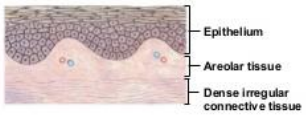
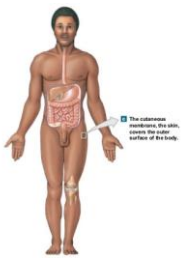
Integumentary System

The Integumentary System

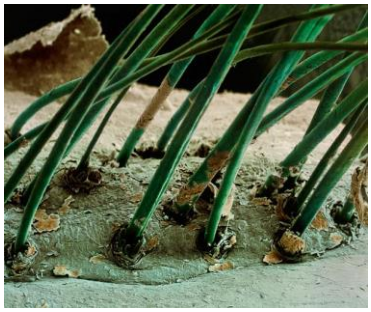
- The **integument**, or skin, is the largest organ in the body.
  - 16% of body weight.
  - 1.5-2m² in area.

- The skin is one of the body's **membranes**, which are boundaries or linings between organs and tissues.
- The skin is a **cutaneous membrane**, made of:
  - Stratified squamous epithelium.
  - Areolar connective tissue.
  - Dense irregular connective tissue.





- Skin also contains **accessory structures**, such as hair, nails, and glands.

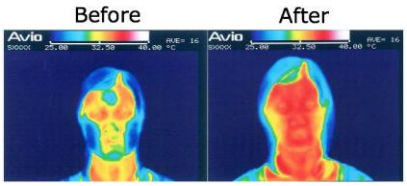


Functions of Skin

- The skin covers and **protects** from impacts, chemicals, infection, and prevents the escape of body fluid.

Sodium hydroxide (NaOH) burn.

- Skin helps in the **homeostasis** of body temperature by providing insulation during cold and sweating when hot.

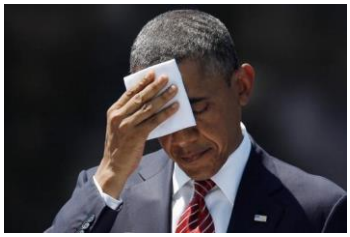


Thermal imaging before and after a workout.

- The majority of the body's **energy storage** is in adipose tissue directly under the skin.

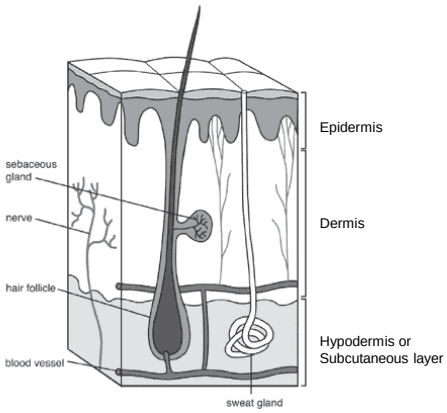
- The skin contains **sensory receptors** for touch, pressure, pain, and temperature stimuli.

- Salts, water, organic wastes, and milk (in women) are all **secreted** by the skin.



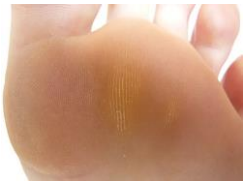
Skin Layers

- There are three layers of skin:
  - The **epidermis**, which is mostly made of dead squamous cells.
  - The **dermis**, which contains blood vessels and accessory structures.
  - The **hypodermis**, or subcutaneous layer, which contains adipose tissue.



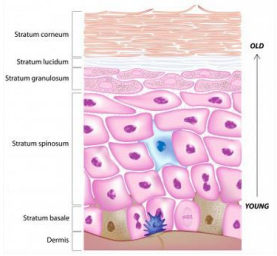
Epidermis

- The composition of the epidermis depends on the location in the body.
- Areas of **thick skin** contain five cell layers.
  - Palms of hands, soles of feet.
- Areas of **thin skin** contain four cell layers.
  - All other locations in the body.

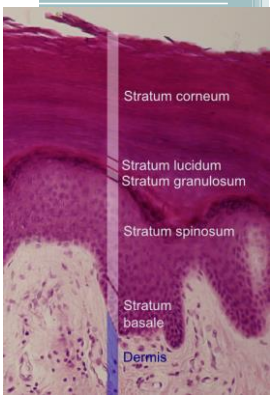


Life Cycle in the Epidermis

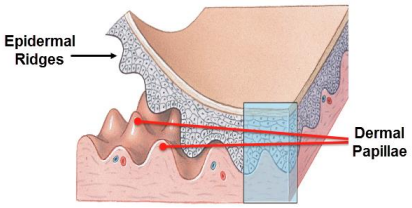
- Cells of the epidermis pass through five different stages as they grow and move outward.
- Cells begin at the base (near the dermis) and gradually move towards the outer surface.
- Each layer is called a **stratum**.



- The deepest layer of the epidermis is called the **stratum basale**.
  - Attached to the basement membrane by desmosomes.
  - Contains large stem cells that continuously divide.

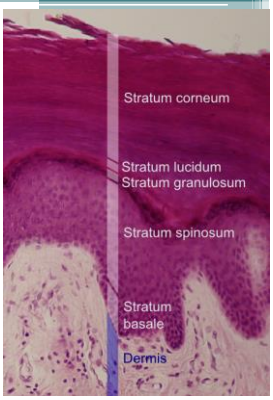


- **Epidermal ridges** are raised areas that increase the surface contact area with the dermis.
  - The epidermis has no blood vessels, so all nutrients and oxygen diffuse from the dermis.



- Epidermal ridges create the whorls and contours known as prints in areas of thick and thin skin.

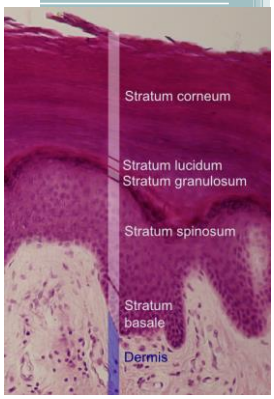
- The **stratum spinosum** contains the daughter cells produced by mitosis within the stratum basale.
  - They continue to divide.
- In the **stratum granulosum**, cells stop dividing and instead produce a protein called keratin.



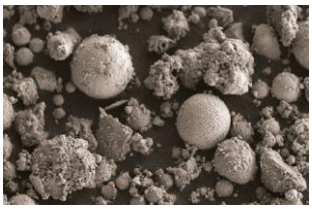
- **Keratin** is a durable, water-resistant protein found in skin, fingernails, and hair.
  - Animal horns and hooves too!

Lee Richmond's world record fingernails (8.65m), grown from 1979-2008. Source: guinnessworldrecords.com.

- The **stratum lucidum** is a layer of keratinized cells only found in thick skin.
- The **stratum corneum** is the outermost and exposed layer of skin.
  - Made of 15-30 layers of dead, flattened, keratinized cells.



- Cells take 7-10 days to reach the stratum corneum, then remain there for about two weeks.
- Dead skin cells are shed continuously, contributing to the formation of dust.



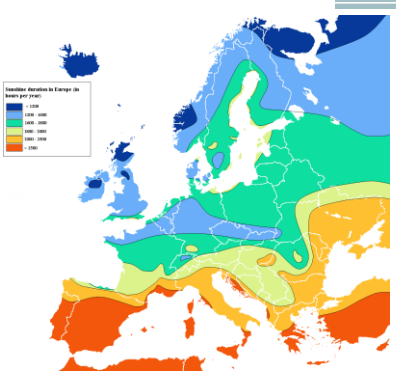
Skin Color

- Ultraviolet light in small doses helps the body produce **Vitamin D**.
  - Essential for the absorption of calcium and phosphorus by the intestines.
  - A vitamin D deficiency causes **rickets**, a softening of the bones.

- The stratum basale contains **melanocytes**; cells that produce the pigment melanin that colors the epidermis.
  - This creates tanning, which helps to protect against UV damage from sun exposure.

Human hand with uneven distribution of melanin.
From wisegeek.org

- **Freckles** are small, concentrated spots of melanin in fair-skinned people.



- Having a darker skin tone helps to protect against UV damage, but also reduces vitamin D production.
  - Ethnicities from areas with less sun tend to be more fair-skinned.

Skin Color Disorders

- **Cyanosis** is a bluing of the skin caused by poor circulation or inadequate oxygen in the blood.
- **Jaundice** is caused by a buildup of a product of red blood cell breakdown in the blood.
  - Usually a sign of liver disease.

Skin Cancer

- **Basal cell carcinoma** affects cells in the stratum basale.
- **Squamous cell carcinoma** occurs in the stratum spinosum.
  - Metastasis is rare, and the tumors can be removed surgically.


(a) Basal cell carcinoma


(b) Squamous cell carcinoma

- **Malignant melanoma** is caused by out of control growth in melanocytes.
  - Can metastasize quickly to blood and lymph vessels.
- Malignant melanomas can be differentiated from normal moles with the ABCD rule.
  - **Asymmetry**, two sides of pigmented mole do not match
  - **Border irregularity**, borders of mole are not smooth
  - **Color**, different colors in pigmented area.
  - **Diameter**, Spot is larger then 6 mm in diameter


(c) Melanoma

- The biggest risk factor for skin cancer is excessive UV exposure from the sun or tanning booths.

The Dermis

- The dermis is the layer underneath the epidermis.
  - The **papillary layer**, contains areolar tissue that contains blood vessels and nerves to support the epidermis.
  - The **reticular layer**, contains dense irregular connective tissue bind skin to deeper layers of tissue.

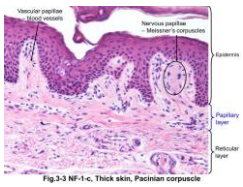
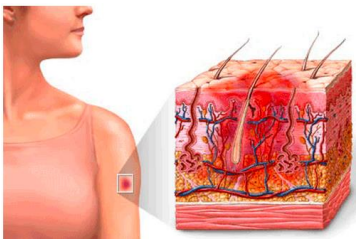


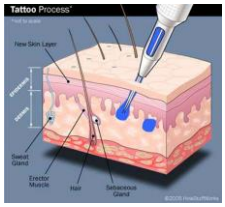
Fig.3-3 NF-1-c, Thick skin, Pacinian corpuscle

- A **bruise** occurs when blood vessels in the dermis break and leak blood into the surrounding tissue.



Tattoos

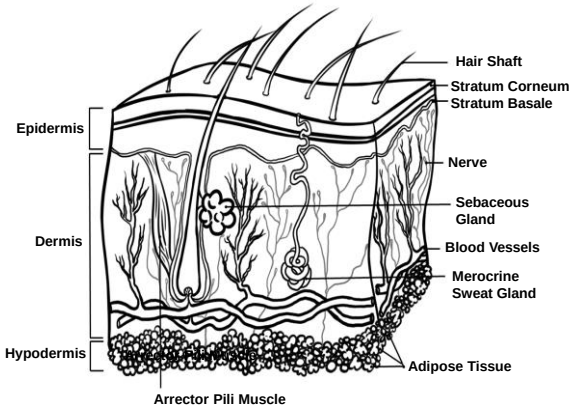
- Tattoos work by injecting small droplets of ink into the dermis.
  - Since the cells of the dermis are more stable than the epidermis, the tattoo is permanent.



- Tattoos can be removed through dermabrasion or laser treatment, which breaks up the ink droplets.

Hypodermis

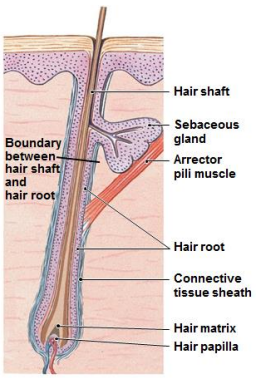
- The hypodermis is not technically part of the integument, but is important in stabilizing skin and separating it from the muscle layer.
  - Made of areolar and adipose tissue with many fat cells.
  - Baby fat is contained within the hypodermis. It provides insulation, shock absorption, and an energy reserve.



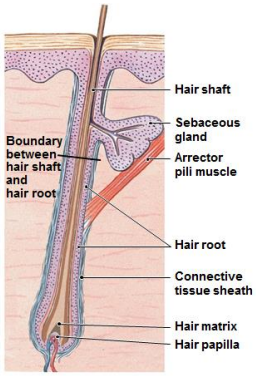
Hair

- Hair is a nonliving structure produced in **hair follicles**.
  - Hair follicles project all the way into the hypodermis.

- The **hair papilla** contains the hair's capillaries and nerves.
- The **hair matrix** contains epithelial stem cells that divide, push towards the surface, and keratinize.



- The hair cells die about halfway between the papilla and surface.
  - Below this point is the **hair root**.
  - Above this point is the **hair shaft**.

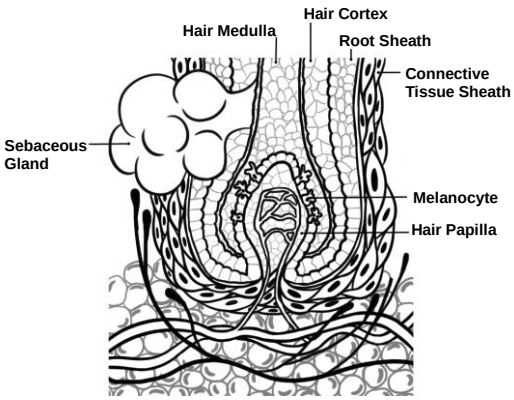


- Hair provides insulation for the head and guards the entrances to the nose, ears, and eyes.
- Each hair has its own sensory nerve fiber, enhancing the sense of touch.

- A bundle of smooth muscle cells called the **arrector pili** can contract and pull on the follicle, causing the hair to stand up.
  - The structure is vestigial in humans, but still used in other mammals.

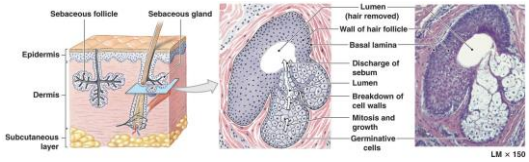
- Hair color is the result of different amounts and types of melanin produced at the hair follicle.
  - Pigment production decreases with age, either resulting in grey (decreased melanin) or white (air bubbles) hair.

- Male pattern baldness is a genetic trait caused by hair follicles that are overly sensitive to one of the male sex hormones.
  - Produces shorter, finer hairs.

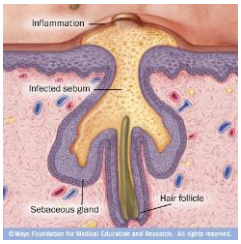


Sebaceous Glands

- Sebaceous glands are exocrine glands that secrete an oil called **sebum** into hair and skin.
  - Prevents drying out and is antibacterial.
  - Sebum production increases with hormone secretion during puberty.



- Acne is the formation of pimples due to the blockage of sebaceous gland pores.
  - Whiteheads are infected and black heads are not.
  - The white pus is made up of white blood cells.



Sweat Glands

- **Apocrine sweat glands** secrete an oily fluid that acts as a pheromone.
  - Only found in the axillary regions (armpits) and around the genitals.
  - Degraded by bacteria, resulting in body odor.

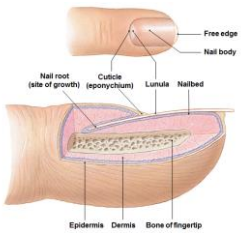
- **Merocrine sweat glands** discharge their secretions directly onto the surface of skin.
  - 90% water
  - 10% electrolytes and organic wastes
- Sweat, as it evaporates, carries away excess heat from the body.

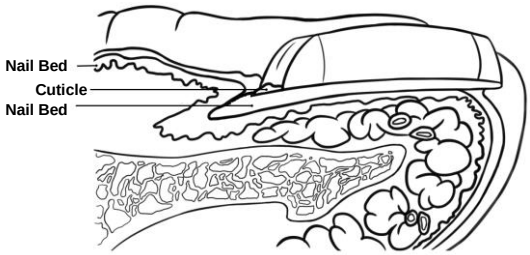
- Sports drinks are formulated to replace the electrolytes lost in sweat.

Nutritional information per 100ml	
Energy content	71KJ, 17Kcal
Protein	0g
Carbohydrate	3.9g
Of which sugars	3.9g
Fat	0g
Of which saturates	0g
Fibre	0g
Sodium	50mg
Potassium	12.5mg
Magnesium	0.6mg
Calcium	1.3mg

Nails

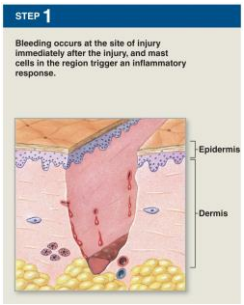
- Nails are keratinized epidermal cells that protect the tips of the fingers and toes.
  - Production of nails comes from the **nail root**.
  - Blood vessels in the underlying **nail bed** give the nail its pink appearance.
  - The **cuticle** is a layer of stratum corneum that overlaps part of the nail.



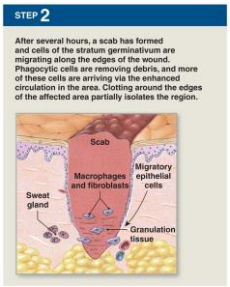


Repair of the Integument

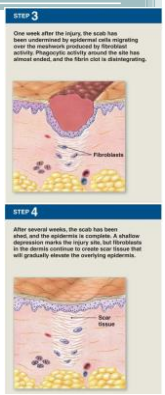
- Bleeding occurs due to broken blood vessels in the dermis.
- **Inflammation**, or an increase in blood flow, occurs.



3. A temporary blood clot or **scab** stabilizes and protects the wound.
4. Cells from the stratum basale surround the injured area.
5. Phagocytes clean the area of bacteria and foreign substances.



6. Fibroblasts move in, producing **scar tissue,** a thick network of collagen fibers to restore the dermis.



- Scar tissue has more collagen fibers, fewer blood vessels, and fewer accessory structures than undamaged skin.

Skin Burns

- **First-degree burns**
  - Only epidermis is damaged
  - Skin is red and swollen
  - Sun burns
- **Second-degree burns**
  - Epidermis and upper dermis are damaged
  - Skin is red with blisters
  - Boiling water burns
- **Third-degree burns**
  - Destroys all layers, including nerves and blood vessels.
  - Burn is gray-white or black, often no pain felt.

Effects of Aging

- The epidermis thins and stem cell (stratum basale) activity declines, resulting in more injury and infection.
- Vitamin D production declines, resulting in reduced bone strength.
- Less melanin is produced, so the skin becomes more sensitive to ultraviolet light.
  - Hair becomes grey or white.

- Gland activity declines, making the skin drier.
- Less hair, and finer hair is produced.
- The network of elastic fibers in the dermis becomes thinner, causing sagging and wrinkling.

Wrinkling in Water

- After about 30 minutes in water, the skin wrinkles.
  - Keratinized cells in the stratum corneum, immersed in a hypotonic solution, absorb water and swell.
  - Deeper layers of cells do not swell, so the upper layers wrinkle upwards.

Botox

- Botox is a toxic substance produced by the bacteria *Clostridium botulinium*.
- Botox blocks a neurotransmitter that signals the contraction of muscles in the skin.
  - This can diminish certain types of wrinkles (brow lines, frown lines)

Skin Infections

- Fungal infections are spread by contact, particularly in dark, moist areas.
  - Athelete's foot, toenail fungus, ringworm.
- Only antifungal medications like Lamisil are effective.

- Bacterial infections, such as impetigo, boils, and staph, are all caused by a normally harmless species of bacteria (*Staphylococcus aureus*).
  - Treated with antibiotics.
  - Transmitted by contact.
- MRSA is a strain of staph that is resistant to many antibiotics.

- Viruses cause chicken pox, warts, and cold sores.
  - Infects epidermal cells, overgrowth and itching.
  - Airborne and direct contact.
- Viral infections are difficult to treat, and must generally be prevented with a vaccination.

Irritation

- **Itching** is a response triggered by nerves that begin firing when an irritant lands on the skin surface and is rubbed into the dermis.
  - Scratching is meant to remove the irritant with the nails.