in the liver and kidneys to form calcitriol (active vitamin D).
- People in cold climates and those who cover the body can be deficient, but calcitriol can be absorbed through intestinal wall.
  - Sources: dairy, liver, egg yolks, supplements.

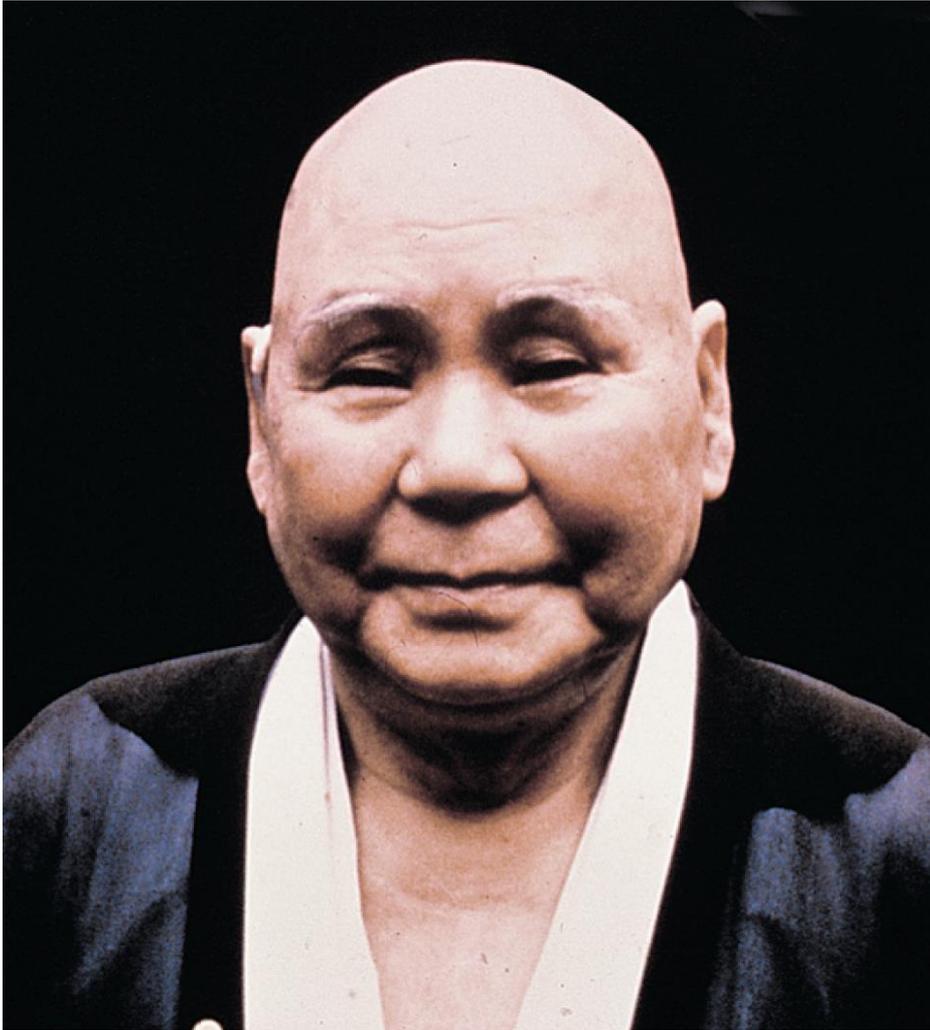
# Physiology of the Integumentary System

- **Excretion**

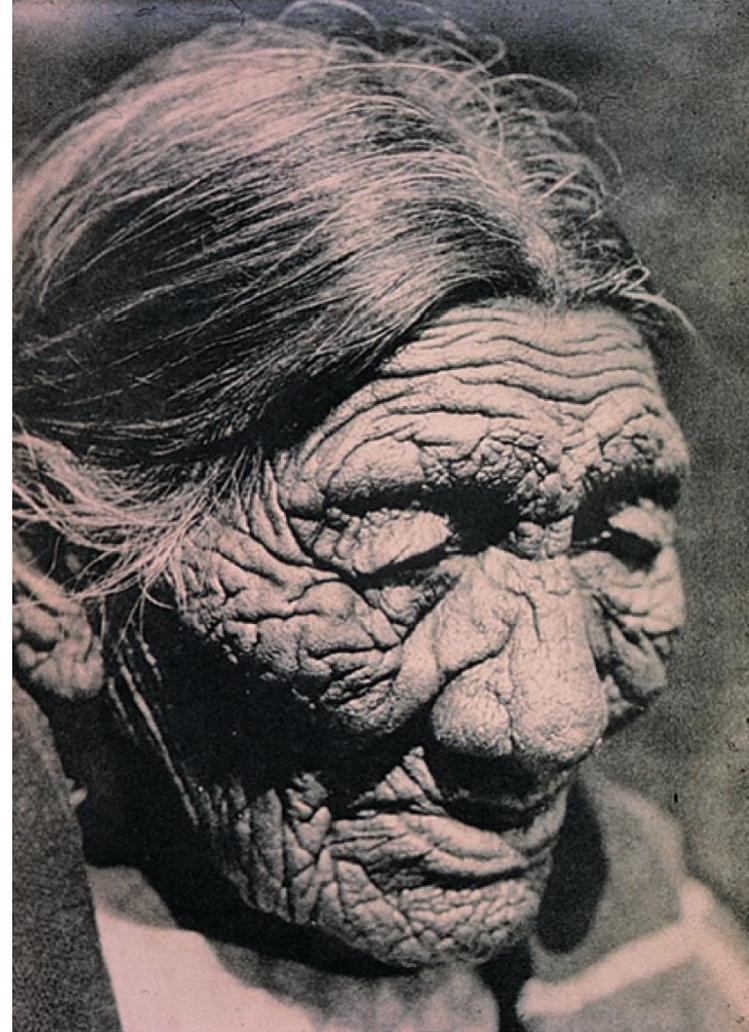
- Removal of waste products from the body.
  - Sweat: Water, salt, urea, ammonia, uric acid.
- Insignificant when compared with kidneys.

## 5.6 Effects of Aging on the Integumentary System

- Skin more easily damaged because epidermis thins and amount of collagen decreases
- Skin infections more likely
- Wrinkling occurs due to decrease in elastic fibers
- Skin becomes drier
- Decrease in blood supply causes poor ability to regulate body temperature
- Functioning melanocytes decrease or increase; age spots
- Sunlight ages skin more rapidly



**(a)**

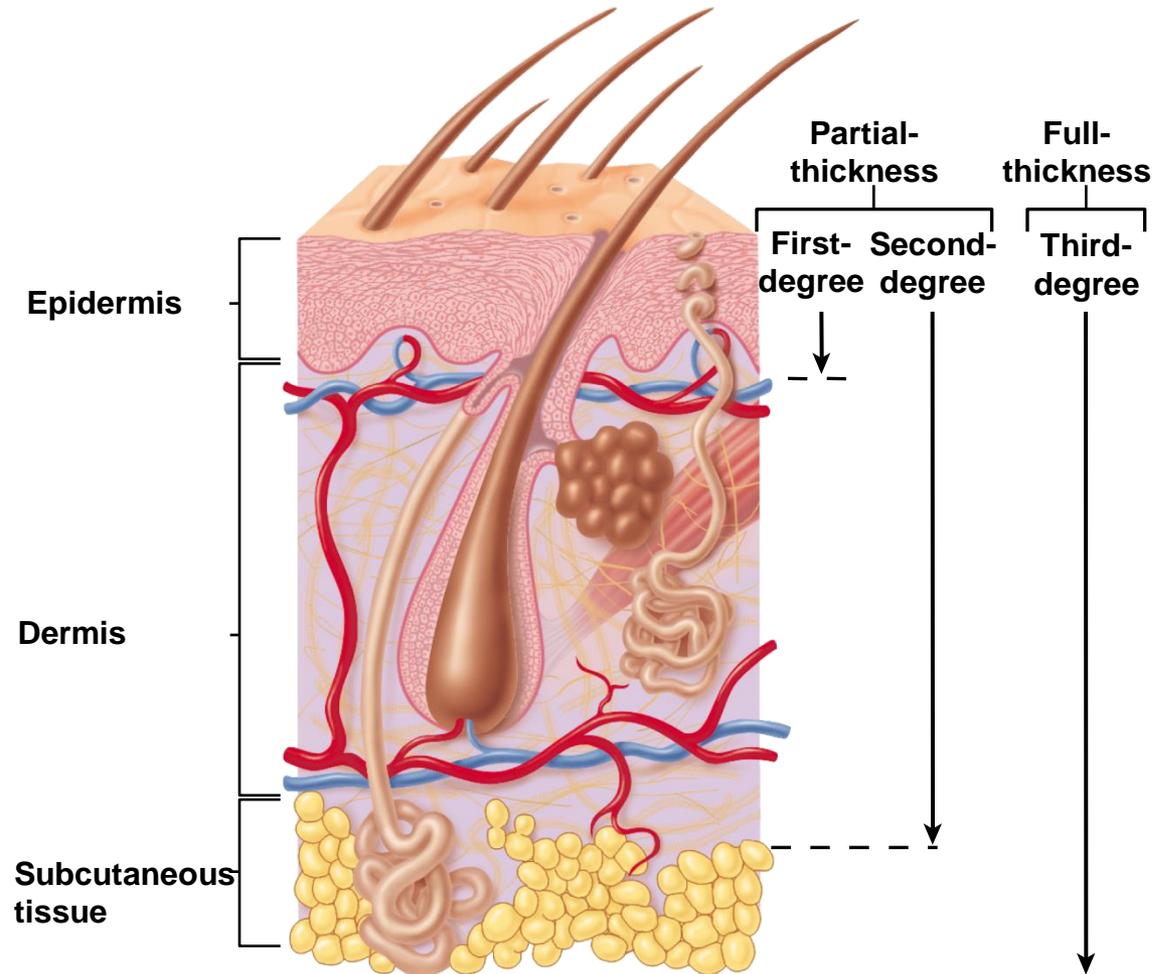


**(b)**

a: Courtesy of A. M. Kligman, Professor of Dermatology, University of Pennsylvania School of Medicine, Philadelphia, PA; b: Edward Curtis photo from Library of Congress; Courtesy of A. M. Kligman, Professor of Dermatology, University of Pennsylvania School of Medicine, Philadelphia, PA.

# Burns

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- **Classifications**
  - First-degree
  - Second-degree
  - Third-degree
- **Skin Grafts**
  - Split skin
  - Artificial skin
  - Cadavers or pigs

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**Full-thickness  
burn**

**Partial-thickness  
burn**



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# The Rule of Nines

- Used to estimate amount of body that is burned.
- Note differing proportions in adult and child.

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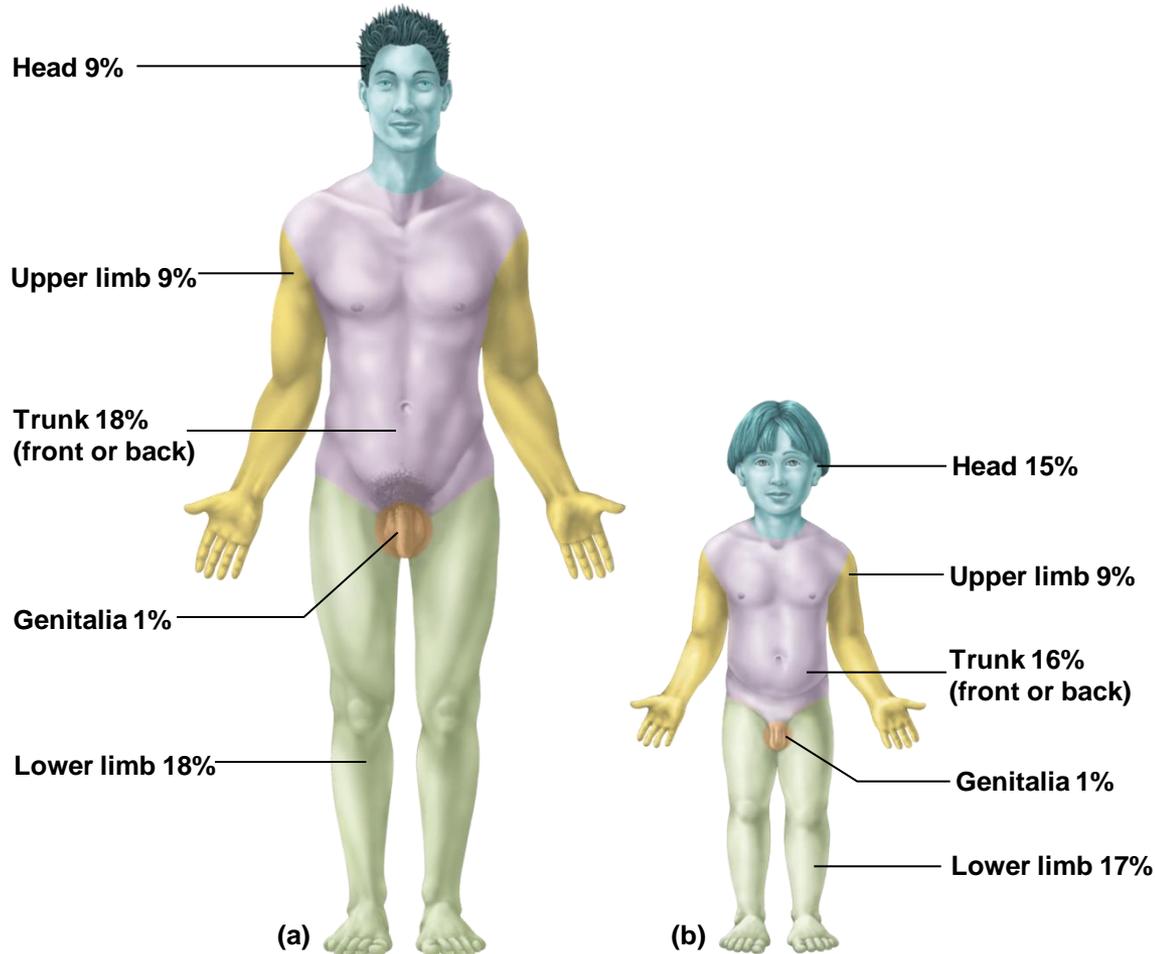


TABLE 5.2

## Skin

Condition	Description
Birthmarks	Congenital (present at birth) disorders of the dermal capillaries
Ringworm	Fungal infection that produces patchy scaling and inflammatory response in the skin
Eczema and dermatitis	Inflammatory conditions of the skin caused by allergy, infection, poor circulation, or exposure to chemical or environmental factors
Psoriasis	Chronic skin disease characterized by thicker than normal epidermal layer (stratum corneum) that sloughs to produce large, silvery scales; bleeding may occur if the scales are scraped away
Vitiligo	Development of patches of white skin where melanocytes are destroyed, apparently by an autoimmune response
<b>Bacterial Infections</b>	
Impetigo	Small blisters containing pus; easily rupture to form a thick, yellowish crust; usually affects children
Erysipelas	Swollen patches in the skin caused by the bacterium <i>Streptococcus pyogenes</i>
Decubitus ulcers (bedsores, pressure sores)	Develop in people who are bedridden or confined to a wheelchair; compression of tissue and reduced circulation result in destruction of the skin and subcutaneous tissue, which later become infected by bacteria, forming ulcers
Acne	Disorder of sebaceous glands and hair follicles that occurs when sloughed cells block the hair follicle, resulting in the formation of a lesion or pimple; the lesion may become infected and result in scarring; acne appears to be affected by hormones, sebum, abnormal keratinization within hair follicles, and the bacterium <i>Propionibacterium acnes</i>
<b>Viral Infections</b>	
Rubeola (measles)	Skin lesions; caused by a virus contracted through the respiratory tract; may develop into pneumonia or infect the brain, causing damage
Rubella (German measles)	Skin lesions; usually mild viral disease contracted through the respiratory tract; may be dangerous if contracted during pregnancy because the virus can cross the placenta and damage the fetus
Chickenpox	Skin lesions; usually mild viral disease contracted through the respiratory tract
Shingles	Painful skin lesions; caused by the chickenpox virus after childhood infection; can recur when the dormant virus is activated by trauma, stress, or another illness
Cold sores (fever blisters)	Skin lesions; caused by herpes simplex I virus; transmitted by oral or respiratory routes; lesions recur
Genital herpes	Genital lesions; caused by herpes simplex II virus; transmitted by sexual contact