Integumentary System
Chapter 5

COMPONENTS

FIGURE 5.1

1. Skin.
   A. The **epidermis** (meaning upon the skin) is a superficial layer of stratified, squamous epithelial tissue.

   B. The **dermis** (meaning skin) is a deeper layer of connective tissue.

   C. The skin (i.e., epidermis and dermis) rests upon the hypodermis, which is a layer of loose connective tissue. It is NOT part of the integumentary system.

2. Hair and associated smooth muscle, glands of the skin, and nails.

SKIN
Epidermis
1. The epidermis has several layers or **strata** of cells.

FIGURE 5.2

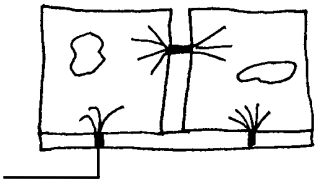
2. The deepest layer produces the more superficial layers which are altered and eventually consists of dead cells that resist abrasion and water loss. This process is called **keratinization**.

3. Analogy: Human life is a continuous process, but it can be divided into stages: newborn, infant, child, teenager, and adult. The epidermis is also continuous, but can be divided into strata.

FIGURE 5.3

Stratum basale
1. The **stratum basale** is the deepest layer. **Keratinocytes** produce the basement membrane upon which they rest, and produce the cells of the more superficial strata.

2. The keratinocytes are attached to the basement membrane by hemidesmosomes, held together by desmosomes, and strengthened internally by **keratin fibers** (protein).



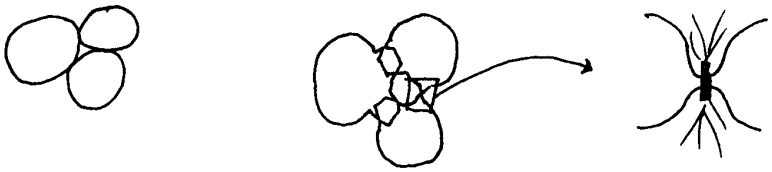
3. The stratum basale contains **melanocytes**, cells that produce the pigment melanin responsible for skin color. **Langerhans cells** are part of the immune system.

Stratum spinosum

1. The **stratum spinosum** is so called because the cells pull apart during preparation and appear spiny where they are held together by desmosomes.

2. Additional keratin fibers and **lamellar bodies** (membrane-bounded sacs filled with lipids) are formed.

3. A small number of cell divisions take place in the stratum spinosum.



Cells before preparation

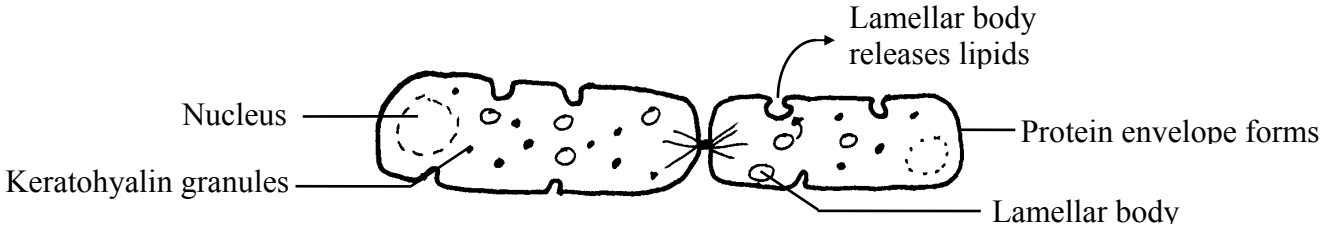
Cells after preparation

Enlargement showing spines are connected by desmosomes

Stratum granulosum

1. The **stratum granulosum** contains large granules of the protein **keratohyalin**. **Lamellar bodies** release lipids to the outside of the cells. A hard **protein envelope** forms on the inside of the plasma membrane.

2. The cells are dying or dead.



Stratum lucidum

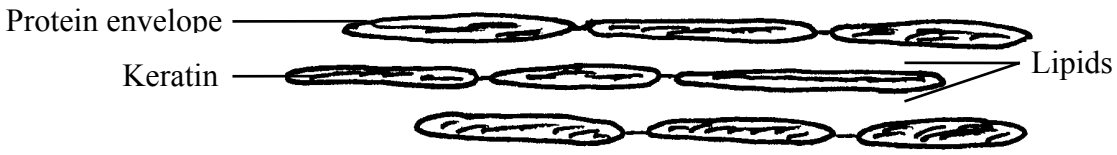
1. In the **stratum lucidum** (= clear) the keratohyalin granules have dispersed and this layer appears clear. Cells are dead.

2. The stratum lucidum is absent from most skin.

Stratum corneum

1. The **stratum corneum** consists of several layers of dead squamous epithelial cells. The cells are filled with **keratin** (a mixture of keratin fibers and keratohyalin), held together by desmosomes, strengthened by a hard protein envelope, and surrounded by lipids.

2. Keratin and the protein envelope makes the cells hard and the lipids prevent water loss.



☞ Scopolamine is a drug used to prevent motion sickness. One method of administering scopolamine is in a skin patch that is attached behind the ear. What properties must scopolamine have in order to diffuse through the skin?

3. Eventually the dead cells are sloughed or **desquamate**. In response to friction, the stratum corneum thickens (more layers of cells) to form a **callus** or **corn**.

Thick and Thin Skin

1. **Thick skin** has all five strata and the stratum corneum has many layers of cells. Found in the digits, palms, and soles of the feet.

2. **Thin skin** is missing the stratum lucidum and has fewer layers of cells per strata. It is more flexible than thick skin. Only thin skin contains hair.

Skin Color

FIGURE 5.4

1. **Melanin** is the term used to describe a group of pigment molecules.
   A. Melanin is produced by melanocytes and packaged into vesicles called **melanosomes**.

B. Keratinocytes adjacent to the melanocyte ingest the cell processes of melanocytes containing the melanosomes. Thus, keratinocytes have melanosomes, but do not produce them.

2. Most melanin pigments are brown to black in color, but some are yellowish or reddish.
   A. Melanin functions to protect cells from ultraviolet (UV) light.

   B. The amount of melanin in the skin can be increased by exposure to UV light and by certain hormones (MSH and ACTH).

   C. The amount of melanin in the skin is genetically determined. Because the number of melanocytes in the skin is the same for different races, it is the amount and kind of melanin that is responsible for the color of the skin of different races.

3. **Carotene** is a yellow plant pigment ingested as a source of vitamin A. Carotene accumulates in the lipids of the stratum corneum.

4. Blood.
   A. Decreased oxygen causes a blue color called **cyanosis**.

   B. Increased blood flow causes a red color, as in blushing, anger, fever, overheating, and the inflammatory response.

   C. Decreased blood flow causes the skin to appear pale, as in shock, cold, and death.

☞ **Practice Problems**

A. Explain the difference in skin color between the anterior and posterior surfaces of the forearm.

B. Explain the difference in skin color between the palms of the hands of a person who does heavy manual labor and one who does not.

C. Explain the difference in skin color between the palms of the hands and the lips.

Dermis

1. The dermis is divided into two layers. The dermis is the site of the TB and other skin tests.

FIGURE 5.2

2. Reticular layer.
   A. The **reticular layer** is dense, irregular connective tissue. It is the main layer of the dermis. The reticular layer is responsible for the strength of the skin and the ability of the skin to stretch.

   B. The reticular layer is a fiber network (reticulum) that connects the papillary layer to the hypodermis.
      1) Rupture of the fibers due to overstretching (e.g., pregnancy) produces lines called **striae** or **stretch marks**.

      2) **Cleavage** or **tension lines** are produced in the skin because of the collagen and elastin fiber orientation.

FIGURE 5.5

☞ Would it be best for surgical incisions to run parallel to cleavage lines or cut across them? Explain.

3. Papillary layer.
   A. The **papillary layer** is loose connective tissue. It has projections called **papillae** (meaning nipple) that extend toward the epidermis. In the digits, palms, and soles of the feet the papillae are arranged in ridges that produce fingerprints and footprints.

   B. The papillary layer contains blood vessels (blood supply to the epidermis) and sensory receptors.

HYPODERMIS

1. The **hypodermis** (subcutaneous tissue, superficial fascia) is a layer of tissue deep to the dermis.
   A. The hypodermis connects the skin to deeper structures (e.g., muscle or bone).

   B. The hypodermis is loose connective tissue containing fat deposits (about half of the body's fat stores).

   C. The hypodermis is the site of subcutaneous injections.

2. The hypodermis is not technically a part of the skin.

ACCESSORY SKIN STRUCTURES

Hair

1. Hair is found on all mammals.

2. Types of hair.
   A. **Lanugo** (meaning down) is delicate, unpigmented hair that covers the fetus.

   B. **Vellus** (meaning fleece) **hair** is short, fine, usually unpigmented hair that replaces most lanugo around the time of birth. Vellus hair covers most of the body.

   C. **Terminal hair** is long, coarse, pigmented hair.
      1) It replaces lanugo of the eyelashes, eyebrows, and scalp near the time of birth.

      2) It replaces vellus hair at puberty (more so in males than in females).

      3) Fur is abundant terminal hairs in other mammals.

Hair Structure

FIGURE 5.6

1. **Hair** is dead, keratinized epithelium produced in a similar fashion to the epidermis.
   A. The hair consist of a **shaft** (above the skin surface), **root** (below the skin surface), and **bulb** (base of root). The hair bulb contains the **matrix**, a region where the cells divide to produce the hair and part of the surrounding hair follicle.

B. The hair consists of an inner **medulla** (soft keratin similar to keratin in skin), an outer **cortex** (hard keratin that makes the hair tougher than the epidermis), and the **cuticle** (a single layer of overlapping cells that attach to the hair follicle wall).

2. Structure of a hair follicle.
   A. The **dermal root sheath** is surrounding dermal connective tissue.

   B. The **epithelial root sheath**, which is between the dermal root sheath and the hair, has two parts.
      1) The **external epithelial root sheath** is an extension of the skin epidermis into the dermis.

      2) The **internal epithelial root sheath** is produced by the matrix,

   C. The papilla in the hair bulb contains blood vessels and nerves.

   ☞ Why is it important for the papilla to have blood vessels?

Hair Growth

1. Hair grows from the matrix, not from the tip of the hair.

2. For scalp hair, there is a growth stage (approximately 3 years) followed by a resting stage (approximately 1-2 years). When the next growth period begins a new hair is formed and the old hair falls out.

3. In some people, the hair falls out and is replaced by vellus hair. In addition, hair follicles stop functioning and are lost. The result is **baldness**. Genetic factors and testosterone are involved in causing baldness.

Hair Color

1. Melanocytes in the matrix transfer melanin to the hair cells as they are formed. This is the same process as occurs in the skin.

2. The amounts and types of melanin determine hair color.
   A. Blonde hair has little black-brown melanin. Jet black hair has the most.

   B. Red hair is caused by varying amounts of a red type of melanin.

   C. A white hair is hair without melanin. Gray hair is a mixture of unfaded, faded, and white hairs.

☞ In the movies it is not uncommon to see the hair of a person who has been very frightened turn white in a short period of time. Explain why you believe or disbelieve this.

Muscles

1. **Arrector pili** are smooth muscles cells that attached to the hair follicle and the papillary layer of the dermis.

2. Contraction of the arrector pili muscles causes the hair to "stand on end" and produces "goose flesh" or "goose bumps."

   ☞ Why would it be advantageous for hair to "stand on end"? (Hint: think of fur).

Glands

FIGURE 5.7

1. Sebaceous glands.
   A. **Sebaceous glands** produce **sebum**, a white lipid that oils the hair and the skin surface, thus preventing drying.

   B. Sebaceous glands usually open into a hair follicle.

   C. Acne.
      1) At puberty, increased levels of the hormone testosterone cause increased sebum production.

      2) The epidermis of the hair follicle produces many cells.

      3) The sebum and cells plug the hair follicle.

      4) Bacteria grow and a pimple results.

      ☞ Why does the pimple get red?

2. Merocrine sweat glands.
   A. **Merocrine sweat glands**produce **sweat** (mostly water and sodium chloride) which functions to cool the body. They are called merocrine sweat glands because they release sweat in a merocrine fashion (i.e., the cells release just the sweat).

   B. Merocrine sweat glands open onto the surface of the skin through sweat pores.

3. Apocrine sweat glands.
   A. **Apocrine sweat glands** produce an organic secretion, which is released in an apocrine fashion (i.e., fragments of the cells are released with the secretion). It is now know that some of the secretion is also release in a merocrine fashion.

   B. Apocrine sweat glands usually open into a hair follicle. They are located in the axillae (armpits) and genitalia (external reproductive structures).

   C. At puberty increased levels of testosterone cause an increased secretion from apocrine glands. The secretion is an odorless organic substance that is broken down by bacteria to produce body odor.

   ☞ Why do you think we have apocrine glands?

   ☞ Can you explain why body odor is not usually a problem in children. Why don't adults develop body odor on the forearm?

4. Other skin glands include ceruminous glands (earwax) and mammary glands (milk).

Nails

FIGURE 5.8

1. The **nail** is found on the ends of the digits. Other mammals can have claws or hoofs.
   A. The nail is stratum corneum with hard keratin.

   B. The nail consists of the **nail body** (uncovered part of nail) and the **nail root** (under the skin)

C. The nail rest on the **nail bed**, the proximal part of which is the **nail matrix** where the nail is formed. The **lunula** is the part of the nail matrix that can be seen through the nail.

D. The **eponychium** (cuticle) is skin that grows onto the base of the nail, and the **hyponychium** is skin is skin beneath the free edge of the nail.

2. The nail grows from the base of the nail (nail matrix), not the tip of the nail. Nails grow continuously (unlike hair).

☞ In the movies, dead people who have been buried and then dug up are sometime shown to have very long nails. Explain why you believe or disbelieve this.

FUNCTIONS OF THE INTEGUMENTARY SYSTEM

Protection

1. Physical barrier.
   A. Prevents the entry of microorganisms and other harmful substances. Loss of the skin, such as in burns, allows microorganisms easy access. Burn patients are kept under aseptic conditions and given antibiotics.

   B. Prevents the loss of water (lipids in epidermis). Burn patients are given fluid. The larger the burn area, the greater the fluid replacement.

   ASSIGNMENT: Know the difference between 1st, 2nd, and 3rd degree burns and be able to use the rule of nines (p. 160). Read the Systems Pathology on Burns for your own interest.

2. Melanin protects against ultraviolet radiation.

3. Desquamation of the stratum corneum protects against abrasion.

Sensation

1. The epidermis and dermis have sensory receptors.

2. Sensations detected include temperature, pressure, light touch, and pain.

Temperature Regulation.

1. Sweating cools the body by evaporation.

2. Vasodilation increases heat exchange and vasoconstriction decreases heat exchange.

FIGURE 5.9

☞ Why does your nose turn red in the cold?

Vitamin D Production

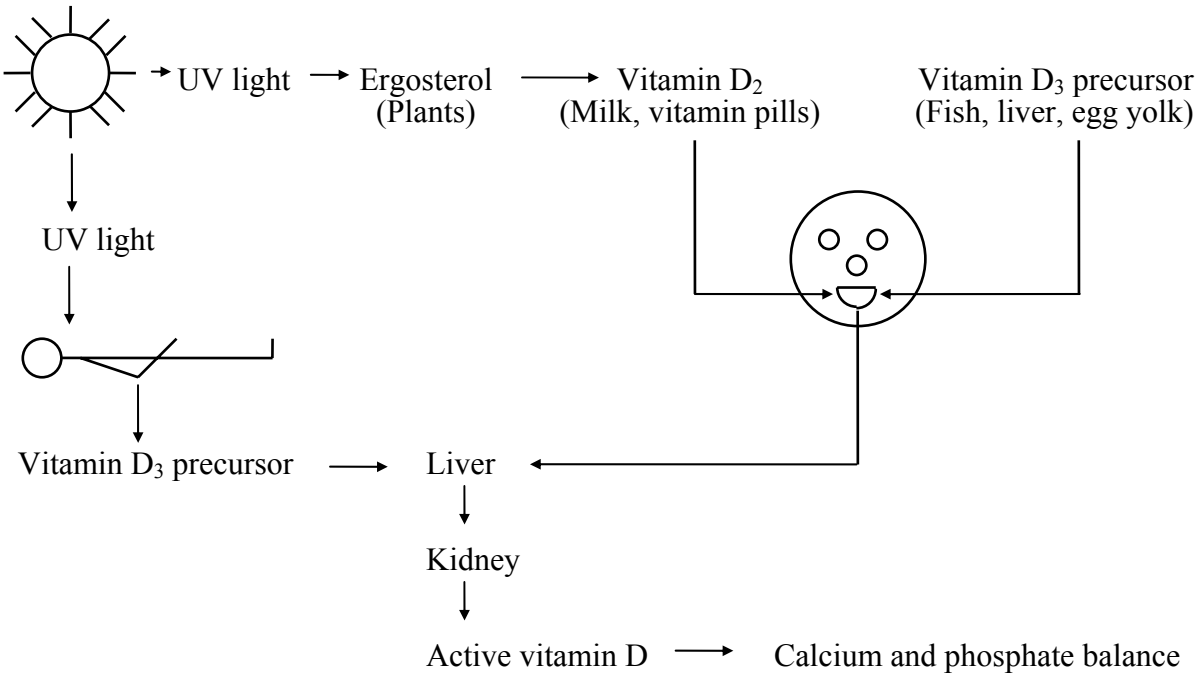
1. Ultraviolet light converts a steroid (a cholesterol derivative) in the skin to vitamin D_3. The vitamin D_3 is transformed in the liver and the kidneys to active vitamin D_3.

2. About 15 minutes of summertime, noontime sun exposure on the hands, arms, and face is sufficient to produce adequate amounts of vitamin D_3. During the winter, sunlight exposure may be inadequate.

3. Vitamin D_3 can be ingested in fish, liver, and egg yolks.

4. Ultraviolet light can be used to convert a fatty substance from plants into vitamin D_2, which is used to fortify milk and vitamin pills.

5. The term vitamin D is used to indicate all of these substances and their derivatives. Vitamin D causes an increase in blood calcium and phosphate levels.



Excretion

1. A very small amount of waste products (such as urea) and salts (sodium chloride) are lost in sweat.

2. Note that sweat is **NOT** an important method of eliminating waste products.