

The Integumentary System

Objectives

The Skin

1. Name the tissue types composing the epidermis and dermis. List the major layers of each and describe the functions of each layer.
2. Describe the factors that normally contribute to skin color. Briefly describe how changes in skin color may be used as clinical signs of certain disease states.

Appendages of the Skin

3. Compare the structure and locations of sweat and oil glands. Also compare the composition and functions of their secretions.
4. Compare and contrast eccrine and apocrine glands.
5. List the parts of a hair follicle and explain the function of each part. Also describe the functional relationship of arrector pili muscles to the hair follicles.
6. Name the regions of a hair and explain the basis of hair color. Describe the distribution, growth, replacement, and changing nature of hair during the life span.
7. Describe the structure of nails.

Functions of the Integumentary System

8. Describe how the skin accomplishes at least five different functions.

Homeostatic Imbalances of Skin

9. Explain why serious burns are life threatening. Describe how to determine the extent of a burn and differentiate first-, second-, and third-degree burns.
10. Summarize the characteristics of the three major types of skin cancers.

Developmental Aspects of the Integumentary System

11. Describe and attempt to explain the causes of changes that occur in the skin from birth to old age.

Suggested Lecture Outline

- I. The Skin (pp. 149-155; Figs. 5.1-5.4)*

- A. The hypodermis, also called the superficial fascia, is subcutaneous tissue beneath the skin consisting mostly of adipose tissue that anchors the skin to underlying muscle, allows skin to slide over muscle, and acts as a shock absorber and insulator (p. 149; Fig. 5.1).
- B. Epidermis (pp. 150–152; Fig. 5.2)
 - 1. The epidermis is a keratinized stratified squamous epithelium.
 - 2. Cells of the Epidermis
 - a. The majority of epidermal cells are keratinocytes that produce a fibrous protective protein called keratin.
 - b. Melanocytes are epithelial cells that synthesize the pigment melanin.
 - c. Epidermal dendritic cells or Langerhans cells, are macrophages that help activate the immune system.
 - d. Tactile cells are associated with sensory nerve endings.
 - 3. Layers of the Epidermis
 - a. The stratum basale (basal layer) is the deepest epidermal layer and is the site of mitosis.
 - b. The stratum spinosum (prickly layer) is several cell layers thick and contains keratinocytes, melanin granules, and the highest concentration of epidermal dendritic cells.
 - c. The stratum granulosum (granular layer) contains keratinocytes that are undergoing a great deal of physical changes, turning them into the tough outer cells of the epidermis.
 - d. The stratum lucidum (clear layer) is found only in thick skin and is composed of dead keratinocytes.
 - e. The stratum corneum (horny layer) is the outermost protective layer of the epidermis composed of a thick layer of dead keratinocytes.
- C. Dermis (pp. 152–153; Figs. 5.3–5.4)
 - 1. The dermis is composed of strong, flexible connective tissue.
 - 2. The dermis is made up of two layers: the thin, superficial papillary layer is highly vascularized areolar connective tissue containing a woven mat of collagen and elastin fibers; and the reticular layer, accounting for 80% of the thickness of the dermis, is dense irregular connective tissue.
- D. Skin color is determined by three pigments: melanin, hemoglobin, and carotene (pp. 154–155).

II. Appendages of the Skin (pp. 155–160; Figs. 5.5–5.7)

- A. Sweat (Sudoriferous) Glands (pp. 155–156; Fig. 5.5)
 - 1. Eccrine sweat glands, or merocrine sweat glands, produce true sweat, are the most numerous of the sweat glands, and are particularly abundant on the palms of the hands, soles of the feet, and forehead.
 - 2. Apocrine sweat glands are confined to the axillary and anogenital areas and produce true sweat with the addition of fatty substances and proteins.
 - 3. Ceruminous glands are modified sweat glands found lining the ear canal that secrete earwax, or cerumen.
 - 4. Mammary glands are modified sweat glands found in the breasts that secrete milk.

- B. Sebaceous (Oil) Glands (pp. 156–157; Fig. 5.5)
 - 1. Sebaceous glands are simple alveolar glands found all over the body except the palms of the hands and soles of the feet that secrete sebum, an oily secretion.
 - 2. The sebaceous glands function as holocrine glands, secreting their product into a hair follicle or to a pore on the surface of the skin.
 - 3. Secretion by sebaceous glands is stimulated by hormones.
- C. Hairs and Hair Follicles (pp. 157–159; Fig. 5.6)
 - 1. Hairs, or pili, are flexible strands produced by hair follicles that consist of dead, keratinized cells.
 - a. The main regions of a hair are the shaft and the root.
 - b. A hair has three layers of keratinized cells: the inner core is the medulla, the middle layer is the cortex, and the outer layer is the cuticle.
 - c. Hair pigments (melanin of different colors) are made by melanocytes at the base of the hair follicle.
 - 2. Structure of a Hair Follicle
 - a. Hair follicles fold down from the epidermis into the dermis and occasionally into the hypodermis.
 - b. The deep end of a hair follicle is expanded, forming a hair bulb, which is surrounded by a knot of sensory nerve endings called a hair follicle receptor, or root hair plexus.
 - c. The wall of a hair follicle is composed of an outer connective tissue root sheath, a thickened basement membrane called a glossy membrane, and an inner epithelial root sheath.
 - d. Associated with each hair follicle is a bundle of smooth muscle cells called an arrector pili muscle.
 - 3. Types and Growth of Hair
 - a. Hairs come in various sizes and shapes, but can be classified as vellus or terminal.
 - b. Hair growth and density are influenced by many factors, such as nutrition and hormones.
 - c. The rate of hair growth varies from one body region to another and with sex and age.
 - 4. Hair Thinning and Baldness
 - a. After age 40 hair is not replaced as quickly as it is lost, which leads to hair thinning and some degree of balding, or alopecia, in both sexes.
 - b. Male pattern baldness, which is a type of true, or frank, balding, is a genetically determined, sex-influenced condition.
- D. Nails (p. 160; Fig. 5.7)
 - 1. A nail is a scalelike modification of the epidermis that forms a clear, protective covering.
 - 2. Nails are made up of hard keratin and have a free edge, a body, and a proximal root.

III. Functions of the Integumentary System (pp. 160–162)

- A. Protection (pp. 160–161)
 - 1. Chemical barriers include skin secretions and melanin.

2. Physical or mechanical barriers are provided by the continuity of the skin, and the hardness of the keratinized cells.
 3. Biological barriers include the epidermal dendritic cells, the macrophages of the dermis, and the DNA itself.
- B. The skin plays an important role in body temperature regulation by using the sweat glands of the skin to cool the body, and constriction of dermal capillaries to prevent heat loss (p. 161).
 - C. Cutaneous sensation is made possible by the placement of cutaneous sensory receptors, which are part of the nervous system, in the layers of the skin (p. 161).
 - D. The skin provides the metabolic function of making vitamin D when it is exposed to sunlight (p. 161).
 - E. The skin may act as a blood reservoir by holding up to 5% of the body's blood supply, which may be diverted to other areas of the body should the need arise (pp. 161–162).
 - F. Limited amounts of nitrogenous wastes are excreted through the skin (p. 162).

IV. Homeostatic Imbalances of Skin (pp. 162–165; Figs. 5.8–5.10)

- A. Skin Cancer (pp. 162–163; Fig. 5.8)
 1. Basal cell carcinoma is the least malignant and the most common skin cancer.
 2. Squamous cell carcinoma tends to grow rapidly and metastasize if not removed.
 3. Melanoma is the most dangerous of the skin cancers because it is highly metastatic and resistant to chemotherapy.
- B. Burns (pp. 163–165; Figs. 5.9–5.10)
 1. A burn is tissue damage inflicted by intense heat, electricity, radiation, or certain chemicals, all of which denature cell proteins and cause cell death to infected areas.
 2. The most immediate threat to a burn patient is dehydration and electrolyte imbalance due to fluid loss.
 3. After the first 24 hours has passed, the threat to a burn patient becomes infection to the wound site.
 4. Burns are classified according to their severity.
 - a. First-degree burns involve damage only to the epidermis.
 - b. Second-degree burns injure the epidermis and the upper region of the dermis.
 - c. Third-degree burns involve the entire thickness of the skin.

V. Developmental Aspects of the Integumentary System (p. 165)

- A. The epidermis develops from the embryonic ectoderm, and the dermis and the hypodermis develop from the mesoderm (p. 165).
- B. By the end of the fourth month of development the skin is fairly well formed (p. 165).
- C. During infancy and childhood, the skin thickens and more subcutaneous fat is deposited (p. 165).
- D. During adolescence, the skin and hair become oilier as sebaceous glands are activated (p. 165).
- E. The skin reaches its optimal appearance when we reach our 20s and 30s; after that time the skin starts to show the effects of cumulative environmental exposures (p. 165).

- F. As old age approaches, the rate of epidermal cell replacement slows and the skin thins, becoming more prone to bruising and other types of injuries (p. 165).

Cross References

Additional information on topics covered in Chapter 5 can be found in the chapters listed below.

1. Chapter 3: Desmosomes
2. Chapter 4: Stratified squamous epithelium, keratinized; basement membrane; loose (areolar) connective tissue; dense irregular connective tissue; fibers in matrix of connective tissue; simple coiled tubular glands; simple branched alveolar glands; merocrine glands; holocrine glands
3. Chapter 13: Cutaneous sensation and reflex activity
4. Chapter 15: Sebaceous and sudoriferous glands of the ear canal
5. Chapter 21: Organ and tissue transplants and prevention of rejection; mechanical and chemical nonspecific defense mechanisms
6. Chapter 23: Jaundice and the buildup of bilirubin
7. Chapter 24: Body temperature regulation
8. Chapter 28: Effects of androgens

Laboratory Correlations

1. Marieb, E. N., and S. J. Mitchell. *Human Anatomy & Physiology Laboratory Manual: Cat and Fetal Pig Versions*. Ninth Edition Updates. Benjamin Cummings, 2009.
Exercise 7: The Integumentary System
Exercise 8: Classification of Covering and Lining Membranes
2. Marieb, E. N., and S. J. Mitchell. *Human Anatomy & Physiology Laboratory Manual: Main Version*. Eighth Edition Update. Benjamin Cummings, 2009.
Exercise 7: The Integumentary System
Exercise 8: Classification of Covering and Lining Membranes

Lecture Hints

1. The strata basale and spinosum are often referred to collectively as the growing layers (stratum germinativum). Some authors consider the stratum germinativum to be only the stratum basale. Students are easily confused if terminology is not consistent between lecture, text, and lab test.
2. Stress that the hypodermis is not a skin layer, but is actually the superficial fascia beneath the skin. Point out that there is a deep fascia beneath the hypodermis under the skin that is covered later in Chapter 9.
3. The hypodermis (superficial fascia) is an important location of fat storage that insulates the body. This layer is more prominent in females than males, resulting in a softer feel to the touch. This softer skin is considered a secondary sex characteristic of the female.

4. Discuss the activity of melanocytes, melanin production, and degree of ultraviolet radiation. Point out the genetic basis of melanocyte activity and the geographic distribution of ancestral humans as an explanation for racial variation. Explain the effect of the degree of exposure to UV radiation and tanning in individuals.
5. During lab, students often try to locate and identify the stratum lucidum in all skin slides. Stress that this layer of the epidermis is present only in thick skin.
6. Explain that the skin plays a role in regulating body temperature by evaporation of sweat and by controlling blood flow through dermal blood vessels.
7. Some sebaceous glands are not associated with hair follicles and open directly onto the skin surface. Examples include the sebaceous glands of the skin, lips, and eyelids (tarsal glands).
8. Actual contact with the environment is through a layer of dead cells (rather than living). This specialization was critical for the evolution of life forms that could survive in a terrestrial environment.

Activities/Demonstrations

1. Audiovisual materials listed under Multimedia in the Classroom and Lab.
2. Show the students a picture of a heavily wrinkled person. Ask them to list all the factors that have contributed to the skin deterioration seen.
3. Provide small glass plates and instruct students to observe the change in the color of their skin while pressing the heel of their hand firmly against the glass. Ask them to explain the color change, and what would happen to the skin if the pressure were prolonged.
4. Have a small fan operating. As students file into the classroom, spray their arm or hand with water. Ask them to describe the sensation as the water evaporates from the skin, and to explain why evaporation of water (or sweat) is important to temperature homeostasis. Repeat the demonstration with alcohol and ask why the cooling effect is greater.
5. Use 3-D models of skin to illustrate layers and strata.
6. Use a microprojector and microscope slides of skin to illustrate layers. Use slides of skin from the scalp and palm to contrast the differences in the layers.

Critical Thinking/Discussion Topics

1. What role does the skin play in the regulation of body temperature?
2. Why exactly can animals with thick fur, such as Alaskan huskies, resist extremely cold temperatures?
3. Humans are often called the “naked apes.” Although we have extensive hair follicles all over our body, why do you suppose we lack body hair?
4. If the skin acts as a barrier to most substances, how can it initiate an allergic response to such things as poison ivy?
5. Many organisms such as snakes, insects, and lobsters shed their “skin” periodically. How does this compare to the process taking place in humans?
6. The air is 80°F and the lake temperature is 70°F. Why do you first feel cold when you enter the water? Why do you feel chilled when exiting the water?

7. Why does axillary hair not grow as long as hair on the scalp? How long would scalp hair grow if it were not cut?
8. Discuss the advantages and disadvantages of using the drug minoxidil for stimulating hair regrowth in bald men.
9. Which structures located in the dermis are of epidermal origin?
10. When fair-skinned individuals go outside on a cold windy day, their skin turns “white” and after a time turns “red.” Explain.
11. Nancy has a dry skin condition and prefers to take her bath in the evening. Would it be more effective for her to apply a skin care lotion such as Keri lotion in the morning or in the evening after taking a bath? Why?
12. Why is it more difficult to get a suntan during the winter months even though the sun is closer to the earth during this season?
13. Individuals living in Ohio may be able to go out into the sun for three hours and not burn, but if they go to Florida during spring break, they may get a sunburn after only two hours. Why?
14. Describe the difference between the A and B types of ultraviolet rays relative to skin damage.
15. Why does a suntan eventually fade?
16. Other than to reduce bleeding, why are wounds sutured together?

Library Research Topics

1. Explore the literature on the latest techniques and materials such as test-tube skin, synthetic skin, and heterograft skin used in skin grafting.
2. The long-term effects of sunburn seem to include severe wrinkling of the skin and skin cancer. What are the latest statistics on this problem and what has been done to correct it?
3. What are the latest therapies for baldness?
4. Although our skin is a “barrier” to microbes, prepare a list of microbes, such as bacteria, yeast, fungi, protozoans, and arthropods, that may reside on or in our skin.
5. Accutane (Isotretinoin) is a prescriptive drug approved in the early 1980s for treatment of severe cystic acne. Is this drug safe to use during pregnancy?
6. Student assignment: Look up the signs and symptoms of basal cell carcinoma, squamous cell carcinoma, and malignant melanoma for class discussion.

Multimedia in the Classroom and Lab

Online Resources for Students

myA&P[™]

www.myaandp.com

The following shows the organization of the Chapter Guide page in myA&P[™]. The Chapter Guide organizes all the chapter-specific online media resources for Chapter 5 in one convenient location, with e-book links to each section of the textbook. Students can also access A&P Flix animations, MP3 Tutor

Sessions, Interactive Physiology® 10-System Suite, Practice Anatomy Lab™ 2.0, PhysioEx™ 8.0, and much more.

Objectives

Section 5.1 The Skin (pp. 149–155)

MP3 Tutor Session: Layers and Associated Structures of the Integument

Art Labeling: Skin Structure (Fig. 5.1, p. 149)

Memory Game: Cutaneous Membrane Components

Memory Game: Integumentary System Components

Section 5.2 Appendages of the Skin (pp. 155–160)

Art Labeling: Structure of a Hair Follicle (Fig. 5.6, p. 158)

Art Labeling: Structure of a Nail (Fig. 5.7, p. 160)

Section 5.3 Functions of the Integumentary System (pp. 160–162)

Section 5.4 Homeostatic Imbalances of Skin (pp. 162–165)

Case Study: Burns

Case Study: Athlete's Foot

Case Study: Skin Cancer

Section 5.5 Developmental Aspects of the Integumentary System (p. 165)

Chapter Summary

Crossword Puzzle 5.1

Crossword Puzzle 5.2

Crossword Puzzle 5.3

Web Links

Chapter Quizzes

Art Labeling Quiz

Matching Quiz

Multiple-Choice Quiz (Level I)

Multiple-Choice Quiz (Level II)

True-False Quiz

Chapter Practice Test

Study Tools

Histology Atlas

myeBook

Flashcards

Glossary

CourseCompass™

Resources in the myA&P™ Chapter Guide are also available in the Chapter Contents section of the CourseCompass™. Students can also access A&P Flix animations, MP3 Tutor Sessions, Interactive Physiology® 10-System Suite, Practice Anatomy Lab™ 2.0, PhysioEx™ 8.0, and much more.

Media

See Guide to Audiovisual Resources in Appendix A for key to AV distributors.

Slides

1. *Systems of the Human Body—The Skin and Its Function Set* (CBS)
2. *Types of Skin* (CBS)
3. *Integument Types Set* (CBS)

Video

1. *The Dangers of Melanoma* (FHS; 29 min., 2003). This Dartmouth-Hitchcock Medical Center Production promotes sun exposure precautions and self-examinations as ways to lower risk of contracting melanoma. Commentary provided by an epidemiologist, a dermatologist, an oncologist, and patients who have lived with melanoma.
2. *The Integumentary System* (IM; 43 min., 2003). This program examines the composition of the integumentary system, explores sensory organs, and considers the functions and processes of each component.
3. *Skin* (FHS; 20 min., 1995). Contains live action video with current imaging technology. Gives a glimpse into the inner workings of the human body. Provides an interesting and informative presentation for an entire class.
4. *Plastic and Reconstructive Surgery* (FHS; 19 min.). This video explains some of the more common cosmetic surgical procedures and the use of computer-generated models that aid in the design.
5. *The Senses: Skin Deep* (FHS; 26 min., 1984). Reviews sense receptors, taste buds, touch sensors, and olfactory cells. Written by a team of internationally recognized medical specialists. The complex world beneath the skin is recreated.

Software

1. *Practice Anatomy Lab™ 2.0: Anatomical Models, Histology* (see p. 9 of this guide for full listing).

Lecture Enhancement Material

To view thumbnails of all the illustrations for Chapter 5, see Appendix B.

Transparencies Index/Instructor Resource DVD

Figure 5.1	Skin structure.
Figure 5.2	The main structural features of the skin epidermis.
Figure 5.3	The two regions of the dermis.
Figure 5.4	Dermal modifications result in characteristic skin markings.
Figure 5.5	Cutaneous glands.
Figure 5.6	Structure of a hair and hair follicle.
Figure 5.7	Structure of a nail.
Figure 5.8	Photographs of skin cancers.
Figure 5.9	Estimating the extent and severity of burns using the rule of nines.
Figure 5.10	Partial thickness and full thickness burns.
Making Connections	Homeostatic Interrelationships Between the Integumentary System and Other Body Systems

Answers to End-of-Chapter Questions

Multiple Choice and Matching Question answers appear in Appendix G of the main text.

Short Answer Essay Questions

13. Cells of the stratum spinosum are called prickle cells because of their spiky shape in fixed tissues; granules of keratohyalin and lamellated granules appear in the cells of the stratum granulosum. (p. 150)
14. Generally not. Most “bald” men have fine vellus hairs that look like peach fuzz in the “bald” areas. (p. 159)
15. On an extremely hot, sunny summer day your integumentary system will function to maintain homeostasis in several ways. First, your skin will sweat. Sweating is a form of thermoregulation that helps prevent you from overheating by increasing blood flow to the skin and allowing it to dump heat into the environment. Second, your melanocytes will begin to produce more melanin. The melanin granules will then be taken into keratinocytes where they will protect the keratinocyte nucleus from the damaging UV rays of the sun. (pp. 150, 161)
16. First-degree burns affect only the epidermis; second-degree burns affect down to the dermis; and third-degree burns affect down to the subcutaneous tissue and muscle. (pp. 163–165)
17. Hair formation begins with an active growth phase, followed by a resting phase. After the resting phase a new hair forms to replace the old one. Factors that affect growth cycles include nutrition, hormones, local dermal blood flow, body region, gender, age, genetic factors, physical or emotional trauma, excessive radiation, and certain drugs. Factors that affect hair texture include hormones, body region, genetic factors, and age. (p. 164)
18. Cyanosis is a condition in which the skin of Caucasians turns blue due to improperly oxygenated hemoglobin. (p. 155)
19. Wrinkling is due to the loss of elasticity of the skin, along with the loss of the subcutaneous tissue, and is hastened by prolonged exposure to wind and sun. (p. 165)
20.
 - a. A whitehead is formed by blockage of the duct of a sebaceous gland with sebum. When this sebum oxidizes, it produces a blackhead. When a blocked sebaceous gland becomes infected, it produces a pimple. (p. 157)
 - b. Noninfectious dandruff is the normal shedding of the stratum corneum of the scalp. (p. 152)
 - c. Greasy hair and a shiny nose both result from the secretion of sebum onto the skin. (p. 156)
 - d. Stretch marks represent small tears in the dermis, as the skin is stretched by obesity or pregnancy. (p. 153)
 - e. A freckle is a small area of pigmentation in the epidermis, caused by an accumulation of melanin. (p. 154)
21. (a) Porphyrin. Porphyrin victims lack the ability to form the heme of Hb. Buildup of intermediate by-products (porphyrins) in the blood cause lesions in sun-exposed skin. Dracula was said to have drunk blood and to have shunned the daylight. (p. 168)
22. Stratum corneum cells are dead. By definition, cancer cells are rapidly dividing cells. (p. 152)
23. Nail body: the visible attached portion of the nail. Nail root: the embedded portion of the nail. Nail bed: the epidermis that extends beneath the nail. Nail matrix: the proximal, thickened portion of the nail bed responsible for nail growth. Eponychium: the cuticle. If the matrix is damaged the nail may not grow back or may grow back distorted. In this case the

nail probably will not grow back because everything including the matrix was lost. (p. 160; Fig. 5.7)

24. See Figure 5.9. (p. 163) (a) 18% posterior trunk + 4.5% (Right buttock*) + 4.5% (Left buttock) = 27%. *buttock is approximate only (b) Entire lower limb = 36% (c) Entire front (anterior) left upper limb = 4.5%
25. Hair is composed of dead keratinized cells. The growth occurs at the hair follicle and is influenced by nutrition and hormones. Cutting the dead hair does not influence the growth at the follicle. (pp. 157, 159)

Critical Thinking and Clinical Application Questions

1. His long-term overexposure to ultraviolet radiation in sunlight is considered a risk factor for the development of skin cancer. In addition, moles or pigmented spots that show asymmetry (A), border irregularity (B), color variation (C), and a diameter greater than 6 mm (D) are all signs of a possible malignant melanoma. He should seek immediate medical attention. If it is a malignant melanoma, the chance for survival is not high, but early detection increases the survival rate. (p. 163)
2. The two most important problems encountered clinically with a victim of third-degree burns are a loss of body fluids resulting in dehydration and an electrolyte imbalance, and the risk of infection. Intact skin effectively blocks not only the diffusion of water and water-soluble substances out of the body, but acts as a barrier limiting the invasion of various microorganisms. (pp. 163–164)
3. Chronic physical irritation or inflammation can lead to excessive hair growth in the region affected due to an increase in blood flow to the area. (p. 159)
4. The appendectomy incision ran parallel to the less dense “lines of cleavage” that separate bundles of collagen fiber in the dermis. The gallbladder incision cut across them. (p. 153)

Suggested Readings

Christensen, Damaris. “Hair Today, Gone Tomorrow?” *Science News* 160 (16) (Oct. 2001): 254–255.

Garnick, Marc. “The Sunshine D-lemma.” *Harvard Health Letter* 3 (Aug. 2008): 6–7.

Glausiusz, Josie. “A Sunscreen for Our Delicate Genes.” *Discover* 22 (3) (March 2001): 13.

Gregoriou, Stamatis, et al. “Nail Disorders and Systemic Disease: What Nails Tell Us.” *Journal of Family Practice* 57 (Aug. 2008): 509–514.

Karow, Julia. “Skin So Fixed.” *Scientific American* 284 (3) (March 2001): 21.

Kirchweger, Gina. “Black and White.” *Discover* 22 (2) (Feb. 2001): 32–33.

Krueger, James G. “Treating Psoriasis with Biologic Agents.” *Science and Medicine* 8 (3) (May/June 2002): 150–161.

Nizet, V., et al. “Innate Antimicrobial Peptide Protects the Skin from Invasive Bacterial Infection.” *Nature* 414 (Nov. 2001): 454–457.

Pins, George D. “An Analog of the Basal Lamina.” *Science and Medicine* 7 (3) (2000): 6–7.

Rusting, Ricki L. “Hair: Why it Grows, Why it Stops.” *Scientific American* 284 (6) (Oct. 2001): 70–79.

Travis, J. “Human Sweat Packs a Germ-Killing Punch.” *Science News* 160 (19) (Nov. 2001): 292.

Wright, Karen. “Skeeter Beaters.” *Discover* 22 (8) (Aug. 2001): 20–21.

