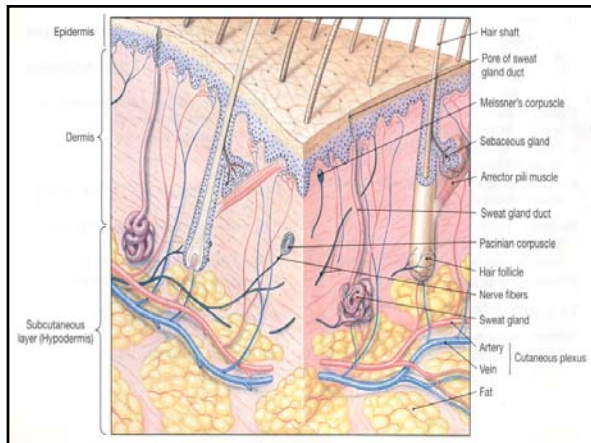


# Integumentary System

## Components of the Integumentary System include

1. cutaneous membrane (skin)
  - a. epidermis (superficial epithelium)
  - b. dermis (under lying connective tissue layer)
2. hair
3. nails } 2,3,4 accessory structures
4. exocrine glands
  - account for 16% of body weight
  - 1½ - 2m<sup>2</sup> in surface area



## General Functions of Skin

- Protection:** of underlying tissues & organs
- Excretion:** of salts, H<sub>2</sub>O, organic wastes
- Maintenance:** of normal body temp.
- Synthesis:** of a steroid, vitamin D<sub>3</sub>-which is converted to a hormone (calcitrol), important to normal calcium metabolism
- Storage:** of nutrients
- Detection:** of various sensations (touch, pressure, pain, temp.)

## The Epidermis

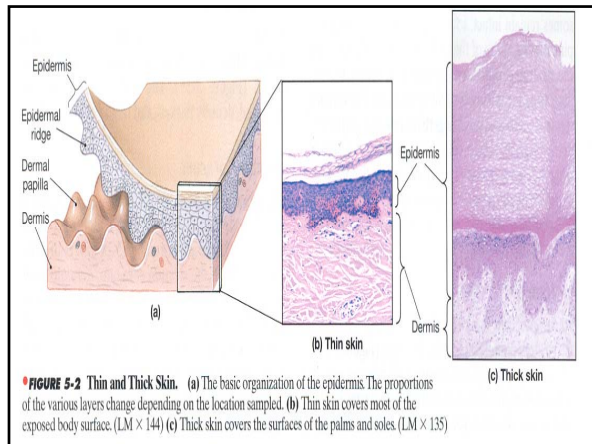
- Provides mechanical protection
- Helps keep microorganisms out of the body
- Consists of stratified squamous epithelium
- Most abundant epithelial cells are called keratinocytes

## Thick Skin

- Palm of hands, sole of foot
- 5 layers of keratinocytes
- Epidermis ≈ 0.48mm thick

## Thin Skin

- Everywhere else
- 4 layers of keratinocytes
- Epidermis ≈ 0.08mm thick



### Stratum Germinativum

- Innermost layer
- Form epidermal ridges to increase contact area to the dermis (better holding power)
- The surface of the skin forms patterns that follow the epidermal ridges, these skin surface ridges
  - a. increase friction
  - b. assure a good grip
  - c. are unique to you
  - d. do not change in your lifetime

- The dominant cells here are **basal cells**, these are stem cells which divide to replace the sloughed off dead skin cells above
- **Merkel cells** are sensitive to touch and when disturbed release chemicals that stimulate nerve endings
- Some **melanocytes** (pigment cells) are located here

### Stratum Spinosum

- Means “spiny layer”
- 8-10 cells thick
- Keratinocytes connected by desmosomes
- Contain **Langerhan cells** (part of immune response)
  - They fight
    - a. microbes invading through skin
    - b. superficial skin cancer

### Stratum Granulosum

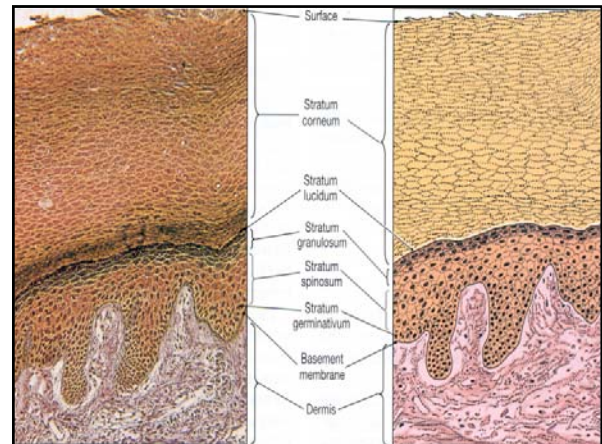
- Means “grainy layer”
- 3-5 cells thick
- Cells start producing large quantities of keratohyalin & keratin
- Keratin is a fibrous protein, as a result of its production, the cells die and dry out

### Stratum Lucidum

- This layer translates to *the clear layer*
- The extra layer in thick skin
- Flattened cells densely packed with keratin

### Stratum Corneum

- Surface layer of skin
- Contain normally 15-30 layers of cells
- Cells tightly connected by desmosomes



### More General Skin Information

- It takes 15-30 days for a cell to move from the stratum germinativum to the stratum corneum
- It generally takes 2 weeks for the dead cells to be shed from the stratum corneum
- This provides a protective barrier of dead, durable, expendable cells
- Also the surface of the stratum corneum is relatively dry so it's unsuitable for the growth of microorganisms.

- The integument is water resistant (not water proof)

a. insensible perspiration  $\approx$  500ml of interstitial fluid makes its way to the skin surface and evaporates each day.

b. sensible perspiration sweating actively w/ sweat glands

- Disruption of epidermal layers or the boundary between the epidermis and dermis can cause a change in the permeability of the skin. The resulting increase in fluid movement causes a blister to form

### Skin Color

- Based on pigment composition/concentration and dermal blood supply.

#### 1. Carotene

- Orange / yellow pigment
- Accumulate in stratum corneum cells of light skinned people
- Also found in the tissue of the dermis. Carotene is found in abundance in some vegetables
  - \*Caucasian vegetarians w/ fondness for carrots can turn orange

- Carotene can be converted to vitamin A, which is needed for

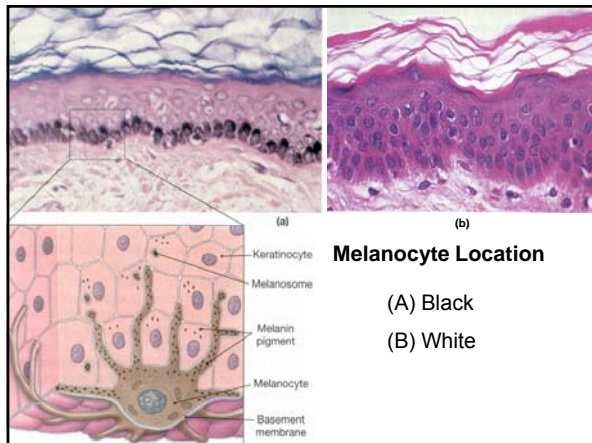
a. epithelial maintenance

b. eye photoreceptor pigment

## 2. Melanin

- Brown, yellow-brown, or black
- Produced by melanocytes
- Found in stratum germinativum
- Manufacture melanin pigment from the amino acid tyrosine
- Package melanin in intercellular vesicles called melanosomes
- Melanosomes can be sequestered in keratinocytes

- This transfer of pigmentation is temporary, until the melanosomes are destroyed by fusion with lysosomes
- In Caucasians, this transfer occurs in the stratum germinativum & stratum spinosum, and the cells of more superficial layers lose their pigmentation.
- In black people, the melanosomes are larger and transfer may occur in the in the stratum granulosum as well; this pigmentation is thus darker and more persistent.
- Freckles and pigmented moles are local accumulations of melanin



## UV Radiation & the Skin

- A small amount of UV radiation can be beneficial (stimulates the synthesis of vitamins)
- Too much UV can damage the DNA causing mutations and promoting cancer development.
- Melanin synthesis increases with exposure to UV rays, but proceeds slowly (peaks 10 days after initial exposure).
- This response, called **a tan** attempts to protect DNA from the UV rays

## Dermal Circulation

- Oxygenated blood bright red (gives normal pink color to Caucasians)
- When circulatory supply is temporarily reduced the skin becomes extremely pale (turns white)
- Sustained lack of blood

## Epidermal Growth Factor

- EGF is produced in the salivary glands and in the duodenum
- EGF has widespread effects on epithelial tissue (esp. in epidermis) including
  - a. promoting division of epidermal germ cells
  - b. accelerating Keratin production in epidermis
  - c. stimulating epidermal growth & repair
  - d. stimulating epithelial gland activity
- EGF can be used to stimulate the growth of epidermal tissues outside of the body (tissue culture)
  - \*use in burn victim treatment

## Dermis

Has two major components:

### 1. Papillary Layer

- Loose connective tissue
- Contains vessels and nerves of skin

### 2. Reticular Layer

- Dense irregular connective tissue
- Bound to papillary layer w/collagen fibers
- Boundary indistinct

## Wrinkles & Stretch Marks

**Collagen:** no stretch but bend and twist

**Elastin:** stretch and rebound

- In skin, collagen and elastin are intertwined to give the skin a limited elasticity
- H<sub>2</sub>O content in the skin helps maintain flexibility and resilience (properties known as skin turgor)
- Dehydration causes a temporary decline in skin flexibility

• Aging, hormones, and the destructive effects of UV radiation permanently reduce the amount of elastin in the dermis, producing wrinkles and sagging skin.

• The extensive distortion of the dermis that occurs over the abdomen during pregnancy or after a substantial weight gain can exceed the elastic capabilities of the skin

• The resulting damage to the dermis prevents it from recoiling to its original size after delivery or a rigorous diet. The skin thin wrinkles and creases, creating a network of stretch marks.

• Tretinoin (Retin-A<sup>tm</sup>) – vitamin A derivative gel, inc. blood flow to the dermis & stimulates dermal repair

## Lines of Cleavage

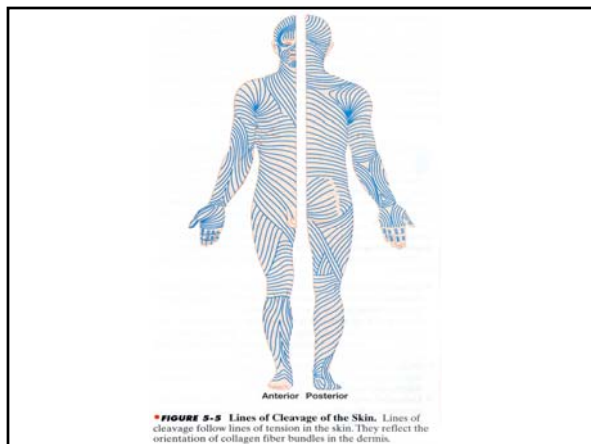
• Collagen & elastin fibers in a location are arranged in parallel bundles

• The bundles are aligned to resist the applied forces in the skin (minimum stress in resting position)

• The patterns these bundles form are called lines of cleavage

• Surgeons cut along the lines of cleavage because there is less strain on the incision and it heals faster.

(Cuts parallel to LOC self seal, cuts perpendicular to LOC tend to rip more)



## Dermal Blood Supply

• Blood vessels supplying the skin form a network in the sub-q layer, just below the reticular layer of the dermis.

• This layer is called the cutaneous plexus

• These vessels branch and head up to the papillary layer of the dermis where they join up again to form a "papillary plexus"

• Ulcers are localized shedding of epithelium

Decubitis Ulcers or Bedsores result in bedridden or mobile patients w/circulatory restrictions esp. when something continuously presses against superficial blood vessels.

- Esp. bad on projecting joints or bone
- Deprived of adequate circulation, the epidermis dies
- If circulation is not restored, the dermis will deteriorate and die as well  
(this type of tissue death is called **necrosis**)
- Ulcers can be prevented or treated by frequently changing the patients position

### **Birthmarks**

- Arise from dermal blood vessel tumors during development
- May be temporary or permanent
- Small birth marks “*capillary hemangioma*” involve the papillary layer of the dermis
- Larger “Port Wine Stain” birth marks involve deeper vessels (*Cavernous hemangiomas*). They may or may not be treatable with laser surgery.

### **Nerve Fibers in the Skin**

1. control blood flow
2. adjust gland secretion rates
3. monitor sensory receptors

**Dermatitis** – Inflammation of the skin. Several examples are...

**Contact dermatitis** - Reaction to chemical irritants.  
Example: Poison Ivy

**Hives** – An allergic response to a food, drug, insect bite, infection or stress. Another name for hives is **Urticaria**.

**Eczema** – Dermatitis triggered by temperature change, fungus, chemical irritants, detergents or stress. There can be environmental or hereditary links.

**Diaper rash** – Caused by moisture and microorganisms from urine & or fecal wastes.

### **The Subcutaneous Layer** (or hypodermis)

- Sub-Q CT is extensively interwoven w/ the CT fibers of the reticular layer
- Not really part of the integument it plays a vital role in positioning of the skin
- Made of loose connective tissue with abundant adipose tissue
- Most infants and small children have extensive “baby fat” to reduce heat loss, for use as an energy reserves, and a shock absorber for rough and tumble play

- As we grow the distribution of sub-Q fat changes

#### **Men accumulate it in:**

Neck, arms, lower back, & buttocks

#### **Women accumulate it in:**

Breasts, buttocks, hips, & thighs

- Back of hands and top of feet have almost no fat accumulation (but lots can be accumulated around the abdomen)

### Accessory Structures

These structures include:

- Hair follicles
- Sebaceous glands
- Sweat Glands
- Nails

\*These originate in the epidermis during embryological development (so they are called embryological derivatives) and reside in the dermis

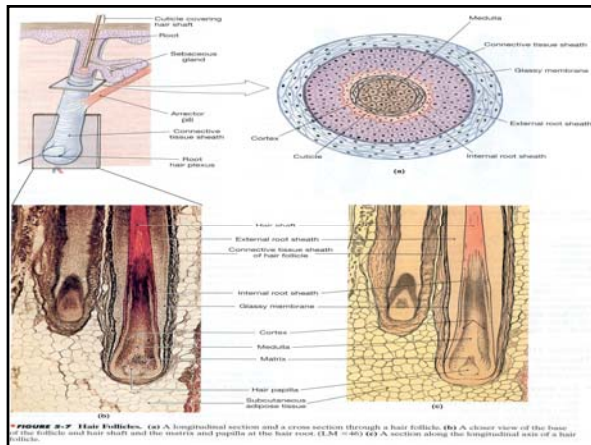
### Hair

•Epidermal cells grow downward forming tubes called **follicles**

•A **papilla** is located at the base of the follicle. The papilla contains blood vessels that nourish cells responsible for forming the hair.

•Hair is composed of cells that contain a harder form of keratin than skin cells.

•The keratinized hair cells are arranged in three concentric layers. (*medulla, cortex, cuticle*)



### Hair Follicles & Hair

•There are  $\approx 5$  million hairs on the human body and 98% are on body surfaces other than the head (we have more hair follicles than a gorilla)

•Hair originates in the hair follicles during a complex process

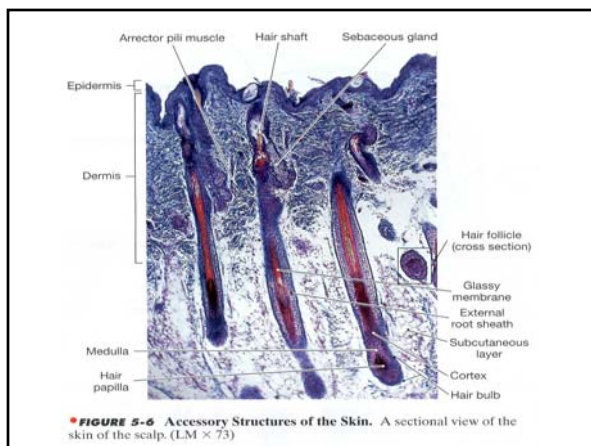


FIGURE 5-6 Accessory Structures of the Skin. A sectional view of the skin of the scalp. (LM  $\times 73$ )

### Functions of Hair

**Head:** -roughly 100,000 hairs

- protects scalp from UV rays
- cushions blows to the head
- insulate the skull

**Nostrils/Ear Canals/Eyes:** -keep foreign particles & insects from entering

•A root hair plexus of sensory nerves surrounds the base of each hair follicle. Because of this we are sensitive to movement of even a single hair. This works as an “early warning system”

### Types of Hairs

Two major types in adult integument:

**Vellus hairs:** fine "peach fuzz" hairs located around the entire body

**Terminal hairs:** heavy, more deeply pigmented and sometimes curly hairs

### Growth & Replacement of Hair

- Our hairs grow and are shed according to our personal hair growth cycle
- Hair in the scalp grows for 2-5 years at a rate of 0.33mm/day
- At the end of the growth cycle the follicle becomes inactive. The hair is now termed a club hair
- Eventually the connection between the follicle and the club hair root breakdown

- When another hair cycle begins and the follicle produces a new hair the old hair is pushed out and eventually shed
- Normal healthy adults lose 50 scalp hairs a day

### Glands in the Skin

- There are two types of exocrine glands in the integument
1. **Sebaceous (oil) glands**
    - Produce an oily lipid that coats hair shaft and the epidermis
    - These are holocrine glands
    - Contractions of the arrector pili muscles (erect the hairs) force the oily lipid sebum onto the surface of the skin.

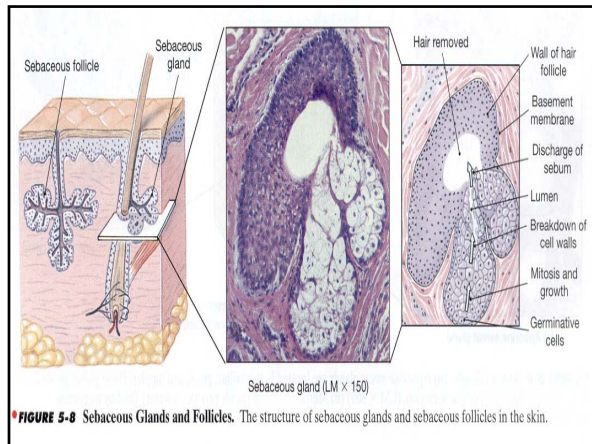
**Note:** An interesting feature of the dermis is the presence of *arrector pili muscles*. These smooth muscle fibers are responsible for "goose bumps" and for the hair "standing on end"

- **Sebum** is a mixture of triglycerides, cholesterol, proteins, and electrolyte
- Provides lubrication
- Inhibits growth of bacteria
- It also protects the hair. Too much shampooing will strip the hair of sebum and make them stiff & brittle

### 2. Sebaceous follicles

- Large sebaceous glands that never produce hairs and are connected directly to the epidermis
- Located on the face, back, chest, nipples, and penis





- Sebum has bactericidal properties, but under some conditions bacteria can invade sebaceous glands
- Bacteria in a sebaceous gland causes a local inflammation known as folliculitis
- If the duct gets blocked , a distinct abscess called a **furuncle forms** (boil) usual treatment is "lancing"

**Sebaceous glands & follicle are sensitive to changes in sex hormones**

- secretory activities accelerate at puberty
- people with large sebaceous glands will be prone to "acne" at this stage during their development
- \*Ducts become blocked
- \*Trapped secretion support bacterial growth
- \*Results in raised pimple

**Sweat Glands**

- Two types of sweat (or sudoriferous) glands

**1. Apocrine**

- Located in armpit, around nipples, and in the groin
- Produce sticky, cloudy, and potentially odorous secretions
- Begin secreting at puberty
- The sweat is a nutrient source for bacteria which intensify its odor

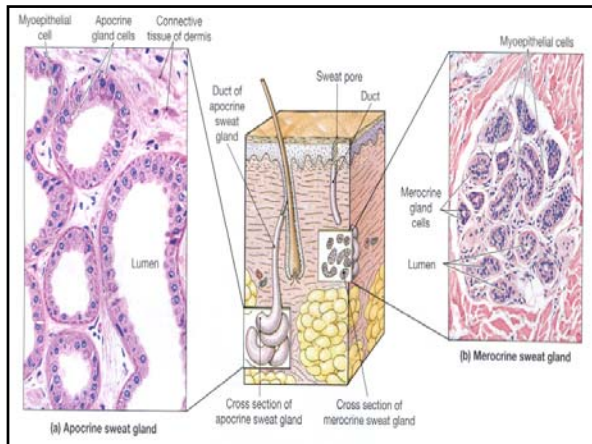
**2. Merocrine (aka eccrine sweat glands)**

- More numerous and widely distributed than apocrine sweat glands
- Adult integument contains 2-5million merocrine sweat glands
- Palm of hand has 3000 / in<sup>2</sup>
- Sweat is 99% H<sub>2</sub>O but contains electrolytes (NaCl), organic nutrients, and waste products
- It has a pH of 4-6.8

- Functions in

1. cooling the surface of the skin
2. excretion of H<sub>2</sub>O
3. protection from environmental hazards

- \* The process of sweating is called **diaphoresis**



**Specialized sweat glands:**

**Mammary glands**

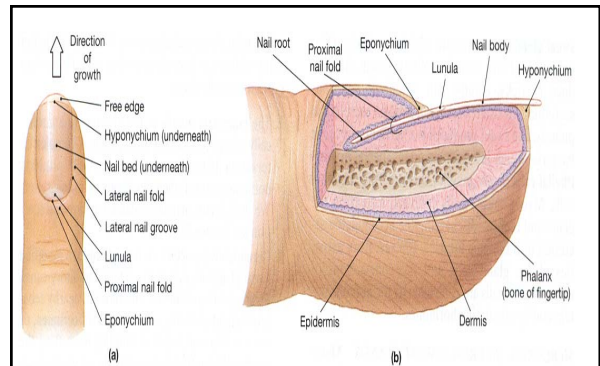
- Located in breasts
- Anatomically related to apocrine sweat glands

**Ceruminous glands**

- Modified sweat glands
- Located in external auditory canal
- Produce secretions that when mixed w/sebum forms ear wax

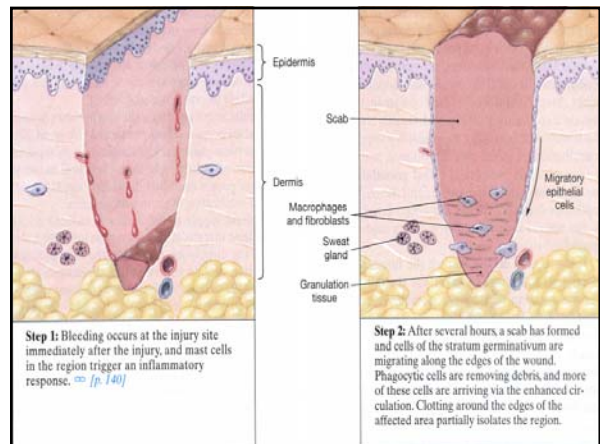
**Nails**

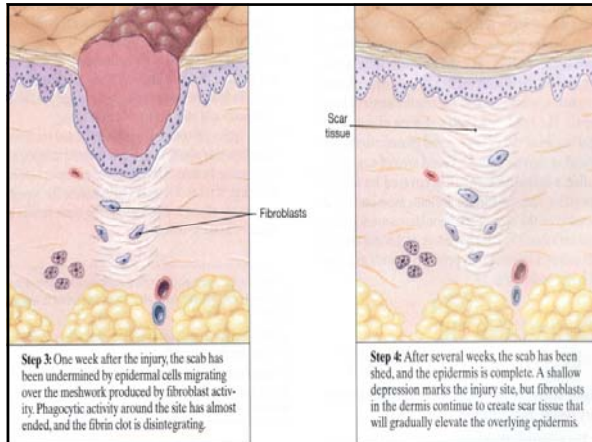
- Protect the fingers & toes. Useful as tools, they help to pick up small objects.
- Like hair, they are composed of *hard keratin*.
- The visible nail is called the **nail body**. The **free edge** of this is what you trim.
- Under the nail body is the **nail bed**.
- The whitish crescent on the nail is called the **lunula** (little moon).
- A portion of the skin grows onto the nail body and is called the **cuticle**.



**FIGURE 5-10** Structure of a Nail. The prominent features of a typical fingernail as viewed (a) from the surface and (b) in section.

# Injury & Repair





- If the wound covers an extensive area or involves a region covered by thin skin, the dermal repair must be underway before epithelial cells can cover the surface.
- Fibroblasts & mesenchymal cells divisions produce mobile cells that invade the deeper areas of the injury.
- These repairs do not restore the integument to its original condition, however, for the dermis will contain an abnormally large number of collagen fibers and relatively few blood vessels.
- The formation of this rather inflexible fibrous, noncellular **scar tissue** can be considered a practical limit to the healing process.

## BURNS

**Burns** - Heat can denature skin proteins. Burns are classified as:

- **First-degree** - Inflammation, usually heals in a few days without scarring. Sunburn is an example.
- **Second-degree** - Much of the epidermal cells are destroyed. Blisters usually occur.
  - \*Blister: when the dermis & epidermis separate to form a fluid filled pocket

**Third-degree** - Portions of the epidermis, dermis and subcutaneous tissue are destroyed.

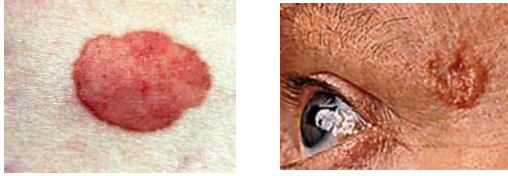
\*Victims feel little pain at first due to the destruction of the nerve endings. The skin loses its waterproofing, fluids are lost and shock may result. Secondary infections are common.

## Skin Cancer

**Skin cancer** - The three most common types are all related to excessive exposure to the sun. Protection from UV radiation is the best protection. If you spend a lot of time in the sun, examine your skin often. Check for asymmetrical, irregular lesions that may contain different colors and have a diameter over 6mm. Always use lotions with UV blocking agents .

- (a) **Basal cell carcinoma** - The least malignant and most common type. Cells of the stratum germinativum may proliferate and invade the dermis and hypodermis. Slow growing and tends not to metastasize. Full cure in 99% of the cases.
- (b) **Squamous cell carcinoma** - Develops in the stratum spinosum. Grows rapidly and could metastasize to nearby lymph nodes if not removed. Good chance of complete cure.
- (c) **Malignant melanoma** - The rarest but most deadly type of skin cancer. Can begin wherever pigment is present, often a mole, but can form anywhere on the skin. Early detection helps in terms of survival.

***Basal cell carcinoma***



***Squamous cell carcinoma***



***Malignant melanoma***



**Note:** Sun tanning salons claim to use "safe" wavelengths. Some medical authorities say that there is potential danger from this practice including cancer, premature aging of the skin, suppression of the immune system, retinal damage, and cataracts.