National University Higher School of Medicine

The Integumentary system

PART I

◆ Pre-test:10 min

◆ Medical terms:10 min

LEARNING OUTCOMES

As a result of the lesson you will be able to:

- List **the functions of the skin** and relate them to its structure
- Describe **the histological structure** of the epidermis, dermis, and subcutaneous tissue and relate them to functions
- Describe the three classes of burns and the priorities in burn treatment

What's Covering You? Why????

- **Integumentary System** – consists of the 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

Tanya's Case: Deadly Flames (20min)

Tanya, an 8-year-old Hispanic female, had suffered severe burns to her lower extremities, hands, and abdomen and minor flash burns to the face following a house fire. Burns appear gray-white with red, blistered borders. Patient just regained consciousness, but disoriented and verbally unresponsive. Vitals are unstable with blood pressure = 60 / 40; heart rate = 165 [beats / min].; and respiratory rate = 35 [breaths / min].

Diagnosis: burn covering 33% of body with third -degree burn on legs and hands, second degree on abdomen and part of limbs, first degree on face. Vital show circulatory shock risk with low BP and high HR/RR.

Tanya's Case: Deadly Flames (20min)

Part I:

1. *What are the main functions of the integumentary system? the structures that enable them?*

Structure of the Skin

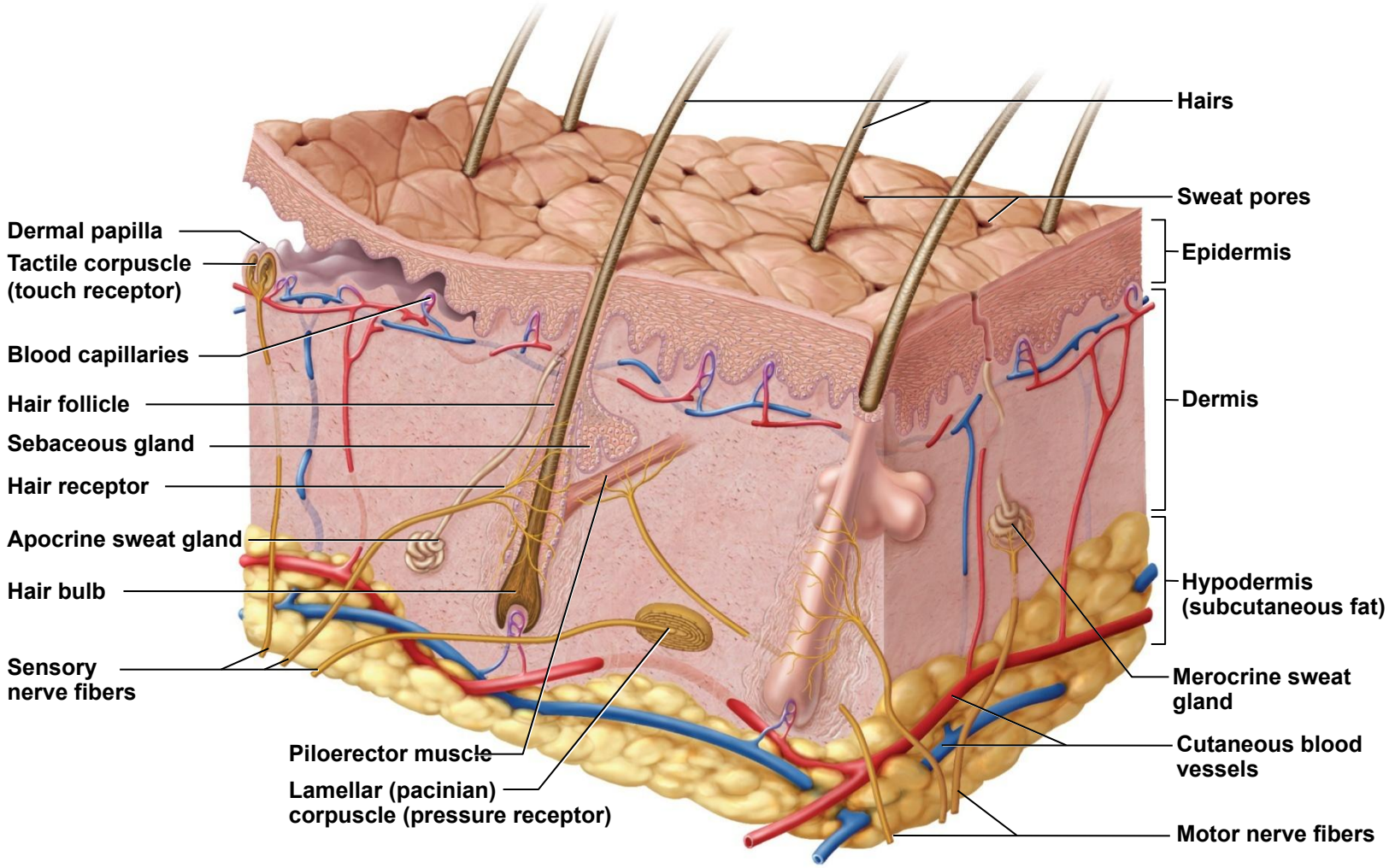

Figure 6.1

Skin and Subcutaneous Tissue

- the body's largest and heaviest organ
  - covers area of 1.5 -2.0 m^2
  - 15 % of body weight
- consists of two layers:
  - epidermis – stratified squamous epithelium
  - dermis – connective tissue layer
- hypodermis – another connective tissue layer below the dermis
- most skin is 1 – 2 mm thick
- ranges from 0.5 mm on eyelids to 6 mm between shoulder blades
- thick skin – on palms and sole, and corresponding surfaces on fingers and toes
  - has sweat glands, but no hair follicles or sebaceous (oil) glands
  - epidermis 0.5 mm thick
- thin skin – covers rest of the body
  - epidermis about 0.1 mm thick
  - possesses hair follicles, sebaceous glands and sweat glands

Functions of the Skin

- resistance to trauma and infection
  - keratin
  - acid mantle
- other barrier functions
  - waterproofing
  - UV radiation
  - harmful chemicals
- vitamin D synthesis
  - skin first step
  - liver and kidneys complete process

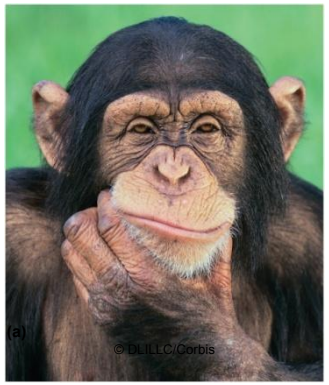

Figure 6.2a

- **sensation**
  - skin is our most extensive sense organ
- **thermoregulation**
  - thermoreceptors
  - vasoconstriction / vasodilation
- **nonverbal communication**
  - acne, birthmark, or scar
- **transdermal absorption**
  - administration of certain drugs steadily through thin skin – adhesive patches

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Figure 6.2b

Epidermis

- epidermis – keratinized stratified squamous epithelium
  - dead cells at the surface packed with tough protein – **keratin**
  - lacks blood vessels
  - depends on the diffusion of nutrients from underlying connective tissue
  - sparse nerve endings for touch and pain

Cells of Epidermis

- five types of cells of the epidermis
  - stem cells
    - undifferentiated cells that give rise to keratinocytes
    - in deepest layer of epidermis (stratum basale)
  - keratinocytes
    - great majority of epidermal cells
    - synthesize **keratin**
  - melanocytes
    - occur only in stratum basale
    - synthesize pigment **melanin** that shields DNA from ultraviolet radiation
    - branched processes that spread among keratinocytes
  - tactile (merkel) cells
    - in basal layer of epidermis
    - touch receptor cells associated with dermal nerve fibers
  - dendritic (langerhans) cells
    - 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

Cell Types and Layers of the of the Epidermis

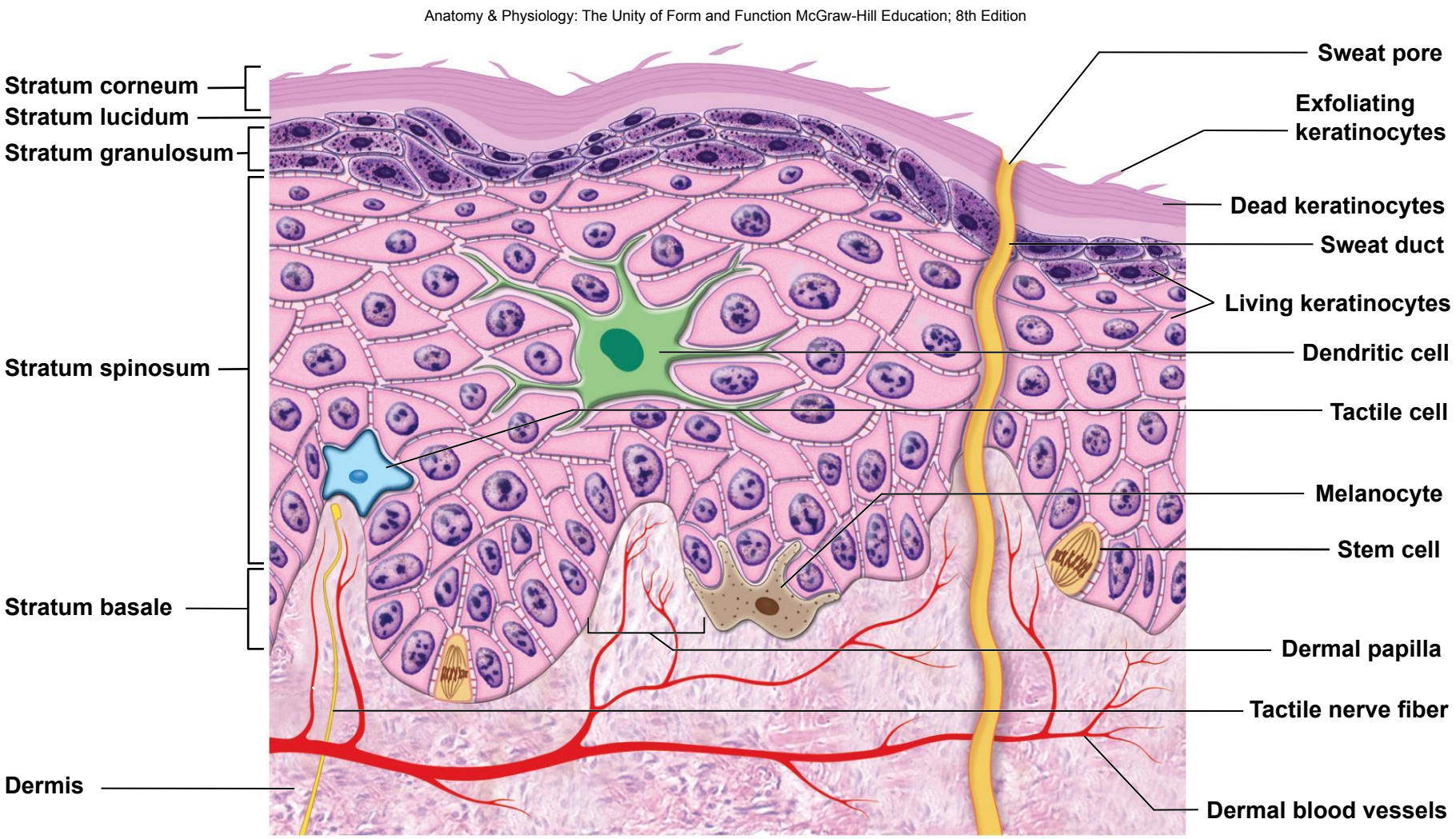
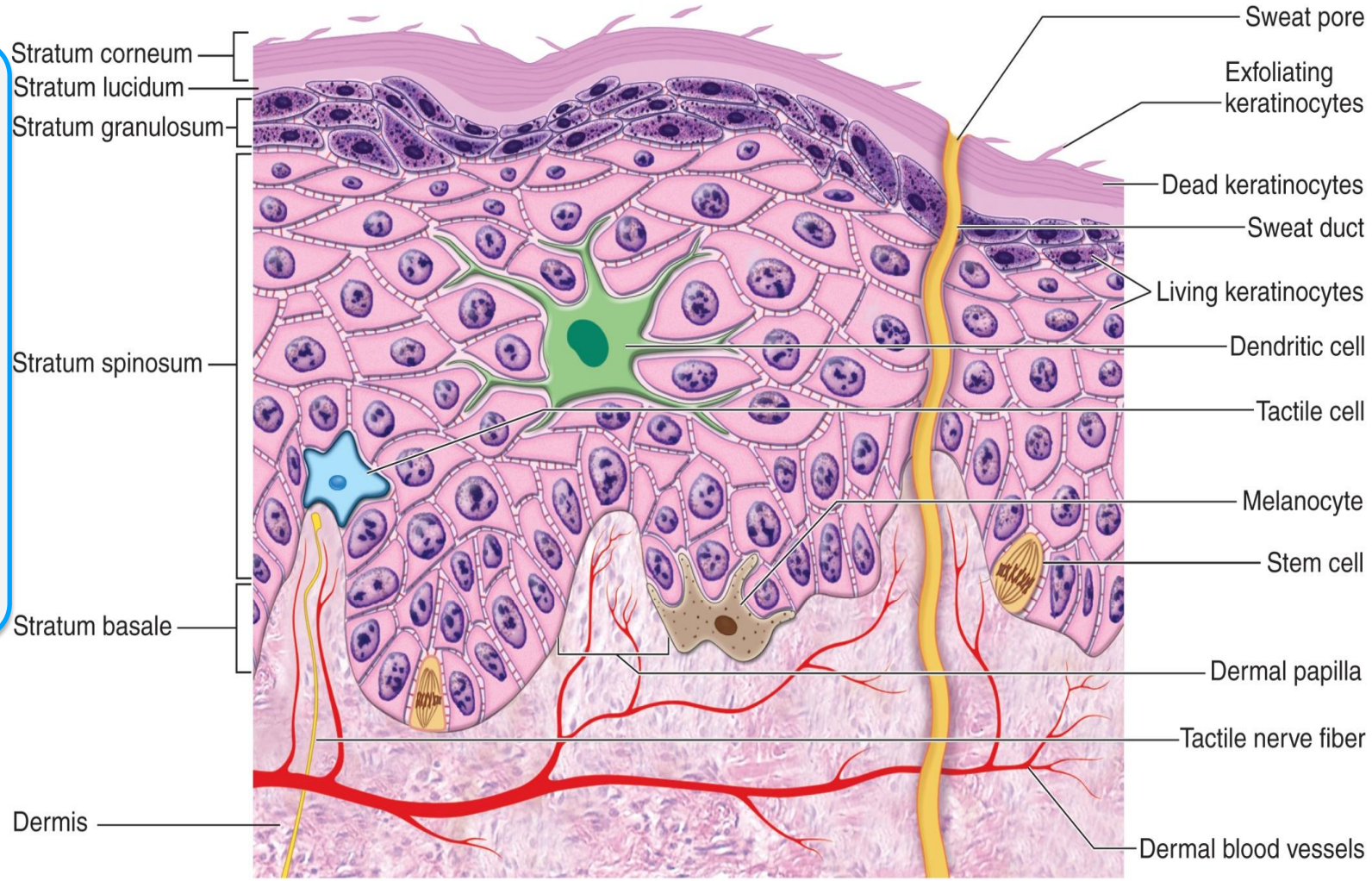


Figure 6.3

Epidermis

Epidermis epidermis – keratinized stratified squamous epithelium

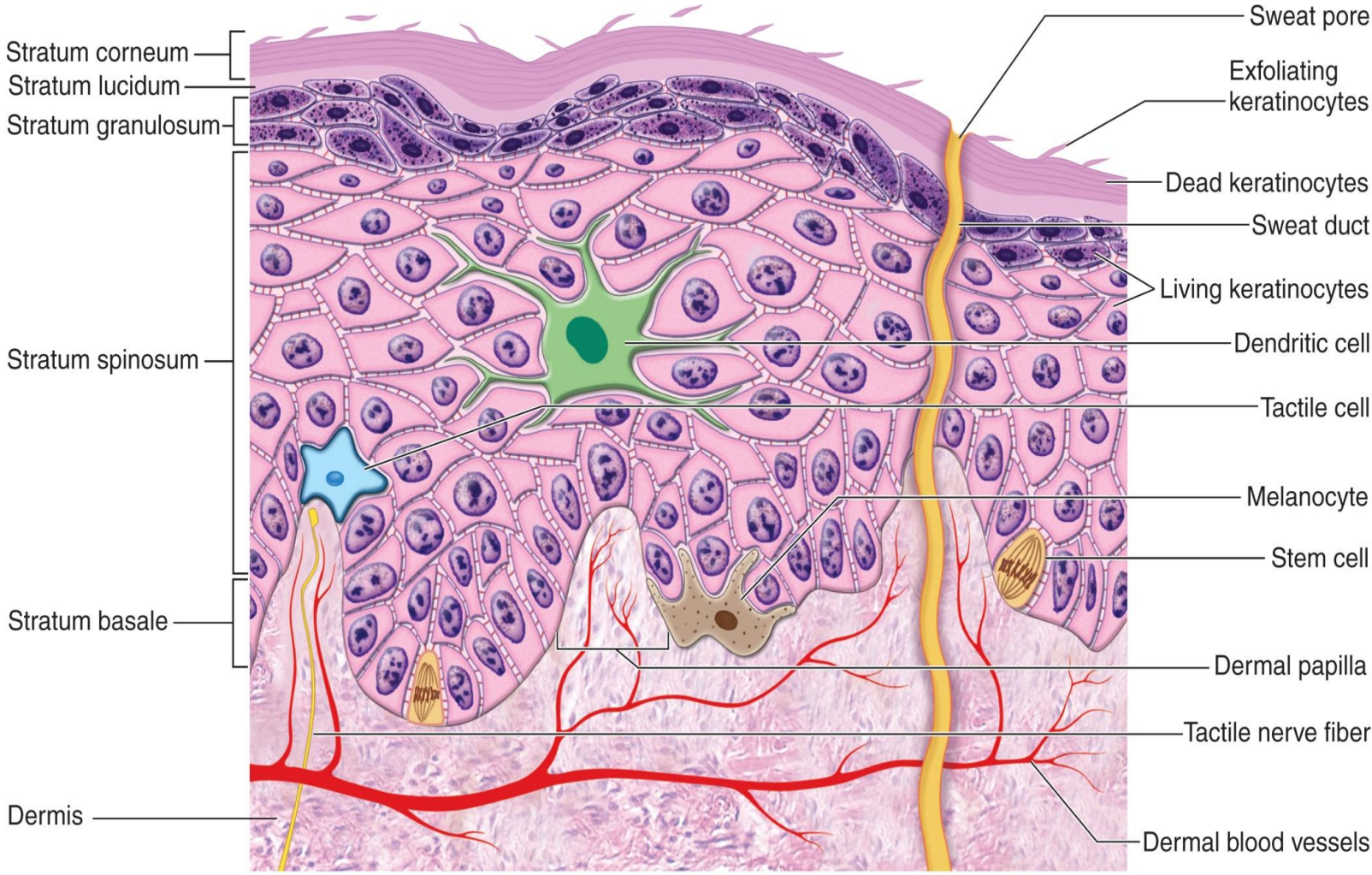
- Dead cells at the surface packed with tough protein – **keratin**
- **L**acks blood vessels
- Depends on the diffusion of nutrients from underlying connective tissue
- Sparse nerve endings for touch and pain



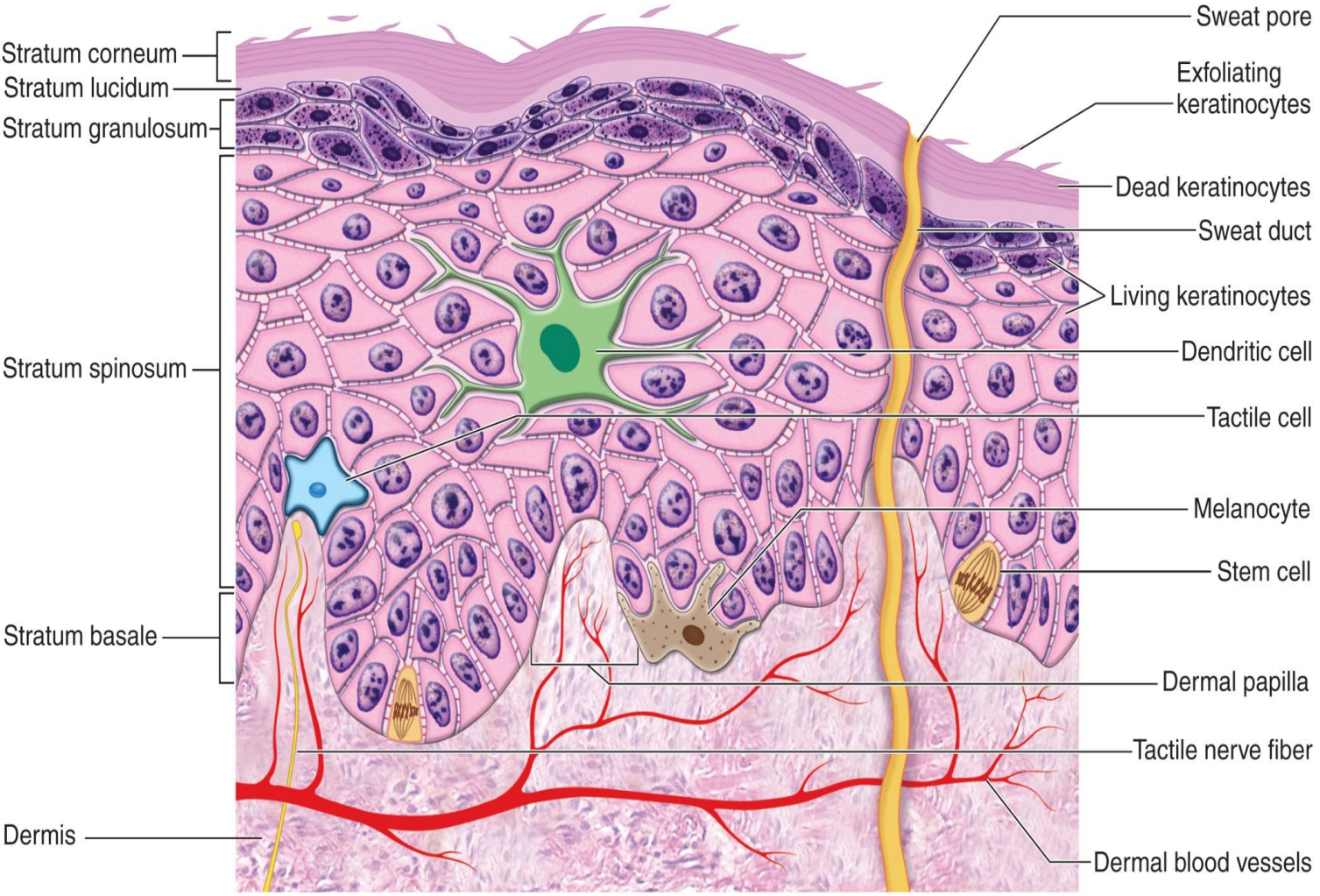
Dermis

connective tissue layer

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**
smooth muscle (piloerector muscles) associated with hair follicles
contract in response to stimuli, such as cold, fear, and touch **– goose bumps**



Cell type of Epidermis



Five types of cells of the epidermis

1) stem cells
undifferentiated cells that give rise to keratinocytes in deepest layer of epidermis (stratum basale)

2) Keratinocytes
great majority - synthesize keratin
filled with keratin (protein) , waterproof barrier

3) Melanocytes
occur only in stratum basale
synthesize pigment melanin that shields DNA from ultraviolet radiation

4) Tactile (merkel) cells
in basal layer of epidermis
touch receptor cells associated with dermal nerve fibers

5) Dendritic (langerhans) cells
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

Layers of the of the Epidermis

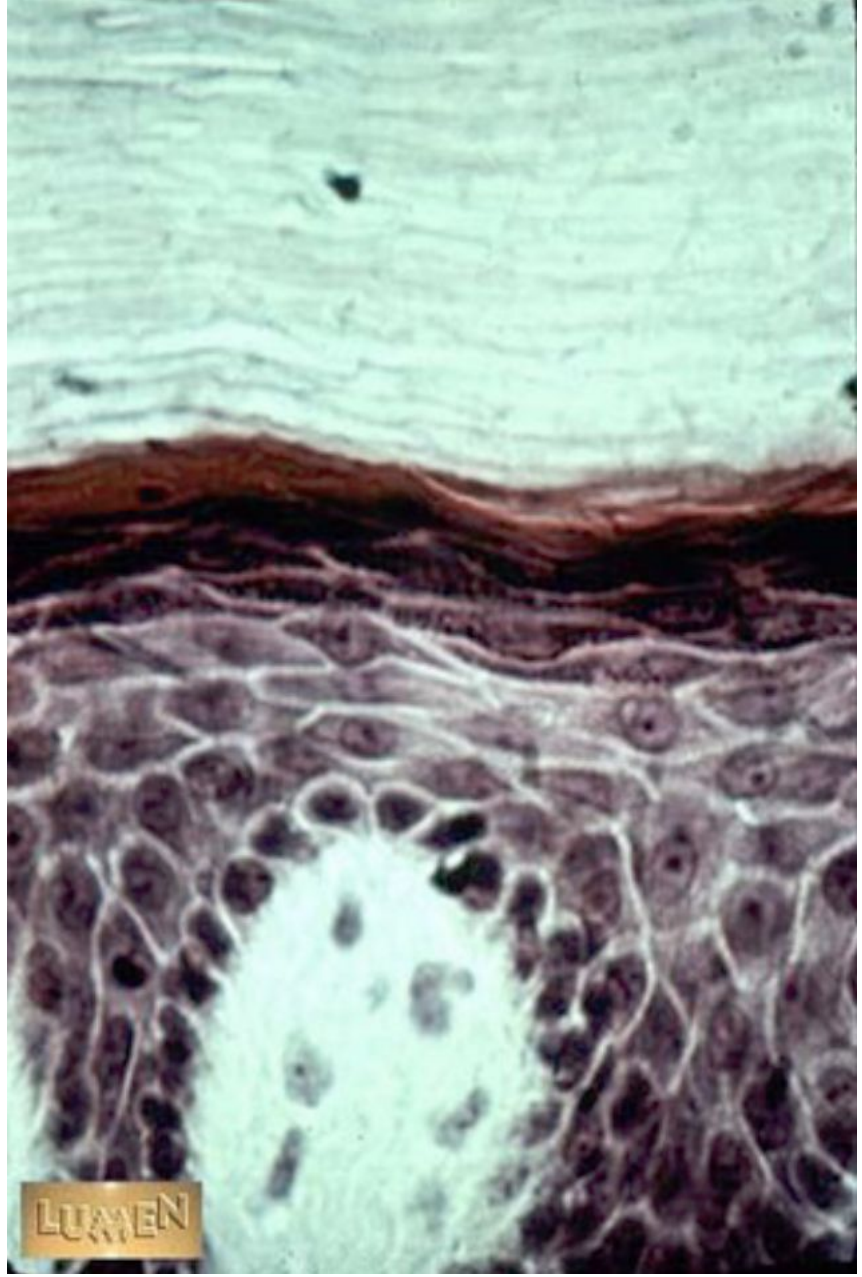
30 layers of dead, scaly, keratinized cells form durable surface layer
surface cells flake off (exfoliate) - dust!
resistant to abrasion, penetration, and water loss

only in thick skin, thin translucent zone,cells have no nucleus or other organelles

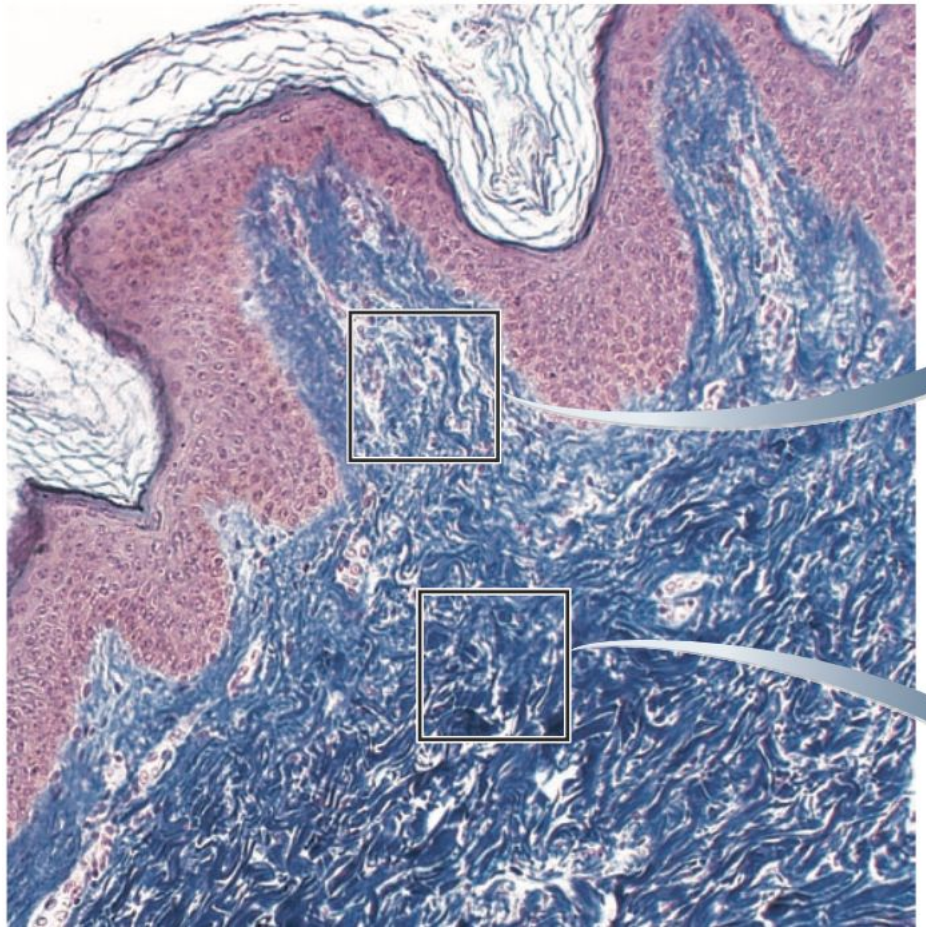
3 to 5 layers flat keratinocytes
contain coarse dark-staining keratohyalin granules

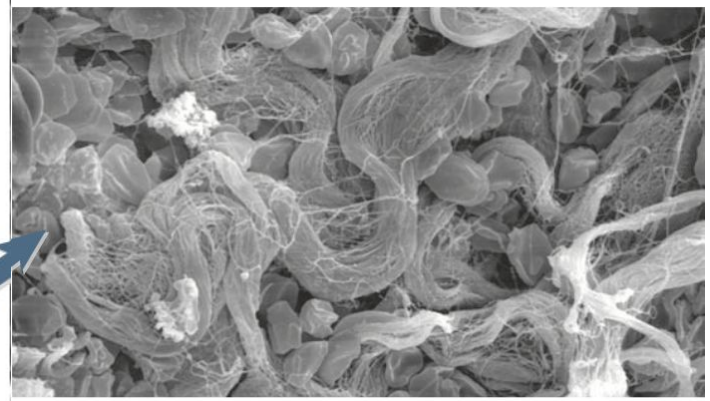
thickest stratum in most skin, consist of several layers of keratinocytes
- capable of mitosis
- Produce keratin filaments which causes cell to flatten
- Dendritic cells

stem cells ,keratinocytes,melanocytes , tactile cells

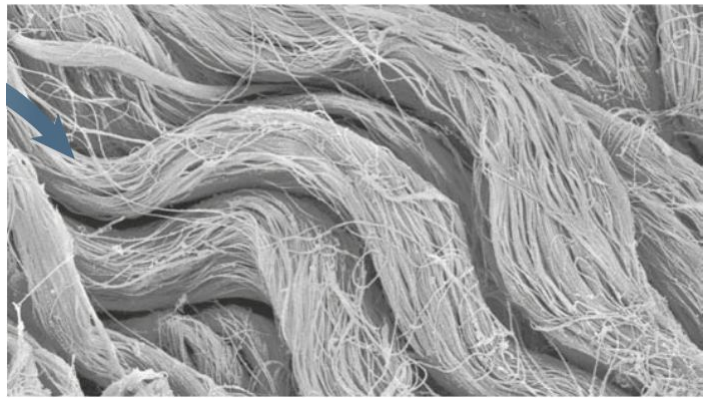


Layers of the of the dermis





The papillary layer, made of **areolar tissue**, forms the **dermal papillae**. Note the **relatively loose organization** of this layer. Many of the visible cells are **white blood cells** wandering among the collagenous fibers.



The reticular layer, made of dense irregular **connective tissue,** forms the deeper four-fifths of the dermis. It is far **more fibrous than cellular,** and thus **tougher** than the papillary layer.

Stratum Basale

- a single layer of cuboidal to low columnar **stem cells** and **keratinocytes** resting on the basement membrane
  - melanocytes and tactile cells are scattered among the stem cells and keratinocytes

- stem cells of stratum basale divide
  - give rise to keratinocytes that migrate toward skin surface
  - replace lost epidermal cells

Stratum Spinosum

- consists of **several layers of keratinocytes**

- thickest stratum in most skin
  - in thick skin, exceeded by stratum corneum

- deepest cells 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

- dendritic cells found throughout this stratum

- named for artificial appearance created in histological section
  - numerous desmosomes and cell shrinkage produces spiny appearance

Stratum Granulosum

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

Stratum Lucidum

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

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 History of Keratinocytes

- keratinocytes are produced deep in the epidermis by stem cells in stratum basale
  - some deepest keratinocytes in stratum spinosum also multiply and increase their numbers

- mitosis requires an abundant supply of oxygen and nutrients
  - deep cells acquire from blood vessels in nearby dermis
  - once epidermal cells migrate more than two or three cells away from the dermis, their mitosis ceases

- newly formed keratinocytes push the older ones toward the surface

- in **30 - 40 days** a keratinocyte makes its way to the skin surface and flakes off
  - slower in old age
  - faster in skin injured or stressed
    - calluses or corns – thick accumulations of dead keratinocytes on the hands or feet
- cytoskeleton proliferates as cells are shoved upward
- cells grow flatter
- produce lipid-filled **membrane-coating vesicles** (lamellar granules)
- in **stratum granulosum** three important developments occur
  - keratinocyte nucleus and other organelles degenerate, **cells die**
  - keratohyalin granules release a protein filaggrin
    - binds the keratin filaments together into coarse, tough bundles
  - membrane-coating vesicles release lipid mixture that spreads out over cell surface and **waterproofs** it

Epidermal Water Barrier

- epidermal water barrier - forms between stratum granulosum and stratum spinosum

- consists of:
  - lipids secreted by keratinocytes
  - tight junctions between keratinocytes
  - thick layer of **insoluble protein** on the inner surfaces of the keratinocyte plasma membranes

- critical to retaining water in the body and **preventing dehydration**

Dermis

- 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**

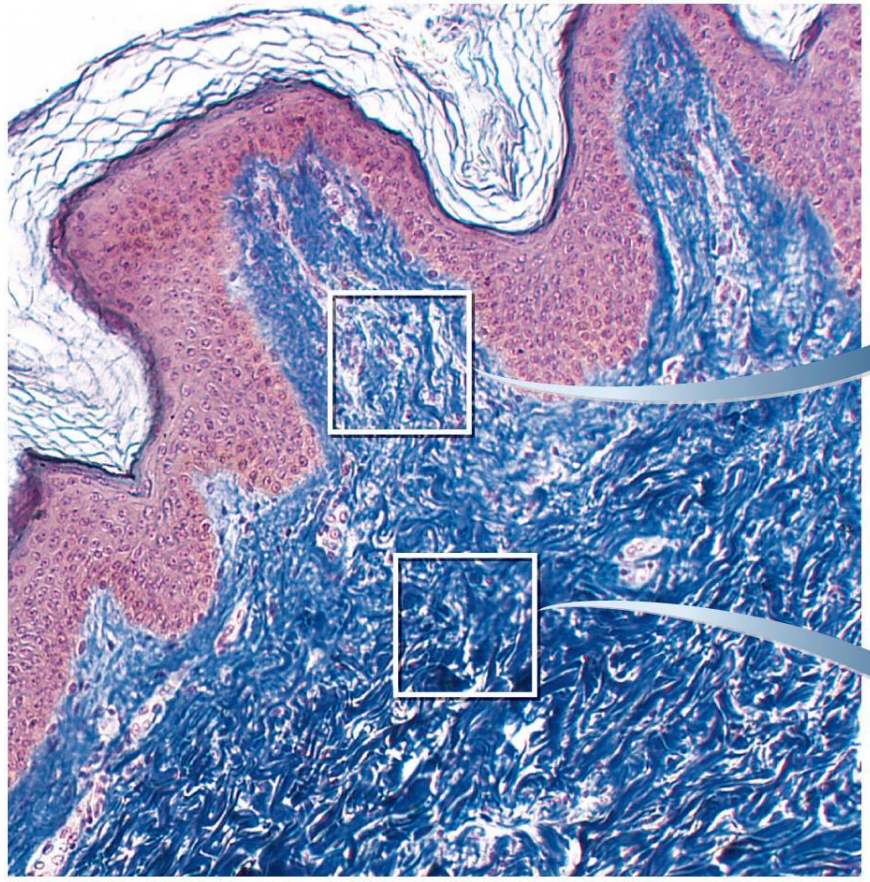
Dermis

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

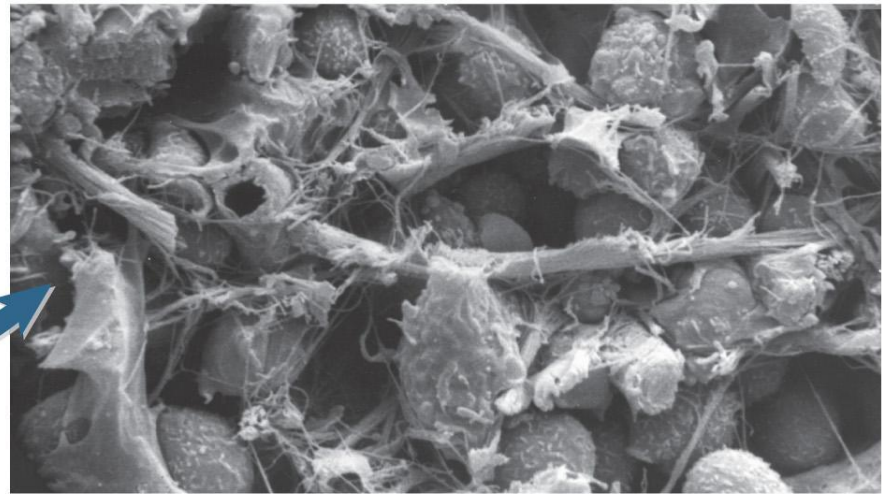
- papillary layer – superficial zone of dermis
  - thin zone of areolar tissue in and near the dermal papilla
  - allows for mobility of leukocytes and other defense cells should epidermis become broken
  - rich in small blood vessels

- 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

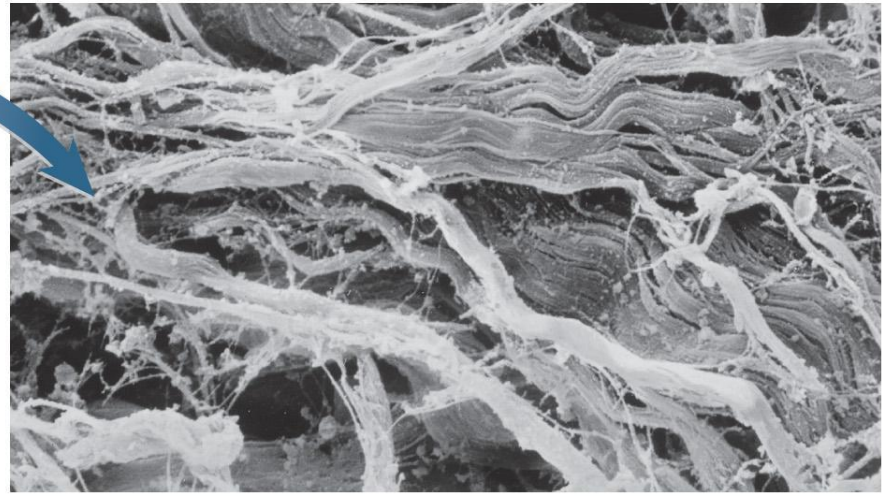
Structure of the Dermis



(a)



(b) Papillary layer of dermis



(c) Reticular layer of dermis

Figure 6.5

Layers of Dermis

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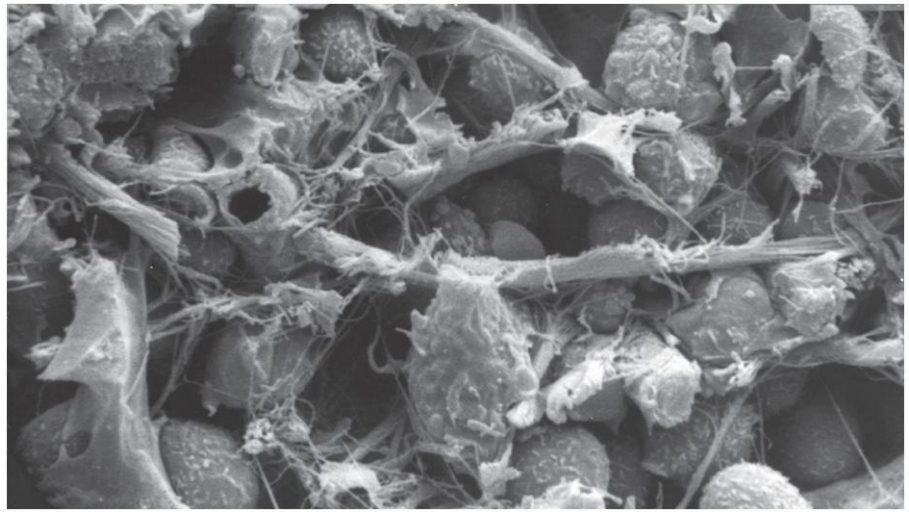
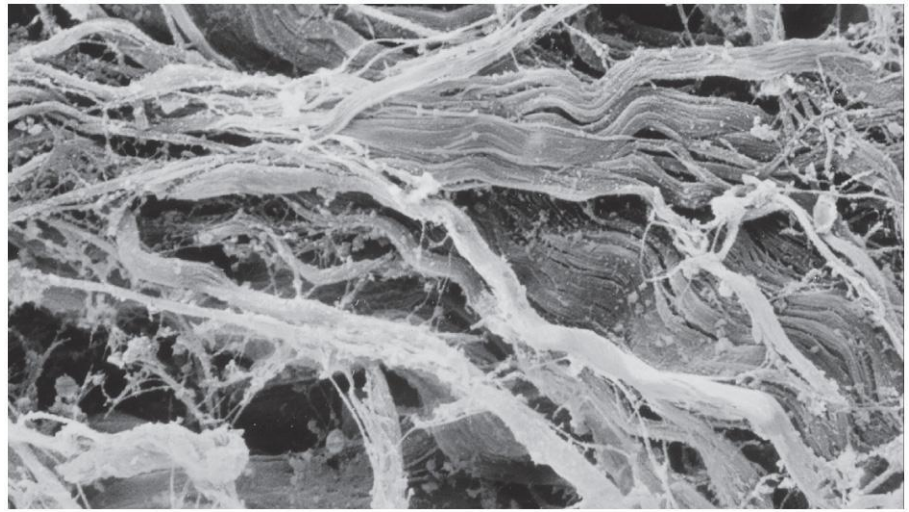


(b) Papillary layer of dermis



(c) Reticular layer of dermis

Figure 6.5b

Figure 6.5c

Hypodermis

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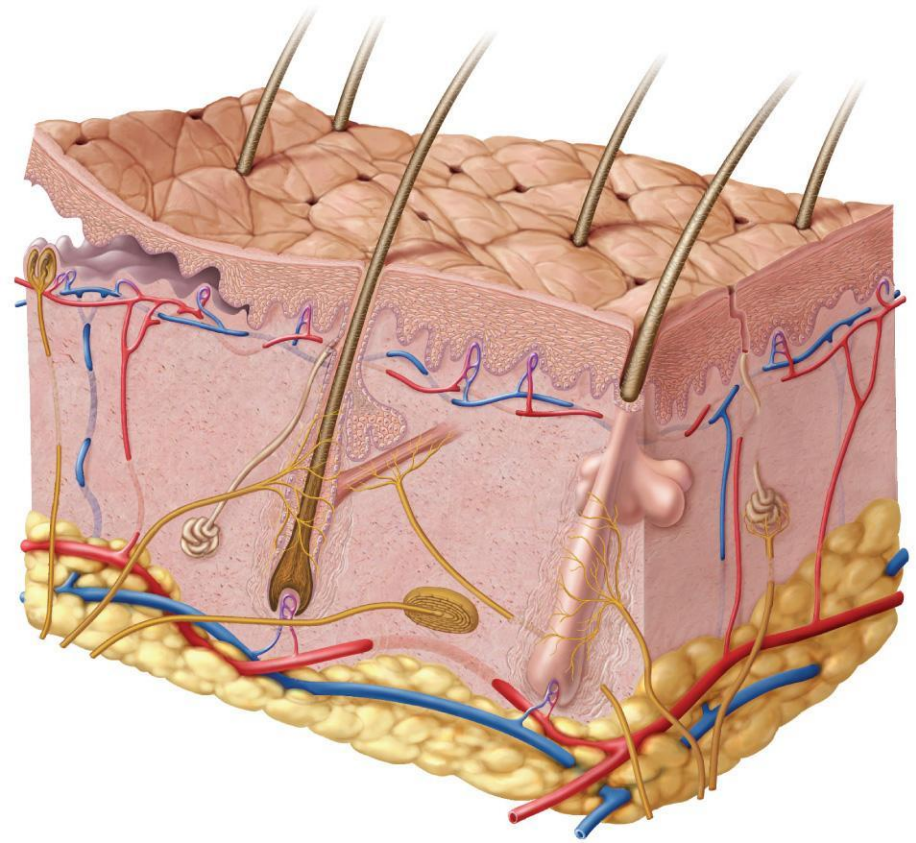

- subcutaneous tissue
- more areolar and adipose than dermis
- pads body
- binds skin to underlying tissues
- drugs introduced by injection
  - highly vascular & absorbs them quickly
- subcutaneous fat
  - energy reservoir
  - thermal insulation
  - 8% thicker in women

Tanya's Case: Deadly Flames (20min)

Part II:

3. Describe the difference between 1st, 2nd, & 3rd degree burns & explain the importance of the "Rule of Nines."

Tanya's Case: Deadly Flames (20min)

Part II:

4. Given the severity of Tanya's burns, label or note which structures of the skin may be damaged.

Tanya's Case: Deadly Flames (20min)

Part II:

5. Given the major threats to the body upon severe burning, list the top 2-3 concerns you have for Tanya.

Summary(5min)