

• INTEGUMENTARY SYSTEM (SKIN)

SKIN FUNCTIONS:

1. protect the body from mechanical abrasion
2. act as a barrier to microorganisms
3. protect the underlying tissues from ultraviolet radiation from the sun
4. thermoregulation (e.g. sweating)
5. synthesis and storage of fat reserves
6. synthesis of a form of vitamin D

Skin has 3 basic layers: the epidermis, the dermis, and the subcutaneous layer (or hypodermis). In addition to these layers the skin contains accessory structures such as hair, nails and a variety of exocrine glands.

EPIDERMIS

Formed of **stratified squamous epithelium**. The outer layers of this epithelium contain high concentrations of the protein **keratin** that is a waterproofing protein that also protects the underlying skin layers from damage due to **ultraviolet rays**. As cell division occurs and cells are pushed to the superficial layers and they become so filled with keratin that the cells die. The epidermis is made of multiple layers of cells called **strata**, but it does not contain blood vessels. Nutrients diffuse to the epidermis from blood vessels that run through the papillary layer of the dermis. Irritation or infection of the epidermis can cause increased blood flow to the papillary layer of the dermis and this increases epidermis production.

There are 4 or 5 layers to the epidermis (from deepest to most superficial):

1. **Stratum Basale** (or **stratum germinativum**) = the deepest epidermal layer composed of **basal cells** and **melanocytes**. A single layer of columnar cells undergoes mitosis (cell division) here. From this cell division, two cells are produced. One remains as a columnar cell in the stratum basale while the other becomes a cell in the stratum spinosum layers. As cells continue to divide they are pushed toward the more superficial cell layers of the skin. This whole process is continuous and takes about two weeks (stratum basale to stratum corneum). Cancer of the basal cells is called **basal cell carcinoma**. **Melanocytes** are cells that contain the pigment called **melanin**. **Melanoma** is a malignant cancer of the melanocytes. Melanin protects the stratum basale and underlying layers from UV ray damage. The number of melanocytes is fairly constant among people of all skin colors, but the amount of melanin produced determines darkness or lightness of the skin color. People with less melanin are more susceptible to UV ray damage (e.g. skin cancer). This layer also contains **Merkel cells** that are specialized for detecting touch. When these cells are compressed they release chemicals that stimulate sensory nerve endings that carry "touch" information to the central nervous system.
2. **Stratum Spinosum** = the layers of cells superficial to the stratum basale. Cells here are held tightly together by special protein junctions, **desmosomes**, that hold the cell membranes of adjacent cells tightly together. These junctions give the cells a star or pin cushion appearance in prepared slides. Melanocytes may also be seen in this layer.
3. **Stratum Granulosum** = the layers of cell superficial to the stratum spinosum. These are cells that were "pushed" from the stratum spinosum and no longer undergo cell division. Cells in this layer manufacture large amounts of **keratin** and **keratohyaline** proteins and become thinner and flatter. The precursor of keratin is found in granules that stain purple in prepared slides. Cell membranes thicken, the cell nucleus degenerates and the cells die as they dehydrate to create an interlocked layer of keratin fibers surrounded by keratohyaline sandwiched between the old cell membranes (phospholipids).
4. **Stratum Lucidum** = layers of keratin filled cells that lie superficial to the stratum granulosum in the thick skin of the palms and the soles of the feet. This layer appears translucent in prepared slides and looks clearish or pink. This layer of cells is only found in the thick skin of the palms and the soles of the feet.

5. Stratum Corneum = layers of keratin filled, dead, flat, interlocked cells that lie superficial to the stratum lucidum or the stratum granulosum. Epithelial cells that are filled with keratin are said to be **keratinized** or **cornified**. Cornification occurs everywhere on the surface of the skin except over the anterior surfaces (conjunctiva) of the eye. The stratum corneum is usually dry and water resistant which helps prevent the growth of microorganisms (e.g. bacteria, etc.). Cells in this layer last about 2 weeks on average before they are shed or lost from the body. The entire surface of the skin is renewed about every 6 weeks.

The deeper layers of the epidermis form ridges that contact the dermal papillae. The contours of the surface of the skin follow these ridges to form the fingerprints.

THICK SKIN = contains 30 or more layers of keratinized cells in the epidermis than thin skin and can be more than six times as thick as thin skin. Thick skin makes up the palms and the soles of the feet and contains the stratum lucidum.

THIN SKIN = has an epidermis that is less than 0.1 mm thick with no stratum lucidum and only a few layers of stratum corneum.

DERMIS (about 2/3 of the thickness of the skin is dermis)

There are 2 layers to the dermis: the more superficial papillary layer and the deeper reticular layer. The boundary between these two layers is often not clearly distinct.

Papillary layer = has **papillae** (bumps) that invade the epidermis to help keep the two layers together. This layer is formed of loose connective tissue that contains capillaries and sensory neurons. Most of the connective tissue fibers in the dermis are collagenous with some elastic and reticular fibers. Blood vessels that pass through the dermis carry nutrients and release heat to the external environment. In warm weather, the capillaries are **dilated** (larger diameter = more open) to release excess body heat. In cold weather, the capillaries are **constricted** (smaller diameter = more closed) to retain body heat. Sensory information from the skin is detected by numerous touch corpuscles found in the dermis. **Meissner's corpuscles** that detect light touch are found in the upper dermis. **Pacinian corpuscles** are deeper sensory receptors that sense pressure. Other sensory receptors in the skin include **thermoreceptors** (detect temperature) and **nociceptors** (which modulate the pain response).

Reticular layer = the deeper and larger layer of the dermis that contains irregular bundles of collagen fibers that extend into the papillary layer and the deeper subcutaneous layer.

Within the skin, at a particular location, the collagen and elastic fibers lie in parallel bundles whose orientation depends on the physical stresses placed on the skin during movement. The bundles are aligned to resist these forces and lie in the **lines of cleavage (or Langer's lines)** of the skin. Surgeons generally make incisions parallel to the lines of cleavage because these incisions tend to stay closed, while incisions perpendicular to the lines of cleavage will be pulled open due to the recoiling of the elastic fibers.

SUBCUTANEOUS LAYER (HYPODERMIS)

This layer is fairly elastic and deep to the dermis. It is formed from loose connective tissue and lots of adipose tissue (fat). Subcutaneous fat serves as an energy reserve and helps reduce heat loss (particularly in infants). Due to exposure to different sex steroids and other factors, men tend to deposit subcutaneous fat in the abdominal region, the neck and lower back while women deposit it in the hips, thighs, buttocks, and breasts. Large blood vessels are only found in the superficial layers. The term **hypodermic needle** is related to this organization as the hypodermis is an excellent place to administer drugs due to its lack of large blood vessels.

TYPES OF INJECTIONS

Subcutaneous or hypodermal injection = injection below the dermis in the hypodermis.

Intradermal injection = injection into the dermis as during skin reaction tests for allergies.

Intramuscular injection = injection deep into muscle as in a flu shot in the arm or butt.

Intraperitoneal injection = injection into the peritoneal cavity (rare in clinical medicine).

Intravenous injection = injection into the venous system (into a vein).

• EPIDERMAL DERIVATIVES (ACCESSORY STRUCTURES)

NAILS

Nails are plates of tightly packed, hard, keratinized cells. Nails protect the exposed tips of the fingers and toes. The nail covers the **nail bed**. Nails grow from a fold of epithelial tissue called the **nail root**. The deepest part of the nail lies near the periosteum of the distal phalanx. The **cuticle** (eponichium) is a fold of the stratum corneum that lies over the nail near the nail root. The **lunula** is the small white crescent at the base of the nail. The **hyponychium** is the region the under the free edge of the nail that extends over the stratum corneum.

HAIR FOLLICLES

Found nearly everywhere on the skin except certain places on the hands, feet, lips, and genitalia.

Hair provides protection, cushioning, insulation, and guards the entrances to the nostrils and external auditory canals. Eyelashes help keep foreign particles out of the eyes.

The **shaft** of the hair extends above the surface of the skin while the **hair root** is enclosed in the **follicle**. Hair follicles are invaginations of the stratum basale and extend into the deep dermis and may project into the subcutaneous layer. A **papilla** is formed at the bottom of the invagination that contains capillaries and nerves. The **hair bulb** is formed of epithelial cells that surround the papilla and this is the region of actively growing hair. The **root sheath** that composes the follicle has an outer dermal layer of connective tissue and an inner epithelial layer. Basal cells at the base of the follicle divide and produce cells that are pushed toward the surface to form the three layers of the hair.

Each hair has three layers that can be seen in microscopic cross section.

1. **cuticle** = outermost layer of keratinized cells ("hard keratin").
2. **cortex** = surrounds the medulla and is tightly compressed keratinized cells ("soft keratin").
3. **medulla** = the innermost core of the hair that contains pigment. The pigment is mostly melanin, but iron-containing pigments will cause the hair to be red in color.

Types of hairs

1. **Vellus hair** = fine "peach-fuzz" found on the face and in children. Vellus hair is replaced by a more heavily pigmented and coarse adult hair.
2. **Determinate hair** = grows to a specific length and then stops.
3. **Indeterminate hair** = continues to grow regardless of the length.

ARRECTOR PILI

Arrector pili muscles are clusters of parallel **smooth muscle** fibers that connect the hair follicle to upper regions of the dermis. In response to cold temperature or sudden fear, the arrector pili contract to produce goose bumps.

EPITHELIAL GLANDS (classified by their mode of secretion)

Formed from invaginations of the stratum basale.

Holocrine gland = produce cells by cell division that are then shed into the lumen of the gland where the cell bursts and releases the secreted substance. (holo = whole)

Apocrine gland = cells produce the secretion at their tips and then the tips burst to release the secreted substance. (apo = away from)

Merocrine (or eccrine) gland = complex and efficient glands that form packaged products that are sent to the cell surface and secreted and released from the cell through the cell membrane by exocytosis. (mero = a part)

SEBACEOUS GLANDS

Holocrine glands that discharge a waxy, oil secretion called **sebum** into the hair follicles to lubricate, waterproof, and prevent chaffing of the hair. Sebaceous glands are concentrated on the nose, lips, areola of the nipple and anus. These glands are not found on the palms or the soles of the feet (helps you keep a good grip!) The quantity of sebum produced and released can be affected by sex hormones that can lead to plugging, bacterial infection and eventually acne (especially during puberty).

SWEAT GLANDS (Sudoriferous glands)

These glands contain special **myoepithelial cells** that can contract to discharge accumulated secretions. The activity of these glands is controlled by the autonomic nervous system and circulating hormones. There are 2 types of sweat glands.

APOCRINE SWEAT GLANDS

Produce “smelly” sweat in the axillae (armpits), around the nipples and in the groin. Apocrine sweat glands are attached to hair follicles. These coiled and tubular glands produce a viscous sweat that contains a higher concentration of organic acids than eccrine glands. Body odor is caused by the interaction of these organic acids with bacteria on the surface of the body.

MEROCRINE (OR ECCRINE) SWEAT GLANDS

These sweat glands are more numerous than apocrine sweat glands and widely distributed on the body. They are smaller and do not extend as far into the dermis. Your palms sweat because there are more eccrine sweat glands on the palms and soles than anywhere else. These coiled, tubular glands release their sweat directly onto the surface of the skin. Sweat is mainly water with NaCl (sodium chloride = salty), and other organic compounds.

Merocrine sweat glands function to:

1. cool the surface of the skin by evaporative heat loss (water has a high heat of vaporization). During heavy exercise this may exceed a gallon or more an hour.
2. secretion of water and electrolytes.
3. discourage the growth of microorganisms.

Sebaceous and apocrine sweat glands are collectively activated by the autonomic nervous system. When one gland is active, they are all active. Merocrine sweat glands can be regionally controlled, so that only certain areas of the body sweat (e.g. the palms).

CERUMINOUS (EARWAX) GLANDS

Modified sweat glands that work with nearby sebaceous glands to form earwax. Earwax probably helps trap foreign particles to prevent them from reaching the eardrum and middle ear.

MAMMARY GLANDS

We will cover these in greater detail later. The mammary glands are related to apocrine sweat glands. Mammary glands produce milk and only make up a portion of the breast that is mostly adipose tissue. Each breast is an accumulation of a few dozen mammary glands.