CHAPTER 5

The Integumentary System

Overview

CHAPTER SUMMARY

Skin, the largest organ in the body, forms the integumentary system in conjunction with its accessory structures. The skin consists of two layers: the epidermis, which includes the outer protective stratum of keratinized epithelial cells, and the dermis, the underlying layer of connective tissue containing blood vessels and nerve endings. The accessory structures include outgrowths of the epidermis (hair and nails). Hair is based in a follicle, which is found in the dermis. Sweat glands and sebum-producing glands are also based in the dermis, releasing their secretions onto the skin surface or into hair follicles via ducts. The skin is not just an “envelope” separating our body from the environment. The integumentary system is important in thermoregulation, protection against infection, protection against dehydration, and sensation. These roles are accomplished, in part, by the physical structure of the skin (the epidermal layer is virtually impermeable), but accessory structures are also involved. For instance, eccrine sweat glands are critical for cooling, and sebum renders skin more water-resistant. Skin and the accessory structures are capable of regeneration, providing that at least some actively dividing cells (for instance, in the nail bed or the stratum germinativum) are unharmed.

This chapter does not contain any difficult concepts, but it does contain a large amount of information. Try to get students to integrate the material to the greatest extent possible, using summary tables, concept maps (see the Study Guide), and perhaps case studies.
UPDATES FROM THE PRIOR EDITION

Significant changes to this edition include the following:

1. The dermal papillae and the labels of Figure 5-1 (skin) have been altered.
2. Typos in the labels of Figures 5-2 and 5-3 have been corrected.

GENERAL RESOURCES

1. This introductory video discusses skin anatomy, function, and some of the cultural aspects of skin and its decorations.
2. This article in National Geographic has exceptional images and authoritative, engaging text about the amazing powers of skin.
3. Online dermatology textbooks provide information about all of the topics discussed in this chapter.

Learning Outcomes and Teaching Tools

1. NAME AND DESCRIBE THE LAYERS OF THE SKIN.

The layers of the skin are illustrated in diagrammatic form (Fig. 5-1) and in a photomicrograph (Fig. 5-2) and summarized in the Web Chart on thePoint. The thickness of the epidermis and dermis varies in different body areas (Box 5-1).

The outermost protective portion of the skin is the epidermis, which contains several layers (strata) of epithelial cells (Fig. 5-1; Chapter 4) Only the cells in the bottom layer (stratum basale or germinativum) divide. Epidermal cells become progressively flatter and keratin-filled (Fig. 5-3) and eventually die as they are pushed into the outer layer (the stratum corneum). The epidermis also contains melanocytes, which synthesize pigment (melanin) and transfer it to the epithelial cells. Melanin protects cells against ultraviolet radiation from the sun. The thickness of the epidermis can be observed in some blisters (the accumulation of fluid between epidermal layers or at the epidermal–dermal boundary). Blisters result when the epidermis detaches from the dermis (or epidermal layers separate) as a result of excess heat or shearing.

The dermis contains dense, fibrous, elastic connective tissue (Chapter 4), blood vessels, nerves, and accessory organs (sweat glands, oil glands, hair follicles). The dermis also contains nerve endings involved in the detection of physical sensations (light touch, deep pressure, temperature, pain). Components of the connective tissue (collagen, elastin, and other components of the matrix) are synthesized by fibroblasts within the dermis. The uppermost portion of the dermis is thrown into folds (dermal papillae; Fig. 5-1) that appear as ridges on the surface of the skin. Because the pattern of ridges is genetically determined and unique to each individual, fingerprints and footprints can be used for identification. The dermal papillae also prevent the epidermis from
detaching from the dermis. They are most abundant in areas of high friction—the fingertips and the bottom of the feet.

**Teaching Tools**

- Alterations in pigmentation are usually due to differences in melanocyte activity, not in melanocyte number. Melanocyte activity is largely determined genetically: individuals with darker skin have more active melanocytes. Environmental factors modulate genetically determined melanocyte activity levels. Melanocyte activity is stimulated by UV radiation (see below), but it is also regulated by a pituitary hormone (melanocyte stimulating hormone, MSH) and female gonadal hormones (estrogen and progesterone). Pregnant women often report hyperpigmentation, because MSH, estrogen, and progesterone are all increased in pregnancy.

- The epidermis is an example of stratified epithelium (Chapter 4).

- Melanocytes are not epithelial cells at all: they are derived from the same embryonic tissue as neurons (the ectoderm).

- The generation of new epidermal cells from the stratum basale is a regulated process (epidermopoiesis). Investigate factors regulating this process, using one of Dermatology textbooks listed under General Resources.

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**2 DESCRIBE THE SUBCUTANEOUS LAYER.**

The subcutaneous layer contains loose (generalized) connective tissue, particularly adipose (Chapter 4), as well as blood vessels and nerves (Fig. 5-1). Anatomists often call this layer the superficial fascia.

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**3 GIVE THE LOCATION AND FUNCTION OF THE ACCESSORY STRUCTURES OF THE INTEGUMENTARY SYSTEM.**

- Sudoriferous (sweat) glands are located in the dermis and subcutaneous tissue (Fig. 5-4). Eccrine sweat glands secrete a watery, salty solution (sweat) directly onto the skin, and are found throughout the body. Their primary function is cooling. Apocrine sweat glands secrete a more viscous substance into hair follicles. Bacteria break down the cellular materials in this secretion, producing body odor. Apocrine glands are located in the axillae, in the areola of the breast, and in the groin.

- Sebaceous glands secrete sebum into hair follicles (Fig. 5-4). They are located everywhere except the palm of the hand and the sole of the foot. Sebum is an oily substance that lubricates and waterproofs the skin and hair.

- Hair grows from follicular cells at the base of a hair follicle (Fig. 5-4), and is found in most areas of the body. Hair is composed primarily of keratin, whereas the follicle is composed of a sheath of connective and epithelial tissue. The follicle is associated with a sebaceous gland, sometimes an apocrine gland, and the arrector pili muscle. The muscle elevates the hair, providing enhanced insulation in animals (but not in humans), and also stimulates secretion from the sebaceous gland. Indeed, hair does not serve an important thermoregulatory role in humans. Head hair may protect the scalp from ultraviolet radiation.

- Nails protect the fingers and toes. Epidermal cells of the stratum corneum found in the nail bed (Fig. 5-5) synthesize the keratin that makes up nails.

A Web chart on thePoint summarizes the accessory skin structures.
Teaching Tools

Ask students to assemble a table, summarizing the location, structure, and function of the accessory structures.

Microscope slides of skin are visually striking and relatively easy for students to interpret. Ask students to identify the layers and the accessory structures in cross-sections of human skin.


Apocrine glands are activated by the sympathetic nervous system, which is in turn activated during stressful situations and during sexual foreplay. Both apocrine and sebaceous glands are activated at puberty.

Ask students to explore the different compositions of sebum, eccrine gland secretions, and apocrine gland secretions using Web site searches. Eccrine secretions (sweat) contain water, sodium chloride (hence the salty taste), vitamin C, antibodies, antibacterial proteins, metabolic wastes, and lactic acid. Apocrine gland secretions contain fatty acids and proteins in addition to these substances, and may also contain pheromones. Sebum contains cholesterol esters, triglycerides, fatty acids, and waxes (Chapter 2). The compositions of these secretions can also be altered by hormones and diet (for instance, people claim to sweat garlic!).

Why aren’t humans furry? One hypothesis is that our lack of extensive body hair enables us to shed heat more easily, permitting humans to travel farther and faster. The evolution of hairlessness and the resulting enhancement of thermoregulatory abilities have been linked to the development of larger brains and upright posture. Students can read more about this topic in the article below.

- Jablonski NG. The Naked Truth. Sci Am 2010(February);302:42–49.

Remedies for baldness have been around for many years. Ask students to research reputable and disreputable therapies for hair loss. Reputable information can be found in the resources listed below, and disreputable Web sites are very easy to find.

- McElwee K. Hair loss, baldness, alopecia, excess hair growth, and treatment information. Available at: http://www.keratin.com
- Rusting RL. Hair: why it grows, why it stops. Sci Am 2001(June);284:70–79.

Apocrine glands are involved in the ability of a newborn to recognize its mother. The odor of the secretions from the areolar apocrine glands rapidly becomes familiar to a breast-feeding baby.

List the main functions of the integumentary system.

- Defense: The interlocking cells of the stratum corneum resist penetration by pathogens. The skin also contains numerous immune cells, and sweat has some antimicrobial characteristics.
- Dehydration: Sebum, released onto the skin surface, and keratin, within the epidermal cells, render the skin virtually waterproof.
- Thermoregulation: The eccrine glands release sweat, which evaporates and cools the body. The blood vessels in the hypodermis can constrict to retain heat or dilate to radiate heat.
- Sensation: The skin contains free nerve endings, which detect pain and temperature changes, Meissner corpuscles, which respond to light touch, and Pacinian corpuscles, which detect deep pressure (Chapter 10).

**Teaching Tools**
- Ask students to add these functions to the table prepared for Outcome 3. For instance, “thermoregulation” could be mentioned for the eccrine sweat glands.
- The delivery of some medications through the skin (transdermal patches) is discussed in Box 5-2 and in the article listed below.

- Langer R. Where a pill won’t reach. Sci Am 2003(April);288:50–57.

- Mucosal membranes (Chapter 4) do not have a thick epithelial layer and are subject to many more infections than regular skin. For instance, mouth ulcers (cold sores) are much more common than skin ulcers. The epithelial layer is thus critical for immune defense.

- The skin contains an important population of harmless and beneficial microbes. These microbes help prevent harmful microbes from colonizing the skin. Some cosmetics may harm the resident flora, and thereby enhance susceptibility to disease. Perhaps “probiotic cosmetics” might be a future trend—students can do a Web site search for this phrase and check for developments.

- Since skin can initiate vitamin D production under the influence of ultraviolet light, some consider the skin to be the largest endocrine gland in the body. A bikini-clad woman with white skin sunbathing in the summer sun can generate 10,000 IU of vitamin D in about 15 minutes, a higher dose than that found in many multivitamin supplements! The low levels of UV light in wintry climes can cause vitamin D deficiency, especially in sunscreen users and individuals with darker skin. Recent studies have linked vitamin D deficiency to cancers and autoimmune diseases. See the article below for more information.


- The movie listed below discusses how the structure and function of skin has changed over the course of evolution.


### DISCUSS THE FACTORS THAT CONTRIBUTE TO SKIN COLOR.

- The pigment melanin contributes a brownish coloration to skin. Melanin levels are determined genetically and by ultraviolet light exposure. Hemoglobin in blood cells usually contributes a reddish coloration, especially when blood flow is high. The vegetable pigment carotene contributes a yellow-orange color.

**Teaching Tools**
- Whenever possible, ask students to link changes in skin appearance with changes in skin.
- It is often thought that darker pigmentation (more melanin) has evolved to protect humans from skin cancer. However, since skin cancer occurs later in life (usually post-reproductive age),
it cannot exert much evolutionary pressure. Moreover, increased pigmentation decreases vitamin D synthesis, as discussed in Outcome 4. The possibility that melanin has evolved to protect body stores of folate from ultraviolet-induced degradation is discussed in the article below.


The response of skin to ultraviolet radiation involves multiple stages. First, existing melanin is redistributed to the superficial side of the cell. This rapid effect explains why individuals can appear to “tan” very rapidly. Second, melanocyte activity is increased. Third, repeated exposure to UV radiation can result in increased numbers of melanocytes.

Using information in the case study and text, describe the specific layer of the integumentary system that was sun-damaged. Ultraviolet light damages the epidermis.


Show how word parts are used to build words related to the integumentary system. Word parts applicable to this and other chapters are listed in the Word Anatomy chart. Learning these word parts will help students memorize terms relevant to the anatomy of skin and the accessory structures.