

INTEGUMENTARY SYSTEM

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Functions

The integumentary system consists of the skin and its associated structures, the hair follicles, the nails, the sweat glands, and the sebaceous (oil) glands.

The functions of the integumentary system include:

- Protection
- Temperature regulation
- Sensation
- Excretion
- Production of vitamin D

Protective Functions

The integumentary system presents three types of barriers:

- (1) physical,
 - (2) chemical, and
 - (3) immunological.
- **Physical barrier**
 - A physical barrier is formed by the continuous epithelial membrane, the skin. The outermost surface of the skin, the epidermis, is covered with dead keratinized cells (stratum corneum).
 - **Chemical barrier**
 - A chemical barrier is formed by the production of acidic (low pH) secretions by the oil (sebaceous) glands. Low pH inhibits the growth of many bacteria.
 - **Immunological barrier**
 - An immunological barrier is formed by the presence of cells of the immune system within the skin. These cells function in immunity and disposal of bacteria and viruses by phagocytosis.

Functions in Temperature Regulation

- The nervous system regulates body temperature (through the skin) by controlling **sweating and dermal blood flow**.
 - The stimulation of sweat (sudoriferous) glands results in increased sweating that cools the body.
 - The dilation of dermal blood vessels helps cool the body and dermal blood vessel constriction helps reduce heat loss from the body.

Functions in Sensation

- The skin houses numerous receptors (part of the nervous system) that function in the perception of external stimuli such as pain (free nerve endings), pressure (Meissner's corpuscles, Pacinian corpuscles, and root hair plexuses), and temperature.

Functions in Excretion

- Excretion is the formation of waste substances (such as sweat and urine) that are removed from the body.
- Some metabolic wastes, electrolytes, and water are lost by sweating (sweat, or sudoriferous, glands).

Function of Vitamin D Production

- In the presence of sunlight a sterol (related to cholesterol) is converted to vitamin D3 (cholecalciferol). Vitamin D3 plays an important role in the intestinal absorption of calcium and regulation of phosphate.

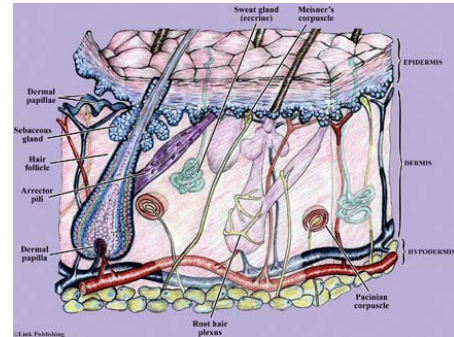


Fig. 9.1

Structure of the Skin

- The skin consists of two regions,
 - (1) the outer epidermis and
 - (2) the underlying dermis.
- Underlying the skin (subcutaneous) is a layer called the hypodermis. The hypodermis consists mostly of adipose tissue and functions in:
 - (1) connecting the skin to underlying structures,
 - (2) providing a protective cushion, and
 - (3) providing a source of reserve energy (adipose).

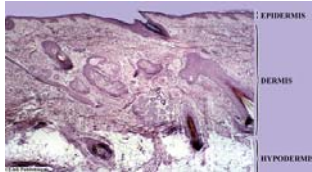


Fig. 9.2

Epidermis

The epidermis is the outermost layer of the skin and is divided into layers according to the structural characteristics of its cells.

Cells of the Epidermis

Keratinocytes
Melanocytes
Langerhan's cells
Merkel cells.

Cells of the Epidermis

- Keratinocytes
 - The structural cells of the epidermis are the **keratinocytes**. Produced in the lower layer (stratum basale) of the epidermis, keratinocytes provide protection from abrasion and water loss.
- Other cells found in the skin include pigment cells called **melanocytes**, disease fighting cells called **Langerhan's cells**, and touch-sensory cells called **Merkel cells**.

Keratinocytes

- Keratinocytes produce and contain the protein keratin. Keratin is organized into cytoskeletal filaments called intermediate filaments, which makes the cells (skin) tough.
- A layer of lipids (glycolipids), located between the keratinocytes, makes the skin almost waterproof.
- The keratinocytes are joined together by cell-to-cell junctions called desmosomes.

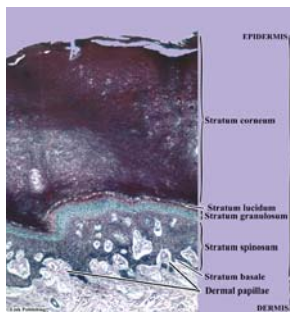


Fig. 9.3

Melanocytes

- Melanocytes are cells that produce a pigment called melanin. In the skin, melanocytes are mostly located in lowest layer of the epidermis, the stratum basale.
- Melanocytes produce melanin containing vesicles (melanosomes) that are transferred to nearby keratinocytes.
- The keratinocytes store melanin in their most superficial surfaces. In this location, melanin blocks the sun's damaging ultraviolet radiation before it strikes and damages the nuclei of the keratinocytes.

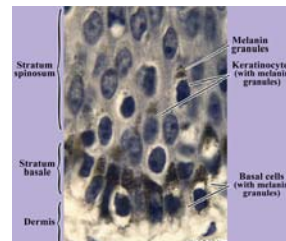


Fig. 9.4

Langerhan's Cells

- Langerhan's cells are specialized cells of the immune system that reside in the epidermis. Produced in the bone marrow, they give phagocytic and immunological functions to the skin.

Layers of the Epidermis

The layers of the epidermis from inner to outer are the

- (1) stratum basale,
- (2) stratum spinosum,
- (3) stratum granulosum,
- (4) stratum lucidum, and
- (5) stratum corneum.

Stratum Basale

- The deepest layer of the epidermis is the stratum basale.
 - Immediately under the stratum basale is the upper layer of the dermis, the dermal papillary layer.
 - Immediately above the stratum basale is the epidermal layer called the stratum spinosum.
- The stratum basale is characterized by the presence of actively dividing keratinocytes, usually in a single layer. The stratum basale also contains melanocytes.

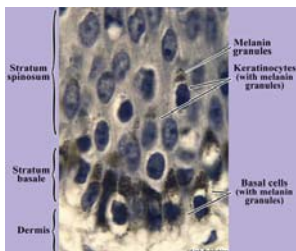


Fig. 9.4

Stratum Spinosum

- The stratum spinosum is located between the deeper stratum basale and the more superficial stratum granulosum.
- The most numerous cells of the layer are the keratinocytes derived from the mitotic activity in the stratum basale.
- Intermediate filaments form a strong intercellular mesh-like cytoskeleton and attach to the numerous cell junctions called desmosomes.
 - Desmosomes and their associated intermediate filaments function in providing great tensile strength that binds the keratinocytes together.

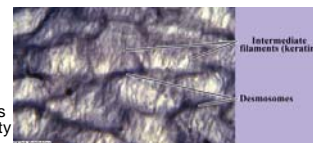


Fig. 9.5

Stratum Spinosum

- During preparation of the tissue, the keratinocytes shrink revealing the desmosomes as “spiny” surface projections (thus, the name stratum spinosum.)
- The stratum spinosum also contains numerous Langerhan’s cells and branches of melanocytes that distribute melanin granules to adjacent keratinocytes.



Fig. 9.6

Stratum Granulosum

- The stratum granulosum is located between the deeper stratum spinosum and the more superficial stratum lucidum.
- This layer is characterized by distinctive granules in the keratinocytes (thus, the name stratum granulosum).
- The layers above the stratum granulosum consist of dead keratinocytes. The death of the cells results in two events: the
 - (1) thickening of the plasma membranes and the
 - (2) disintegration of the granules.

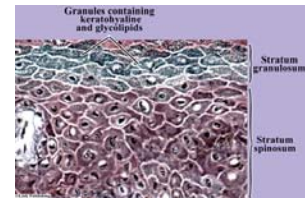


Fig. 9.7

Types of Granules

- Two distinctive types of granules are found in the keratinocytes.
- Keratohyaline
 - One type of granule contains the protein **keratohyaline**. Keratohyaline binds the keratin intermediate filaments together forming larger and stronger filaments.
- Glycolipids
 - The other type of granule is a lamellated granule that contains **glycolipids**. When these granules disintegrate, the glycolipids they release move into the extracellular spaces of the stratum granulosum and the more superficial epidermal layers. The glycolipids function to **waterproof** the epidermis.

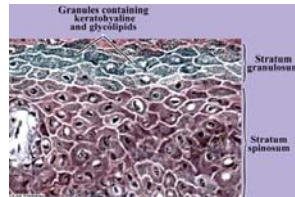


Fig. 9.7

Stratum Lucidum

- The stratum lucidum is only located in thick skin such as the palms, soles, and fingertips. In thick skin, it is located between the deeper stratum granulosum and the more superficial stratum corneum. The stratum lucidum is a thin layer of dead, clear, and thin keratinocytes.

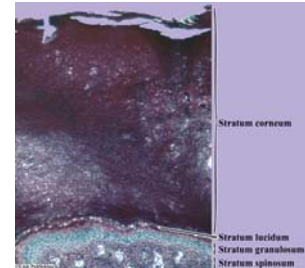


Fig. 9.8

Stratum Corneum

- The stratum corneum forms the outermost layer of the epidermis.
 - In thick skin such as the soles, palms, and fingertips, the stratum corneum is located superficial to the stratum lucidum. In all other skin, the stratum corneum is located superficial to the stratum granulosum.
- The stratum corneum consists of dead, thin, flat keratinocytes.
 - The keratinocytes exhibit great **tensile strength** due to their thickened keratin intermediate filaments. Held together by **desmosomes**, the keratinocytes provide a protective membrane that resists abrasion and other types of physical trauma. The **glycolipids** located in the extracellular spaces produces a nearly **waterproof** barrier.

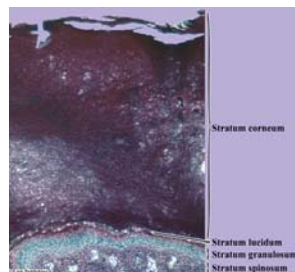


Fig. 9.8

DERMIS

The dermis is the connective tissue layer located under the epidermis and superficial to the subcutaneous layer, or hypodermis.

DERMIS

- The dermis is a layer of connective tissues with structural cells called fibroblasts. Other cells that may be found in the dermis include **phagocytes** (macrophages), **mast cells**, and **melanocytes**.
- The dominate connective tissue fibers are **collagen fibers** that give the dermis strength. Other fibers such as **elastic fibers** give the dermis elasticity and **reticular fibers** contribute to the tissue's framework.
- The dermis consists of two layers; the uppermost layer is the
 - (1) **papillary layer** and the
 - (2) underlying layer is the **reticular layer**.

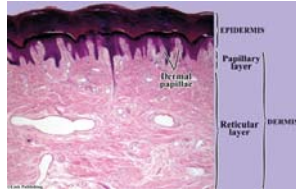


Fig. 9.9

Dermal Papillary Layer

- The papillary layer is located deep to the stratum basale of the epidermis and superficial to the other dermal layer, the reticular layer.
- The papillary layer is formed from areolar tissue (loose connective tissue). The surface of the papillary layer is modified into numerous nipple-like projections, the **dermal papillae**.



Fig. 9.1

Dermal Papillary Layer

- The dermal papillae increase the surface area between the dermis (papillary layer) and the epidermis (stratum basale). Increasing the surface area
 - (1) allows strong bonding between the dermis and epidermis,
 - (2) makes more blood vessels (capillaries) available to support the avascular epidermis,
 - (3) allows for increased density of receptors such as free nerve ending and touch receptors, and
 - (4) makes the skin's surface rough.

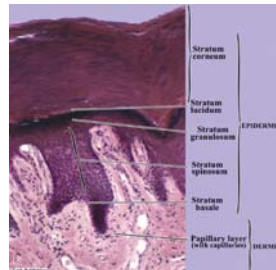


Fig. 9.11

Dermal Reticular Layer

- The reticular layer functions in providing great strength and elasticity to the dermis.
 - The **reticular layer** is formed from **dense irregular connective tissue** with some elastic fibers.
 - Its interwoven collagenous fibers give the dermis great **tensile strength in all directions of movement**. Elastic fibers contribute to the elasticity and recoil of the dermal tissue.
- Dermal ridges** along with the dermal papillae form the epidermal ridges characteristic of fingerprints, sole prints, and palm prints.

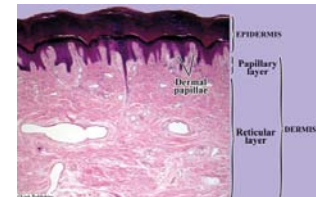


Fig. 9.12

Dermal Reticular Layer

- Located within the reticular layer are numerous blood vessels and nerves. Depending upon location other structures, such as sudoriferous (sweat) glands, sebaceous (oil) glands, and hair follicles, may also be present.

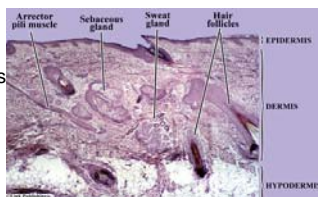


Fig. 9.13

Lab Activity 1 - SKIN Hairless – Fingertip

- Observe a slide preparation labeled "Skin, fingertip."

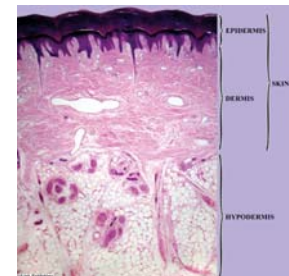


Fig. 9.10

Lab Activity 1 - SKIN Hairless - Epidermis

- The epidermis consists of stratified squamous epithelium, keratinized variety.
- Identify the layers of the epidermis. From inner to outer the epidermal layers are:
 - (1) stratum basale,
 - (2) stratum spinosum,
 - (3) stratum granulosum,
 - (4) stratum lucidum, and
 - (5) stratum corneum.
- The stratum lucidum is only several layers thick and is observed only in thick skin preparations such as the palms, fingertips, and soles.

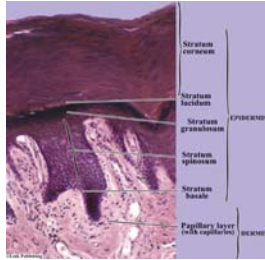


Fig. 9.11

Lab Activity 1 - SKIN Hairless - Dermis

The dermis consists of two layers.

- The uppermost dermal layer is the papillary layer. The papillary layer consists of areolar connective tissue.
 - Dermal papillae increase the surface area between the dermis and the epidermis and along with dermal ridges give unique surface marking (such as fingerprints) to the skin.
- Deep to the papillary layer is the reticular layer. The reticular layer consists of dense irregular connective tissue with elastic fibers.

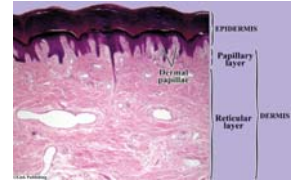


Fig. 9.12

Lab Activity 2 - SKIN Hairy

Observe a slide preparation labeled "Skin, scalp."



Fig. 9.13

Lab Activity 2 - SKIN Hairy - Epidermis

The epidermis consists of a thin layer of stratified squamous epithelium, keratinized variety.

- The epidermis is divided into layers according to the structure of its cells. Identify the layers of the epidermis. From inner to outer the epidermal layers are:
 - (1) stratum basale,
 - (2) stratum spinosum,
 - (3) stratum granulosum, and
 - (4) stratum corneum.
- The stratum lucidum is observed only in thick skin preparations such as the palms, fingertips, and soles.



Fig. 9.14

Lab Activity 2 - SKIN Hairy - Dermis

The dermis consists of two layers.

- The uppermost dermal layer is the **papillary layer**. The papillary layer consists of areolar connective tissue.
- Deep to the papillary layer is the **reticular layer**. The reticular layer consists of dense irregular connective tissue with elastic fibers.

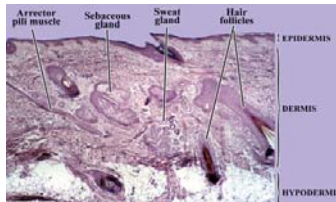


Fig. 9.13

SKIN COLOR

The two primary pigments of skin that contribute to skin color are (1)melanin, and (2)carotene.

Additionally, (1) dermal blood flow and the (2) amount of oxygen binding to hemoglobin of red blood cells, influences skin color.

Melanin

The primary pigment of skin is melanin.

- Melanin is produced by cells called melanocytes. Melanocytes are distributed throughout the skin, but various areas like freckles and the pigmented areas around the nipples, the areolae, have higher concentrations.
- The general distribution and number of melanocytes are considered to be about the same for all races.
- Skin color varies mostly due to the activity of the melanocytes. **Melanocytes function in the production and distribution of melanin to keratinocytes.**

Lab Activity 2 – Skin, pigmented

- Observe a slide preparation labeled “Skin, pigmented.” If a slide preparation is not available, use the following illustrations and photographs to complete the study.



Fig. 9.15

Carotene

- Carotene is the another pigment found in the skin. Carotene is not produced in the skin but has a dietary origin. Carotene is the yellow-to-red pigment abundant in plants such as carrots, sweet potatoes, and certain leafy vegetables. Dietary carotene accumulates mostly in the stratum corneum and the fatty tissue of the hypodermis giving these tissues a slightly yellowish appearance.

Blood Flow and Hemoglobin

- Blood flow in the dermis and the amount of oxygen binding to hemoglobin influences the color of skin. Skin that has a small amount of melanin normally appears pinkish due to the flow of oxygen rich blood in the dermis. Since epidermal melanin masks dermal blood flow, increasing the amount of melanin decreases the influence blood has on skin coloration.
- A person is described as **cyanotic** when the skin, mucous membranes, and nail beds, are bluish due to a lack of oxygenated hemoglobin in the blood.
- Skin may be described as having **pallor**, or **pale**ness, due to lack of blood flow in the dermis.

ACCESSORY STRUCTURES OF THE SKIN

The accessory structures (appendages) of the skin include the

1. hair follicles,
2. nails,
3. sweat (sudoriferous) glands, and
4. sebaceous (oil) glands.

These structures originate from the epidermis and grow into the dermis (or hypodermis.)

Hair

Hair Functions

- Hair functions mostly in **protection**.
 - Hair, especially of the scalp, provides physical protection against skin abrasion and trauma.
 - Hair protects against exposure to sunlight.
 - In areas such as the eyelids, nose and ear canal, hair protects these areas from foreign materials.
 - Because hair is directly associated with sensory receptors (root hair plexus), hair functions to provide protective sensory information regarding mechanical stimuli.

Hair Structure

- A hair, or pilus, is of epidermal origin. During the fourth to sixth months of development, primary epidermal germ centers grow down from the epidermis into the dermis (and hypodermis). These germ centers produce a pilosebaceous unit, a tubular unit that develops into a hair (pilus) and its sebaceous gland (and sometimes an associated apocrine sweat gland.)
- A hair consists of three regions. From outer to inner the regions of the hair are the: (1) cuticle, (2) cortex, and (3) medulla.

Hair Structural Regions

- **Cuticle**
 - The outermost cuticle is formed from a single layer of flat cells that contain abundant keratin. The strong cuticle cells provide strength to the hair. They are arranged partly overlapping one another, with their free (distal) surfaces facing the end of the hair.
- **Cortex**
 - The cortex is located under the cuticle and its keratinized cells form most of the structure of the hair.
- **Medulla**
 - The innermost layer, the medulla, consists of only several rows of keratinocytes.
In hair with color, the keratinocytes of the cortex and medulla are pigmented with various types of melanin. Colorless hair, such as the gray-to-white hair, has little or no melanin.

Hair Structural Regions

- **Shaft**
 - The shaft of the hair extends outward from the skin.
- **Root**
 - The portion of the hair that is housed within the skin is called the root. At the base of the root, a small portion of the dermis extends into the hair follicle. This dermal extension, called a **dermal papilla**, brings dermal blood vessels in close proximity to the region of hair growth, the matrix.

Hair Growth

Hair growth is cyclic, consisting of an active stage and an inactive stage.

- **Active Stage**
 - In the active stage, the cells of the matrix rapidly undergo mitosis to produce new cells. The new cells grow, produce keratin, some pick up melanin (in pigmented hair), and then they die. Depending upon their location in the matrix, the cells become organized into the three regions of the hair. After a period of growth, which varies among the hairy regions of the body, hair enters the inactive stage.
- **Inactive Stage**
 - During this stage the matrix becomes inactive. The hair usually remains attached in the follicle until the active stage begins again. Then the old hair is pushed out by the emergence of the new hair.

Hair follicle

The hair follicle surrounds the root of the hair.

Hair follicle

- Hair Bulb
 - The lower expanded portion of the hair follicle is called the hair bulb. Associated with the hair bulb is a network of nerve fibers (a plexus) with sensory endings. A group of nerve fibers and sensory endings surrounding the hair bulb is called the **root hair plexus**. The root hair plexus makes hairs important structures in gathering sensory information.

Wall of Hair Follicle

The wall of the hair follicle is formed primarily from two coverings (sheaths), the

- (1) internal root sheath,
 - The internal root sheath, surrounding only the lower portion of the follicle, is produced by the outer cells of the growth area, the matrix.
- (2) external root sheath.
 - The external root sheath begins as a tubular invagination of the epidermis. The upper portion of the external root sheath contains the same layers as the epidermis.

Arrector Pili Muscle

- Associated with each hair follicle is a small band of smooth muscle, called the **arrector pili muscle**.
 - One end of the arrector pili muscle attaches at the papillary layer of the dermis and the other end attaches to the connective sheath of the hair follicle.
 - Contraction of the arrector pili muscle causes the hair to become more upright.

Sebaceous (oil) Glands

Sebaceous glands are found associated with the skin of the entire body except for the palms and soles.

Sebaceous (oil) Glands

- A sebaceous gland consists of small clusters (alveoli) of cells. Sebaceous glands produce sebum, which lubricates the skin and helps prevent the growth of bacteria.



Fig. 9.16

Sweat (sudoriferous) glands

Sweat glands are found associated with the skin of the entire body except for the nipples and regions of the external genitalia. There are two types of sweat glands, (1) eccrine (or merocrine) and (2) apocrine.

Sweat (sudoriferous) glands

Eccrine, or merocrine, sweat glands

- Eccrine sweat glands are the most abundant of the sweat glands, and are highly concentrated in the palms, soles, and axillae. Sweat functions to regulate body temperature by cooling the body. Sweat mostly consists of water and electrolytes; other constituents include some amino acids, ammonia, urea, etc.

- Apocrine sweat glands

- Apocrine glands are mostly located in the axillae, anogenital region, and the pigmented area around the nipples, the areolae. The ducts of apocrine glands empty into hair follicles.
- Sweat production by apocrine sweat glands is not significant in body temperature regulation. However, when apocrine sweat is attacked by normal skin bacteria an odor results. This resulting odor leads to speculation that apocrine glands are analogous to scent glands of many animals.

Lab Activity 4

Accessory Structures of Skin

- Observe a slide preparation labeled "Skin, scalp," or "Skin, monkey."
- A slide preparation of hairy skin (43x) shows various accessory structures of the skin. When viewing a single section, continuity among the various structures is difficult to visualize.

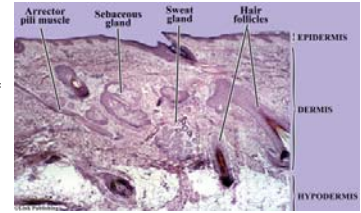


Fig. 9.16

Lab Activity 4

Accessory Structures of Skin

Hair and its associated sebaceous gland (100x) originate from the epidermis during the fourth to sixth months of development. Hair extends into the dermis and hypodermis.

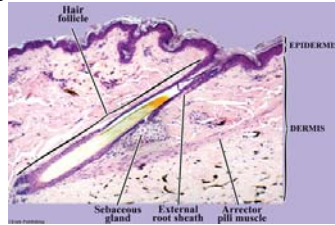


Fig. 9.17

Lab Activity 4

Accessory Structures of Skin

- The base of a hair follicle (430x) contains a projection of the dermis, the dermal papilla.
- The dermal papilla houses blood vessels that nourish the area of hair growth, the matrix.

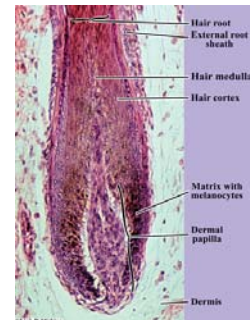


Fig. 9.18

Skin Innervation

The nervous system innervates the skin serving both sensory and motor (control) functions.

Skin Innervation

- The skin is considered the largest sensory organ of the body. Among its receptors, are receptors for touch, temperature, pain, deep pressure, etc. Receptors, when presented with an appropriate stimulus, result in the production of a nerve impulse, which is sent to and interpreted by the central nervous system.
- Two receptors that are frequently observed on slide preparations of the skin are **Meissner's corpuscles** and **Pacinian corpuscles**.

Lab Activity 5 – Meissner's Corpuscle

- Obtain a slide preparation of "Skin, fingertip," or "Meissner's corpuscle."
- Meissner's corpuscles are located in the dermal papillae. Since they function in **light touch**, they are abundant in the fingertips.
 - A Meissner's corpuscle consists of a receptive region (dendrite) surrounded by a connective tissue capsule.

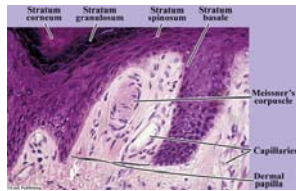


Fig. 9.19

Lab Activity 6 – Pacian Corpuscle

- Search a preparation of either "Skin, hairy" or "Skin, fingertip."
- Pacinian corpuscles are usually located deep in the dermis of the skin. They consist of a central receptor (dendrite) surrounded by concentric layers of supporting cells, and both are covered with a connective tissue capsule.

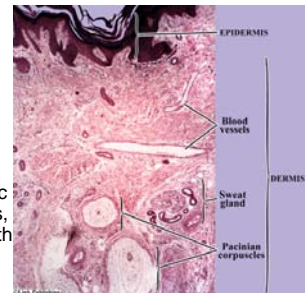
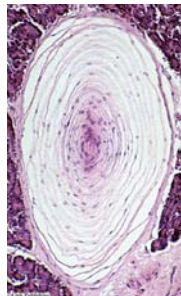


Fig. 9.20

Pacian Corpuscle

- A Pacinian corpuscle consists of a central receptor surrounded by several layers of cells, both covered with a connective tissue capsule.
- Pacinian corpuscles function mainly as pressure and stretch receptors. This Pacinian corpuscle (430x) is located in a visceral organ.



Nails

- Nails are located on the dorsal surfaces of the distal portions of the digits. Nails function in
- (1) providing physical protection to the tips of the digits and
 - (2) increasing the dexterity of the hands, especially for scratching the skin and the movement of small objects.

Structure of a Nail

- Like hair, nails consist of hard keratinized cells of epidermal origin. A nail consists of three parts:
 - (1) a body,
 - (2) a free edge, and
 - (3) a root.

Structure of a Nail

- Nail Body
 - The body of the nail is the main visible portion of the nail. The body of the nail appears pinkish except for a crescent white region, the **lunula**, near its root. The pinkish coloration is due to the presence of oxygen rich blood in the vascular tissue of the nail's underlying layer, the nail bed. At the lunula, the thickened stratum basale associated with the root mostly obscures the vascular tissue.
 - The nail body has a distal free edge and a proximal portion, the nail root.

Structure of a Nail

- Nail Root
 - The nail root is the portion of the nail that is embedded in the skin. Growth of the nail occurs at a region at the base of the nail root called the nail **matrix**. The nail matrix is basically the modified stratum basale of the epidermis except that the nail cells it produces are highly **keratinized**, extremely **hard**, and **organized into the nail**. As cells are added to the nail root at the matrix, the nail slides outward over the nail bed.

Structure of a Nail

- Cuticle
 - The cuticle, or eponychium, is derived from the stratum corneum from the nail root and extends from the root over the superficial proximal surface of the nail body.
- Hyponychium
 - The hyponychium is a region of the stratum corneum to which the nail is distally anchored.