

The Body Systems: Clinical and Applied Topics

This section relates aspects of the normal anatomy and physiology of each body system to specific clinical conditions, diagnostic procedures, and other relevant topics. Each body system will be briefly reviewed, and specific disorders affecting the system will be approached from a diagnostic standpoint. Case studies and other exercises following major sections will give you the chance to apply the concepts you have learned.

The Integumentary System

The structures of the integumentary system include the skin, hair, nails, and several types of exocrine glands. The integumentary system has a variety of functions, including the protection of underlying tissues, the maintenance of body temperature, the excretion of salts and water in sweat, cutaneous sensation, and the production of vitamin D₃.

The skin is the most visible organ of the body. As a result, abnormalities are easily recognized. A bruise, for example, often creates a swollen and discolored area where the walls of blood vessels have been damaged. Changes in skin color, skin tone, and the overall condition of the skin often accompany illness or disease. These changes can assist in diagnosis. For example, extensive bruising without obvious cause may indicate a blood-clotting disorder; a yellow color in the skin and mucous membranes may indicate *jaundice*, a sign that usually indicates some type of liver disorder. The general condition of the skin may also be significant. For example, color changes or changes in skin flexibility, elasticity, dryness, or sensitivity often appear following the malfunctions of other organ systems.



EXAMINATION OF THE SKIN

When examining a patient, dermatologists (skin specialists) use a combination of investigative interviews (“What have you done?” or “How does it feel?”) and physical examination to arrive at a diagnosis. The condition of the skin is carefully observed. Notes are made concerning the presence of **lesions**, which are changes in skin structure caused by disease processes. These lesions are also called **skin signs**, because they are measurable, visible abnormalities of the skin surface. Figure A-12 diagrams the most common skin signs and related disorders.

The distribution of lesions may be an important clue to the source of the problem. For example, in *shingles* there are painful blisters on the skin that follow the path of peripheral sensory nerves. A ring of slightly raised scaly (papular) lesions is typical of fungal infections that may affect the trunk, scalp, and nails. Examples of skin disorders caused by infection or allergic reactions are included in Table A-12, with descriptions of the related lesions. Skin lesions caused by trauma are considered in a separate section entitled “A Classification of Wounds” (p. 47).

Table A-12 considers signs on the skin surface, but signs involving the accessory organs of the skin can also be important. For example,

- Nails have a characteristic shape that can change due to an underlying disorder. An example is *clubbing* of the nails, often a sign of *emphysema* or *congestive heart failure*. In these conditions the fingertips broaden, and the nails become distinctively curved.

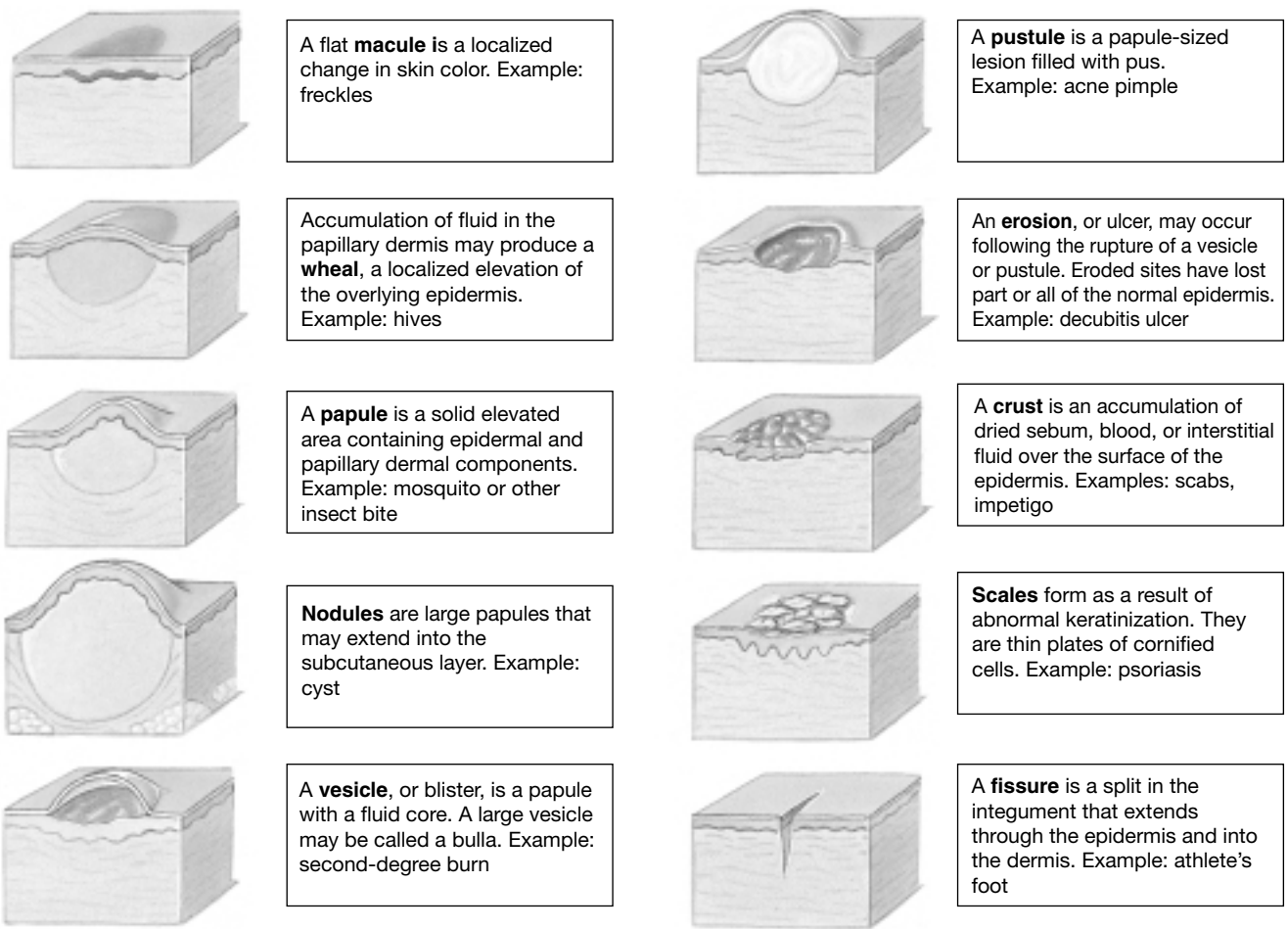


Figure A-12 Skin Signs

Table A-12 Skin Signs of Various Disorders

<i>Cause</i>	<i>Examples</i>	<i>Resulting Skin Lesion</i>
Viral infections	Chicken pox	Lesions begin as macules and papules but develop into vesicles
	Measles (rubeola)	A maculopapular rash that begins at the face and neck and spreads to the trunk and extremities
	Erythema infectiosum (fifth disease)	A maculopapular rash that begins on the cheeks (slapped-cheek appearance) and spreads to the limbs
	Herpes simplex	Raised vesicles that heal with a crust
Bacterial infections	Impetigo	Vesiculopustular lesions with exudate and yellow crusting
Fungal infections	Ringworm	An annulus (ring) of scaly papular lesions with central clearing
Parasitic infections	Scabies	Linear burrows with a small, very pruritic papule at one end
	Lice (pediculosis)	Dermatitis: excoriation (scratches) due to pruritis (itching)
Allergies to medication	Penicillin	Wheals (urticaria or hives)
Food allergies	Eggs, certain fruits	Wheals
Environmental allergies	Poison ivy	Vesicles

- The condition of the hair can be an indicator of the overall health of the individual. For example, depigmentation and coarseness of hair occurs in protein deficiency disease called *kwashiorkor*.

Diagnosing Skin Conditions

Table A-13 introduces several major types of lesions associated with blood vessels. A single vascular lesion, such as a *hematoma*, can have multiple causes. This is one of the challenges facing dermatologists—the signs may be apparent, but not the underlying causes. Making matters more difficult, many different skin disorders produce the same uncomfortable sensations. For example, **pruritis** (proo-RĪ-tus), an irritating itching sensation, is an extremely common symptom associated with a variety of skin conditions. Questions concerning medical history, medications, possible sources of infection, and other signs can be the key to making an accurate diagnosis.

Pain is another common symptom of many skin disorders. Although pain is unwelcome, cutaneous sensation is an important function of the integumentary system. This is dramatically demonstrated in the condition of *leprosy*, or *Hansen's disease*. Hansen's disease is caused by bacteria that have an affinity for cooler regions of the body. The bacteria destroy cutaneous nerve endings sensitive to touch, pain, hot, and cold. Damage to the extremities then occurs and accumulates because the individual is no longer aware of painful stimuli. Hansen's disease is considered in more detail in a later section (p. 79).

Figure A-13 is an overview of skin disorders. Diagnostic tests that may prove useful in distinguishing among them include:

- Scrapings of affected tissue, a process often performed to check for fungal infections
- Culturing of fluid removed from a lesion to aid in identification of infection and to determine drug sensitivity for treatment
- Biopsy of affected tissue to view cellular structure
- Skin tests: Various types of disorders can be detected through use of a *skin test*. In a skin

test a localized area of the skin is exposed to an inactivated pathogen, a portion of a pathogen, or a substance capable of producing an allergic reaction in sensitive individuals. Exposure may be by injection or surface application. For example, in a tuberculosis skin test a small quantity of tuberculosis antigens is injected *intradermally* (*intra*, within). If the individual has been infected in the past, or currently has tuberculosis, there will be erythema and swelling at the injection site 24–72 hours later. *Patch testing* is used to check sensitivity to *allergens*, environmental agents that can cause allergic reactions. In a patch test the allergen is applied to the surface of the skin. If erythema, swelling, and/or itching develop, the individual is sensitive to that allergen.

Infections of the skin are caused by various bacteria, viruses, fungi, and parasites. Table A-14 summarizes information about common infections of the integumentary system.

Disorders of Keratin Production

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Not all skin signs are the result of infectious, traumatic, or allergic conditions. Excessive production of keratin is called **hyperkeratosis** (hi-per-ker-a-TŌ-sis). The most obvious effects are easily observed as calluses and corns. Calluses are thickened patches that appear on already thick-skinned areas, such as the palms of the hands or the heels of the foot, in response to chronic abrasion and distortion. Corns are more localized areas of excessive keratin production, and they form in areas of thin skin on or between the toes.

In **psoriasis** (so-RĪ-a-sis) the stratum germinativum becomes unusually active, causing hyperkeratosis in specific areas, including the scalp, elbows, palms, soles, groin, and nails. Normally an individual stem cell divides once every 20 days, but in psoriasis it may divide every day and a half. Keratinization is abnormal and often incomplete by the time the outer layers are shed. The affected areas have red bases covered with small silvery scales that continually flake away. Psoriasis develops in 20–30 percent of the individuals with an inherited tendency for the condition. Roughly 5 per-

Table A-13 Examples of Vascular Lesions

Lesion	Features	Some Possible Causes
Echymosis	Reddish purple, blue, or yellow bruising related to trauma	Blood-clotting disorder; thrombocytopenia; increased tendency to bruise is normal with aging or sun-damaged skin
Hematoma	Pooling of blood forming a mass; associated with pain and swelling	Trauma: a broken blood vessel
Petechiae	Small red to purple pinpoint dots appearing in clusters	Leukemia; septicemia (toxins in blood), thrombocytopenia
Erythema	Red flushed color of skin due to dilation of blood vessels in the skin	Extensive: drug reactions; localized burns, dermatitis

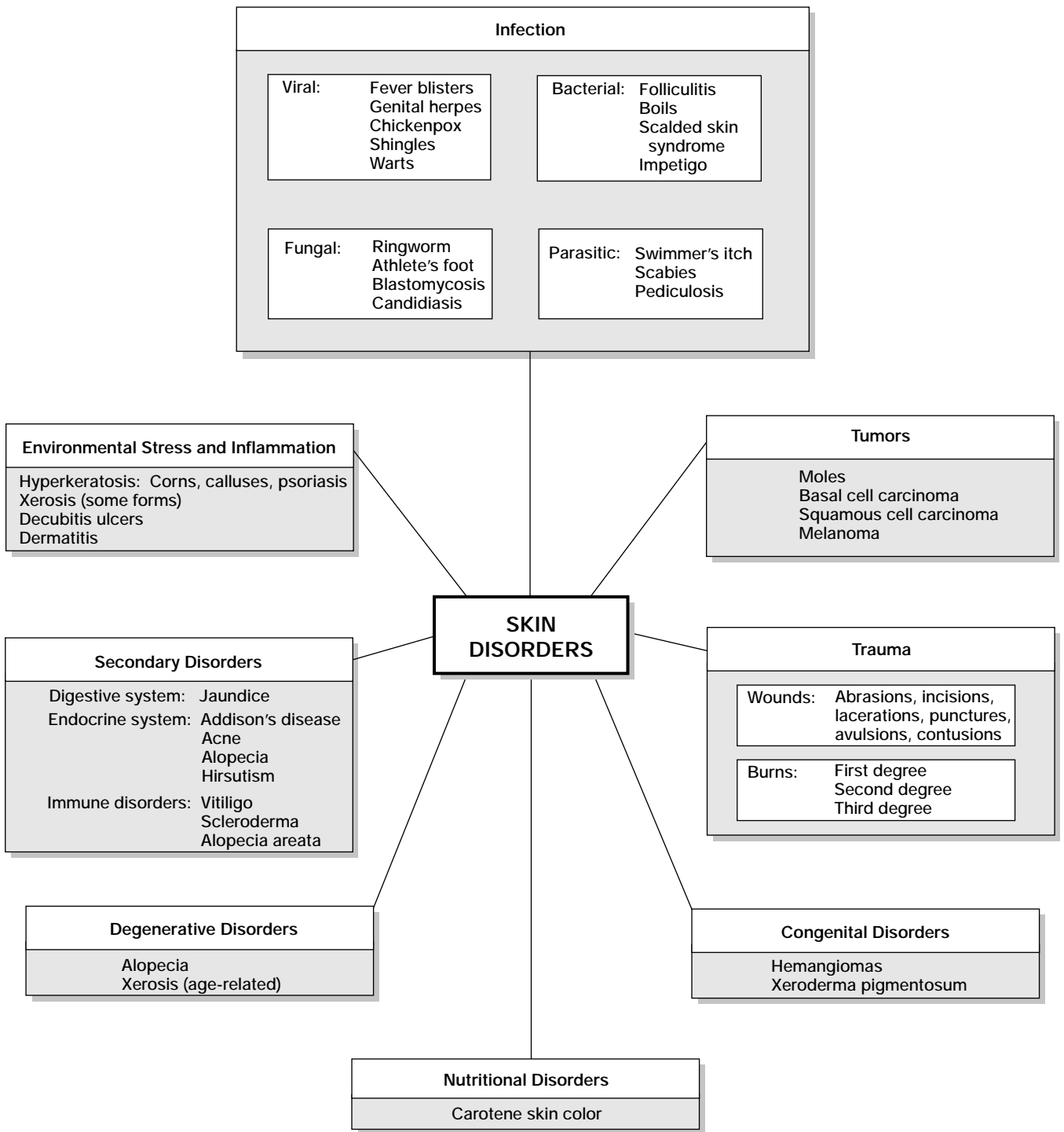


Figure A-13 Disorders of the Integumentary System

cent of the general U.S. population has psoriasis to some degree, aggravated by stress and anxiety. Most cases are painless and controllable, but not curable.

Xerosis (ze-RŌ-sis), or "dry skin," is a common complaint of the elderly and people who live in arid climates. Under these conditions, cell membranes in the outer layers of the skin gradually deteriorate

and the stratum corneum becomes more a collection of scales than a single sheet. The scaly surface is much more permeable than an intact layer of keratin, and the rate of insensible perspiration increases. In persons afflicted with severe xerosis, the rate of insensible perspiration may increase by up to 75 times.

Table A-14 Common Infectious Diseases of the Integumentary System

<i>Disease</i>	<i>Organism (Name)</i>	<i>Description</i>
Bacteria		
Folliculitis	<i>Staphylococcus aureus</i>	Infections of hair follicles may form pimples, furuncles (boils), and abscesses.
Scalded skin syndrome	<i>Staphylococcus aureus</i>	In infants; large areas of skin blister, peel off, and leave wet, red areas.
Impetigo	<i>Staphylococci, Streptococci, or both</i>	Pustules form on skin, dry, and become crusts; skin pigment may not reappear after healing.
Viruses		
Oral herpes	Herpes simplex 1	Vesicles (blisters), also called cold sores, form on lips (fever blisters) and hands; vesicles disappear but may reappear at various times.
Genital herpes	Herpes simplex 2	Lesions similar to those in oral herpes form on external genitalia; vesicles disappear and reappear.
Chickenpox (<i>varicella</i>)	Herpes varicella-zoster	In children; small, red macules form vesicles, which dry and become crusts.
Shingles (<i>zoster</i>)	Herpes varicella-zoster	In adults; lesions form a pattern, usually on trunk; severe pain often follows attack.
Warts	Human papillomaviruses	Dermal warts form in the epidermis; genital warts may become malignant and may be sexually transmitted.
Fungi		
Ringworm (<i>tinea</i>)	<i>Epidermophyton, Microsporum, and Trichophyton</i>	Dry, scaly lesions form on the skin in different parts of the body: scalp (<i>tinea capitis</i>), body (<i>tinea corporis</i>), groin (<i>tinea cruris</i>), foot (<i>tinea pedis</i>), and nails (<i>tinea unguium</i>).
Blastomycosis	<i>Blastomyces dermatitidis</i>	Pustules and abscesses form in the skin; may affect other organs.
Candidiasis	<i>Candida albicans</i>	Normal inhabitant of the human body; may infect many organs; red lesions form in skin infections; nails may also become infected.
Parasites		
Swimmer's itch	<i>Schistosoma</i> worms (flukes)	Freshwater larval stages of schistosome worms (flukes) burrow into skin and cause itching.
Scabies	<i>Sarcoptes scabiei</i> (itch mite)	Itch mite burrows and lays eggs in skin in areas between fingers and at the wrists, armpits, and genitals; entrance marked by tiny, scaly swellings that become red and itchy.
Pediculosis	<i>Pediculus humanus</i> (human body louse) <i>Phthirus pubis</i> (pubic louse)	Lice infestations on body and scalp; bites produce redness, dermatitis, and itching. "Crabs"; lice infestation of the pubic area; their bites produce intense itching.



Transdermal Medications EAP p. 112

Several drugs are now routinely administered transdermally:

- Transdermal *scopolamine*, a drug that affects the nervous system, is used to control the nausea associated with motion sickness.
- Transdermal *nitroglycerin* can be used to improve blood flow within heart muscle and prevent a heart attack.

- Transdermal *estrogens* may be administered to women to reduce symptoms of menopause.
- Transdermal *nicotine* can be used to suppress the urge to smoke cigarettes.

In addition, pain medications and drugs to control high blood pressure may be administered via transdermal patches.

DMSO (dimethyl-sulfoxide) is a transdermal drug intended for the treatment of injuries to the muscles and joints of domesticated animals, such as horses or cows. It is a solvent that rapidly

crosses the skin, and some drugs dissolved in DMSO will be carried into the body at the same time. DMSO has not been tested and approved for the treatment of human patients in the United States, either for joint or muscle injuries or as a transdermal solvent. However, it can be prescribed in Canada and Europe. The long-term risks associated with it are unknown; reported short-term side effects include nausea, vomiting, cramps, and chills.

Abnormal Skin Pigmentation EAP p. 112

Several diseases that have primary impacts on other systems may have secondary effects on skin color and pigmentation. Because the skin is easily observed, these color changes can be useful in diagnosis. For example:

- In *jaundice* (JAWN-dis) the liver is unable to excrete bile, and a yellowish pigment accumulates in body fluids. In advanced stages, the skin and whites of the eyes turn yellow. Eating large amounts of carotene (found in carrots and other vegetables) may yellow the skin and mimic jaundice.
- Some tumors affecting the pituitary gland result in the secretion of large amounts of *melanocyte-stimulating hormone* (MSH). This hormone causes a darkening of the skin, as if the individual has an extremely deep bronze tan.
- In *Addison's disease* the pituitary gland secretes large quantities of *ACTH*, a hormone that is structurally similar to MSH. The result of ACTH on the skin coloration is also similar to that of MSH.
- In *vitiligo* (vi-ti-LĪ-gō) individuals lose their melanocytes. The condition develops in about 1 percent of the population, and the incidence increases among individuals with thyroid gland disorders, *Addison's disease*, and several other disorders. It is suspected that this disorder develops when the immune defenses malfunction, and antibodies attack normal melanocytes. The primary problem with vitiligo is cosmetic, especially for individuals with darkly pigmented skin. Michael Jackson is said to suffer from vitiligo.

Color changes affecting the integument as a whole are discussed in the text. Examples include *cyanosis* and *Addison's disease*. Dilation of the blood vessels in the dermis of a light-skinned individual can produce a color change known as **erythema** (*erythros*, "red"). Erythema may affect the entire body surface, or it may be localized to a particular region. For example, a transient erythema is produced on the cheeks when some individuals become embarrassed. More permanent localized vascular changes in the skin usually reflect either an increase or decrease in local vascularity, dam-

age to blood vessels, or problems with the clotting system. Table A-14 introduces several major types of vascular lesions.

Skin Cancers

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Almost everyone has several benign tumors of the skin; freckles and moles are examples. Skin cancers are the most common form of cancer, and the most common skin cancers are caused by prolonged exposure to the ultraviolet radiation in sunlight.

A **basal cell carcinoma** is a malignant cancer that originates in the germinativum (basal) layer. This is the most common skin cancer, and roughly two-thirds of these cancers appear in areas subjected to chronic UV exposure.

Squamous cell carcinomas are less common but almost totally restricted to areas of sun-exposed skin. Metastasis seldom occurs in squamous cell carcinomas and virtually never in basal cell carcinomas, and most people survive these cancers. The usual treatment involves surgical removal of the tumor, and 95 percent of patients survive five years or more after treatment. (This statistic, the five-year survival rate, is a common method of reporting long-term prognosis.)

Compared with these common and seldom life-threatening cancers, **malignant melanomas** (mel-a-NŌ-maz) are extremely dangerous. In this condition, cancerous melanocytes grow rapidly and metastasize through the lymphatic system. The outlook for long-term survival depends on when the condition is diagnosed. If localized, the five-year survival rate is 99 percent; if widespread, the survival rate drops to 14 percent.

To detect melanoma at an early stage, it is essential to know what to look for when examining your skin. The key points can be remembered most easily using the mnemonic ABCD:

- A is for *asymmetry*: melanomas tend to be irregular in shape. Often they are raised; they may ooze or bleed.
- B is for *border*: usually irregular, sometimes notched.
- C is for *color*: often mottled, with many different colors (tan, brown, black, red, pink, white, and/or blue) or very dark.
- D is for *diameter*: a dark growth more than about 5 mm (0.2 in.) in diameter, or roughly the area covered by the eraser on a pencil, is dangerous.

A new experimental treatment for melanoma uses genetic engineering technology to manufacture antibodies that target the MSH (melanocyte-stimulating hormone) receptors on the surfaces of melanocytes. Melanocytes coated with these antibodies are then recognized and attacked by cells of the immune system.

Fair-skinned individuals who live in the tropics are most susceptible to all forms of skin cancer, because their melanocytes are unable to shield them from the ultraviolet radiation. Sun damage can be prevented by avoiding exposure to the sun during the middle hours of the day, wearing hats and clothing cover-ups, and by using a sunblock (not a tanning oil)—a practice that also delays the cosmetic problems of sagging and wrinkling. *Everyone* who expects to be out in the sun for any length of time should choose a broad-spectrum sunblock with a sun protection factor (SPF) of at least 15; blonds, redheads, and people with very fair skin are better off with a sun protection factor of 20 to 30. (One should also remember the risks before spending hours in a tanning salon or tanning bed.)

The use of sun screens now becomes even more important as the ozone gas in the upper atmosphere is destroyed by our industrial emissions. Ozone absorbs UV before it reaches the earth's surface, and in doing so, it assists the melanocytes in preventing skin cancer. Australia, which is most affected by the depletion of ozone near the south pole (the "ozone hole"), is already reporting an increased incidence of skin cancers.

Tumors in the Dermis EAP p. 114

Tumors seldom develop in the dermis, and those that do appear are usually benign. Two forms of **hemangiomas** may appear among dermal blood vessels during development. Viewed from the surface, these form prominent **birthmarks**. A **capillary hemangioma** involves capillaries of the papillary layer. It usually enlarges after birth, but subsequently fades and disappears. **Cavernous hemangiomas**, or "port-wine stains," affect larger vessels in the dermis, and such birthmarks usually last a lifetime.

Dermatitis EAP p. 114

Because of the abundance of sensory receptors in the skin, regional infection or inflammation can be very painful. **Dermatitis** (der-muh-TĪ-tis) is an inflammation of the skin that primarily involves the papillary layer. In typical dermatitis, inflammation begins in a portion of the skin exposed to infection or irritated by chemicals, radiation, or mechanical stimuli. Dermatitis may cause no physical discomfort, or it may produce an annoying itch, as in poison ivy. Other forms of this condition can be quite painful, and the inflammation may spread rapidly across the entire integument.

There are many forms of dermatitis, some of them quite common:

- *Contact dermatitis* usually occurs in response to focal contact with strong chemical irritants. It produces an itchy rash that may spread to other areas; poison ivy is an example.
- *Eczema* (EK-se-muh) is a dermatitis that can be triggered by temperature changes, fungus,

chemical irritants, greases, detergents, or stress. Hereditary or environmental factors or both can encourage the development of eczema.

- *Diaper rash* is a localized dermatitis caused by a combination of moisture, irritating chemicals from fecal or urinary wastes, and flourishing microorganisms, often fungi.
- *Urticaria* (ur-ti-KAR-ē-uh), also known as *hives*, is an extensive allergic response to a food, drugs, an insect bite, infection, stress, or other stimulus.

DISORDERS OF THE ACCESSORY ORGANS OF THE SKIN

There are many disorders that affect accessory organs of the skin, especially the hair and the exocrine glands. We will consider only three relatively common examples: *baldness*, *hirsutism*, and *acne*.

Baldness and Hirsutism EAP p. 114

Hairs are dead, keratinized structures, and no amount of oiling, shampooing, or dousing with kelp extracts, vitamins, or nutrients will influence the follicle buried in the dermis. Skin conditions that affect follicles can contribute to hair loss; temporary baldness can also result from exposure to radiation or to many of the toxic (poisonous) drugs used in cancer therapy.

Two factors interact to determine baldness. A bald individual has a genetic susceptibility to hair loss that is triggered by sufficient quantities of male sex hormones. Many women carry the genetic background for baldness, but unless major hormonal abnormalities develop, as in certain endocrine tumors, hair loss does not occur.

Male pattern baldness affects the top of the head first, only later reducing the hair density along the sides. Thus hair follicles can be removed from the sides and implanted on the top or front of the head, temporarily delaying a receding hairline. This procedure is rather expensive (thousands of dollars) and not every transplant is successful.

Finasteride is a prescription drug that blocks one form of testosterone. In low doses it slows progression of male pattern baldness. *Minoxidil*, a drug originally marketed for the control of blood pressure, appears to stimulate inactive hair follicles when rubbed onto the scalp. It is now available without a prescription, as Rogaine, and is most effective in preventing progression of early hair loss.

Alopecia areata (al-Ō-PĒ-shē-uh ar-ē-AH-ta) is a localized, temporary hair loss that can affect either sex. The cause is not known, and the severity of hair loss varies from case to case. This condition is associated with several disorders of the immune system; it has also been suggested that periods of stress may promote alopecia areata in individuals already genetically prone to baldness.

Hirsutism (HER-soot-izm; *hirsutus*, “bristly”) refers to the growth of hair on women in patterns usually characteristic of men. Because considerable overlap exists between the two sexes in terms of normal hair distribution, and there are significant racial and genetic differences, the precise definition is more often a matter of personal taste than objective analysis. Age and sexual hormones play a role, for hairiness increases late in pregnancy, and menopause produces a change in body hair patterns.

Severe hirsutism is often associated with abnormal androgen (male sex hormone) production, either in the ovaries or in other endocrine organs. Unwanted follicles can be permanently “turned off” by plucking a growing hair and removing the papilla. Electrocautery, which destroys the follicle with a jolt of electricity, requires the services of a professional, but the results are more reliable. Patients may also be treated with drugs that reduce or prevent androgen stimulation of the follicles.

Acne

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Individuals with a genetic tendency toward acne have larger than average sebaceous glands, and when the ducts become blocked, the secretions accumulate. Inflammation develops, and bacterial infection may occur. The condition usually surfaces at puberty, as sexual hormone production accelerates and stimulates the sebaceous glands. Their secretory output may be further encouraged by anxiety, stress, physical exertion, certain foods, and drugs.

The visible signs of acne are called **comedos** (ko-MĒ-doz). “Whiteheads” contain accumulated, stagnant secretions. “Blackheads” contain more solid material that has been invaded by bacteria. Although neither condition indicates the presence of dirt in the pores, washing may help keep superficial oiliness down.

Acne usually fades after sex hormone concentrations stabilize. Topical (applied) antibiotics, vitamin A derivatives, such as *Retin-A*, or peeling agents may help reduce inflammation and minimize scarring. In cases of severe acne, the most effective treatment usually involves the discouragement of bacteria by the administration of antibiotic drugs; because oral antibiotic therapy has risks, including the development of antibiotic-resistant bacteria, this therapy is not used unless other treatment methods have failed. Truly dramatic improvements in severe cases have been obtained with the prescription drug *Accutane*. This compound is structurally similar to vitamin A, and it reduces oil gland activity on a long-term basis. A number of minor side effects, including dry skin rashes, have been reported; these apparently disappear when the treatment ends. However, the use of *Accutane* during the first month of pregnancy carries a high (25 times normal) risk of inducing birth defects.

INJURIES AND TREATMENT OF SKIN CONDITIONS

Topical (applied on the skin) **anti-inflammatory drugs**, such as the steroid **hydrocortisone**, can be used to reduce the redness and itching that accompanies a variety of skin conditions. Some systemic (injected or swallowed) drugs may also be helpful; aspirin is a familiar systemic drug with anti-inflammatory properties. Isolated growths, such as skin tumors or warts, may be surgically removed. Alternatively, abnormal cells may be destroyed by electrical currents (**electrosurgery**) or by freezing (**cryosurgery**). Ultraviolet radiation may help conditions such as acne or psoriasis, whereas using a sunscreen or sunblock is important in controlling sun-sensitive outbreaks.

A Classification of Wounds EAP p. 118

Injuries, or **trauma**, involving the integument are very common, and a number of terms are used to describe them. Traumatic injuries usually affect all components of the integument, and each type of wound presents a different series of problems to clinicians attempting to limit damage and promote healing.

An **open wound** is an injury producing a break in the epithelium. The major categories of open wounds have been illustrated in Figure A-14. **Abrasions** are the result of scraping against a solid object. Bleeding may be slight, but a considerable area may be open to invasion by microorganisms. **Incisions** are linear cuts produced by sharp objects. Bleeding may be severe if deep vessels are damaged. The bleeding may help flush the wound, and closing the incision with bandages or stitches can limit the area open to infection while healing is under way. A **laceration** is a jagged, irregular tear in the surface produced by solid impact or an irregular object. Tissue damage is more extensive, and repositioning the opposing sides of the injury may be difficult. Despite the bleeding that usually occurs, lacerations are prone to infection. **Punctures** result from slender, pointed objects piercing the epithelium. Little bleeding results, and any microbes delivered under the epithelium in the process are likely to find conditions to their liking. In an **avulsion**, chunks of tissue are torn away by the brute force of an auto accident, explosion, or other incident. Bleeding may be considerable, and even more serious internal damage may be present.

Closed wounds may affect any internal tissue, but because the epithelium is intact, the likelihood of infection is reduced. A **contusion** (or bruise) is caused by bleeding in the dermis. “Black and blue” marks are familiar examples of contusions that are taken lightly; contusions of the head, such as “black eyes,” may be harmless or a sign of dangerous intracranial bleeding. In general, closed wounds affecting internal organs and organ systems are serious threats to life.

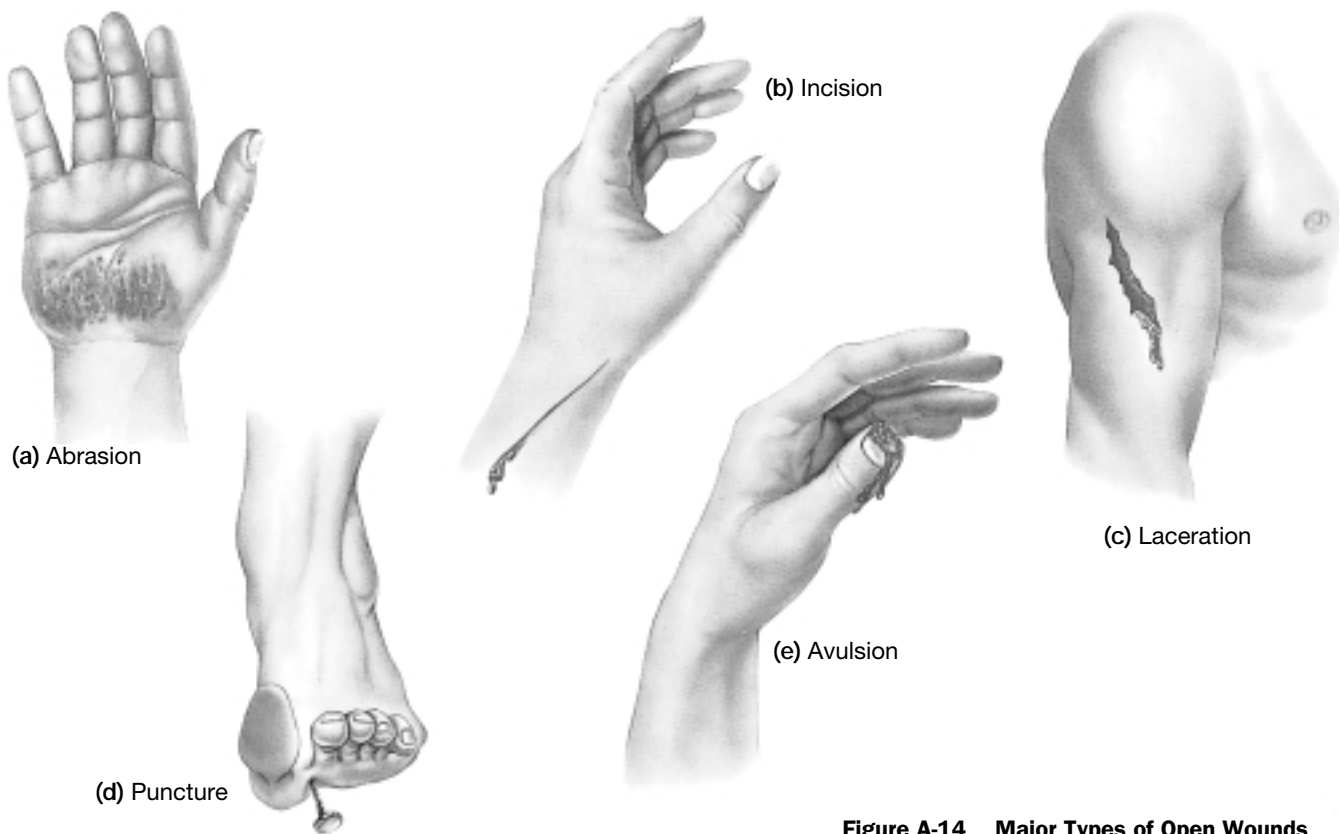


Figure A-14 Major Types of Open Wounds

✚ Burns and Grafts

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Burns result from exposure of the skin to heat, radiation, electrical shock, or strong chemical agents. The severity of the burn reflects the depth of penetration and the total area affected.

First- and second-degree burns are also called **partial-thickness burns** because damage is restricted to the superficial layers of the skin. Accessory structures such as hair follicles and glands are usually unaffected. **Full-thickness burns**, or **third-degree burns**, destroy the epidermis and dermis, extending into subcutaneous tissues. These burns are actually less painful than second-degree burns, because sensory nerves are destroyed along with accessory structures, blood vessels, and other dermal components. Extensive third-degree burns cannot repair themselves, and the site remains exposed to potential infection.

Roughly 10,000 people die from burns each year in the United States. The larger the area burned, the more significant the effects on integumentary function. Figure A-15 presents a standard reference for calculating the percentage of total surface area involved. Burns that cover more than 20 percent of the skin surface represent serious threats to life because they affect the following functions:

- *Fluid and electrolyte balance.* Even areas with partial-thickness burns lose their effectiveness

as barriers to fluid and electrolyte losses. In full-thickness burns, the rate of fluid loss through the skin may reach five times the normal level.

- *Thermoregulation.* Increased fluid loss means increased evaporative cooling. More energy must be expended to keep body temperature within acceptable limits.
- *Protection from attack.* The epidermal surface, damp from uncontrolled fluid losses, encourages bacterial growth. If the skin is broken at a blister or the site of a third-degree burn, infection is likely. Widespread bacterial infection, or **sepsis** (*septikos*, rotting), is the leading cause of death in burn victims.

Effective treatment of full-thickness burns focuses on these procedures:

1. Replacing lost fluids and electrolytes.
2. Providing sufficient nutrients to meet increased metabolic demands for thermoregulation and healing.
3. Preventing infection by cleaning and covering the burn while administering antibiotic drugs.
4. Assisting tissue repairs.

Because large full-thickness burns cannot heal unaided, surgical procedures are necessary to

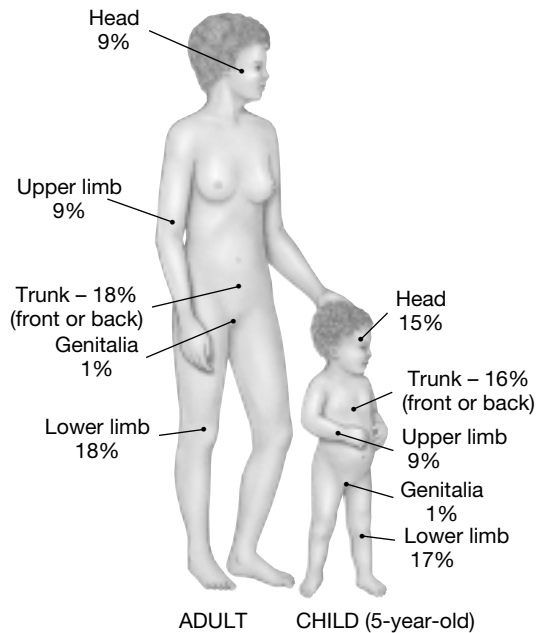


Figure A-15 A Quick Method for Estimating the Percentage of Surface Area Affected by Burns in Adults and Small Children

The method of estimation is called the “rule of nines” because of the surface area proportion in the adult. This rule must be modified in children because their proportions are quite different.

encourage healing. In a **skin graft**, areas of intact skin are transplanted to cover the burn site. A **split-thickness graft** takes a shaving of the epidermis and superficial portions of the dermis. A **full-thickness graft** involves the epidermis and both layers of the dermis.

With the development of fluid replacement therapies, infection control methods, and grafting techniques, the recovery rate for severe burns has improved dramatically. At present, young patients with burns over 80 percent of the body have approximately a 50 percent chance of recovery.

Recent advances in cell culture techniques may improve survival rates further. It is now possible to remove a small section of undamaged epidermis and grow it under controlled laboratory conditions. Over time, the germinative cell divisions produce large sheets of epidermal cells that can then be used to cover the burn area. From initial samples

the size of postage stamps, square yards of epidermis have been grown and transplanted onto body surfaces. Although questions remain concerning the strength and flexibility of the repairs, skin cultivation represents a substantial advance in the treatment of serious burns.

R Synthetic Skin

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Traditional skin grafts involve covering areas of complete skin loss or destruction with pieces of undamaged skin from other areas of the body. If the damaged area is large, there may not be enough normal skin available for grafting. *Epidermal culturing* can produce a new epithelial layer to cover a burn site. An epidermal sample from the victim can be cultured in a controlled environment that contains epidermal growth factors, fibroblast growth factors, and other stimulatory chemicals. This artificially produced epidermis can then be transplanted to cover an injury site. The larger the area that must be covered, the longer the culturing process continues. After three or four weeks of culturing, the cells obtained in the original sample can provide enough epidermis to cover the entire body surface of a normal adult.

The major problem that reduces grafting success is the contamination of the wound site by bacteria while the epidermis is being cultured. This is prevented by the use of a skin *allograft*. Skin from a frozen cadaver is removed and placed over the wound as a temporary method of sealing the surface. Before the immune system of the patient attacks the graft, it will be partially or completely removed to provide a binding site for the epidermal transplant. After grafting, the complete reorganization and repair of the dermis and epidermis at the injury site takes approximately five years.

A second new procedure provides a model for dermal repairs that takes the place of normal tissue. A special synthetic skin is used. A biosynthetic dermis made of collagen and a silicon polymer called “Integra,” used either alone or covered by a cultured epidermal layer, covers the burn site. Over time, fibroblasts migrate among the collagen fibers and gradually replace the model framework with their own. The silastic epidermis is intended only as a temporary cover that will be replaced by either skin grafts or a cultured epidermal layer.

CRITICAL-THINKING QUESTIONS

1-1. Charlie is badly burned in an accident with fireworks on the Fourth of July. When he reaches the emergency room, the examining physician determines the severity of the incident as a third-degree burn. The physician would likely order

- IV (intravenous) fluids and electrolytes
- antibiotics

- a high-nutrient diet
- all of the above

1-2. John, who has sailed boats professionally for years, visits his dermatologist. John’s wife has noticed a mole on the back of his neck with suspicious characteristics. The dermatologist makes note of the irregular border of the nevus (mole), and the black coloration. John’s wife reports that

the mole has undergone these changes in the last month. The dermatologist recommends immediate biopsy of the nevus, suspecting

- a. basal cell carcinoma
- b. melanoma
- c. squamous cell carcinoma
- d. hemangioma

1-3. Carrie, a vegetarian, tells her physician about a yellow discoloration of the palms of her hands and the soles of her feet. Further inspection reveals that her forehead and the area around her nose are also yellow in color. The physician determines that Carrie has not been exposed to hepati-

tis, and she has normal liver function tests. What might be the problem?

1-4. Sam likes to work on his motorcycle on weekends, and he spends a great deal of time cleaning engine parts with organic solvents. He doesn't wear gloves while working, and notices that after he is finished, his hands feel painfully dry for several hours. What is the probable cause?

1-5. During pregnancy it is not uncommon for skin and hair color to become darker, especially around the genitals, nipples, and face. What is the probable cause of these changes?

NOTES