Integumentary System

Skin trivia

The skin has a surface area of 1.5 - 2 square meters, weighs from 9 to 11 pounds (about 7% of total adult body weight).

A square centimeter of skin contains about 70 cm of blood vessels, 55 cm of nerves, 15 oil glands, 230 sensory receptors, and about ½ a million cells.

The skin varies in thickness from about 1.5 mm to 4.0 mm depending on its location on the body.

Skin is made up of two distinct regions, the epidermis and the dermis.

Epidermis

The epidermis is the outermost protective shield of the body.

It is a thick keratinized stratified squamous epithelium consisting of 4 cell types and 4 or 5 distinct layers.

Cell types

Keratinocytes - produce keratin. Keratin is a fibrous protein that gives skin the majority of its protective properties. Keratinocytes are tightly connected to each other. They arise in the stratum basale (the deepest layer of the skin) and are pushed upward to the surface as they undergo almost continuous mitosis. By the time they reach the surface layers of the skin they a little more than dead, scalelike bags of keratin.

Melanocytes - are specialized epithelial cells that produce melanin. Melanin is the pigment that gives akin, and hair, its particular color. Melanocytes are spider-shaped cells whose branches reach to the keratinocytes in the stratum basale. The melanin produced in the melanocytes is passed through these branches to the keratinocytes where it is deposited. Melanin serves to protect cells from the harmful effects of UV radiation.

Langerhans' Cells - arise from the bone marrow and migrate to the epidermis. These are specialized macrophages which help to activate our immune system.

Merkel Cells - are found in small numbers at the junction between the dermal and epidermal layers. Each Merkel cell is associated with a special nerve ending and hence these cells function as sensory receptors for touch.

Layers of the Epidermis

In thick skin we see 5 layers. In thin skin there are only 4 layers.

Stratum basale - is the deepest epidermal layer. it is firmly attached to the underlying dermis. Mostly it is a single row of cells representing the youngest keratinocytes. Here we should see many mitotic nuclei representing the rapid division of these cells. 10% to 25% of the cells seen here are melanocytes. We will also find some Merkel cells here.

Stratum spinosum - is several cells thick. These cells are connected by a weblike system of intermediate filaments made mostly of tension resisting bundles of keratin filaments.

Stratum granulosum - is a layer 3 to 5 cells thick where a dramatic change in the keratinocytes is occurring. The cells flatten and their nuclei and organelles begin to disintegrate. We begin to see keratohyaline granules and lamellated granules.

Keratohyalin granules - associate with the keratin filaments and cause them to aggregate in parallel arrays.

Lamellated granules - contain a waterproofing glycolipid that is spewed into the extracellular space and is a major factor in slowing water loss across the epidermis.

Stratum lucidum - is found only in thick skin. It is found as a very thin layer of cells between the stratum granulosum and the stratum corneum. Here we also see keratohyaline granules associating with keratin filaments.

Stratum corneum - is the outermost layer of the skin. It is 20 to 30 cells thick. The keratin and thickened plasma membranes of the cells found here protect the skin against abrasion and penetration. The glycolipid between the cells provides waterproofing. Keep in mind that this layer of the skin is completely dead.

Dermis

The dermis is a strong, flexible connective tissue layer. It contains all of the cell types normally found in connective tissue: fibroblasts, macrophages, mast cells, and white blood cells, to name a few.

This layer is heavily embedded with collagen, elastin, and reticular fibers.

The dermis is richly supplied with blood vessels, lymphatic vessels, and nerve fibers. Although they are derived from epidermal tissues we will also find hair follicles, and oil and sweat glands in the dermis.

The dermis can be divided into two layers, the papillary layer and the reticular layer

Papillary layer - Is the tine superficial layer of the dermis. It is located just deep to the stratum basale of the epidermis. It is mostly composed of connective tissue highly invested with blood vessels. Its superior surface is folded into projections called dermal papillae. Many of these dermal papillae contain capillary loops or house free nerve endings (pain) and touch receptors (Meissner's corpuscles.

Reticular layer - accounts for about 80% of the dermis. It is dense irregular connective tissue. It contains thick bundles of interlacing collagen fibers which run in various planes, although most run parallel to the skin surface. These collagen fibers give skin strength and resiliency that prevent most jabs and scrapes from penetrating. Additionally, collagen binds water helping to maintain the hydration of the skin. Elastin fibers help to provide stretch and recoil to the skin.

Skin color

Skin color is determined by three pigments, melanin, carotene, and hemoglobin

Melanin - is a polymer made of tyrosine amino acids. It ranges in color from yellow, to reddish-brown, to black. Its synthesis depends on an enzyme in melanocytes called tyrosinase. Racial differences in skin color are due to the relative kind and amount of melanin made.

Carotene - is a yellowish pigment found in certain plant products. It tends to accumulate in the stratum corneum and in the fatty tissue of the hypodermis. Is easily noticed in the skin of the palms and soles of the feet. This pigment is **not** associated with the yellowish tint of the skin of Asian people.

Hemoglobin - not a pigment. The color of oxygenated hemoglobin can sometimes be seen as blood circulates through the dermal capillaries, especially in fair skinned people.

It is important to recognize factors influencing skin color since many times skin color may be an indicator of a disease state.

*cyanosi*s - a blue color of the skin. Most often seen in fair skinned people. Indicates inadequate oxygenation of the blood.

erythema (redness) - may indicate embarrassment, fever, hypertension, inflammation, or allergy.

Pallor (blanching) - may indicate emotional stress (fear, anger) but may also signify anemia or low blood pressure.

Jaundice - is an abnormal yellow skin tone which usually signifies a liver abnormality.

Bronzing - is a sign of Addison's disease, a hypofunction of the adrenal cortex.

Bruises (hematomas) - indicate where blood has escaped from the circulation and clotted under the skin. May be due to trauma or several various disease states.

Appendages of the skin

Sweat (Sudoriferous) Glands - are spread over the entire area of the skin except the nipples and parts of the external genitalia. There are two types of sweat glands.

Eccrine sweat glands - although found in all areas of the body they are far more numerous in the palms, soles of the foot, and the forehead. These are simple, coiled, tubular gland. The secretory portion of these glands lie in the dermis and the duct extends to the surface at a pore. The secretions from eccrine glands (sweat) are hypotonic filtrates of the blood that passes through the secretory portion of the glands. It is released by exocytosis. Sweat is 99% water with some salts (mostly sodium chloride), vitamin C, antibodies, traces of metabolic wastes (urea, uric acid, ammonia), and lactic acid (mosquito attractant).

Sweating is controlled by the sympathetic portion of our nervous system. We have no control over this system. Sweating, is used as a means of temperature regulation to prevent the body from overheating. Heat induced sweating begins on the forehead and spreads to the rest of the body. Emotionally induced sweating usually begins on the palms, soles of the feet and axillae.

Apocrine sweat glands - are usually found in axillary and anogenital areas. They are larger than eccrine glands and their duct empty into hair follicles. The sweat from these glands has the same contents as that of the eccrine glands except for the addition of some fatty substances and proteins. This sweat is odorless when secreted, however when its organic molecules are decomposed by bacteria on the skin, it may take on a rather unpleasant odor.

Ceruminous glands - are modified apocrine glands found lining the external ear canal. They secrete cerumin (ear wax).

Mammary glands - are another specialized sweat gland. These will be covered along with the female reproductive system.

Sebaceous Glands

- (oils glands) are simple alveolar glands found all over the body except for the palms and the soles. They secrete an oily secretion known as sebum. The central cells of the alveoli accumulate lipids until they burst, which makes these glands functionally holocrine glands. Sebum is usually secreted into hair follicles but occasionally to a pore on the skin surface. Sebum softens and lubricates the hair and skin, slows water loss from the skin, and most importantly acts as a bactericide.

When sebaceous gland ducts become blocked a "whitehead" forms. If the material oxidizes and dries it darkens to form a "blackhead." Acne is an active inflammation of the sebaceous glands. It is usually caused by bacterial infection, particularly staphylococcus. Sebum secretion is stimulated by hormones, especially androgens, which explains why pimple and acne are more prevalent in both sexes during puberty.

Hair

Hairs are flexible strands that consist mainly of keratinized cells from the hair follicle. This hard keratin differs slightly from the keratin found in epidermal cells. It is tougher and more durable, and its individual cells do not flake off.

Hair typically has two chief regions the shaft and the root

Shaft - projects from the skin

Root - the portion embedded in the skin

Hair can be divided into three regions in cross section.

medulla - the central core of the hair. The medulla consists of large cells that are partially separated by air spaces. Note that the medulla is absent in fine hair.

cortex - a bulky layer surrounding the cortex, consists of several layers of flattened cells.

cuticle - covers the cortex. It is a single layer of flattened cells that overlap one another from below. This overlapping helps to keep hair from matting. If the cuticle becomes worn away, as is common at the tip of the hair, the keratin fibrils in the cortex and medulla may expand out causing a condition known as "split ends."

Hair pigmentation is determined at the base of the hair follicle where melanocytes transfer pigment into the developing cortical cells. Gray and white hair results from decreased melanin production and replacement of melanin in the hair shaft with air bubbles.

Hair Follicles

Are little more than specialized infoldings of the epidermis down to the layer of the dermis. At the deep end of a follicle, it expands to form a region known as the hair bulb. There is a cluster of nerve endings (root hair) surrounding each hair bulb. Bending of a hair stimulates these nerves thus making our hairs sensitive touch receptors. At the base of the hair bulb there is a papilla of

dermal tissue containing capillaries which protrudes into the hair bulb supplying nutrients to the growing hair.

Hair follicles are generally separated into an outer layer, known as the connective tissue root sheath, and an inner layer known as the epithelial root sheath. The inner epithelial root sheath is then further subdivided into an internal and external root sheath. The epithelial root sheath thins as it reaches the papilla region of the hair bulb so that each layer is only one cell thick over the region of the papilla. Note that the cells which actively divide to make the hair matrix are located slightly above the hair bulb. When chemical signals from the papilla reach these cells, they migrate toward the papilla and begin to divide and produce hair cells. As new hair cells are produced the old hair cells are pushed upward.

Arrector pili m. - Each hair follicle has a small muscle associated with it. This is the arrector pili muscle. When these muscles contract, they pull the hair follicle into an upright position. This also causes a dimpling of the skin known as "goose bumps." In humans this has no functional significance however in animals with fur and feathers (modified hair) is serves to puff up the fur to assist in insulating the animal as well as making the animal appear larger to its enemies.

Types and distribution of hair

With the exception of the lips, nipples, parts of the external genitalia, and thick-skinned areas of the palms and soles of the feet, millions of hairs are scattered all over the body. These hairs are generally of two types, Vellus and terminal.

> Vellus hair - the body hair of children and adult females. Is usually pale and fine.
>
> Terminal hair - course, often longer and darker hair of the eyebrows and scalp. At puberty terminal hairs appear in the axillary and pubic regions of both sexes and face, chest, and arms and legs of males. Terminal hair growth is in response to male sex hormones called androgens, of which testosterone is the most common.

Hair growth

The rate of hair growth varies depending on the type of hair, the body region, and the sex and age of the individual, but in general is about 2 mm per week. Hair grows in cycles and has an active growth phase and a resting phase. During the resting phase the follicle and hair bulb atrophy to some degree. This causes the hair to become detached and soon after the resting phase that hair will fall out, or be pushed out.

The follicles of the scalp remain active for years (average 4) and then enter a resting phase which lasts for a few months. Follicles of the eyebrows have an active phase of only three to four months.

Alopecia - baldness, is usually related to age. Since hair growth slows after the age of 40 the hairs are not replaced as fast as they are shed. Baldness usually starts at the anterior hairline and proceeds posteriorly. Although most people refer to baldness as the absence of hair, in reality the course terminal hair is often replace by fine vellus hair

Male pattern baldness - is a genetically determined condition. A delayed action gene switches on during adulthood and affects the response of the hair follicle to testosterone. The growth phase of the follicle becomes so short that most of the hairs never reach the surface of the skin. The few hairs hat do reach the surface are usually vellus hairs that are very soft and wispy.

Nails

Nails - are a scalelike modification of the epidermis. Nails contain “hard keratin.” Each nail has a free edge, a body, and a root. The deeper layers of the epidermis extend beneath the nail as the nail bed, with the nail itself corresponding to the superficial keratinized layers. The growth area of the nail is the thickened, proximal portion of the nail bed called the nail matrix. Nails normally appear pink because of the rich capillary bed beneath them. There is a white crescent shaped area at the proximal end of the nail called the Lunula which is actually the nail matrix viewed through the nail.. The proximal and lateral edges of the nail are overlapped by fold of skin referred to as nail folds. The proximal nail fold extends onto the nail as the eponychium (cuticle). The hyponychium is the thickened epidermis distal to the nail and covered by the free edge of the nail.

Functions of the Integumentary System

Protection - the skin makes up at least three types of barriers, chemical, physical, and biological.

Chemical - include skin secretions and melanin. The low pH of skin secretions is called the acid mantle. The acid mantle serves to retard bacterial replication. Melanin in the skin also serves to provide a chemical protection to harmful ultraviolet radiation. The glycolipids of the epidermis block the diffusion of water and water soluble substances preventing loss and entry from and into the body. Note that some substances do penetrate the skin in limited amounts. Some of these substances are 1, lipid soluble substances such as oxygen, carbon dioxide, fat soluble vitamins (A, D, E ,K) and steroids, 2, oleoresins of certain plants (poison ivy and poison oak), 3 organic solvents such as acetone, dry-cleaning fluid, and paint thinners, 4, salts of heavy metals such as lead, mercury, and nickel, and 5, certain substances known as penetration enhancers such as dialkylamino acetates or DMSO.

Physical (mechanical) - are provided by the continuity of the skin and the hardness of its keratinized cells.

Biological - Langerhans’ cells and macrophages. Langerhans’ cells present antigens to the specialized white blood cells called lymphocytes. Dermal macrophages attack viruses and bacteria that manage to penetrate the epidermis and also act as antigen presenting cells.

Temperature regulation

The skin functions as the body’s radiator. When temperatures rise blood vessels in the skin dilate and blood flow to the skin is increased. This caused increased sweating. Under normal resting conditions, with environmental conditions below 31° - 32° C (88° - 90°F) sweat glands continuously secrete small amounts of swear (about 500 ml per day). When the body temperature rises the dermal vessels dilate and sweating starts. Sweat output increases dramatically and can account for the loss of up to 12 liters of sweat per day. The evaporation of the sweat from the body surface cools the body and prevents overheating.

When the external temperature is cold the blood vessels in the skin constrict thereby preventing blood flow to the body surface. This slows heat loss from the body.

Cutaneous Sensation

The skin is richly supplied with various nerve receptors which are actually part of the nervous system. Because these receptors respond to external stimuli they are referred to as exteroceptors.

Meissner’s corpuscles (in dermal papillae) allow us to feel touch

Pacinian receptors in the dermis and hypodermis allow us to feel bumps and contacts involving deep pressure.

Root hair plexuses allow sensations of movements

bare nerve endings respond to painful stimuli such as irritating chemicals, and extreme hot/cold.

Metabolic Functions

The skin plays a role in some metabolic functions such as the synthesis of vitamin D. When sunlight hits the skin modified cholesterol molecules in the epidermal layers are converted into a Vitamin D precursor. This is absorbed into the dermal capillaries and transported to other areas of the body. This essentially makes the skin an endocrine organ.

The skin also makes chemical conversions, Examples are: keratinocyte enzymes can disarm many carcinogens, keratinocytes also activate some steroid hormones (transform cortisone into hydrocortisone, a potent anti-inflammatory drug).

Blood Reservoir

The skin can hold 5% of the blood volume of the body. When there is an increased demand for blood, vessels in the skin can constrict thereby diverting much of the blood flow to the skin to other body regions.

Excretion

Some nitrogen containing wastes (ammonia, urea, uric acid) are eliminated in sweat. However, these amounts are limited. The major loss due to excretion is water and sodium chloride.

Homeostatic imbalances of the skin

Burns

A burn is tissue damage inflicted by intense heat, electricity, radiation, or certain chemicals. Burns denature cells proteins and cause cell death.

Severe burns cause a catastrophic loss of body fluids containing proteins and electrolytes. As fluid seeps from the burned surfaces dehydration and electrolyte imbalance occur. These lead to renal shutdown and circulatory shock.

Explain the rule of nines

Burn patients need thousands of extra food calories per day to replace the lost proteins and allow for tissue repair. no human can possible eat this much per day so these patients must be given supplements via IV's and gastric tubes.

Also of immediate concern is infection. Remember that the skin barrier is now destroyed and the exposed tissue is rich in nutrient fluids. This is the perfect environment for the growth of bacteria. It is essential that burn patients be kept in as sterile an environment as possible. To compound this problem, the immune system typically shuts down one or two days after a severe burn injury.

Classification of burns

first degree burns - only the epidermis is affected. Symptoms include localized redness, swelling, and pain. These burns heal in two or three days. A sunburn is a typical first-degree burn.

second degree burns - injure the epidermis and the upper layers of the dermis. Symptoms are similar to those of first degree burns with the addition of blisters. These burns generally heal with little or no scarring in three to four weeks. What does this tell us about the growth rate of skin?

Third degree burns - involve the entire thickness of the skin. The damaged area may appear gray-white, cherry red, or blackened. Also, there is no initial edema. It is also important to note that there is no pain in the area of the burn **WHY?** Skin regeneration may eventually occur from cells growing in from the edges of the burned area, however by this time infection has usually set in and it is too late. Skin grafting is a must.

Burns are generally considered critical if any of the following conditions apply:
1. over 25% of the body has second degree burns
2. over 10% of the body has third degree burns
3. there are third degree burns of the face, hands, or feet.

Skin Cancer

Most tumors that arise in the skin are benign and do not spread to other body areas. A wart (neoplasm) is one example. However, some skin tumors can be malignant and invade other body areas.

Basal Cell Carcinoma - is the least malignant and most common skin cancer. Cells of the stratum basale proliferate and invade the underlying dermis and hypodermis. These are most commonly seen on areas of the body exposed to the sun. These are relatively slow growing cancers and they are usually noticed and excised before metastasis occurs. Excision results in a full cure in 99% of cases.

Squamous Cell Carcinoma - arises from the keratinocytes of the stratum spinosum. Most often seen on the scalp, ears, dorsum of the hands, and lower lip. These cancers grow rapidly and metastasis to adjacent lymph nodes if not removed. If caught early, surgical removal and radiation therapy afford a good chance of complete cure.

Malignant Melanoma - is cancer of the melanocytes. It is the most dangerous form of skin cancer. Fortunately, it accounts for only 5% of skin cancers. This cancer can begin wherever there is pigment. Most of these cancers develop spontaneously but about 1/3 develop from pigmented moles. These cancers rapidly metastasize to surrounding lymph and blood vessels. The survival rate is approximately 50% with early detection a must. Treatment includes wide surgical excision accompanied by immunotherapy.

American Cancer Guidelines for Identifying Melanoma

ABCD Rule

A - asymmetry: the two side of the pigmented spot do not match
B - border irregularity: the borders of the lesion are not smooth but exhibit indentations
C - color: the pigmented spot contains several colors
D - Diameter - the spot is larger than 6 mm diameter.