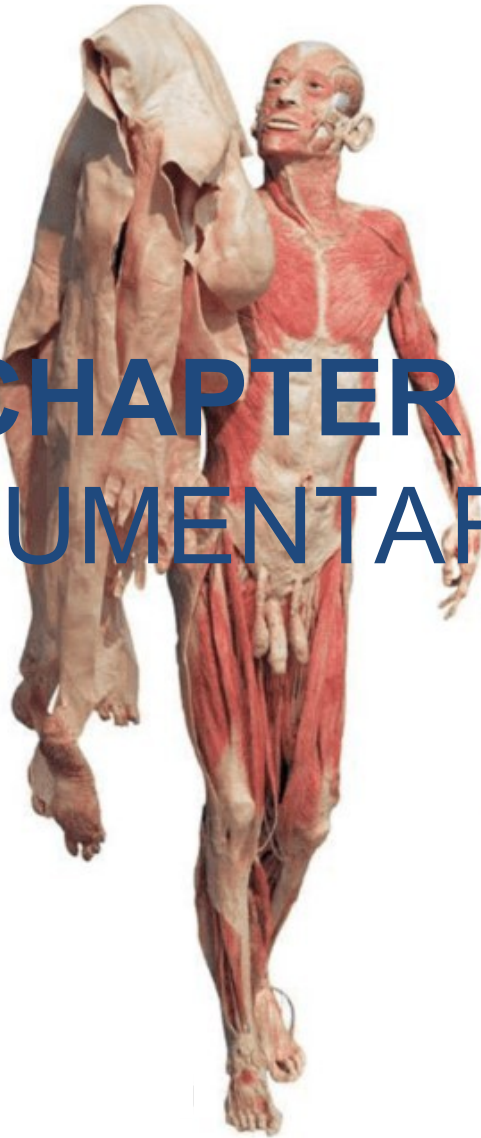




CHAPTER 5

THE INTEGUMENTARY SYSTEM

Introduction

- Tissues are organized to form an organ, and organs are organized to form systems
- Integumentary system
- Dermatology

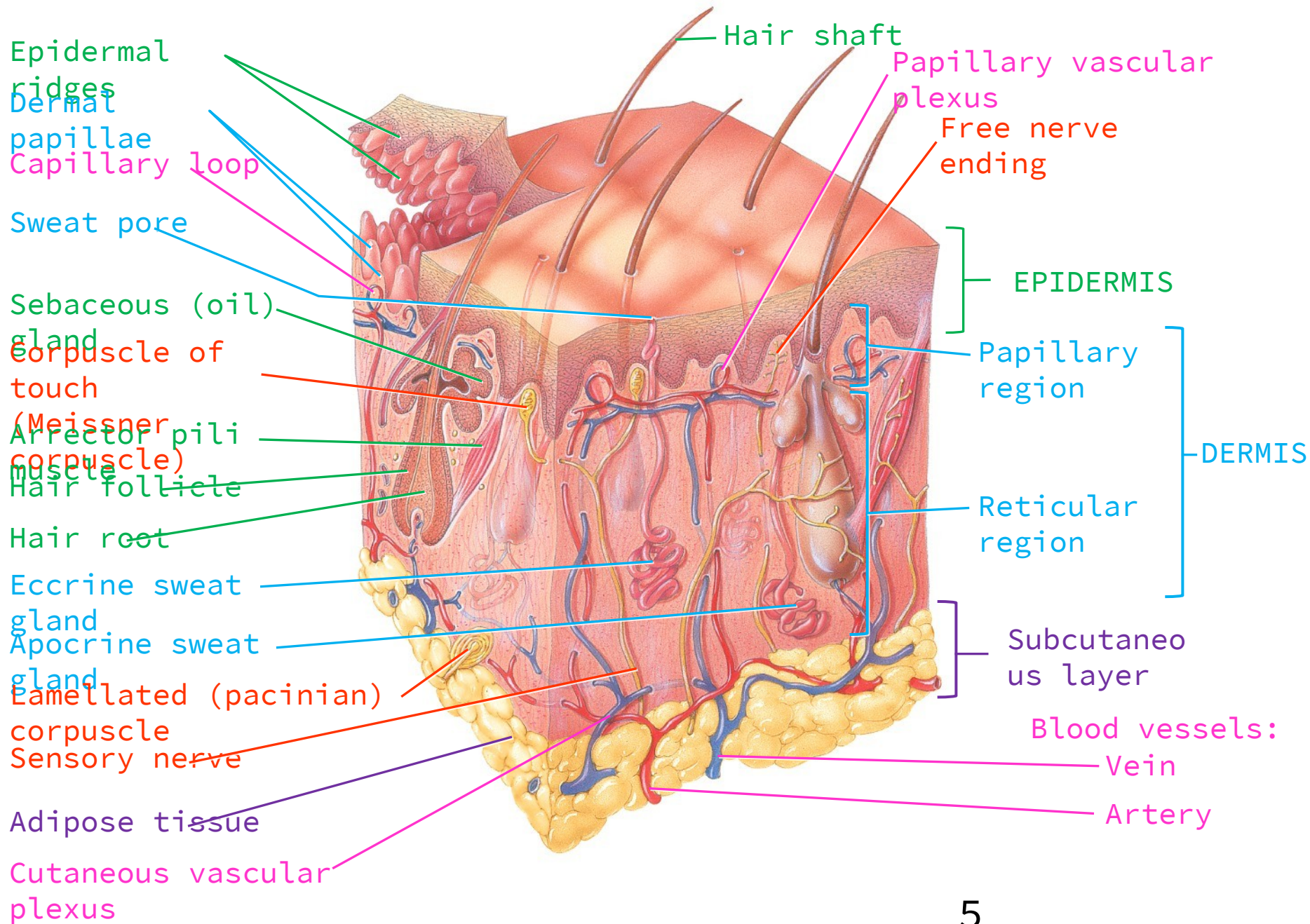
Structure of the Skin

- Cutaneous membrane
- Largest organ of the body
 - covers about 2 m² (22 feet²)
 - weighs ~ 10 -11 lb. (~ 7% of body weight)
 - is 0.5 – 4 mm thick (depends on location)
- Covers the external surface of the body
- The skin is the largest organ of the body in surface area and weight.
- The principal parts of the skin are the epidermis (superficial) and dermis (deep).

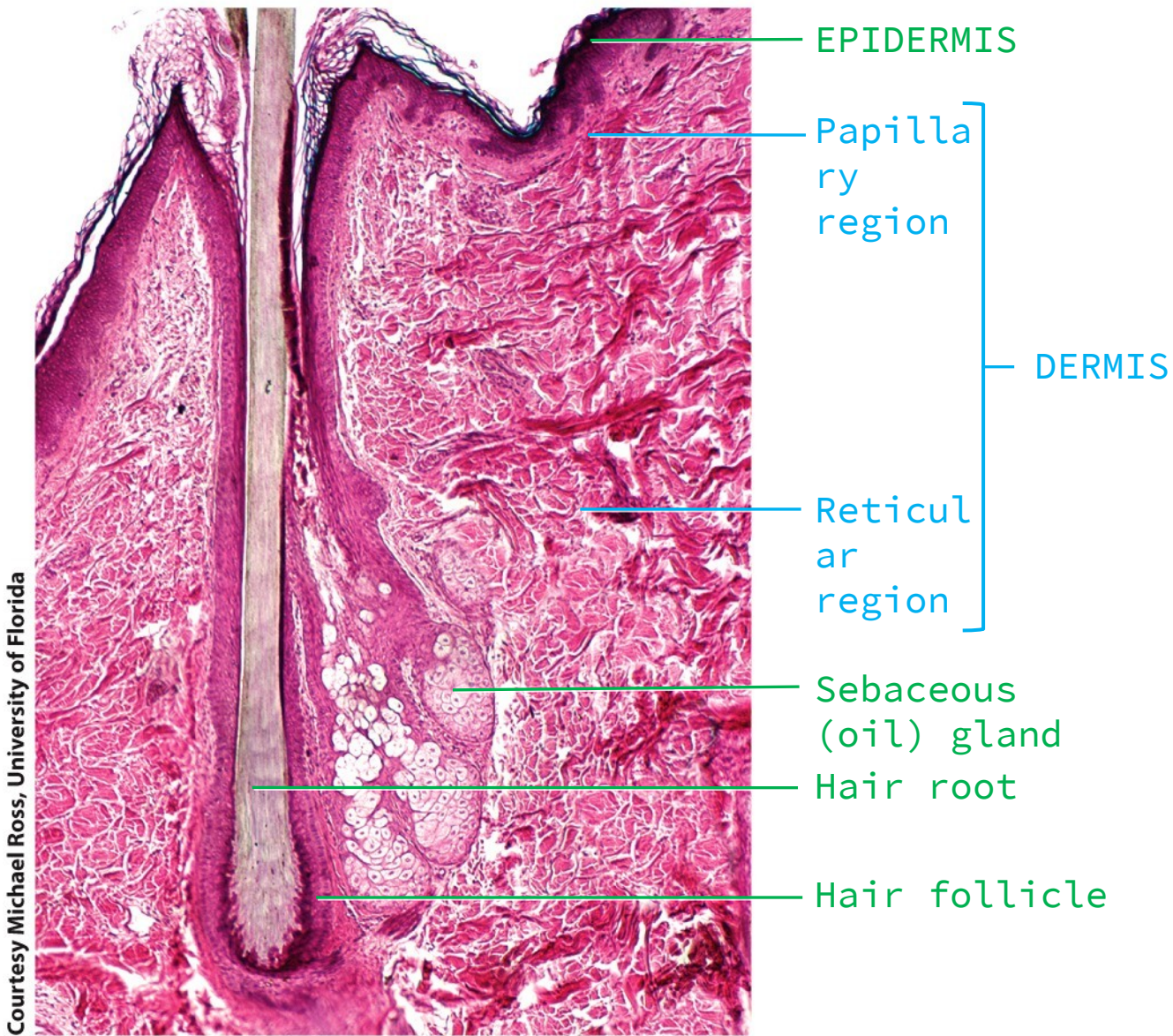
Integumentary System Components

- SKIN:
 - Epidermis (superficial)
 - Dermis (deep)
- SUBCUTANEOUS LAYER (hypodermis)
- The skin and subcutaneous layer form the **integument**.
- **Epidermis:** superficial, thinner portion, which is composed of epithelial tissue, is the avascular (if you scratch the epidermis there is no bleeding).
- **Dermis:** deeper, thicker, connective tissue is vascular (a cut that penetrates to the dermis produces bleeding).
- **Subcutaneous (subQ) layer** or **hypodermis:** Deep to the dermis, but not part of the skin
- consists of areolar and adipose tissues
- attaches the dermis to the fascia of the body.

COMPONENTS OF THE INTEGUMENTARY SYSTEM



SECTIONAL VIEW OF SKIN



LM 60x

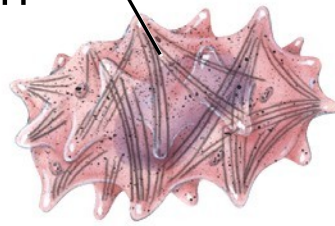
Functions of the Skin

- Thermoregulation
- Blood reservoir
- Protection
- Cutaneous sensations
- Excretion and absorption
- Synthesis of vitamin D

Structure of the Skin - Epidermis

- The epidermis has a number of important characteristics:
 - keratinized stratified squamous epithelium
 - contains four major types of cells:
 - Keratinocytes
 - Melanocytes
 - Intraepidermal macrophage or Langerhans
 - Tactile epithelial
- Keratinocytes make up about 90% of these cells

Kerati
n



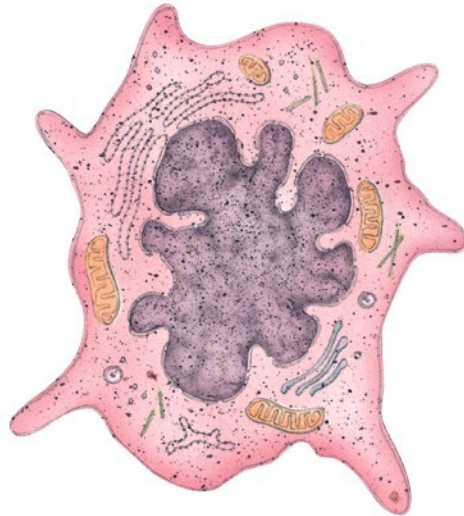
(a)

Keratinocyte

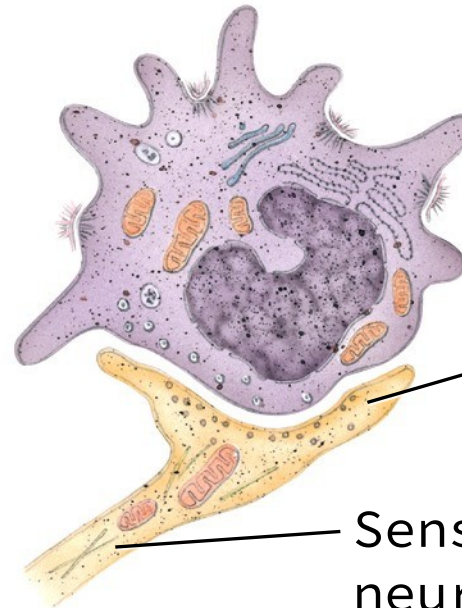
Melani
n
granul
e



(b) Melanocyte



(c) Intraepidermal
macrophage
(Langerhans) cell

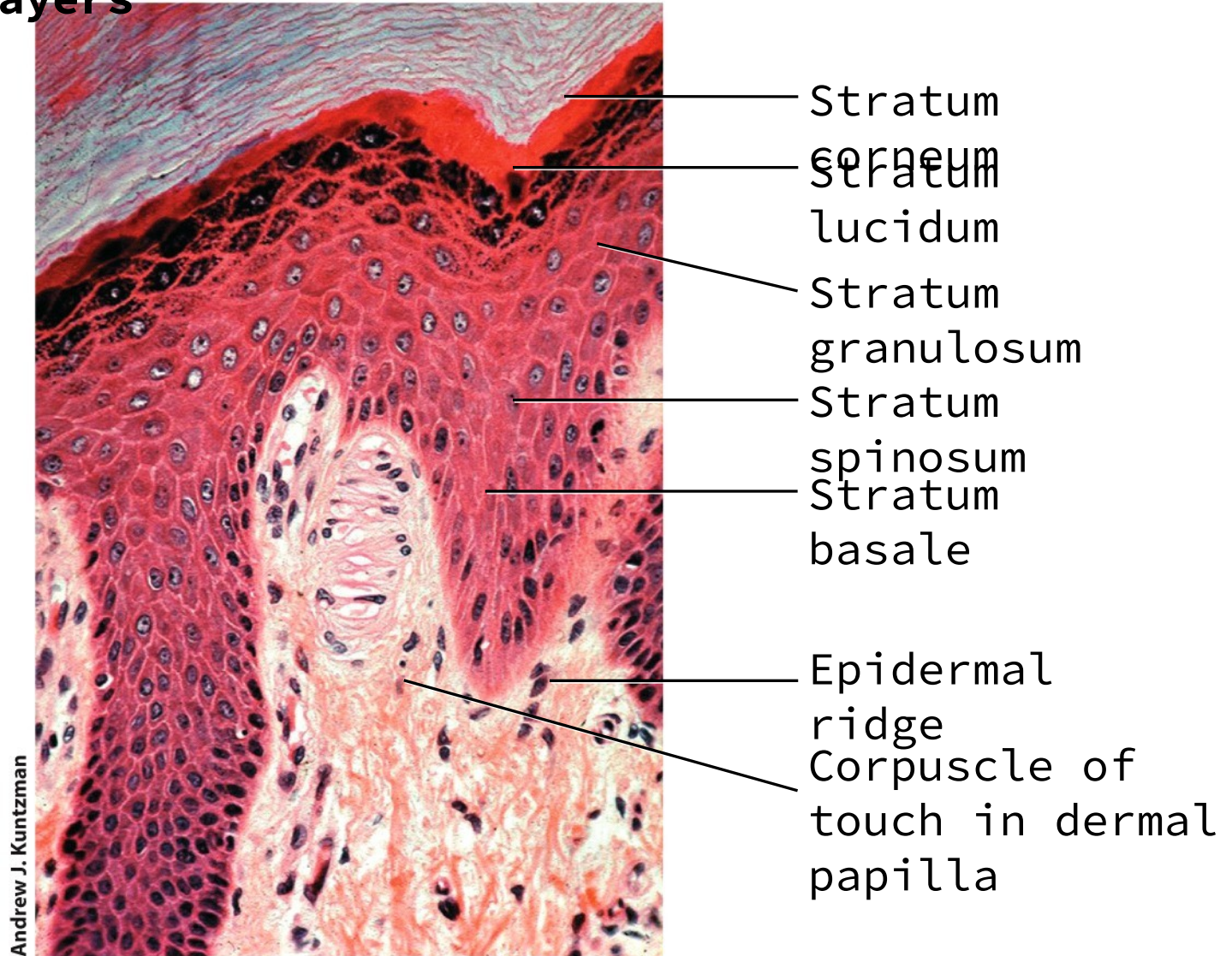


(d) Tactile
epithelial
(Merkel) cell

Tactile
(Merkel)
disc

Sensory
neuron

Sectional view of dermal papillae, epidermal ridges, and epidermal layers



Epidermis:

Stratum corneum

Stratum lucidum

Stratum
granulosum

Stratum
spinosum

Stratum basale

Dead
keratinocytes

Lamellar
granules
Keratinocyte

Intraepidermal
macrophage cell

Tactile
epithelial cell
Tactile disc

Sensory neuron

Melanocyte

Dermis

Superficial

Deep

Location of four principal cell types in
thick skin

11

Epidermis

- The epidermis contains four major layers (thin skin) or five major layers (thick skin)
- **1- Stratum Basale:** The deepest layer of the epidermis, single row of cuboidal or columnar cells, some are stem cells
- **Keratinocytes**
- A large nuclei
- cytoplasm: many ribosomes, a small Golgi complex, a few mitochondria, some RER.
- cytoskeleton: scattered intermediate filaments called *keratin intermediate filaments* (tonofilaments electron microscopy) form *keratin* tough protein in the more superficial epidermal layer
 - protects the deeper layers from injury
 - attach to desmosomes (basal cell to basal cell & basal cell to stratum spinosum cells) and hemidesmosomes (basal cell to basement membrane)
- **Melanocytes** and **tactile epithelial cells** (with their associated tactile discs) are scattered among the keratinocytes of the basal layer.

Epidermis

- **2- Stratum Spinosum** Superficial to the stratum basale
- ***keratinocytes***
- 8 -10 layers, more superficial layers become somewhat flattened
- produced by the stem cells in the basal layer, same organelles as cells of the stratum basale, some can still divide
- produce coarser bundles of keratin intermediate filaments, insert into desmosomes provides strength and flexibility

Intraepidermal macrophage cells and projections of ***melanocytes***

Epidermis

- **3- Stratum Granulosum:** middle of the epidermis, marks transition between deeper, metabolically active strata and the dead cells of the more superficial strata
- 3-5 layers of flattened **keratinocytes** that are undergoing apoptosis (nuclei and other organelles degenerate as lose nutrition (the dermal blood vessels) hence keratin intermediate filaments become more apparent
- **Keratohyalin:** protein involved in assembling keratin intermediate filaments into keratin can be seen (darkly stains)
- **lamellar granules:** membrane-enclosed, fuse with the plasma membrane and *release a lipid-rich secretion*
 - deposited in the spaces between cells of three epidermal layers: the stratum granulosum, lucidum, & corneum
 - acts as a *water-repellent* sealant, retarding loss of body fluids and entry of foreign materials

Epidermis

- **4-Stratum Lucidum** **present in the thick skin of areas such as the fingertips, palms, and soles
- 4-6 layers of clear, flat, dead keratinocytes
 - contain large amounts of *keratin* (more regularly arranged parallel to the skin surface)
 - and *thickened plasma membranes*

Epidermis

- **Stratum Corneum**
- average of 25 to 30 layers of flattened dead keratinocytes (range - a few cells in *thin* skin - 50 +or in *thick* skin)
- Cornified layer (strong connections between layers) protects deeper layers from injury and microbial invasion.
- **corneocytes** or **squames**
- final product - extremely thin, flat, plasma-membrane-enclosed packages of keratin
 - no nuclei or internal organelles
 - within each layer overlap one another like the scales on the skin of a snake. plasma membranes of adjacent corneocytes are arranged in complex, wavy folds continuously shed
- **Keratinization:** 4-6 weeks in an average epidermis of 0.1 mm (.04 in.) thickness.

As newly formed cells are pushed slowly through the various layers to the skin's surface, they *accumulate more keratin*, then go through apoptosis, and then are sloughed off.

Epidermis

Growth

- **rate of cell division increases* when the outer layers of the epidermis are stripped away, as in abrasions and burns

epidermal growth factor (EGF) hormone-like proteins play a role but mechanisms not well understood

- **Callus:** abnormal thickening of stratum corneum due to constant friction (stimulates increased cell production and keratin production) **vs bunions**
- **Dandruff:** excessive amount of keratinized cells shed from the skin of the scalp

Structural Basis of Skin Color

Variations in skin color arise from variations in the amounts of three pigments

- Melanin

- Number of melanocytes are about the same in all people

- Hemoglobin

- Carotene

Dark skinned vs Light skinned

Structural Basis of Skin Color

- **Freckles:** melanin accumulates in patches
- **Liver spots:** appear as a person ages, a form of dark freckles, range in color from light brown to black
- **Moles:** (Nevus) round, flat, or raised area that usually develops in childhood or adolescence and represents a benign localized overgrowth of melanocytes



Structural Basis of Skin Color

- **Vitiligo** (vit-i-LĪ-gō), the partial or complete loss of melanocytes from patches of skin produces irregular white spots. The loss of melanocytes may be related to an immune system malfunction in which antibodies attack the melanocytes.
- **Albinism** is the inherited inability of an individual to produce melanin (most have melanocytes unable to synthesize tyrosinase). Melanin is missing from their hair, eyes, and skin. This results in problems with vision and a tendency of the skin to burn easily from overexposure to sunlight.



Clinical Connection – Skin Colour as a Diagnostic Clue

- **Cyanotic:** When blood is not picking up an adequate amount of oxygen from the lungs, as in someone who has stopped breathing, the mucous membranes, nail beds, and skin appear bluish.
- **Jaundice:** is due to a buildup of the yellow pigment bilirubin in the skin. This condition gives a yellowish appearance to the skin and the whites of the eyes, and usually indicates liver disease.



Clinical Connection – Skin Colour as a Diagnostic Clue

- **Erythema:** redness of the skin, is caused by engorgement of capillaries in the dermis with blood due to skin injury, exposure to heat, infection, inflammation, or allergic reactions. This reddish tint also appears in facial blushing, when the relatively thin skin of the face fills with blood during a moment of embarrassment.
- **Pallor:** or paleness of the skin, may occur in conditions such as shock and anemia.



Structure of the Skin - Dermis

composed of connective tissue – a combination of collagen and elastic fibers

- **strength**
- **extensibility** the ability to stretch
- **elasticity** the ability to return to original shape after stretching

Two layers of dermis are

- **Papillary** region (thin superficial)
- **Reticular** region (thick deeper)

Structure of the Skin - Dermis

- composed of a strong dense irregular connective tissue containing collagen and elastic fibers
- much thicker than the epidermis
 - varies from region to region in the body (thickest on palms and soles)
 - **cellulite: dermis is typically thinner in women than men, many women have the appearance of dimples in skin**
- has great *tensile strength* (resistance to pulling or stretching forces)
- has the ability to stretch and recoil easily (leather we use)
- cells present in the dermis are scattered
 - fixed cells: predominantly fibroblasts
 - wandering cells: include macrophages, mast cells, eosinophils, neutrophils, and dermal interstitial dendritic cells (immune surveillance cells)
- Blood vessels, Nerves, Glands, Hair follicles (two epithelial invaginations of the epidermis)

Based on tissue structure, the dermis can be divided by an ***indistinct boundary*** into a thin, superficial papillary region and a thick, deeper reticular region.

TABLE 5.2**Summary of Papillary and Reticular Regions of the Dermis (See also **Figure 5.1b**)**

REGION	DESCRIPTION
Papillary region	The superficial portion of the dermis (about one-fifth); consists of areolar connective tissue with thin collagen fibers and fine elastic fibers; contains dermal papillae that house blood capillaries, corpuscles of touch, and free nerve endings.
Reticular region	The deeper portion of the dermis (about four-fifths); consists of dense irregular connective tissue with bundles of thick collagen and some coarse elastic fibers. Spaces between fibers contain some adipose cells, hair follicles, nerves, sebaceous glands, and sudoriferous glands.

Clinical Connection – Skin Grafts

- **stratum basale** and its stem cells
- to protect against
 - fluid loss and infection
 - promote tissue healing
 - reduce scar formation
 - prevent loss of function
 - for cosmetic reasons
- **Autograft:** same individual
- **Isograft:** identical twin

Autologous skin transplantation

- Autologous skin transplantation: performed most often for severely burned patients
- small amounts of an individual's epidermis are removed and *the keratinocytes* are cultured in the laboratory to produce thin sheets of skin
- new skin is transplanted back to the patient so that it covers the burn wound and generates a permanent skin. Also available as skin grafts for wound coverage are products (Apligraf® and Transite®) grown in the laboratory from the foreskins of circumcised infants

Clinical Connection - Tension Lines

(lines of cleavage)

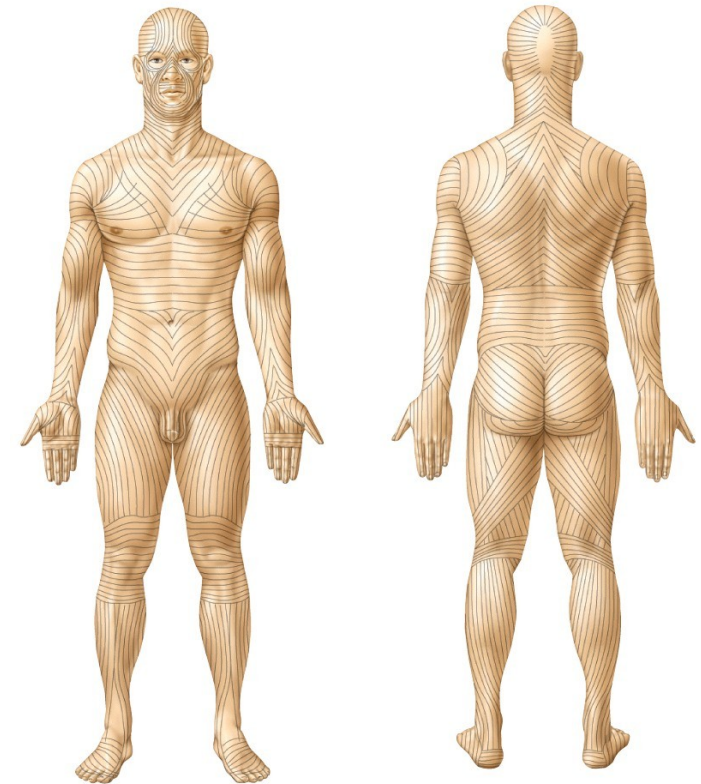
Tension lines in the skin indicate the predominant direction of underlying collagen fibers in the reticular region

- Result from bony projections, orientation of muscles, and movements at joints

The more regular netlike arrangement of collagen fibers enables alignment with the local tensile forces to help the skin **resist stretching**.

Tension lines are clinically important because surgical incisions parallel to them leave only fine scars, but a surgical incision made across several layers of tension lines will tend to gape open and heal in a broad, thick scar.

Knowledge of tension lines is especially important to plastic surgeons. For example, a surgical incision running parallel to the collagen fibers will heal with only a fine scar.



(a) Anterior view

(b) Posterior view

Clinical Connection – Finger Prints



(c) Epidermal ridges and sweat pores

Clinical Connection – Finger Prints

epidermal ridges produced during 3rd month of fetal development as the epidermis projects downward into the dermis appear either as straight lines or as a pattern of loops and whorls, as on the tips of the digits. The epidermal ridges serve multiple functions:

(1)increase surface area of epidermis - function to increase the grip of the hand or foot by increasing friction

(2)interdigitating pattern between epidermal ridges and dermal papillae creates a stronger bond between the epidermis and dermis in regions of high mechanical stress

(3)greatly increase the surface area, which increases the number of corpuscles of touch and thus increases tactile sensitivity.

fingerprints (or **footprints**) when a smooth object is touched the sweat and ridges form this genetically determined ridge pattern (unique - even identical twins have different patterns). Normally, the does not change during life, except to enlarge, and thus can serve as a permanent basis for identification.

Dermatoglyphics

The study of the pattern of epidermal ridges that is concerned with the identification and classification of fingerprints

In addition to forming epidermal ridges, the complex papillary surface of the dermis has other functional properties.

Clinical Connection - Stretch Marks



Striae (stretch marks) can result from internal damage to dermis
When the skin is overstretched, the mechanical demands placed on this layer exceed

- the strength of the collagen bonding
- the stretch available from elastic fibers and creases in skin

Tattooing and Body Piercing

- Tattooing is a permanent coloration of the skin
- Body piercing is the insertion of jewelry through an artificial opening

Subcutaneous Layer or Hypodermis

- not part of skin, connective tissue that varies from region to region
- active metabolic tissue with numerous nerve endings
Lamellated corpuscles and rich vascular networks

FUNCTIONS

- loose binding tissue that unites the upper layers of the skin to deeper structures & allows the skin to move freely
- a storage depot for fat
 - insulation helps retard heat loss from body
 - provides energy
- Forms fat pads - absorb shock and protect underlying muscle and bone

Clinical Connection – Skin Cancer

- Non-melanoma skin cancers (males > females)
 - Basal cell carcinomas
 - Squamous cell carcinomas
- Malignant melanomas
 - A is for asymmetry
 - B is for border
 - C is for color
 - D is for diameter: ordinary moles tend to be smaller than 6 mm (0.25 in.), about the size of a pencil eraser. Once a malignant melanoma has the characteristics of A, B, and C, it is usually larger than 6 mm

Normal Mole and Malignant Melanoma

Alain Dex/Photo Researchers, Inc.



(A) Normal nevus (mole)



(B) Malignant melanoma

Biophoto Associates/Photo Researchers, Inc.

Clinical Connection - Skin Cancer

Some risk factors for skin cancer:

- **Skin type:** Individuals with light-colored skin who never tan but always burn are at high risk.
- **Sun exposure:** People who live in areas with many days of sunlight per year and at high altitudes (where ultraviolet light is more intense) have a higher risk of developing skin cancer. Likewise, people who engage in outdoor occupations and those who have suffered three or more severe sunburns have a higher risk.

Clinical Connection - Skin Cancer

- **Family history:** Skin cancer rates are higher in some families than in others.
- **Age:** Older people are more prone to skin cancer owing to longer total exposure to sunlight.
- **Immunological status:** Individuals who are immunosuppressed have a higher incidence of skin cancer

Accessory Structures of the Skin

- Organs that develop from the embryonic epidermis
 - hair, skin glands, and nails
- Hairs (pili) have a number of important characteristics:
- Primary functions
 - protection, reduction of heat loss, and sensing light touch

Anatomy of a Hair

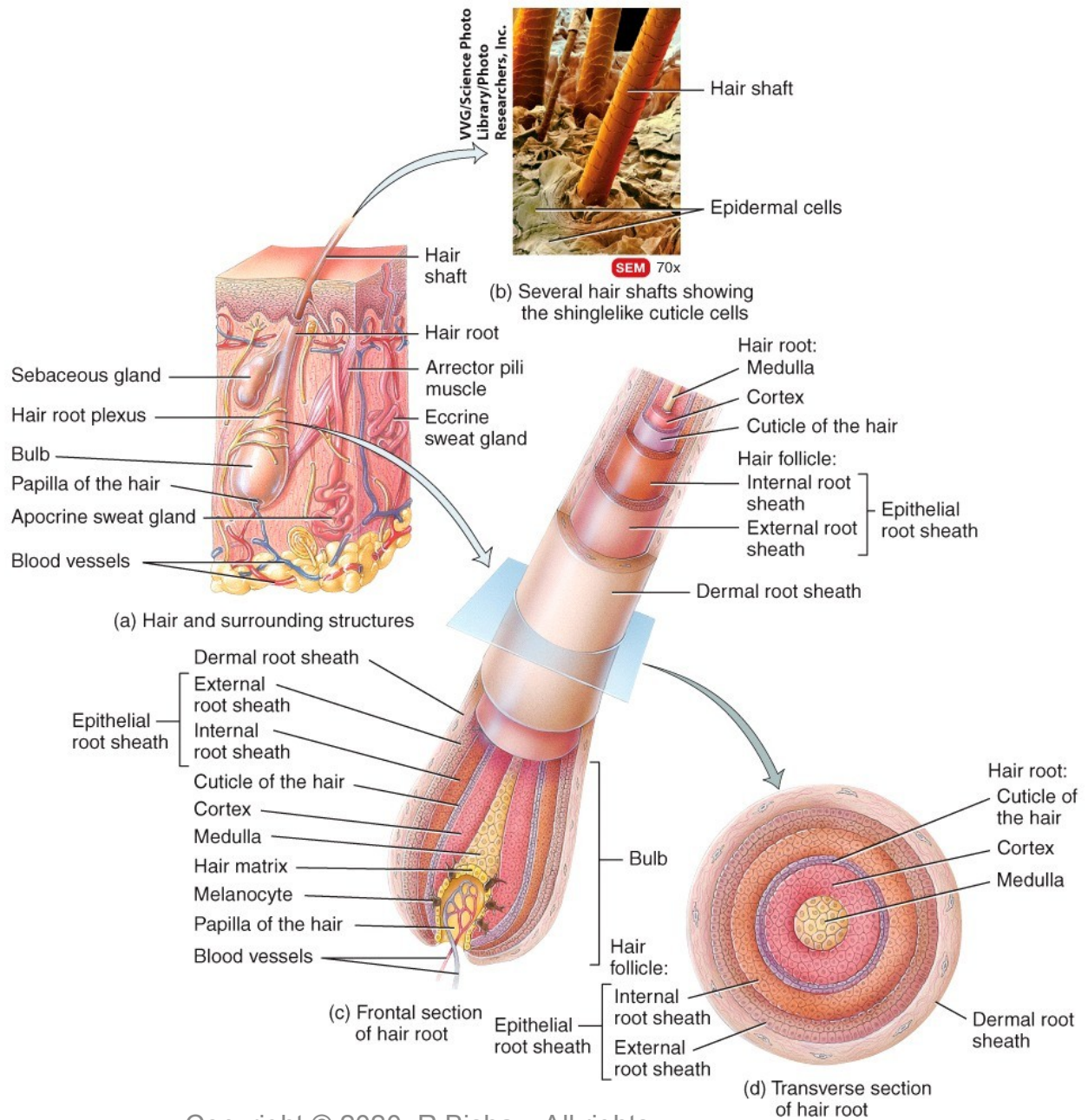
- Hair is composed of dead, keratinized epidermal cells
 - **Each hair consists of:**
 - **Shaft:** superficial part above the surface of skin
Shape: curly (bean), wavy (oval), straight (circular)
 - **Root:** portion of the hair that is deep to the shaft that penetrates into the dermis and sometimes into the subcutaneous layer
 - **Hair Follicle:** surrounds the root;
- Internal root sheath: produced by hair matrix, forms cellular tubular sheath of epithelium between external root sheath the hair)
- External root sheath: downward continuation of epidermis (at surface contains all layers, at base only contains stratum basale)

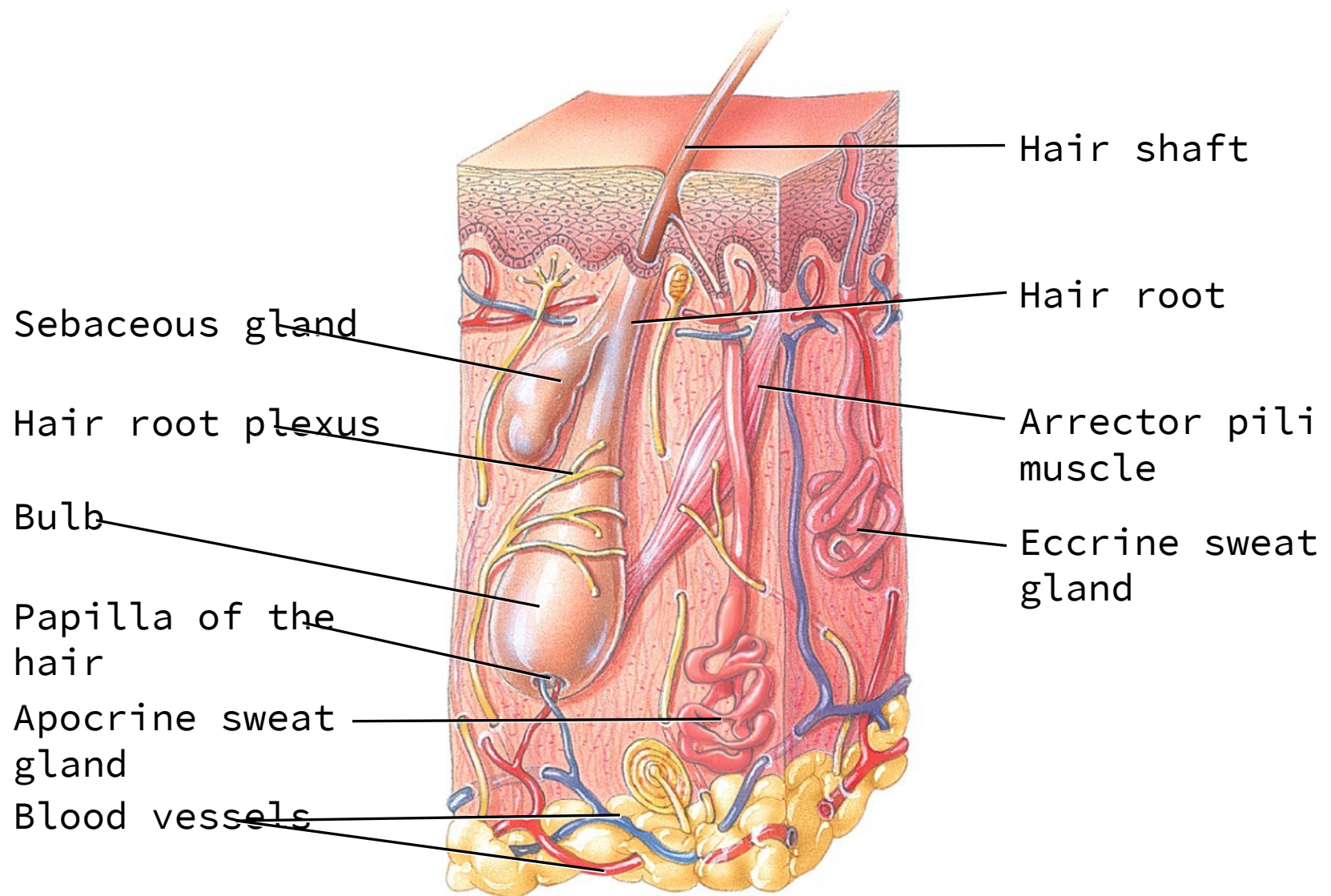
Anatomy of a Hair

- **Bulb** (onion shaped structure): base of each hair follicle and its surrounding dermal root sheath
- *Papilla* of the hair indents the bulb at its base, contains areolar connective tissue and many blood vessels (nourishment)
- **Hair matrix** : Germinal cell layer in the bulb, arise from stratum basale - give rise to internal root sheath and growth of hair itself
- **Sebaceous (oil) glands, arrector pili muscles, and hair root plexuses**

Anatomy of a Hair

- **arrector pili** bundle of smooth muscle cells, extend from the superficial dermis to the connective tissue sheath around the hair follicle.
- In its normal position, hair emerges at an angle to the surface of the skin.
- Under physiological or emotional stress, such as cold, fright, or anger, autonomic nerve endings stimulate the arrector pili muscles
- to contract, which pulls the hair shafts perpendicular to the skin surface. This action, which results in a slight elevation around
- each shaft of hair, causes “**goosebumps**” or “gooseflesh.”
- **Why does this happen?**
- in animals with a lot of hair, this mechanism can be very important for survival.
- *Insulation*: By erecting the hairs on their bodies, most mammals can trap dead (unmoving) air between the hairs, creating dead air space, double-pane insulated glass windows
- *Intimidation*: mammals look bigger and more formidable
- **hair root plexus**: Dendrites of neurons surround each hair follicle, sensitive to touch





(a) Hair and surrounding structures

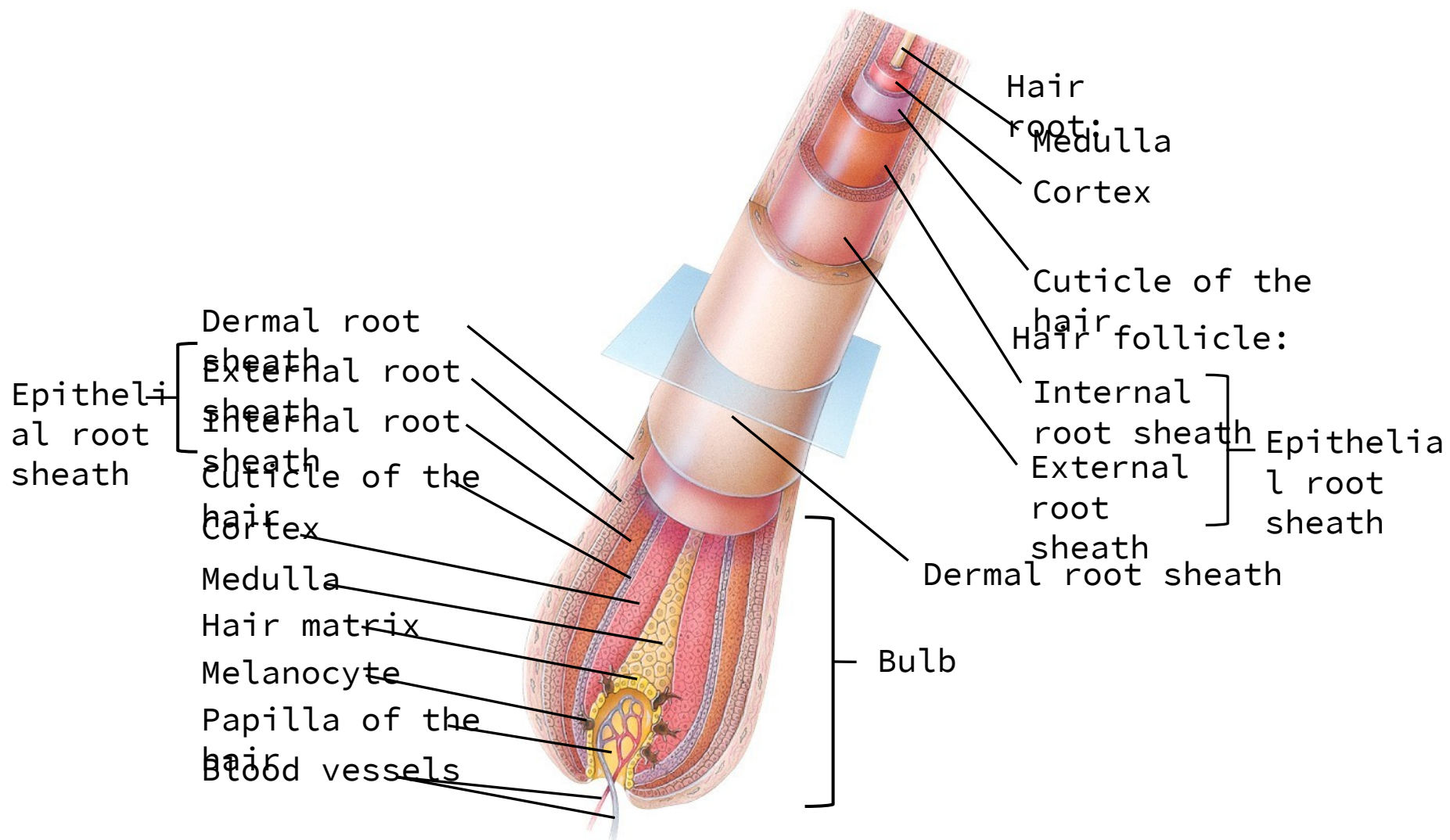


Hair shaft

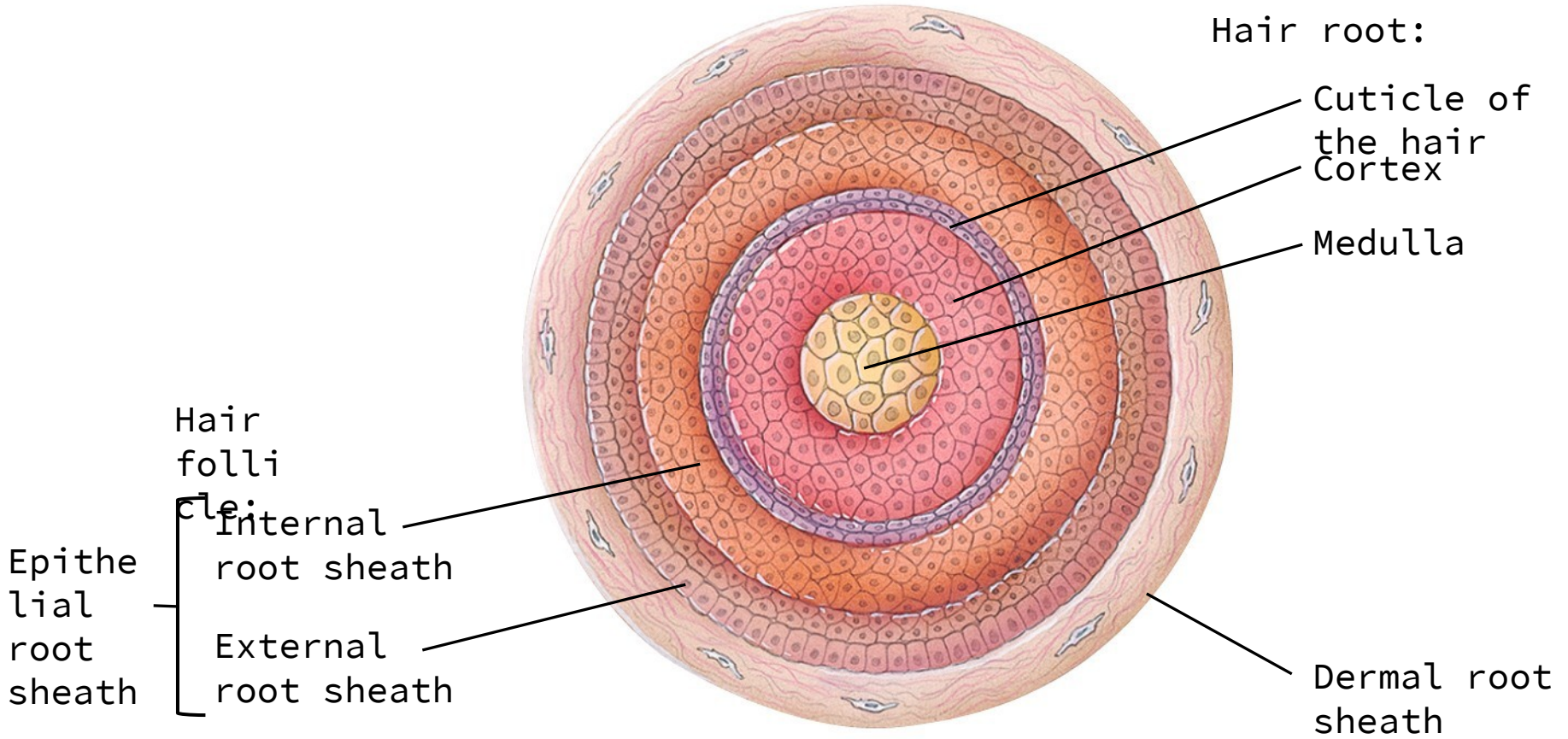
Epidermal
cells

SEM 70x

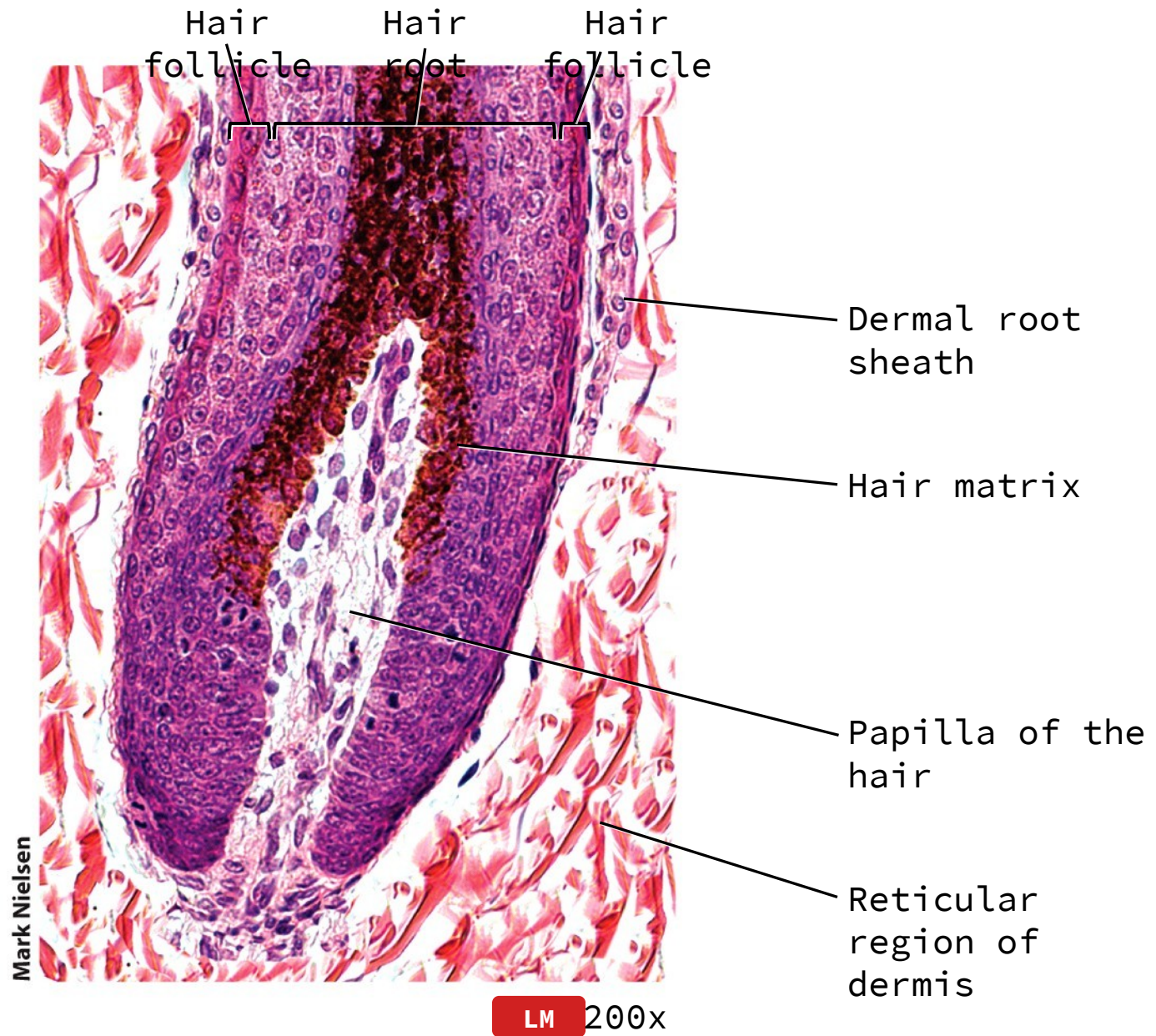
(b) Several hair
shafts showing the
shinglelike cuticle
cells



(c) Frontal section of hair root



(d) Transverse section of hair root



(e) Hair root

Hair Growth

- Normal hair loss 70–100 hairs per day.
- *Both the rate of growth and the replacement cycle* can be altered by illness, diet, high fever, surgery, blood loss, severe emotional stress, and gender. Rapid weight-loss diets that severely restrict the intake of calories or protein increase hair loss.
- An increase in the rate of hair shedding can also occur with certain drugs, after radiation therapy for cancer, and for 3–4 months after childbirth.
- Each follicle goes through a growth cycle including
 - Growth stage
 - Regression stage
 - Resting stage

Hair Growth

- **growth stage**, cells of the hair matrix divide. As new cells from the hair matrix are added to the base of the hair root, existing cells of the hair root are pushed upward and the hair grows longer. While the cells of the hair are being pushed upward, they become keratinized and die.
- **regression stage**, when cells of the hair matrix stop dividing, the hair follicle atrophies (shrinks), and the hair stops growing
- **resting stage**. Following the resting stage, a new growth cycle begins. The old hair root falls out or is pushed out of the hair follicle, and a new hair begins to grow in its place.
- *In TCM: Body hair is under control of LU*
- *While scalp hair is under control of And*
- (Colour is under control of KI while texture is under control of LR)

Hair Growth

- Scalp hair is in the growth stage for 2 to 6 years, the regression stage for 2 to 3 weeks, and the resting stage for about 3 months. At any time, about 85 percent of scalp hairs are in the growth stage.
- Visible hair is dead, which is why, despite the fears of many children, haircuts don't hurt a bit. However, until the hair is pushed out of its follicle by a new hair, portions of its root within the scalp are alive and surrounded by nerve endings, which is the reason for the verbal explosions that result if those same children yank on the hair of their siblings.

Clinical Connection – Hair & Hormones

- Puberty
- Androgenic alopecia or male-pattern baldness
- Hirsutism: **Hirsutism** excessive body hair, or hairiness in areas that are usually not hairy (in women or prepubescent males). Occasionally, a tumor of the adrenal glands, testes, or ovaries produces an excessive amount of androgens.

Clinical Connection – Chemotherapy and Hair Loss

- Chemotherapeutic agents interrupt the life cycle of rapidly dividing cancer cells
- hair matrix cells are affected
- since 85% are in growth phase at any one time = hair loss
- Once therapy stops, hair matrix cells replace hairs again

Types of Hairs

- **Lanugo:** DOWNY very fine, non-pigmented hairs that are produced by hair follicles, cover the body of fetus usually by 5th month. This hair is shed before birth, except from the scalp, eyebrows, and eyelashes.
- **Vellus hairs:** short, slightly thicker (still fine) hairs replace lanugo a few months after birth in the infant, commonly called “peach fuzz.”
- **Terminal hairs:** hair that develops at puberty, together with the head, eyebrows, and eyelashes
- Color of hair is determined primarily by the amount and type of melanin

Clinical Connection – Hair Removal

- Electrolysis: electric current is used to destroy the hair matrix so the hair cannot regrow.
- Laser treatment: may also be used to remove hair.

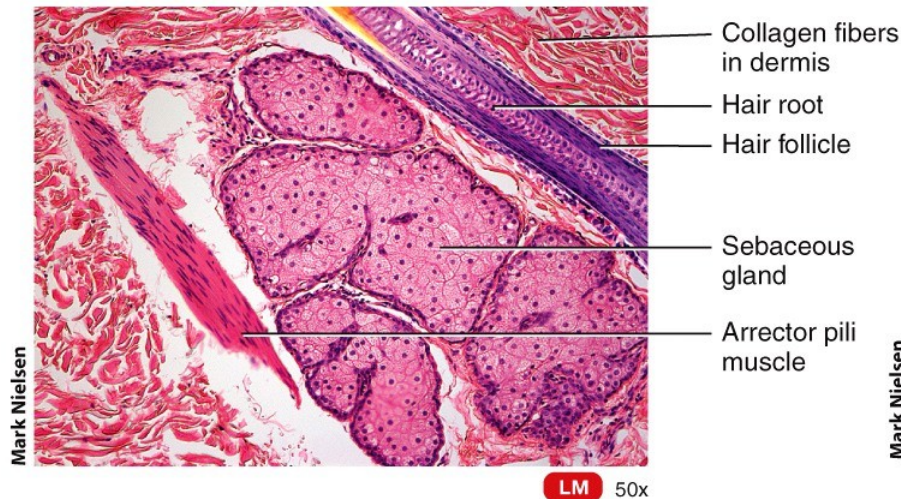
Skin Glands

- Sebaceous (oil) glands have several important characteristics:
 - typically connected to hair follicles

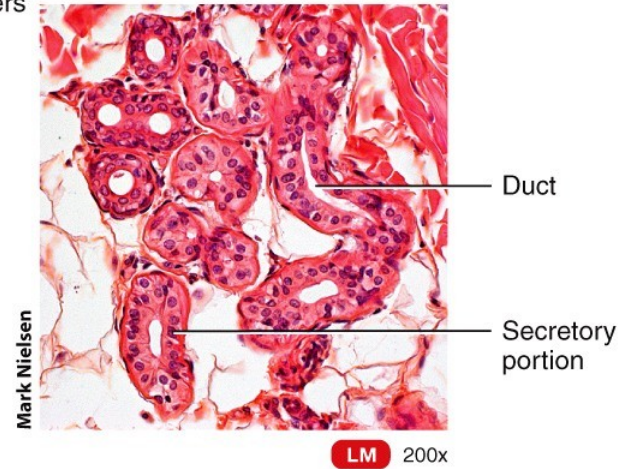
Sebum

- prevents dehydration of hair and skin, and inhibits growth of certain bacteria
- Sudoriferous (sweat) glands
 - eccrine and apocrine sweat glands

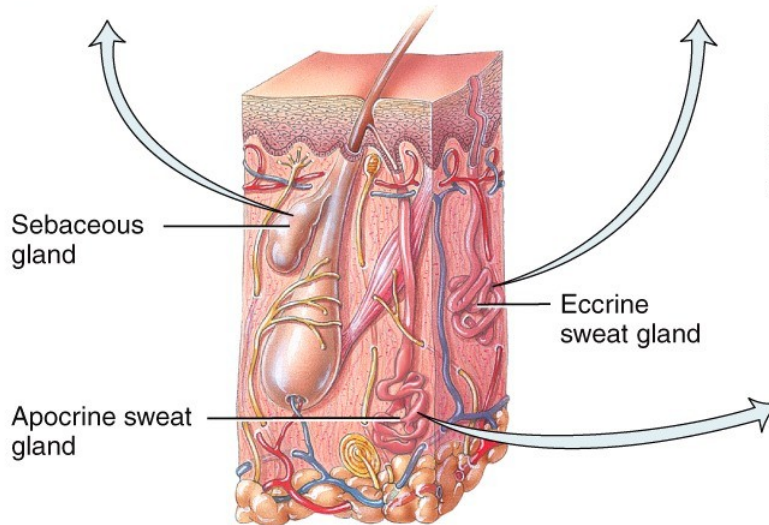
Histology of Skin Glands



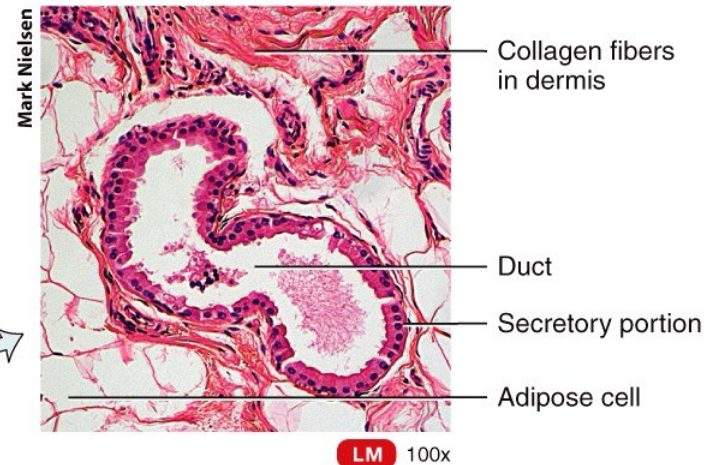
(a) Sebaceous gland



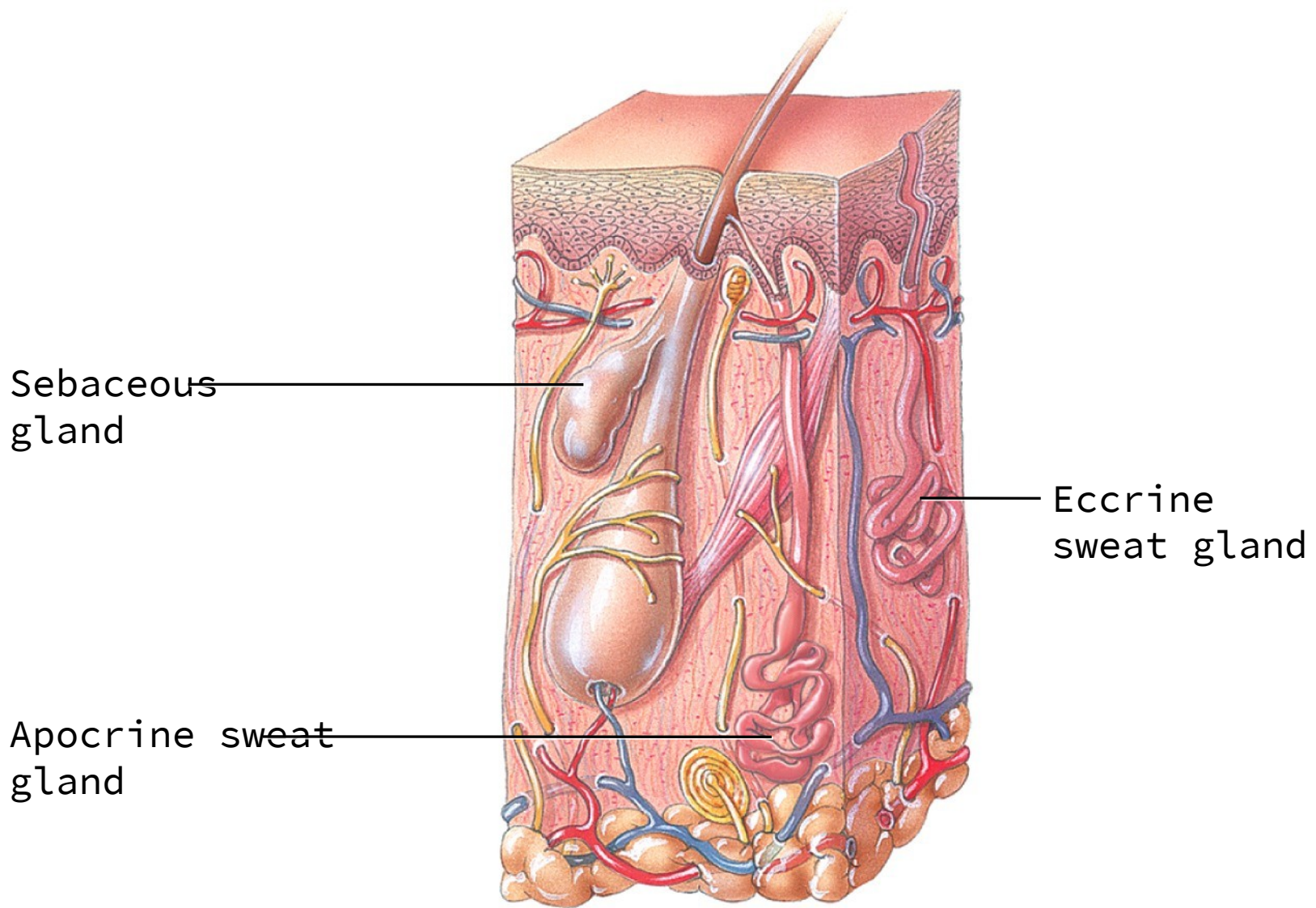
(b) Eccrine sweat gland



Location of skin glands



(c) Apocrine sweat gland



Location of skin glands



Collagen fibers
in dermis

Hair root

Hair follicle

Sebaceous gland

Arrector pili
muscle

LM 50x

(a) Sebaceous gland

Sebaceous (oil) glands

- vary in size, shape and number
- connected to hair follicles and found all over body except in palms and soles
- simple, branched acinar (rounded) glands
- secreting portion lies in dermis, typically situated in the angle the arrector pili muscle forms with the outer wall of a hair follicle
- usually opens into the neck of the hair follicle
- can also open directly onto the surface of the skin (lips, glans penis, and labia minora)

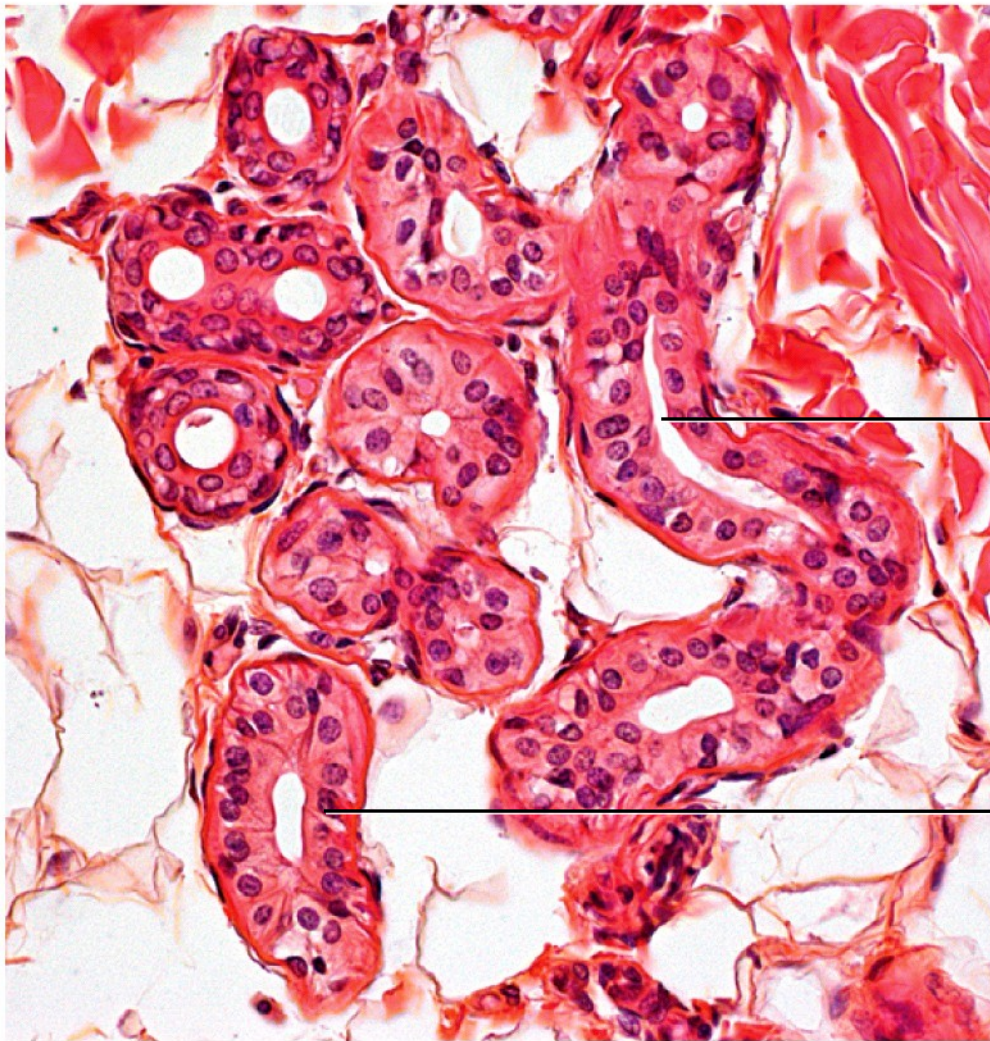
Clinical Connection

- **Childhood:** sebaceous glands are relatively small and inactive.
- **Puberty:** androgens from the testes, ovaries, and adrenal glands stimulate sebaceous glands to ↑ size and ↑ production of sebum.
- **Acne** is an inflammation of sebaceous glands that usually begins at puberty, when the sebaceous glands are stimulated by androgens. Acne occurs predominantly in sebaceous follicles that have been colonized by bacteria, some of which thrive in the lipid rich sebum.
- **Cystic acne:** The infection may cause a cyst or sac of connective tissue cells to form, which can destroy and displace epidermal cells. This condition can permanently scar the epidermis.

Sudoriferous (Sweat) Glands

- 3-4 million **sweat glands** in body.
- cells release their secretions by **exocytosis** onto the skin surface through pores or into hair follicles.
- Eccrine (or merocrine) sweat glands :
 - insensible perspiration or sensible perspiration
 - are much more common than apocrine sweat glands
- Apocrine sweat glands:
- **No Holocrine type of sweat glands**

Mark Nielsen



Duct

Secretory
portion

LM 200x

(b) Eccrine sweat gland

Eccrine sudoriferous (sweat) glands

- most numerous skin glands (up to 3000/inch²)
- present in all skin except margins of the lips, nail beds, glans penis, glans clitoris, labia minora, and eardrums
- function soon after birth
- simple, coiled tubular glands
- secretory part is highly coiled and lies deep in the dermis or subcutaneous/hypodermis layer
- a slender straight duct ascends through the dermis to empty onto the surface of the skin

Eccrine sudoriferous (sweat) glands

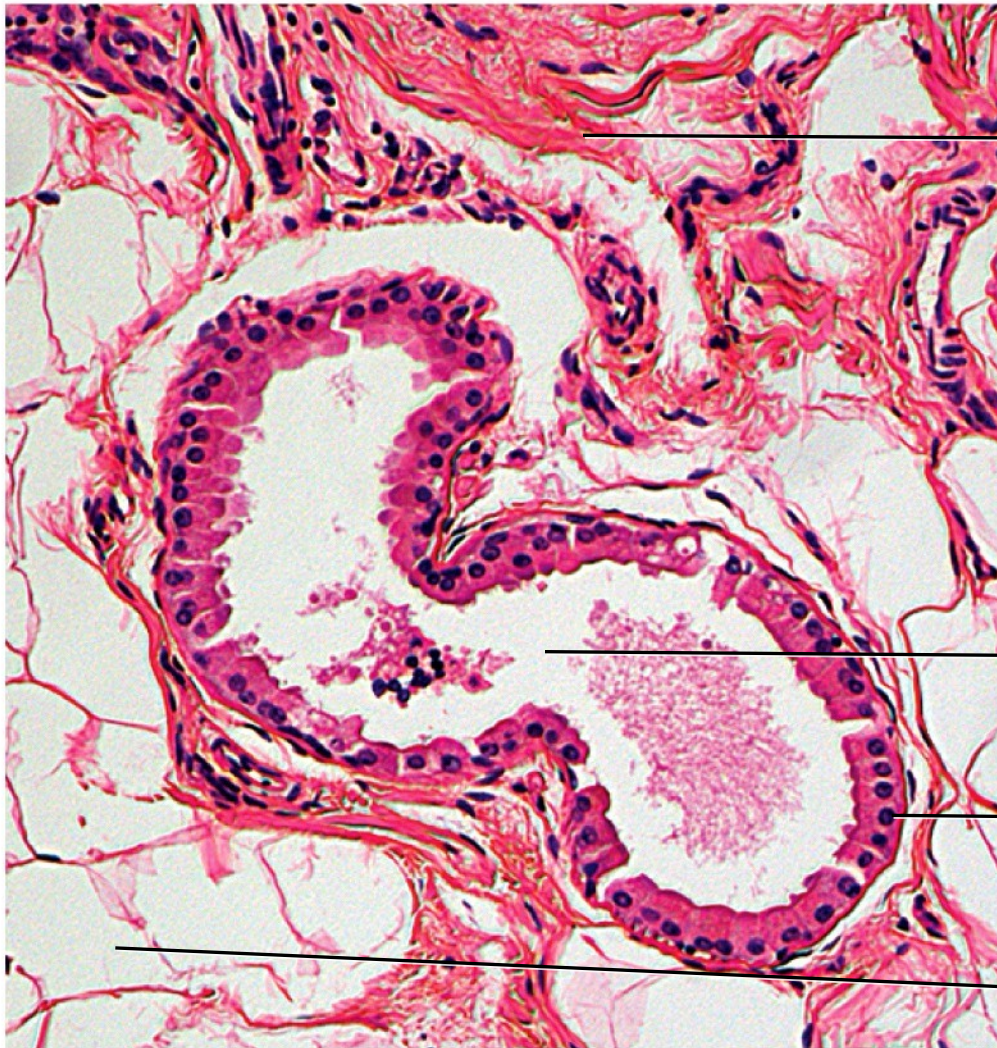
Sweat consists of water, ions (Na^+ Cl^-), urea, uric acid, ammonia, amino acids, glucose, lactic acid

Functions of Sweat

- Thermoregulation
 - Insensible perspiration
 - Sensible perspiration
- Waste Elimination (urea, uric acid, ammonia)
- Emotional sweating (cold sweat)

Apocrine (sweat) glands

- simple, coiled tubular glands
- function after puberty
- found mainly in the skin of the axilla (armpit), groin, areolae of breasts, bearded regions of the face in adult males
- secretory portion mostly in subcutaneous layer, excretory duct opens into the hair follicles
- body odor – secretion is slightly viscous compared to eccrine (same plus lipids & proteins)
- active during emotional stress & sexual excitement
- not active in thermoregulatory sweating



Collagen
fibers in
dermis

Duct

Secretory
portion

Adipose cell

LM 100x

(c) Apocrine sweat gland

Ceruminous Glands

- modified sweat glands in the external ear produce a yellowish waxy lubricating secretion **cerumen**
- secretory portions lie in the subcutaneous layer, deep to sebaceous glands
- excretory ducts open either directly onto the surface of the external auditory canal (ear canal) or into ducts of sebaceous glands
- **Earwax:** combined secretion of the ceruminous and sebaceous glands

TABLE 5.3**Summary of Skin Glands (See also Figures 5.1 and 5.4a)**

FEATURE	SEBACEOUS (OIL) GLANDS	ECCRINE SWEAT GLANDS	APOCRINE SWEAT GLANDS	CERUMINOUS GLANDS
Distribution	Large in lips, glans penis, labia minora, and tarsal glands; small in trunk and limbs; absent in palms and soles	Throughout skin of most regions of the body, especially in skin of forehead, palms, and soles	Skin of axilla, groin, areolae, bearded regions of face, clitoris, and labia minora	External auditory canal
Location of secretory portion	Dermis	Mostly in deep dermis	Mostly in subcutaneous layer	Subcutaneous layer
Termination of excretory duct	Mostly connected to hair follicles	Surface of epidermis	Hair follicle	Surface of external auditory canal or into ducts of sebaceous glands
Secretion	Sebum (mixture of triglycerides, cholesterol, proteins), and inorganic salts	Less viscous; consists of water, ions (Na^+ , Cl^-), urea, uric acid, ammonia, amino acids, glucose, and lactic acid	More viscous; consists of the same components as eccrine sweat glands plus lipids and proteins	Cerumen, a waxy material
Functions	Prevent hairs from drying out, prevent water loss from skin, keep skin soft, and inhibit growth of some bacteria	Regulation of body temperature, waste removal, and stimulation during emotional stress	Stimulation during emotional stress and sexual excitement	Impedes entrance of foreign bodies and insects into external ear canal, waterproofs canal, and prevents microbes from entering cells
Onset of function	Relatively inactive during childhood; activated during puberty	Soon after birth	Puberty	Soon after birth

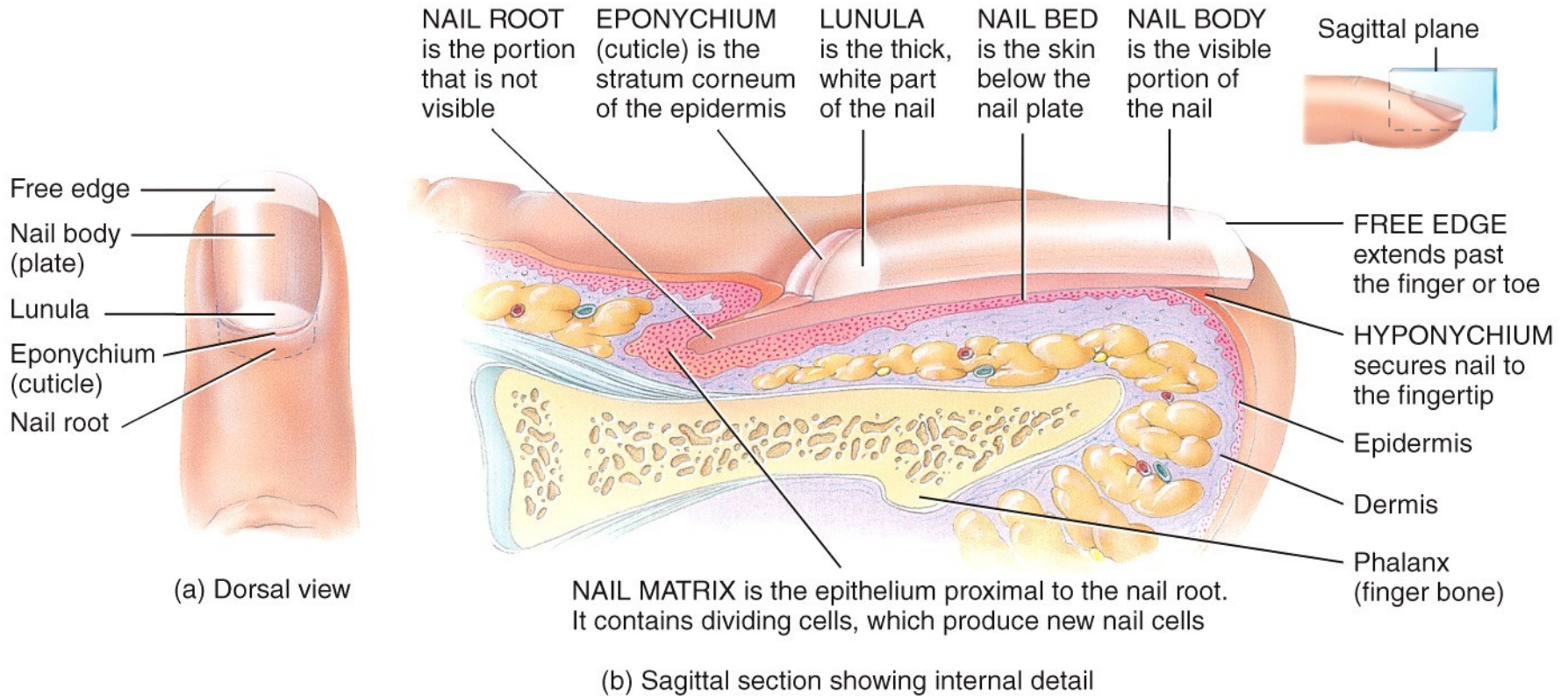
Nails - Structure

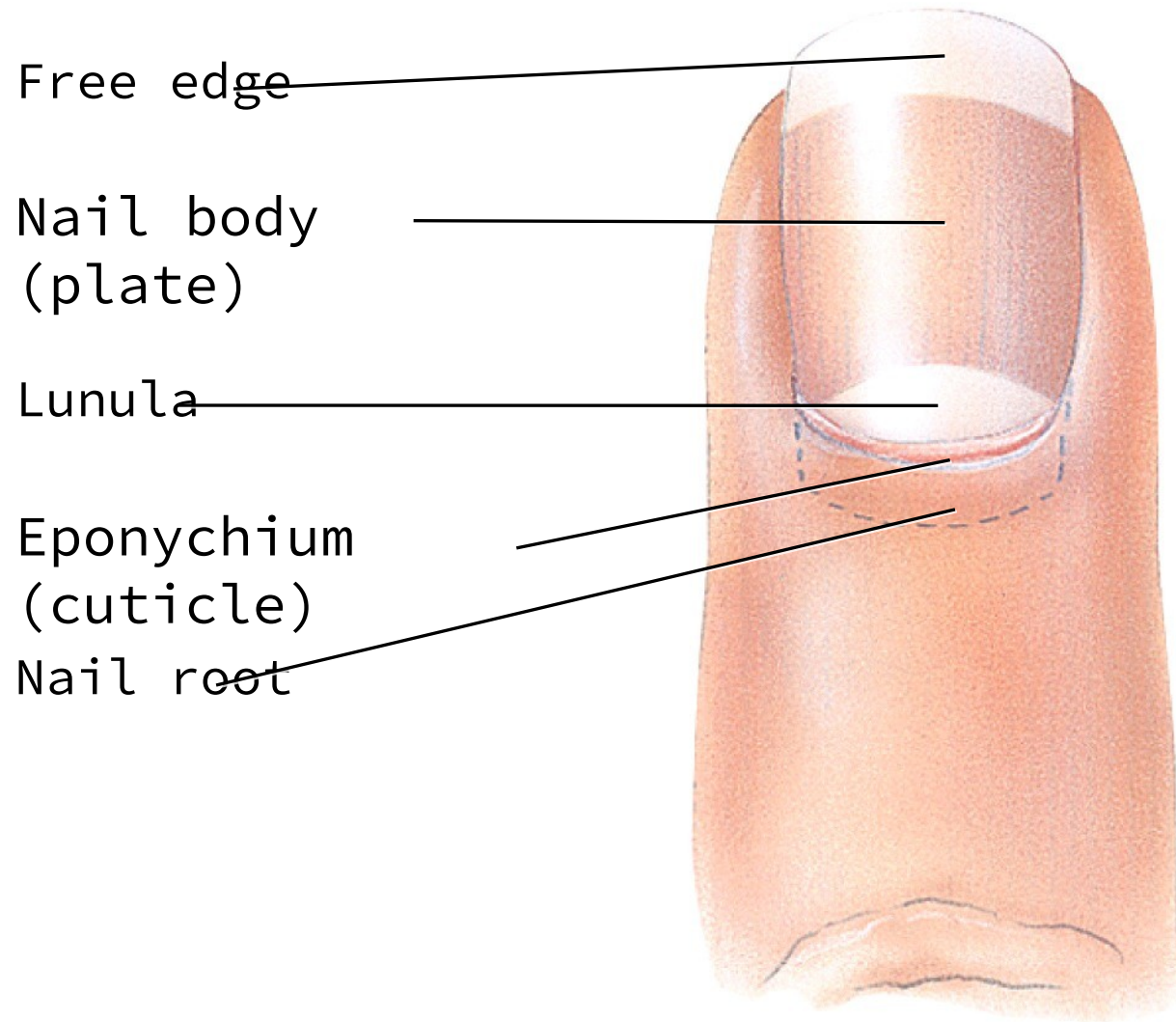
- plates of tightly packed, hard, dead keratinized epidermal cells
- cells form a clear, solid covering over the dorsal surfaces of the distal portions of the digits
- Each nail consists of:
 - Nail body
 - Free edge
 - Nail root

The Nail - Functions

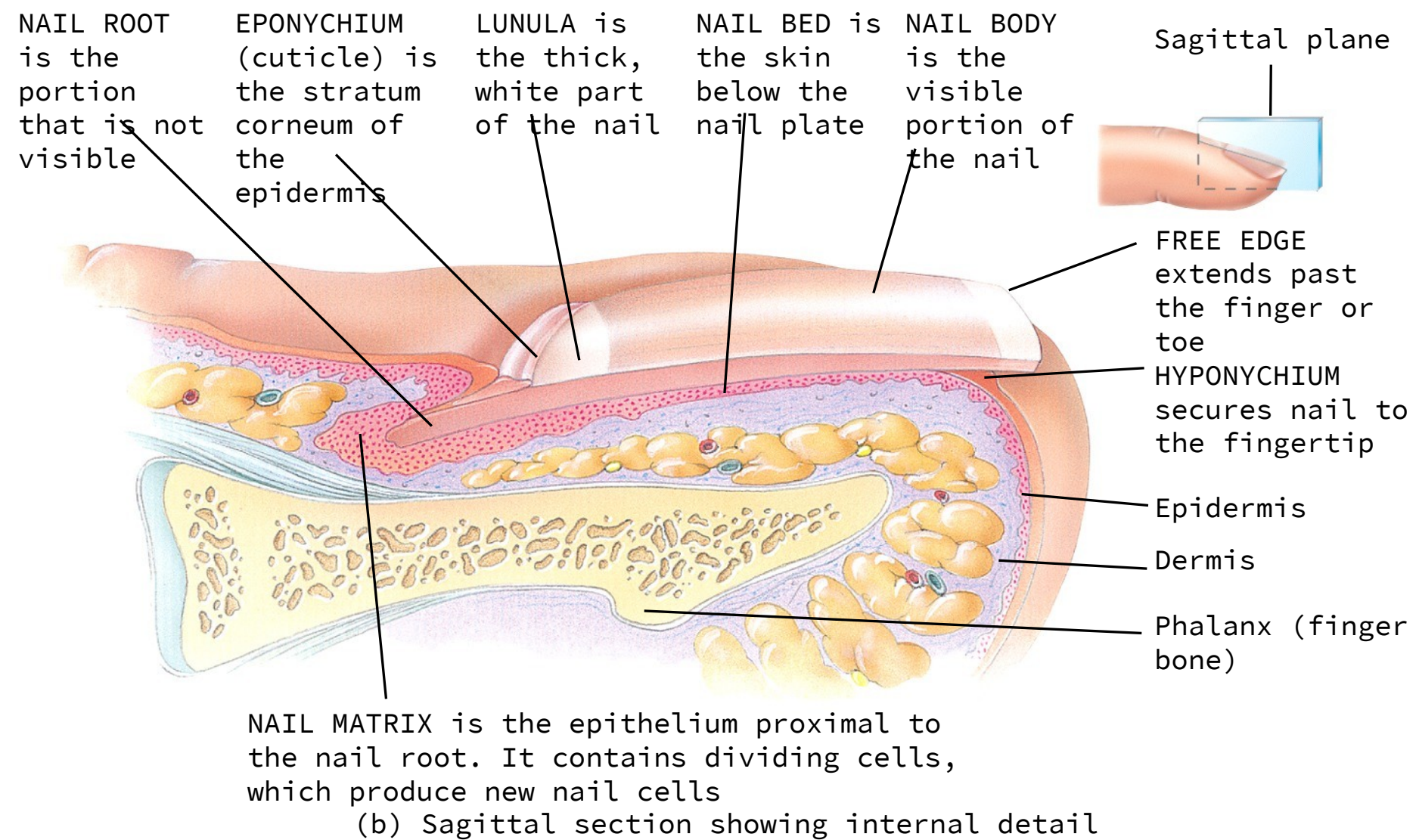
- grasp and manipulate objects
- protect distal ends of digits
- scratching various body parts
- providing support and counter pressure to the palmar surface of the finger

Nails

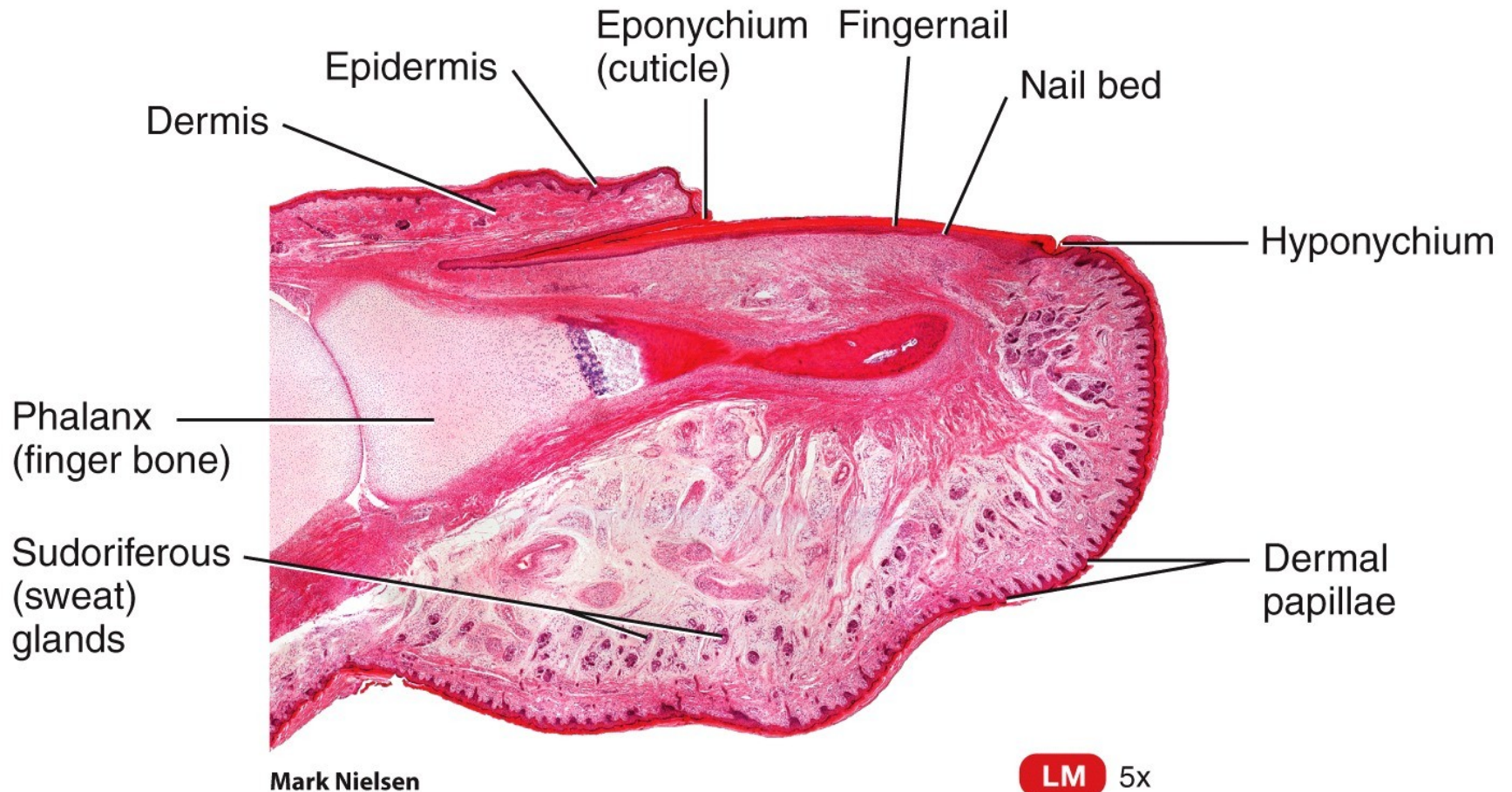




(a) Dorsal
view



Nails



(c) Photomicrograph of fingertip

Types of Skin

- There are two major types of skin
 - thin (hairy) skin
 - thick (hairless) skin
- Despite skin being similar in structure, there are many local variations related to **thickness of the epidermis**, strength, flexibility, degree of keratinization, distribution and type of hair, density and types of glands, pigmentation, vascularity (blood supply), and innervation (nerve supply).
- The greatest contributor to epidermal thickness is the ↑ number of layers in the stratum corneum. This arises in response to the greater mechanical stress in regions of **thick** skin.

TABLE 5.4**Comparison of Thin and Thick Skin**

FEATURE	THIN SKIN	THICK SKIN
Distribution	All parts of the body except areas such as palms and palmar surface of digits, and soles	Areas such as the palms, palmar surface of digits, and soles
Epidermal thickness	0.10–0.15 mm (0.004–0.006 in.)	0.6–4.5 mm (0.024–0.18 in.), due mostly to a thicker stratum corneum
Epidermal strata	Stratum lucidum essentially lacking; thinner strata spinosum and corneum	Strata lucidum present; thicker stratum spinosum and corneum
Epidermal ridges	Lacking due to poorly developed and fewer and less-well-organized dermal papillae	Present due to well-developed and more numerous dermal papillae organized in parallel rows
Hair follicles and arrector pili muscles	Present	Absent
Sebaceous glands	Present	Absent
Sudoriferous glands	Fewer	More numerous
Sensory receptors	Sparser	Denser

Functions of the Skin

- **Thermoregulation:** by liberating sweat at its surface: In response to high environmental temperature or heat produced by exercise, sweat production from eccrine sweat glands increases; the evaporation of sweat from the skin surface helps lower body temperature. In response to low environmental temperature, production of sweat from eccrine sweat glands is decreased, which helps conserve heat.
- by adjusting the flow of blood in the dermis: blood vessels in the dermis of the skin dilate (become wider); consequently, more blood flows through the dermis, which increases the amount of heat loss from the body. In cold, will constrict (become narrow), which decreases blood flow through the skin and reduces heat loss from the body.

Functions of the Skin

- Thermoregulation
- **Blood reservoir:** The dermis houses an extensive network of blood vessels that carry 8–10 percent of the total blood flow in a resting adult. For this reason, the skin is considered a *blood reservoir*.

Functions of the Skin

- Thermoregulation
- Blood reservoir
- **Protection:** The skin provides *protection* to the body in various ways.
- Keratin protects underlying tissues from microbes, abrasion, heat, and chemicals; the tightly interlocked keratinocytes resist invasion by microbes.
- Lipids released by lamellar granules inhibit evaporation of water from the skin surface, thus protecting against dehydration; they also retard entry of water across the skin surface during showers and swims.

Functions of the Skin

- The oily sebum from the sebaceous glands protects skin and hairs from drying out and contains *bactericidal chemicals* (substances that kill bacteria). The acidic pH of perspiration retards the growth of some microbes.
- The pigment melanin helps shield against the damaging effects of ultraviolet light.
- Two types of skin cells carry out protective functions that are immunological in nature.
 - Intraepidermal macrophage cells alert the immune system to the presence of potentially harmful microbial invaders by recognizing and processing them, and
 - macrophages in the dermis phagocytize bacteria and viruses that manage to bypass the intraepidermal macrophage of the epidermis.

Functions: Non-Specific Disease Resistance Mechanisms

Integument acts as a Barrier

- Physical Defense (epidermis, hair, nails)
- Chemical Defense (acids, anti-microbial chemicals in sweat and sebum)
- Cellular Defence: *epidermal* **Langerhans cells**, which process and present antigens to alert the immune system
- dermal* **macrophages** which phagocytize invading cells, and also process and present antigens

Functions of the Skin

- Thermoregulation
- Blood reservoir
- Protection
- Cutaneous sensations

Functions of the Skin

- Thermoregulation
- Blood reservoir
- Protection
- Cutaneous sensations
- Excretion and absorption

You must be connected to the Internet and in Slideshow Mode to run this animation.

Functions of the Skin

- Thermoregulation
- Blood reservoir
- Protection
- Cutaneous sensations
- Excretion and absorption
- Synthesis of vitamin D

You must be connected to the Internet and in Slideshow Mode to run this animation.

Clinical Connection - Burns

- Tissue damage caused by
 - excessive heat
 - electricity
 - radioactivity
 - corrosive chemicals

that denature (destroy) proteins in the skin cells.

- Are graded according to their severity.

Clinical Connection - Burns

The severity of a burn is determined by

- its depth
- extent of area involved
- person's age and general health

Clinical Connection - Effects of Burns

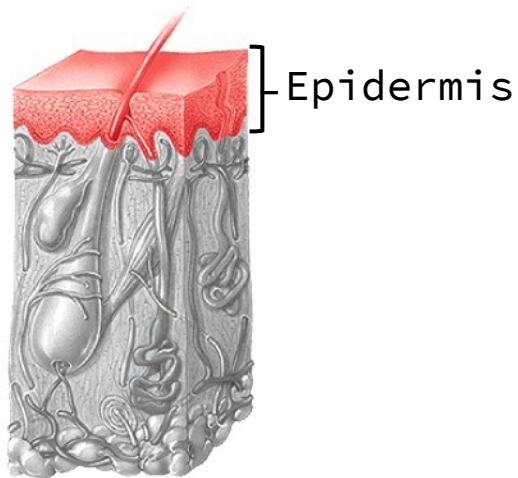
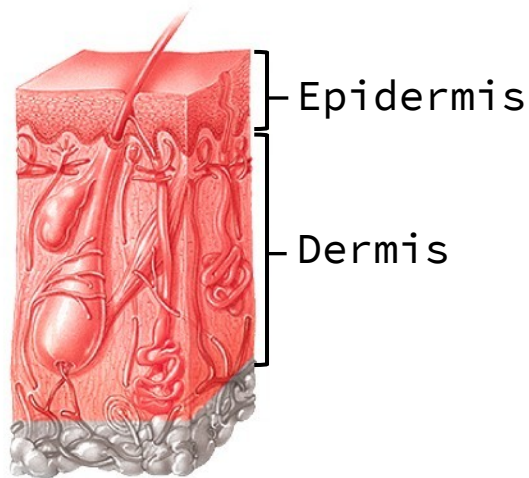
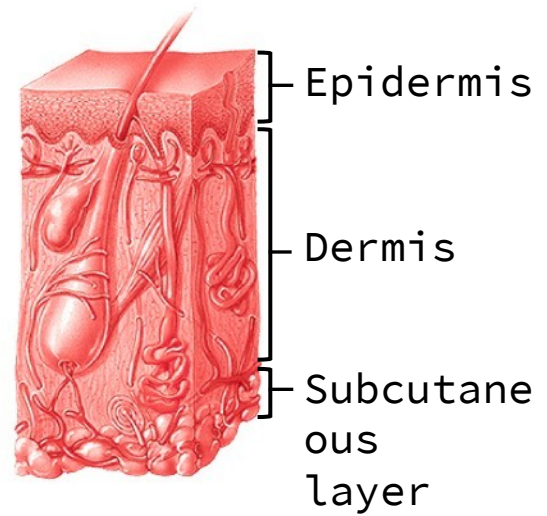
local effects: injury to the skin tissues directly in contact with the damaging agent

systemic effects: usually from a major burn, are a greater threat to life and may include:

- a large loss of water, plasma, and plasma proteins, which causes shock
- bacterial infection
- reduced circulation of blood
- decreased production of urine
- diminished immune responses



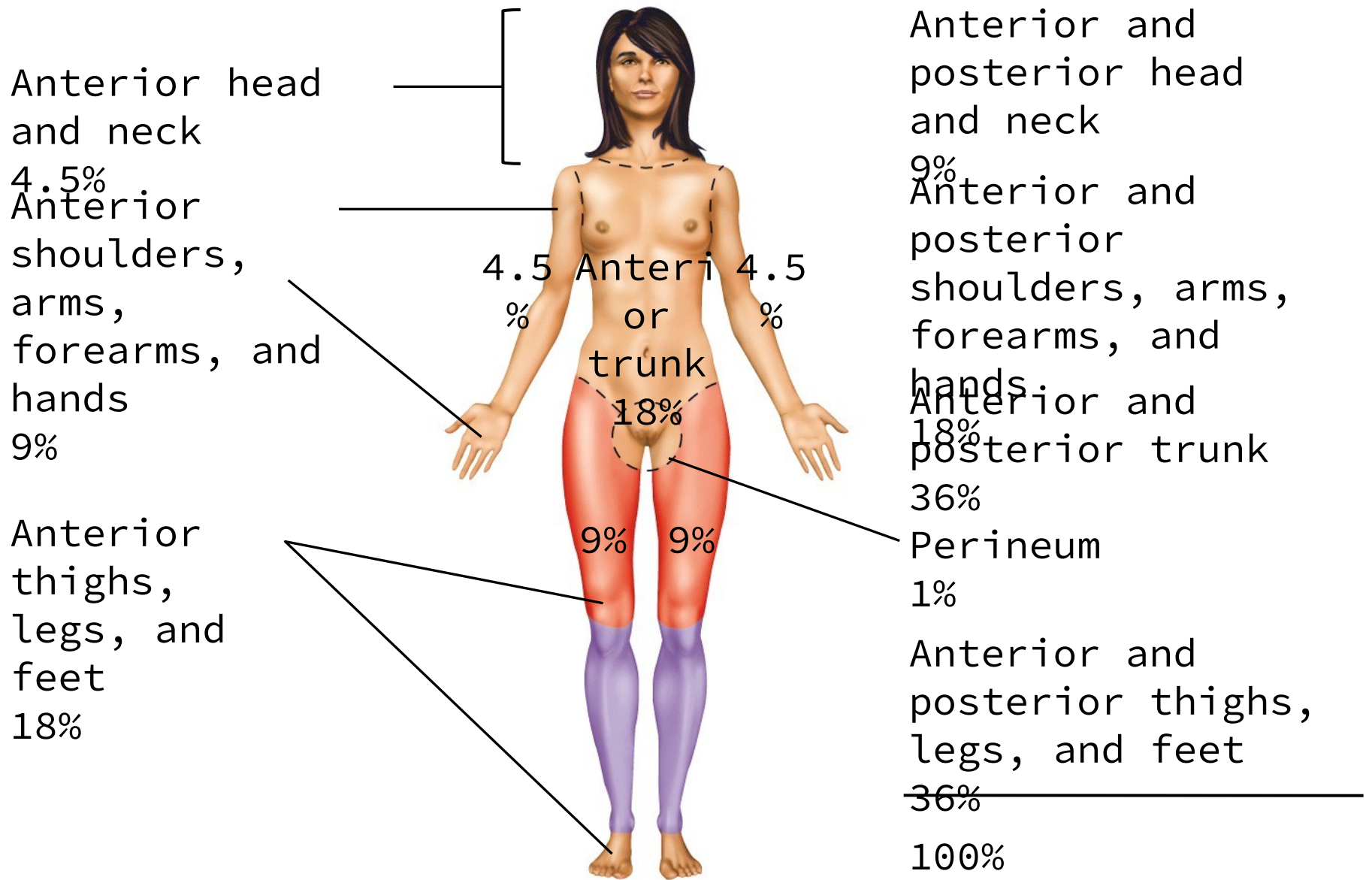
St. Stephen's Hospital/Science Photo Library/Photo Researchers, Inc.



(a) First-degree burn (sunburn)

(b) Second-degree burn (note the blisters in the photograph)

(c) Third-degree burn

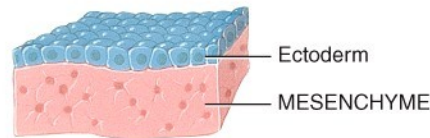


(d) Anterior view illustrating rule of

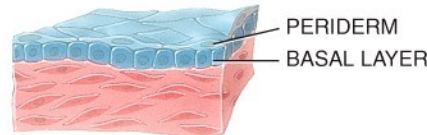
Blood Supply of the Integumentary System

- The epidermis is avascular
- The dermis receives blood from:
 - branches of arteries supplying skeletal muscles
 - arteries that supply the skin directly, including:
 - cutaneous plexus
 - papillary plexus
 - Venous plexuses drain blood from the dermis into larger subcutaneous veins.

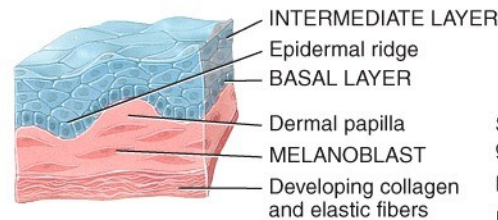
Development of the Integumentary System



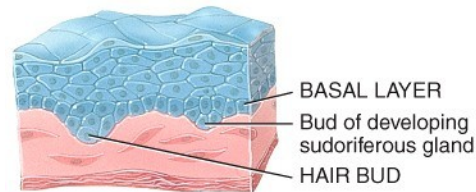
(a) Fourth week



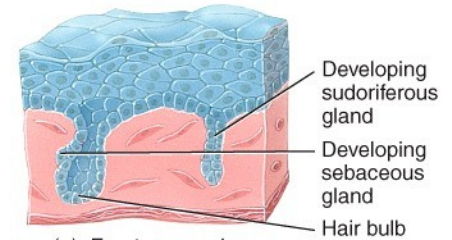
(b) Seventh week



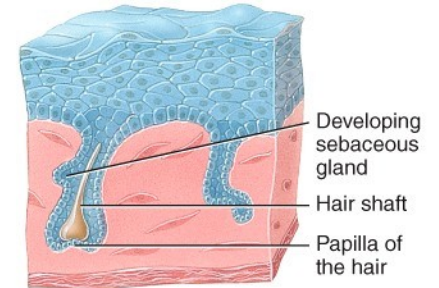
(c) Eleven weeks



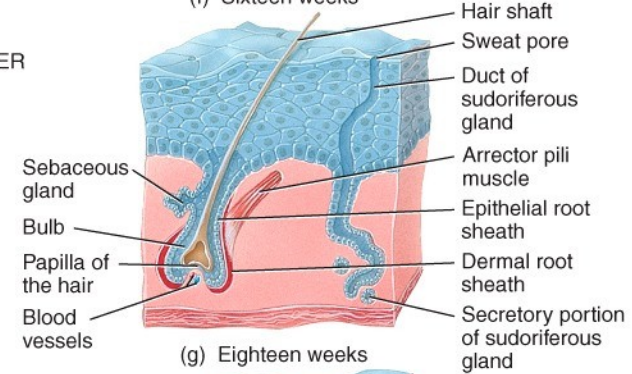
(d) Twelve weeks



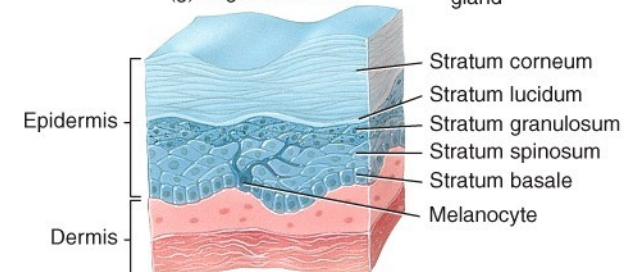
(e) Fourteen weeks



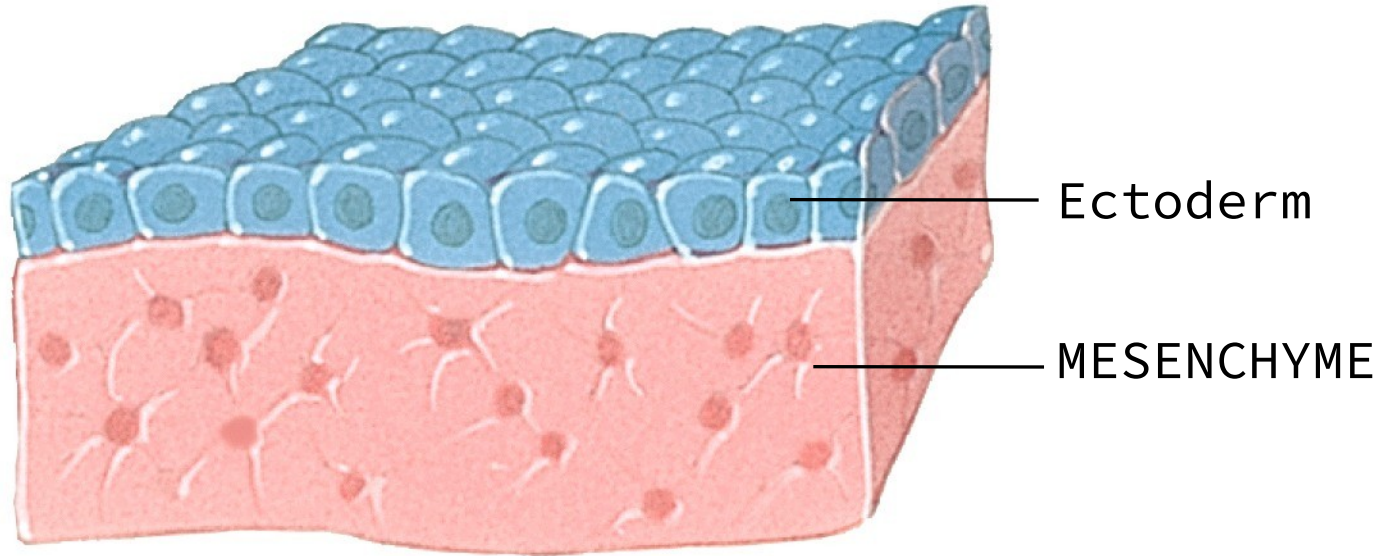
(f) Sixteen weeks



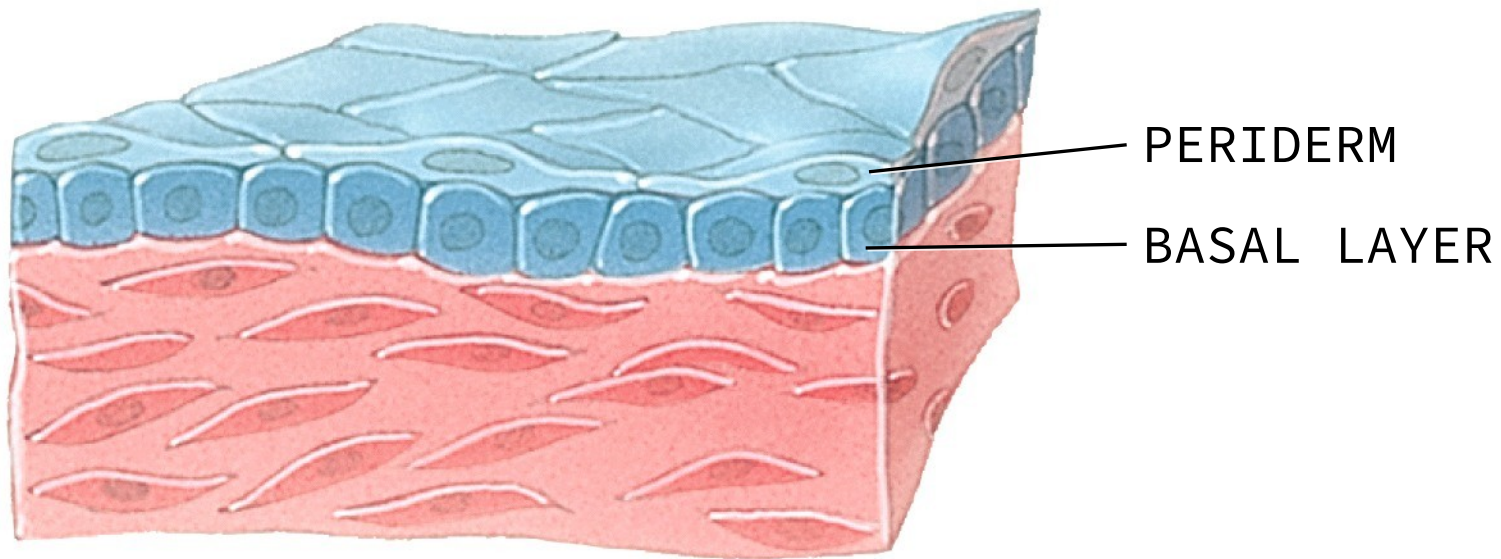
(g) Eighteen weeks



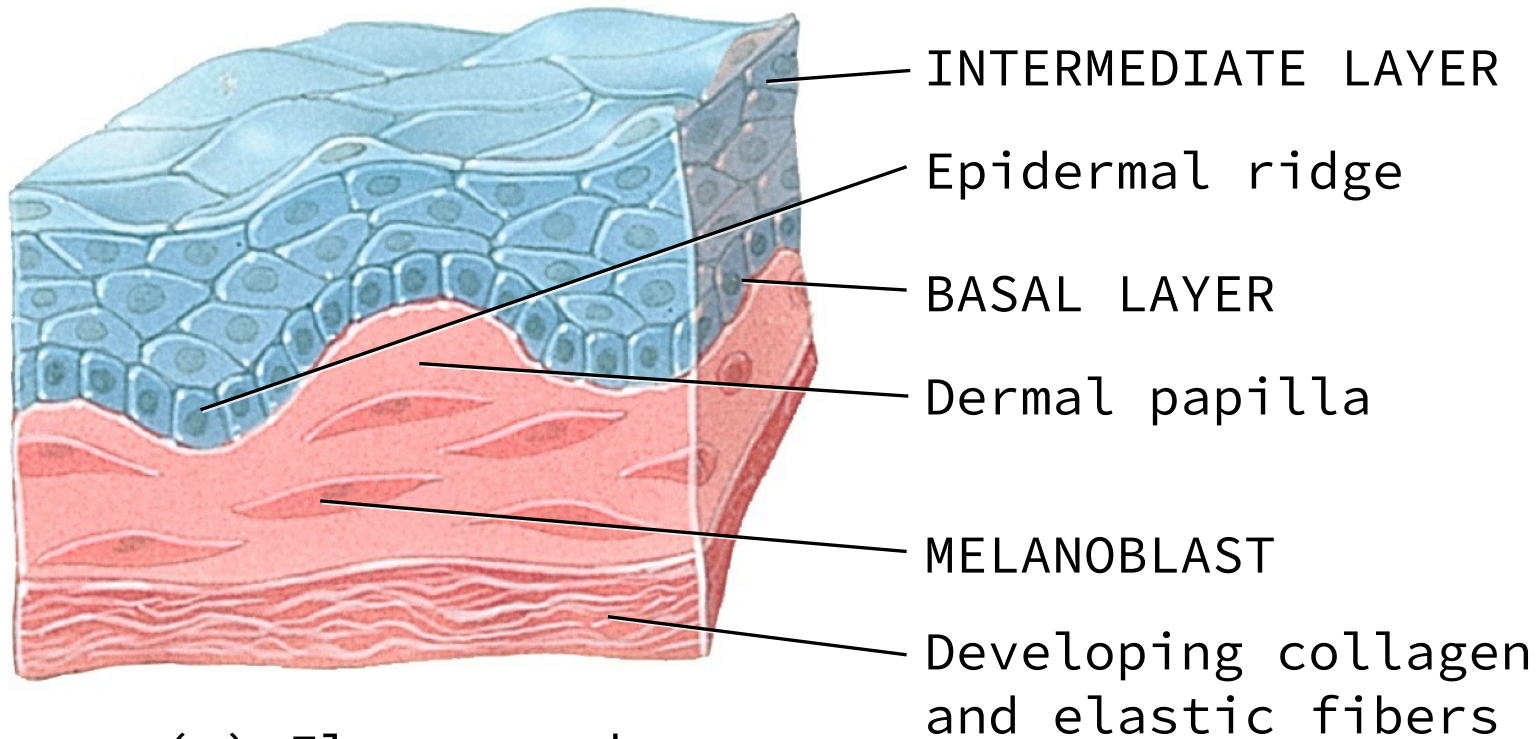
(h) At birth



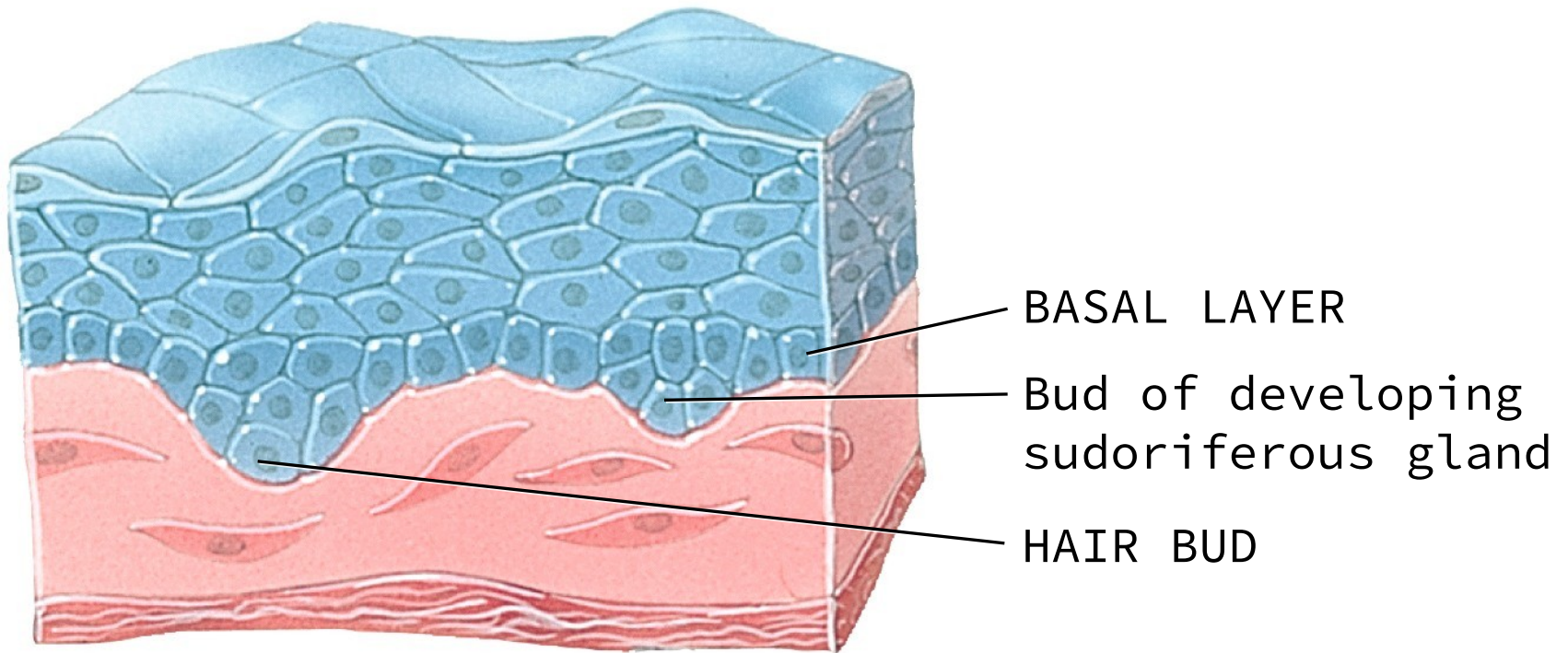
(a) Fourth week



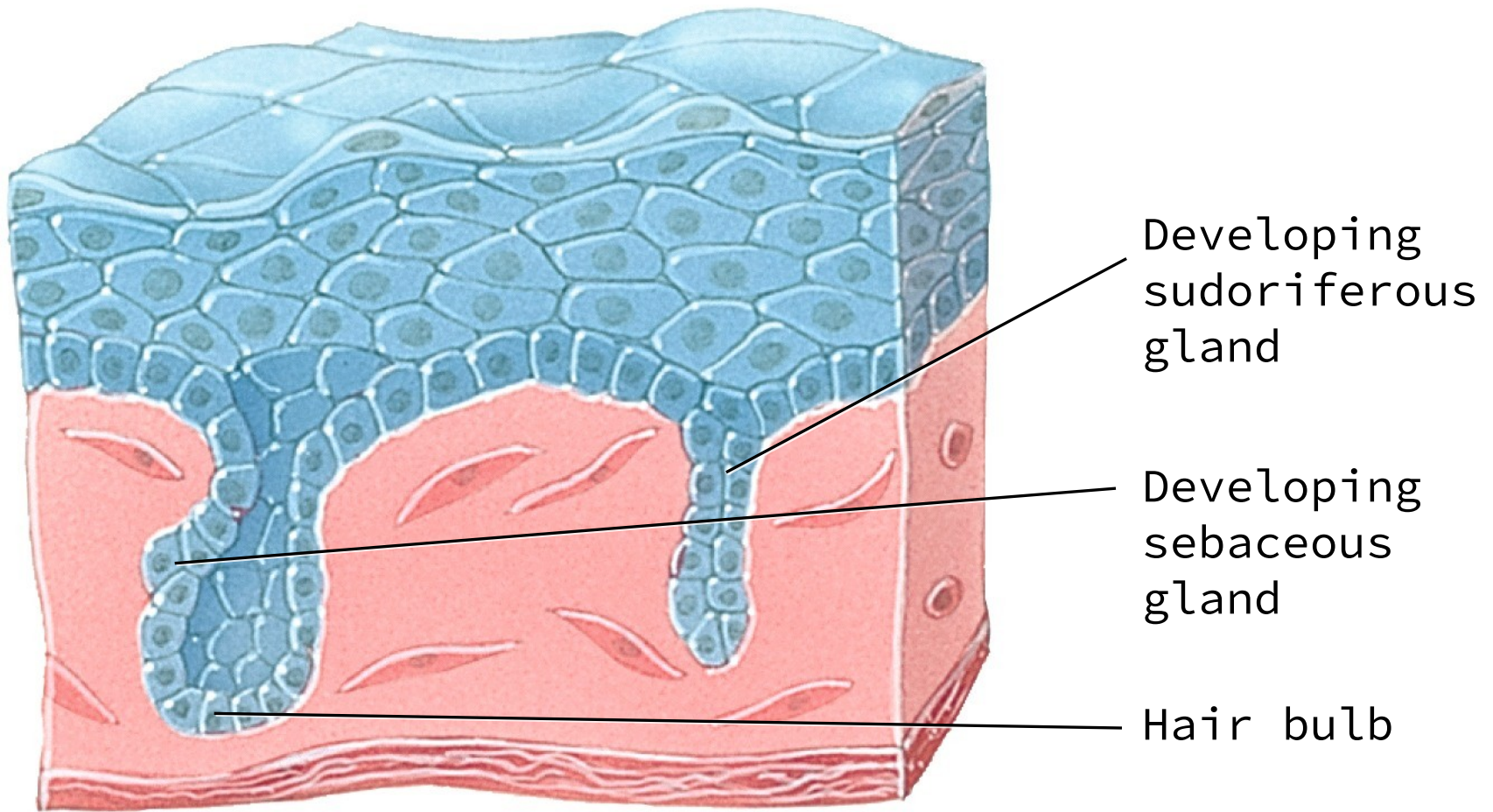
(b) Seventh week



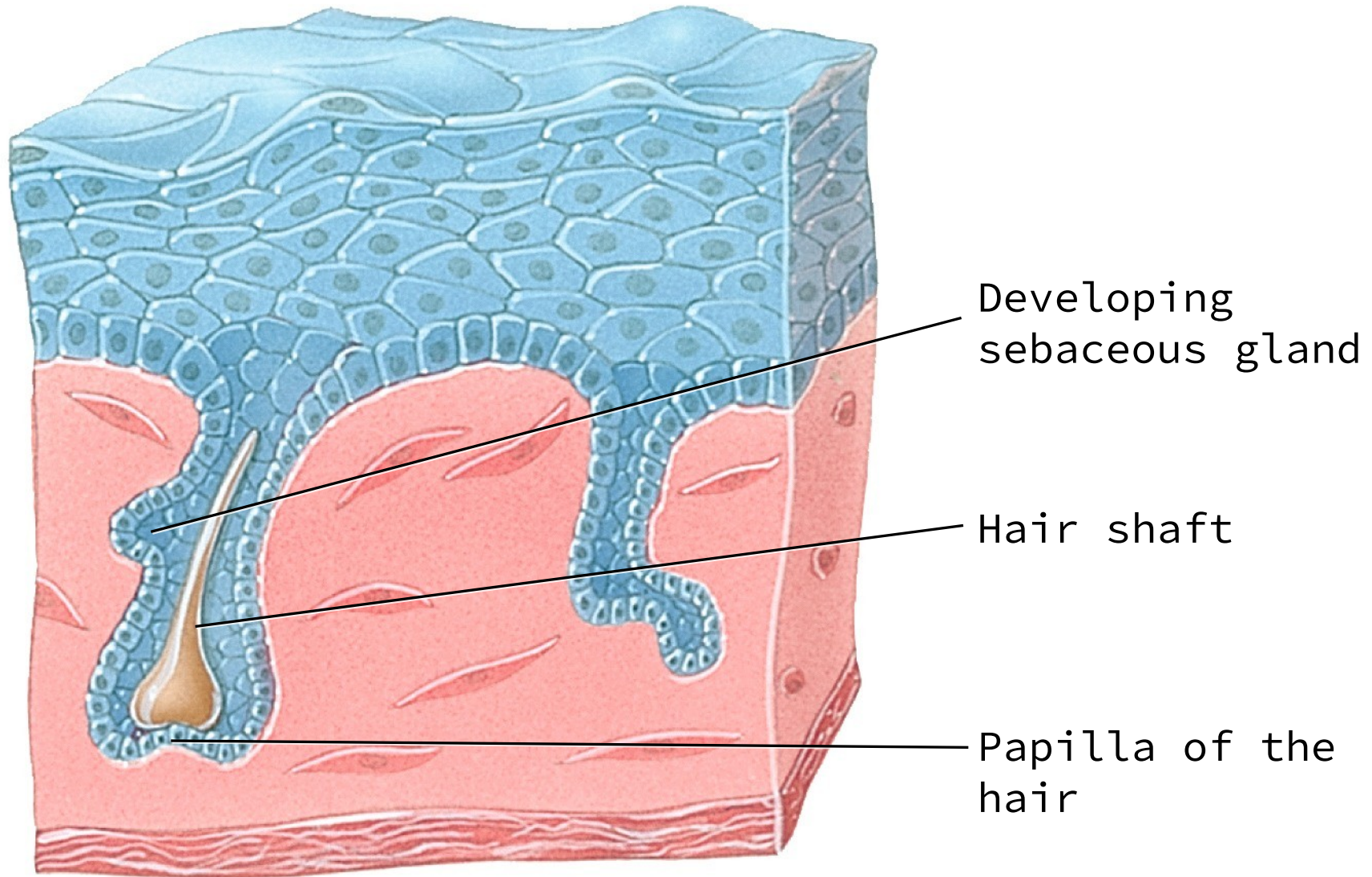
(c) Eleven weeks



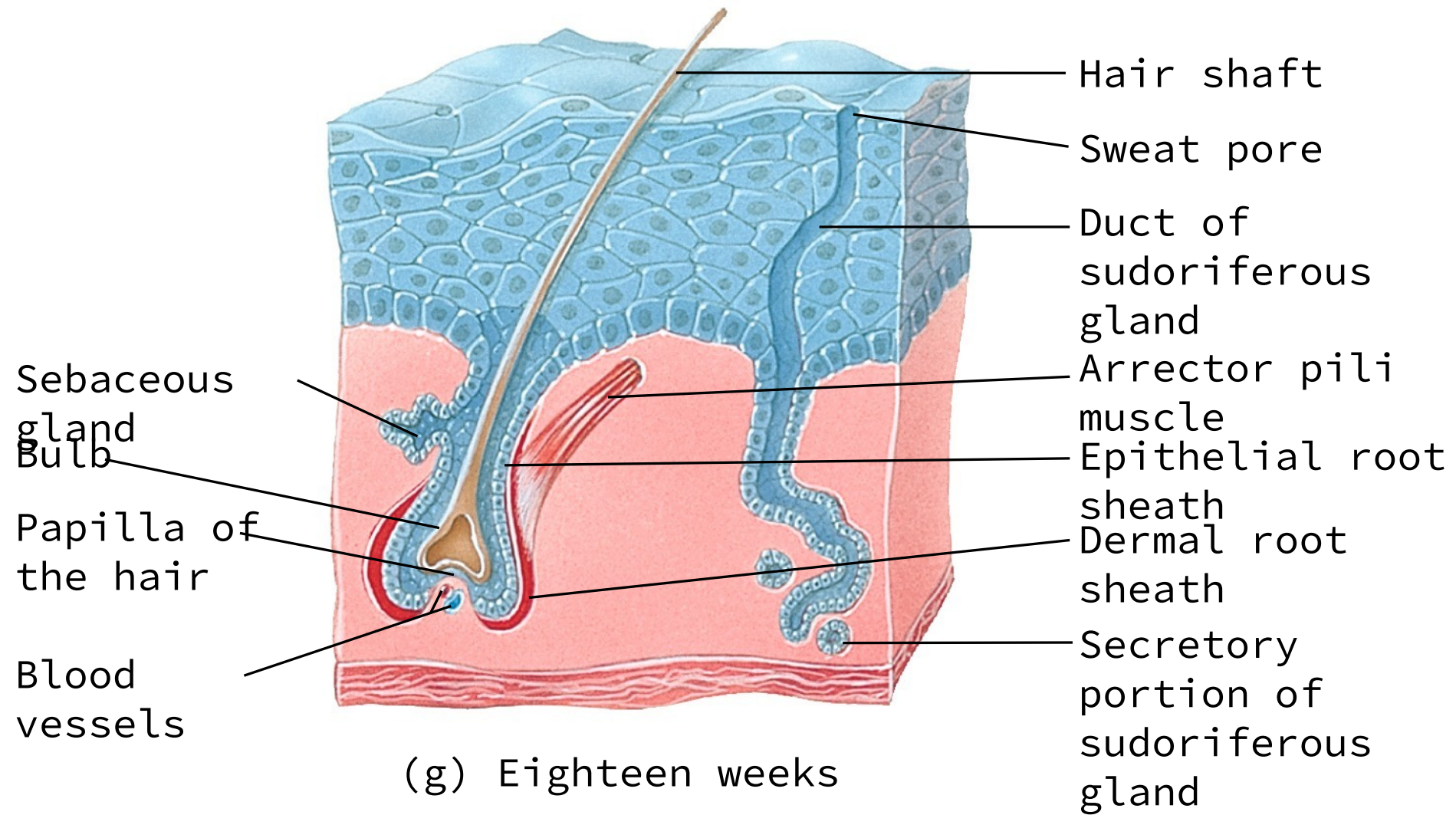
(d) Twelve weeks

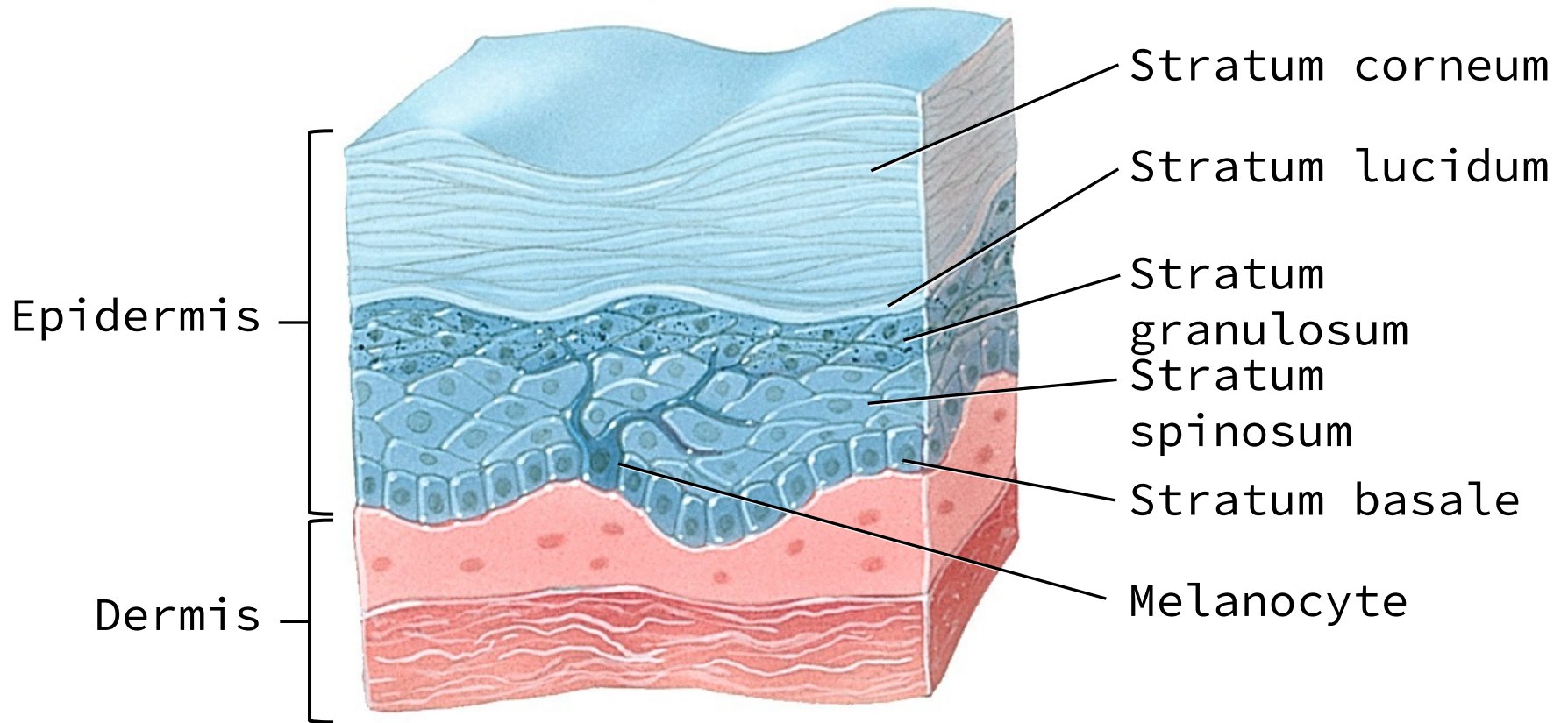


(e) Fourteen weeks



(f) Sixteen weeks





(h) At birth

Aging and the Integumentary System

- **Effects:**
- Wrinkles: characteristic crevices and furrows in skin
- Decrease skin's immune responsiveness
- Dehydration and cracking of the skin
- Decreased sweat production
- Decreased numbers of functional melanocytes resulting in gray hair
- Increased susceptibility to pathological conditions
- Growth of hair and nails decreases; nails may also become more brittle with age.

Anti-aging Treatments

- **1. Topical products** that bleach the skin to tone down blotches and blemishes (hydroquinone) or decrease fine wrinkles and roughness (retinoic acid)
- 103
- **2. Microdermabrasion** a process that uses tiny crystals under pressure to remove and vacuum the skin's surface cells to improve skin texture and reduce blemishes
- **3. Chemical peel**, the application of a mild acid (such as glycolic acid) to the skin to remove surface cells to improve skin texture and reduce blemishes

Anti-aging Treatments

- **4. Laser resurfacing**, use of a laser to clear up blood vessels near the skin surface, even out blotches and blemishes, and decrease fine wrinkles
- **5. Dermal fillers**, injections of collagen from cows, hyaluronic acid (Restylane®), or calcium hydroxylapatite (Radiesse®), or polylactic acid (Sculptra®) that plumps up the skin to smooth out wrinkles and fill in furrows, such as those around the nose and mouth and between the eyebrows
- **6. Fat transplantation**, a process in which fat from one part of the body is injected into another location such as around the eyes.

Anti-aging Treatments

- **7. Botulinum toxin or Botox®**, a diluted version of the toxin that inhibits nerve impulse transmission to skeletal muscles, which is injected into the skin to paralyze muscles that cause the skin to wrinkle
- **8. Radio frequency nonsurgical facelift**, a procedure that uses radio frequency emissions to tighten the deeper layers of the skin of the jowls, neck, and sagging eyebrows and eyelids
- **9. Facelift, browlift, or necklift**, invasive surgery in which loose skin and fat are removed surgically and the underlying connective tissue and muscle are tightened
- **10. Micro-needling facial rejuvenation**, considered the safest among all above mentioned lines of therapy, meanwhile considered one of the highly effective methods