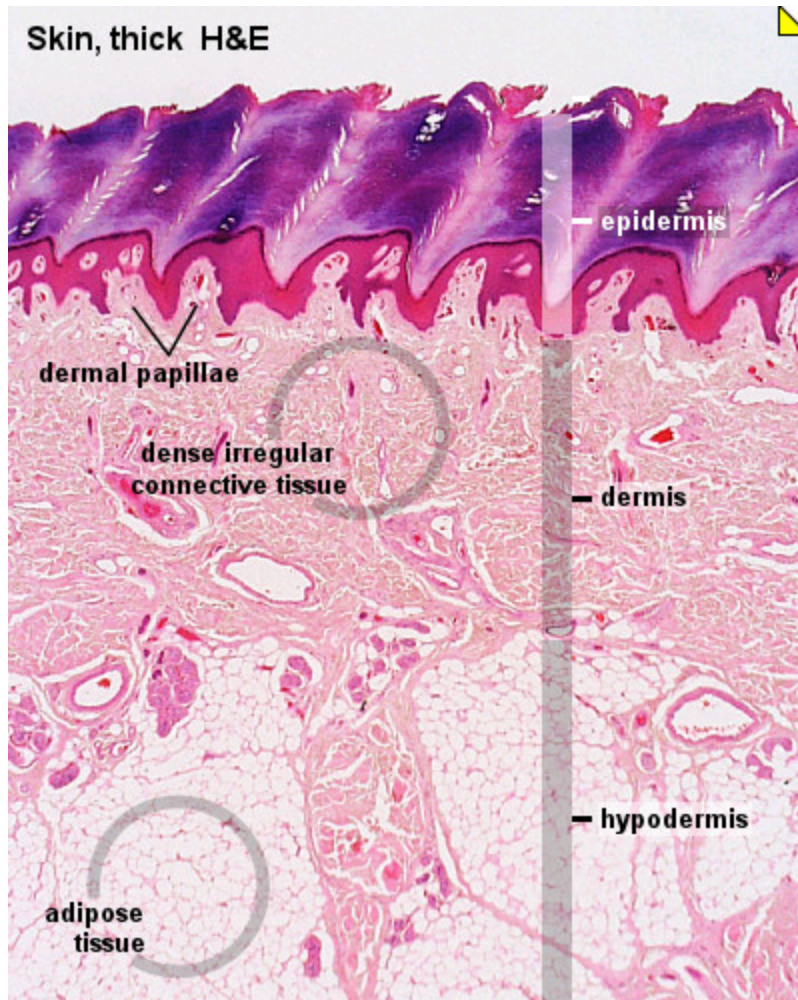


Integumentary System
Danil Hammoudi.MD



The cutaneous membrane (skin) and its accessory structures (hair, scales, feathers, nails, exocrine glands) make up the Integumentary system.

Dermatology - the branch of medicine dealing with the integumentary system.

The skin is the largest organ in the body: 12-15% of body weight, with a surface area of 1-2 meters.

Skin is continuous with, but structurally distinct from

- mucous membranes that line the mouth,
- anus,
- urethra,
- and vagina.

There are three layers of skin:

- **the dermis**
 - **epidermis.**
 - **subcutaneous tissue.**
- The basic cell type of the epidermis is the **keratinocyte**, which contain **keratin**, a fibrous protein.
 - **Basal cells** are the innermost layer of the epidermis.
 - **Melanocytes** produce the pigment melanin, and are also in the inner layer of the epidermis.
 - The dermis is a connective tissue layer under the epidermis, and contains nerve endings, sensory receptors, capillaries, and elastic fibers.

The integumentary system has multiple roles in homeostasis, including

- protection,
- temperature regulation,
- sensory reception,
- biochemical synthesis,
- and absorption.

. Cutaneous glands include:

- Sudoriferous glands - or sweat glands
- Sebaceous glands - oil-producing glands
- Ceruminous glands - glands of the ear canal that produce cerumen (earwax)
- Mammary glands - milk-producing glands located in the breasts.

All body systems work in an interconnected manner to maintain the internal conditions essential to the function of the body.

Developmental Aspects of the Integument:

Fetal

- Epidermis develops from ectoderm
- Dermis and hypodermis develop from mesoderm

- Lanugo – downy coat of delicate hairs covering the fetus
- Vernix caseosa – substance produced by sebaceous glands that protects the skin of the fetus in the amnion

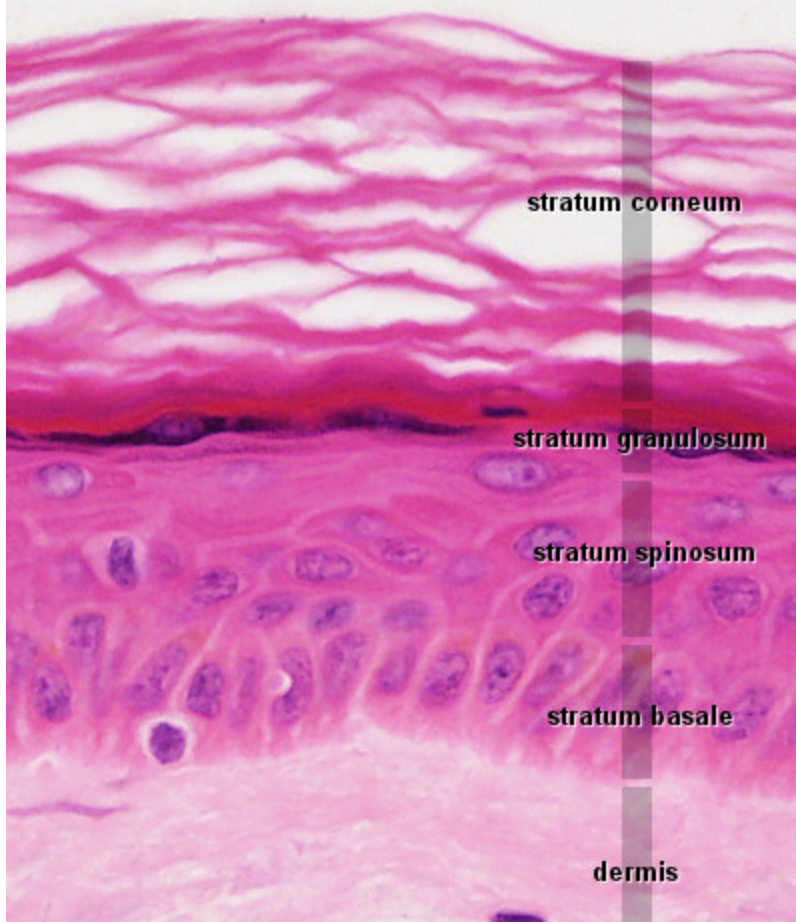
Adolescent to Adult

- Skin and hair become oilier and acne may appear
- Skin shows the effects of cumulative environmental assaults around age 30
- Scaling and dermatitis become more common

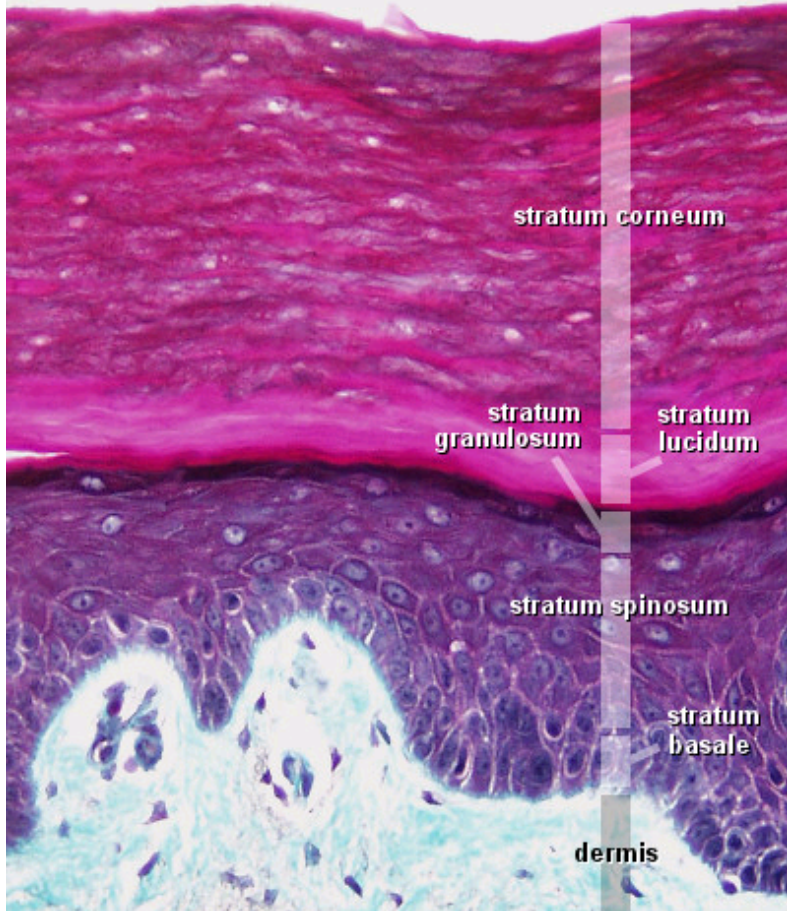
Old Age

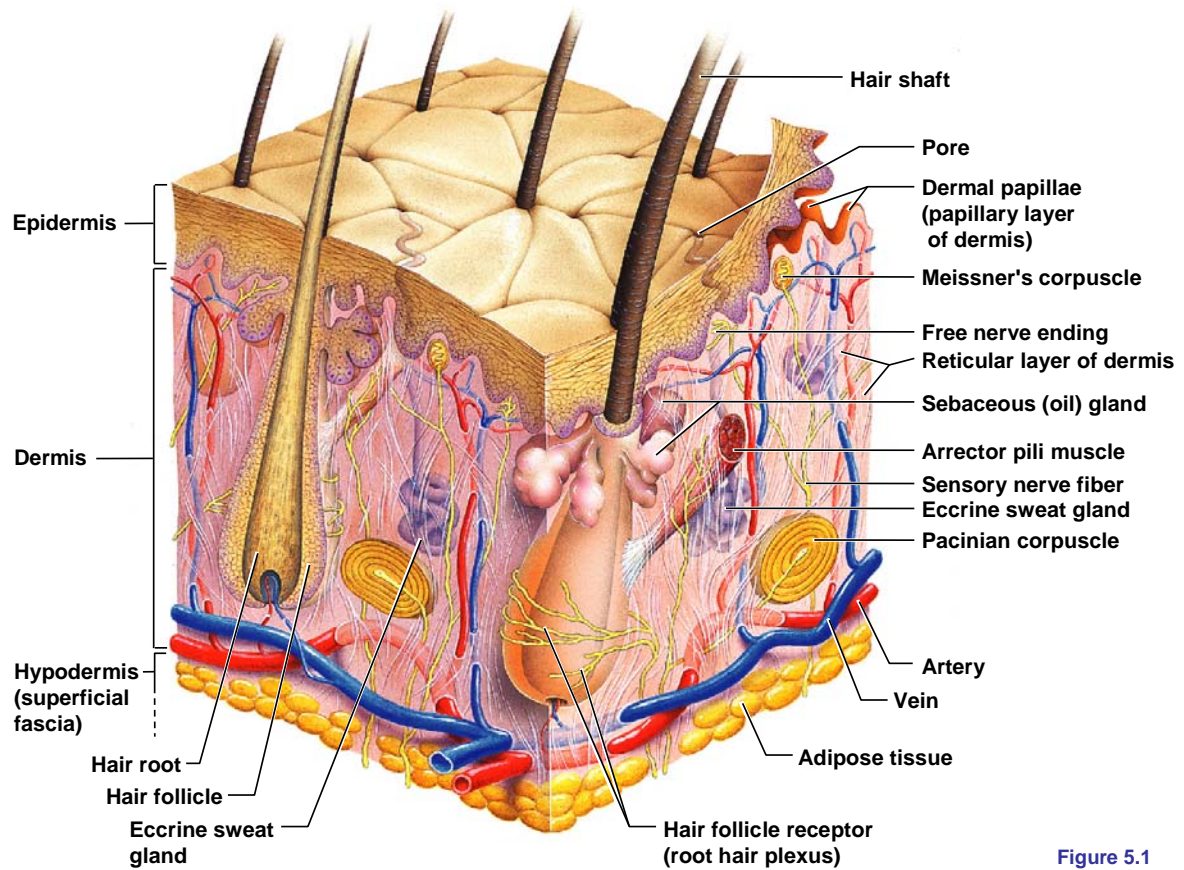
- Epidermal replacement of cells slows and skin becomes thinner
- Skin becomes dry and itchy
- Subcutaneous fat layer diminishes, leading to intolerance of cold
- Decreased elasticity and loss of subcutaneous tissue leads to wrinkles
- Decreased numbers of melanocytes and Langerhans' cells increase the risk of skin cancer

Skin, thin H&E



Skin, thick trichrome

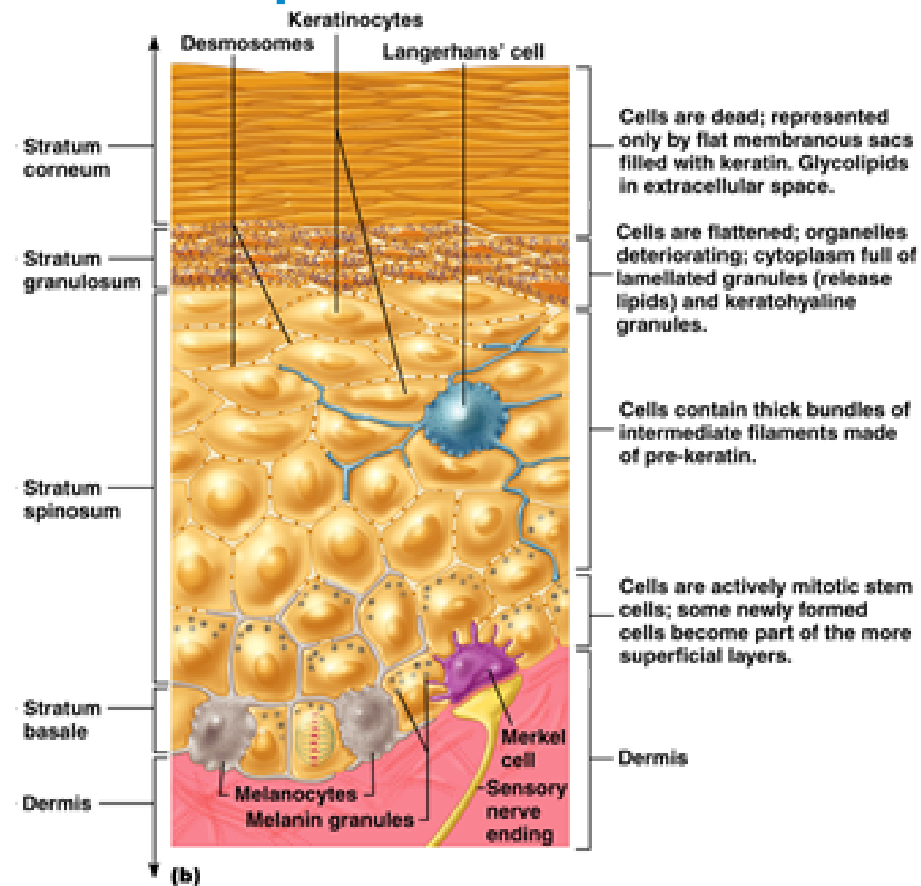




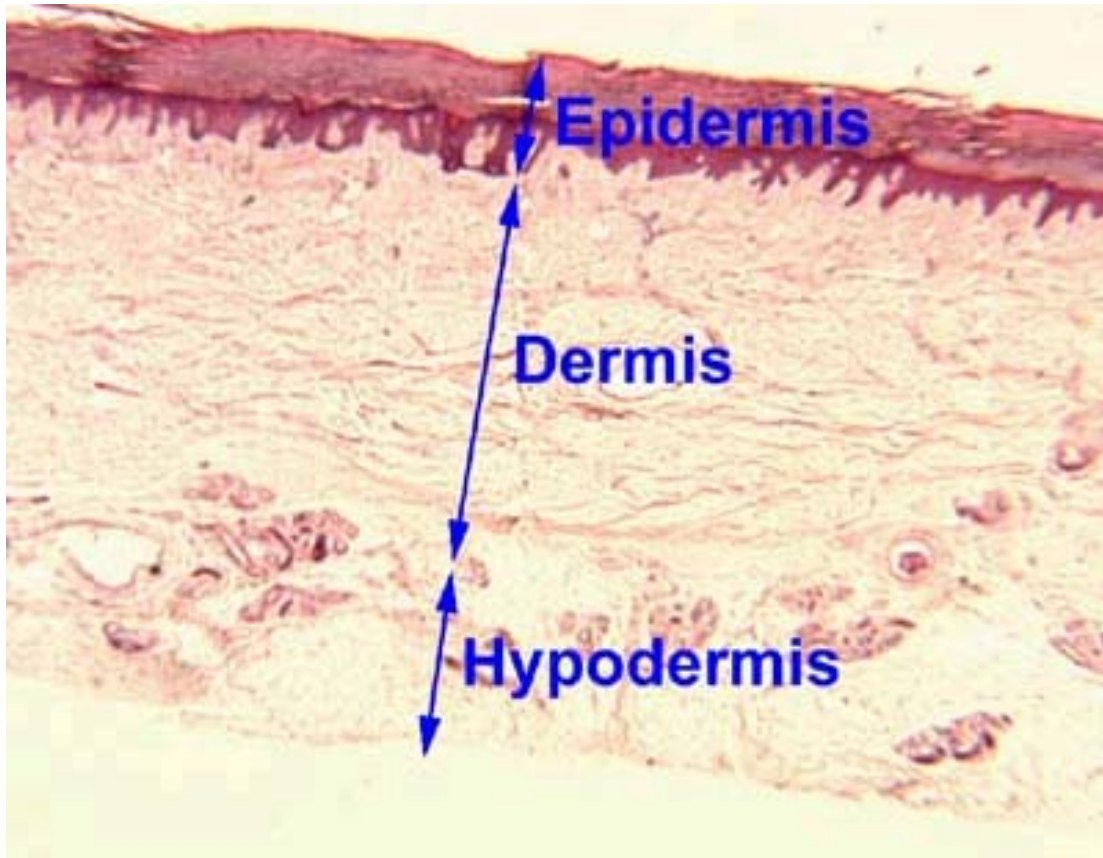
- ## Skin (Integument)

- ## Functions of the Integumentary System

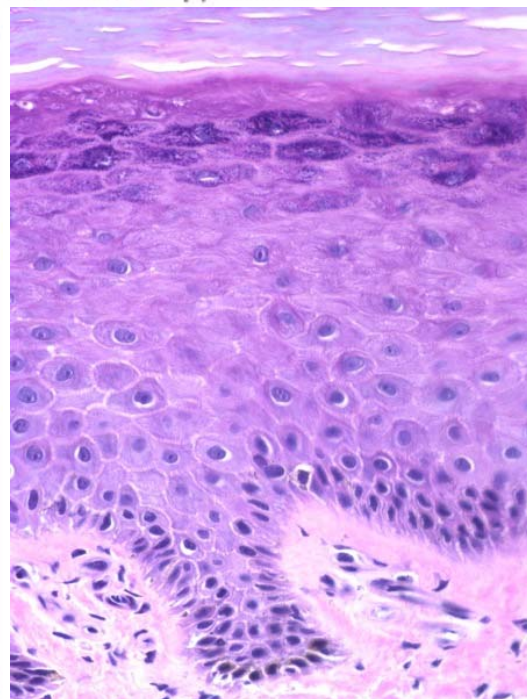
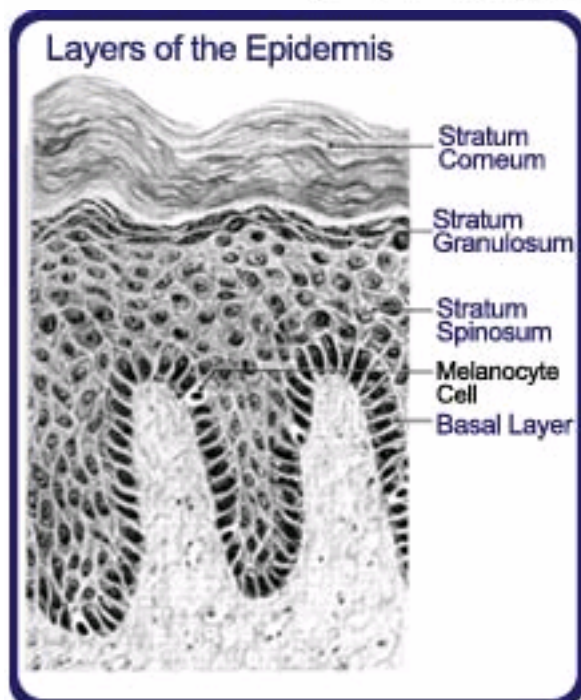
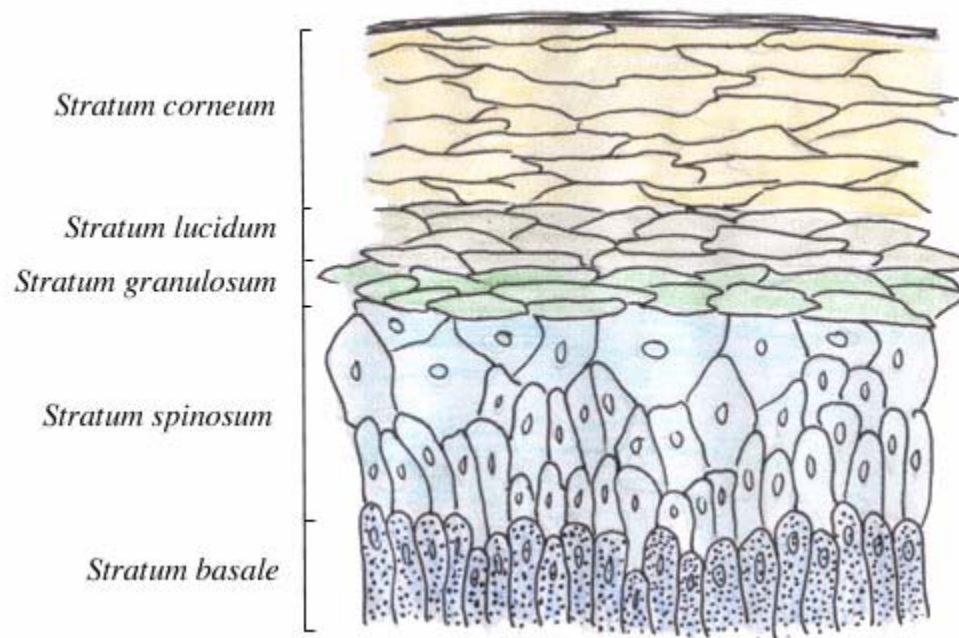
Layers of the Epidermis



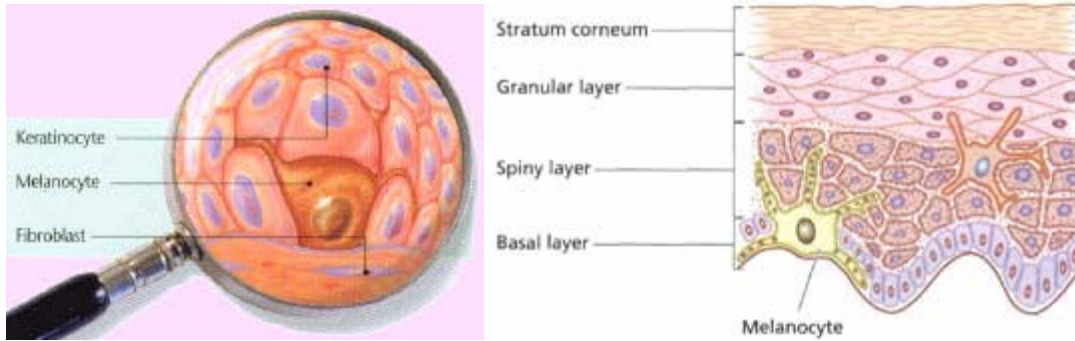
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**Epidermis**

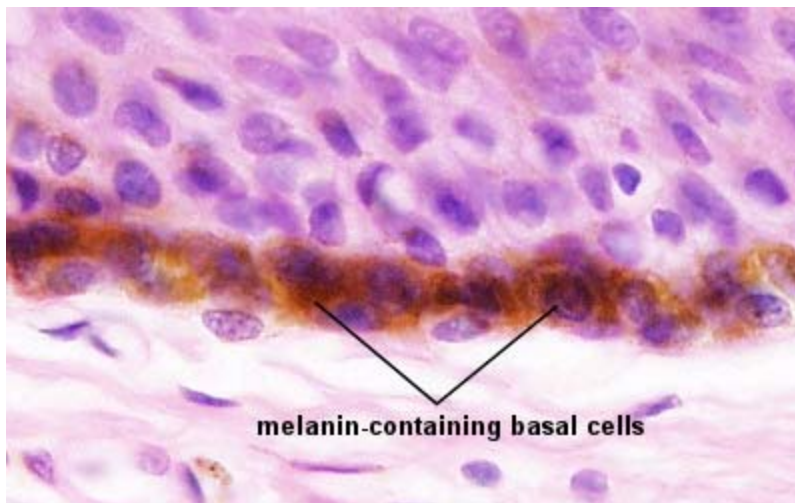
- Composed of keratinized stratified squamous epithelium, consisting of four distinct cell types and four or five layers
- Cell types include keratinocytes, melanocytes, Merkel cells, and Langerhans' cells
- Outer portion of the skin is exposed to the external environment and functions in protection



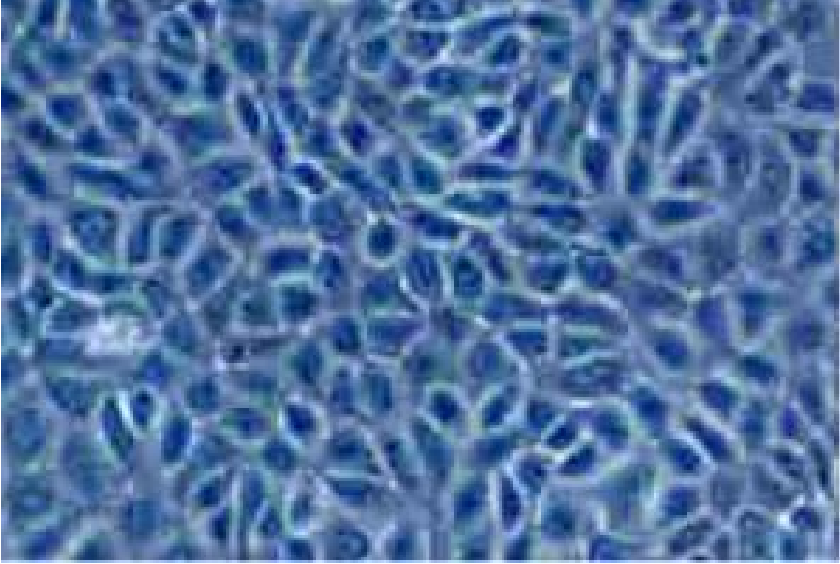
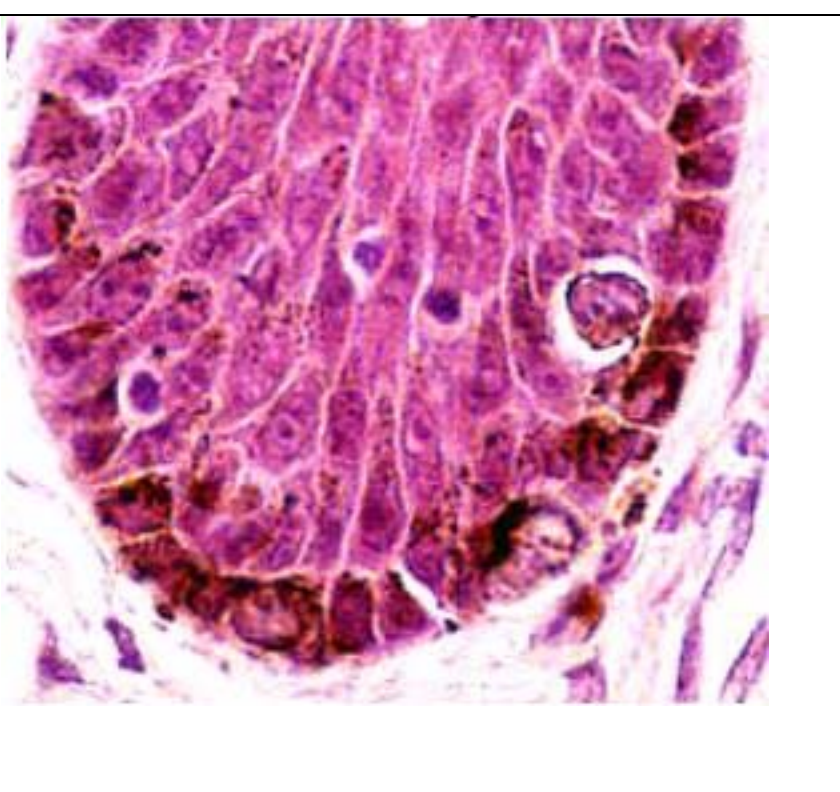
Cells of the Epidermis

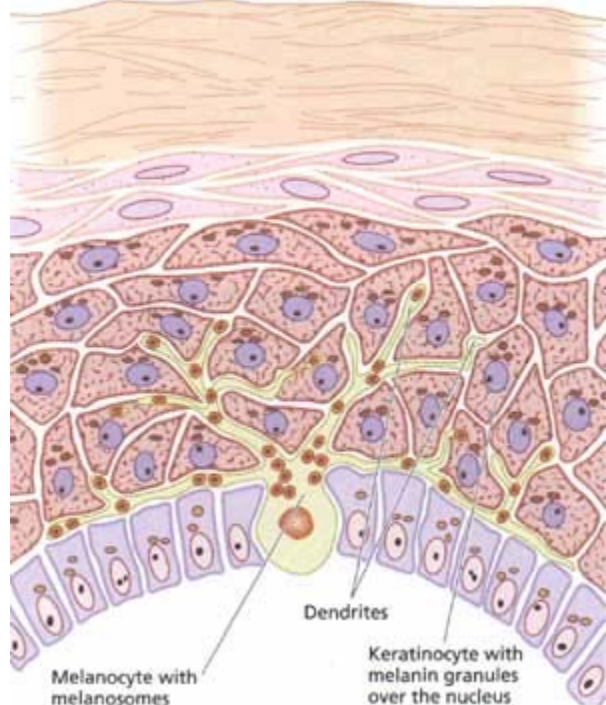
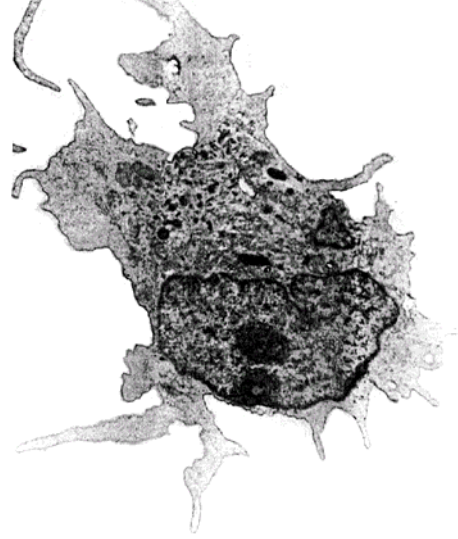


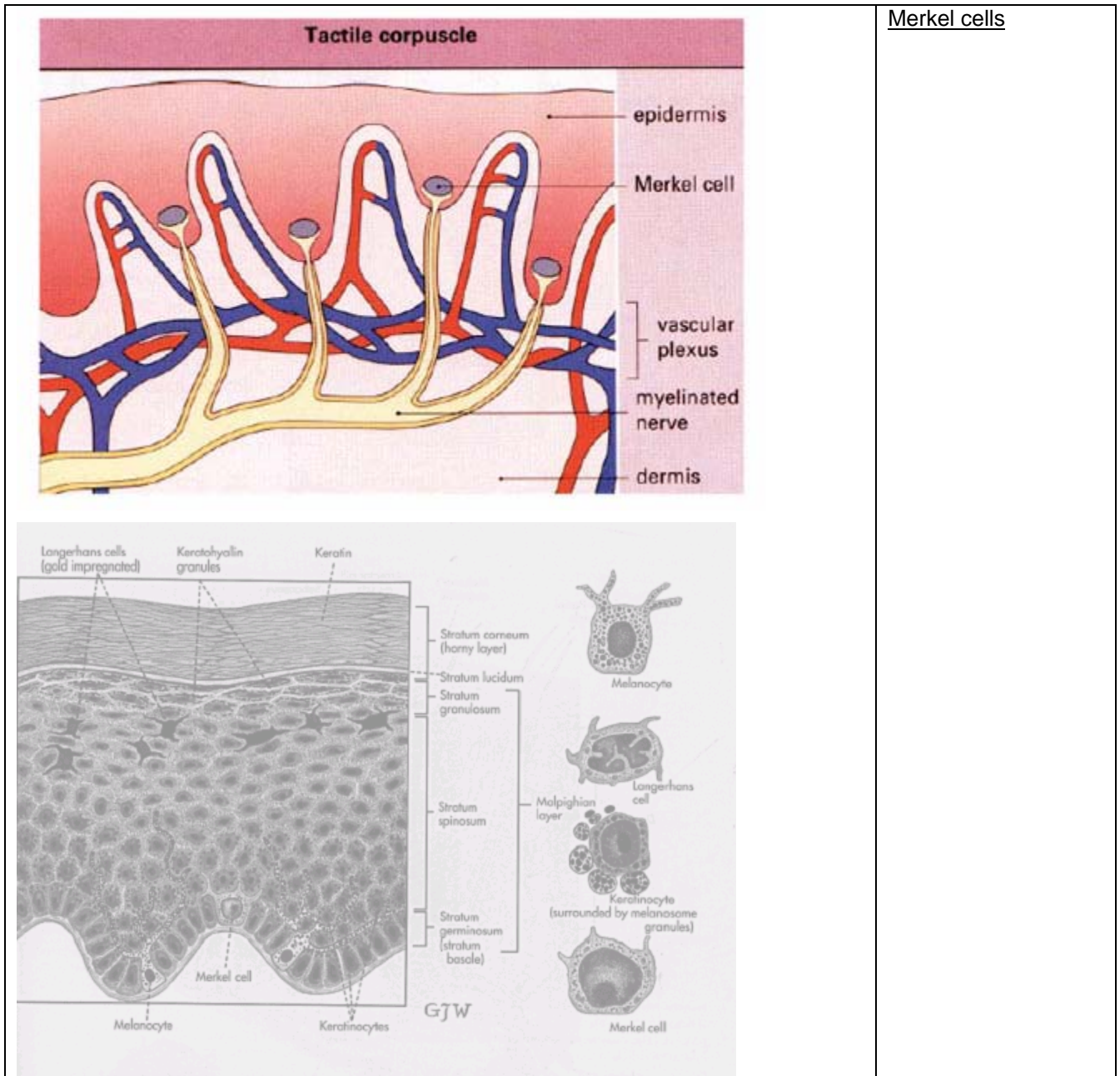
- **Keratinocytes** – produce the fibrous protein keratin
- **Melanocytes** – produce the brown pigment melanin
- **Langerhans' cells** – epidermal macrophages that help activate the immune system
- **Merkel cells** – function as touch receptors in association with sensory nerve endings



- Its layers are made of Mostly DEAD CELLS.
- Most of the cells of the Epidermis undergo rapid cell division (MITOSIS).
- As new cells are produced, they push Older cells to the surface of the skin. The older cells become Flattened, Lose their Cellular Contents and begin making **KERATIN**.
- **KERATIN** IS A TOUGH FIBROUS PROTEIN AND FORMS THE BASIC STRUCTURE OF HAIR, NAILS, AND CALLUSES.
- In animals keratin forms cow horns, reptile scales, bird feathers, and porcupine quills.
- Eventually, the Keratin-producing Cells (KERATINCYTES) DIE AND FORM A TOUGH, FLEXIBLE WATERPROOF COVERING ON THE SURFACE OF THE SKIN. Our thickest Epidermis is on the palms and soles.
- THIS OUTER LAYER OF DEAD CELLS IS SHED OR WASHED AWAY ONCE EVERY 14 TO 28 DAYS.

	<p><u>Keratinocytes</u></p>
	<p>MELANOCYTES</p> <p>The pigment is made on tiny structures called melanosomes, which aggregate as granules and are delivered in small 'packages' to each basal cell by slender filaments called dendrites. One melanocyte supplies about 36 keratinocytes with melanin granules. These tiny packages of pigment sit over the nucleus - the vital centre of the cell - in every cell in the epidermis, and protect it from the harmful rays of the sun.</p>

 <p>A diagram of a skin cross-section. The epidermis is shown with several layers. The basal layer contains a layer of cells. One cell is highlighted in yellow and labeled 'Melanocyte with melanosomes'. It has long, thin processes called 'Dendrites' that extend upwards into the layers above. These dendrites are surrounded by other cells, some of which are labeled 'Keratinocyte with melanin granules over the nucleus'. The granules are small, dark brown dots. The overall structure shows the distribution of melanin throughout the epidermis.</p>	
 <p>A black and white micrograph of a Langerhans' cell. The cell is large and has an irregular, spread-out shape with many fine, hair-like projections (microvilli) extending from its surface. The nucleus is large and dark, and the cytoplasm is filled with granular material. The overall appearance is that of a specialized immune cell within the skin.</p>	<p><u>Langerhans' cells</u></p>



Langerhans' cells are immature dendritic cells containing large granules called Birbeck granules. On infection of an area of skin, the local Langerhans' cells will take up and process microbial antigens before travelling to the T-cell areas in the cortex of the draining lymph node and maturing to become fully-functional antigen-presenting cells.

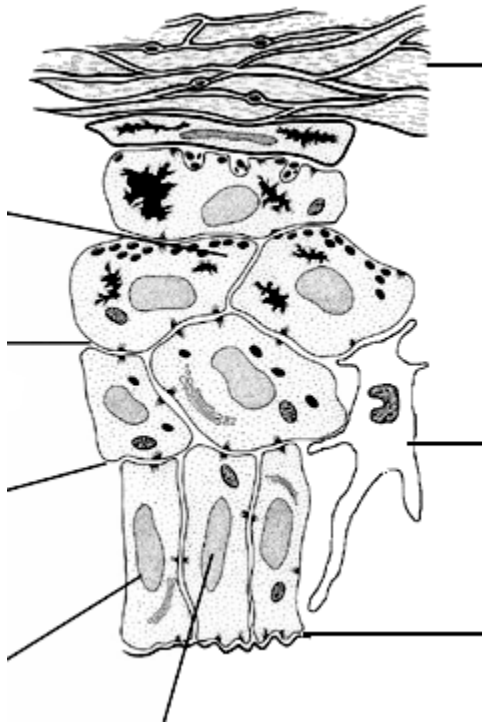
Generally, dendritic cells in tissue (such as Langerhans' cells) are active in the capture, uptake and processing of antigens. Once dendritic cells arrive in secondary lymphoid tissue however, they lose these properties while gaining the capacity to interact with naive T-cells.

In the rare disease Langerhans' cell histiocytosis (LCH), an excess of these cells is produced,

which can cause damage to skin, bone and other organs.

Langerhans' cells are derived from the cellular differentiation of monocytes with the marker "Gr-1" (also known as "Ly-6c/G"). The differentiation requires stimulation by colony stimulating factor-1.

Langerhans' cells have been observed in foreskin, vaginal, and oral mucosa of humans; the lower concentrations in oral mucosa suggest that it is not a likely source of HIV infection relative to foreskin and vaginal mucosa.



Barrier

Function Epidermal
Embryogenesis Epidermal
Connexins Langerhans Cells in
Immune Defense IKeratin in
Genetic Diseases Extracellular Proteolysis
and Migration Keratinocyte
Stem Cells Regulation of Cell Growth
and Wound Repair

- The stratum corneum (outermost), stratum lucidum (limited to thick skin), stratum granulosum, stratum spinosum, and stratum basale.
- Recall that the cells of the stratum spinosum are mechanically attached by desmosomes.
- Keratohyaline granules give the stratum granulosum its dark appearance.
- The stratum basale is the germinal layer of the epidermis and often shows mitotic figures.

Layers of the Epidermis:

1. Stratum Basale (Basal Layer)

- Deepest epidermal layer firmly attached to the dermis

- Consists of a single row of the youngest keratinocytes
- Cells undergo rapid division, hence its alternate name, stratum germinativum

2. Stratum Spinosum (Prickly Layer)

- Cells contain a weblike system of intermediate filaments attached to desmosomes
- Melanin granules and Langerhans' cells are abundant in this layer

3. Stratum Granulosum (Granular Layer)

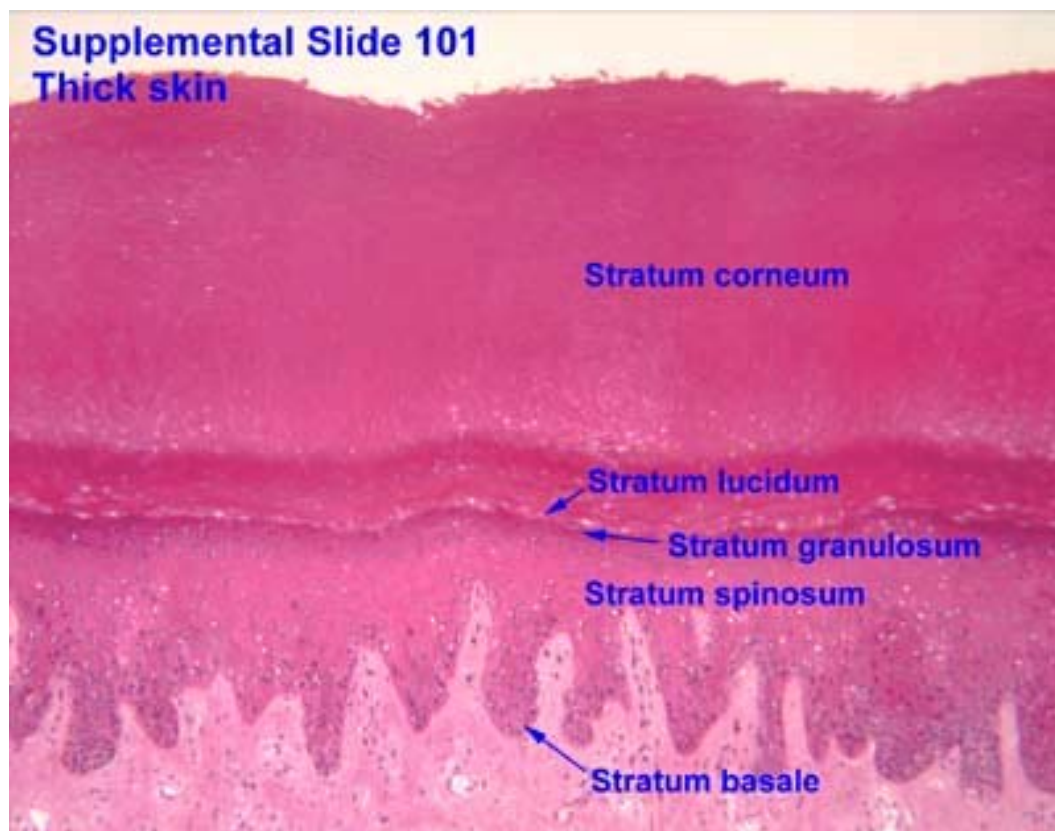
- Thin; three to five cell layers in which drastic changes in keratinocyte appearance occurs
- Keratohyaline and lamellated granules accumulate in the cells of this layer

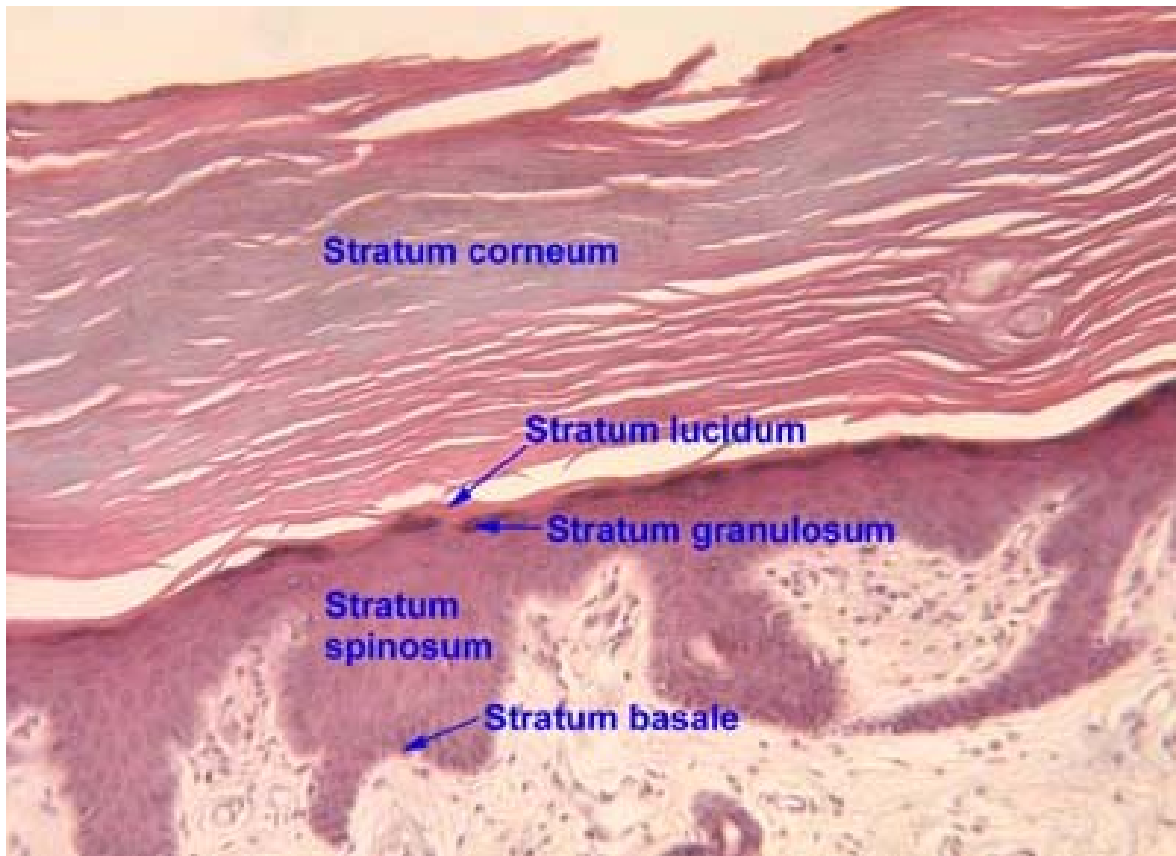
4. Stratum Lucidum (Clear Layer)

- Thin, transparent band superficial to the stratum granulosum
- Consists of a few rows of flat, dead keratinocytes
- Present only in thick skin

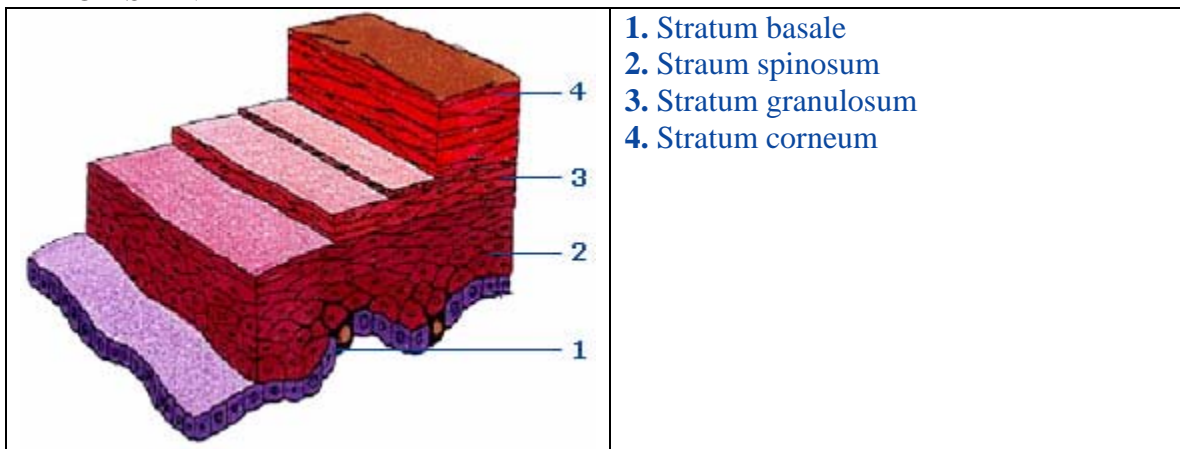
5. Stratum Corneum (Horny Layer)

- Outermost layer of keratinized cells
- Accounts for three quarters of the epidermal thickness
- Functions include:
 - Waterproofing
 - Protection from abrasion and penetration
 - Rendering the body relatively insensitive to biological, chemical, and physical assaults





THICK SKIN



Dermis

- Second major skin region containing strong, flexible connective tissue
- Cell types include fibroblasts, macrophages, and occasionally mast cells and white blood cells
- Composed of two layers – papillary and reticular

The Dermis helps us to control our body temperature:

A. On a cold day when the body needs to conserve heat, the Blood Vessels in the Dermis NARROW.

B. On hot days, the Blood Vessels WIDEN, warming the skin and increasing heat loss.

Tiny Muscle fibers attach to Hair Follicles contract and pull hair upright when you are cold or afraid, producing what is commonly called Goose Bumps.

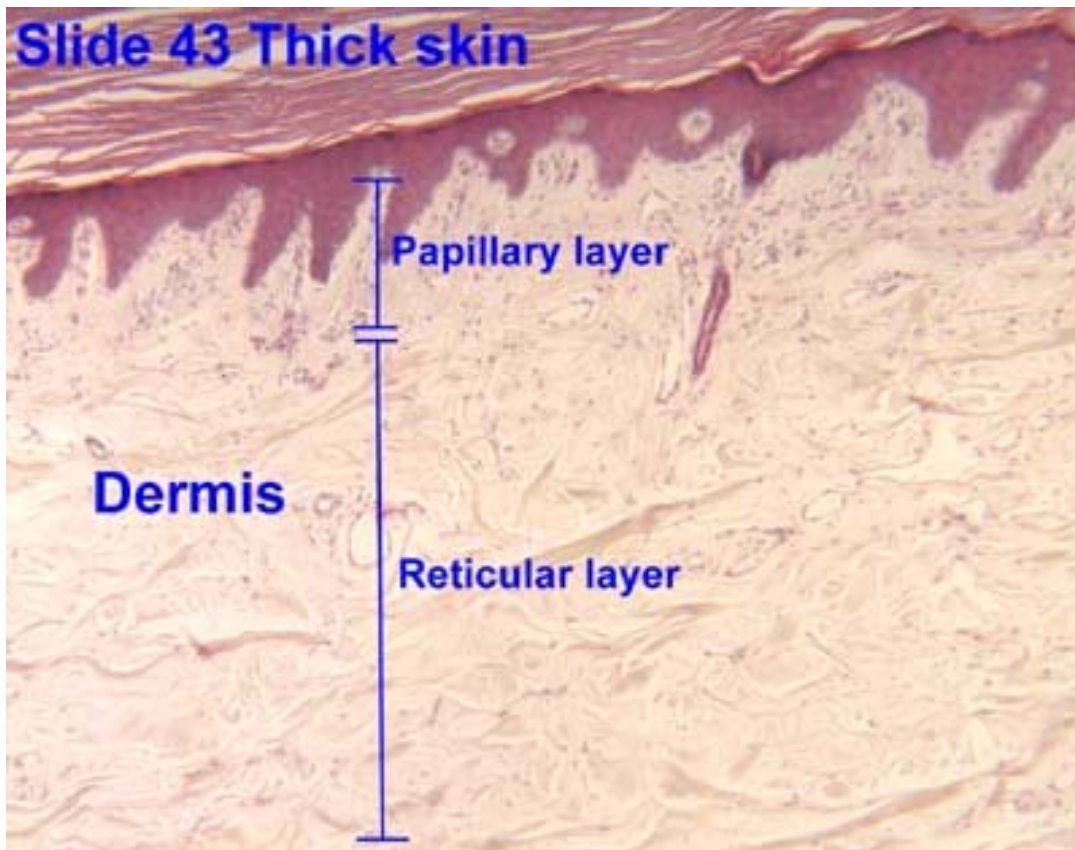
Layers of the Dermis:

1. Papillary Layer

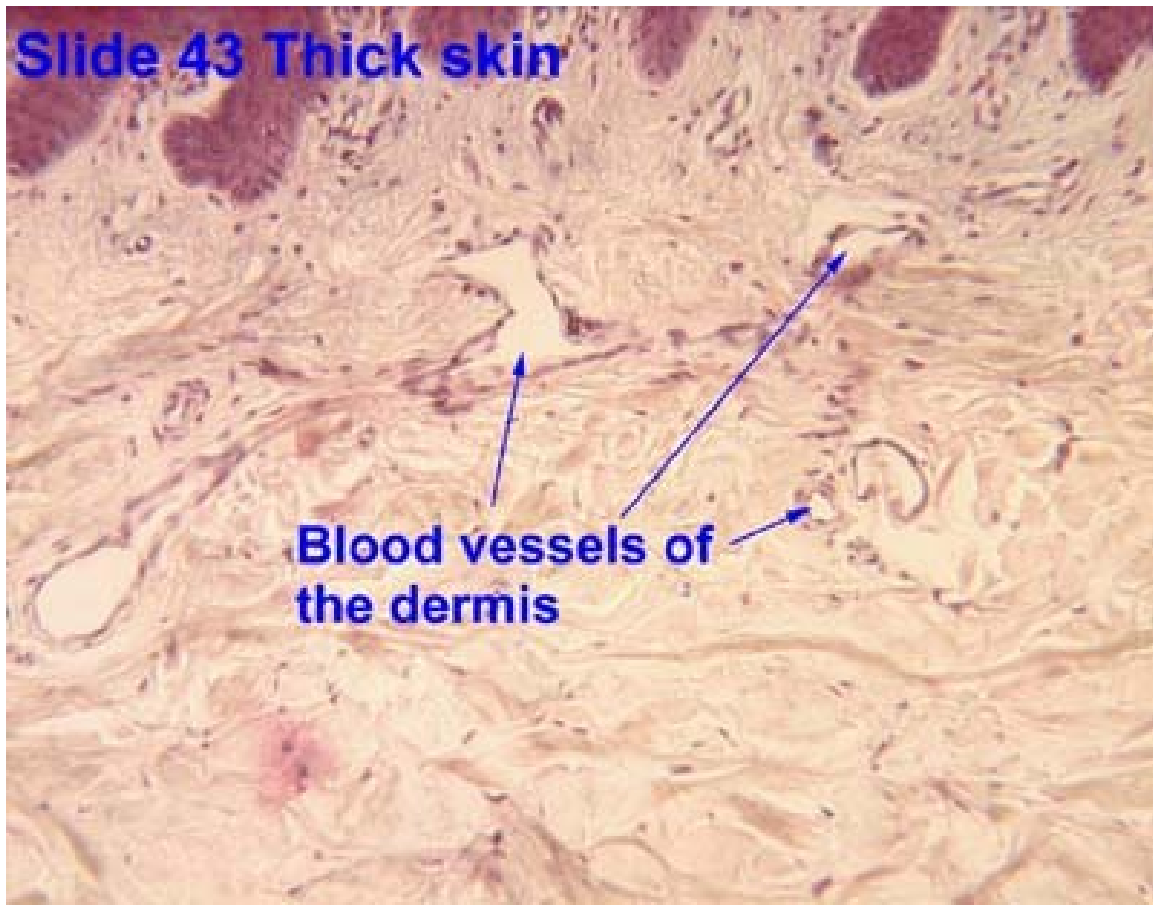
- Areolar connective tissue with collagen and elastic fibers
- Its superior surface contains peglike projections called dermal papillae
- Dermal papillae contain capillary loops, Meissner's corpuscles, and free nerve endings

2. Reticular Layer

- Accounts for approximately 80% of the thickness of the skin
- Collagen fibers in this layer add strength and resiliency to the skin
- Elastin fibers provide stretch-recoil properties



Slide 43 Thick skin

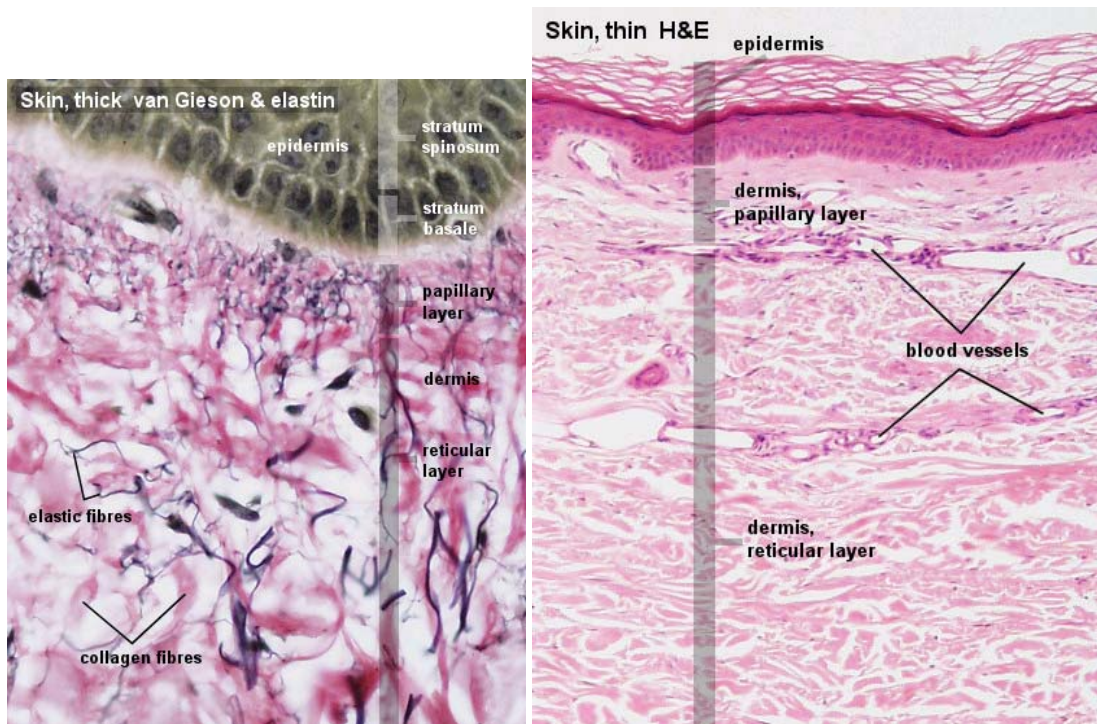


DERMIS . The dermis is composed of two layers: the papillary layer and reticular layer .

The papillary layer is closest to the epidermis.

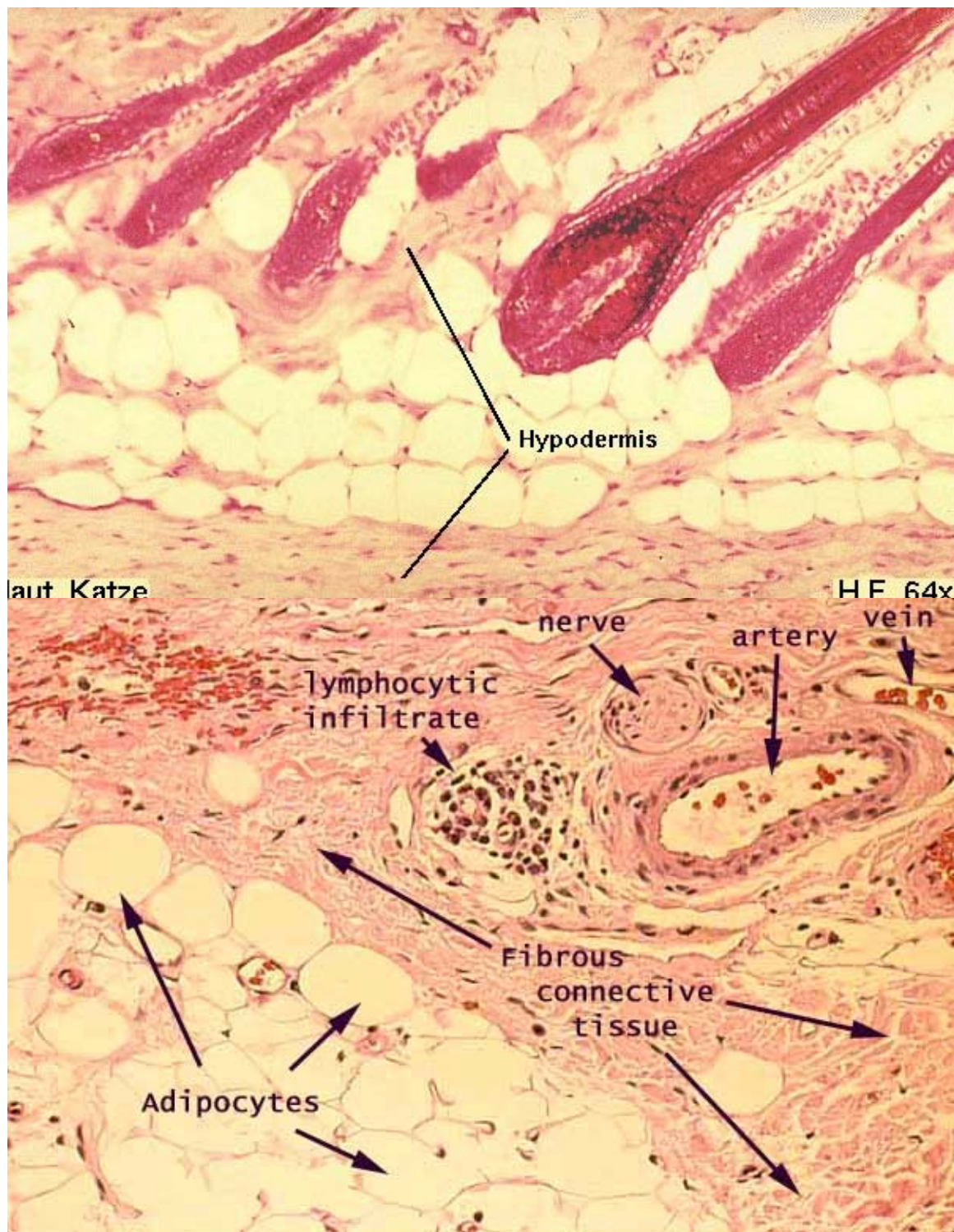
Connective tissue here is less dense than in the reticular layer.

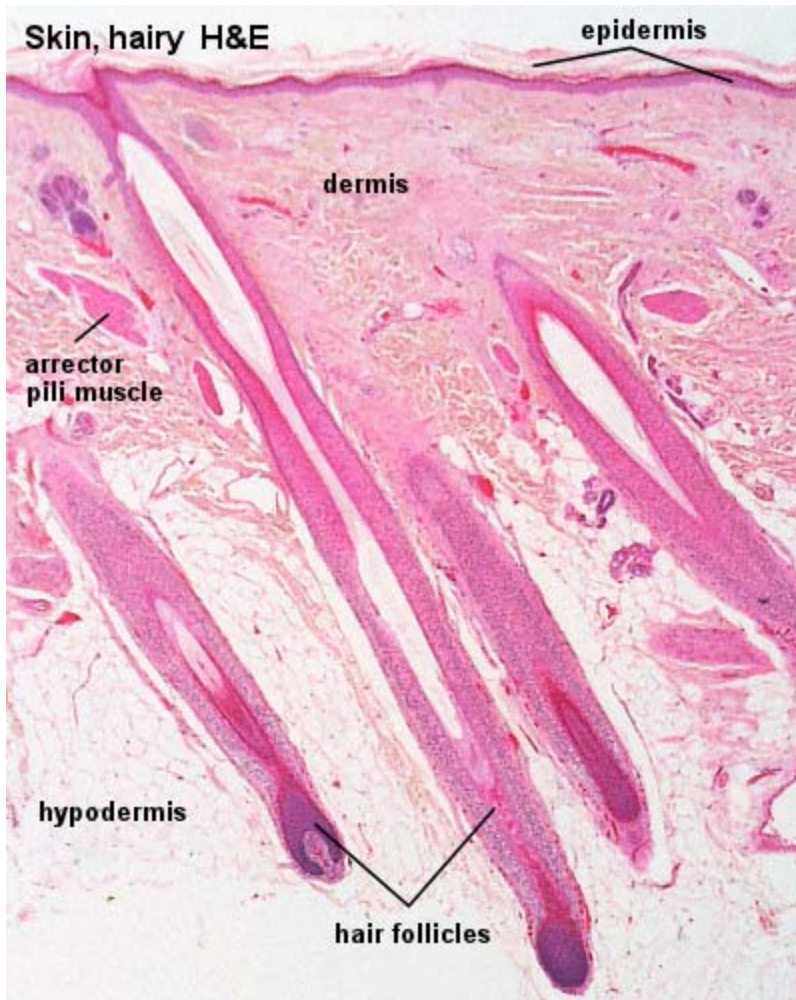
There are numerous sections of blood vessels (arterioles, venules, and capillaries) in the dermis.

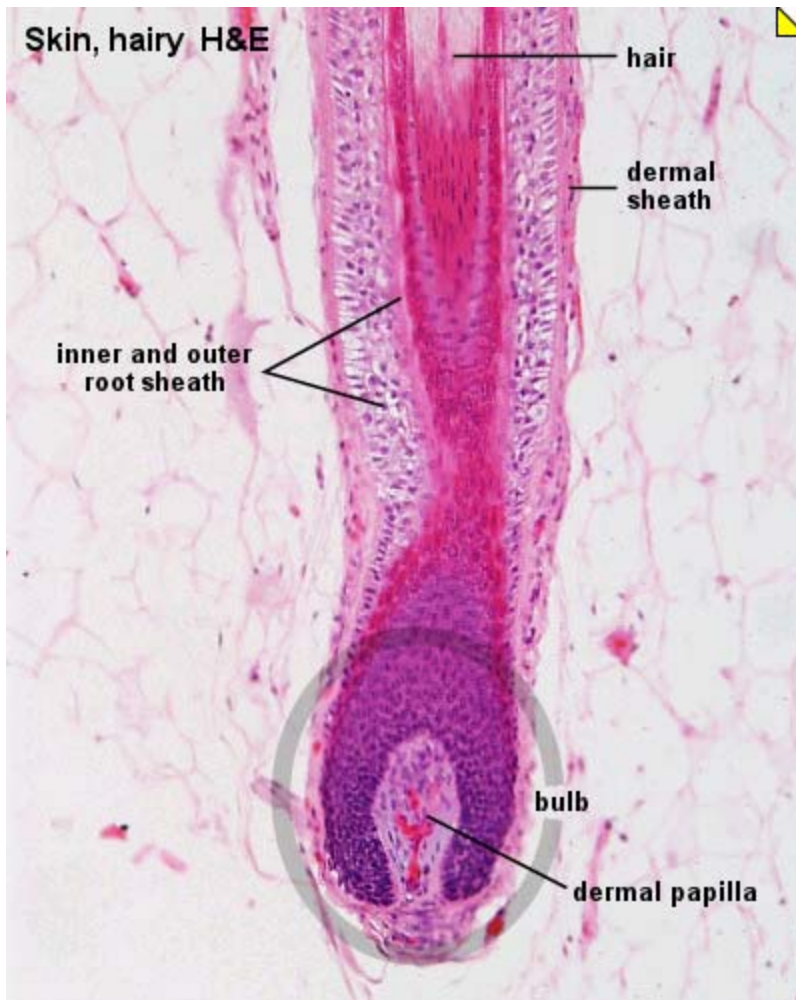


Hypodermis

- The hypodermis is the innermost and thickest layer of the skin
- Subcutaneous layer deep to the skin
- Composed of adipose and areolar connective tissue
- The hypodermis is used mainly for fat storage.
- It invaginates into the dermis and is attached to the latter, immediately above it, by collagen and elastin fibres.
- It is essentially composed of a type of cells specialised in accumulating and storing fats, known as adipocytes.
- These cells are grouped together in lobules separated by connective tissue .







The hypodermis, also called the hypoderm, subcutaneous tissue, or superficial fascia.

It is the lowermost layer of the integumentary system in vertebrates.

Types of cells that are found in the hypodermis are

- Fibroblasts,
- Adipose Cells,
- and Macrophages.

It is derived from the mesoderm, but unlike the dermis, it is not derived from the dermatome region of the mesoderm.

It is missing on parts of the body where the skin is especially thin-

- the eyelids,
- nipples,
- genitals,
- and shins.

▪Subcutaneous tissue acts both as an insulator, conserving body heat, and as a shock absorber, protecting internal organs from injury.

▪ It also stores fat as an energy reserve in the event extra calories are needed to power the body.

•The blood vessels, nerves, lymph vessels, and hair follicles also cross through this layer.

The anatomical position of the hypodermis is clearly a sexual characteristic. Whilst the hypodermis is distributed over the entire body, it has a tendency to accumulate above the belt over the abdomen and shoulders in men, and in women, below the waist around the thighs, hips and buttocks.

Skin Color



- Three pigments contribute to skin color
 - Melanin – yellow to reddish-brown to black pigment, responsible for dark skin colors
 - **Freckles and pigmented moles – result from local accumulations of melanin**
 - Carotene – yellow to orange pigment, most obvious in the palms and soles of the feet
 - Hemoglobin – reddish pigment responsible for the pinkish hue of the skin

Skin functions in homeostasis include **protection, regulation of body temperature, sensory reception, water balance, synthesis of vitamins and hormones, and absorption of materials.**

The skin's primary functions are to serve as a barrier to the entry of microbes and viruses, and to prevent water and extracellular fluid loss.

Acidic secretions from skin glands also retard the growth of fungi.

Melanocytes form a second barrier: protection from the damaging effects of ultraviolet radiation. When a microbe penetrates the skin (or when the skin is breached by a cut) the inflammatory response occurs.

Heat and cold receptors are located in the skin. When the body temperature rises, the hypothalamus sends a nerve signal to the sweat-producing skin glands, causing them to release about 1-2 liters of water per hour, cooling the body. The hypothalamus also causes dilation of the blood vessels of the skin, allowing more blood to flow into those areas, causing heat to be convected away from the skin surface. When body temperature falls, the sweat glands constrict and sweat production decreases. If the body temperature continues to fall, the body will engage in thermogenesis, or heat generation, by raising the body's metabolic rate and by shivering.

Water loss occurs in the skin by two routes.

1. evaporation
2. sweating

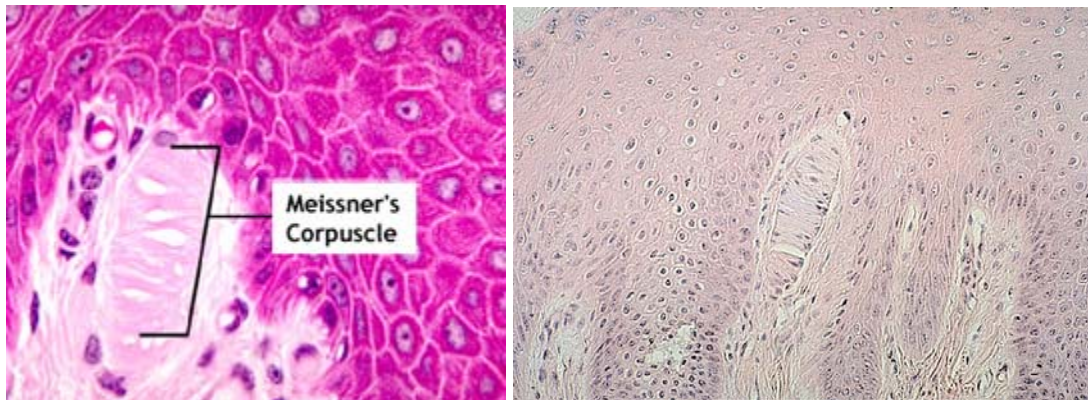
In hot weather up to 4 liters per hour can be lost by these mechanisms. Skin damaged by burns is less effective at preventing fluid loss, often resulting in a possibly life threatening problem if not treated.

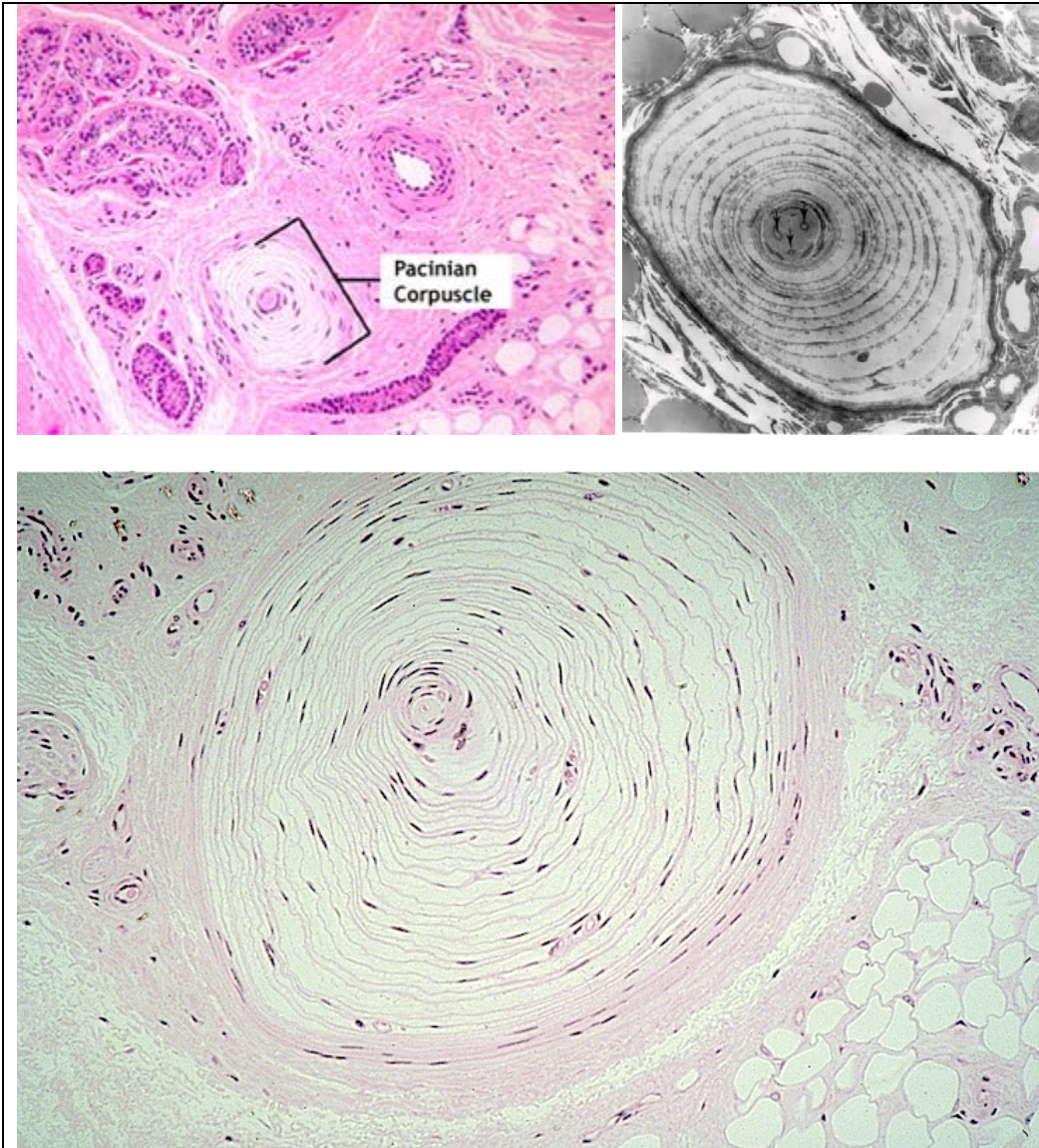
Skin and Sensory Reception

Sensory receptors in the skin include those for pain, pressure (touch), and temperature.

Deeper within the skin are **Meissner's corpuscles**, which are especially common in the tips of the fingers and lips, and are very sensitive to touch.

Pacinian corpuscles respond to pressure. Temperature receptors: more cold ones than hot ones.





Skin and Synthesis

Skin cells synthesize melanin and carotenes, which give the skin its color.

The skin also assists in the synthesis of **vitamin D**.

Children lacking sufficient vitamin D develop bone abnormalities known as **rickets**.

Skin Is Selectively Permeable

The skin is selectively soluble to **fat-soluble substances such as vitamins A, D, E, and K**, as well as steroid hormones such as estrogen.

These substances enter the bloodstream through the capillary networks in the skin.

Patches have been used to deliver a number of therapeutic drugs in this manner.

These include estrogen, scopolamine (motion sickness), nitroglycerin (heart problems), and nicotine (for those trying to quit smoking).

Follicles and Glands

Hair follicles are lined with cells that synthesize the proteins that form hair.

A sebaceous gland (that secretes the oily coating of the hair shaft), capillary bed, nerve ending, and small muscle are associated with each hair follicle.

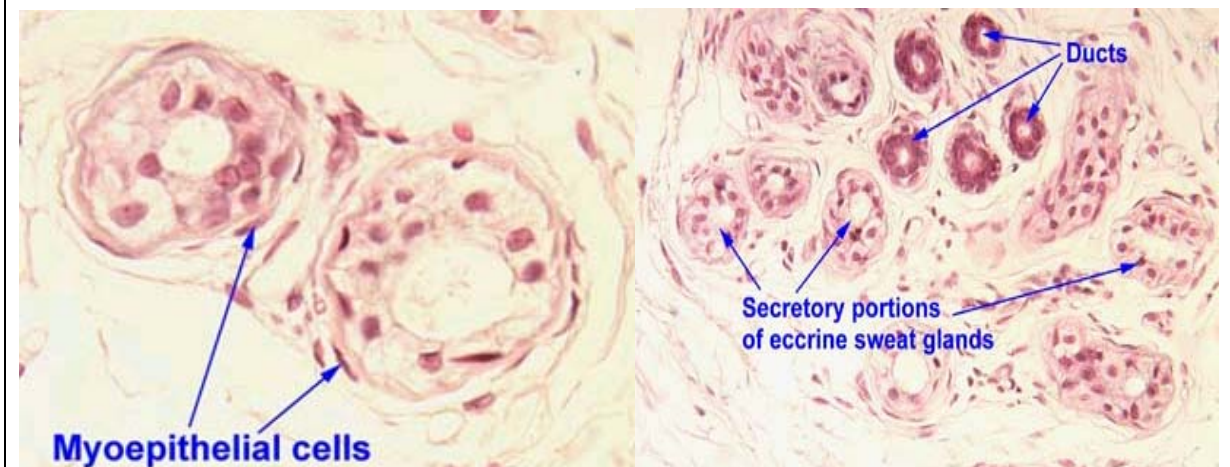
If the sebaceous glands becomes plugged and infected, it becomes a skin blemish (or pimple).

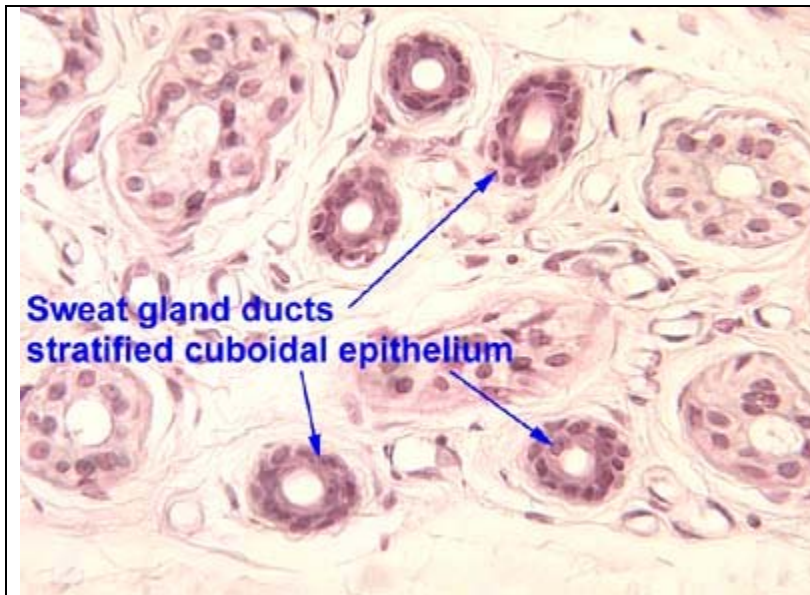
The sweat glands open to the surface through the skin pores.

Eccrine glands are a type of sweat gland linked to the sympathetic nervous system; they occur all over the body.

Apocrine glands are the other type of sweat gland, and are larger and occur in the armpits and groin areas; these produce a solution that bacteria act upon to produce "body odor".

ECCRINE SWEAT GLANDS .



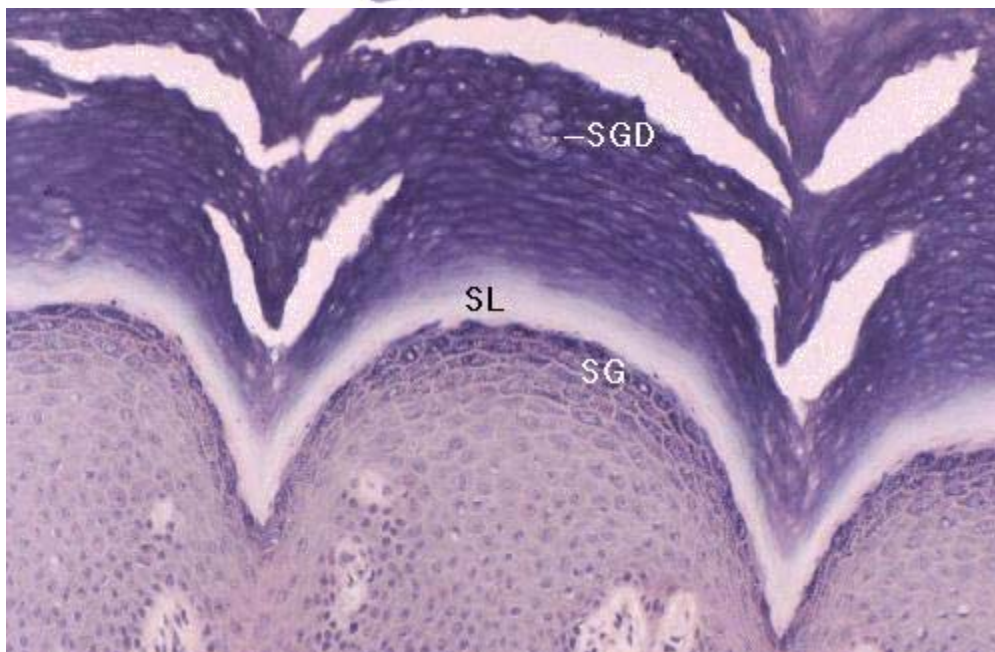


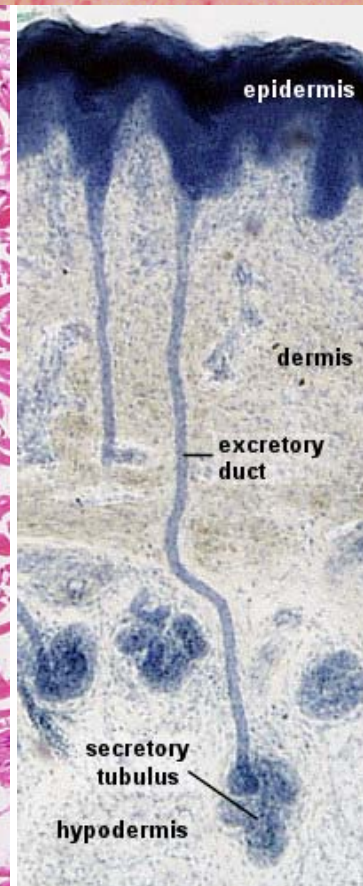
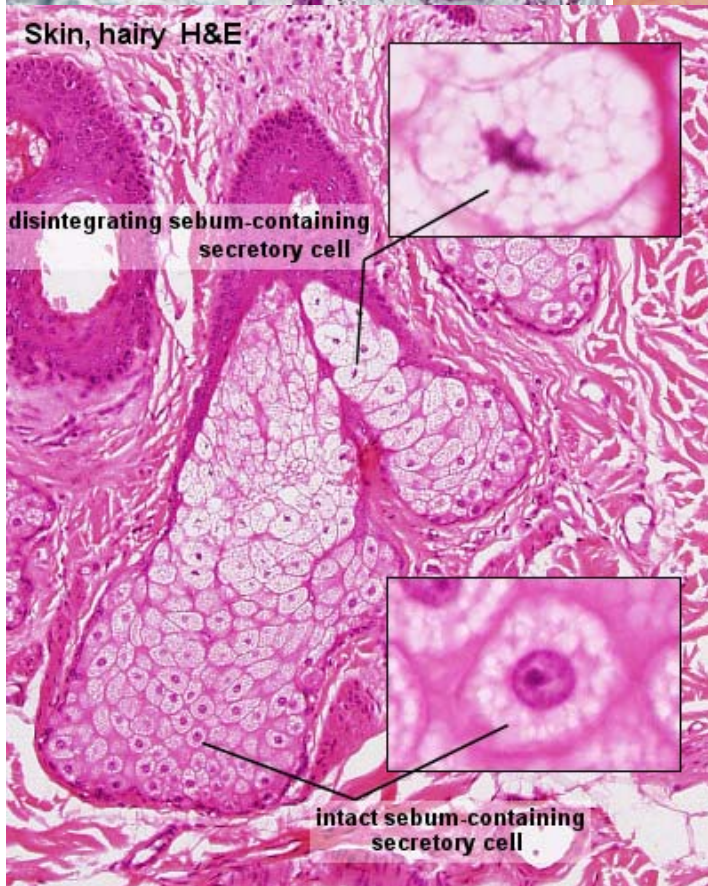
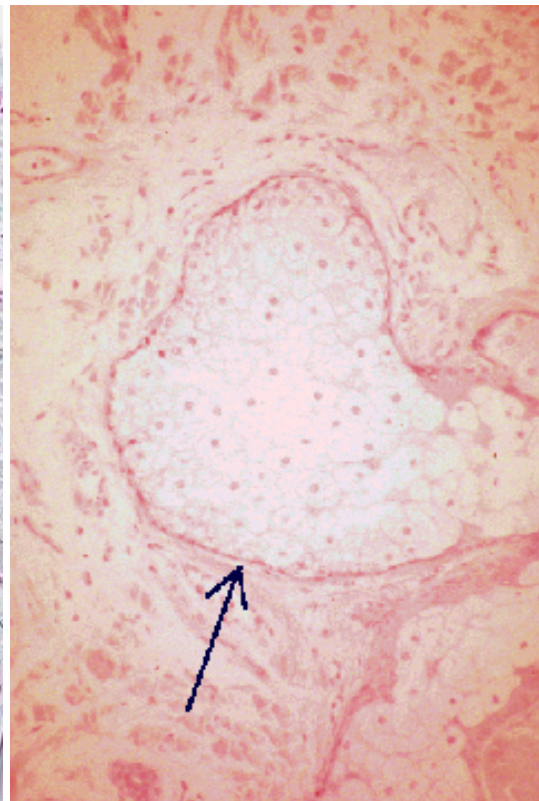
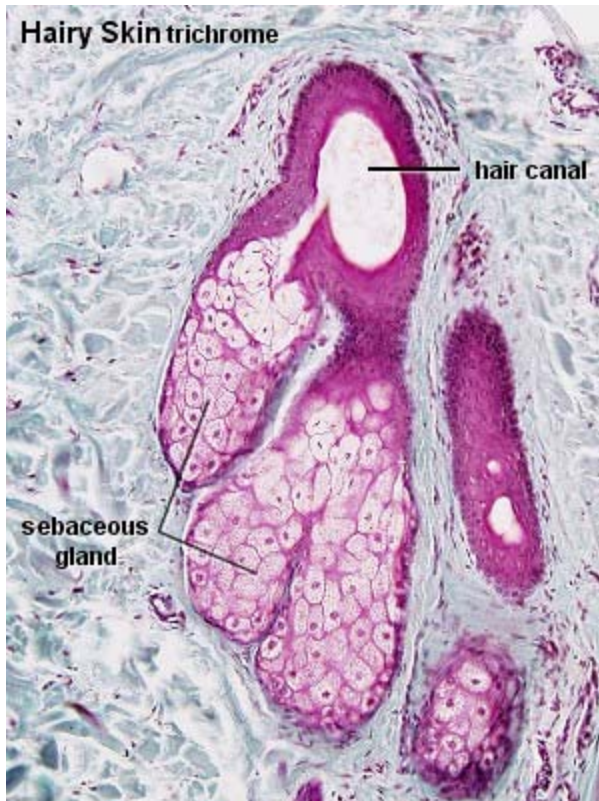
Sweat Glands

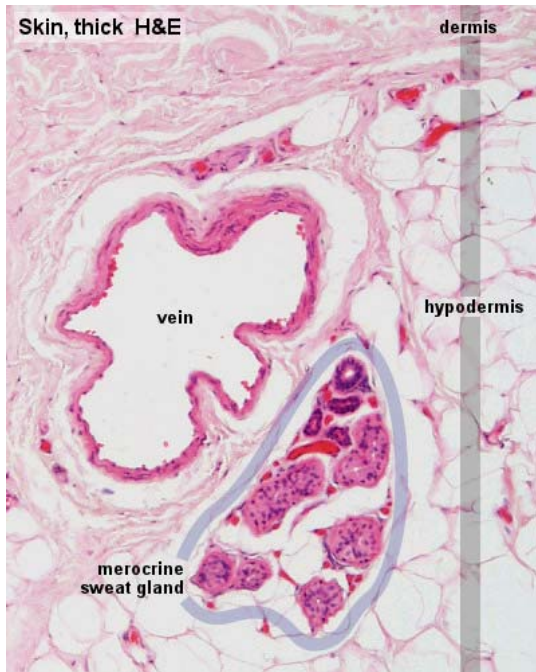
- Different types prevent overheating of the body; secrete cerumen and milk
 - **Eccrine sweat glands** – found in palms, soles of the feet, and forehead
 - **Apocrine sweat glands** – found in axillary and anogenital areas
 - **Ceruminous glands** – modified apocrine glands in external ear canal that secrete cerumen
 - **Mammary glands** – specialized sweat glands that secrete milk

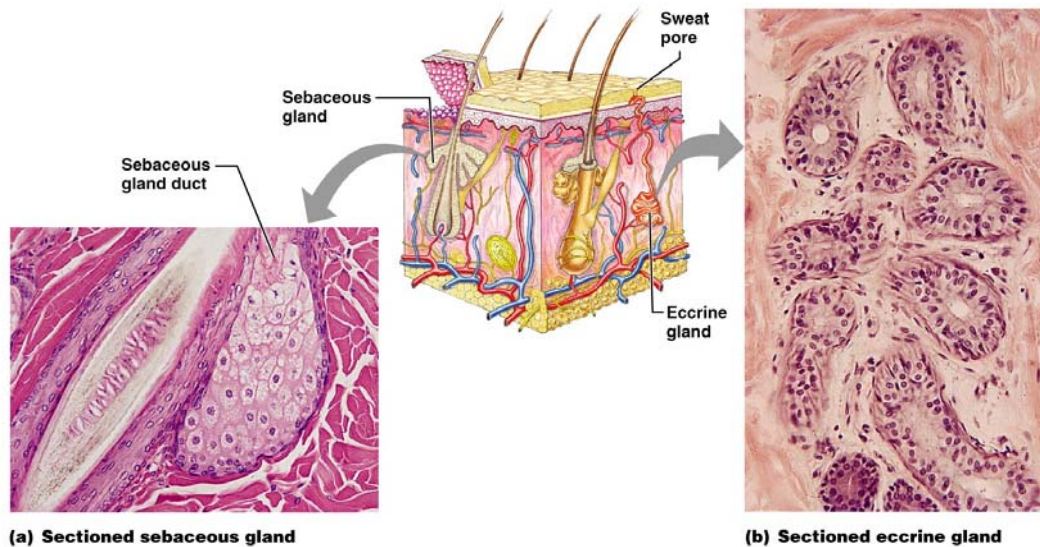
Sebaceous Glands

- Simple alveolar glands found all over the body
- Soften skin when stimulated by hormones
- Secrete an oily secretion called sebum



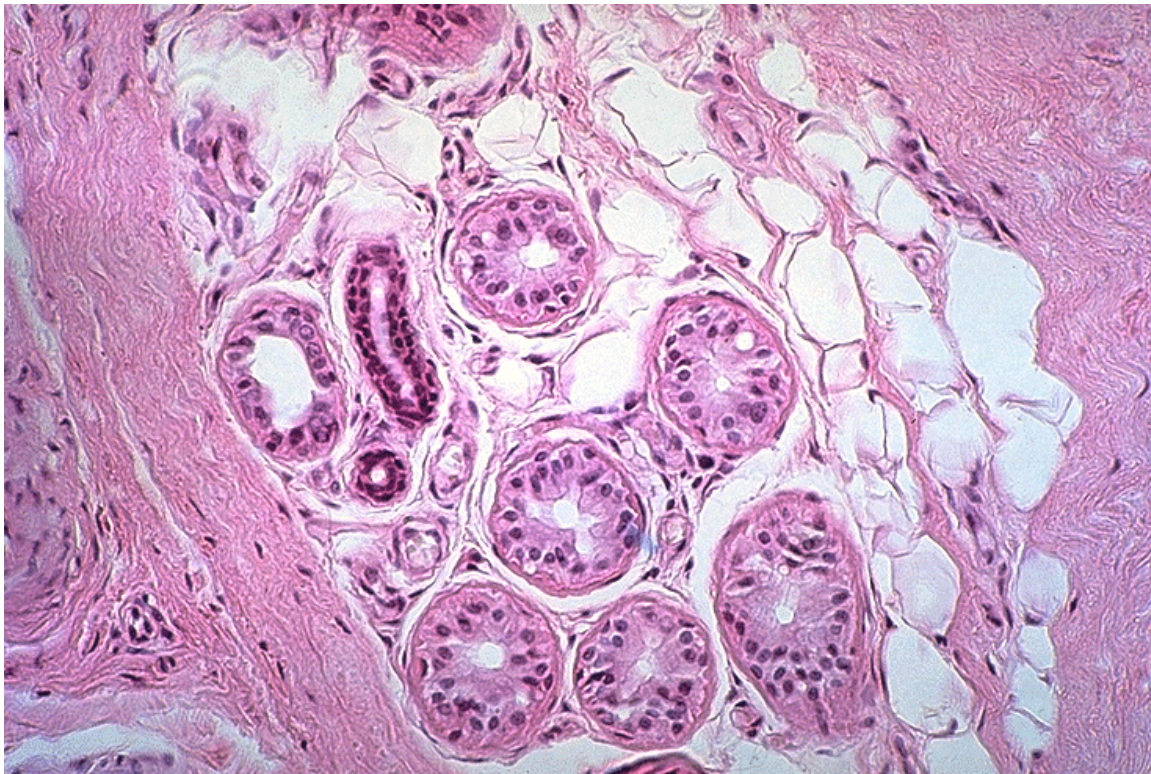






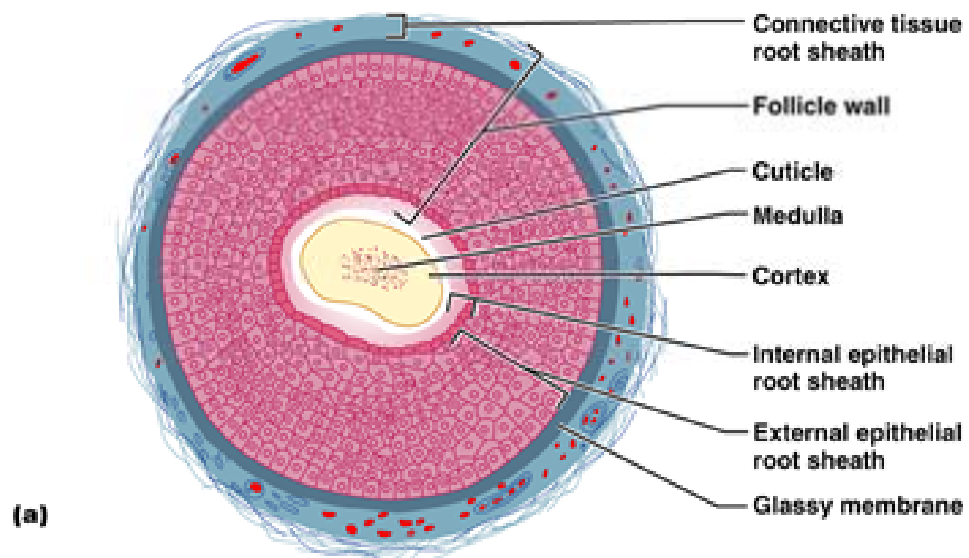
SEBACEOUS GLANDS, (OIL GLANDS) PRODUCE OILY SECRETION KNOWN AS **SEBUM** THAT SPREADS OUT ALONG THE SURFACE OF THE SKIN AND KEEPS THE KERATIN RICH EPIDERMIS FLEXIBLE AND WATERPROOF.

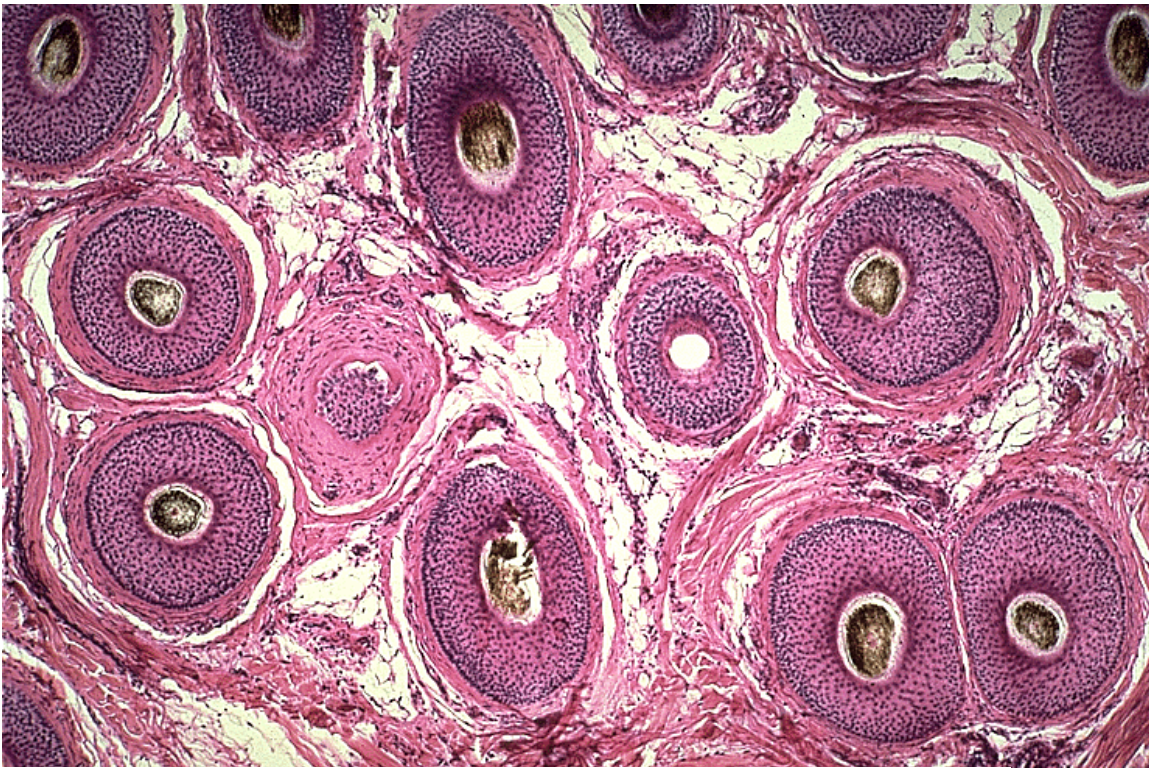
- . The production of Sebum is controlled by Hormones.
- . Oil Glands are usually connected by Tiny Ducts (Exocrine Glands) to Hair Follicles. Sebum coats the surface of the skin and the shafts of hair, preventing excess water loss and lubricating and softening the Skin and Hair.
- . Sebum is mildly toxic to some Bacteria - protection.
- . If the Ducts of Oil Glands become clogged with excessive amounts of Sebum, Dead Cells, and Bacteria, the Skin disorder **ACNE** can result.
- . When first wearing new shoes, the skin of the foot may be subject to friction. This will separate layers of Epidermis, or separate the Epidermis from the Dermis, and tissue fluid may collect, causing a **BLISTER**.
- . If the skin is subjected to pressure, the rate of mitosis will increase and create a thicker Epidermis; we call this a **CALLUS**.



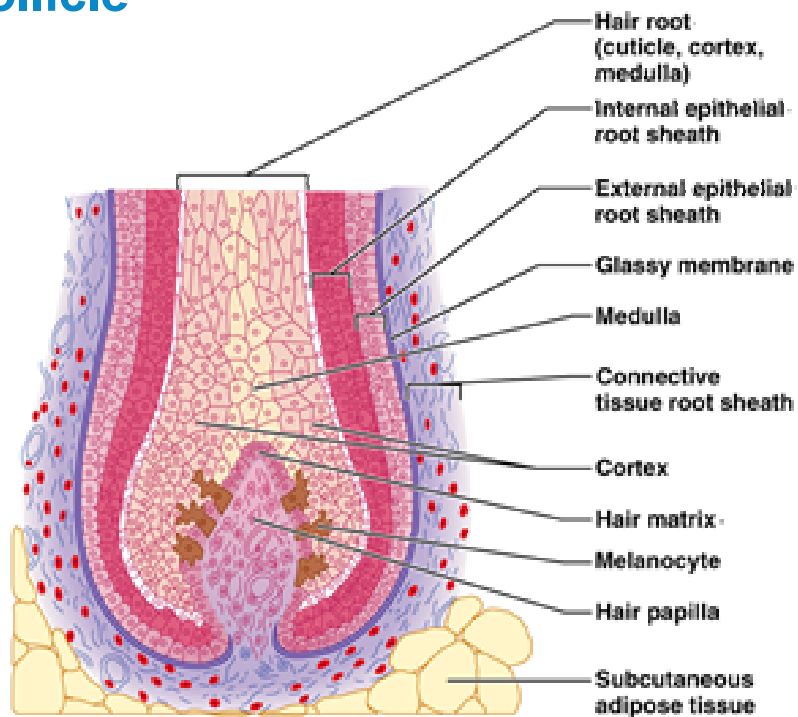
Sweat Gland Secretory Portion

Hair Follicle

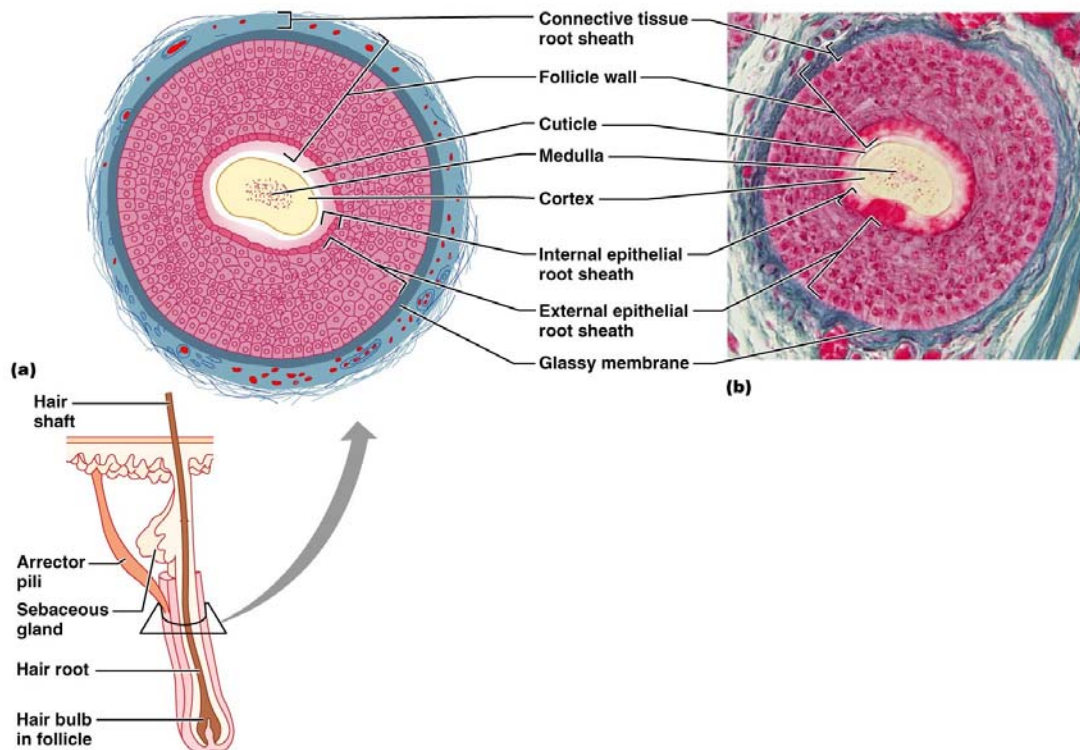




Hair Follicle

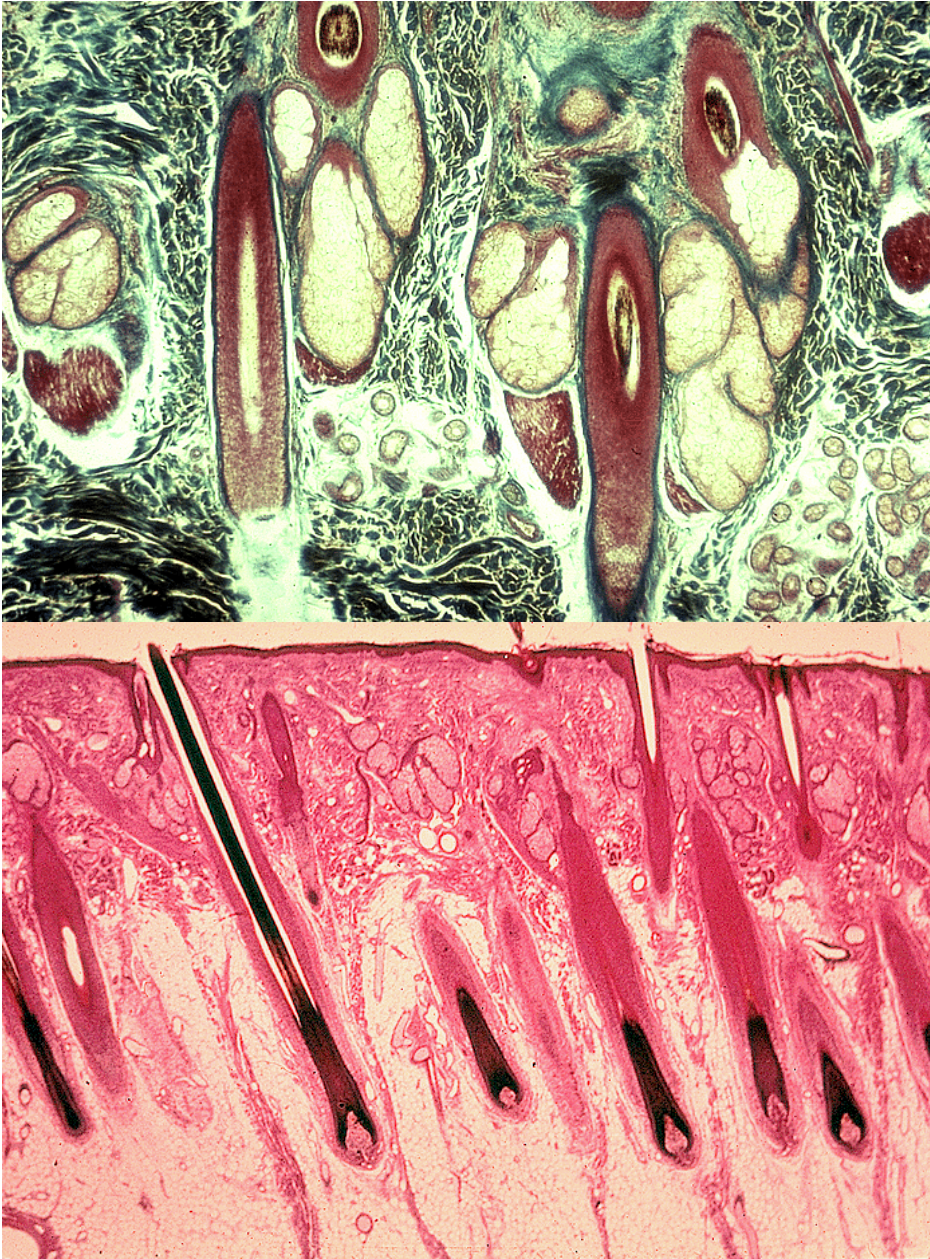


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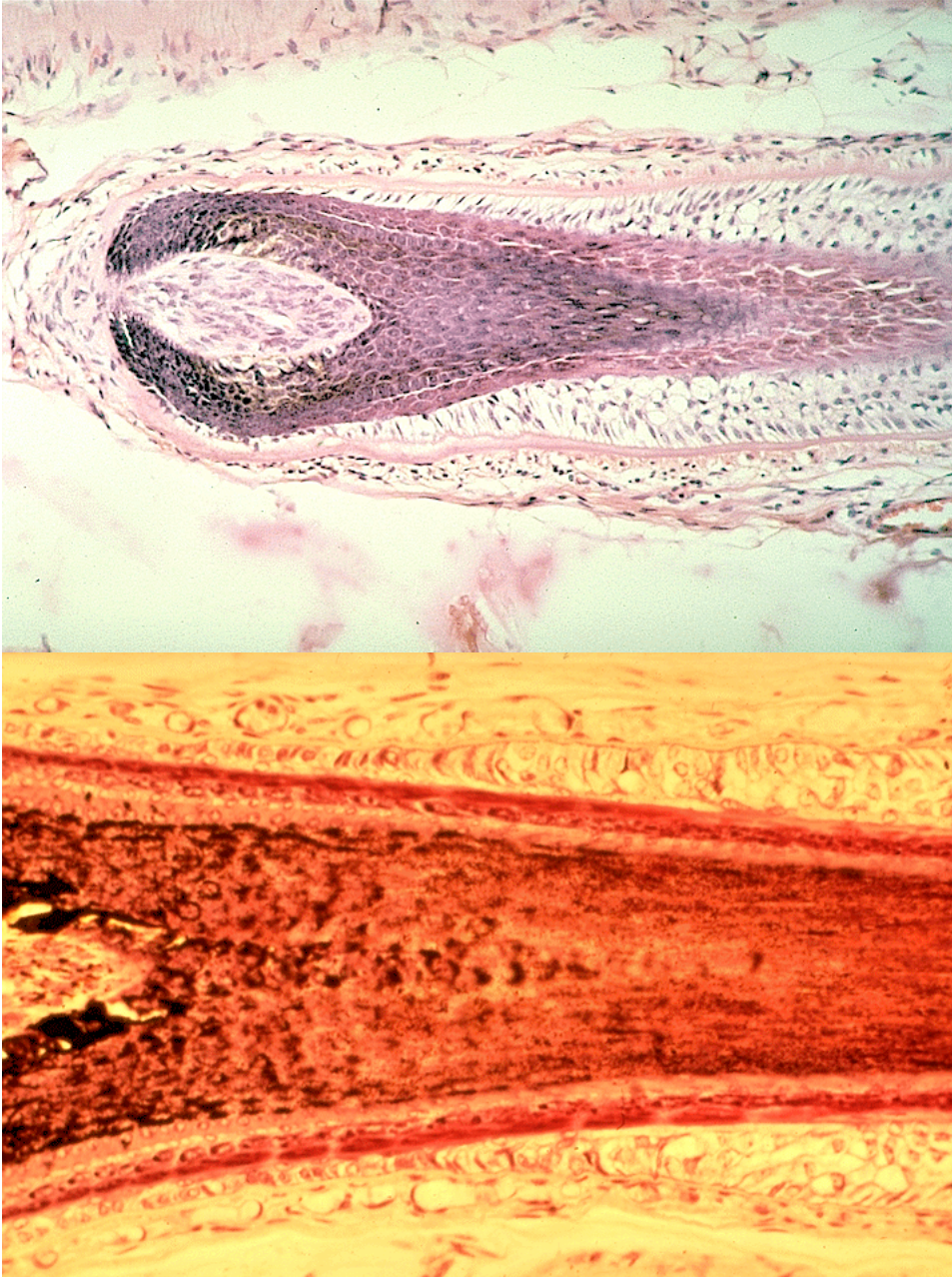
Hair and Nails

- Hair, scales, feathers, claws, horns, and nails are animal structures derived from skin.
- The hair shaft extends above the skin surface, the hair root extends from the surface to the base or hair bulb.
- Genetics controls several features of hair: baldness, color, texture.
- Nails consist of highly keratinized, modified epidermal cells.
- The nail arises from the nail bed, which is thickened to form a lunula (or little moon).
- Cells forming the nail bed are linked together to form the nail.



Hair

- Filamentous strands of dead keratinized cells produced by hair follicles
- Contains hard keratin which is tougher and more durable than soft keratin of the skin
- Made up of the shaft projecting from the skin, and the root embedded in the skin
- Consists of a core called the medulla, a cortex, and an outermost cuticle
- Pigmented by melanocytes at the base of the hair

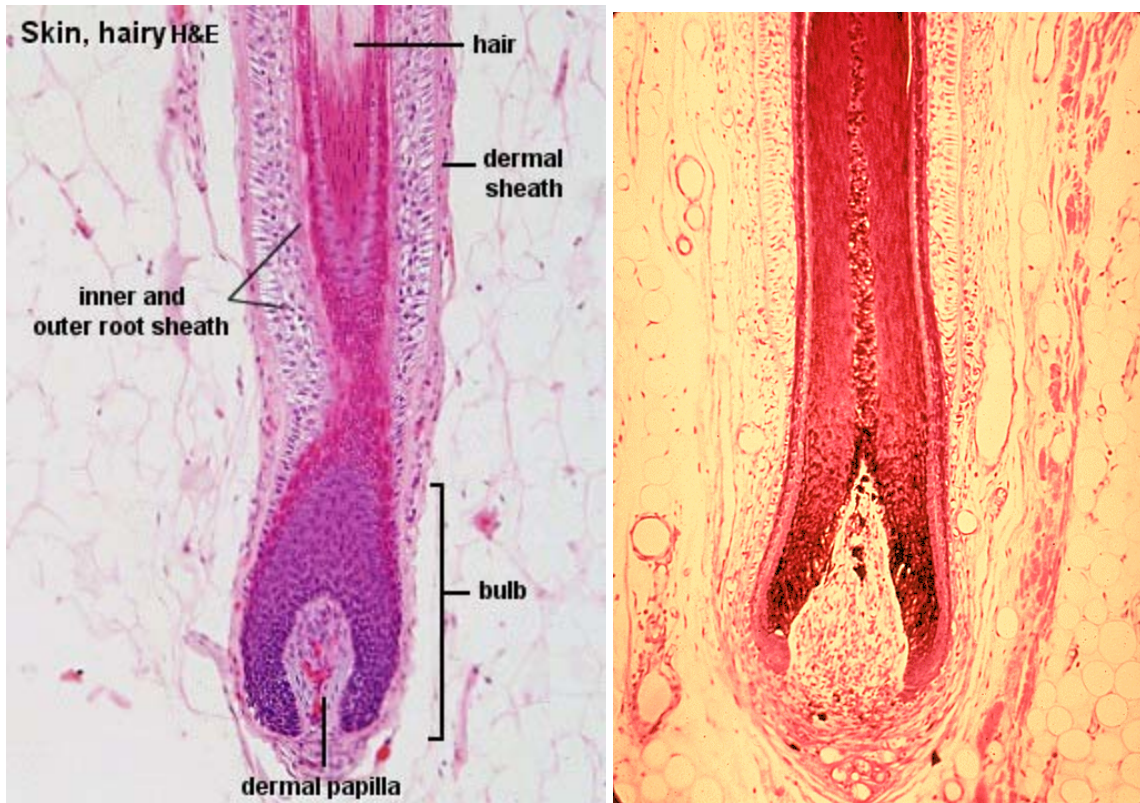


Hair Function

- Functions of hair include:
 - Helping to maintain warmth
 - Alerting the body to presence of insects on the skin
 - Guarding the scalp against physical trauma, heat loss, and sunlight

Hair Distribution

- Hair is distributed over the entire skin surface except:
 - Palms, soles, and lips
 - Nipples and portions of the external genitalia



Hair Follicle

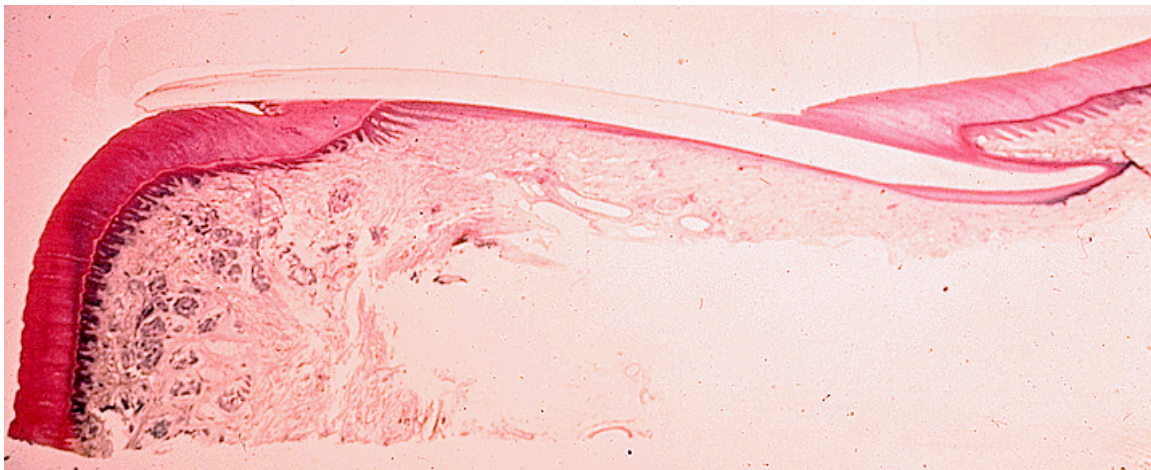
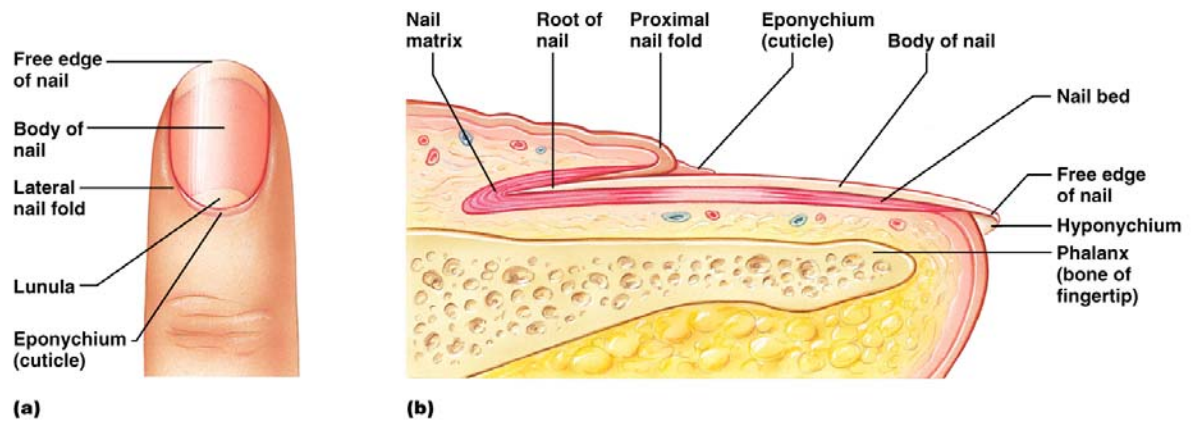
- Root sheath extending from the epidermal surface into the dermis
- Deep end is expanded forming a hair bulb
- A knot of sensory nerve endings (a root hair plexus) wraps around each hair bulb
- Bending a hair stimulates these endings, hence our hairs act as sensitive touch receptors

Types of Hair

- Vellus – pale, fine body hair found in children and the adult female
- Terminal – coarse, long hair of eyebrows, scalp, axillary, and pubic regions

Hair Thinning and Baldness

- Alopecia – hair thinning in both sexes
- True, or frank, baldness
 - Genetically determined and sex-influenced condition
 - Male pattern baldness – caused by follicular response to DHT



Structure of a Nail

- Scalelike modification of the epidermis on the distal, dorsal surface of fingers and toes

Skin Cancer

- Most skin tumors are benign and do not metastasize
- A crucial risk factor for nonmelanoma skin cancers is the disabling of the *p53* gene
- Newly developed skin lotions can fix damaged DNA
- The three major types of skin cancer are:
 - Basal cell carcinoma
 - Squamous cell carcinoma
 - Melanoma

Basal Cell Carcinoma

- Least malignant and most common skin cancer

- Stratum basale cells proliferate and invade the dermis and hypodermis
- Slow growing and do not often metastasize
- Can be cured by surgical excision in 99% of the cases



Squamous Cell Carcinoma

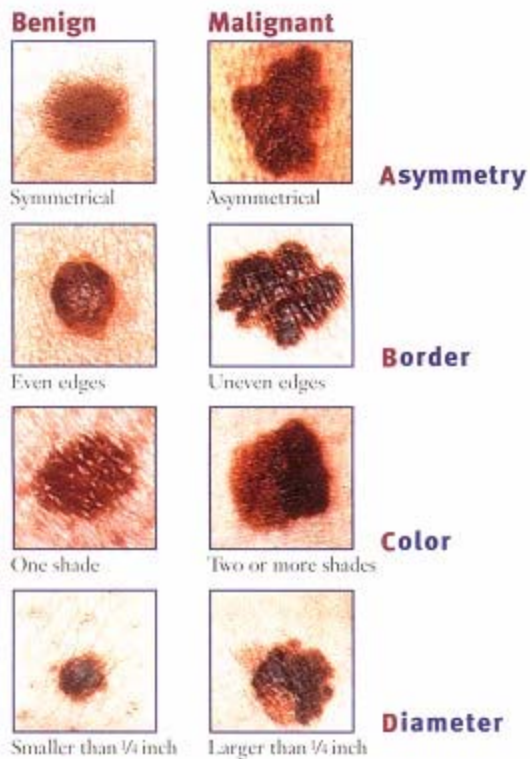
- Arises from keratinocytes of stratum spinosum
- Arise most often on scalp, ears, and lower lip
- Grows rapidly and metastasizes if not removed

- Prognosis is good if treated by radiation therapy or removed surgically



Melanoma

- Cancer of melanocytes is the most dangerous type of skin cancer because it is:
 - Highly metastatic
 - Resistant to chemotherapy
- Melanomas have the following characteristics (ABCD rule)
 - A: Asymmetry; the two sides of the pigmented area do not match
 - B: Border is irregular and exhibits indentations
 - C: Color (pigmented area) is black, brown, tan, and sometimes red or blue
 - D: Diameter is larger than 6 mm (size of a pencil eraser)
- Treated by wide surgical excision accompanied by immunotherapy
- Chance of survival is poor if the lesion is over 4 mm thick



Figures are provided courtesy of Robert J. Friedman, MD.

Burns

- First-degree – only the epidermis is damaged
 - Symptoms include localized redness, swelling, and pain
- Second-degree – epidermis and upper regions of dermis are damaged
 - Symptoms mimic first degree burns, but blisters also appear
- Third-degree – entire thickness of the skin is damaged
 - Burned area appears gray-white, cherry red, or black; there is no initial edema or pain

(since nerve endings are destroyed)

First Degree Burns

- First degree burns (pink and red, no blisters) can be treated at home.
- Take off hot clothes or metal rings. Cut clothing if needed.
- Put the burned area under cold water. Do not use ice.
- To prevent infection, keep the area clean and dry.
- Do not put butter or cream on the burn.
- Give acetaminophen (such as Tylenol) for pain.
- If blisters form, call your doctor.
- Keep your child away from the cause of the burn. For example, if she has a sunburn, keep her out of the sun.

Second Degree Burns

- Skin burns that form blisters are second degree burns. They should be seen by a doctor.
- If the skin is opened, peeling, or blistered, see a doctor.
- If the area is small, cover it with a clean, wet cloth and take the child to the emergency room or your doctor.
- If the burned area is large, call 911. Cover the child with a cloth or a clean sheet.
- Do not move the child unless needed for safety.
- Give acetaminophen (such as Tylenol) for pain.
- If the child shivers, stop cooling and keep her warm.

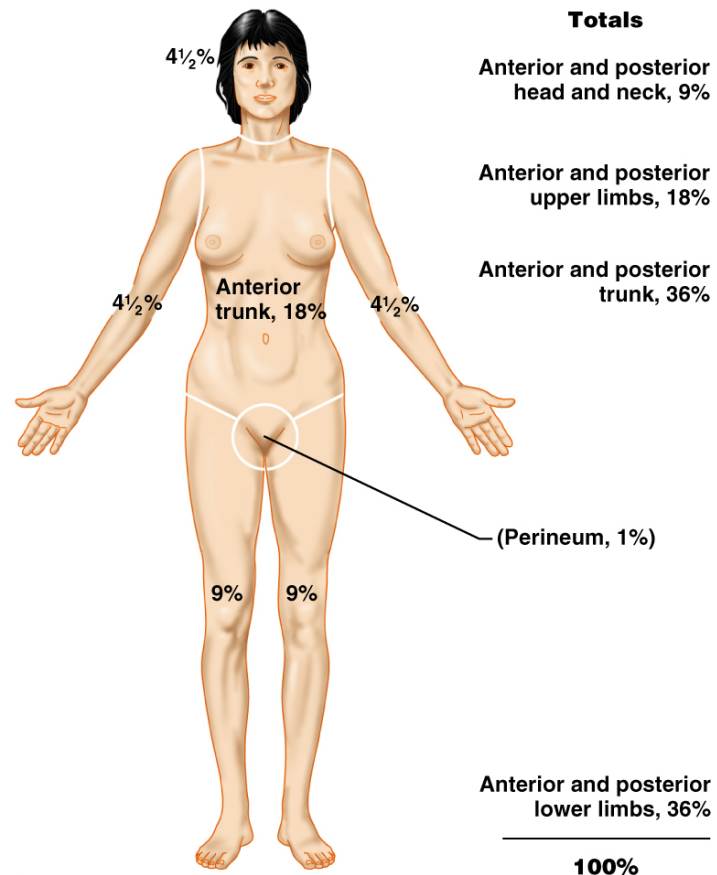
Third Degree Burns

- Third degree burns are the most serious. They leave the skin charred (black).
- Your child's breathing should be checked first. Take care of burns after.
- Treat like a second degree burn.
- Take your child to the emergency room

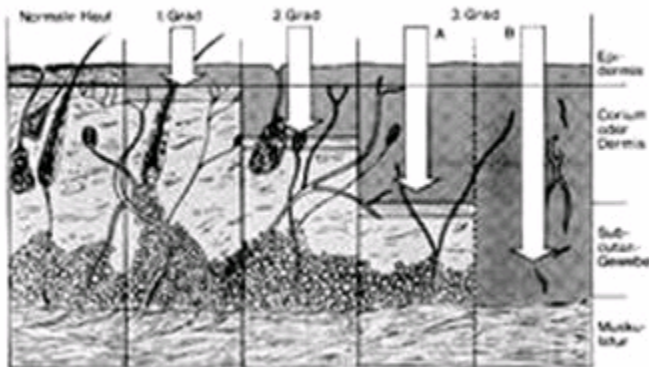
Rule of Nines

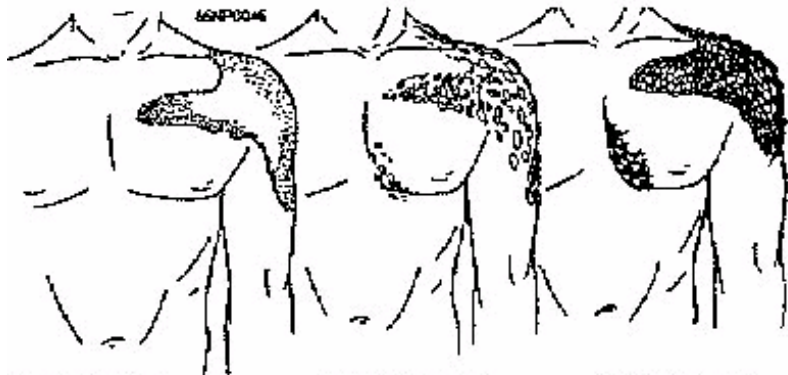
- Estimates the severity of burns
- Burns considered critical if:
 - Over 25% of the body has second-degree burns
 - Over 10% of the body has third-degree burns
 - There are third-degree burns on face, hands, or feet

Rule of Nines



(a)





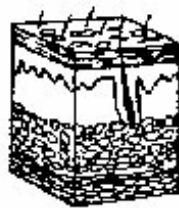
FIRST DEGREE
PARTIAL THICKNESS

SECOND DEGREE
PARTIAL THICKNESS

THIRD DEGREE
FULL THICKNESS



SKIN REDDENED



BLISTERS



CHARRING

EPIDERMIS
DERMIS
FAT
MUSCLE