Chapter 1

Anatomy of Skin

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The skin is the largest organ of the body, accounting for about 15% of the total adult body weight. It performs many vital functions, including protection against external physical, chemical, and biologic assailants, as well as prevention of excess water loss from the body and a role in thermoregulation. The skin is continuous, with the mucous membranes lining the body's surface.[1] The integumentary system is formed by the skin and its derivative structures (see Figure 1). The skin is composed of three layers: the epidermis, the dermis, and subcutaneous tissue[1].

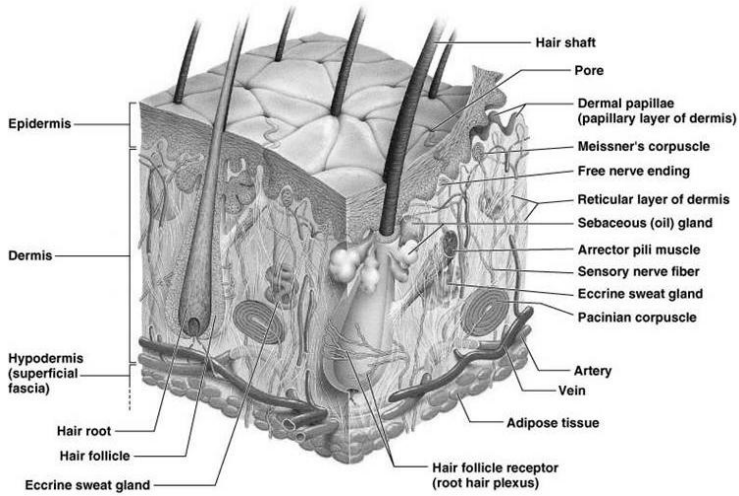

Figure 1. *Cross section of the skin.*

1.1 Skin Performs the Following Functions:[2–4]

Protection: an anatomical barrier from pathogens and damage between the

internal and external environment in bodily defense; Langerhans cells in the skin are part of the adaptive immune system.

Sensation: contains a variety of nerve endings that react to heat and cold, touch, pressure, vibration, and tissue injury.

Heat regulation: the skin contains a blood supply far greater than its requirements which allows precise control of energy loss by radiation, convection and conduction. Dilated blood vessels increase perfusion and heatloss, while constricted vessels greatly reduce cutaneous blood flow and conserve heat.

Control of evaporation: the skin provides a relatively dry and semi-impermeable barrier to fluid loss. Loss of this function contributes to the massive fluid loss in burns.

Aesthetics and communication: others see our skin and can assess our mood, physical state and attractiveness.

Storage and synthesis: acts as a storage center for lipids and water, as well as a means of synthesis of vitamin D by action of UV on certain parts of the skin.

Excretion: sweat contains urea, however its concentration is 1/130 that of urine, hence excretion by sweating is at most a secondary function to temperature regulation.

Absorption: the cells comprising the outermost 0.25–0.40 mm of the skin are "almost exclusively supplied by external oxygen", although the "contribution to total respiration is negligible" In addition, medicine can be administered through the skin, by ointments or by means of adhesive patch, such as the nicotine patch or iontophoresis. The skin is an important site of transport in many other organisms.

Water resistance: The skin acts as a water resistant barrier so essential

nutrients aren't washed out of the body.

1.2 Structure of the Skin

The integumentary system is formed by the skin and its derivative structures (see Figure 1). The skin is composed of three layers: the epidermis, the dermis, and subcutaneous tissue[1].

1.2.1 Epidermis[5]

The epidermis contains no blood vessels and is entirely dependent on the underlying dermis for nutrient delivery and waste disposal via diffusion through the dermoepidermal junction. The epidermis is a stratified, squamous epithelium that consists primarily of keratinocytes in progressive stages of differentiation from deeper to more superficial layers. The named layers of the epidermis include the stratum germinativum, stratum spinosum, stratum granulosum, and stratum corneum.

Keratinocytes

The stratum germinativum, or the basal layer, is immediately superficial to the dermoepidermal junction. This single cell layer of keratinocytes is attached to the basement membrane via hemidesmosomes.

As keratinocytes divide and differentiate, they move from this deeper layer to the more superficial layers. Once they reach the stratum corneum, they are fully differentiated keratinocytes devoid of nuclei and are subsequently shed in the process of epidermal turnover. Cells of the stratum corneum are the largest and most abundant of the epidermis. This layer ranges in thickness from 15-100 or more cells depending on anatomic location and is the primary protective barrier

from the external environment.

Melanocytes

Melanocytes, derived from neural crest cells, primarily function to produce a pigment, melanin, which absorbs radiant energy from the sun and protects the skin from the harmful effects of UV radiation. Melanin accumulates in organelles termed melanosomes that are incorporated into dendrites anchoring the melanosome to the surrounding keratinocytes. Ultimately, the melanosomes are transferred via phagocytosis to the adjacent keratinocytes where they remain as granules. Melanocytes are found in the basal layer of the epidermis as well as in hair follicles, the retina, uveal tract, and leptomeninges. These cells are the sites of origin of melanoma.

In areas exposed to the sun, the ratio of melanocytes to keratinocytes is approximately 1:4. In areas not exposed to solar radiation, the ratio may be as small as 1:30. Absolute numbers of melanosomes are the same among the sexes and various races. Differing pigmentation among individuals is related to melanosome size rather than cell number. Sun exposure, melanocyte-stimulating hormone (MSH), adrenocorticotropic hormone (ACTH), estrogens, and progesterones stimulate melanin production. With aging, a decline is observed in the number of melanocytes populating the skin of an individual. Since these cells are of neural crest origin, they have no ability to reproduce.

Langerhans Cells

Langerhans cells originate from the bone marrow and are found in the basal, spinous, and granular layers of the epidermis. They serve as antigen-presenting cells. They are capable of ingesting foreign antigens, processing them into small peptide fragments, binding them with major histocompatibility complexes, and

subsequently presenting them to lymphocytes for activation of the immune system. An example of activation of this component of the immune system is contact hypersensitivity.

Merkel Cells

Merkel cells, also derived from neural crest cells, are found on the volar aspect of digits, in nail beds, on the genitalia, and in other areas of the skin. These cells are specialized in the perception of light touch.

1.2.2 Dermis[6]

The primary function of the dermis is to sustain and support the epidermis. The dermis is a more complex structure and is composed of 2 layers, the more superficial papillary dermis and the deeper reticular dermis. The papillary dermis is thinner, consisting of loose connective tissue containing capillaries, elastic fibers, reticular fibers, and some collagen. The reticular dermis consists of a thicker layer of dense connective tissue containing larger blood vessels, closely interlaced elastic fibers, and coarse bundles of collagen fibers arranged in layers parallel to the surface.

The reticular layer also contains fibroblasts, mast cells, nerve endings, lymphatics, and epidermal appendages. Surrounding the components of the dermis is the gel-like ground substance, composed of mucopolysaccharides (primarily hyaluronic acid), chondroitin sulfates, and glycoproteins. The deep surface of the dermis is highly irregular and borders the subcutaneous layer, the panniculus adiposus, which additionally cushions the skin.

Fibroblasts

The fibroblast is the major cell type of the dermis. These cells produce and

secrete procollagen and elastic fibers. Procollagen is terminally cleaved by proteolytic enzymes into collagen that aggregates and becomes cross-linked. These tightly cross-linked collagen fibers provide tensile strength and resistance to shear and other mechanical forces. Collagen makes up 70% of the weight of the dermis, primarily Type I (85% of the total collagen) and Type III (15% of the total collagen). Elastic fibers constitute less than 1% of the weight of the dermis, but they play an enormous functional role by resisting deformational forces and returning the skin to its resting shape.

1.3 Epidermal Appendages[7, 8]

Epidermal appendages are intradermal epithelial structures lined with epithelial cells with the potential for division and differentiation. These are important as a source of epithelial cells, which accomplish reepithelialization should the overlying epidermis be removed or destroyed in situations such as partial thickness burns, abrasions, or split-thickness skin graft harvesting.

Epidermal appendages include the following:

- Sebaceous glands
- Sweat glands
- Apocrine glands
- Mammary glands
- Hair follicles

They often are found deep within the dermis and in the face may even lie in the subcutaneous fat beneath the dermis. This accounts for the remarkable ability of the face to reepithelialize even the deepest cutaneous wounds.

1.3.1 Sebaceous Glands

Sebaceous glands, or holocrine glands, are found over the entire surface of the body except the palms, soles, and dorsum of the feet. They are largest and most concentrated in the face and scalp where they are the sites of origin of acne. The normal function of sebaceous glands is to produce and secrete sebum, a group of complex oils that include triglycerides and fatty acid breakdown products, wax esters, squalene, cholesterol esters, and cholesterol. Sebum lubricates the skin to protect it against friction and makes the skin more impervious to moisture.

1.3.2 Sweat Glands

Sweat glands, or eccrine glands, are found over the entire surface of the body except the vermillion border of the lips, the external ear canal, the nail beds, the labia minora, and the glans penis and the inner aspect of the prepuce. They are most concentrated in the palms and soles and the axillae.

Each gland consists of a coiled secretory intradermal portion that connects to the epidermis via a relatively straight distal duct. The normal function of the sweat gland is to produce sweat, which cools the body by evaporation. The thermoregulatory center in the hypothalamus controls sweat gland activity through sympathetic nerve fibers that innervate the sweat glands. Sweat excretion is triggered when core body temperature reaches or exceeds a set point.

1.3.3 Apocrine and Mammary Glands

Apocrine glands are similar in structure, but not identical, to eccrine glands. They are found in the axillae, in the anogenital region, and, as modified glands, in the external ear canal (ceruminous glands), the eyelid (Moll's glands), and the

breast (mammary glands). They produce odor and do not function prior to puberty, which means they probably serve a vestigial function. The mammary gland is considered a modified and highly specialized type of apocrine gland.

1.3.4 Hair Follicles

Hair follicles are complex structures formed by the epidermis and dermis. (See the image below.) They are found over the entire surface of the body except the soles of the feet, palms, glans penis, clitoris, labia minora, mucocutaneous junction, and portions of the fingers and toes. Sebaceous glands often open into the hair follicle rather than directly onto the skin surface, and the entire complex is termed the pilosebaceous unit.

1.4 Cutaneous Blood Supply

Cutaneous vessels ultimately arise from underlying named source vessels. Each source vessel supplies a 3-dimensional vascular territory from bone to skin termed an angiosome. Adjacent angiosomes have vascular connections via reduced caliber (choke) vessels or similar caliber (true) anastomotic vessels. The cutaneous vessels originate either directly from the source arteries (septocutaneous or fasciocutaneous perforators) or as terminal branches of muscular vessels (musculocutaneous perforators).

During their course to the skin, the cutaneous vessels travel within or adjacent to the connective tissue framework and supply branches to each tissue with which they come into close contact (bone, muscle, fascia, nerve, fat). They emerge from the deep fascia in the vicinity of the intermuscular or intramuscular septa or near tendons and travel toward the skin, where they form extensive subdermal and dermal plexuses. The dermis contains horizontally arranged superficial and deep

plexuses, which are interconnected via communicating vessels oriented perpendicular to the skin surface. Cutaneous vessels ultimately anastomose with other cutaneous vessels to form a continuous vascular network within the skin. Clinically, this extensive horizontal network of vessels allows for random skin flap survival[9–11].

1.5 Lymphatic's

Skin lymphatics parallel the blood supply and function to conserve plasma proteins and scavenge foreign material, antigenic substances, and bacteria. Blind-ended lymphatic capillaries arise within the interstitial spaces of the dermal papillae. These unvalved, superficial dermal vessels drain into valved deep dermal and subdermal plexuses. These then coalesce to form larger lymphatic channels, which course through numerous filtering lymph nodes on their way to join the venous circulation near the subclavian vein – internal jugular vein junction bilaterally[6].

1.6 Skin Innervation

Sensory perception is critically important in the avoidance of pressure, mechanical or traumatic forces, and extremes of temperature. Numerous specialized structures are present in the skin to detect various stimuli. As previously mentioned, Merkel cells of the epidermis detect light touch. Meissner corpuscles also detect light touch. These are found in the dermal papillae and are most concentrated in the fingertips. Pacini corpuscles are found deep within the dermis or even in the subcutaneous tissue. These structures are specialized to detect pressure.

Pain is transmitted through naked nerve endings located in the basal layer of the epidermis. Krause bulbs detect cold, whereas Ruffini corpuscles detect heat. Heat, cold, and proprioception also are located in the superficial dermis. Cutaneous nerves follow the route of blood vessels to the skin. The area supplied by a single spinal nerve, or a single segment of the spinal cord, is termed a dermatome. Adjacent dermatomes may overlap considerably, which is important to note when performing field blocks with local anesthesia[12].