Integumentary System

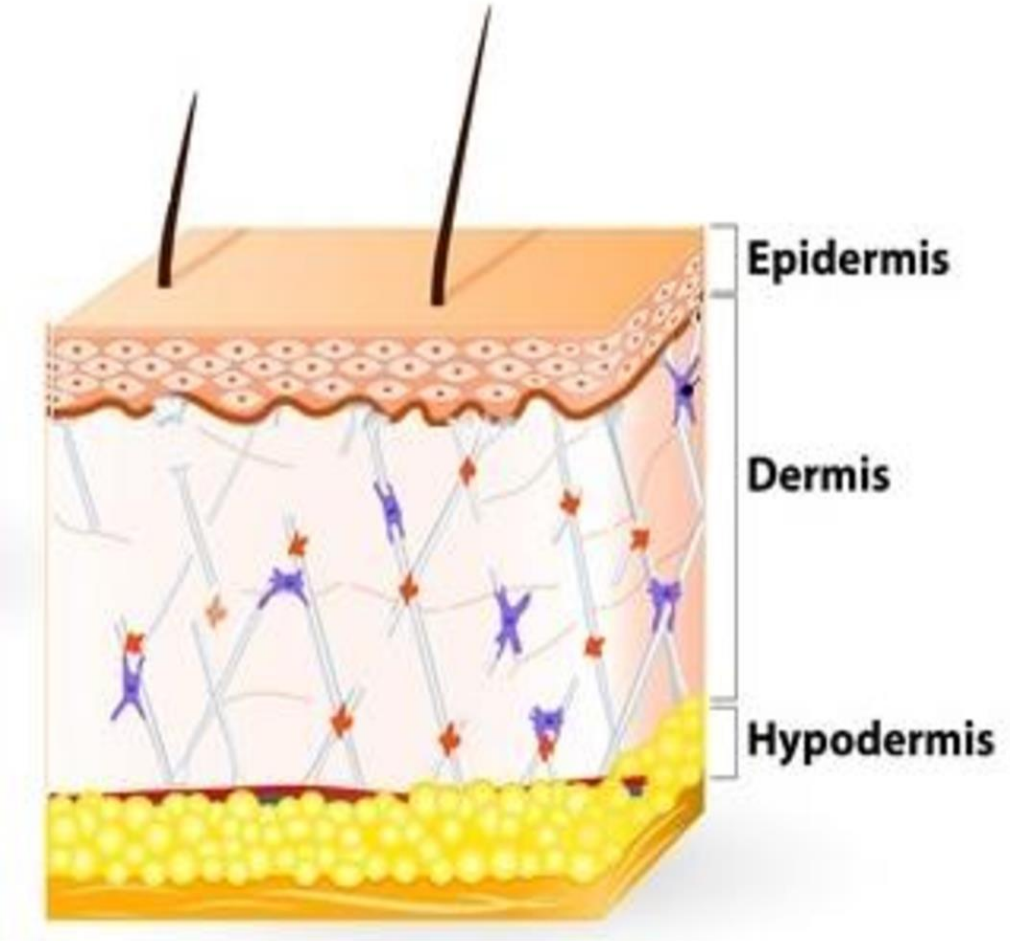
- Consists of three major regions

- Epidermis – outermost superficial region
- Dermis – middle region
- Hypodermis – deepest region

Skin layers

The skin is organized as follows, from superficial to deeper layers:

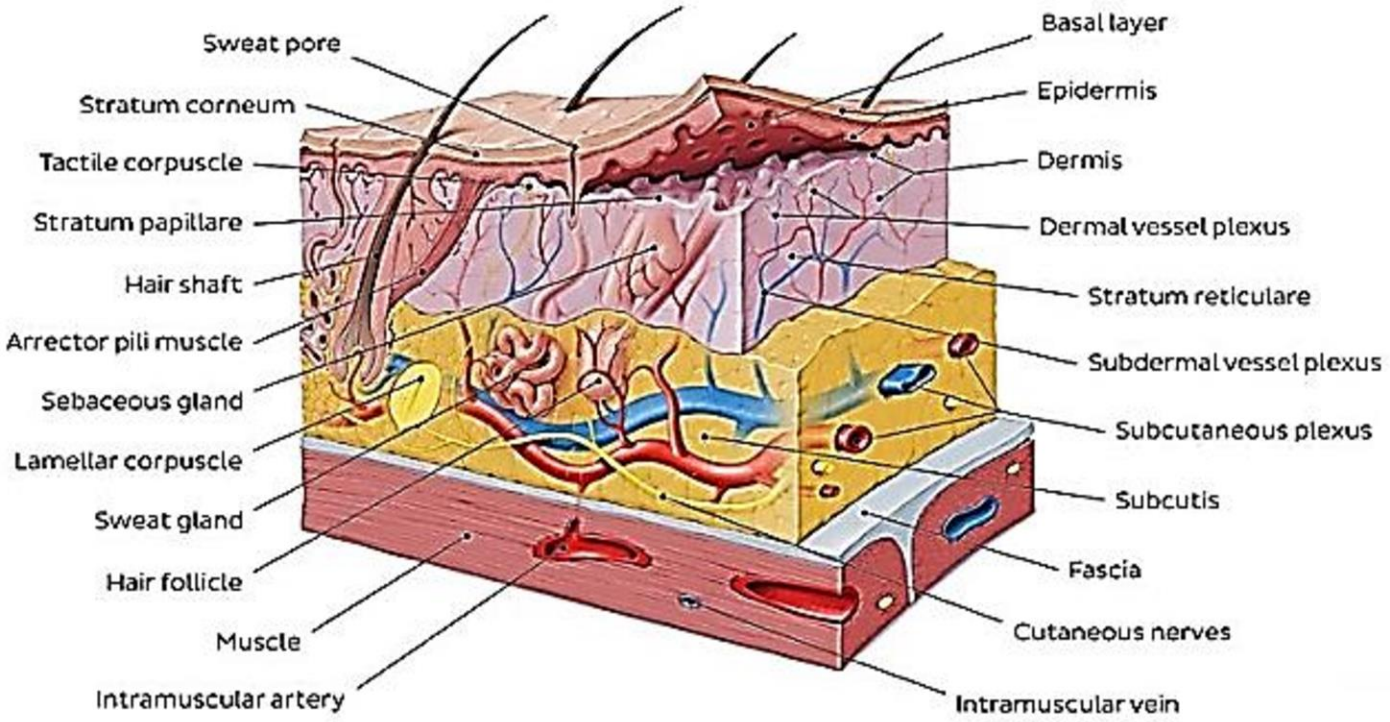
- Epidermis
- Dermis
- Hypodermis



Definition

- The integumentary system, or skin, is the largest organ in the body.

- It comprises of skin and skin appendages including hairs, nails, sweat glands and sebaceous glands.



• Functions of Skin

- **Resistance to trauma and infection**
  - Keratin
  - Dermacidin and defensins
  - Acid mantle
- **Other barrier functions**
  - Water
  - UV radiation
  - Harmful chemicals
- **Vitamin D synthesis**
  - Skin carries out first step
  - Liver and kidneys complete process

- **Sensation**
  - Skin is an extensive sense organ
  - Receptors for temperature, touch, pain, and more
- **Thermoregulation**
  - Thermoreceptors
  - Vasoconstriction/vasodilation
  - Perspiration
- **Nonverbal communication**
  - Facial expression
  - Importance in social acceptance and self image

Skin

- The skin is the largest component of this system.
- It forms an outer, protective coat around the entire external surface of the body.
- The thickness of skin varies from 0.5mm thick on the eyelids to 4.0mm thick on the heels of feet.

- **The Skin and Subcutaneous Tissues**
- **Skin is body's largest and heaviest organ**
  - Covers 1.5 to 2.0 m^2 ; composes 15% of body weight
- **Layers**
  - **Epidermis:** stratified squamous epithelium
  - **Dermis:** deeper connective tissue layer
  - **Hypodermis**—connective tissue layer below dermis (not part of skin, but associated with it)
- **Skin thickness ranges from 0.5 to 6 mm**
  - **Thick skin** covers front of hands, bottoms of feet
    - Has sweat glands, but no hair follicles or sebaceous (oil) glands
    - Epidermis 0.5 mm thick
  - **Thin skin** covers rest of the body
    - Possesses hair follicles, sebaceous glands, and sweat glands
    - Epidermis about 0.1 mm thick

- Types of Cells

- Keratinocytes – produce the fibrous protein *keratin*
- Melanocytes – produce the brown pigment *melanin*
- Langerhans' cells – epidermal macrophages that help activate the immune system
- Merkel cells – function as touch receptors in association with sensory nerve endings

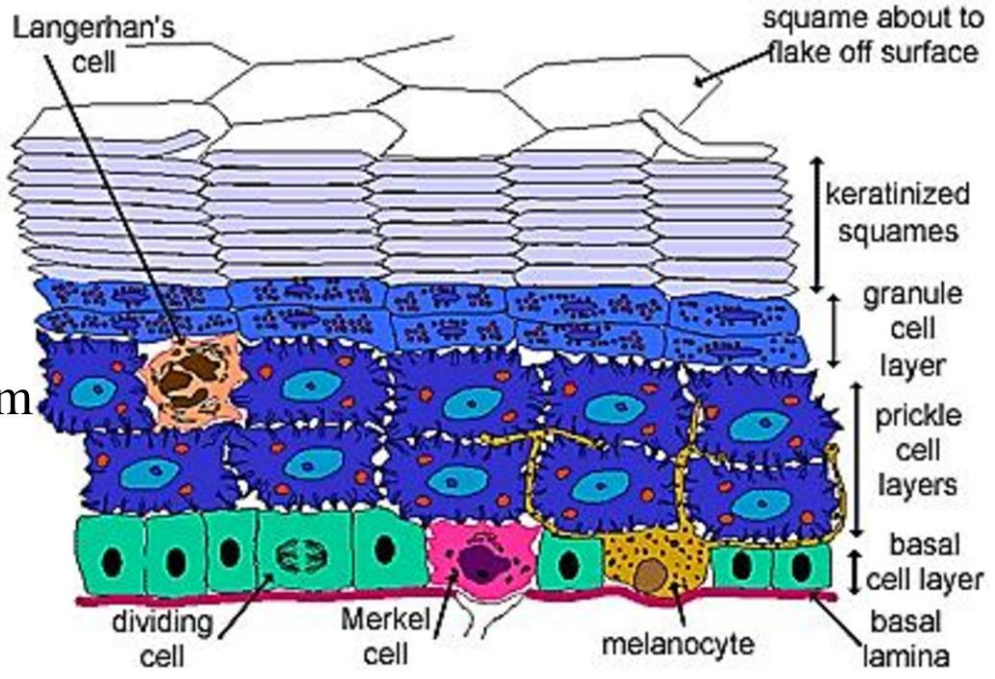
Skin Cells

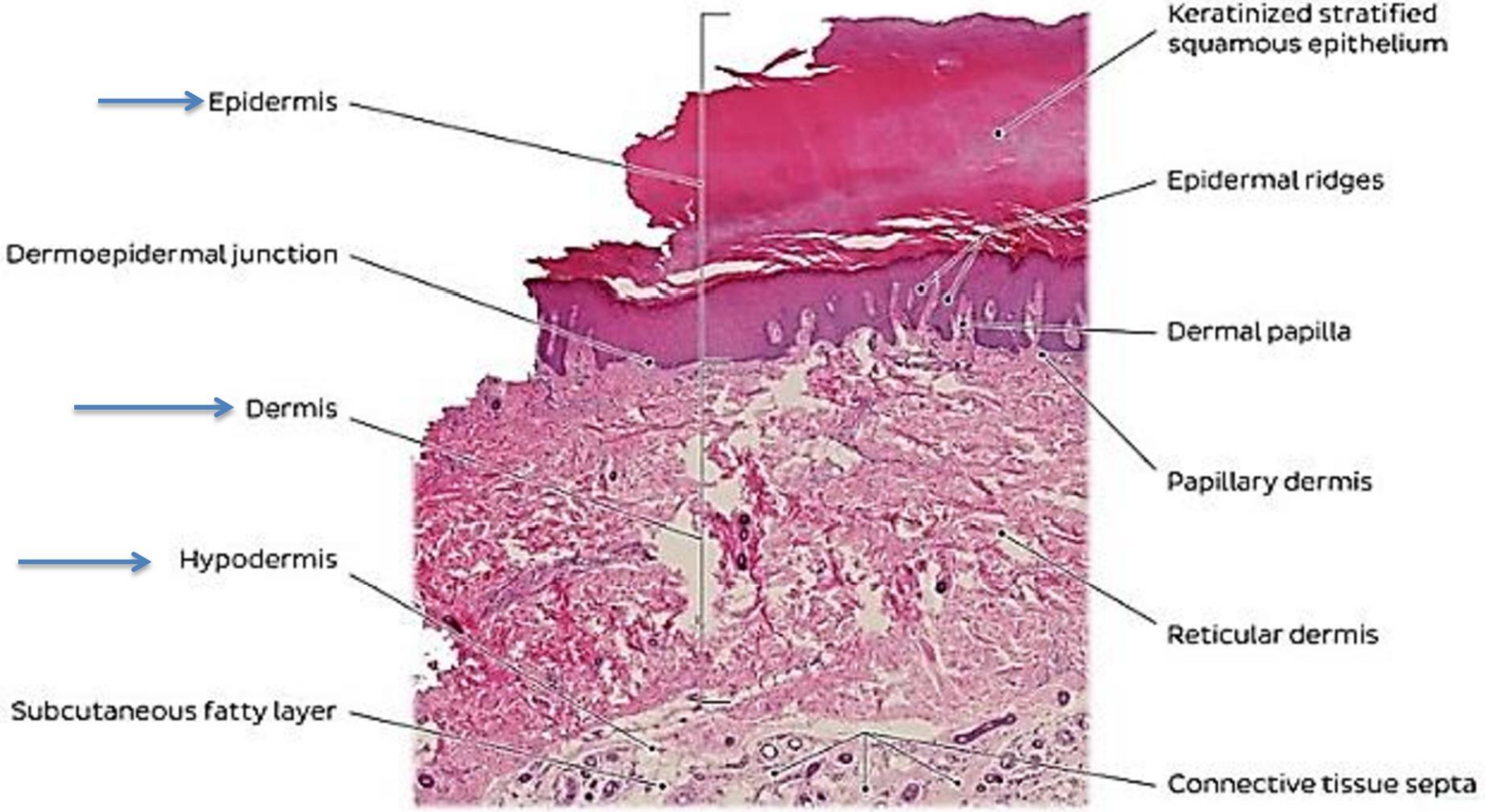
Keratinocytes (also called prickle cells): These cells are found in all of the layers except the stratum basale. A **keratinocyte** is a cell that manufactures and stores the protein keratin. **Keratin** is an intracellular fibrous protein that gives hairs, nails, and skin their hardness and water-resistant properties.

Melanocytes: They are found in the stratum basale, produces the pigment melanin. **Melanin** gives hair and skin its color, and also helps protect the living cells of the epidermis from ultraviolet (UV) radiation damage.

Langerhans cells (dendritic cells): They are found in **stratum spinosum** which functions as a macrophage by engulfing bacteria, foreign particles, and damaged cells that occur in this layer.

Merkel cells: They are found in stratum basal layer of epidermis which functions as a receptor and is responsible for stimulating sensory nerves that the brain perceives as touch.





Layers of the skin

Epidermis

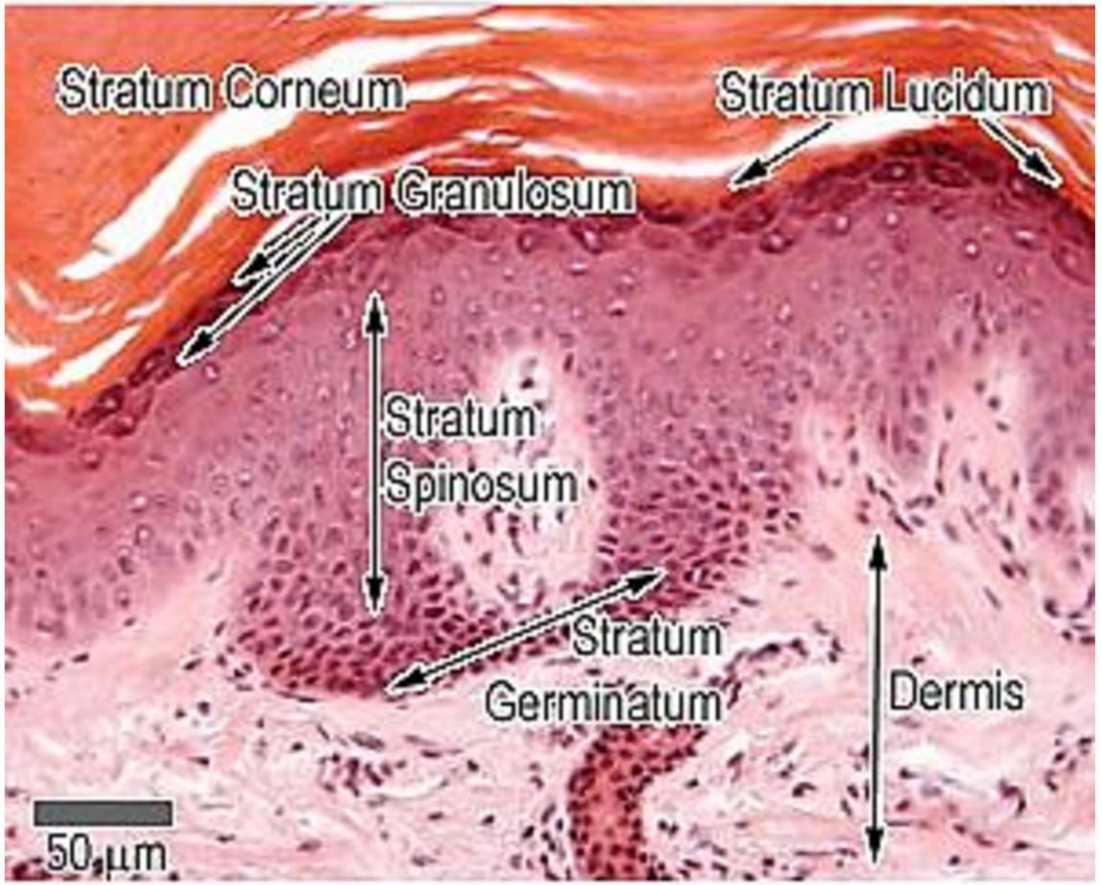
- Keratinized stratified squamous epithelium.

- It provides a barrier to infection from environmental pathogens and regulates the amount of water released from the body into the atmosphere.

- The epidermis **does not contain blood vessels** and is nourished by **diffusion** from the dermis.

Epidermis layers

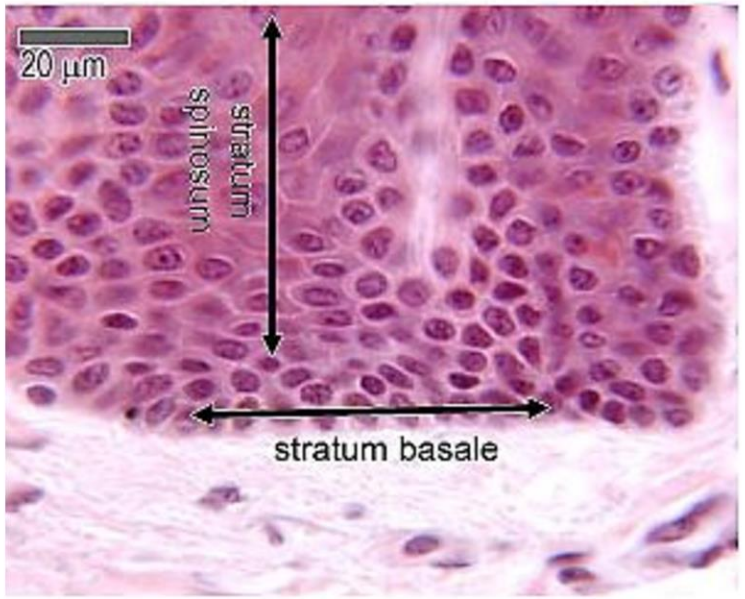
It is composed of the following layers (**strata**):
Stratum corneum,
Stratum lucidum,
Stratum granulosum,
Stratum spinosum and
Stratum basale.



Stratum basale, and stratum spinosum

- The basal cell layer (**stratum basale**, or stratum germinosum), is a single layer of cells, closest to the dermis. It is usually only in this layer that cells divide. Some of the dividing cells move up to the next layer.

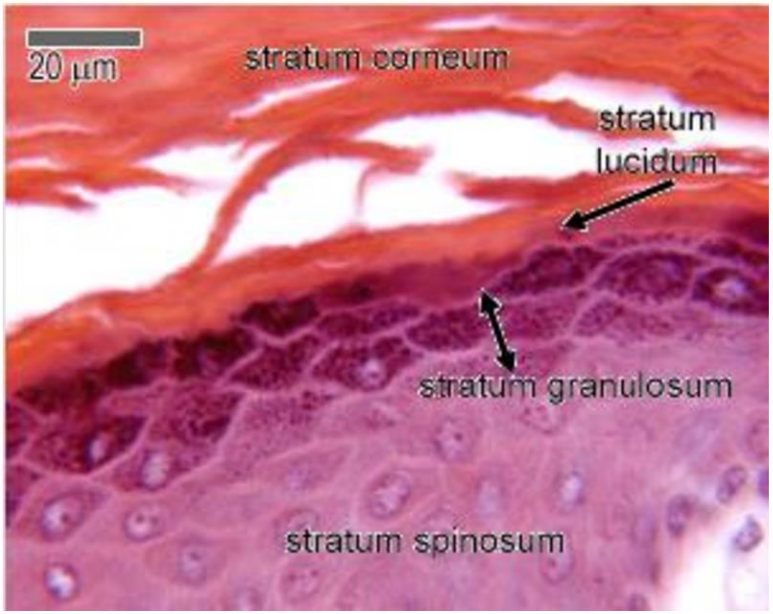
- The prickle cell layer (**stratum spinosum**) is the next layer (8-10 layers of cells). The cells in these layers have lots of desmosomes, which anchor the cells to each other, and contain thick tufts of intermediate filaments (keratin).



Stratum granulosum and stratum lucidum

- The granule cell layer (**stratum granulosum**) is the next layer (3-5 layers of cells). As the cells move up into this layer, they start to lose their nuclei and cytoplasmic organelles, and turn into the keratinised squames of the next layer.

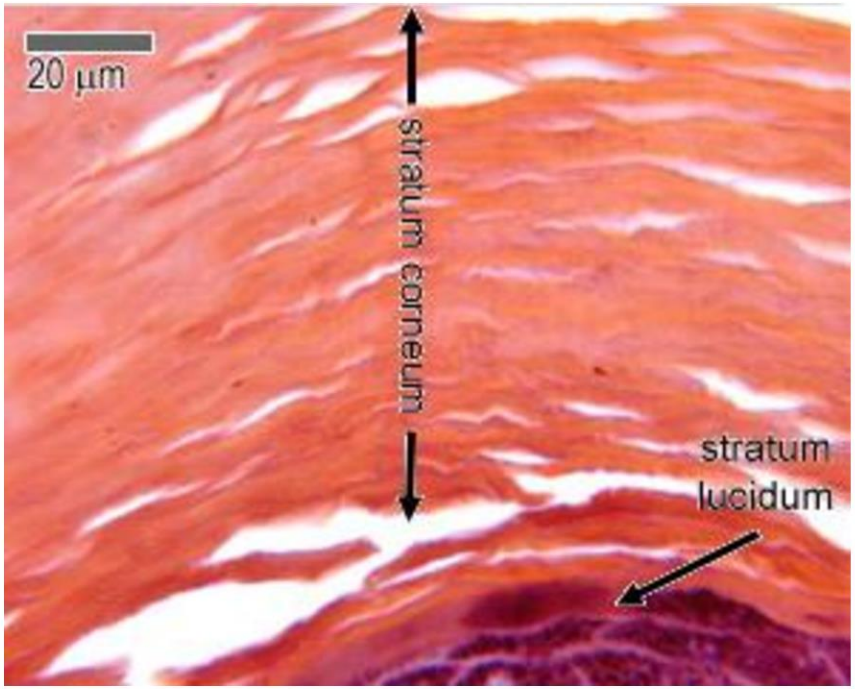
- **Stratum lucidum** is sometimes identified - between the stratum granulosum and stratum corneum layer. It is a thin transparent layer, difficult to recognize in routine histological sections.



Stratum corneum

The keratinised squames layer (**stratum corneum**) is the final layer.

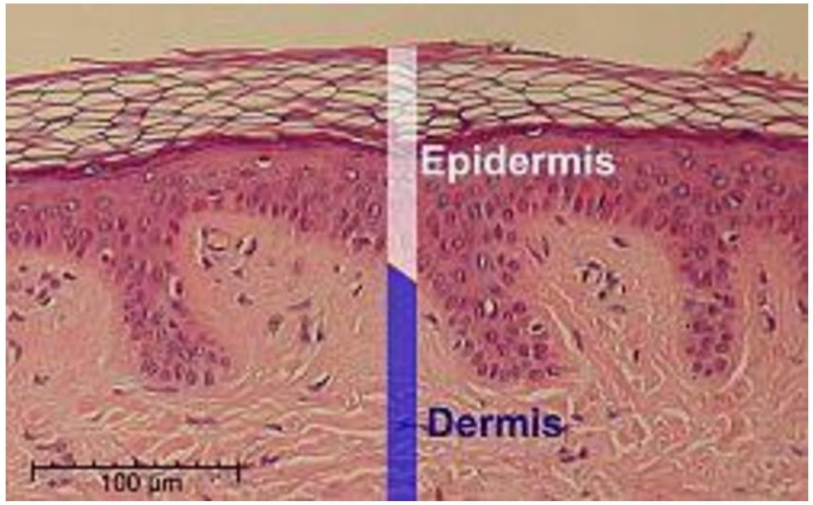
These are layers of dead cells, reduced to flattened scales, or squames, filled with densely packed keratin.



Dermis

- The dermis is the layer of skin that lies beneath the epidermis.

- It is the thickest layer of the skin, and is made up of fibrous and elastic tissue. Thus it provides strength and flexibility to the skin.



- It is comprised of two layers:
  - The papillary dermis
  - The reticular dermis

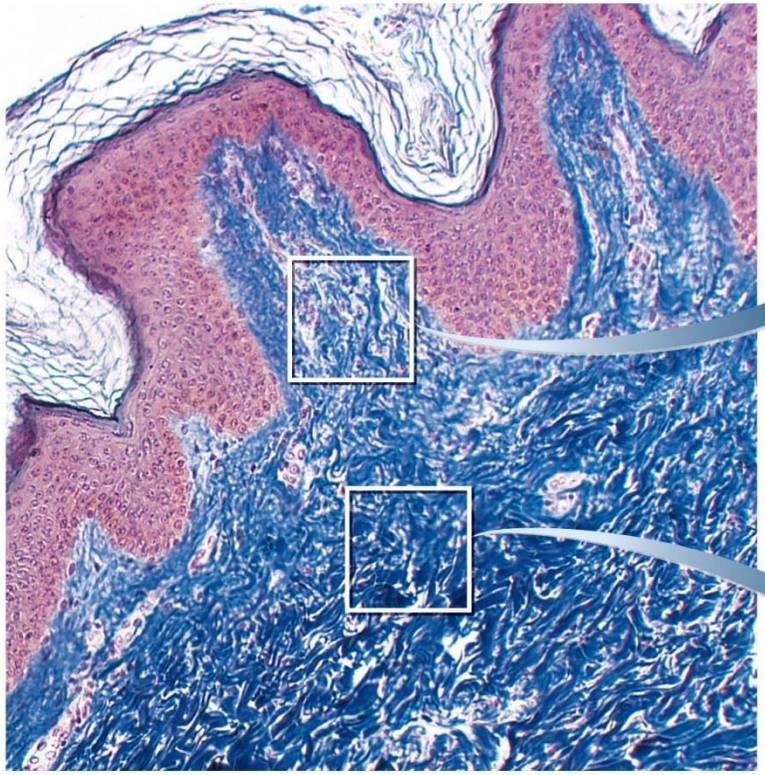
- **Papillary layer**—superficial zone of dermis
  - Thin zone of areolar tissue in and near the dermal papilla
  - Allows for mobility of leukocytes and other defense cells
  - Rich in small blood vessels

- **Reticular layer**—deeper and 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

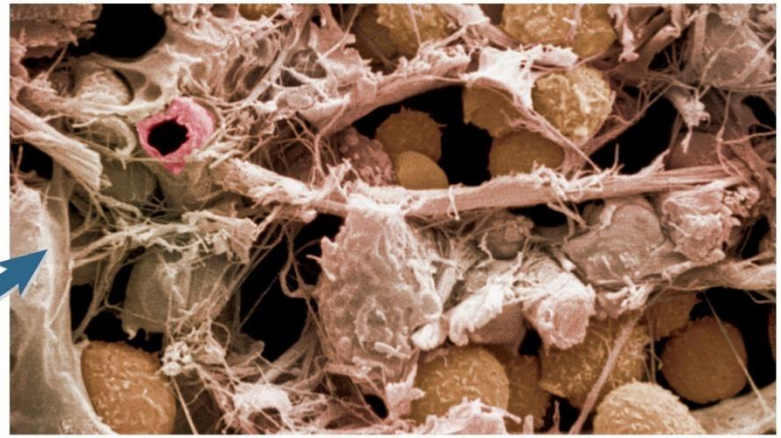
The **papillary dermis** is the more superficial of the two.
It is made up of **loose connective tissue**, which includes:
Capillaries
Elastic fibers
Reticular fibers
Collagen

The **reticular dermis** is the deeper and thicker layer of the dermis.
It contains **dense connective tissue**, which includes:
Blood vessels
Elastic fibers
Collagen fibers
Fibroblasts
Mast cells
Nerve endings

The Dermis



(a)



(b) Papillary layer of dermis

(c) Reticular layer of dermis

Figure 6.5

Hypodermis

The **hypodermis** (also called the subcutaneous layer or superficial fascia) is a layer directly below the dermis and serves to connect the skin to the underlying fascia (fibrous tissue) of the bones and muscles.

It consists of **loose connective tissue** and **adipose tissue.**

Adipose tissue present in the hypodermis consists of fat-storing cells called **adipocytes**. This stored fat can serve as an energy reserve, insulate the body to prevent heat loss, and act as a cushion to protect underlying structures from trauma.

Epidermal Derivatives

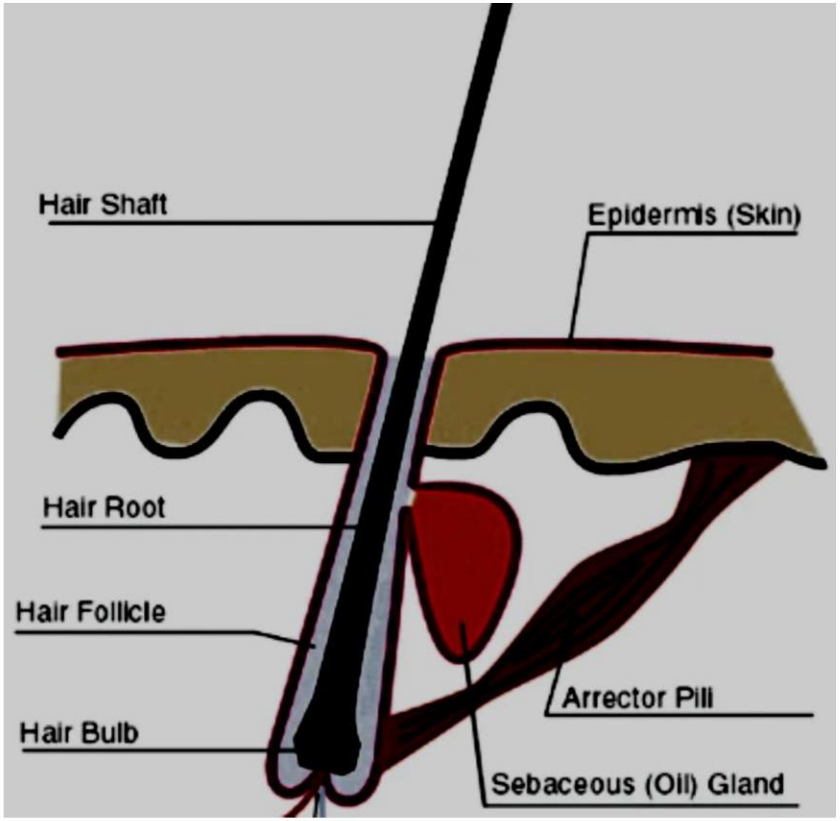
- Epidermal derivatives (also called epidermal appendages), Accessory structures of the skin include **hairs, nails** and **glands**.

- They are derived from the **stratum basale** of the epidermis and are embedded in the **reticular layer** of the dermis.

Hair

- Hair is made up of columns of dead keratinized cells.
- Hair consist of a **shaft**, **root** and **hair follicle**

The **hair shaft** is the part of the hair **not anchored to the follicle, and much of this is exposed at the skin's surface**. The rest of the hair, which **is anchored in the follicle,** lies below the surface of the skin and is referred to as the **hair root.**



- **Three layers of the hair in cross section**
  - **Medulla**
    - Core of loosely arranged cells and air spaces
  - **Cortex**
    - Constitutes bulk of the hair
    - Consists of several layers of elongated keratinized cells
  - **Cuticle**
    - Composed of multiple layers of very thin, scaly cells that overlap each other
    - Free edges directed upward

Structure of the Hair and Follicle

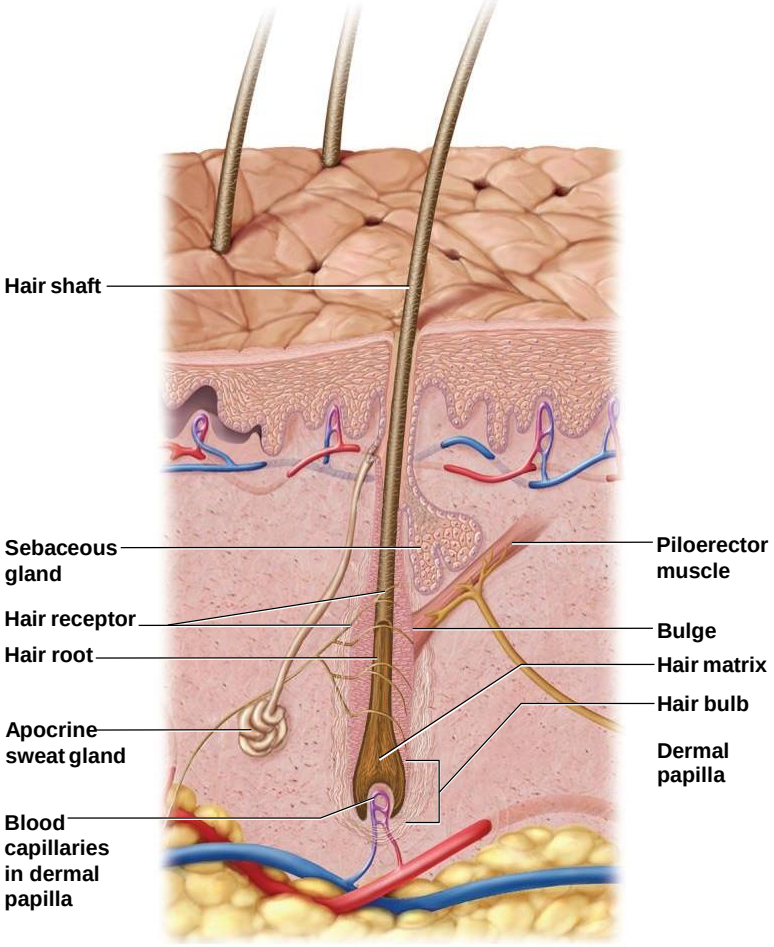


Figure 6.7a

- **Hair is divisible into three zones along its length**
  - **Bulb:** a swelling at the base where hair originates in dermis or hypodermis
    - Only living hair cells are in or near bulb
  - **Root:** the remainder of the hair in the follicle
  - **Shaft:** the portion above the skin surface

Hair shaft consist of

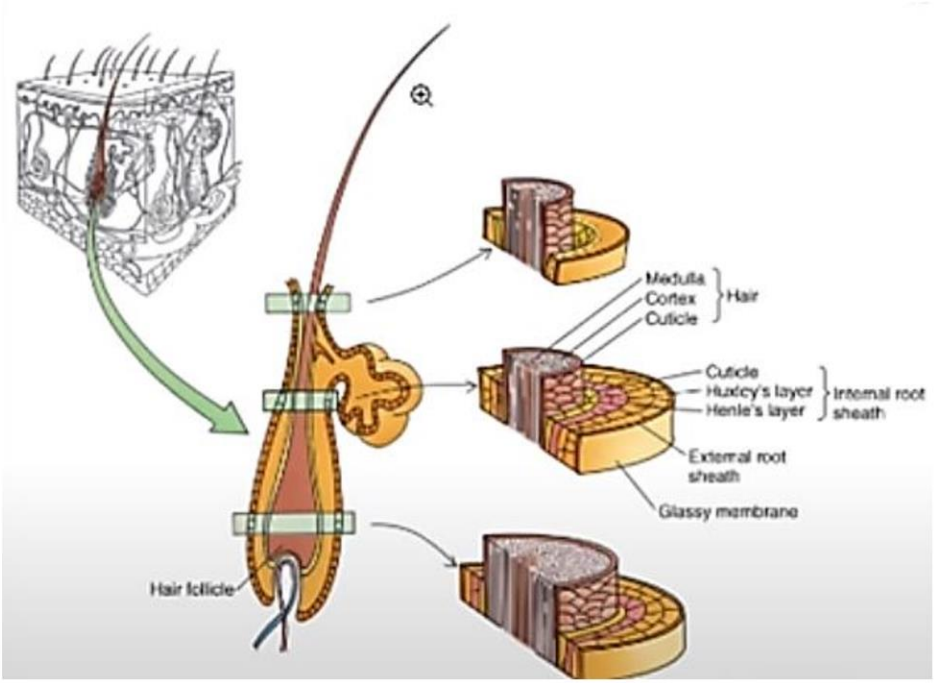
Medulla
Cortex
Cuticle

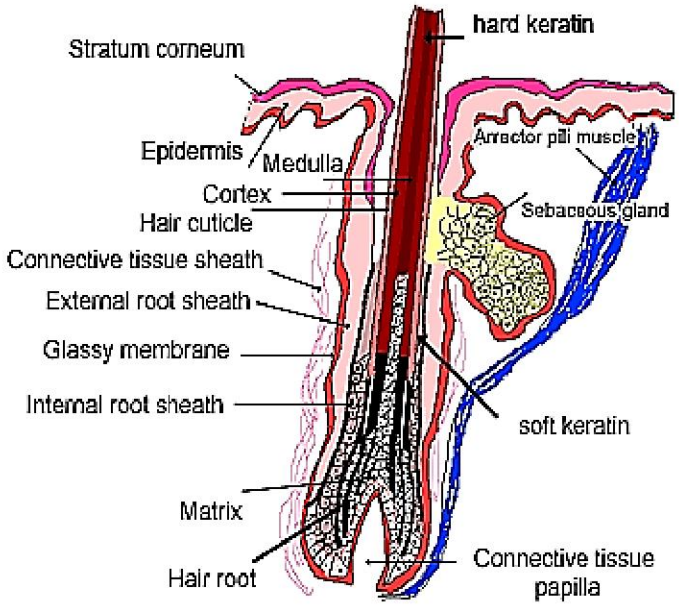
Hair follicle consist of

- **Inner root sheath**
  Cuticle
  Huxley's layer
  Henle's layer
- **Outer root sheath** (Surrounding the **internal root sheath).** It is a tubular invagination of the epidermis)

It is separated from the surrounding connective tissue by a **glassy basement membrane.**

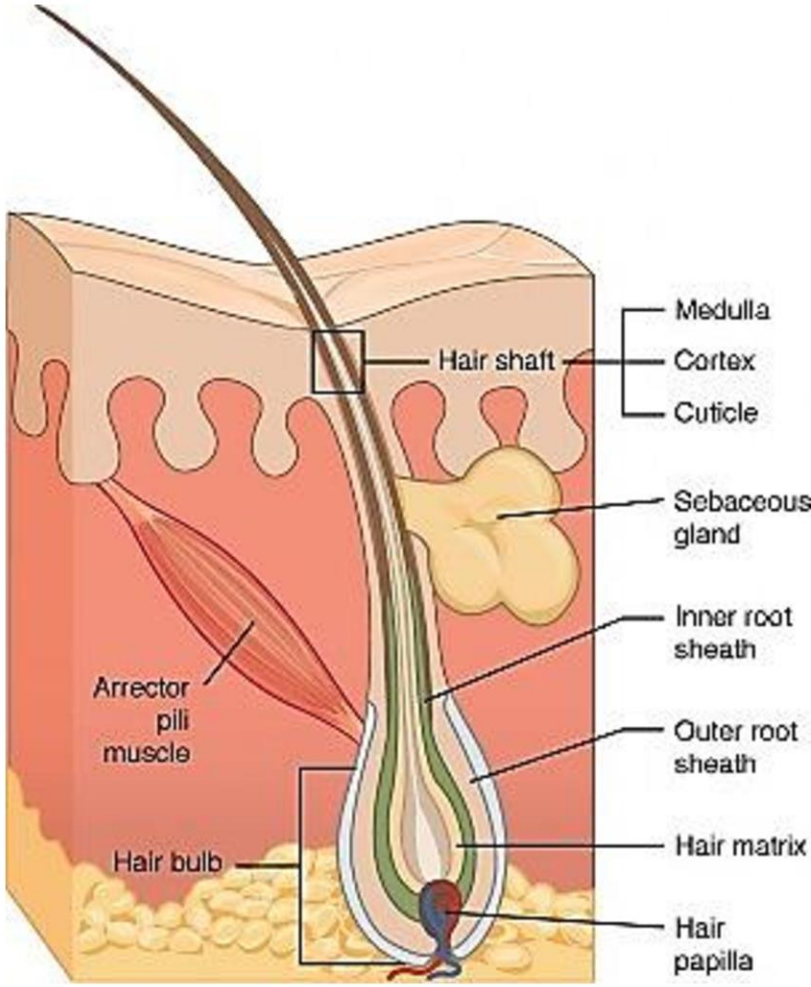
- **Connective Tissue sheath**





- At the base of the hair follicle/hair bulb, there is a **dermal papilla**, which contains the blood supply for the hair.
- The **hair matrix**, which contains the proliferating cells that generate the hair and the internal root sheath, is just above the dermal papilla.

The cells in the hair matrix proliferate and move upwards, gradually becoming keratinised to produce the hair.



- The **arrector pili muscle** is a small bundle of smooth muscle cells associated with the hair follicle. Contractions of this muscle elevate the hair, forming **goose bumps**, to release heat and help sebum to be released from gland into duct.

• Nails

- **Fingernails and toenails—**clear, hard derivatives of stratum corneum
  - Composed of thin, dead cells packed with **hard keratin**
- **Functions:**
  - Improve grooming, picking apart food, other manipulations
  - Provide a counterforce to enhance sensitivity of fleshy fingertips to tiny objects
- **Nail plate—**hard part of the nail
  - **Free edge:** overhangs the fingertip
  - **Nail body:** visible attached part of nail
  - **Nail root:** extends proximally under overlying skin

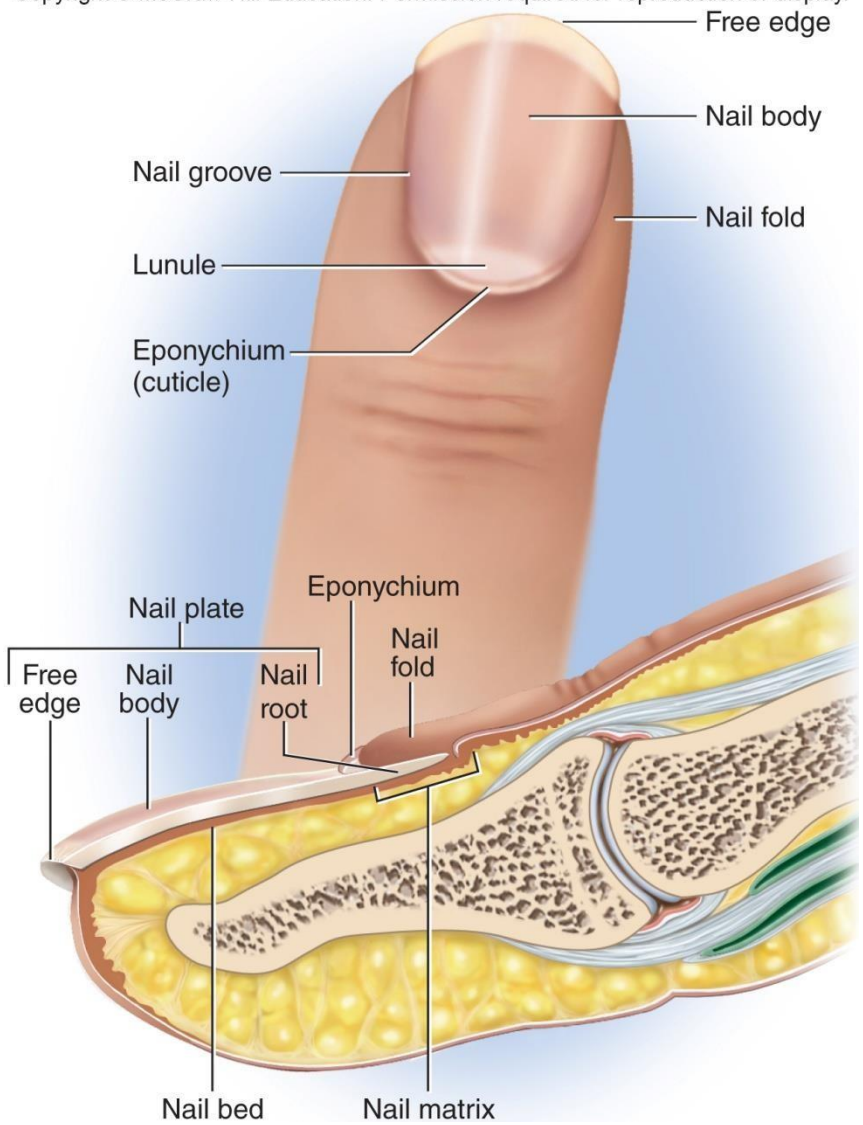
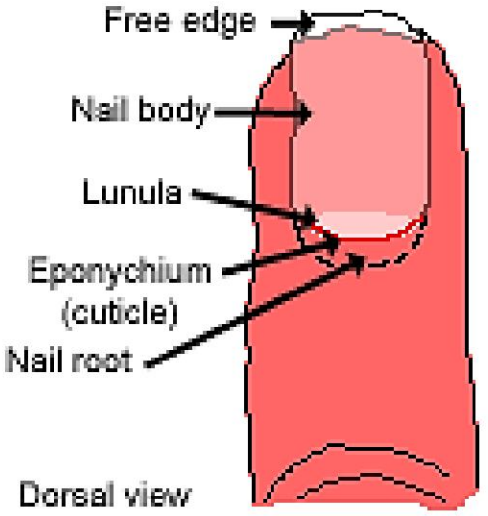


Figure 6.10

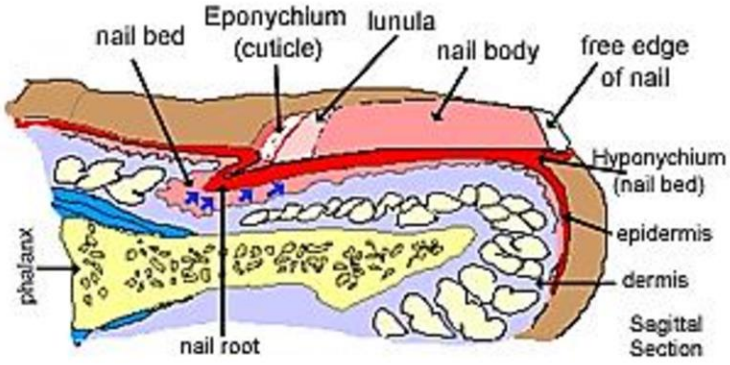
Nails



- The **nail** is made up of hard, keratinized epidermal cells. It has a **nail body**, a **free edge**, and **nail root.**

- The proliferating cells in the **nail root** form the **nail matrix**, and their proliferation (in the stratum basale) make the nail elongate continuously.

- The white crescent at the proximal end is called the **lunula**



- The nail fold that meets the proximal end of the nail body forms the **nail cuticle**, also called the **eponychium**.

- **Hyponychium**: It consists of a thickened layer of stratum corneum.

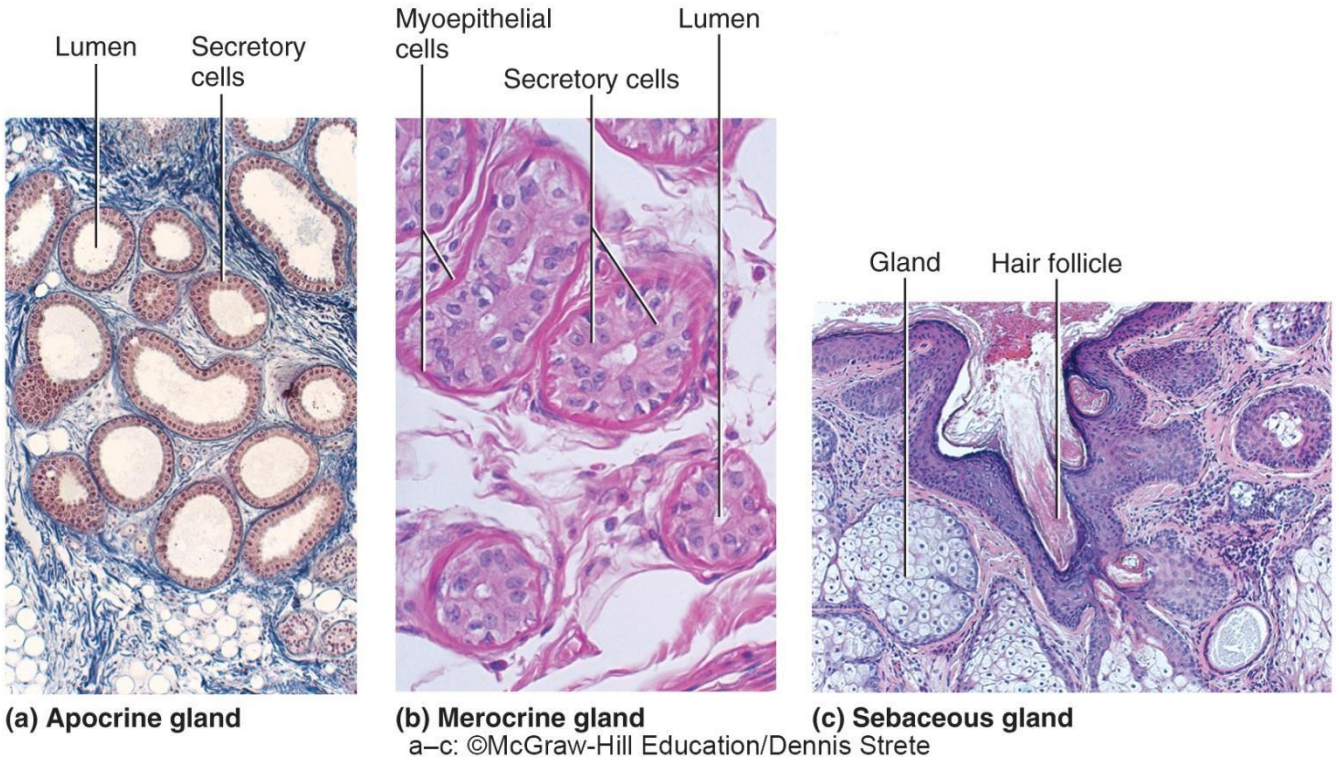


Figure 6.11a Figure 6.11b Figure 6.11c

- **The skin has five types of glands: merocrine sweat glands, apocrine sweat glands, sebaceous glands, ceruminous glands, and mammary glands**

- **Two kinds of sweat (sudoriferous) glands: apocrine and merocrine**
  - **Apocrine sweat glands**
    - Locations: groin, anal region, axilla, areola, beard area in men
      - Inactive until puberty
    - Ducts lead to nearby hair follicles
    - Produce sweat that is milky and contains fatty acids
    - Respond to stress and sexual stimulation
      - Believed to secrete **pheromones**—chemicals that can influence behavior of others
    - **Bromhidrosis—**disagreeable body odor produced by bacterial action on sweat from apocrine glands

(Continued)

- **Merocrine (eccrine) sweat glands**
  - Most numerous skin glands—3 to 4 million in adult skin
    - Especially dense on palms, soles, and forehead
  - 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
  - Found in both apocrine and merocrine glands

- **Sweat**—begins as a protein-free filtrate of blood plasma produced by deep secretory portion of gland
  - Some sodium chloride and other small solutes remain in the sweat
    - Some sodium chloride reabsorbed by duct
  - Some drugs are excreted in sweat
  - On average, 99% water, with pH range of 4 to 6
    - **Acid mantle**—inhibits bacterial growth
  - **Insensible perspiration**—500 mL/day
    - Does not produce visible wetness of skin
  - **Diaphoresis**—sweating with wetness of the skin
    - Exercise—may lose 1 L sweat per hour

- **Sebaceous glands are flask-shaped and have short ducts opening into hair follicles**
- **Holocrine secretion style**
- **Sebum**—oily secretion of sebaceous glands
  - Keeps skin and hair from becoming dry, brittle, and cracked
  - Lanolin—sheep sebum

- Ceruminous glands are simple, coiled, tubular glands in **external ear canal**
- Their secretion combines with sebum and dead epithelial cells to form **earwax (cerumen)**
  - Keeps eardrum pliable
  - Waterproofs the canal
  - Kills bacteria
  - Makes guard hairs of ear sticky to help block foreign particles from entering auditory canal

- **Mammary glands**—milk-producing glands that develop only during pregnancy and lactation
  - Modified apocrine sweat glands
  - Rich secretion released through ducts opening at nipple
- **Mammary ridges or milk lines**
  - Two rows of mammary glands in most mammals
  - Primates kept only two glands, but a few people have additional nipples along the milk line (polythelia)

Cutaneous Glands

TABLE 6.2	Cutaneous Glands
Gland Type	**Definition**
Sudoriferous glands	Sweat glands
Merocrine glands	Sweat glands that function in evaporative cooling; widely distributed over the body surface; open by ducts onto the skin surface
Apocrine glands	Sweat glands that function as scent glands; found in the regions covered by the pubic, axillary, and male facial hair; open by ducts into hair follicles
Sebaceous glands	Oil glands associated with hair follicles
Ceruminous glands	Glands of the ear canal that contribute to the cerumen (earwax)
Mammary glands	Milk-producing glands located in the breasts

Glands

- **Sebaceous glands:**

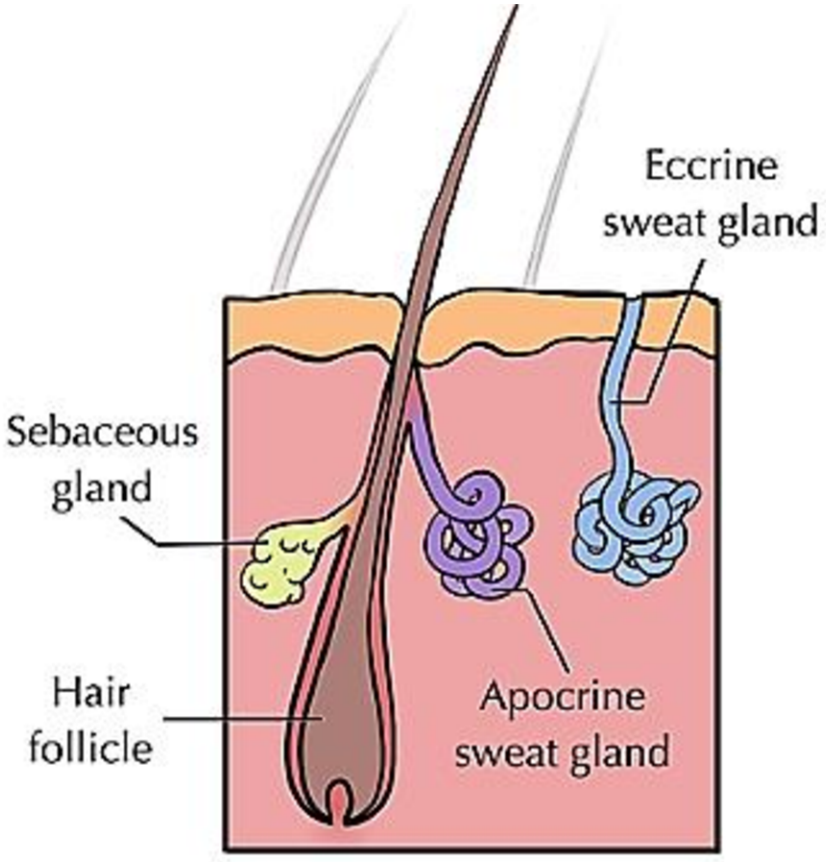
secrete a mixture of lipids into hair follicles or to the skin surface in hairless regions.

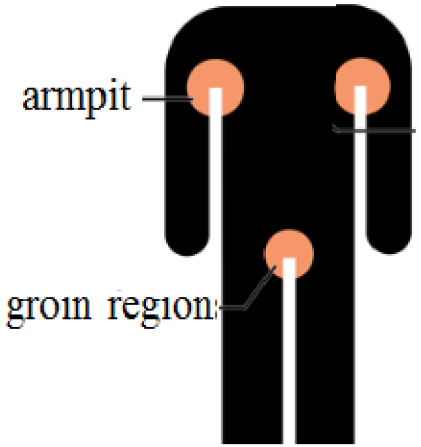
- **Eccrine sweat glands:**

are widespread throughout the skin; they secrete a watery liquid to the skin surface(sweat).

- **Apocrine sweat glands:**

are found mainly in the armpit and groin regions; they secrete a liquid that combines with oils from Sebaceous glands. This mixture is odorless until it comes into contact with bacteria on skin and hair.





Skin receptors (Cutaneous **receptors)**

- Skin is the most extensive sensory receptor of the body, and both dermis and epidermis layers contain nerve tissue.

- Cutaneous receptors :

Mechanoreceptors (touch & pressure).
Thermoreceptors (temperature).
Nociceptors (pain)

- Include:

Free Nerve Endings
Merkel's disks.
Krause end bulbs
Meissner's corpuscles
Pacinian corpuscles.
Ruffini's corpuscles.