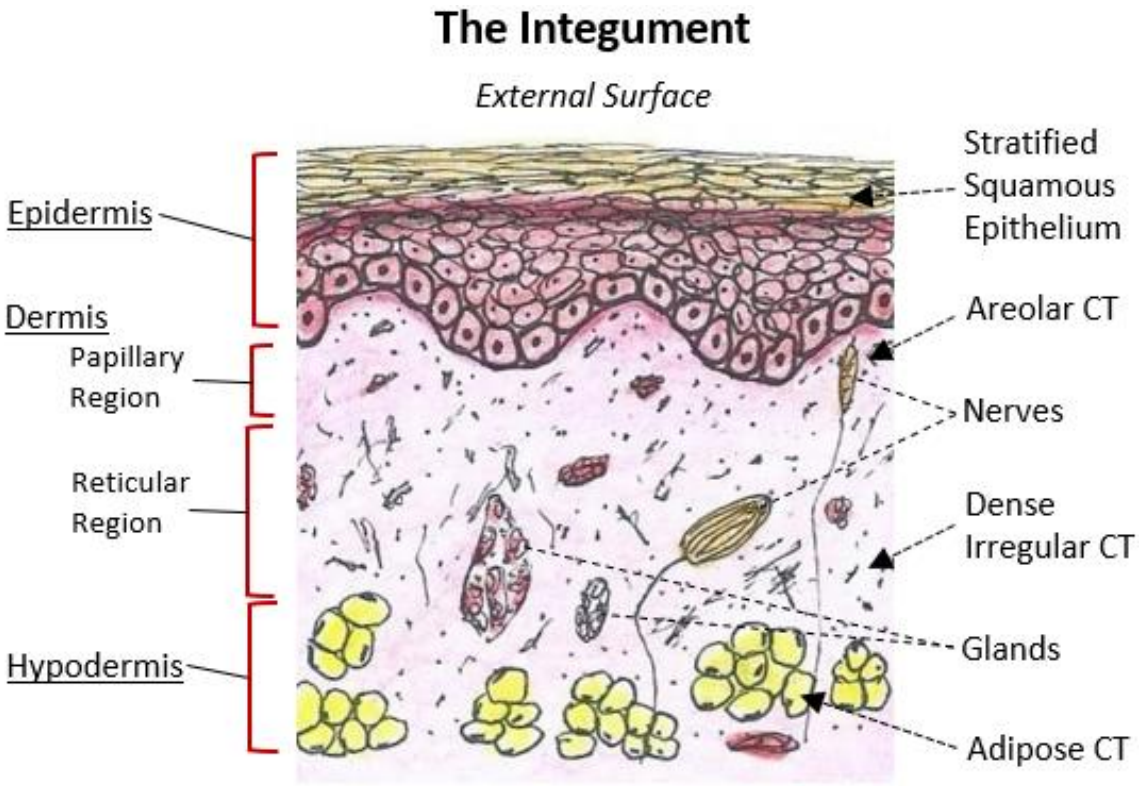
Anatomy Lecture Notes Section 1: The Integumentary System

Introduction to the Integumentary System
The integument is a tough outer protective covering that is made up of skin, hair, glands and nails. As the integument contains all four primary tissues (epithelium, connective, muscle and nervous), it is considered an organ. In fact, it is the largest organ of the body.

The integumentary system is comprised of two main elements:
1) The **cutaneous membrane** which is called the **skin**.
2) Associated structures which are **hair**, **glands** and **nails**.

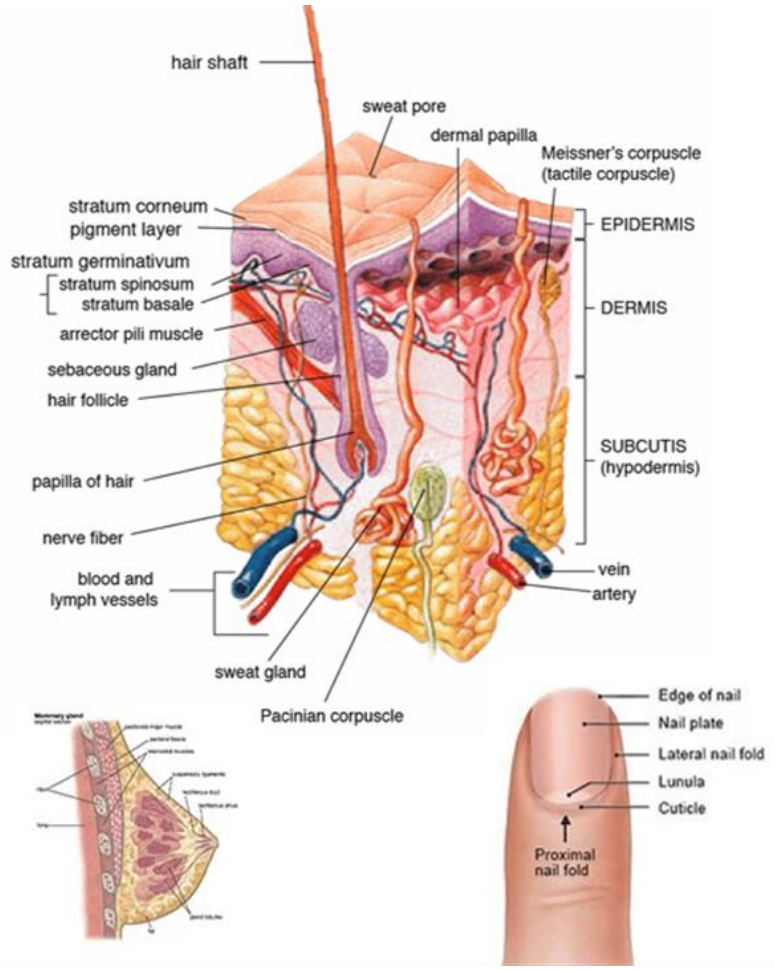


In essence, the associated structures are embedded within the cutaneous membrane. The most superficial portion of the integumentary system is comprised of stratified squamous (keratinized) epithelial tissue which makes the **epidermis** of the skin. Recall that epi means above, on top, or upon. Deep to this is a combination of areolar and dense irregular connective tissue that makes up most of the **dermis**. The associated structures include **exocrine glands**, such as sebaceous (oil) and sudoriferous (sweat) glands, **hair** and **hair follicles**, and finger and toe**nails**.

Gross Anatomy of the skin, hair, glands and nails
In the notes for the previous section discussing membranes in anatomy, we saw that the integumentary system includes the cutaneous membrane, what we know as skin. Let's remind ourselves what is a membrane? It is like a formula:

$$\text{Membranes in Anatomy} = \frac{\text{Epithelial Tissue}}{\text{Connective Tissue}}$$

Thus, the integument is the skin, plus all the associated accessory structures mixed in for good measure. When examining models, drawings or slides of the skin, keep in mind that it will always be the superficial epithelium that is on the top – a better anatomical visualization would be that the epithelial tissue is always the exposed surface whenever it is part of a membrane. Also, as the 'formula' on the previous page indicates, a membrane will always consist of a connective tissue that is deeper to (under) the epithelial layer. Review the characteristics of epithelial and connective tissues and see how the qualities of these different tissues apply when examining the skin as a membrane. Think of its function to protect and to be sensitive. Examine the accessory structures of the skin (hair, glands and nails) remembering that they are all derived from **epithelial tissue** even though they originate in the dermis portion of the skin.



General Functions of Integumentary System

A. Gives Physical Protection

B. Prevents Pathogen Invasion

C. Restricts Desiccation (Dehydration)

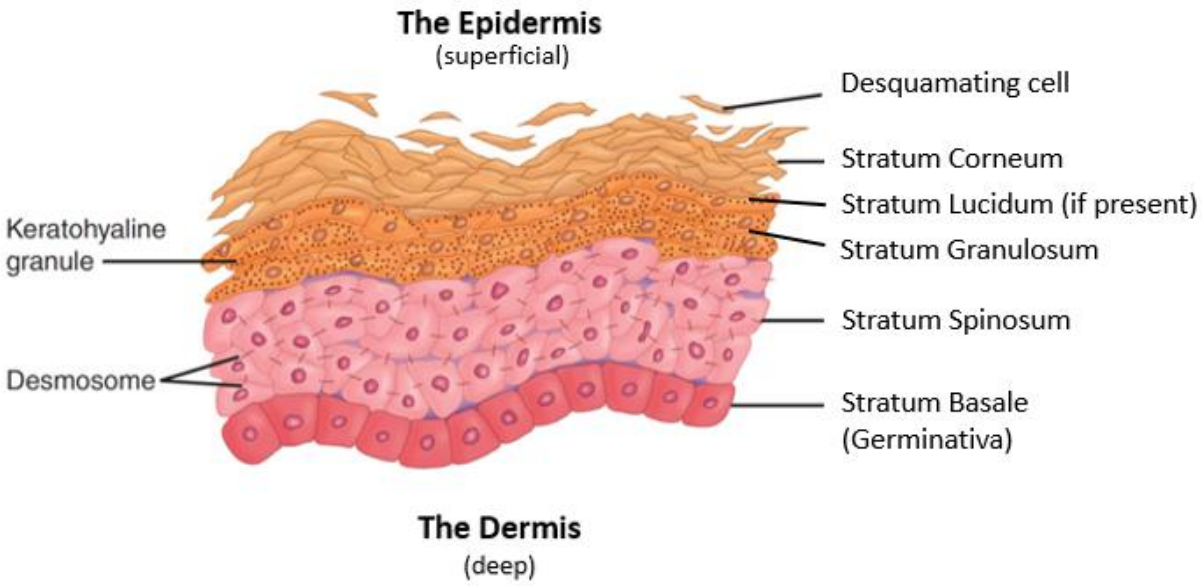
D. Provides Sensory Perception

E. Vitamin D Production

The Epidermis – The most superficial layer of the skin is made of epithelial tissue. It is classified as *stratified squamous keratinized (dry) epithelium*. The epidermis has either 4 (thin skin) or 5 (thick skin) distinct layers or 'strata' that can be identified under the microscope. The Latin and English terms for these layers are used interchangeably, thus it is first helpful to know that stratum means layer.

The term **basale**, like *basal*, means bottom. This layer can also be called the stratum germinative, from the term geminate, as in reproduce and grow! The term **spinosum** means spine-like, as a reflection of the way this region looks after its histological preparation (to visualize with a microscope). The term **granulosum** means it has granules present. If there is a stratum **lucidum** present (it is only found in thick skin), lucidum means transparent, because it allows light to pass through it. Finally, the stratum **corneum**, like cornu, this means tough and horn-like.

The image below displays the 5 possible strata (singular stratum) in the epidermis. Technically there is no stratum lucidum in this drawing so it is not 'thick skin', but it shows where this layer would be located. The more detailed descriptions of each of the possible layers of the epidermis, from the deepest layer (basale) to the most superficial (corneum), are presented on the following pages.



A. The Strata (Layers) of the Epidermis

When examining the layers of the epidermis, it is useful to begin with the deepest layer called the ***Germinativa***. The term ***germinativa*** means capable of **creating**, it is the **seed**, the part that is able to **germinate** and give life. The epidermis of the skin actually starts here at this stratum (layer) for obvious reasons - it is the starting point for the germination of the rest of the layers. Also recall that this deepest layer sits closest to the underlying connective tissue, and is therefore closest to the blood supply.

Reading through the discussion below it will become clear that the appearance and functions of the other layers superficial to this first layer (which all other layers are derived from) are a consequence of how far away they are from this germinative layer. The further a layer is from the dermis (upon which the stratum basale sits), the further away it is from nutrients and oxygen. Therefore, cells within further layers begin to die after a critical distance.

It is usually in the stratum granulosum that epidermal cells begin to die. The multiple cellular attachments in epithelial tissue continues to keep all cells (living and dead) tethered to the dermis and to each other. It is only in the outermost stratum corneum that dead cells are shed (desquamated), often in aggregates or sheets of cells. As the dead cells are sloughed off, they are continuously replaced by the stratum basale.

1. Stratum Basale (Germinativa) - this layer is composed essentially of a single row of cells that make the deepest layer of the epidermis. Roughly estimating, the cells in this layer are about 80-90% **keratinocytes** and 10-20% **melanocytes**. The keratinocytes have mitotic potential which means they can multiply and rapidly reproduce in order to continue replacing themselves. These cells are the '**stem cell**' of the bulk of the epidermis, as alluded to already, the name germinativa means 'to germinate', like a seed beginning to grow. These cells are sitting directly on the basement membrane, which is attached to connective tissue directly deep to it. Since epithelial tissue is avascular (lacks its own blood supply), the close proximity of these cells to the blood supply in the dermis keeps them healthy and able to actively reproduce. The melanocytes located in this layer are the cells that produce the dark pigmented molecule **melanin**. When melanin granules are released into the tissue in response to UVA light stimulation, the skin becomes darker. The melanin released provides protection to the keratinocytes against excessive UVA irradiation.

2. Stratum Spinosum - this layer can be several cell layers thick. It has mostly spindly keratinocytes here, with some scattered **Langerhans cells** that provide defensive protection to the epidermis. The term spinosum means 'spiny' and this name was given because of the spiny appearance of the cells in this area, significantly due to the histological preparation of the tissue, especially the dehydration process. The cells here are living here, though some cells in this layer may be beginning to die, due to the greater distance away from nutrients and oxygen in the blood supply of the dermis.

3. Stratum Granulosum - this layer is from 3 to 5 levels of flattened keratinocytes containing darkly staining *keratohyalin*, and *lamellated* **granules** which are a prominent component of this layer. These granules are the precursor to keratin. It is the cross-linking of keratin filaments that creates a tight, almost impermeable hydrophobic barrier to protect the body. You will notice that your epidermis is sort of 'waterproof', this is to protect you against substances penetrating the skin, and to protect against water loss and dehydration. It is the incorporation of these hydrophobic substances that are very effective in waterproofing the outside of our bodies to provide protection against dehydration at the surface of the skin. When the cells begin to die, the keratinization process begins.

4. Stratum Lucidum - this layer is a thin **translucent** band, composed of a few cell layers. Importantly, this layer is ***only*** found in **thick skin**, that is, the skin found on the **palms** of the hands and **soles** of the feet. There is an abundance of keratin here in this layer. The cells in this layer are completely dead, as they are too far away from the capillaries in the underlying connective tissue to continue to thrive.

5. Stratum Corneum - this layer is the most superficial (outermost) as it is the external or exposed layer of the epidermis. This layer is also the thickest of all the layers of the epidermis in terms of the number of cells stacked up in this layer, at least 10, though the cells are incredibly flat in this layer. The many cells here are **cornified** (horn-like) which is a term that means the formation of a layer of dead cells that creates a physical barrier for the skin. This layer is also thoroughly **keratinized**, filled mostly with keratin and dead keratinocytes that provide a substantially protective and waterproof barrier. This stratum is always the thickest, and for thick skin (palms and soles), the cellular attachments of the epithelium can keep 20 to 30 cell layers remaining in this stratum corneum. This last layer is where dead cells 'slough off' and are removed from the epidermis. Often the cells will come off in connected sheets due to their strong cellular attachments.

A **callus** is a thickening of the skin caused by repeated pressure or friction at the location where it develops. A **corn** is usually a small callus that is tender appearing on the top or side of a toe. Predominately corns are caused by wearing bad ill-fitting shoes.

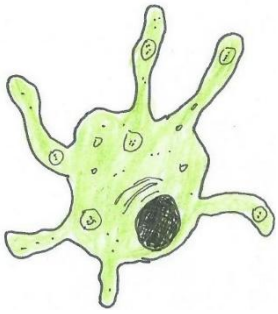
B. Cells of the Epidermis

The strata of the epidermis contain four (4) different types of cells.

1) Keratinocytes represent about 80 to 90% of all cells found in the epidermis. They start as the stem cell in the stratum basale of the epidermis and can be referred to as "basal cells". These cells make **keratin**, a tough lipoprotein that acts as a sealing and waterproof agent for skin. The main function of keratinocytes is creating a protective barrier against environmental elements, such as pathogens (bacteria, fungi and viruses), heat, UVA radiation and water loss. If pathogens begin to invade the superficial epidermis, keratinocytes react by producing pro-inflammatory mediators, particularly chemokines which attract leukocytes to the site of invasion. Go leukocytes.

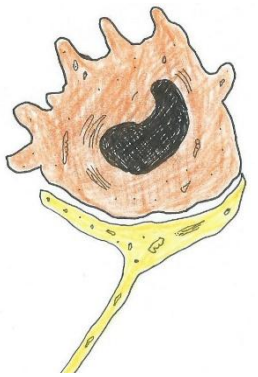
Structural proteins like keratin, and antimicrobial agents contribute to the important barrier function of this cell in the skin. Keratinized epithelial tissue means it is waterproofed (dry) and this cornification provides a significant physical barrier, especially in thick skin (palms and soles). The fully cornified keratinocytes that form the outermost layer are constantly shed and replaced by new cells.

2) <u>Melanocytes</u> make up about 10% of the cells in the epidermis. These cells make **melanin**, a dark brown pigment which is primarily responsible for skin color. Melanocytes (from Greek melas meaning 'dark or black') are located mostly in the stratum basale of the epidermis. After synthesizing melanin, it is packed into a little container called a melanosome and transported along its arm-like structures (dendrites) so that they can reach and release its melanin to the keratinocytes, which take up the melanin for protection against ultraviolet A (UVA) radiation.

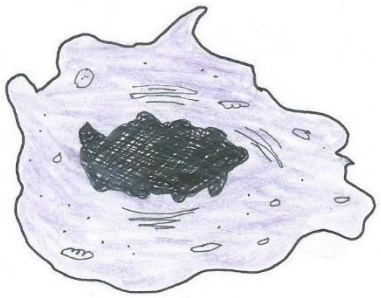


*There are actually two main types of melanin: **Eumelanin**, which is brown/black; and **Pheomelanin**, which is reddish yellow.

3) <u>Merkel cells</u> (Merkel-Ranvier) are tactile discs that act as receptors for light touch found in the epidermis. They are usually associated with a sensory nerve ending for tactile information, but also may play a role resolving fine spatial detail of touch.



4) <u>Langerhans cells</u> are the defense cells of the epidermis. They are a type of immune cell that can phagocytose an invader. They are most prominent in the stratum spinosum but can be found in all layers of the epidermis and can also wiggle into the papillary layer of the dermis. Langerhans are dendritic cells that can take up and process microbial antigens to become antigen-presenting cells – quite an accomplishment in the world of defense cells.



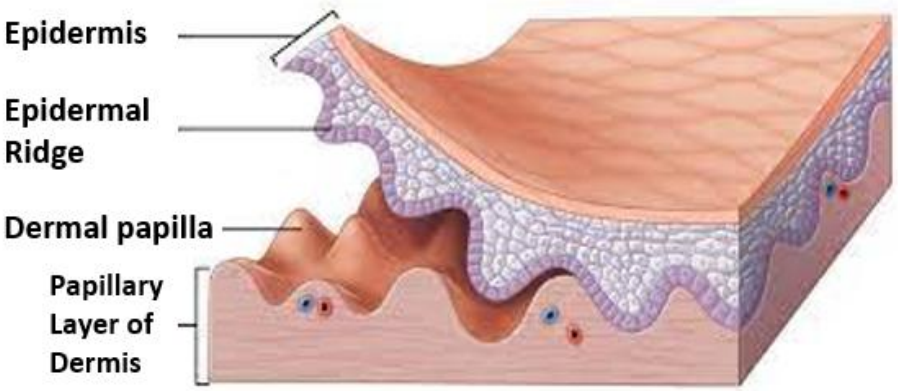
C. The Dermis

The dermis of the skin is the **connective tissue portion** of the cutaneous membrane. The dermis is divided into two regions or layers, the superficial **papillary layer**, and the deep **reticular layer**. A different type of connective tissue is predominate in each of these layers.

<u>The Papillary Layer</u>: This region is immediately deep to the stratified squamous keratinized epithelium of the epidermis and is composed of **areolar connective tissue**.

The underside of the **epidermal ridges** of the epidermis can be seen in the image to the left. The arrangement between the epidermal ridges of the epidermis and the **dermal papillae** of the papillary region allows these two tissues to interlock with each other, assisting in holding them together. The epidermal ridges of the epidermis are thought to be responsible for creating 'friction ridges' on the outermost surface of the epidermis, which are seen as **fingerprints**.

See the image to the right that highlights the arrangement of the epidermal ridges of the epidermis and the dermal papillae of the dermis. Also shown is the papillary region (or layer) of the dermis, which only accounts for about **1/5** of the total thickness of the dermis.



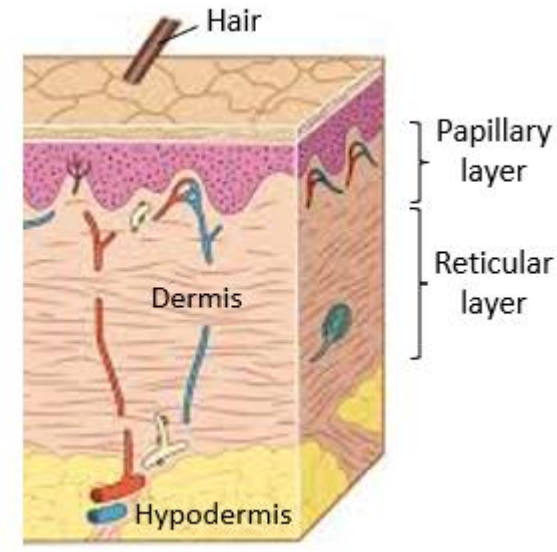
The other basic elements of this papillary layer are:

a. A network of blood vessels and capillaries here called the **papillary plexus**. The rich blood supply in this areolar connective tissue enables the epidermis, which is located immediately above it, to be well supplied with nutrients and oxygen, at least the basal end of that epithelial tissue.

b. There are a number of **free nerve endings** located here. These detect basic sensations of hot and cold, itch and general pain (nociception).

c. Also located here in the papillary layer are the **Meissner's corpuscles** (or tactile corpuscles) which are sensory nerve receptors for the detection of light touch. They are nestled in the dermal papillae in the papillary layer of dermis. The close proximity to the epidermis allows for detection of distention of the surface of the skin.

The Reticular Layer: This region is deep to the papillary layer and has quite a few things going on in it. This layer accounts for approximately **4/5** of the total thickness of the dermis, therefore much of what is located in the more superficial regions of the skin are anchored here in the reticular layer.

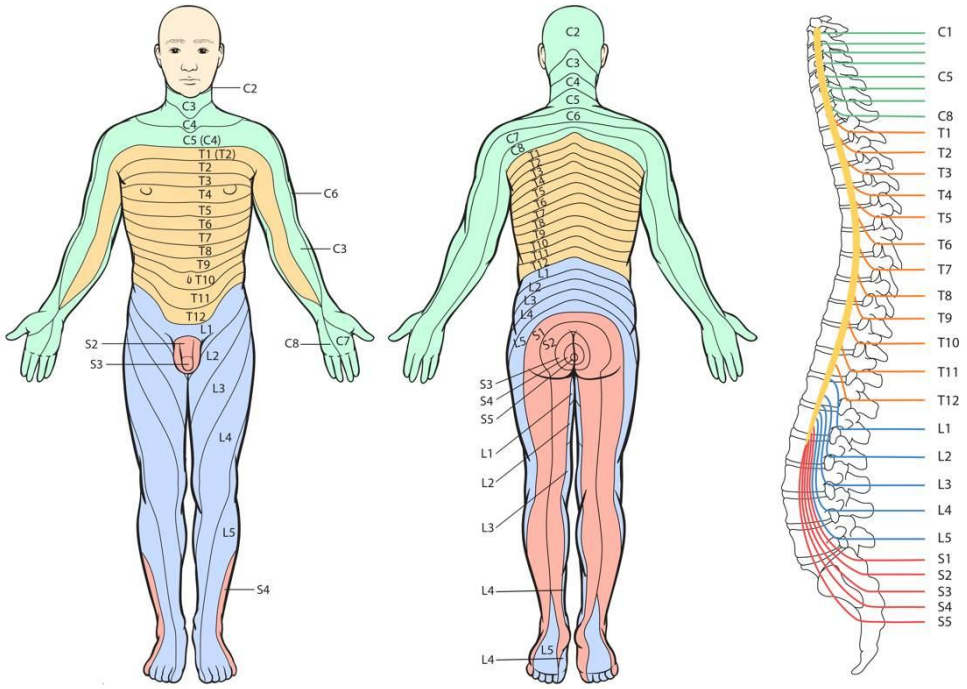


As seen in the image at the left and many other images of the dermis seen in these notes, the 2 layers of the dermis - the superficial papillary region and the deeper reticular region are distinct from each other, yet they are also intricately associated with each other. The reticular layer which is the deepest layer of the true cutaneous membrane is predominantly made of the tough and flexible **dense irregular connective tissue**. All of the associated structures are embedded in this region, and there are many blood vessels here as well.

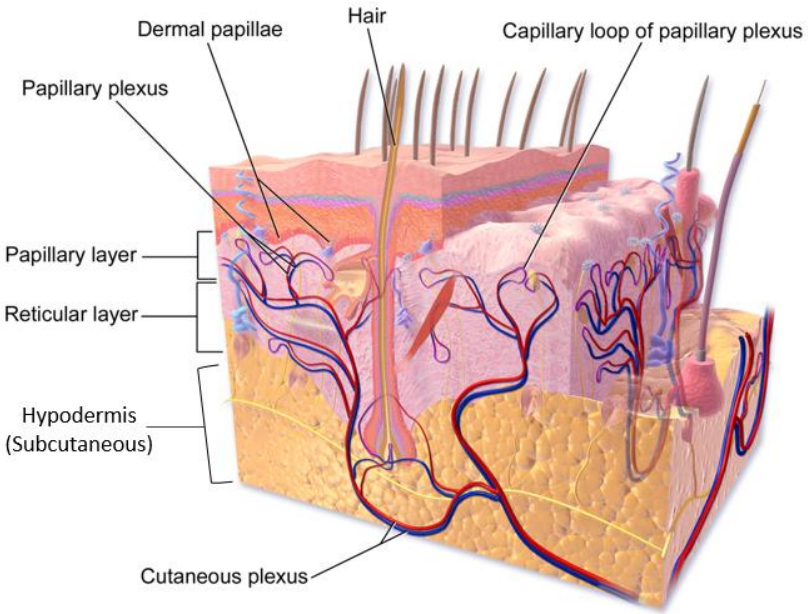
Deep to the reticular layer is the **hypodermis**. It provides protection and insulation to the skin and attaches it to other tissues deep to it. Technically, the hypodermis is not a part of the cutaneous membrane (skin). For that reason, it is also referred to as the **subcutaneous**, meaning 'below the skin'. The hypodermis is mostly composed of adipose (fat) tissue and has a number of other vital roles discussed briefly below.

Dermatomes

The abundance of collagen fibers 'irregularly' arranged in the dermis of the skin allows for the distention of this tissue in multiple directions. It turns out that even if the arrangement of collagen seems haphazard in this tissue down the microscope, the fibers are methodically arranged in this tissue - as evident by lines of tension/cleavage that are seen in the **dermatomes** of the body, yielding directionality and creases in the skin.



The term "dermatome" comes from derma (= skin) and tome (= cutting, or thin segment), such that they are specifically defined regions of the skin that are innervated and connected to the dorsal root of particular spinal nerve roots emanating from the spinal cord. As seen in the drawing above, these connections are like a map of the spinal cord and spinal nerve reflected onto the surface of the body within the skin. It is very useful to know the state of the spinal nerves are reflected all around the body, especially in the skin.



The other basic elements of the reticular layer are:

a. A larger network of blood vessels located here called the **cutaneous plexus**. This blood supply often sits deep in the reticular layer and even in the hypodermis region too. This vascular bed is to supply all of the associated structures found in the reticular layer of the dermis.

b. There are many bundles of **collagen fibers** (crisscrossing).

c. More free nerve endings are located here, including those responsible for deeper pain sensation.

d. **Pacinian corpuscles** (or lamellated corpuscles) are located deep in the reticular layer of dermis and are mechanoreceptors for the detection of deep pressure. This is in contrast to the Meissner's corpuscles, which are located higher up in the papillary region which are for light touch.

e. Numerous cell types may be found in this region, including: Fibroblasts; Adipocytes; Macrophages Mast cells (histiocytes), and Leukocytes.

D. The Hypodermis

The **hypodermis** can also be referred to as the **subcutaneous** layer, as well as **superficial fascia**. These are three different names for the exact same region. As mentioned above, this layer is immediately deep to the reticular layer of the dermis and consists mostly of adipose tissue with a very good blood supply.

For all intents and purposes the hypodermis represents the bottom layer of skin. It usually sits on top of skeletal muscle that is deep to it. This region has many important functions, including **insulation** for both body heat and impact, as the fat tissue located here provides a nice cushion against any physical trauma. Taking a bit of a tumble on the grass would hurt more if not for this padding.

It is also extremely important that adipocytes store triglycerides (lipids) and therefore this tissue **stores a lot of energy** for the body. Any time the glucose supply gets low in the body, we can burn fats with ease. The hypodermis connects the dermis layer of your skin to your muscles and bones, and another of its major functions is to stabilize position of the skin and provide a great reservoir of blood for the tissues above it, as it is very vascular tissue, meaning it has a rich blood supply.

E. Accessory Structures of the Integumentary System are Epidermal Appendages

All of the ***accessory structures*** in the integument, that is, **hair**, **glands** and **nails**, are actually all derived from the epidermis, that is, they are made of ***epithelial tissue***. It may appear as if these structures are derived from the connective tissue of the dermis because of their location, but they are made of epithelia tissue as an invagination of the epidermis. This may be surprising initially, however as we look more closely at the anatomy of these structures it will become more obvious that sure enough, they are coming from epithelial tissue.

1. Hair – This fluffy stuff on the surface of your skin grows from a hair matrix in the hair papilla that has a good blood supply enclosed in the region of the hair bulb and sheath. Hair has an inner layer, an outer layer, and a protective cuticle. The hair is housed in a hair follicle, which is like another protective shell for the hair. There are several additional structures that are associated with the hair and the hair follicle. Below are the main structures associated with hair.

The **arrector pili** that is associated with a hair follicle is made of ***smooth muscle***. It is attached to the hair follicle and when it contracts, it makes the hair stand erect, hence its name. Pili means hair, by the way. When a person is cold, afraid or angry, often this will result in 'goose bumps' occurring on the surface of the skin. That is from the actions of the arrector pili linked to hair follicles. It has been suggested that hair and hair follicles are extensions of the nervous system. Hair is derived from the ectoderm, just as the nervous system is, and hair is responsive to changes in emotions, atmosphere, etc. We understand that hair does not hurt when we cut it, but we sense when our hair is being touched or moved. This sensory connection within the hair and hair follicle is part of the body's overall nervous system.

The anatomy and physiology of hair and its follicle may be more complex than many realize. As seen in the sketch (below right), **hair** is always housed in a **hair follicle**. The follicle provides structure, protection and is interconnected with many other structures in the dermis, such as nerves, muscles and glands.

a. There is an involved **nerve plexus** around base of hair, and around the hair follicle that detects the movement of the hair, and it is also painful when hair is pulled out.

b. Sebaceous glands - make the oily substance **sebum** (oil) to condition the hair and skin and keep both hair and skin supple. Also prevents hair from becoming dry and brittle.

c. Apocrine sweat glands – as described more fully below, there are modified sweat glands that open into hair follicles in specific areas, which then leads to the surface of the skin. Apocrine glands are associated with hair on the scalp, in the axillary region (armpits), the anus and the groin.

The actual **hair** has 3 layers: The medulla, cortex and cuticle.

The **medulla** (from 'marrow' in Latin) is the innermost layer of the hair and is composed of large cells. Represented as green in the drawing to the right. These cells form a shaft through the middle of the hair. Different amounts of medulla may be present in a hair.

The **cortex** (from Latin 'bark of a tree' or outer husk) is the layer between the cuticle and medulla and contains keratin and pigment (melanin or trichosiderin). Represented as blue the drawing to the right. It represents the bulk and strength of hair.

This intervening layer of the hair is made of spindle shaped cells and the pigment granules that give color to the hair. Ovoid bodies of large pigment granules may be found here, and cortical fusi (small bubble-like structures) are also in the cortex.

The **cuticle** (Latin diminutive for 'skin') is the outermost layer of the hair. Represented as red in the drawing to the right. It is transparent and protects the inner layers. A healthy cuticle gives a shiny appearance for hair and unhealthy cuticle gives lifeless look. It is basically made of keratin. The cuticle is really a series of overlapping scales and is very resistant to chemical decomposition.

Hair thickness is anywhere between 1/1500 to 1/450 inches or **17** to **181** microns (µm) thick. Hair color is the biggest factor in thickness. Flaxen hair (yellowish brown) is the finest (1/1500 to 1/500 inches, 17 to 51 µm) and black hair is the coarsest (1/450 to 1/140 inches, 56 to 181 µm).

Note: There are several significant problems with using hair characteristics in criminal cases – most notably because hair is not uniform! Hair from the **same person** in the **same body region** will not be exactly the same! This is why a minimum of 12 hair samples are taken at different places on a person's head. Even

this is not enough! This is because different parts on the same hair can look very different! It is complicated.

Basically speaking, there are **three (3) different types of hair** that humans have.

1. **Lanugo hair**. This is very thin and soft, and it is usually unpigmented (not colored) hair that is found covering the unborn or newborn babies.

2. **Vellus hair**. This is the short, fine body hair that grows on the surface of the skin, in both sexes and in most places on the body. It is akin to "peach fuzz" on our skin.

3. **Terminal hair**. This is probably the type of hair that we are most familiar with. It is longer, coarser, thicker and darker hair, like hair of the scalp, or eyebrows. This is fully developed hairs.

It is not really relevant to anatomy per se, but forensic scientists distinguish six types of hair on the human body: 1) scalp hair; 2) eyebrows and eyelashes; 3) facial hair (beard and mustache); 4) axillary (underarm) hair; 5) auxiliary (general body) hair; and 6) pubic hair.

Hair Follicles
As already mentioned, the hair follicle is like a house for a single hair. Importantly, this structure acts as a protective covering for the living growing hair **bulb** and **root**. It is basically composed of an inner medulla and outer cortex, and an external & internal root sheath (as seen in the drawing on previous page).

2. Sudoriferous Glands – these are sweat glands, they are numerous on the face, scalp, chest, and feet. There are two types of sweat glands: Merocrine and Apocrine.

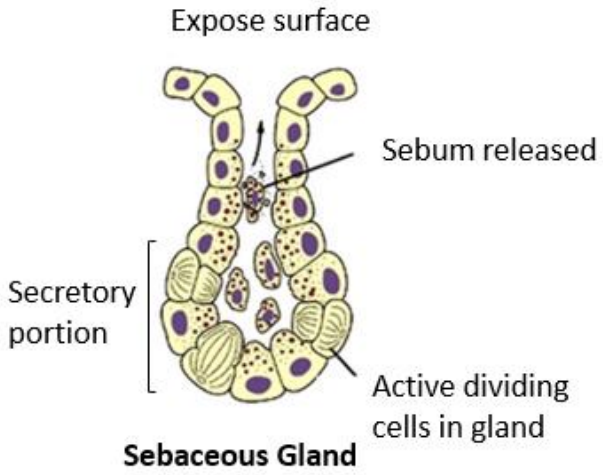
a. *Merocrine* (or eccrine) – these produce **watery sweat**, primarily functions in thermoregulation, specifically for cooling the body down. They also contain lysozyme, an antimicrobial agent. The highest density of these glands is found on **palms**, **soles** and **forehead**. On the palms and soles the sweat works in concert with thick epidermal ridges, better known as fingerprints and footprints, where they increase the friction for better grip. These glands are by far the most numerous type of sweat gland in the body.

b. *Apocrine* – these glands are located in specific regions of the body, such as **axillary** areas, **inguinal** (genital), **anal** and **breasts** regions. They produce a more **vicious type of sweat** that is lipid rich and also contains chemical signal molecules called **pheromones**. These are odorless chemical signals that travel from one individual to another and can have an effect on behavior. Good examples are the 'musk-like' pheromones that are related to sexual attraction between individuals. Another is **oxytocin**, thought to be pheromone released into the external environment by one individual, having an effect on another individual, especially common in bonding situations. For example, it can be displayed in the mother-child bonding of early infancy, in close friendships, or team sports, and in combat. In this capacity, apocrine sweat glands can be considered 'scent' glands for humans, though people are not consciously aware of the fragrance of the pheromones.

The structure of sudoriferous glands, whether merocrine or apocrine, is simple coiled tubular. The mode of secretion is merocrine for all sudoriferous glands too. This mode involves packing the material to be secreted into vesicles in the cytoplasm of the cells. These vesicles then fuse with the plasma membrane

of the cell and release the contents of the vesicles to the outside by way of exocytosis (exo meaning out and cytosis meaning of the cell).

3. Sebaceous Glands. These glands make an oily, waxy material called sebum (meaning fat or tallow in Latin). They are exocrine glands located in the dermis of the skin to lubricate and waterproof the surface of the skin and hair. They occur in the greatest number on the face and scalp and are associated with hair follicles. They are essentially found on all parts of the skin, **except** the **palms** of the hands and **soles** of the feet. In addition, sebaceous glands are also found in hairless areas (or glabrous regions, meaning smooth), such as the skin of the eyelids, nose, penis, labia minora and nipples. Sebaceous glands within the eyelids are known as meibomian or tarsal glands; these are associated with eyelashes and contribute to maintaining the lubrication of the eyes with the oily secretion added to the lacrimal solution.



Sebaceous Gland

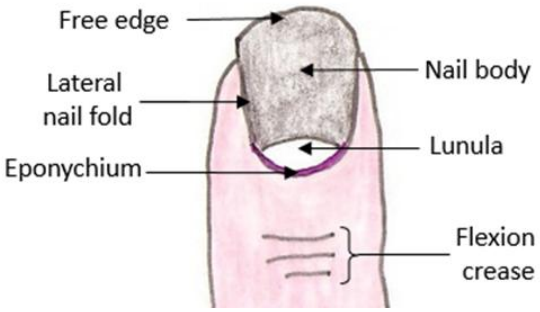
The structure of a sebaceous gland is compound acinar, with ducts leading directly to the hairs they are associated with or they can also deposit sebum directly to the surface of the skin, as shown in the drawing to the left. The mode of secretion for sebaceous glans is called **holocrine**, this process involves the cells of the secretory portion of the glans filling with so many vesicles that it causes the cells to rupture or burst, and as they disintegrate, they release the sebum and the remnants cellular debris with the secreted sebum.

There is a difference between **sebaceous glands**, which have ducts that are connected to hair follicles, and **sebaceous follicles**, which are typically larger glands that are independent of hair follicles. One or more sebaceous glands may surround each hair follicle.

4. Ceruminous Glands. These glands are found in the external auditory (ear) canal, and they produce earwax or **cerumen**. They are actually a type of modified sudoriferous (sweat) gland. Often located deep in the subcutaneous tissue of the external auditory canal, the structure of ceruminous glands is a simple coiled tubular type. Earwax or cerumen is made by a mixture of sticky lipid rich secretion with sebum and dead epidermal cells to produce cerumen.

The main role of cerumen is to keep the eardrum (tympanic membrane) pliable and to maintain the lubrication and waterproofing of the external auditory canal. It also contains antimicrobial agents that kill bacteria, preventing colonization by microbes, otherwise they might set up a campsite in your cozy ear canal. Cerumen also serves as a sticky barrier trapping foreign particles like dust, fungal spores, etc., by coating the guard hairs of the ear.

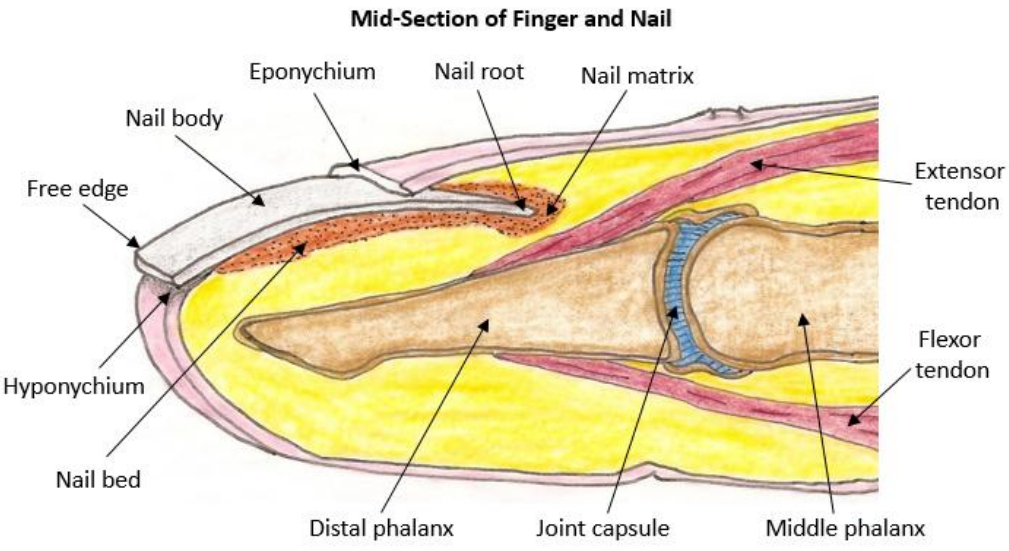
5. Fingernails and Toenails. Fingernails in the body are made of heavily keratinized material that grows from the **nail root** and creates a visible **nail bed**. Finger and toenails are basically made up of dead epidermal skin cells and can be thought of as a specialized modification of the *stratum corneum* of the epidermis. They are predominantly made of keratinocytes, which also make keratin, the lipoprotein found in nails that makes them tough.



The **nail matrix** is deep to the surface where the nail grows. It receives oxygen and nutrients to remain healthy. The matrix becomes the nail plate and **nail bed** and as cells are continuously made, they push older cells forward, compressing and flattening them until they become translucent (allow light to pass through). This is why you can see vascular tissue deep to the nail as a pink-ish color below the surface of the nail. EMTs or paramedics may use the *blanch test* on a fingernail bed to test peripheral perfusion. The nail is briefly squeezed to turn the nail bed white, then the pressure is released and the normal pink should be restored within a few seconds. A delay in the return of a pink color may indicate shock or dehydration.

The little moons of finger and toenails are called the **lunula** (meaning small moon) and represent the crescent-shaped visible part of nail matrix at the base of the visible nail. The **eponychium** and the cuticle are actually separate structures, and both help to create a protective seal at the proximal end of the nail. The eponychium is the fold of skin cells that makes the cuticle – which is an almost invisible layer of non-living skin cells that cover the proximal nail.

The **hyponychium** is also known as the "quick" of the nail. When you cut or bend your fingernail back too close to the quick, it can be painful! The hyponychium is located on the underside of the free edge and is essentially the junction of where the epidermis beneath the nail plate meets the skin of the fingertip. Here a seal forms to protect the nail bed and keep the nail body attached to the nail bed.



The **free edge** or free margin (margo liber) is the distal edge, anterior margin of the nail plate corresponding to the abrasive or cutting edge of the nail. The lateral margin (margo lateralis) lies beneath the nail wall on the sides of the nail and the **lateral nail folds** (sulcus matricis unguis) are the cutaneous slits into which the lateral margins are embedded.

The rate of nail growth is related to the length of the distal phalanx (bone of the digits). For example, the nail of the index finger grows faster than the nail of the little finger; and fingernails grow up to four times faster than toenails. On average, nails grow at a rate of 3 mm (0.12 in) a month.

Nails are not an impermeable barrier but rather, are more permeable than skin. Nails are often composed of up to 10% water. What this means is that harmful and toxic substances applied to the nails can penetrate into the body. Water and other substances including pesticides and other toxins can enter via nails, so it is worth being aware of what your nails are exposed to.

Skin Color

The color of the skin is related to three different pigmented molecules: **1) Melanin**; **2) Hemoglobin**; and **3) Carotene**. As we have already seen, melanocytes are one of four basic cell types found in the epidermis.

Melanocytes make **melanin**, a dark brown molecule that is deposited in the epidermis of the skin. The melanocytes in the epidermis respond to ultraviolet radiation **A** (UVA) from the sun by making more melanin, which acts to protect the nucleus of living cells against damage from UVA rays.

Please Note: The sun's rays also contain ultraviolet radiation **B** (UVB), and it is UVB that is responsible for making **vitamin D** in the epidermis from a precursor molecule derived from cholesterol. Without exposure of the skin to UVB rays your body cannot make its own vitamin D. If you do not know how vitally important vitamin D is to your health, I strongly suggest you find out. It is also worth noting that it is the UV**A** that can create what is called "photo-damage" to your skin. You can think of the A for Aging and the B for Beneficial.

Here is a question: According to what you may have learned, what time of the day should you be sure to avoid sun exposure, in order to be safe from danger? From 10am to 2pm, right? It turns out the only time to maximize UVB exposure is between the hours of, yes, 10am and 2pm. So unfortunately that advice seems contrary to getting good UVB exposure. Furthermore, the use of toxic carcinogenic chemicals that are in most sun blocks, such as the ingredient oxybenzone, act to block UVB, not UVA! In addition to blocking the good ray, oxybenzone also introduces a steady stream of estrogen mimickers into the body.

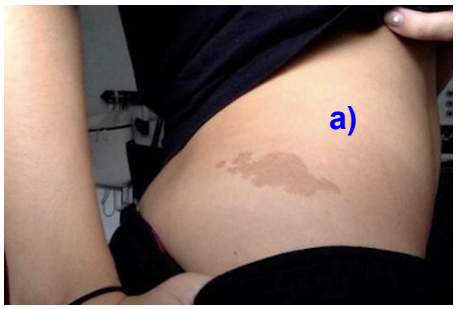
Hemoglobin (Hb) is a pigmented molecule found in erythrocytes (red blood cells) of the blood. When oxygen gas (O_2) is bound to Hb, its color is bright red. When Hb has low O_2 levels, a purple color will result and if virtually no O_2 is bound to Hb, then an almost blueish purple color of the blood prevails. Therefore, the level of oxygenation of the blood will contribute to the overall color of an individual's skin. An easy example to think of it is if you are asked to dig in the garden on a hot day, your completion will become more red, indication 2 things: an increased supply of blood to the skin (to cool down) and a more richly oxygenated blood supply, because you are outside using your body!

Finally, **carotene** is an orange-yellow pigment found in certain foods (like carrots, pumpkin and sweet potato) and the consumption of food containing carotene will contribute to an orangey-yellow of the skin. It tends to collect more in the stratum corneum.

The Anatomy of Various Skin Conditions

What is a Birthmark?

A birthmark is a colored skin spot present at birth or developing shortly after birth. They can occur anywhere on the skin. Their color varies. Some are surface colorations, while others are raised or extend into deeper tissues. Birthmarks appear to be caused from an overgrowth of blood vessels, melanocytes, smooth muscle, fat, fibroblasts, or keratinocytes at that site. There are two main categories of birthmarks:



a) Pigmented birthmarks – these are caused by excess melanocytes in the skin, which release more of the dark pigment melanin. Examples of these include moles, café au lait spots, and Mongolian spots. Marks can range from brown or black to bluish or blue gray in color.

b) Vascular birthmarks – these are caused by increased blood vessels at the site. These include hemangiomas, macular stains (salmon patches), and Port-wine stains. They are often called red birthmarks.

c) Vitiligo

Vitiligo is a skin condition in which portions of the skin lose their pigmentation and become more pale than the rest of the skin around it. This is usually caused by the destruction of melanocytes in that region, thus causing an absence of melanin in that body region. What triggers this condition is largely unknown. There may be a familial predisposition that can be coupled with external triggers. Vitiligo can affect any area of skin, but it commonly occurs on the face, neck and hands, and in skin creases. See image **c)**.

d) Keloids

A keloid is a type of scar formed on the surface of the skin from an injury. It results in an overgrowth of tissue at the site of a healed skin injury – it is usually caused by collagen type 3 (which is more elastic and energetic) being slowly replaced by collagen type 1 (which is more stiff giving tensile strength).

Keloids can be rubbery, shiny firm lesions or fibrous nodules. The color can vary from pink, or red to dark brown. Keloids are benign and not contagious but can sometimes involve severe itchiness, pain, and changes in texture, see image **d)**. Injuries of the skin that can contribute to the formation of a keloid include: Body piercing, surgical incision, burns, acne scars and chickenpox scars. Keloids should not be confused with hypertrophic scars, which are raised scars that do not grow beyond the boundaries of the original wound.