Chapter 15
Integument

15.1. Features and Functions of the Integument and It's Derivatives

The integumentary system consists of the skin, hypodermis, and a series of suborgans or skin derivatives. The skin consists of two tissue layers: The Epidermis, a superficial epithelial component. and the Dermis, an underlying; connective tissue layer. Deep to the dermis of the skin is a second connective tissue layer rich in adipose called the Hypodermis. Together the skin and hypodermis invest the entire external surface of the body. The appendages of the skin develop from the epidermis and so are of epithelial derivation. The skin is the heaviest and most versatile of the body's organs. It accounts for approximately 16% of one's body weight. The integument is an effective protective shield against a wide range of chemical, physical, and biological insults. Ex; The skin is an effective screen against ultraviolet radiation.

The skin is highly regenerative. This allows it to heal quickly. This also allows it to synthesize a variety of substances such as vitamin D. The skin shows great topographic diversity. It ranges from thick to thin, from rough to smooth, from noticeably hairy to less so. The skin is an organ of personal recognition (ex; fingerprints) and sexual attraction. The skin is a very plastic, resilient, and mobile organ. It will conform to the body's contours. It will readily adapt to constant body movements. The skin is an important thermoregulatory organ. Body temperature is controlled by vasoconstriction and vasodilation of the cutaneous vasculature. The skin also allows for cooling of the body through evaporational cooling provided by sweating.

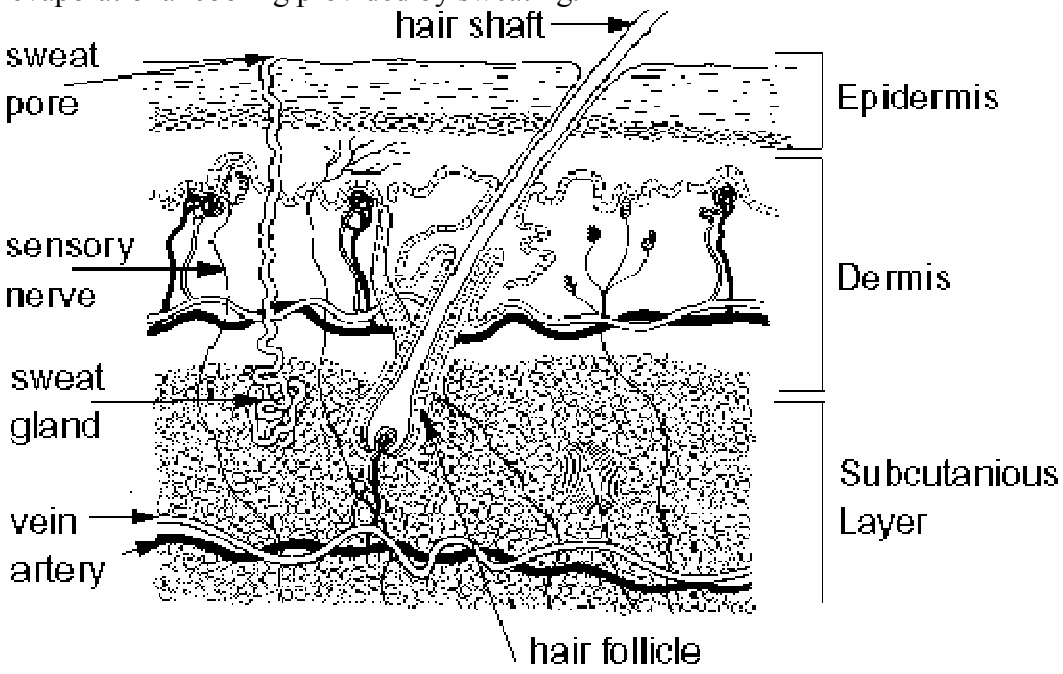

Fig.15.1. Structure of the skin

The integument is a very vascular structure. It can store up to 4.5% of the total blood

volume. This vasculature can also exert a control over blood pressure. Capillary shunts in the integument can lower blood pressure. The skin can be considered to be the largest sense organ in the body. It detects pain, pressure, heat, cold, and touch. The integument is continuous with internal mucus membranes at the eyelids, nostrils, lips, prepuce, vulva, and anus. These transitional zones are termed Mucocutaneous Junctions. The integument is involved in the immune system. This is due in part to the Langerhans Cells, the macrophages of the integument. They monitor the external and internal integumentary environments. They also sensitize lymphocytes against antigens by acting as "presenter cells".

15.2. The Epidermis

15.2.1. Introduction

The epidermis consists of stratified squamous epithelium, keratinized type. It is composed of four different cell types or lines: keratinocytes, melanocytes, Langerhans cells, and Merkel cells. These four groups of cells can be considered to make up a series of epidermal minisystems:

1. the keratinizing or malpighian system,
2. the pigmentary or melanocyte system,
3. the reticuloendothelial or Langerhans system,
4. and the Merkel system.

Being an epithelium the epidermis lacks blood and lymph vessels. So it's cells must receive oxygen and nutrients via diffusion from the dermis The epidermis does contain sensory nerve endings. However the bulk of integumentary innervation occurs in the dermis.

15.2.2. The Layers of the Epidermis

The stratified epithelium of the epidermis is divided into layers based upon the life stages of the keratinocytes, the predominant cell type. The layers progress from the deepest, most basal, to the superficialmost. The deeper, living, layers are collectively called the Stratum Malpighi. The stratum malpighi will always be composed of three layers: stratum basale, stratum spinosum, and stratum granulosum. The superficial, dead, layers are collectively called the Stratum Corneum. The stratum corneum will be of two layers in thick skin and one layer in thin skin. In thick skin the two layers are stratum lucidum and stratum corneum (proper). Thick skin is restricted to the palms and soles in humans. In thin skin the stratum lucidum is absent. Thin skin is much more widely distributed than is thick skin.

a) The Histology of the Epidermal Layers

1) The Stratum Malpighi - The viable cell layers

a] The Stratum Basale/Stratum Germinativum: The stratum basale is the deepest layer and rests on the basement membrane. It is a single layer of cuboidal or columanr shaped cells. This is a layer of great mitotic activity. It serves as a source of stem cells for new keratinocytes.

b] The Stratum Spinosum: The stratum spinosum is actually several layers of polyhedral shaped cells. The term "spinosum" refers to the spine-like appearance of these cells under early light microscopic studies. Today these "spines" are known to be an artifact due to excessively dehydrating the tissue. The stratum spinosum also displays some mitotic activity and the beginning of keratin deposition in the keratinocytes (slight).

c] The Stratum Granulosum: The stratum granulosum is made up of several layers of flattened cells. These keratinocytes have conspicuous lamellated granules of keratohyaline. It is in this stratum that keratinization begins in earnest and the deposition of keratin achieves it's greatest rate. There is no mitotic activity in this layer or in any layers superficial to it.

2) The Stratum Corneum - The horny cell layers.

a] The Stratum Lucidum: The stratum lucidum is made up of several layers of flattened, anucleate cells. These keratinocytes are dead. Their living material has been replaced by keratin. As it's name indicates, the stratum lucidum has a clear appearance. It is found only in thick skin.

b] The Stratum Corneum/Stratum Corneum Proper

The stratum corneum proper is composed of many layers of dead, flattened, keratin-rich cells. The number of layers will vary based on the degree of mechanical abuse.

15.2.3. The Cells of the Epidermis

a) The Keratinocytes

Keratinocytes are the most abundant cell type of the epidermis. They are named for the rich amounts of keratin which will accumulate in the cell as it matures. The production of keratin is the main function of these cells. The basal keratinocytes, along with producing new keratinocytes, are the developmental source of the cutaneous appendages. It is the morphology of the various keratinocyte life stages which is the basis for naming the layers of the epidermis. The phases of cytomorphosis of the keratinocyte are: proliferation, differentiation, and exfoliation.

1] Proliferation (i.e.; mitosis) - the production of new keratinocytes. The stratum basale is an inexhaustible source of keratinocytes. Due to it's high mitotic activity the epidermis is continually renewing itself to compensate for cell loss. Normally the rate of proliferation is equal to the rate of exfoliation.

2] Differentiation - the process of keratinization and the changes which the keratinocytes undergo towards this end. As the keratinocytes migrate superficially and lose their mitotic potential they begin to synthesize amorphous proteins and increasing amounts of fibrillar proteins to form the fibril-matrix complex, or "keratin pattern", that fills the cornified cells. In the stratum granulosum keratohyaline granules appear. These granules will become part of the keratin pattern. Also, in the stratum granulosum, the keratinocytes contain smaller membrane-bound organelles called Keratinosomes/Membrane-Coating granules. The products of the keratinosomes will be discharged extracellularily and will serve to bind the keratinocytes to one another in the stratum corneum.

3] Exfoliation - the lose of keratinocytes from the surface layers of the epidermis.

This is the final stage in the keratinocyte life cycle. It is a continuous process whereby the outermost surface layers of keratin-rich cells are shed away by the body.

b) The Melanocytes

The melanocytes are scattered among the keratinocytes throughout the stratum malpighi, hair follicles, and dermal connective tissues. They produce the protective pigment Melanin. Melanocytes are derived from neural crest ectoderm. Morphologically they are dendrite bearing cells with a prominent perinuclear cytoplasm. They also have cytoplasmic processes which extend to neighboring keratinocytes. Melanocytes produce

melanin through the process of Melanogenesis. Melanogenesis occurs in the Melanosomes of the melanocytes. Melanosomes are membrane bound, pigment forming organelles. They contain the amino acid Tyrosine which undergoes oxidation to produce melanin. Melanin will accumulate in the melanosomes as melanogenesis progresses. Once melanogenesis is completed, melanin bearing melanosomes are transferred to the adjacent keratinocytes by the cytoplasmic processes of the melanocytes. There are no sex or racial difference in the approximate number of melanocytes. The differences are due to the size and number of the melanosomes as well as the distribution of the melanocytes within the keratinocytes.

c) The Langerhans cells

These cells are located throughout the stratum malpighi. Like the monocytes they are derived from, Langerhans cells have an indented nucleus. They have a clear cytoplasm containing modest amounts of endoplasmic reticuli, Golgi, and mitochondria. They also have rod-shaped granules called Langerhans Granules. The function of Langerhans granules is still undetermined. Langerhans cells clear antigens from the integument. This is done both by phagocytosis and by sensitizing lymphocytes to the antigen. The Langerhans cell will bind to antigens and migrate to the lymph nodes so as to stimulate production of antibodies specific for the antigen. Today Langerhans cells are known to exist in other stratified squamous epithelia. Ex; the oral mucosa,the esophagus, the cervix, and the vagina. They are also found in hair follicles, sebaceous glands and their ducts, apocrine gland ducts, the dermis, the thymus, lymph nodes, and dermal lymph vessels. So Langerhans cells may prove to be circulating cells of a greater immunological function.

d) The Merkel Cells

They are distributed among the keratinocytes in or near the stratum basale. Merkel cells have a distinctive, clear appearance. They have an irregularly shaped nucleus and many scattered granules. These granules **may** produce polypeptide hormones but their placement in the neuroendocrine system is strictly conjecture at this point. Merkel cells have an intimate association with dermal and epidermal nerve fibers that are believed to be sensory in nature. As a result they are believed to be involved in touch reception..

15.3. The Dermis

15.3.1. Introduction

Like all epithelia, the epidermis rests on a basement membrane which sits on an underlying loose connective tissue. The dermis is this connective tissue layer in the skin. The interface between the dermis and epidermis is called the Dermoepidermal Junction. It varies throughout the body from relatively smooth in thin skin to highly corrugated in thick skin. Projections of the dermis called Papillae interdigitate with the epidermis to better establish this interaction. Like other connective tissues, the dermis is composed of various morphologic and functional frameworks,; collagen, reticular, and elastic fibers embedded in an amorphous ground substance. It also includes the customary nerves, blood vessels, and lymph vessels. The dermis will also contain various cutaneous appendages which have invaginated from the epidermis.

Smooth muscle is found in the dermis. It is associated with the blood vessels. It is also associated with the hair follicles where it is known as the Arrector Pili Muscle. In some regions of the body dermal smooth muscle may also be arranged into a meshwork Ex; the

dartos muscle of the scrotum. The cellular elements are relatively sparse. The most abundant cell type is the fibroblast. There are also macrophages, mast cells, melanocytes, plasma cells, adipocytes, and a variety of wandering leucocytes.

15.3.2. The Dermis Is Divided Into Two Layers

a) The Papillary Layer: The papillary layer is the most superficial layer, it sits just below the epidermis. It gets it's name from the dermal papillae which interdigitate with undulations of the epidermis. The papillary layer comprises 20% of the dermis. The papillary layer is a loose connective tissue. It is characterized by a loose arrangement of thin fibers embedded in a considerable amount of ground substance.

b) The Reticular Layer: The reticular layer is the deeper portion of the dermis, it sits just above the hypodermis. The reticular layer comprises 80% of the dermis. The reticular layer is a dense irregular connective tissue. It is characterized by a dense pattern of thick fibers embedded in lesser amounts of ground substance. There are fewer cellular elements in this portion of the dermis. The term "reticular" comes from the meshwork (or retinaculumn) of collagen fibers in this layer; not to the presence of reticular fibers. Most of the nerve supply and all of the blood supply of the integument is found in the dermis and hypodermis. Remember the vasculature of the dermis services the epidermis as well as the dermis. There are many atriovenous anastomes to allow for atriovenous shunts past capillary beds to help control such as blood volume and heat loss.

13.3.3. Functions of the Dermis

(a) It protects and cushions the body. (b) It provides resistance to mechanical stresses. c) It serves as a barrier to infection. (d) It participates actively in wound healing and inflammation. (e) It has an inductive effect on the epidermis. (f) It is involved in the thermoregulation of the body..

13.4. The Hypodermis

The hypodermis is a layer of loose connective tissue, rich in adipocytes, located immediately deep to the skin. There are two classes of hypodermis:

13.4.1. Panniculus Adiposis - a hypodermis which is massively infiltrated with adipocytes. This makes up the bulk of the hypodermis in humans.

13.4.2. Panniculus Carnosus - a hypodermis which contains sheets of skeletal muscle. These cutaneous muscles move the skin. The panniculus carnosus is well developed in all mammals except for humans. In humans the panniculus carnosus is restricted to the anterior neck and the muscle component is known as the platysma muscle. The hypodermis will vary in thickness throughout the body and in response to nutritional levels. The hypodermis is connected to underlying structures such as the deep fascia, aponeuroses, or periosteum. The hypodermis has a number of functions:

(1) It provides support for the above lying skin. (2) It stores fat. (3) It cushions the body. (4) It insulates the body. (5) It serves as a passage for the large blood vessels of the skin.

The dermis and hypodermis contain some of the sensory receptors of the integument:

1) Pacinian Corpuscles: Pacinian corpuscles are large encapsulated dendritic endings found in the hypodermis, and occasionally in the dermis, which monitor vibrations. They are found in all of the deep connective tissues of the body. They are especially abundant in the fingers and also in deep musculoskeletal tissues

2) Genital Corpuscles: Genital corpuscles are similar to pacinian corpuscles but are

restricted to the external genitalia.

3) Meissner's Corpuscles: These are smaller encapsulated dendritic endings found in the dermal papillae of hairless skin. They are especially abundant in the tips of the fingers and toes.Meissner's corpuscles are touch receptors..

13.5. The Cutaneous Appendages

13.5.1 The Sudoriferous Glands

Sudoriferous glands are the sweat glands. Based on mode and nature of secretion the sudoriferous glands are divided into two classes: apocrine and eccrine.

a) Eccrine Glands

Eccrine glands are the most numerous and widely distributed class of sudoriferous gland. They are found throughout the integument being absent only in a very few areas. They are absent at the lips, glans penis, glans clitoris, labia minora, and beneath the nails. They are at their greatest numbers per unit area on the palms and soles. Eccrine glands are simple coiled tubular glands. Their tightly coiled secretory unity may be located in either the dermis or hypodermis. This causes two subclasses of eccrine glands to be recognized: Shallow and Deep Eccrine Glands (respectively).

Histologically, the duct is composed of a two layered stratified cuboidal epithelium. The secretory unit is composed of a single layer of pyramidal shaped cells. Myoepithelial cells are located between the secretory cells and the basement membrane. The secretory portion is composed of two cell types:

a} Clear Cells - clear staining cells having a broad base and a narrow apex. They secrete a solute containing, watery fluid through an active transport-diffusion mechanism (a form of merocrine secretion).

b} Dark Cells - darkly staining cells having a narrow base and a broad apex. They secrete a mucin-rich fluid through merocrine secretion. Eccrine glands function primarily in thermoregulation and slightly in the removal of wastes.

b) Apocrine Glands

Apocrine glands are much less widely distributed than are eccrine glands. They are found primarily in the axillary and perianal areas. They are associated with hair follicles. They become active with the onset of puberty. Structurally apocrine glands are similar to eccrine glands in that they are also coiled tubular glands. However the secretory portion is larger in apocrine glands. The secretory portion can also be located in either the dermis or hypodermis. The duct will run parallel to a hair follicle. It opens into the hair follicle. **Typically** the duct opens into the hair follicle above the opening point of the sebaceous gland.

Histologically, The duct is a two layered stratified cuboidal epithelium. The secretory portion is composed of a single layer of cuboidal or columnar shaped cells resting on a basement membrane. Between the secretory cells and the basement membrane are myoepithelial cells. The secretory cells have basally oriented nuclei, numerous mitochondria, numerous Golgi, and numerous granules. Their product is secreted by merocrine, apocrine, and holocrine mechanisms. Along with playing a role in thermoregulation and the removal of wastes, apocrine glands may also release pheromones and may play a role in chemical communication.

(i) Specialized Apocrine Glands

a] Ceruminous Glands - lining the external auditory canal these glands produce Cerumen,

ear wax.
b] Mammary Glands

13.5.2. The Sebaceous Glands

Sebaceous glands are also widely distributed glands being found on all surfaces of the body except for the soles and palms. The secretory portion is located in the dermis. Their ducts are associated with hair follicles and they release their product into the upper hair follicle. Sebaceous glands are simple branched acinar glands.

Histologically, the duct is composed of stratified squamous epithelium, keratinized. It is continuous with the epithelium of the epidermis and/or hair follicle. The secretory portion consists of acinar cells in various stages of differentiation. In the periphery of the acinus the cells are small and resemble basal keratinocytes. Towards the center of the acinus the cells are enlargened with accumulated lipid. As the amount of lipid increases in the cell, the cell dies.

The Mode of Secretion and Secretion is as follows: The sebaceous glands secrete their product by holocrine mechanisms. The product of the sebaceous gland is Sebum, oil. The release of sebum is under hormonal control. Sebaceous glands become enlarged and more active with the onset of puberty. Sebum may lubricate and soften hairs and the cornified layers of the skin. It may also help to prevent their drying out. Sebum may also contain some pheromones.

15.5.3. The Hair

Hairs are filamentous strands of fused keratinocytes projecting from the surface of the skin. Hairs are produced by and located in Follicles. Follicles are epidermal invaginations into the dermis and/or hypodermis. Hairs are found over most of the body. The distribution, number, and thickness of the follicles will vary. The follicles are associated with sebaceous glands and form units called Pilosebaceous Units. Hairs grow to a certain length, enter a resting phase, are shed, and are then replaced periodically. This is called the Hair Growth Cycle. Projecting into the base of the hair follicle is an indentation of highly vascularized connective tissue known as the Dermal Papillae. The dermal papillae has an inductive influence on hair formation. If the dermal papillae is destroyed the hair can not be replaced. The keratin of the hair is different from the keratin of the epidermis being what is called "Hard Keratin".

a) Structure

The hair has an exposed portion called the Shaft. The shaft has a central Medulla typically. Surrounding the medulla of the shaft is the Cortex. Surrounding the cortex is the Cuticle which is composed of overlapping plates of keratinocytes. The hair also has a portion embedded in the integument called the Root. The root also has an expanded portion at it's base called the Bulb. The root contains Matrix Cells. Matrix cells are pleuripotent stem cells located in the hair bulb and in the dermal papillae. They have a high degree of mitotic activity and will give rise to the keratinocytes of the hair. Matrix cells derive from basal epidermal cells. The root also will contain some melanocytes, especially in the hair bulb and even in the dermal papillae.

As in the epidermis, these melanocytes will provide pigmentation to the developing keratinocytes. Surrounding the root, and those portions of the shaft located within the skin, are the Root Sheaths. The Internal Root Sheath is the inner sheath. It is composed of a sleeve of cells extending from the root to about the level of the sebaceous pore. The cells are derived from matrix cells. The External Root Sheath is located outside of the

internal root sheath. It is an extension of the basal layers of the surrounding epidermis. The hair follicle is made up of the embedded portions of the hair and the surrounding root sheaths. Associated with the hair follicle are:sebaceous glands, on rare occasion an apocrine gland, the arrector pili muscle, and the Root Hair Plexus. The root hair plexus is a meshwork of free dendritic endings located at the base of the hair. These nerve endings are tactile receptors. The hair plays a role in: thermoregulation, protection, and tactile perception.

15.5.4. The Nails

The finger and toe nails are tightly packed plates of keratinocytes that cover the dorsal surfaces of the digits at their distal ends. Like hair, nails are composed of hard keratin. The nail will have a Matrix located in the dermis (as did the hair). The matrix is mitotically active and will give rise to the nail plate. It is derived from an invagination of the epidermis. The distal portion of the matrix can often be seen in the nail as a half moon shaped white area called the Lunula. The portion of the skin that the nail covers or rest on is called the Nail Bed. The epidermis of the nail bed consists only of the stratum basale and stratum spinosum typically.