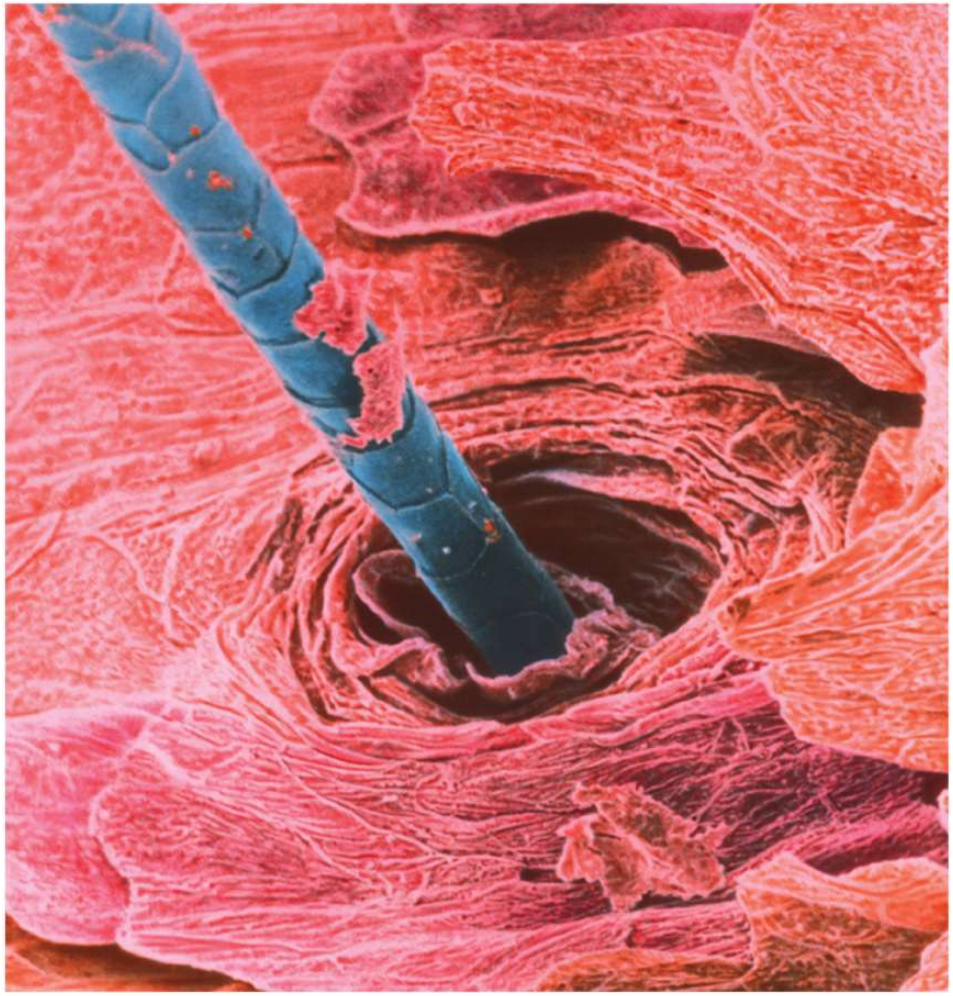
Chapter 6.1

Integumentary System



What is the Integument System?

- skin and its accessory organs // hair, nails, and cutaneous glands
- most visible system and more attention paid to this organ system
- inspection of the skin, hair, and nails is significant part of a physical exam
- skin is the most vulnerable organ // exposed to radiation, trauma, infection, and injurious chemicals
- receives more medical treatment than any other organ system
- dermatology – scientific study and medical treatment of the integument system

About Skin and Subcutaneous Tissue

- the body's largest and heaviest organ /// covers area 1.5 -2.0 m^2 /// 15 % of body weight

- consists of two layers:

  - epidermis – stratified squamous epithelium // epidermis about 0.1 mm thick

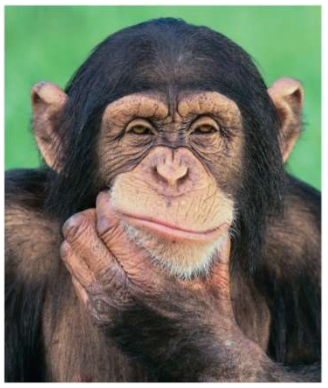
  - dermis – connective tissue layer

- hypodermis // another connective tissue layer deep to the integument // not part of the skin // connects skin to muscles

- most skin is 1 – 2 mm thick // ranges from 0.5 mm on eyelids to 6 mm between shoulder blades

Skin Functions

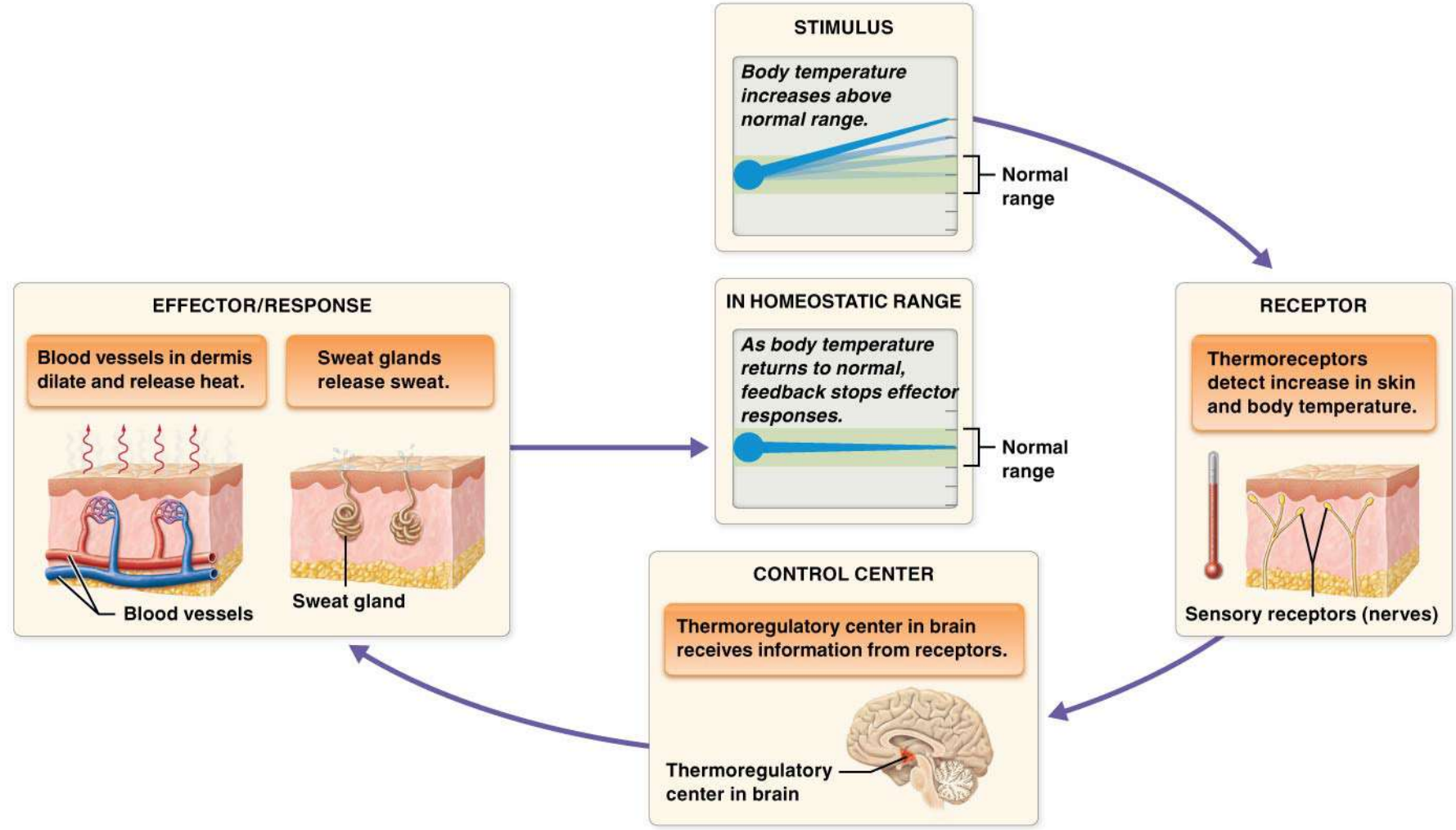
- **resistance to trauma and infection ///** keratin /// acid mantle
- **provide other barrier functions ///** waterproofing - UV radiation - harmful chemicals
- **vitamin D synthesis** /// cholesterol is precursor for the “sunshine hormone” - first step takes place in skin then completed in liver and then kidney // hormone needed to absorb calcium across intestinal mucosa
- **sensations -** skin is our most extensive sense organ
- **nonverbal communication ///** Smile, frown, contemplative, cry, scream
- **transdermal absorption ///** administration of certain drugs steadily through thin skin – adhesive patches
- **thermoregulation** /// hot and cold thermoreceptors /// vasoconstriction vs vasodilation /// sweating



Skin Communicates Emotions

Homeostatic regulation by the integument system.

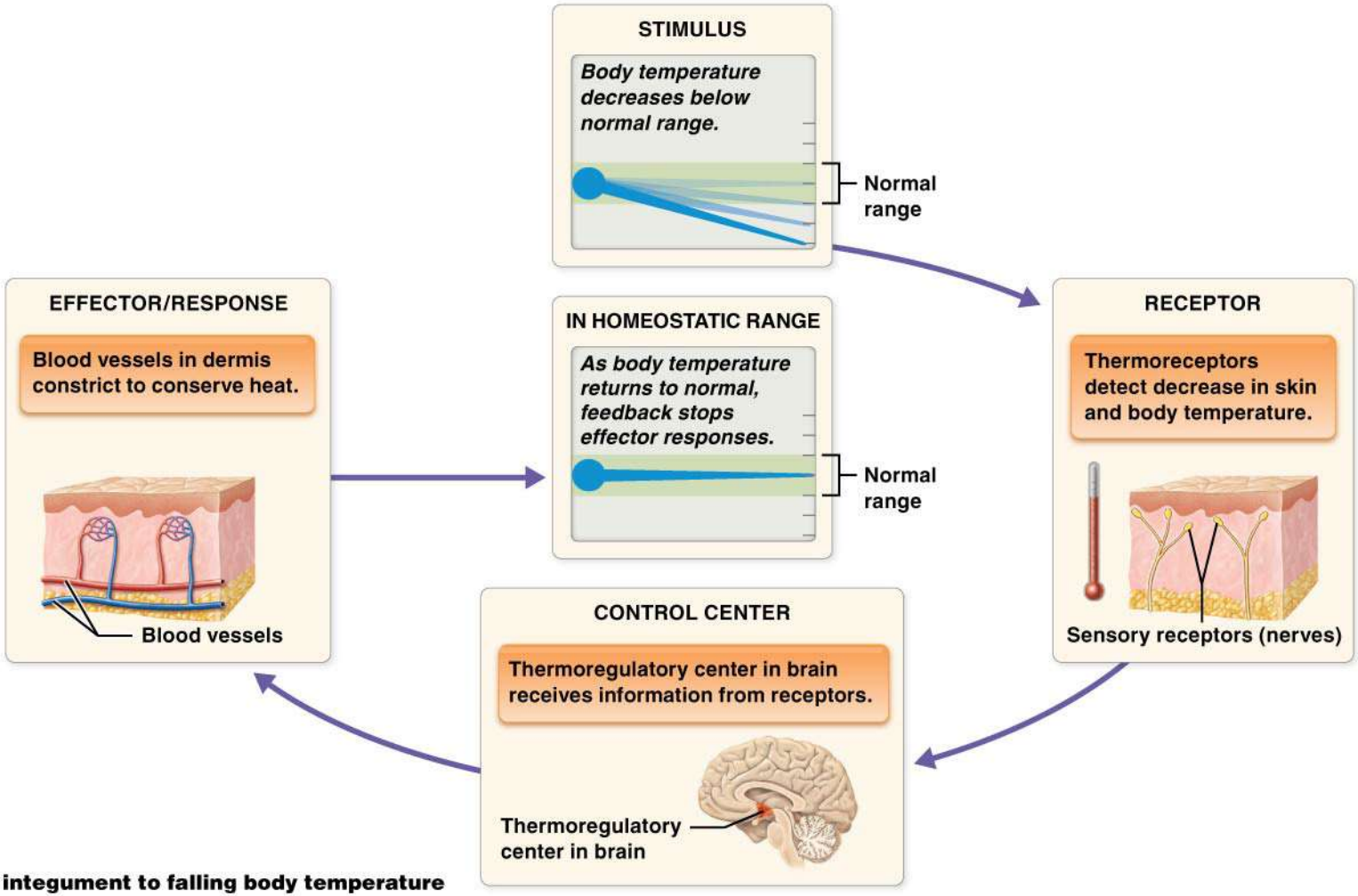
Response to Rising Body Temperature



(a) Response of the integument to rising body temperature

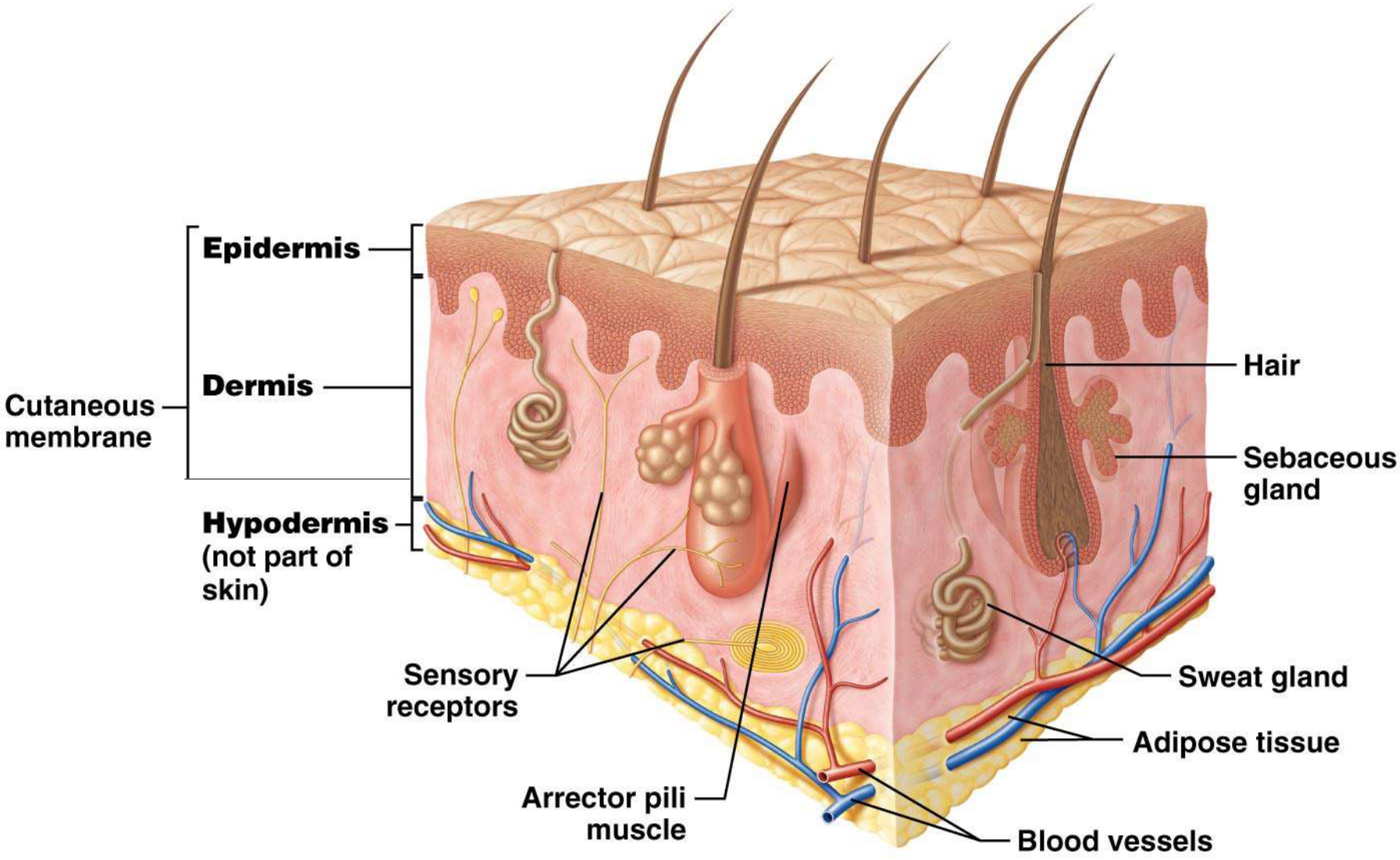
Homeostatic regulation by the integumentary system.

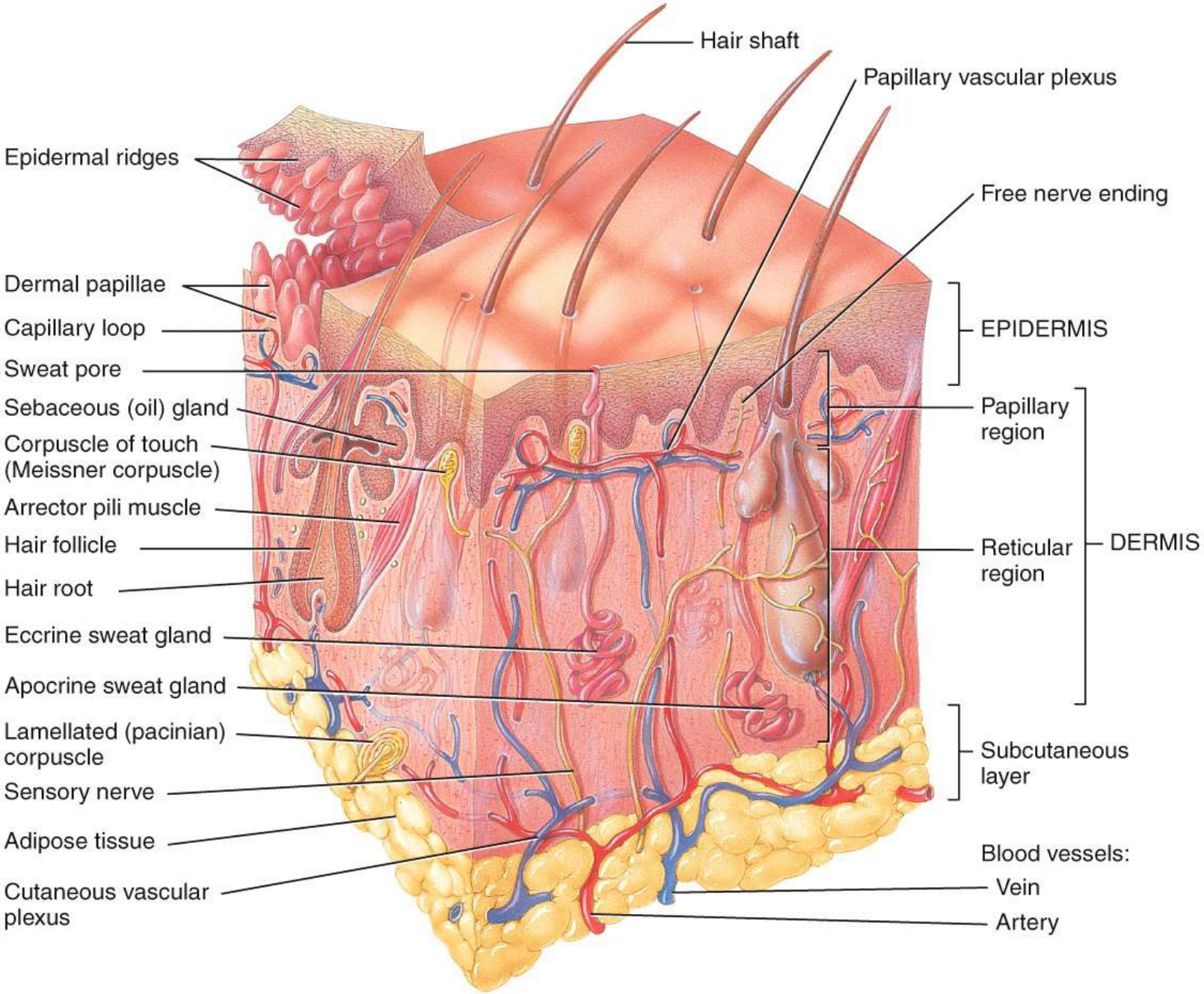
Response to Falling Body Temperature



(b) Response of the integument to falling body temperature

Basic anatomy of the skin.





(a) Sectional view of skin and subcutaneous layer

Can you identify three types of skin in this model?

(See Anatomy Web Site for More Information)

Four Cell Types of the Epidermis

- **#1 - Stem cells (which make the keratinocyte)**
  - undifferentiated cells that give rise to keratinocytes (stem cells)
  - in deepest layer of epidermis (stratum basale)
  - great majority of epidermal cells
  - synthesize **keratin**

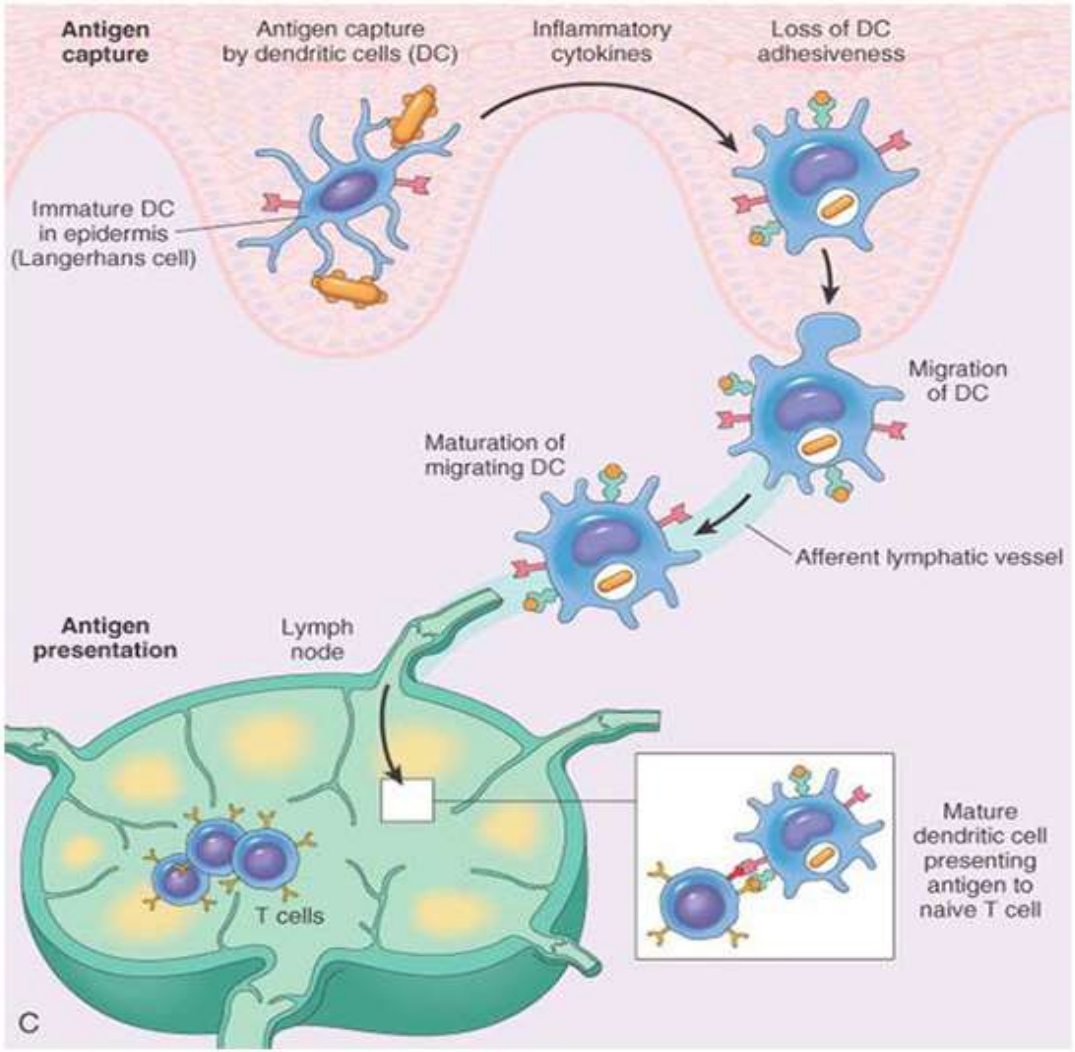
- **#2 - Melanocytes**
  - occur only in stratum basale
  - synthesize pigment **melanin** that shields DNA from ultraviolet radiation
  - branched processes that spread among keratinocytes

- **#3 - Tactile (Merkel) cells**
  - in basal layer of epidermis
  - touch receptor cells associated with dermal nerve fibers
  - Merkel epithelial cell / tactile disc / sensory neuron

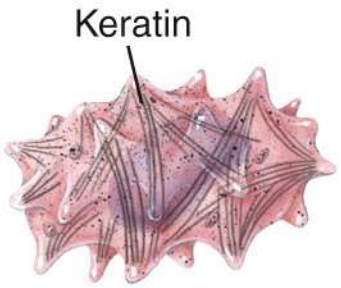
The Four Cells of the Epidermis

- **#4 – Dendritic cells (Langerhans cells also intra-epidermal macrophage)**
  - macrophages originating in bone marrow that guard against pathogens
  - found in stratum spinosum and granulosum
  - stand guard against toxins, microbes, and other pathogens that penetrate skin
  - see next slide

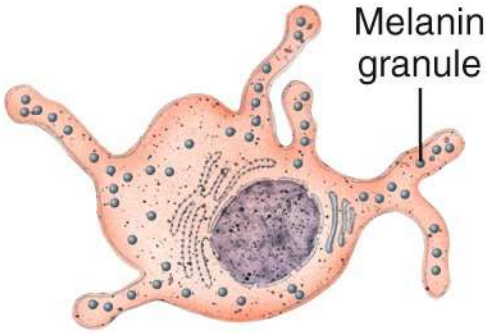
Dendritic Cells



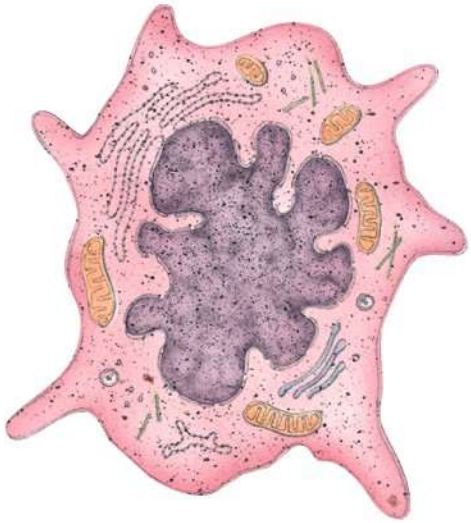
Dendritic cells play an essential role in the adaptive immune response!



(a) Keratinocyte

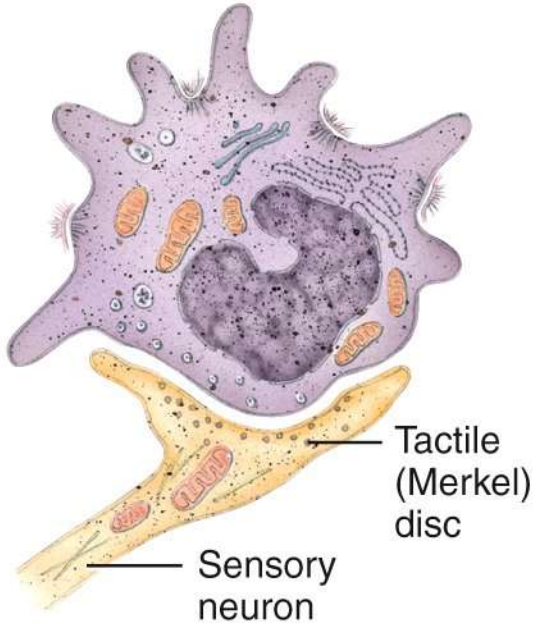


(b) Melanocyte



Dendritic Cell

(c) Intraepidermal
macrophage
(Langerhans) cell



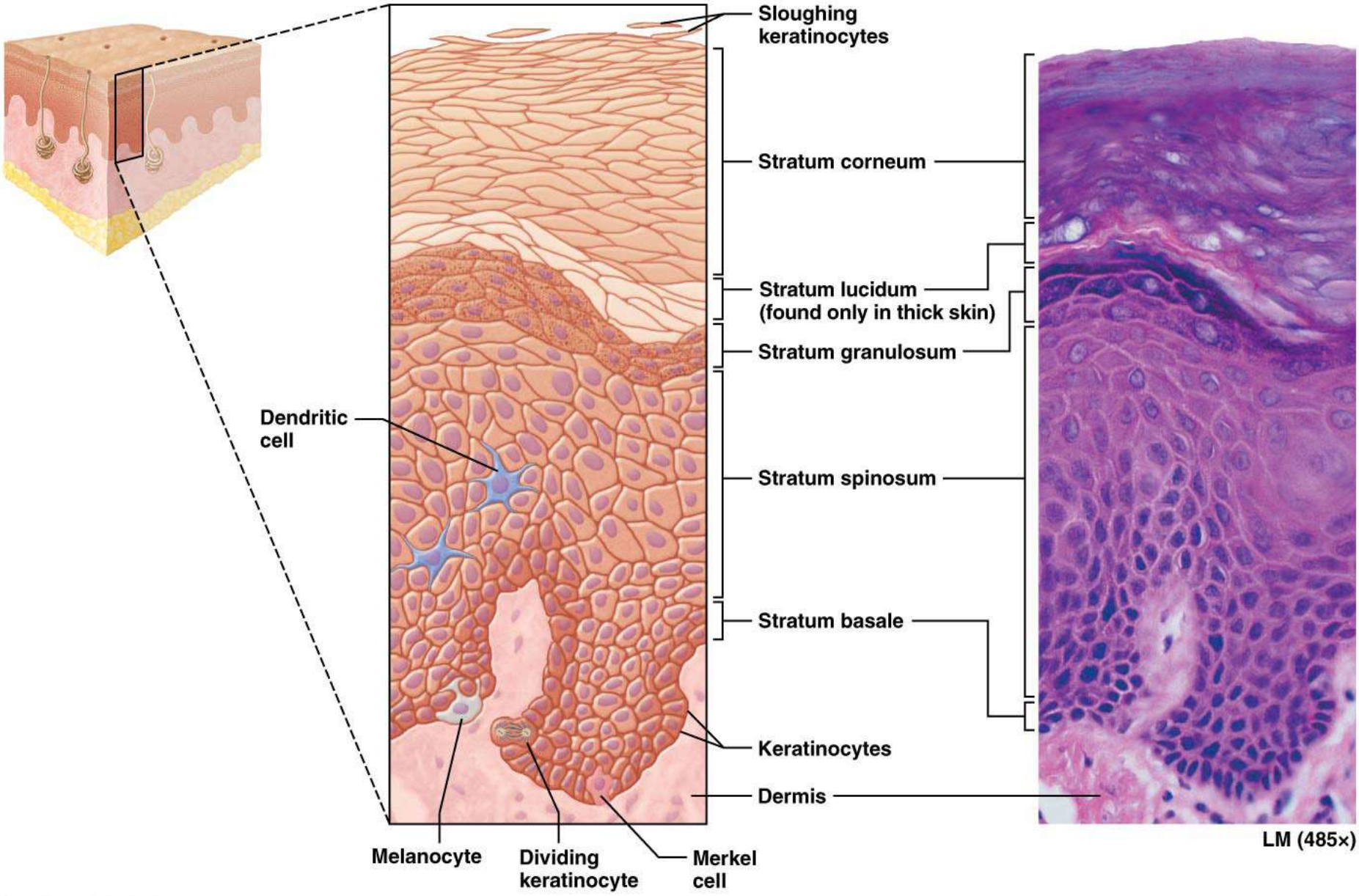
(d) Tactile epithelial
(Merkel) cell

The Epidermis

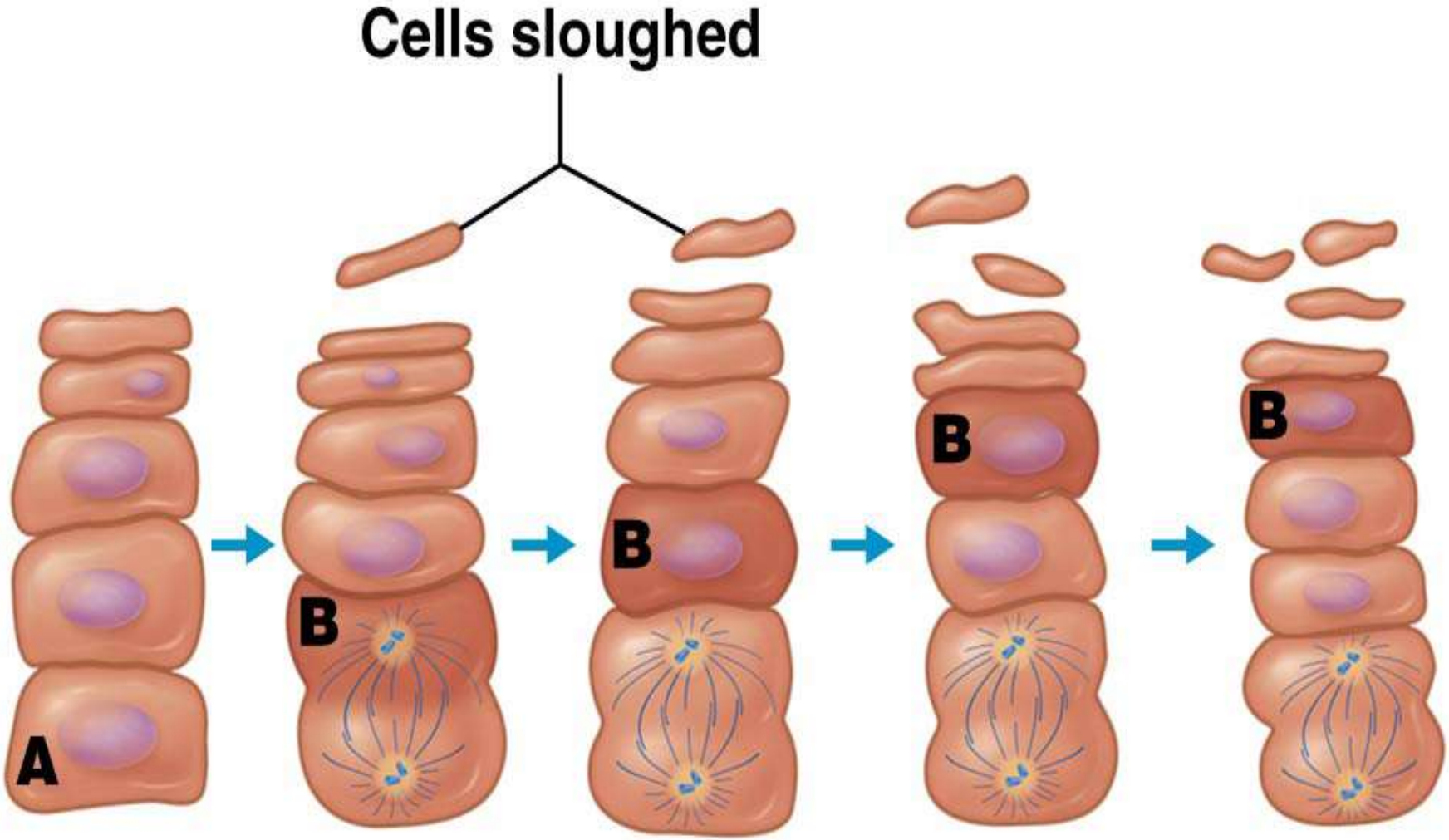
- Epidermis = stratified keratinized squamous epithelium
  - deepest cell layer undergo mitosis
  - superficial layer are dead cells packed with tough protein – **keratin**
  - epidermal layer lacks blood vessels
  - depends on the diffusion of nutrients from underlying connective tissue
  - sparse nerve endings for touch and pain

The Five Stratum of the Epidermis

Where are dendritic cells located?
Significance?



Where are capillaries located?
Significance?



Skin “Thickness”

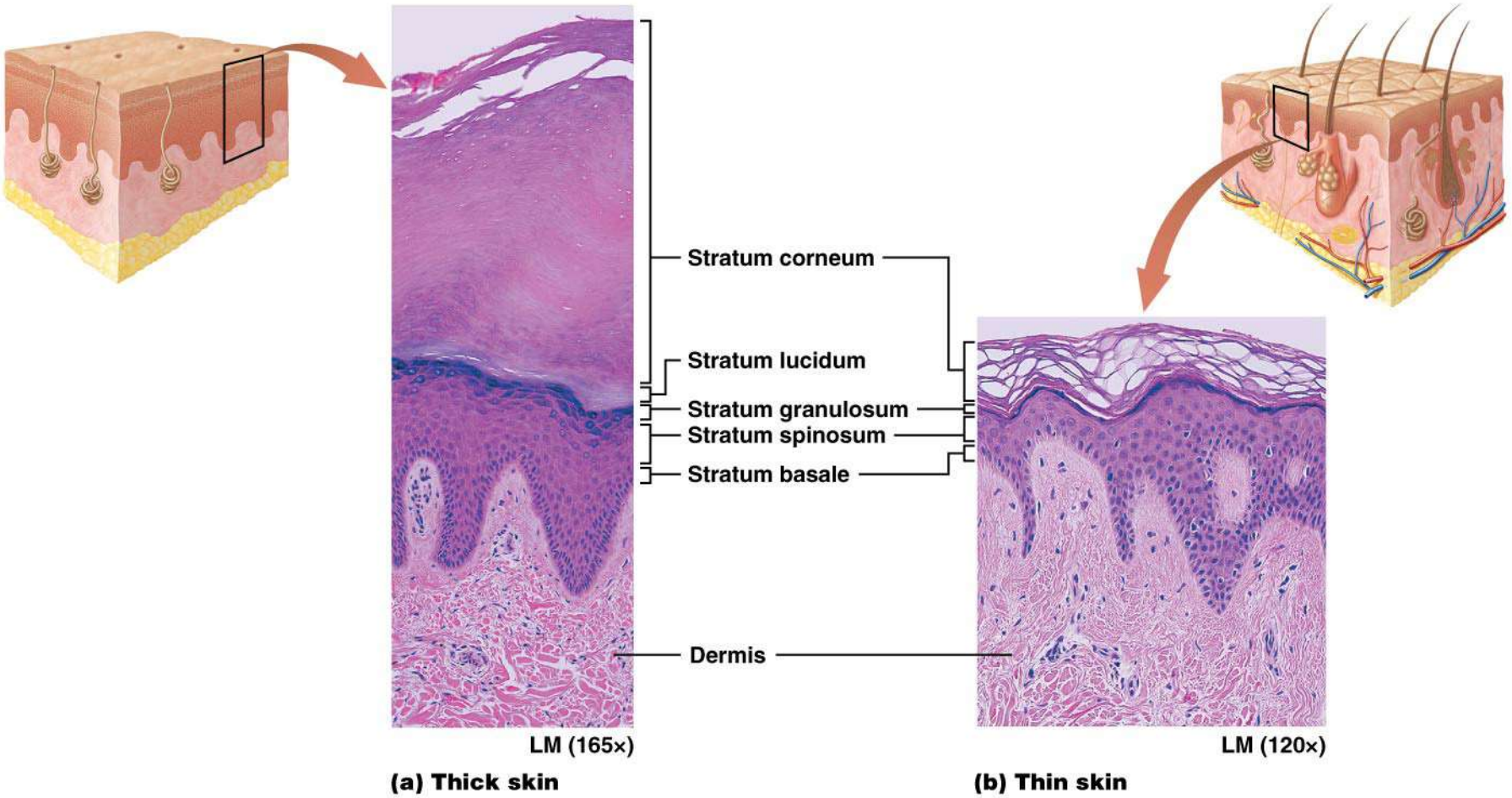
thick skin

- on palms and sole, corresponding surfaces on fingers and toes
- sweat glands
- no hair follicles or sebaceous (oil) glands
- epidermis 0.5 mm thick
- only skin with stratum lucidum

thin skin

- covers rest of the body
- possesses hair follicles, sebaceous glands and sweat glands

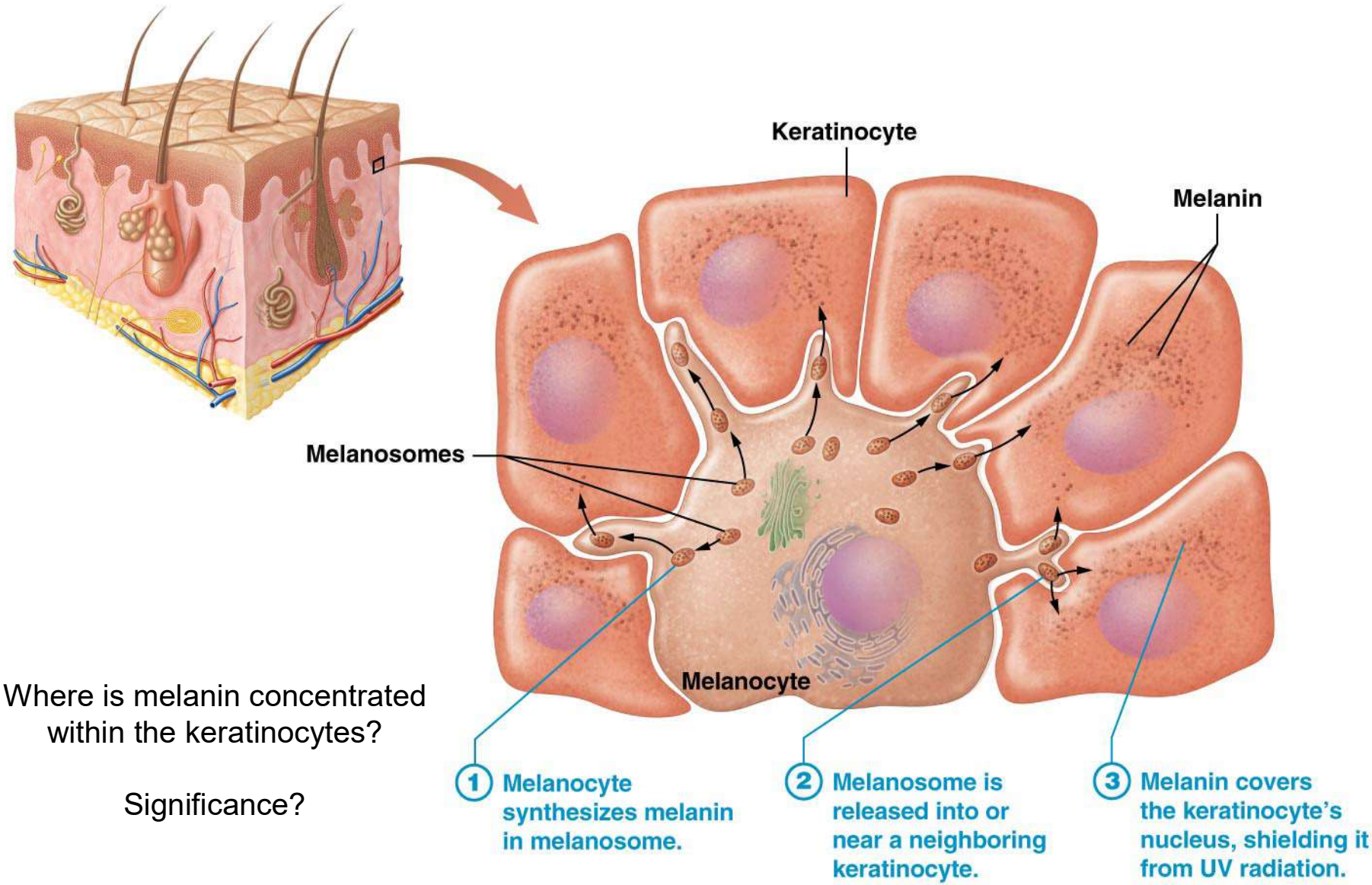
Thick and thin skin.



> Thick skin is only found on the soles of feet and palms of hands.
> The stratum lucidum is only found in thick skin.

> Note difference in accessory stuctures in thick and thin skin!

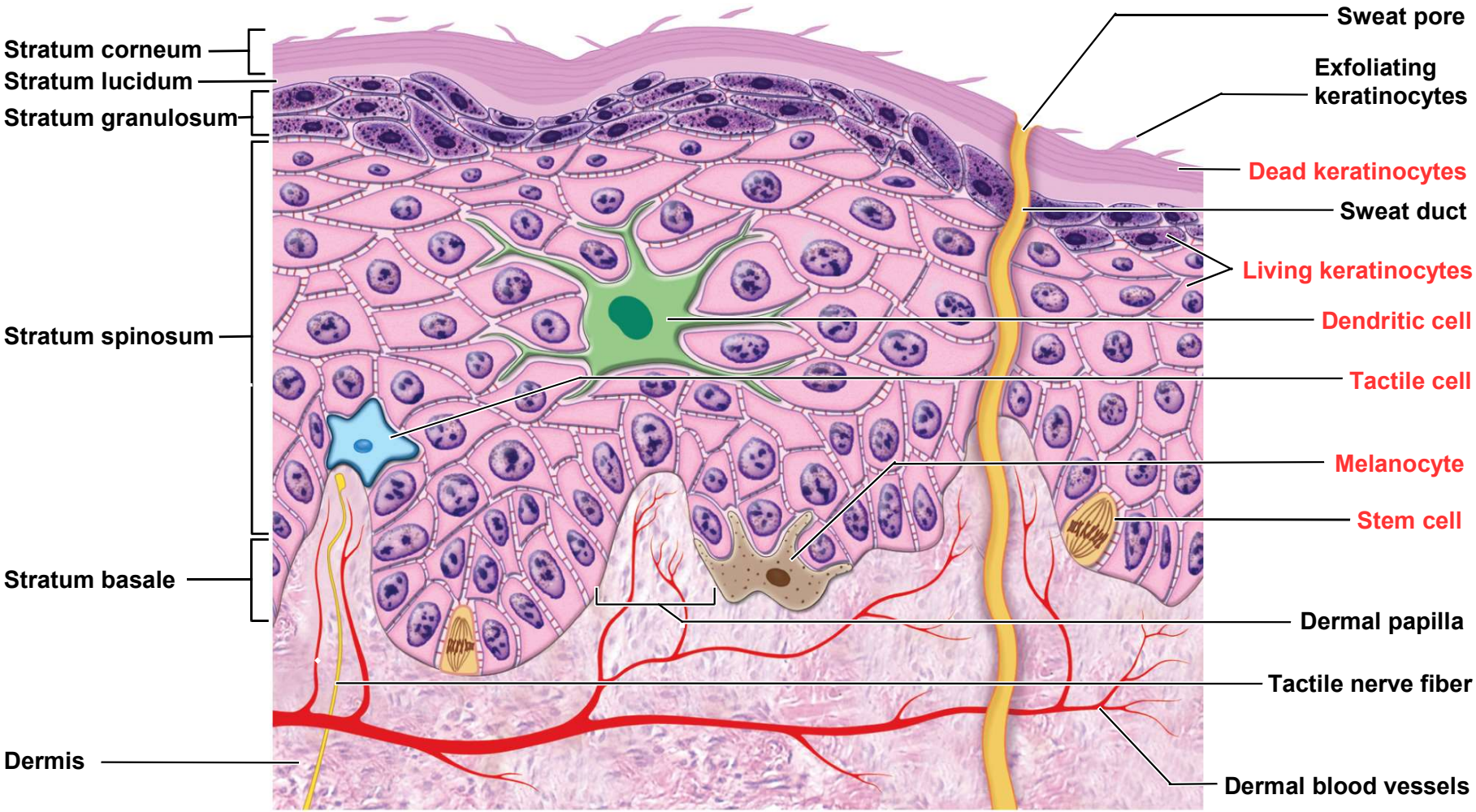
Melanocytes and melanin function.



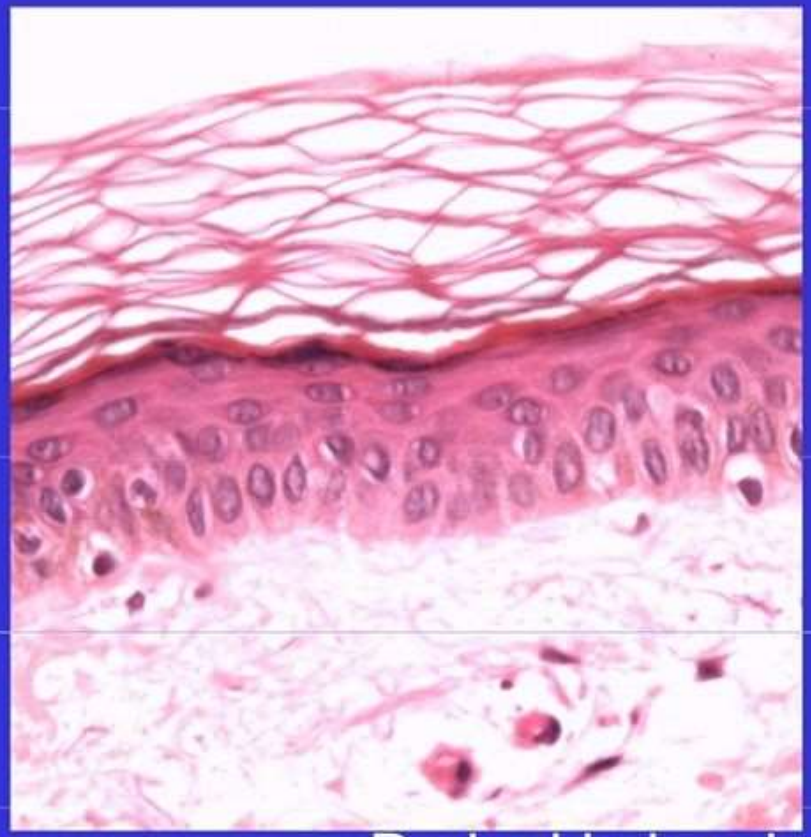
Where is melanin concentrated within the keratinocytes?

Significance?

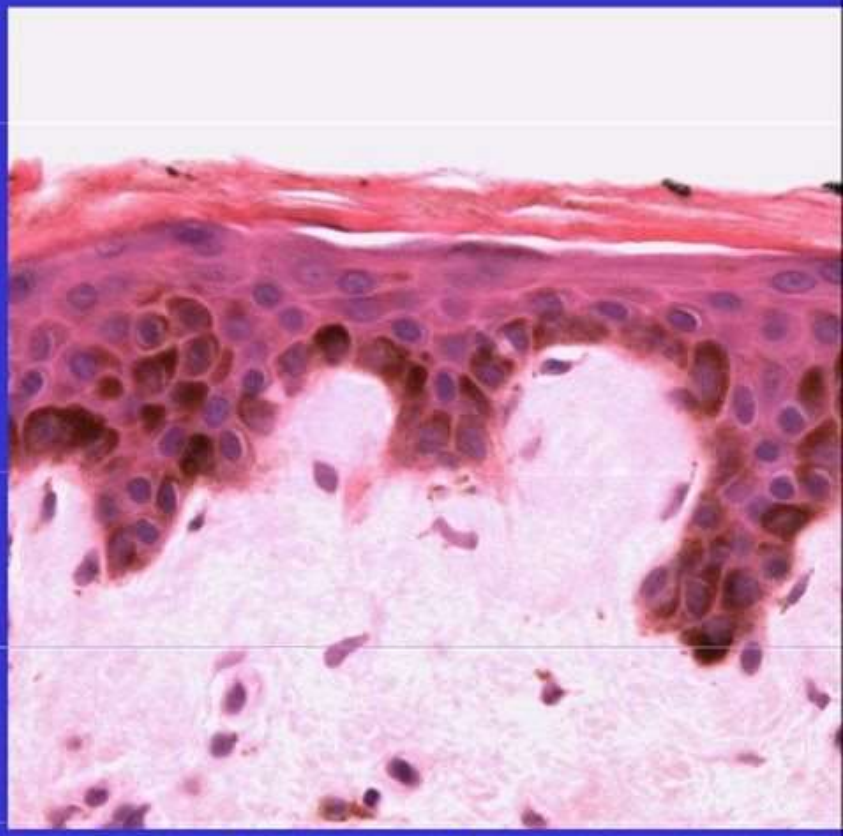
Cell Types and Layers of the of the Epidermis



Light skin



Dark skin



Dark skin has increased production of melanosomes, and melanin
More transfer of melanin to keratinocytes
Slower rate of degradation of melanosomes

Vitiligo

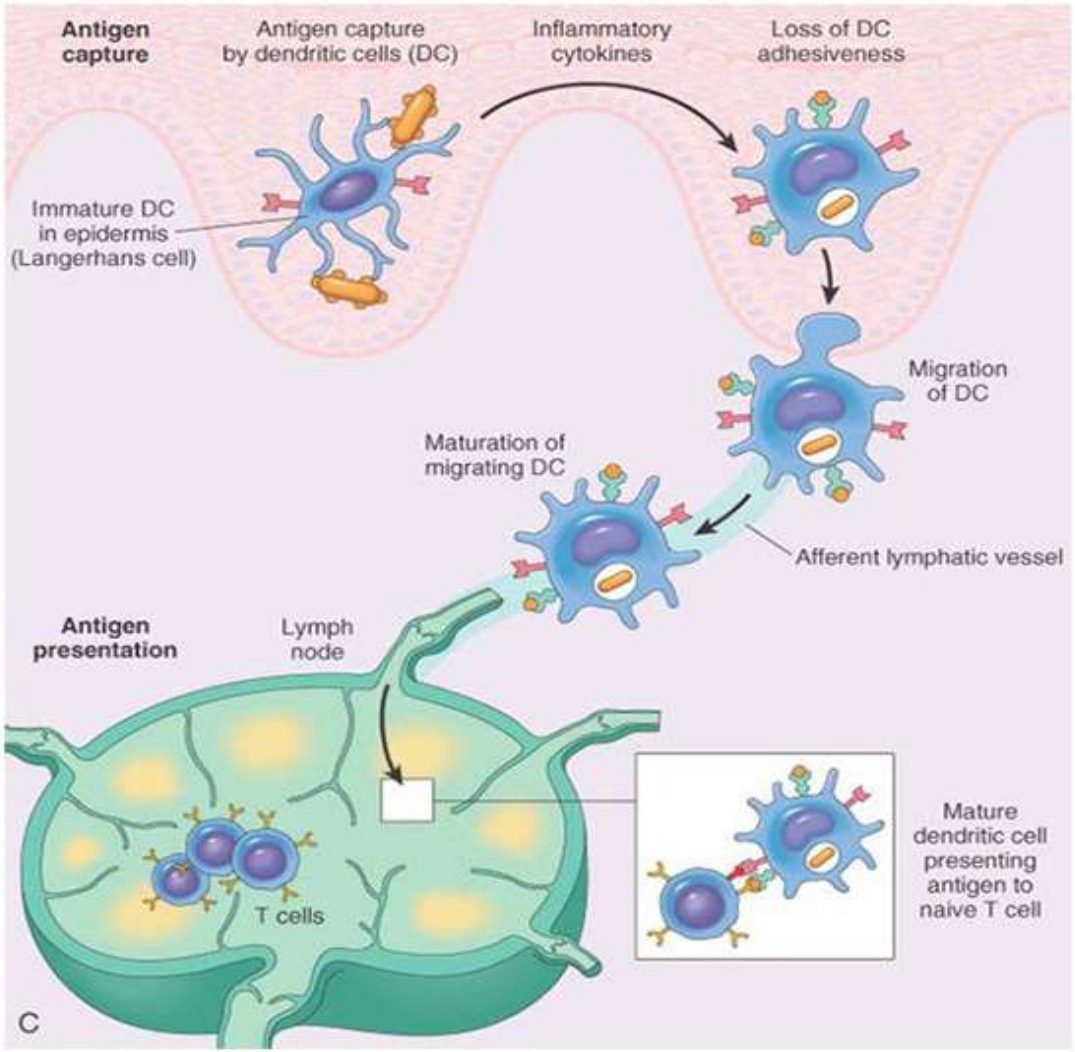
Stratum Basale

- A single layer of cuboidal to low columnar stem cells
  - stem cells produce keratinocytes resting on the basement membrane
  - melanocytes and tactile cells are scattered among the stem cells / keratinocytes
- Stem cells of stratum basale divide
  - give rise to keratinocytes that migrate toward skin surface
  - replace lost epidermal cells
  - entire process takes three to four weeks (benchmark = 30 days)
  - localized stumulus can increase mitosis resulting in a build up of the stratum corrneum (e.g. calus)

Stratum Spinosum

- consists of several layers of keratinocytes
- thickest stratum in most skin // thick skin's stratum corneum only exception
- deepest cells within this layer remain capable of mitosis // cease dividing as they are pushed upward
- produce more and more keratin filaments which causes cell to flatten // higher up in this stratum, the flatter the cells appear
- named for artificial appearance created in histological section
-
  - as cells shrink they produce spiny appearance because of numerous desmosomes
- dendritic cells found throughout this stratum

Dendritic Cells



Dendritic cells play an essential role in the adaptive immune response!

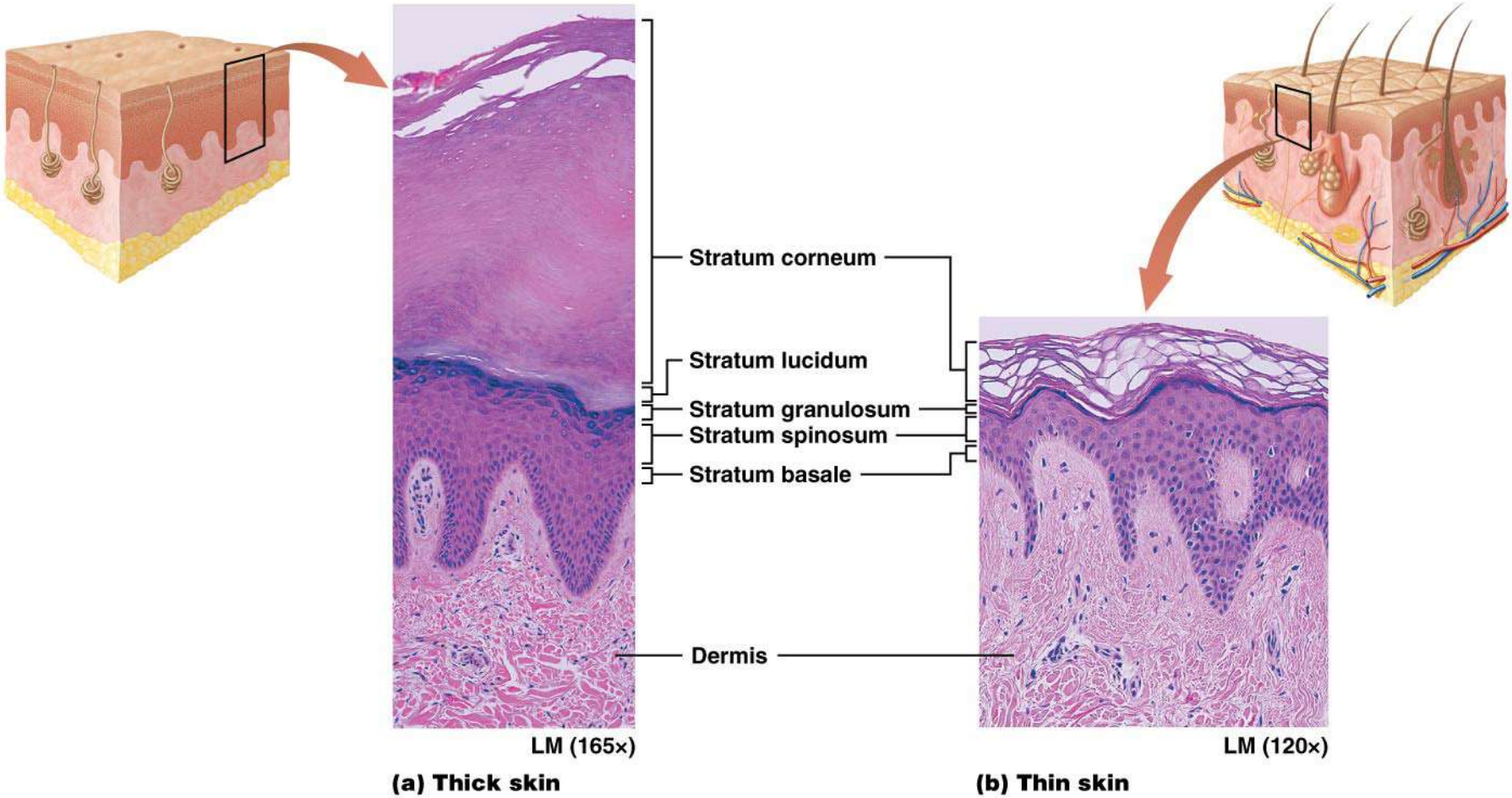
Stratum Granulosum

- consists of **3 to 5 layers of** flat keratinocytes
- contain coarse dark-staining = **keratohyalin granules**

Stratum Lucidum

- seen only in thick skin
- **thin translucent zone** superficial to stratum granulosum
- keratinocytes in this layer are densely packed with **eleidin**
- cells have no nucleus or other organelles
- zone has a pale, featureless appearance with indistinct boundaries

Thick Skin VS Thin Skin



Only on palms of hands
and sole of feet

Stratum Corneum

- up to 30 layers of dead, scaly, keratinized cells
- form durable surface layer // surface cells flake off (exfoliate)
- resistant to abrasion, penetration, and water loss

Life Cycle of Keratinocytes

- newly formed keratinocytes push the older ones toward the surface

- a keratinocyte makes its way to the skin surface and flakes off // replace skin every 3 to 4 weeks (test benchmark = 30 days)
  - slower in old age
  - faster in skin injured or stressed
  - calluses or corns – thick accumulations of dead keratinocytes on the hands or feet

- cells above the water barrier quickly die
  - barrier cuts them off from nutrients below
  - dead cells exfoliate (dander)
  - dandruff – clumps of dander stuck together by sebum (oil)

Dermis

- connective tissue layer beneath the epidermis
- ranges from 0.2 mm (eyelids) – 4 mm (palms & soles)
- composed mainly of collagen with elastic fibers, reticular fibers, and fibroblasts
- well supplied with blood vessels, sweat glands, sebaceous glands, and nerve endings
- hair follicles and nail roots are embedded in dermis
- smooth muscle (erector pili muscles) associated with hair follicles /// contract in response to stimuli, such as cold, fear, and touch – goose bumps

- Your leather coat is made from the dermis. The liver of chronic alcoholics produce aldehydes which cross link collagen fibers in dermis to transform the dermis into “leather”. Chronic alcoholics skin looks like “leather”.

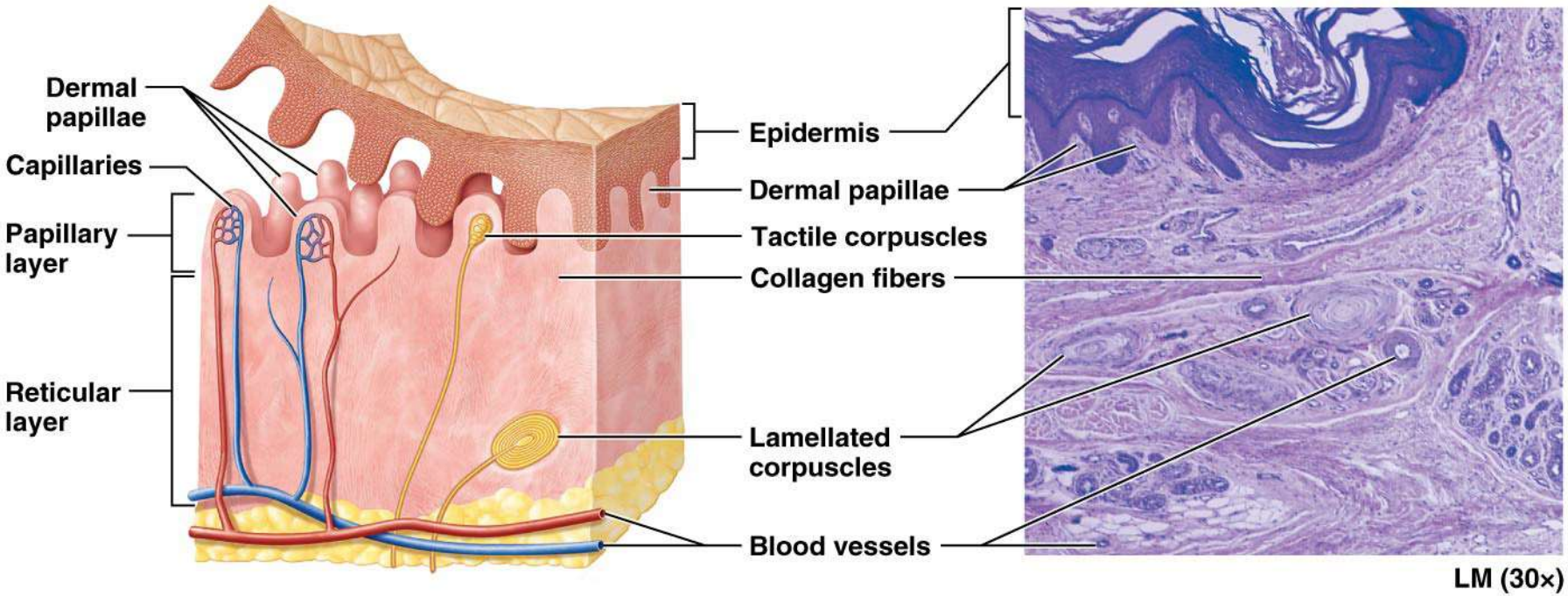
The Dermis Structure

- dermal papillae
  - upward fingerlike extensions of the dermis
  - form the friction ridges on fingertips that leave fingerprints

- papillary layer
  - superficial zone of dermis
  - thin zone of areolar tissue in and near the dermal papilla
  - allows for mobility of leukocytes and other defense cells should epidermis become broken
  - rich in small blood vessels

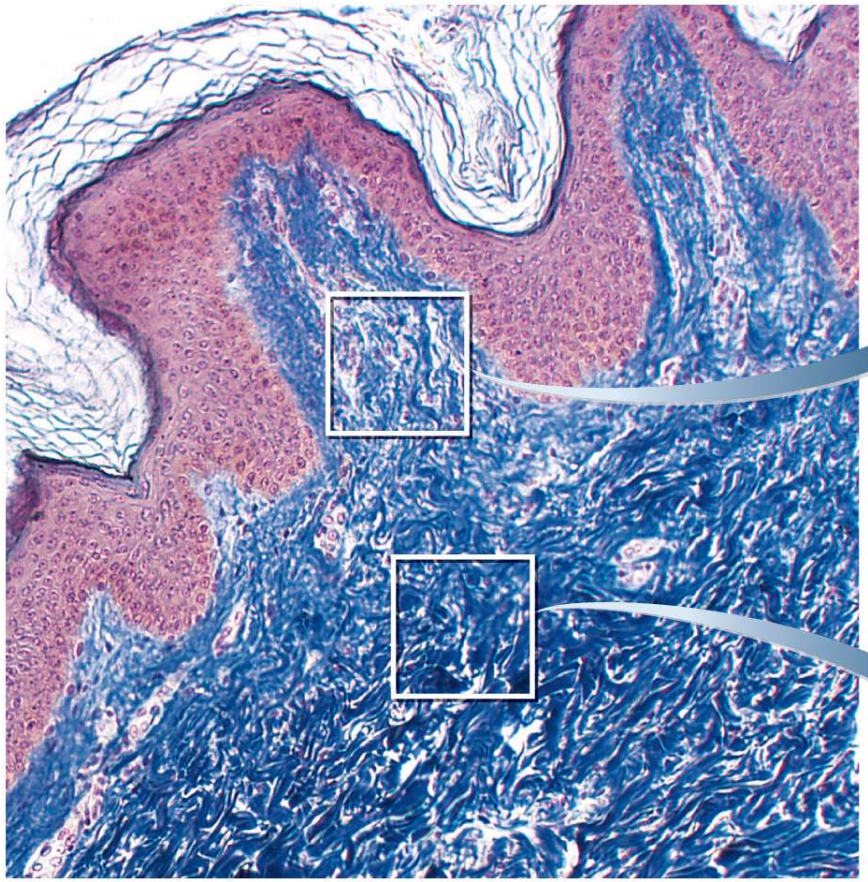
- reticular layer
  - deeper and much thicker layer of dermis
  - consists of dense, irregular connective tissue
  - stretch marks (striae) – tears in the collagen fibers caused by stretching of the skin due to pregnancy or obesity
  - stretching ruptures blood vessels to produce initial red lines which will be replaced by “scar tissue” which are the white lines

Structure of the dermis.

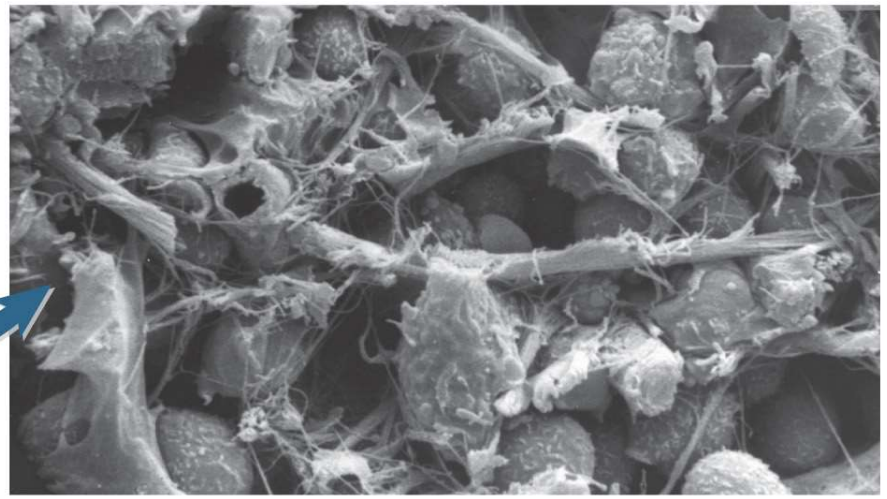


What is the significance of the epidermal ridges and dermal papillae?

Structure of the Dermis

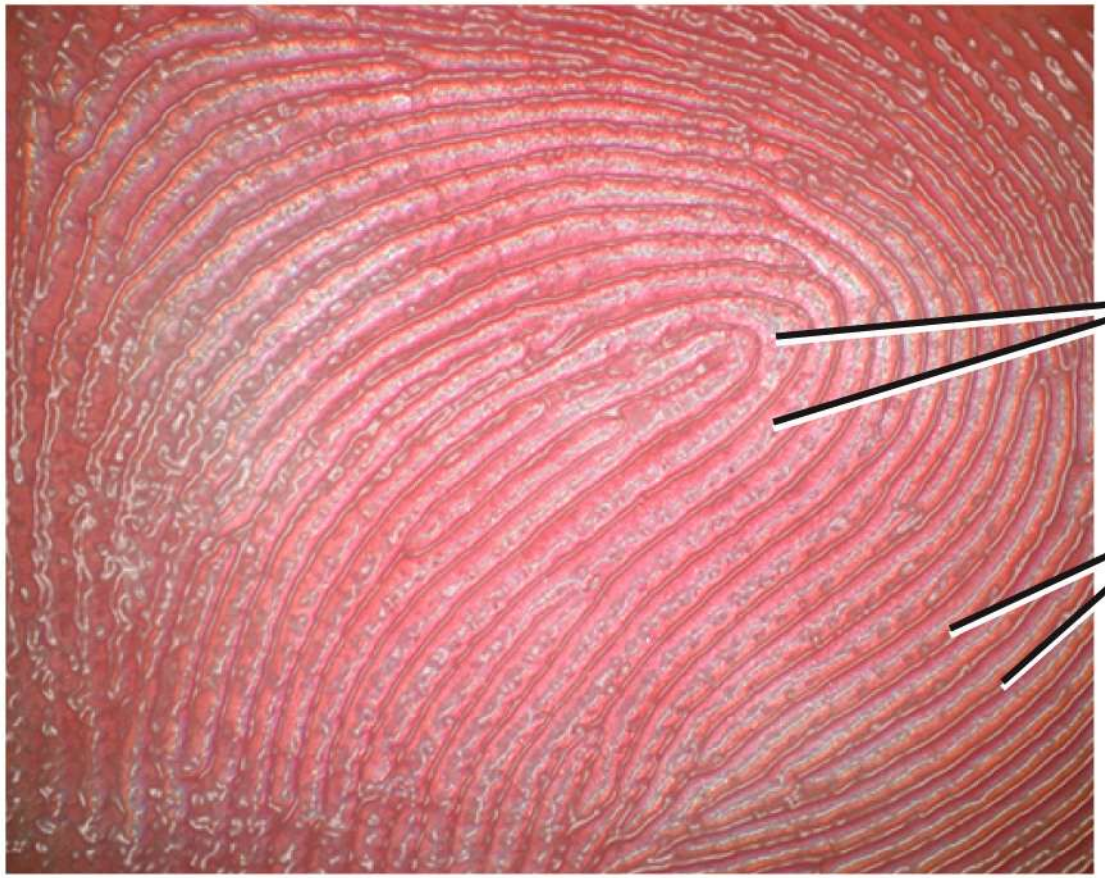


(a)



(b) Papillary layer of dermis

(c) Reticular layer of dermis



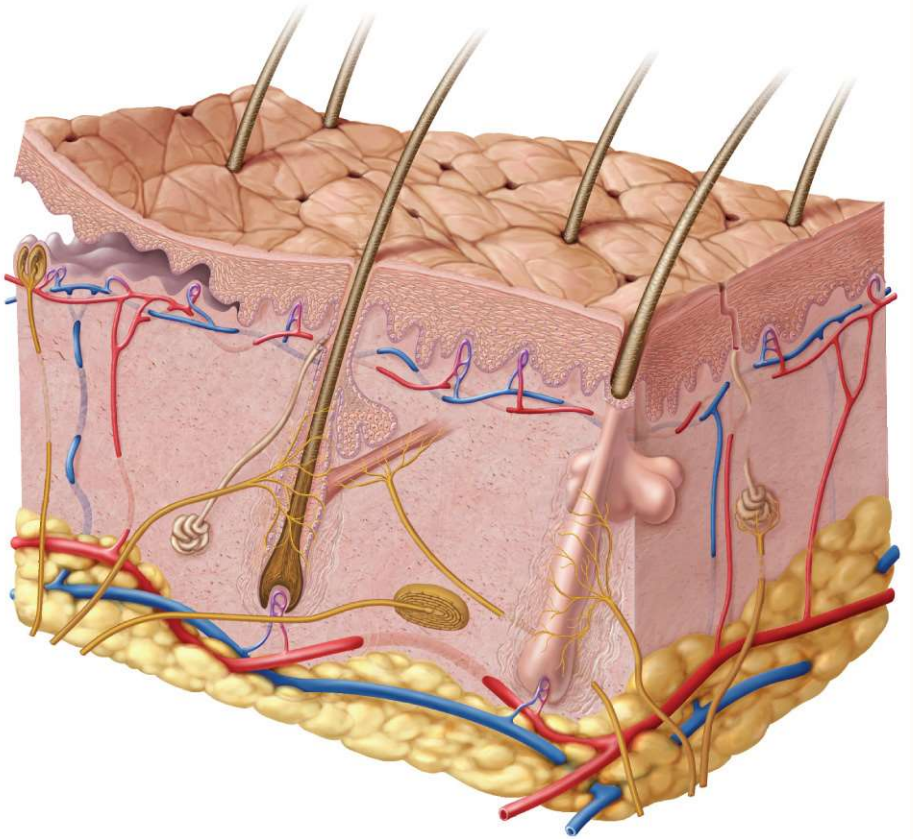
David Becker/Photo Researchers, Inc.

(c) Epidermal ridges and sweat pores

See Anatomy Web Site to watch secretion of sweat from pores.

What are we looking at? What structure causes these “prints”?

Hypodermis



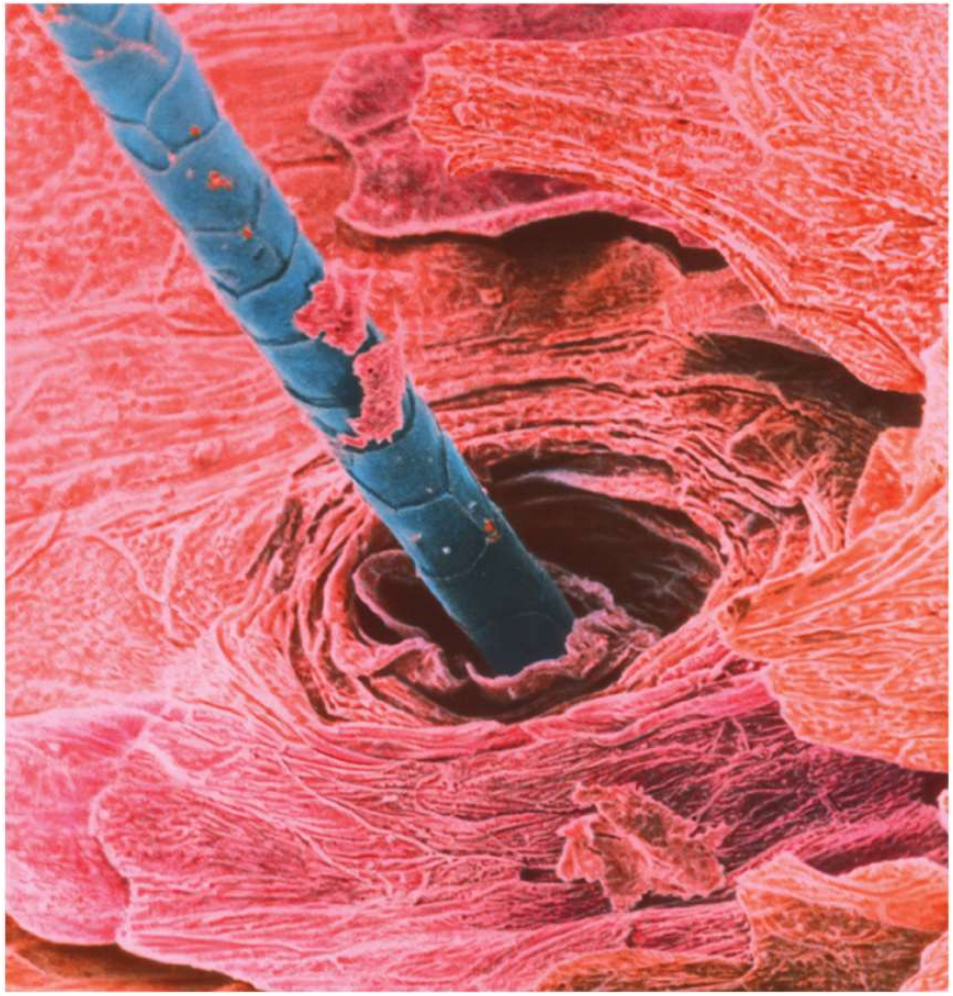
- The hypodermis is not part of "skin" // it's below the "skin"
- subcutaneous tissue
- more areolar and adipose than dermis
- pads body
- binds skin to underlying tissues
- drugs introduced by injection // highly vascular & absorbs them quickly
- subcutaneous fat
  - energy reservoir
  - thermal insulation
  - 8% thicker in women

Can you identify the three type of skin in this model?

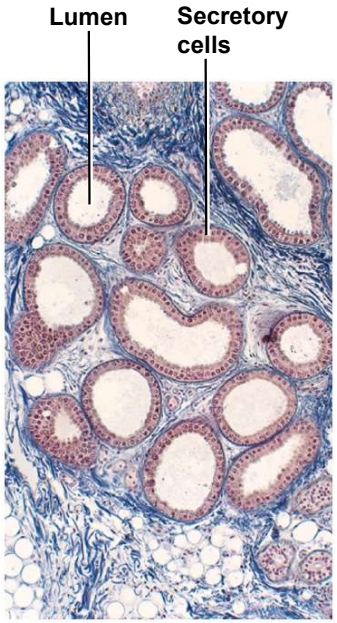
(See Anatomy Web Site Flash Box Study Aid)

Chapter 6

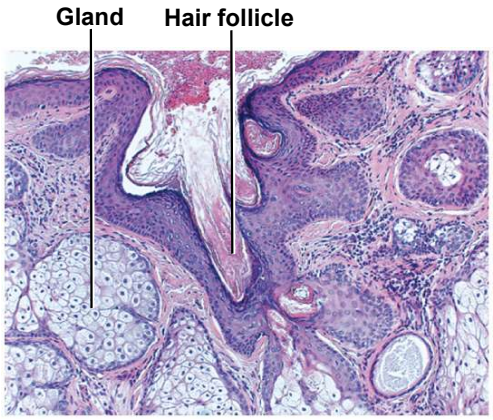
Cutaneous Glands



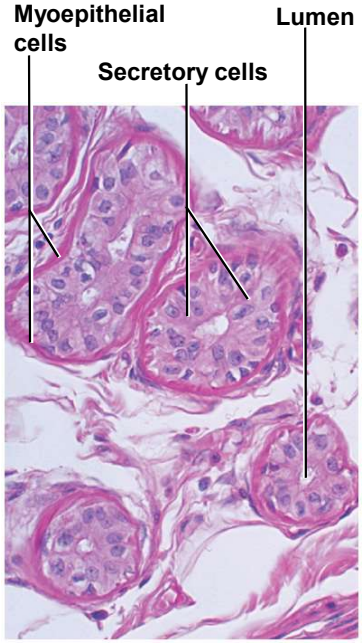
Cutaneous Glands



(a) Apocrine gland



(c) Sebaceous gland



(b) Merocrine gland

The skin has five types of glands

- merocrine sweat glands (sudoriferous)
- apocrine sweat glands
- sebaceous glands
- ceruminous glands
- mammary glands

Two Kinds of Sweat Glands (Sweat Glands = Sudoriferous Glands)

Merocrine sweat glands (also called Eccrine glands)

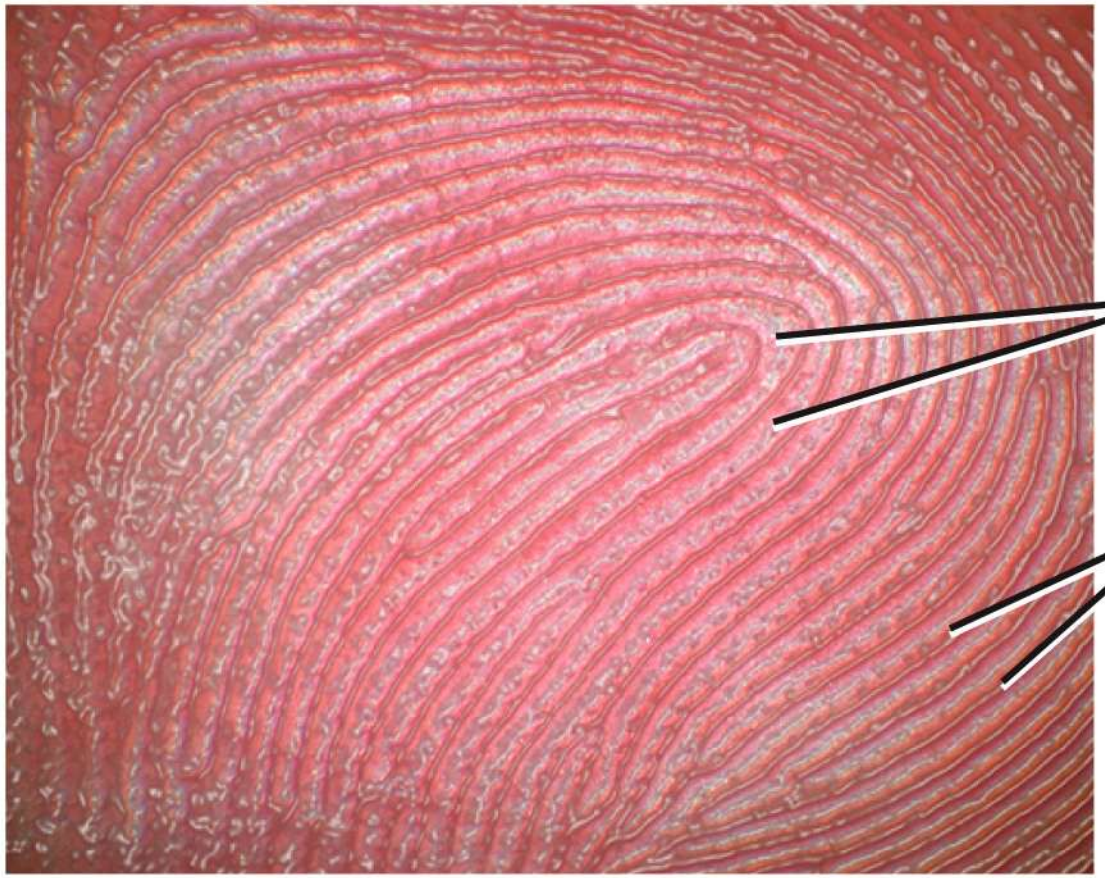
most numerous skin glands - 3 to 4 million in adult skin
are simple tubular glands
watery perspiration that helps cool the body
myoepithelial cells – contract in response to stimulation by sympathetic nervous system and squeeze perspiration up the duct

Apocrine sweat glands

- occur in groin, anal region, axilla, areola, bearded area in mature males
  ducts lead to nearby hair follicles
- produce sweat that is thicker, milky, and contains fatty acids
  scent glands that respond to stress and sexual stimulation
- glands become active at puberty to produce **pheromones** – chemicals that influence the physiology and behavior of other gender of their species
- **bromhidrosis** - body odor produced by bacteria that metabolize fatty acids

Sweat

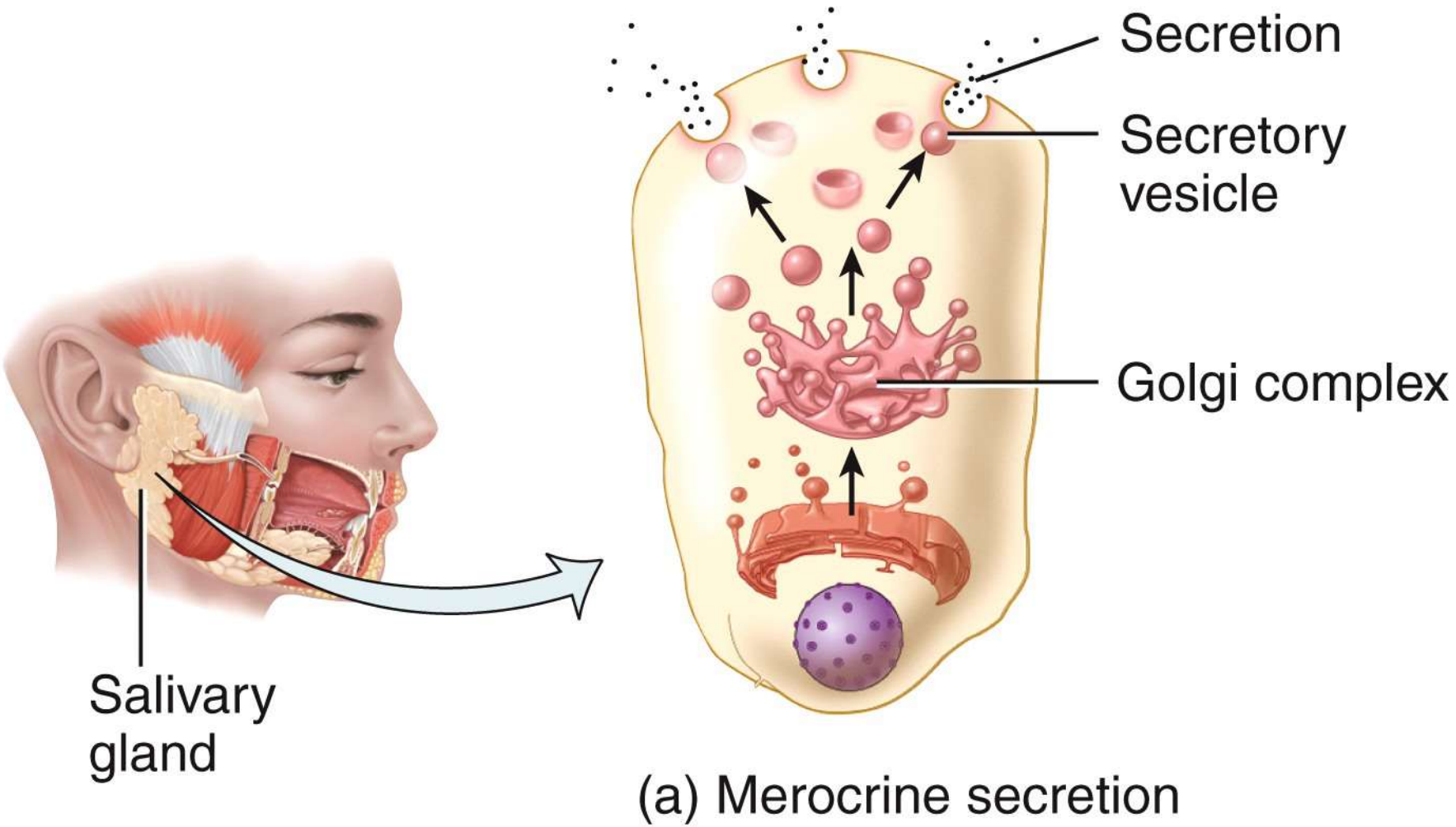
- Begins as a protein-free filtrate of blood plasma produced by deep secretory portion of gland
  - potassium ions, urea, lactic acid, ammonia, and some sodium chloride remain in the sweat, most sodium chloride reabsorbed by duct
  - some drugs are also excreted in sweat
  - on average, 99% water, with pH range of 4 to 6 /// **acid mantle** – inhibits bacterial growth
  - **insensible perspiration** – 500 ml per day /// does not produce visible wetness of skin
  - **diaphoresis** – sweating with wetness of the skin // produced during exercise – may lose up to one liter of water (sweat) per hour



David Becker/Photo Researchers, Inc.

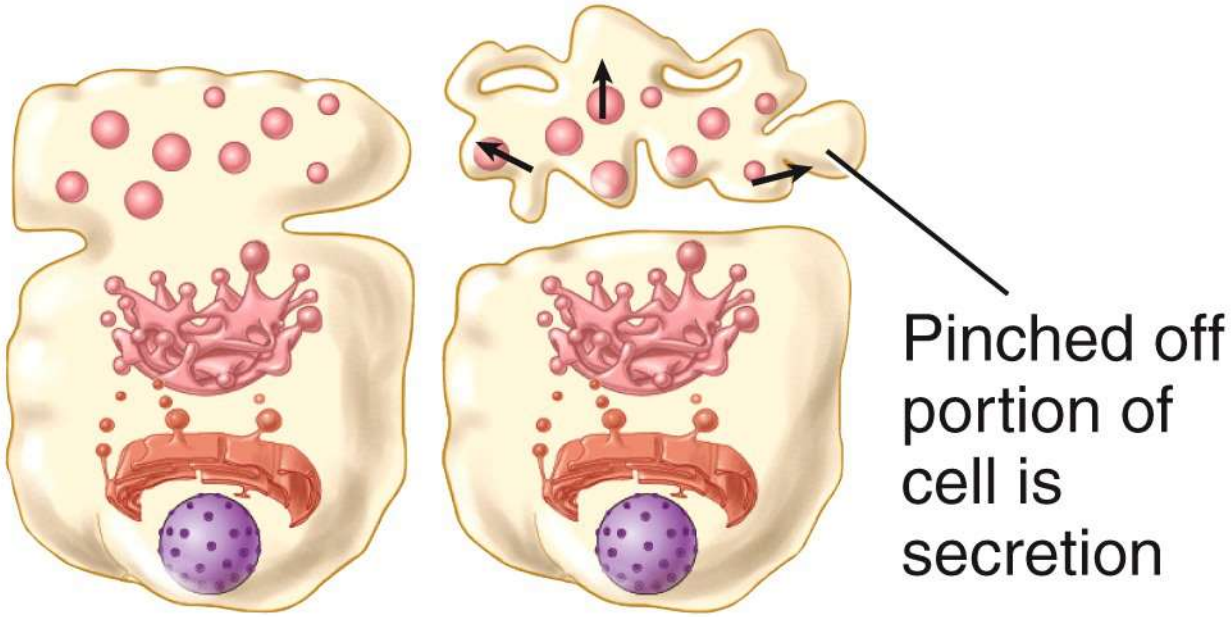
(c) Epidermal ridges and sweat pores

See Anatomy Web Site to watch secretion of sweat from pores.



(a) Merocrine secretion

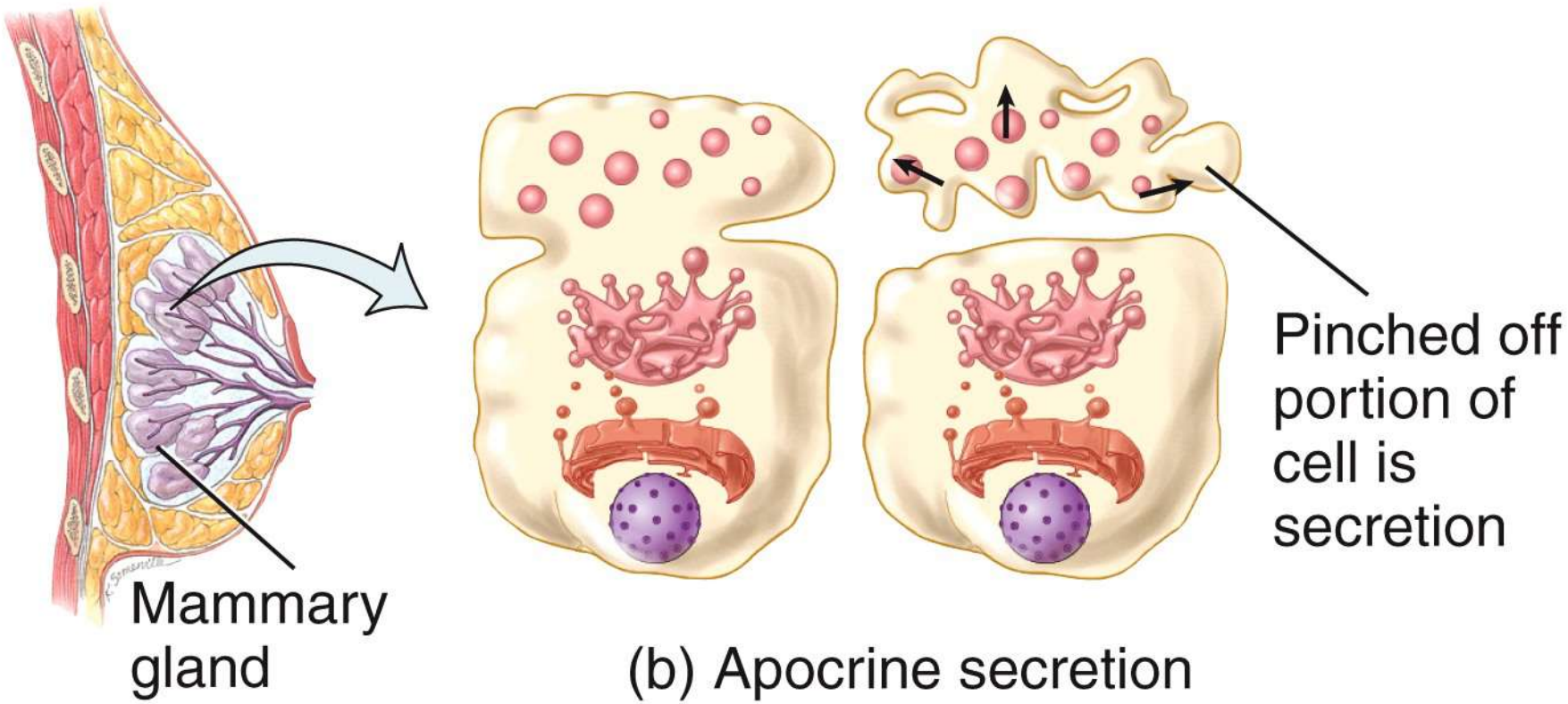
Apocrine Secretions



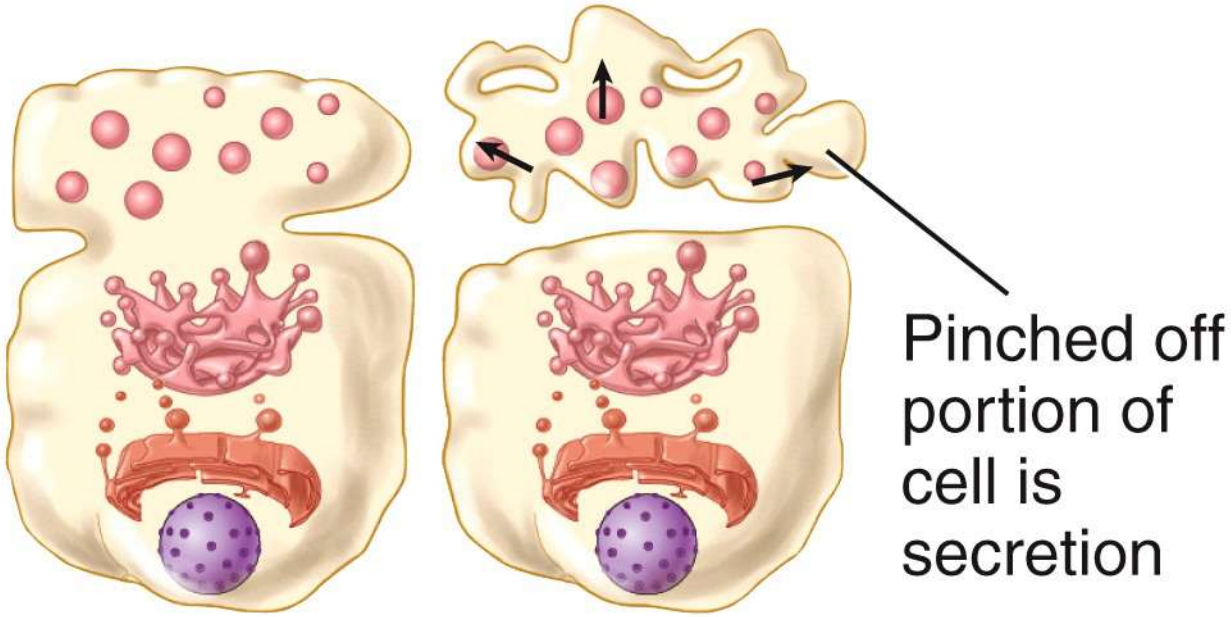
(b) Apocrine secretion

This type of secretory cell isolates secretory vesicles near the apical surface and then pinches off a portion off the cytoplasm with the secretory vesicles. The cell does not die but loses some of its cytoplasm in the process.

Apocrine Secretions



Another Functional Apocrine Secretion

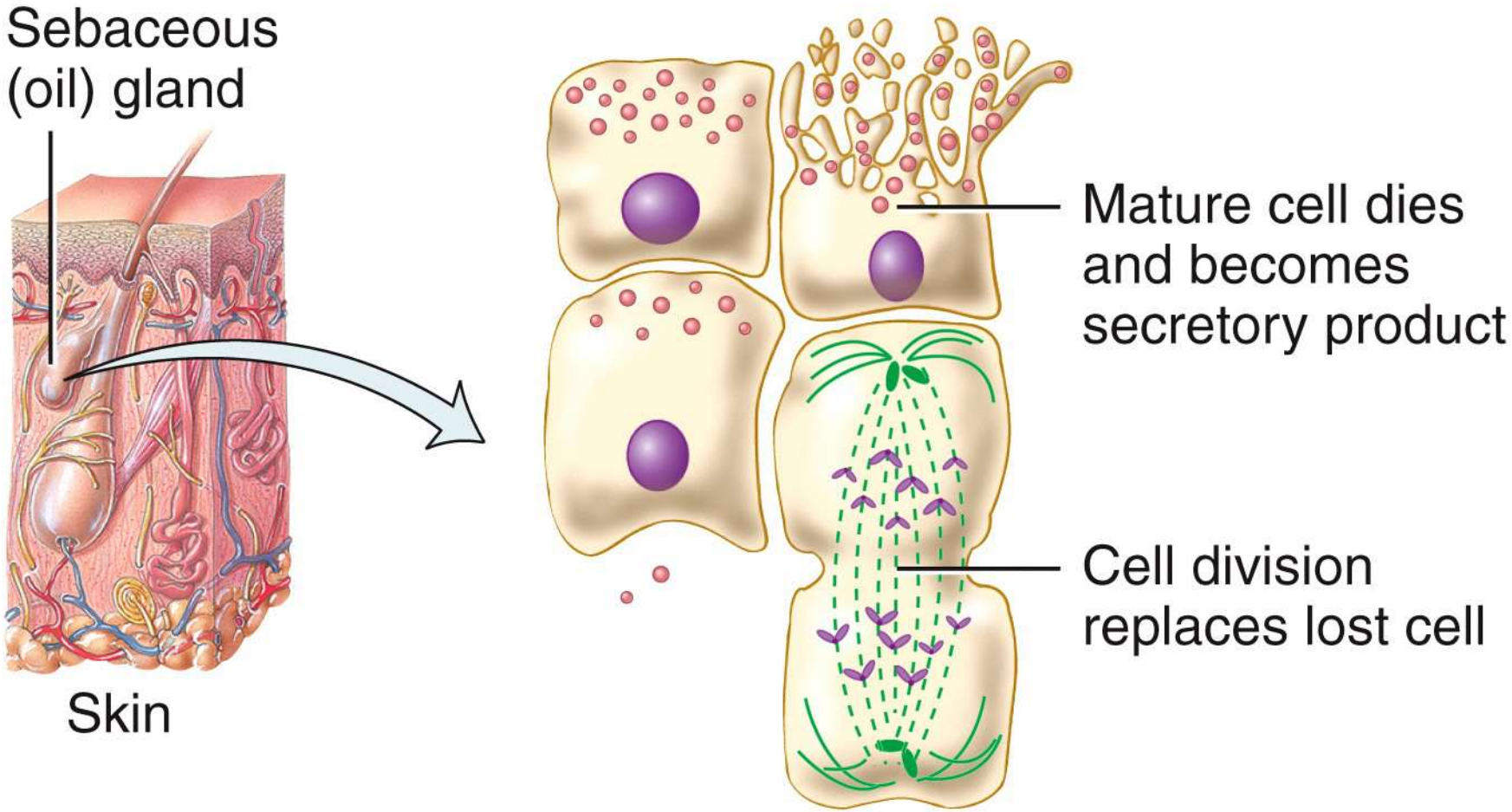


(b) Apocrine secretion

These apocrine secretory cells only become active after puberty. These cells produce pheromones which are sent molecules to signal the individual is sexually mature. These cells are located in the axillary region, around the anus, in males around the beard, and in females around the areola.

Sebaceous Glands

- sebum – oily secretion produced by sebaceous glands
- flask-shaped glands with short ducts opening into hair follicle
- holocrine gland – secretion consists of broken-down cells /// replaced by mitosis at base of gland
- keeps skin and hair from becoming dry, brittle, and cracked
- lanolin – sheep sebum // *We wash off our sebum so we can rub into our skin the sebum of sheep!*



(c) Holocrine secretion

Note: cell dies in order to release secretory product.

Ceruminous Glands

- found only in **external ear canal**
- ceruminous gland secretion combines with sebum and dead epithelial cells to form **earwax (cerumen)**
  - keep eardrum pliable
  - waterproofs the canal
  - kills bacteria
  - makes guard hairs of ear sticky to help block foreign particles from entering auditory canal
- simple, coiled tubular glands with ducts that lead to skin surface

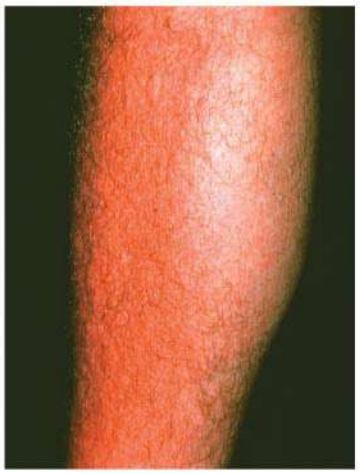
Mammary Glands

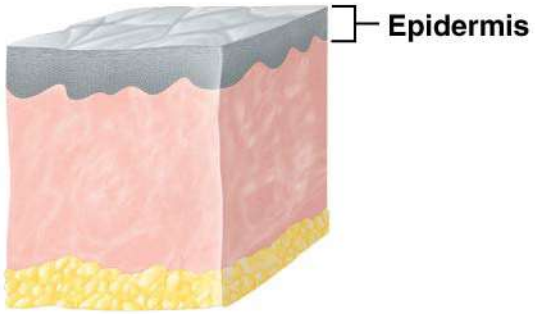
- **breasts (mammae)** of both sexes contain very little glandular material

- **mammary glands are** milk-producing glands of females that develop only during pregnancy and during lactation
  - modified apocrine sweat gland
  - secretions released into ducts that open into the nipple

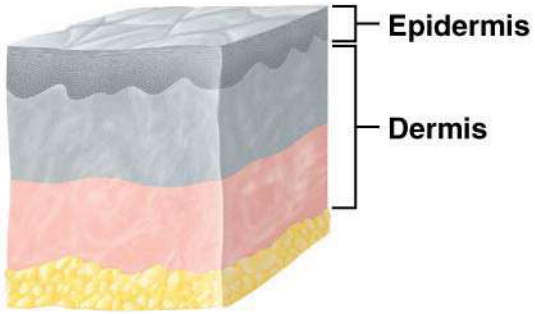
- **mammary ridges or milk lines**
  - two rows of mammary glands in most mammals
  - primates kept only one “set” of these glands
  - additional nipples (**polythelia**) // may develop along milk line

The three classes of burns.

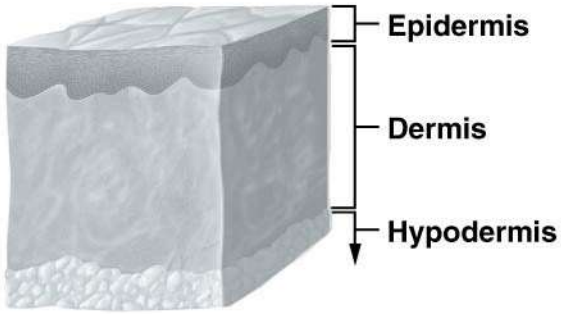




(a) First-degree burn involves epidermis only.



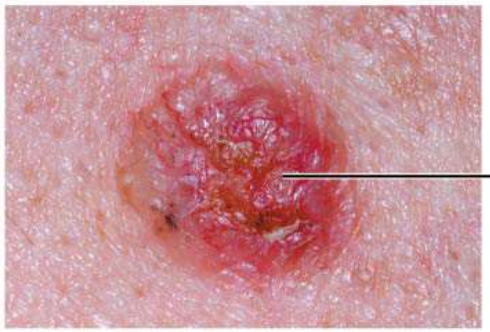
(b) Second-degree burn involves epidermis and part or all of the dermis.



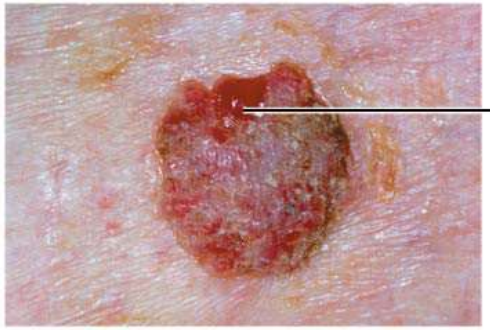
(c) Third-degree burn involves epidermis, dermis, hypodermis, and possibly deeper tissues.

Partial Thickness (1st and 2nd degree) VS Full Thickness

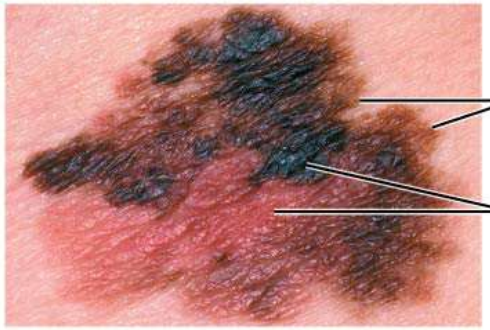
The three main forms of skin cancer.



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



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



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

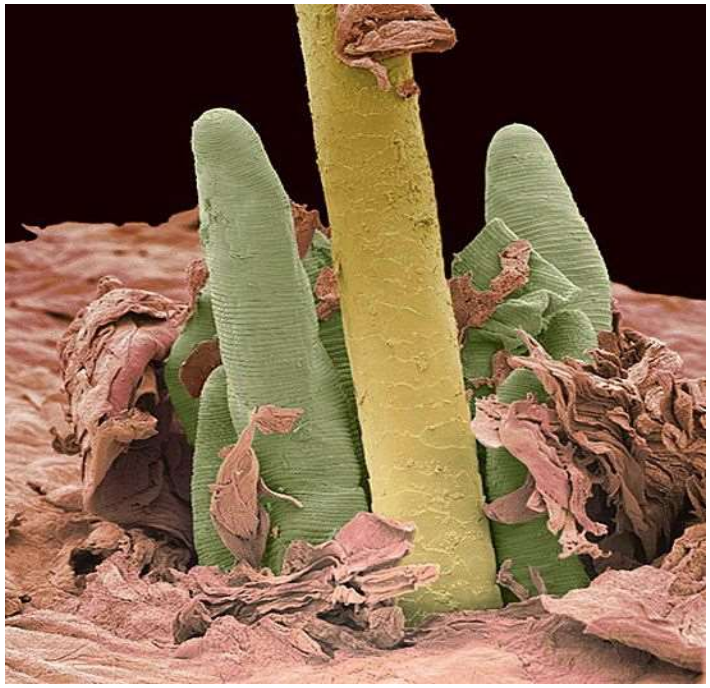
Dermatophagoides farinae (American house dust mite)

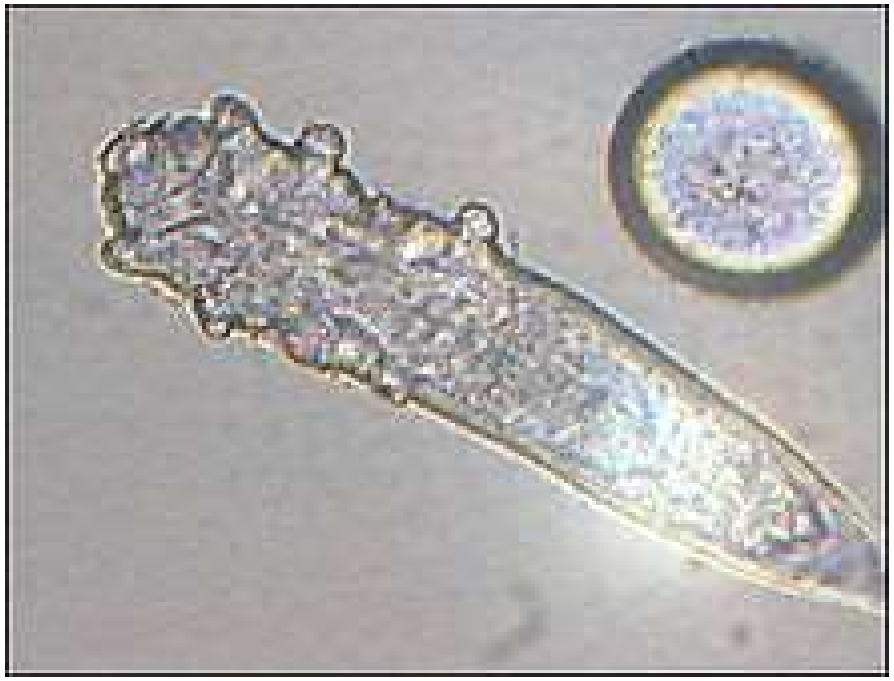
Dermatophagoides farinae (American house dust mite)

House dust mites are small, invisible-to-the-eye insects that live in our homes. They are a common part of the household ecosystem, however most people never realize they exist.

Their role in our homes is to eat our waste (dead skin). They specialize in eating dust because indoor dust is made up of primarily dead skin. For this reason, they thrive in warm, moist areas. Carpets and couches make great hiding places, but their favorite place is in our beds! A teaspoon of household dust will contain about 2,000 dust mites and an estimated 250,000 allergy causing dust mite waste pellets. In a average six room American house 80 pounds of dust is produced each year. Exposure to dust mites and their waste products causes an estimated 150,000 emergency room visits a year.

Demodex folliculorum (Face Mite)





D. folliculorum and D. brevis are typically found in/on humans. D. folliculorum is adapted to live inside hair follicles, and therefore is thin and worm-like, with short legs. The mites are obligate commensals of humans, and can only live on the skin; they soon dry out and die if they leave the host. The eight legged adult exit the hair follicle to copulate and return to the hair follicle to deposit their eggs in sebaceous gland. The six-legged larvae hatch after 3-4 days, and the larvae develop into adults in about 7 days. It has a 14-day life cycle. The total lifespan of a Demodex mite is several weeks. The dead mites decompose inside the hair follicles or sebaceous glands.

Demodex spp are examples of coevolution. D. folliculorum has been part of the human ecosystem for over six million years. D. brevis invaded humans about 40,000 years ago.

Can you identify the three type of skin in this model?

(See Anatomy Web Site Flash Box Study Aid)