chapter 3

Physiologic Changes

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Objectives

1. Describe the most common structural changes observed in the normal aging process.
2. Discuss the impact of normal structural changes on the older adult's self-image and lifestyle.
3. Describe the most commonly observed functional changes that are part of the normal aging process.
4. Discuss the impact of normal functional changes on the older adult's self-image and lifestyle.
5. Identify the most common diseases related to aging in each of the body systems.
6. Differentiate between normal changes of aging and disease processes.
7. Discuss the impact of age-related changes on nursing care.

Key Terms

carcinoma (kăr-sĭ-NŌ-mă) (p. 35)
cardiomegaly (kăhr-dē-ō-MĔG-ă-lē) (p. 47)
cataracts (KĂT-ă-răkts) (p. 64)
dementia (dē-MĔN-shē-ă) (p. 58)
diverticulosis (dĪ-vĕr-tĭk-ū-LŌ-sĭs) (p. 53)
glaucoma (glă-KŌ-mă) (p. 64)
hypothyroidism (hĪ-pōTHĪ-royd-ĭzm) (p. 60)
ischemic (ĭs-KĒ-mĭk) (p. 46)
nystagmus (nĭs-TĂG-mŭs) (p. 66)
orthostatic hypotension (ŏr-thō-STĂT-ĭk hĪ-pō-TĔN-shŭn) (p. 45)
osteoporosis (ŏs-tē-ō-pă-RŌ-sĭs) (p. 39)
seborrheic dermatitis (sĕb-ō-RĒ-ĭk dĕr-mă-TĪ-tĭs) (p. 36)
seborrheic keratosis (sĕb-ō-RĒ-ĭk kĕr-ă-TŌ-sĭs) (p. 33)
senile lentigo (SĒ-nīl lĕn-TĪ-gō) (p. 33)
senile purpura (SĒ-nīl PŪR-pū-ră) (p. 34)
xerosis (zĕr-Ō-sĭs) (p. 34)

The changes in body function that occur with aging are not random and do not develop suddenly or without warning. Rather, they are part of a continuum that begins the moment life begins. From the moment of conception, tissues and organs develop in an orderly manner. When fully developed, these organs and tissues perform specific functions and interact together in a predictable way. Throughout life, human growth and development occur methodically.

Early in life, the physical changes are dramatic. In only 9 months of gestation, the human organism develops from two almost invisible cells into a unique, functioning individual measuring approximately 20 inches in height and usually weighing between 6 and 9 pounds. For the next 13 to 15 years, rapid physical growth continues. By approximately age 18, the human body reaches full anatomic and physiologic maturity.

The peak years of physiologic function last from the late teens through the thirties—the so-called prime of life. Physiologic changes are still occurring during this time, but they are subtle and not easily recognized. Because these changes do not happen as rapidly or as dramatically as do those that occur early in life, they are more likely to be ignored.

As a person moves into his or her fifth and sixth decades of life, these physiologic changes become more apparent. In the seventh and eighth decades and beyond, they are significant and no longer deniable.

It is important to recognize that although age-related changes are predictable, the exact time at which they occur is not. Just as no two individuals grow and develop at exactly the same rate, no two individuals show the signs of aging at the same time. There is wide person-to-person variation in when—and to what degree—these changes occur. Heredity, environment, and health maintenance significantly affect the timing and magnitude of age-related changes. Some people are chronologically quite young but appear old. The most severe cases of this occur in a rare condition called **progeria.** When they are only 8 or 9 years of age, children with progeria have the physiology and appearance of 70-year-olds. At the other extreme, there are persons in their sixties, seventies, and even older who are vigorous and appear much younger than their chronologic age. Most people show the signs of aging at a rate somewhere between these two extremes.

We can observe many normal changes in the body's physical structure and function during the aging process. There are also changes that indicate the onset of disease or illness. Nurses are expected to be able to tell

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Key Points

- Many biologic, environmental, and psychosocial theories have been proposed to explain why we age.
- These theories remain theories because the exact processes that cause the changes seen with aging are not completely understood.
- Further research and study are needed to determine which theory or combination of theories is most accurate.
- Once this is determined, we will be able to institute measures to slow aging and prolong the human life span.
- To date, hormone replacement therapy appears to have more risks than benefits.

Additional Learning Resources

SG Go to the Study Guide on pp. 379–397 for additional learning activities to help you master the chapter content.

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- Animations
- Answer Guidelines for Nursing Care Plan Critical Thinking Questions
- Answers and Rationales for Review Questions for the NCLEX® Examination
- Glossary with pronunciations in English and Spanish
- Video Clips

Review Questions for the NCLEX® Examination

1. A friend asks the nurse what could be done to improve the chance of a long life. Using current theories of aging, the nurse recommended that her friend discuss this first with her physician, but the one approach more likely to cause harm than good was:
   1. Antioxidant foods such as vitamins A, B_6, B_{12}, C, and E
   2. Hormones such as HGH, DHEA, and estrogen
   3. Calorie-restricted diet
   4. Herbal and nutritional supplements
2. The same friend asks how long humans can live. The nurse would reply that currently the maximum life expectancy of humans appears to be:
   1. 100 years
   2. 105 years
   3. 110 years
   4. 120 years
3. According to Erikson, the primary developmental task of the elderly population is:
   1. Generativity versus stagnation
   2. Trust versus mistrust
   3. Intimacy versus isolation
   4. Integrity versus despair

the difference between normal changes and abnormal changes that signify a need for medical or nursing intervention. To identify these differences, nurses must have a good understanding of the normal structures and functions of the body. This knowledge should help nurses understand how normal and abnormal changes affect the day-to-day functional abilities of older adults. As nurses, we must be aware of the physical changes that are likely to occur, assess each individual to determine the extent to which these changes have occurred, and then make our care plans in response to that specific person's needs.

Some diseases are more commonly seen with advanced age. Most older adults experience one or more chronic conditions. The leading causes of disability over age 65 are heart disease, stroke, arthritis, hypertension, accidents, diabetes mellitus (DM), cancer, and diseases of the ears and eyes. Currently, the five leading causes of death among older adults are (1) heart disease, (2) cancer, (3) cardiovascular disease (primarily stroke), (4) pneumonia, and (5) chronic obstructive pulmonary disease.

It is essential for nurses to learn that each aging person, just like each younger person, is unique. The type and extent of changes seen with aging are specific and unique to each person. Nurses must avoid falling into the trap of stereotyping older adults. Stereotyping is dangerous because it leads us to accept as inevitable some changes that are not inevitable. Stereotyping can also cause us to mistake early signs of disease as a part of aging.

THE INTEGUMENTARY SYSTEM

The integumentary system, which includes the skin, hair, and nails, undergoes significant changes with aging. Because many of these structures are visible, changes in this system are probably the most obvious and are evident to both the aging individual and others.

The **epidermis,** the outermost layer of the skin, is an important structure that provides protection for internal structures, keeps out dangerous chemicals and microorganisms, functions as part of the body's fluid regulation system, and helps regulate body temperature and eliminate waste products. It also contains melanocytes that produce the pigment **melanin,** which provides protection from ultraviolet radiation.

The **dermis** contains **collagen** and elastin fibers, which give strength and elasticity to the tissues. The **sebaceous** (oil-producing) and eccrine (sweat-producing) glands are located in the subcutaneous tissue, as are the hair and nail follicles and the **sensory nerve receptors.** Hair and nails are composed of dead **keratinized** cells. Hair pigment, or color, is related to the amount of melanin produced by the follicle and, like skin pigmentation, is hereditary. Nails are rigid structures that protect the sensitive, nerve-rich tissue at the tips of the fingers and toes. Nails also aid dexterity in fine finger manipulation.

Subcutaneous tissue consists of **areolar connective tissue,** which connects the skin to the muscles, and **adipose tissue,** which provides a cushion over tissue and bone. Subcutaneous tissue provides insulation to regulate body temperature. It is here that **white blood cells** (WBCs) are available to protect the body from microbial invasion through the skin. Blood vessels in the subcutaneous tissue supply the tissue with nourishment and assist in the process of heat exchange. These superficial blood vessels dilate or constrict as needed to release heat or to conserve heat lost through convection.

EXPECTED AGE-RELATED CHANGES

With aging, the epidermis becomes more fragile, increasing the risk for skin damage such as tears, maceration, and infection. Rashes caused by contact with chemicals, such as detergents or cosmetics, are increasingly common in older individuals. Skin repairs more slowly in older than in younger individuals, increasing the risk for infection.

Melanocyte activity declines with age, and in light-skinned individuals, the skin may become very pale, making older individuals more susceptible to the effects of the sun. Clusters of melanocytes can form areas of deepened pigmentation, a condition called **senile lentigo**; these areas are often referred to as *age spots* or *liver spots* and are most often seen on areas of the body that are most exposed to sunlight. In a condition called **seborrheic keratosis**, slightly raised, wartlike macules with distinct edges appear (Figure 3-1). These lesions, which can range in color from light tan to black, are most often observed on the upper half of the body, and they may cause discomfort and itching. Skin tags, or **cutaneous papilloma,** are small, brown or flesh-colored projections of skin that are most often observed on the necks of older adults.

Aging results in decreased elastin fibers and a thinner dermal layer (Table 3-1). With the loss of elasticity, the skin starts to become less supple. "Crow's feet," or wrinkles, develop. Skin that is very dry or that has had excessive exposure to sunlight or harsh chemicals is more likely to wrinkle at a younger age. Hair color tends to fade or "gray" because of pigment loss, and hair distribution patterns change. Color changes, and hair loss patterns tend to be hereditary. The hair on the scalp, pubis, and axilla tends to thin in both men and women. Hairs in the nose and ears often become thicker and more noticeable. Some women experience the growth of facial hair, particularly after menopause. Fingernails grow more slowly, may become thick and more brittle, and ridges or lines are commonly observed. Toenails may become so thick that they require special equipment for trimming.

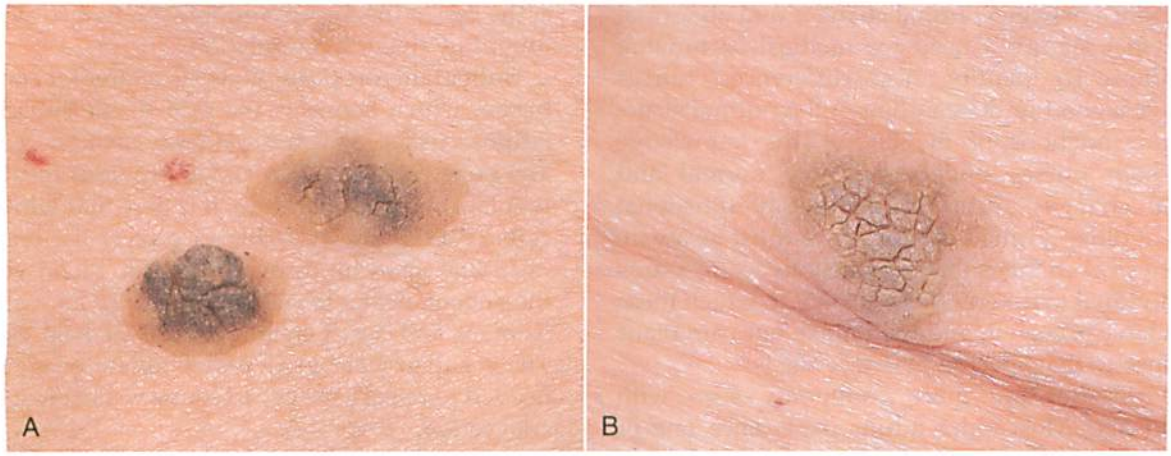

FIGURE 3-1 Seborrheic keratoses usually appear at approximately the fifth decade of life and gradually increase in number with age. These superficial, benign growths can enlarge to 20 mm in diameter and have a convoluted surface.

Table 3-1 Integumentary Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased vascularity of dermis	Increased pallor in white skin
Decreased amount of melanin	Decreased hair color (graying)
Decreased sebaceous and sweat gland function	Increased dry skin; decreased perspiration
Decreased subcutaneous fat	Increased wrinkling
Decreased thickness of epidermis	Increased susceptibility to trauma
Increased localized pigmentation	Increased incidence of brown spots (senile lentigo)
Increased capillary fragility	Increased purple patches (senile purpura)
Decreased density of hair growth	Decreased amount and thickness of hair on head and body
Decreased rate of nail growth	Increased brittleness of nails
Decreased peripheral circulation	Increased longitudinal ridges of nails; increased thickening and yellowing of nails
Increased androgen/estrogen ratio	Increased facial hair in women
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO INTEGUMENTARY CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Monitor skin temperature.	Adjust room temperature and provide adequate clothing or covers to prevent chilling.
Assess skin turgor over sternum or forehead, not forearm. Check tongue for furrows.	Provide adequate fluid to prevent dehydration.
Assess for skin breakdown or changes in color or pigmentation.	Institute measures to reduce pressure over bony prominences; possible dermatology referral.
Assess areas where skin surfaces touch and trap moisture (under breasts, adipose rolls, etc.) for signs of maceration or yeast infection.	Keep skin dry. Pad surfaces to reduce friction. Report abnormal observations for treatment.
Determine adequacy of hygiene and need for toenail trimming.	Modify skin care to reduce drying. Refer to podiatrist.

Sweat gland function decreases, and thus the amount of perspiration decreases. This results in heat intolerance because the body's cooling system through the process of evaporation is less efficient.

A decrease in the function of sebaceous and sweat gland secretion increases the likelihood of dry skin, or **xerosis** (Figure 3-2). Dry skin is probably the most common skin-related complaint among older adults, particularly when it is accompanied by itching, or **pruritus.** This problem is often more severe on the lower extremities because of diminished circulation.

The walls of the capillaries become increasingly fragile with age and may hemorrhage, leading to **senile purpura**, the red, purple, or brown areas commonly

FIGURE 3-2 Xerosis.

seen on the legs and arms. By 70 years of age, the body has approximately 30% fewer cells than at age 40. The remaining cells enlarge, so body mass appears approximately the same. Total body fluid decreases with age. Plasma and extracellular volume remain somewhat constant, but intracellular fluid decreases. This loss of intracellular fluid increases the risk for dehydration. Tissue changes include a decrease in subcutaneous tissue that is visible in the eye orbits, hollows in the supraclavicular space, and sagging of breasts and neck tissue.

COMMON DISORDERS SEEN WITH AGING

Basal Cell Carcinoma and Melanoma

It is important to distinguish normally occurring changes in the skin from lesions that may be precancerous or cancerous. Cases of basal cell **carcinoma** are commonly observed in older adults who have spent significant amounts of time in the sun. By age 70 approximately 20% of white, non-Hispanic men have developed a non-melanoma cancer. Male senior citizens are also most at risk for melanoma, a potentially deadly form of skin cancer due to its ability to metastasize. In 2009 more than 8,000 deaths were attributed to melanoma.

The unusual appearance of moles should be suspected to be melanoma. Irregular shapes, irregular borders, changes in color, changes in size or symptoms, such as itchiness or bleeding, are all considered to be abnormal. Elderly men, in particular, should be taught to self-screen for changes in the skin. Suspicious changes should be documented and reported so that it can be examined promptly by a physician. Early diagnosis and treatment is effective at prolonging life.

Pressure Ulcers

Shrinkage in the cushion provided by subcutaneous tissue along with vascular changes places the older adult at increased risk for pressure ulcers (i.e., breakdown of the skin and tissues located over bony prominences) (see Figure 3-3). This is a significant problem for immobilized people such as those who are bedridden or confined to wheelchairs. Special precautions to prevent this type of problem are discussed in Chapter 17.

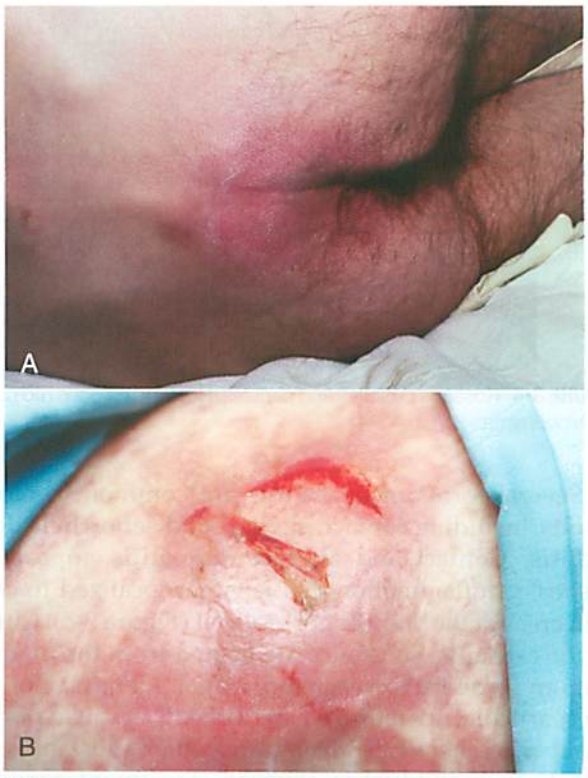

FIGURE 3-3 Pressure ulcers. A, Early-stage pressure ulcers, or stage I lesions, are commonly dismissed as minor abrasions because their primary attribute is nonblanchable erythema. B, Stage II ulcer, which is characterized by some skin loss, may be difficult to identify accurately because of its resemblance to a blister or abrasion.

Inflammation and Infection

Changes in the integumentary system increase the older adult's risk for skin inflammation and infection. Skin inflammation and infection often occur on visible surfaces of the body such as the face, scalp, and arms, making the conditions distressing to the older adult.

Common types of inflammation include rosacea and various forms of dermatitis. **Rosacea** appears as redness, dilated superficial blood vessels, and small "pimples" on the nose and center of the face (Figure 3-4). It may spread to cover the cheeks and chin. Left untreated, it can lead to swelling and the enlargement of the nose or to conjunctivitis. There is no known cause for this disorder, but it is most common in postmenopausal women, people who flush easily, and individuals taking vasodilating medications. Treatment of vasodilation includes lifestyle modification such as avoidance of triggers such as stressful situations, extreme heat, sun exposure, spicy foods, and alcoholic beverages. In addition oral and topical medications or light and laser treatments may provide some benefits.

FIGURE 3-4 Rosacea pustules and papules. Note the bulbous red nose of rhinophyma.

Several forms of dermatitis are common in older adults, including contact, allergic, and **seborrheic dermatitis**. **Contact** and **allergic dermatitis** appear as rashes or inflammation that is either localized to certain areas of the body or generalized (Figure 3-5). Clues to the causative substance are gained from the unique pattern presented on each individual. Identification of the particular irritant may be difficult because of the number of chemicals, drugs, and other substances to which an individual is exposed. Treatment consists of avoiding the offending substance.

Seborrheic dermatitis is an unsightly skin condition characterized by yellow, waxy crusts that can be either dry or moist (Figure 3-6). Caused by excessive sebum production, seborrheic dermatitis can occur on the scalp, eyebrows, eyelids, ears, axilla, breasts, groin, and gluteal folds. There is no known cure, but treatment with special shampoos and lotions helps control the problem.

Infectious diseases of the skin and nails commonly seen in older adults include herpes zoster (also called *shingles*); fungal, yeast, and bacterial infections; and infestation with scabies (mites). Each of these diseases has a unique cause, characteristic appearance, and specific treatment that are beyond the scope of this text.

FIGURE 3-5 *Rhus* dermatitis. Linear bullae are characteristic of an allergic contact dermatitis.

FIGURE 3-6 Seborrheic dermatitis is characterized by itching and patches of scales that exfoliate. The most common sites are on the scalp, behind the ears, and on the midface, including the eyebrows and lashes.

Hypothermia

The decrease in the amount of subcutaneous tissue reduces the older adult's ability to regulate body temperature. Very thin older adults lose the insulation provided by subcutaneous and adipose tissue. This loss of insulation is most likely to result in hypothermia if the person is exposed to an environment that is too cold.

THE MUSCULOSKELETAL SYSTEM

The musculoskeletal system performs many functions. The bones of the skeleton provide a rigid structure that gives the body its shape. The red bone marrow in the cavities of spongy bones produces red blood cells (RBCs), platelets, and WBCs. Structures such as the ribs and pelvis protect easily damaged internal organs. The muscles provide a power source to move the bones. The combined functions of bones and muscles allow free movement and participation in the activities necessary to maintain a normal life.

BONES

Bone consists of protein and the minerals calcium and phosphorus. Calcium is necessary for bone strength, muscle contraction, myocardial contraction, blood clotting, and neuronal activity. It is normally obtained by eating dairy products and dark-green leafy vegetables. Vitamin D is needed for the absorption of calcium and phosphate through the small intestine; vitamins A and C are needed for **ossification,** or bone matrix formation.

For the long bones to remain strong, adequate dietary intake of these nutrients is important. However, the dietary intake of minerals alone does not maintain bone strength. It is also necessary to apply stress to the long bones to keep the minerals in the bones. This needed stress is best provided by weight-bearing activities such as standing and walking. The calcium that is

needed for clotting and nerve and muscle functions is constantly being withdrawn from the bone and moved into the bloodstream to maintain consistent blood levels. Calcium is normally redeposited in the bone at an equal rate, replacing the calcium that is lost. As long as this movement of calcium is in balance, the bone remains strong.

Hormones also play an important role in bone maintenance. **Calcitonin,** which is produced by the thyroid gland, slows the movement of calcium from the bones to the blood and lowers the blood calcium level. Parathyroid hormone (PTH) increases the movement of calcium from the bones to the blood and increases the blood calcium level. PTH also increases the absorption of calcium from the small intestine and kidneys, thus further increasing the blood calcium level. Insulin and thyroxine aid in the protein synthesis and energy production needed for bone maintenance. Estrogen and testosterone, produced by the ovaries and testes, respectively, help retain calcium in the bone matrix.

VERTEBRAE

The spinal column consists of a series of small bones, called **vertebrae,** that stack up to form a strong, flexible structure. The spinal column supports the head and allows for flexible movement of the back. The segments of the spinal column consist of cervical, thoracic, lumbar, and sacral vertebrae. The muscles that move the back connect at bony processes that protrude from each vertebra. The **spinal cord,** the nerve tissue that extends downward from the brain, passes through the **vertebral canal,** which runs through an opening in each vertebra. The bones of the spinal column protect this nerve tissue from injury.

Fibrous pads, called **intervertebral disks,** are located between the vertebrae and cushion the impact of walking and other activities.

JOINTS

Joints are the places where bones meet. The freely moving synovial joints are lined with **cartilage,** which allows free movement of the joint surfaces. Many of these joints contain a **bursa,** which is a fluid sac that provides lubrication to enhance joint mobility (Figure 3-7).

TENDONS AND LIGAMENTS

Tendons are structures that connect the muscles to the bone, and **ligaments** are structures that connect bones to other bones.

MUSCLES

There are three types of muscle tissue in the body: cardiac muscle, smooth muscle, and skeletal muscle. **Cardiac muscle,** located in the heart only, is responsible for the pumping action of the heart that maintains the blood circulation. **Smooth muscle** is found in the walls of hollow organs such as the blood vessels, stomach, intestines, and urinary bladder. Because cardiac and smooth muscle normally cannot be stimulated by conscious effort, they are called **involuntary muscles.**

Skeletal muscle accounts for the largest amount of muscle tissue in the body. The major function of skeletal muscle is to move the bones of the skeleton.

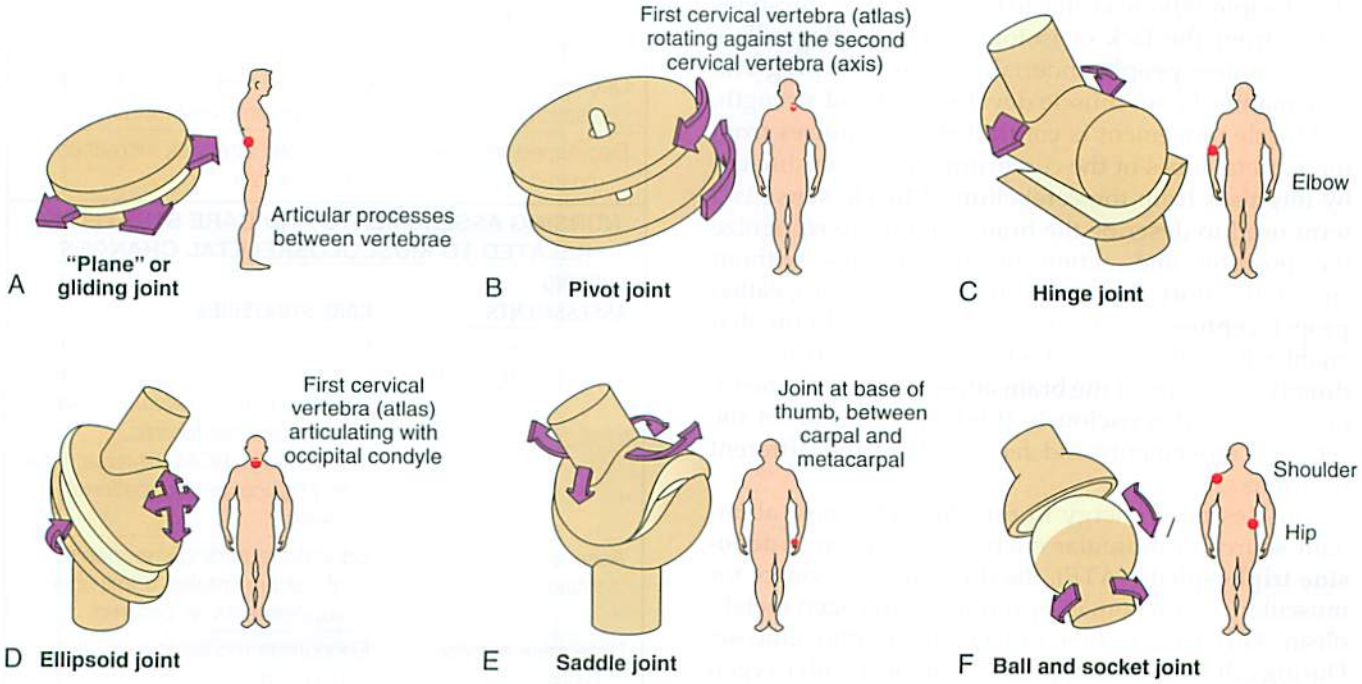

FIGURE 3-7 Types of synovial joints. **A,** Plane, or gliding joint. **B,** Pivot joint. **C,** Hinge joint. **D,** Ellipsoid joint. **E,** Saddle joint. **F,** Ball and socket joint.

Because their actions can be controlled by conscious effort, skeletal muscles are considered **voluntary muscles.** Muscles are connected to bones by tendons. Contraction or relaxation of muscles causes the bones to move. Controlled and coordinated movement of bones and muscles allows us to perform the variety of movements required for activities of daily living. Special effort and practice allow us to perform special activities such as dancing, playing sports, and playing the piano.

The amount of muscle mass and the type of muscle development differ greatly among individuals. Men normally have larger muscles, or more muscle mass, than do women, particularly in the muscles of the upper body. The male hormone testosterone stimulates muscle development. In both men and women, the largest and strongest skeletal muscles are found in the legs and upper arms; the smallest and weakest are located in the lower back.

Muscle tissue is normally in a state of slight contraction. This muscle tone is necessary to support the head, to keep the spine erect, and to perform any controlled movement. Muscle mass is built and muscle tone is maintained by means of exercise. There are two general types of exercise: **isometric exercise,** which involves muscle contraction without body movement, and **isotonic exercise,** which involves muscle contraction with body movement. Isometric exercise helps maintain muscle tone and strength but does little to increase muscle size. Isotonic exercise maintains muscle tone and strength and increases muscle mass if it is done repetitively. **Aerobic exercise** is isotonic exercise that occurs for 30 minutes or longer. Aerobic exercise strengthens the skeletal, cardiac, and respiratory muscles. People who lead inactive or sedentary lifestyles suffer from the lack of isotonic exercise. Regardless of age, unless people undertake an exercise program, they manifest poor muscle development and strength.

Muscle movement is controlled by impulses from the parietal lobes of the cerebrum and is coordinated by impulses from the cerebellum. **Muscle sense** is a term used to describe the brain's ability to recognize the position and action of the muscles without conscious effort. Receptor cells in the muscles, called **proprioceptors,** send information to the brain that enables it to integrate all body movements. This coordinative function of the brain allows us to walk, bend, or eat without consciously thinking about all of the separate movements and feeling all of the different positions.

Muscles need energy to function. The most abundant source of muscular energy is glycogen. **Adenosine triphosphate** (ATP), the direct energy source for muscular contraction, is a product of glycogen metabolism. Glycogen is first broken down into glucose. During cell metabolism, glucose interacts with oxygen transported in the bloodstream by hemoglobin or oxygen stored in the muscle fibers as myoglobin. This reaction involves the production of ATP, heat, water, and carbon dioxide. If muscle fibers do not receive enough oxygen, glucose may not be oxidized completely, and a chemical intermediate, **lactic acid,** is produced. Elevated levels of lactic acid may result in muscle fatigue and soreness.

EXPECTED AGE-RELATED CHANGES

The major bone-associated change related to aging is the loss of calcium (Table 3-2). This change begins between 30 and 40 years of age. With each successive decade, the skeletal bones become thinner and relatively weaker. Women lose approximately 8% of skeletal mass each decade, whereas men lose approximately 3%. Decalcification of various parts of the skeleton, including the epiphyses, vertebrae, and jaw bones, can result in increased risk for fracture, loss of height, and loss of teeth.

The intervertebral disks shrink as the thoracic vertebrae slowly change with aging. This results in a condition called **kyphosis,** which gives the older adult a stooped or hunchback appearance, with the head dropping forward toward the chest. The combination

Table 3-2 Musculoskeletal Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased bone calcium	Increased osteoporosis; increased curvature of the spine (kyphosis)
Decreased fluid in intervertebral disks	Decreased height
Decreased blood supply to muscles	Decreased muscle strength
Decreased tissue elasticity	Decreased mobility and flexibility of ligaments and tendons
Decreased muscle mass	Decreased strength; increased risk for falls
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO MUSCULOSKELETAL CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess strength and functional mobility.	Provide assistance as needed, modify physical environment, initiate safety precautions to decrease risk for falls, encourage ROM exercise, refer to physical or occupational therapy.
Assess nutritional intake.	Educate regarding importance of calcium intake, administer supplements as ordered.
Determine activity patterns.	Encourage regular low-impact exercise.

of disk shrinkage and kyphosis results in loss of overall height. A person can lose as much as 2 inches of height by age 70. People who are concerned about their appearance find these changes disturbing because clothing no longer fits properly, and it is increasingly difficult to find flattering styles.

Connective tissues tend to lose elasticity, leading to restriction of joint mobility. Loss of flexibility and joint mobility begins as early as the teen years and is common with aging. Regular stretching exercises can help slow or even reverse flexibility problems.

Muscle tone and mass typically decrease with aging, and these decreases are directly related to decreased physical activity and exercise. People of all ages who exercise regularly have better muscle mass and tone. Hormonal changes, particularly the decrease in testosterone level, tend to reduce muscle mass in aging men. Reduction in blood supply to the muscles as a result of aging or disease can lead to changes in muscle function. Less glycogen is stored in aging muscles, thereby decreasing the fuel available for muscle contraction. Any condition that restricts oxygen availability (e.g., anemia and respiratory problems) can lead to an excessive production of waste products such as lactic acid and carbon dioxide. This can increase the incidence of muscle spasms and muscle fatigue with minimal exertion. Decreased endurance and agility may result from a combination of these factors. Neuronal changes in the areas of the brain responsible for muscle control can result in alterations of muscle sense, which may be observed in older adults as an unsteady gait and impairment of other activities that require muscular coordination.

As a person ages, muscle mass decreases, and the proportion of body weight resulting from fatty, or **adipose,** tissue increases. This is significant in the administration of medications. Intramuscular injection sites may not be as well muscled, and fatty tissue tends to retain medication differently than does lean tissue. Absorption and metabolism of drugs can be significantly different from those in younger persons.

COMMON DISORDERS SEEN WITH AGING

Osteoporosis

Excessive loss of calcium from bone combined with insufficient replacement results in osteoporosis. Currently, 55% or more of Americans over age 50 have decreased bone density, and more than 10 million have osteoporosis. This disorder is projected to become even more common as the population ages. **Osteoporosis** is characterized by porous, brittle, fragile bones that are susceptible to breakage. Spontaneous fracture of the vertebrae or other bones can occur in the absence of obvious trauma. In fact, spontaneous hip fractures may lead to a fall, rather than the fall leading to the hip fracture. Simple falls or other traumas are more likely to result in fractures in people who have osteoporosis. Common fracture sites include the hip (usually the neck of the femur), ribs, clavicle, and arm (when trying to break a fall). Factors that increase the risk for osteoporosis include the following:

- Female gender
- Caucasian or Asian race
- Small body frame
- Family history of osteoporosis
- Poor nutrition (diet low in calcium and vitamin D)
- Malabsorption disorders such as celiac disease
- Menopause (low estrogen levels)
- Chemotherapy
- Lack of exercise/immobility
- Excessive alcohol consumption
- Cigarette smoking
- Hormonal imbalances (hyperthyroidism and hyperparathyroidism)
- Long-term use of medications, including phenytoin (Dilantin), heparin, and oral corticosteroids

Osteoporosis is best prevented and treated by lifestyle modifications and medications. Lifestyle modifications include a well-balanced diet with adequate amounts of calcium and vitamin D, regular exercise, smoking cessation, and restriction of alcohol intake. Calcium and vitamin D supplements are commonly necessary for individuals who do not consume adequate amounts of these nutrients. Medications that increase bone strength and density are often prescribed. These include alendronate (Fosamax), risedronate (Actonel), ibandronate (Boniva), raloxifene (Evista), and calcitonin (Calcimar). Hormone replacement therapy (HRT) has beneficial effects on bone density but also brings increased risk for heart attack, blood clots, stroke, and breast cancer. Use of hormonal therapy is controversial and requires a candid risk/benefit analysis between the patient and physician.

Degenerative Joint Disease

Osteoarthritis. The incidence of **osteoarthritis,** the most common form of arthritis, increases with age. Osteoarthritis is estimated to affect 43 million adults in the United States and to cost $86 billion annually in treatment costs. By age 70, as many as 70% of adults will experience some degree of disability or discomfort from this disorder. Although common with aging, osteoarthritis is not a normal part of aging. It affects men and women equally, although men are usually affected at a younger age. The cause of osteoarthritis is unknown; however, chemical, nutritional, genetic, hormonal, and mechanical factors are believed to play a role. People employed in jobs that involve placing a high amount of physical stress on certain joints are likely to experience changes in those joints later in life. After years of normal joint use, the cartilage on the bones' articulating surfaces thins and begins to wear out. Bony particles or spurs (osteophytes) may form

within the joint, causing pain, swelling, and restriction of movement in affected joints. **Heberden's nodes,** which are caused by abnormal cartilage or bony enlargement, may be seen in the distal joints of the fingers. Pain may occur with activity or exercise of the affected joints and may worsen with emotional stress. Synovial membrane of the bursa may become damaged or inflamed. This is particularly true in the weight-bearing joints of the spine, hips, knees, and ankles. Obesity increases the stress on joints and can aggravate symptoms.

Osteoarthritis is treated by administering nonsteroidal antiinflammatory drugs (NSAIDs), by injecting corticosteroids into the joints, by rest and heat, and by an individualized exercise program. Dietary supplements, including glucosamine, chondroitin sulfate, and various vitamins, have shown benefits for some individuals and are being studied for safety and effectiveness. Intraarticular injection of hyaluronic acid, a joint lubricant, has received mixed reviews. In severe cases, arthroscopic removal of bone fragments or surgical joint replacements may be necessary.

Rheumatoid Arthritis. **Rheumatoid arthritis** is a collagen disease that results from an autoimmune process. This disease causes inflammation of the synovium, damage to the cartilage and bone of joints, and instability of ligaments and tendons that support the joints. The onset is typically earlier in life, occurring at between 30 and 50 years of age, although a significant number of individuals first develop the disease after age 60. This form of arthritis is seen more commonly in women. Rheumatoid arthritis is characterized by periods of exacerbation (sometimes called *flares*), during which the symptoms are severe and cause further damage, and **remission,** during which the progress of the disease halts. Rheumatoid arthritis can also result in muscle atrophy, soft tissue changes, and bone and cartilage changes. Symptoms of rheumatoid arthritis include the following:

- Pain and stiffness, particularly in the morning or after a period of rest
- Warm, tender, painful joints
- Fatigue
- Sense of feeling unwell
- Occasional fevers

The most serious deformities and problems are typically observed when an individual has suffered from this disease for an extended period. Affected individuals are best treated by a **rheumatologist,** a physician who specializes in the disorder.

Treatments for rheumatoid arthritis include lifestyle changes such as stress reduction, balanced rest and exercise, and joint care using splints to support joints. A wide variety of classifications of medications are used to treat this condition, including the following:

- NSAIDs—such as aspirin, acetaminophen, ibuprofen, naproxen
- Corticosteroids—such as methylprednisone
- Disease-modifying antirheumatic drugs (DMARDs)—such as cyclosporine, azathioprine, sulfasalazine, methotrexate
- Tumor necrosis factor inhibitors—such as etanercept, infliximab
- Interleukin-1 inhibitor—such as anakinra

Surgical interventions, including synovectomy, tendon reconstruction, and joint replacement, may be performed to reduce pain, to improve joint function, and to allow the individual to maintain the highest possible level of independent function.

Bursitis. **Bursitis,** inflammation of the bursa and the surrounding fibrous tissue, can result from excessive stress on a joint or from a localized infection. Bursitis commonly results in joint stiffness and pain in the shoulder, knee, and elbow, ultimately leading to restricted or reduced mobility. Although this problem can occur at any age, age-related changes in the musculoskeletal system make it a more common problem in older individuals. Treatment includes resting the joint and administering NSAIDs. Corticosteroid preparations are occasionally injected into the painful areas to reduce inflammation. Mild range-of-motion exercise is encouraged to prevent permanent reduction or the loss of joint function.

Gouty Arthritis. Gouty arthritis is caused by an inborn error of metabolism that results in elevated levels of uric acid in the body. Crystals of these acids deposit within the joints and other tissues, causing episodes of severe, painful joint swelling. Some joints, such as those of the great toe, are more commonly affected. Chills and fever may accompany a severe attack. Attacks of gout become more frequent as a person ages. If left untreated, this disease can result in the destruction of the joints. It is observed more often in men but is also common in women after menopause. Weight reduction and decreased intake of alcohol and foods rich in purines, such as liver or dried beans or peas, are often recommended.

THE RESPIRATORY SYSTEM

The respiratory system provides the body with the oxygen needed for life. Without oxygen, cells quickly die. The brain cells are the most sensitive cells in the body; they will die if deprived of oxygen for as little as 4 minutes. Breathing, the process of inhaling to take in oxygen and exhaling to release carbon dioxide, occurs at a rate of 12 to 20 times per minute for our entire lives. The respiratory system is typically divided into two parts: the upper respiratory tract and the lower

respiratory tract. The entire respiratory tract is lined with mucous membranes.

UPPER RESPIRATORY TRACT

On its way to the lungs, air passes through the **upper respiratory tract,** which includes the air passages of the nose, mouth, and throat, all of which are located above the chest cavity. Mucous membranes line the nasal passages and warm and humidify the air that passes through the nose. Cilia and mucus in the nasal passages trap particulate matter (bacteria and debris) and sweep it toward the pharynx, where it is routinely swallowed and destroyed by gastric acid. The cough and sneeze reflexes also help prevent debris and foreign objects from entering the respiratory tract. The **pharynx,** which is located at the back of the oral cavity, has three segments: the oropharynx, nasopharynx, and **laryngopharynx.**

The nasopharynx is connected to the middle ear by the **eustachian tubes,** which help maintain proper air pressure in the middle ear. The **larynx,** or voice box, is composed of cartilage rings and folds of tissue, called **vocal folds.** The **epiglottis,** which is the uppermost cartilage ring, prevents food from entering the airway. During inhalation, the vocal folds move to the sides of the larynx to allow air to pass freely. During exhalation, we can speak and sing by controlling the distance between these folds, which vibrate when air is forced through them and produce sound.

LOWER RESPIRATORY TRACT

The **lower respiratory tract** includes the lower trachea, bronchial passages, and alveoli, all of which lie within the chest cavity. The **trachea** is a cartilaginous passageway that connects the larynx to the bronchial passages of the lungs. The trachea branches into two major **bronchi,** which further divide like the branches of a tree into smaller and smaller **bronchioles.** At the ends of the bronchioles are the **alveoli,** or air sacs, which are the functional units of respiration. A thin layer of fluid lines each tiny air sac, which is surrounded by pulmonary capillaries to allow the efficient exchange of gases by diffusion. It is here that oxygen enters the bloodstream for transport to body tissue, and it is here that carbon dioxide from the body leaves the bloodstream. This gaseous exchange is essential for normal cell function and for the maintenance of the blood's acid-base balance.

Because the alveoli have a moist lining, their surfaces could adhere if they touched when the alveoli were empty. This is prevented by a special protein substance called **surfactant.**

AIR EXCHANGE (RESPIRATION)

The movement of air into and out of the alveoli is called **ventilation.** Ventilation requires the action of muscles, primarily the **diaphragm** and the **intercostal muscles.** During inhalation, the diaphragm contracts and moves downward while the intercostal muscles pull the ribs upward and outward. These combined activities increase the size of the chest cavity until the air pressure inside the lungs is lower than the atmospheric pressure and air is drawn into the lungs. This process is known as **inhalation** or **inspiration.** When the air pressure inside the lungs equals or exceeds atmospheric pressure, air ceases to enter the lungs. When the diaphragm and intercostal muscles relax, the diaphragm moves upward and the ribs move inward, making the chest cavity smaller. As the chest cavity becomes smaller, the pressure in the lungs becomes greater than the atmospheric pressure. Air is forced out of the lungs until the pressure in the lungs equals the atmospheric pressure. This action is known as **exhalation** or **expiration.** Regulation of respiration is both neurologic and chemical. The respiratory centers in the medulla and pons of the brainstem continuously monitor and control the rate and depth of involuntary respiration. Most breathing is unconscious and involuntary. If we had to think about inhaling and exhaling every breath, we would have little time to do anything else. However, breathing can be conscious and voluntary. When swimming, singing, or engaging in other activities that require breath control, we can temporarily alter our breathing patterns.

EXPECTED AGE-RELATED CHANGES

With aging, changes are seen throughout the respiratory tract (Table 3-3; Box 3-1). Years of exposure to air pollution, cigarette smoke, and other hazardous chemicals may take their toll on the air passageways and lung tissue. Decrease in elastic recoil of the lungs leads to diminished air exchange. Mucous membranes in the nose become drier as the fluid content of body tissue decreases; thus, the incoming air is not humidified as effectively. The number of cilia decreases, diminishing the ability of the cilia to trap and remove debris. Decreased vocal cord elasticity leads to changes in voice pitch and quality, and the voice develops a more tremulous character.

Musculoskeletal system changes that occur with aging alter the size and shape of the chest cavity. Kyphosis contributes to a barrel-chested appearance. Costal cartilage located at the ends of the ribs calcifies and becomes more rigid, thus reducing the mobility of the rib cage. Intercostal muscles atrophy, and the diaphragm flattens and becomes less elastic. All of these changes reduce lung capacity and interfere with respiratory function, resulting in a decreased ability to inhale and exhale deeply.

Several factors increase the possibility of inadequate oxygenation and the risk for respiratory tract infections in older adults. The cilia movement inside the lungs decreases. The airways and alveoli are less elastic, and there is a decrease in the number of

Table 3-3 Respiratory Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased body fluids	Decreased ability to humidify air resulting in drier mucous membranes
Decreased number of cilia	Decreased ability to trap debris
Decreased number of macrophages	Increased risk for respiratory infection
Decreased tissue elasticity in the alveoli and lower lung lobes	Decreased gas exchange; increased pooling of secretions
Decreased muscle strength and endurance	Decreased ability to breath deeply; diminished strength of cough
Decreased number of capillaries	Decreased gas exchange
Increased calcification of cartilage	Increased rigidity of rib cage; decreased lung capacity
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO RESPIRATORY CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess breathing depth and effort.	Position to facilitate ease of respiration. Encourage incentive spirometry or nebulizer as ordered.
Assess cough and sputum production.	Encourage adequate fluid intake. Encourage smoking cessation and avoidance of environmental pollutants.
Assess for signs and symptoms of respiratory infection.	Teach avoidance of individuals with active infection. Teach careful handwashing and disposal of contaminated secretions. Encourage annual influenza vaccination.

Box 3-1 Pulmonary Function Changes Commonly Observed With Aging

- Diminished breath sounds
- Lower maximum expiratory volume
- Increased residual volume
- Reduced vital capacity

capillaries surrounding the alveoli, which interferes with gas exchange. The lung tissue itself has decreased physical mobility and elasticity, with can lead to increased pooling of secretions, especially in the lower lobes.

COMMON DISORDERS SEEN WITH AGING

Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is not a single disease but a group of three commonly occurring respiratory disorders: asthma, emphysema, and chronic bronchitis. Although they may appear independently, these disorders usually occur in a combination. COPD is common in people who have a history of smoking or who have had a high level of exposure to environmental pollutants. In **asthma,** the trachea and bronchioles are extremely sensitive to a variety of physical stimuli and emotional stress that then cause constriction of the bronchial passages and increase mucus production within the airways. This narrows the airways and restricts airflow. Elderly individuals may be less aware of bronchospasms and therefore be slower to seek emergency care. This can result in poor outcomes. **Emphysema** is characterized by changes in the structure of the alveoli. The air sacs lose elasticity, become overinflated, and are ineffective in gas exchange. **Chronic bronchitis** involves inflammation of the trachea and bronchioles. Chronic irritation leads to excessive mucus secretion and a productive cough.

Individuals with COPD manifest symptoms such as productive cough, wheezing, cyanosis, and dyspnea on exertion. They are at higher risk for developing respiratory tract infections; in severe cases, respiratory failure can occur.

Influenza

Influenza, often referred to as the *flu*, is a highly contagious respiratory infection caused by a variety of influenza viruses. Many different strains of influenza have been identified, and new forms are being identified continually. The various forms of influenza, such as the Hong Kong or Beijing flu, are often named for the area where they are first recognized. Epidemics occur at regular intervals and are seen most often in the winter months. The virus is usually spread through airborne droplets and moves quickly through groups of people who live or work in close contact with one another. The incubation period is brief, often only 1 to 3 days from the time of exposure. The onset of symptoms is sudden; symptoms include chills, fever, cough, sore throat, and general malaise and may be dramatic and leave the victim feeling severely ill.

Older adults are at higher risk for serious complications of influenza than are younger people. More than 90% of deaths resulting from influenza occur in the older-than-65 population. Influenza presents a special danger for older adults with a history of respiratory disease or other debilitating conditions. Yearly flu shots are recommended for all persons older than 65 years of age to reduce the chance of contracting the

most common forms of influenza. Immunizations should be given in the fall so that the level of immunity is high before the risk for exposure occurs. Immunization should be obtained every year because the vaccine is different from the previous year. Each year the vaccine is customized to protect against the particular strain of the virus that is anticipated to be prevalent in the country.

Some people refuse or are hesitant to take the vaccine because of the mild symptoms that may be experienced after inoculation. It is important to explain to older adults that these symptoms are mild and will protect them from more severe problems later. Individuals who are allergic to eggs should not receive the vaccine. Influenza vaccine is cultured in egg protein and can cause a serious allergic reaction in allergic individuals. Given properly, these vaccines are 70% to 80% effective in preventing illness.

Pneumonia

Pneumonia is acute inflammation of the lungs caused by bacterial, viral, fungal, chemical, or mechanical agents. In response to the agent, the alveoli and bronchioles become clogged with a thick, fibrous substance that decreases the ability of the lung to exchange gases. Pneumonia can progress to a state in which the exudate fills the lung lobes, which then become consolidated or firm. Pneumonia can be detected by radiologic examination. Breath sounds exhibit characteristic changes.

The symptoms of pneumonia differ with the causative organism. Viral pneumonia, sometimes called *walking pneumonia*, is most commonly seen following influenza or another viral disease. Symptoms include headache, fever, aching muscles, and cough with mucopurulent sputum. Treatment for viral pneumonia varies according to the symptoms.

Bacterial pneumonia can be caused by a number of organisms, most commonly *Staphylococcus*, *Streptococcus*, *Klebsiella*, and *Legionella*. The symptoms of bacterial pneumonia are abrupt and dramatic in onset. Chills, fever up to 105° F, tachycardia, and tachypnea are common, as is pain with respiration, or dyspnea. The associated cough may be dry and unproductive or purulent and productive. The color of the sputum is significant and should be observed carefully. The type of microorganism involved can be determined by Gram stain and sputum culture. Bacterial pneumonia is treated with bacteria-specific antibiotics and supportive medical and nursing care.

Aspiration pneumonia is an inflammatory process of the bronchi and lungs caused by inhalation of foreign substances such as food or acidic gastric contents. The risk for aspiration is highest in older adults with a poor gag reflex and in those who must remain supine, because these individuals can easily inhale or regurgitate food during oral or tube feeding. Aspiration of highly acidic gastric secretions can lead to cell membrane damage with exudation and, ultimately, to respiratory distress. Aspiration of large amounts of feeding solution is likely to trigger coughing or choking episodes and dyspnea. If these fluids are not removed immediately by suction, respiratory distress and death may result. Aspiration of small amounts of liquid can result in continued and progressive inflammation of the lungs. The person suffering from aspiration pneumonia typically has a rapid pulse and respiratory rate. Sputum is frothy but free of bacteria; however, a superimposed bacterial infection may develop.

Tuberculosis

Tuberculosis is an infectious disease caused by the bacillus *Mycobacterium tuberculosis*, which spreads by means of airborne droplets. When an infected person coughs or sneezes, contaminated droplets are released into the air. These droplets are inhaled by other people, the bacillus lodges in their lungs, and the disease spreads. Malnutrition, weakening of the immune system, crowded living conditions, poor sanitation, and the presence of systemic diseases such as diabetes and cancer increase the older adult's risk for contracting tuberculosis.

The symptoms of tuberculosis include cough, night sweats, fever, dyspnea, chest pain, anorexia, and weight loss. The cough may be nonproductive or productive. Sputum may be green or yellow; with hemoptysis, the presence of blood may impart a rusty color.

Because skin tests for tuberculosis are not reliable in older adults, diagnosis is based on chest radiography or sputum cultures of acid-fast bacilli. Early detection is important to prevent further spread of the disease.

Treatment today consists of drug therapy using a variety of antimicrobial agents such as isoniazid, rifampin, ethambutol, and streptomycin. A combination of these drugs is usually administered and continued for many months. Many of these drugs are associated with numerous adverse effects, particularly in older adults. Nursing care of the older adult with tuberculosis focuses on maintaining good nutrition, monitoring compliance with the medication administration schedule, and detecting side effects.

Lung Cancer

Lung cancer, or bronchogenic cancer, is one of the most deadly forms of cancer in the United States. The age range at which diagnosis of lung cancer peaks is 55 to 65 years. Although lung cancer is more common in men, it has become increasingly common in women and has recently passed breast cancer as a leading cause of death. The survival rate after diagnosis of lung cancer is poor, rarely exceeding 5 years.

Lung cancer results from exposure to **carcinogenic,** or cancer-causing, agents, particularly tobacco smoke, air pollution, asbestos, and other hazardous industrial substances. Cough, chest pain, and blood-tinged sputum are typical symptoms, which can easily be missed because they resemble those of pneumonia and other common respiratory conditions of older adults.

The treatment of choice is surgical resection of the lungs. This procedure is associated with a high mortality rate in older adults. Radiation and chemotherapy are used in some patients, with varying amounts of success.

THE CARDIOVASCULAR SYSTEM

The cardiovascular system moves blood throughout the body. This continuous, closed system is responsible for the transportation of blood with oxygen and nutrients to all body tissue. It also transports waste products to the organs that remove them from the body. Through its action, the cardiovascular system helps maintain homeostasis within the body. The heart pumps the blood, and the blood vessels dilate or constrict to aid in the maintenance of blood pressure and exchange of materials between the blood and body tissue.

HEART

The heart is a muscular organ located centrally in the thoracic cavity between the lungs. The **sternum,** or breastbone, protects its anterior surface. The heart's tip, or **apex,** projects toward the left side of the body and extends directly above the diaphragm muscle.

Three **pericardial membranes** form a sac around the heart. The innermost membrane is on the surface of the heart and is called the **epicardium,** or **visceral pericardium.** The middle membrane is the **parietal pericardium,** and the outermost membrane is the **fibrous pericardium.** The space between the epicardium and the parietal pericardium is the **pericardial cavity;** it contains a small amount of **serous fluid** that prevents the membrane surfaces from rubbing together during cardiac activity.

The heart, which is composed of cardiac muscle (called **myocardium**), is a hollow organ with four distinct chambers. The right side of the heart consists of the **right atrium** and **right ventricle,** which are separated by the **tricuspid valve.** The right side of the heart is a low-pressure pump that moves deoxygenated blood through the pulmonary valve and pulmonary artery and out to the lungs. After the blood is oxygenated, it returns to the left side of the heart through the **pulmonary vein.** Because less effort is required to move blood the short distance through the lungs of a healthy individual, the muscle wall of the right side of the heart is relatively thin. The left side of the heart also has two chambers, the **left atrium** and **left ventricle,** which are separated by the **mitral valve.** The pressure within the left side of the heart is higher than that in the right side because the left side is responsible for blood distribution to the entire body. To provide the necessary force, the left ventricle has a thicker muscle wall than does the right ventricle. When blood leaves the left ventricle, it proceeds through the aortic valve into the **aorta** and its branches and out to the rest of the body.

The heart chambers and valves are lined with **endocardial** tissue. **Endothelial** tissue continues out from the heart and lines all of the blood vessels. This smooth layer allows the blood to flow freely and reduces the risk for clot formation.

BLOOD VESSELS

The **arteries** are blood vessels that carry blood away from the heart. With the exception of the pulmonary artery, arteries carry oxygenated blood. The aorta, the largest artery in the body, leaves the heart and branches into a series of progressively smaller arteries and capillaries. These vessels run through the entire body and reach all organs and tissues.

Arterial walls are composed of three layers of tissue. The innermost layer is the **endothelium,** or **tunica intima.** This layer is a continuation of the endocardial tissue that lines the inside of the heart. The middle layer, or **tunica media,** is composed of smooth muscle and connective tissue. This smooth muscle is controlled by the autonomic nervous system and dilates or constricts the artery to maintain the blood pressure. The outermost layer, or **tunica externa,** is composed of strong fibrous tissue that protects the vessels from bursting or rupturing under high pressure. The relative thickness of the tunica media and externa enables the arteries to perform properly.

The **veins** are vessels that carry blood toward the heart. With the exception of the **pulmonary vein,** veins carry deoxygenated blood. **Venules,** the smallest veins, are connected to the smallest capillaries. Veins and venules are composed of the same three layers of tissue seen in arteries. The veins use a system of **valves,** which are created by endothelial tissue folds, to aid in the return of blood to the heart. The valves prevent backflow of blood, which could be a problem when the blood is moving toward the heart against the force of gravity.

The smooth muscle layer of the veins is much thinner than that of the arteries because the veins are not as important in the regulation of blood pressure. The outer fibrous layer is also thinner because blood pressure in the veins is much lower than that in the arteries.

A special set of blood vessels, the **coronary arteries** and **veins,** supplies the heart with blood enriched with oxygen and nutrients. These arteries are the first branches of the ascending aorta. Because the heart muscle works continuously, it has high oxygen demands. Any condition that obstructs the normal supply of blood to the heart can damage the myocardium. If it is severely deprived of oxygen and nutrients, the heart muscle will die. Too much damaged or destroyed tissue results in cardiovascular system failure and death.

CONDUCTION SYSTEM

To function effectively, the cardiovascular system must work in a controlled, organized, and rhythmic manner. The heart's rhythm is established by specialized cells within the heart muscle that make up the electrical system of the heart. The body's natural pacemaker, the **sinoatrial node,** is a group of specialized cells in the right atrium. Impulses generated in the sinoatrial node travel across the atria to the **atrioventricular node** in the lower interatrial septum. From there they are conducted through the bundle of His, through the right and left bundle branches, through the Purkinje fibers, and, finally, to the ventricular myocardium. When the cells of the heart's electrical system **depolarize,** the myocardium depolarizes and the heart contracts (systole), following which the special cells and the myocardium repolarize as the heart relaxes (diastole). This process alternately empties and fills the chambers, which pump blood through the circulatory system.

EXPECTED AGE-RELATED CHANGES

The heart does not atrophy with aging as other muscles do. In fact, the heart muscle mass increases *slightly* with age, and the thickness of the wall of the left ventricle also increases slightly. The increase in muscle mass may occur to offset some loss of tone. The aging heart may function less effectively even when no pathologic changes are present (Table 3-4). Loss of tone typically leads to the decrease in maximal cardiac output seen in older adults. The normal conduction system, SA node, AV node, the bundle of His, and its branches all lose cells starting fairly early in life (in the twenties). Cardiac response to autonomic stimulation shows decreased response to adrenergic stimulation due to changes in the receptors. Older persons enhance cardiac output by increasing stroke volume, whereas younger persons increase output by increasing heart rate.

The heart valves show some degree of thickening and increased calcification with aging, resulting in mild degrees of mitral valve regurgitation. As in other body tissues, the endocardium and endothelium lose elasticity with aging. When these tissues become increasingly fibrous and sclerotic, venous return from the peripheral areas of the body decreases. **Orthostatic hypotension** occurs because the circulation does not respond quickly to postural changes. Less effective pumping of the heart muscle combined with sclerotic changes in the veins can lead to **dependent edema** and to the appearance of **varicosities** in the lower extremities. Weakness of the valves in the rectal veins can lead to hemorrhoids.

Table 3-4 Cardiovascular Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased cardiac muscle tone	Decreased tissue oxygenation related to decreased cardiac output and reserve
Increased heart size, left ventricular enlargement	Compensation for decreased muscle tone
Decreased cardiac output	Increased chance of heart failure; decreased peripheral circulation
Decreased elasticity of heart muscle and blood vessels	Decreased venous return; increased dependent edema; increased incidence of orthostatic hypotension; increased varicosities and hemorrhoids
Decreased pacemaker cells	Heart rate 40–100 beats per minute; increased incidence of ectopic or premature beats; increased risk for conduction abnormalities
Decreased baroreceptor sensitivity	Decreased adaptation to changes in blood pressure
Increased incidence of valvular sclerosis	Increased risk for heart murmurs
Increased atherosclerosis	Increased blood pressure, weaker peripheral pulses
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO CARDIOVASCULAR CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess apical and peripheral pulses.	Observe closely for abnormal sounds; determine presence and strength of peripheral pulses comparing both sides of the body. When assessing lower extremities, start distally and move toward trunk.
Assess blood pressure lying, sitting, and standing.	Hypotension is likely to occur while changing position; encourage patient to change positions slowly and to seek assistance if dizzy.
Assess ability to tolerate activity.	Instruct patient to rest if short of breath or fatigued.

COMMON DISORDERS SEEN WITH AGING

Cardiovascular disease is the leading cause of morbidity and mortality in the United States, accounting for more than 75% of all deaths in men and women older than 65 years of age.

Coronary Artery Disease

Some degree of coronary artery disease is present in most persons older than age 70. The coronary arteries supply blood to the heart. If these vessels become narrowed or obstructed because of atherosclerosis, the heart may not receive adequate oxygen and nutrients. Many older adults have seriously obstructed coronary arteries, yet they remain essentially asymptomatic. Once circulation to the heart muscle decreases significantly, the amount of oxygen delivered to the heart decreases and ischemia occurs. The pain that may be experienced with ischemia is referred to as **angina pectoris** (literally, chest pain). Although the symptoms of ischemia do include chest pain or pain radiating down the left arm, such pain is not always present or recognized in older adults. Vague gastrointestinal (GI) discomfort or shortness of breath may be reported, or there may be no symptoms at all. People experiencing an angina attack are advised to decrease their activity and rest until the episode passes. Physicians usually prescribe coronary vasodilators, such as nitroglycerin, or β-adrenergic blocking agents for people with **ischemic** heart disease.

When one or more coronary arteries become totally obstructed by atherosclerosis or embolus, the person is said to have a **myocardial infarction** (MI), or heart attack. The mortality rate from MI is four times higher in those older than 70 years of age than in younger individuals. Symptoms of a heart attack in older adults are more variable than in younger people. Most older adults are likely to have symptoms such as sudden-onset dyspnea or chest discomfort, confusion, syncope, and decreased urine production. Diaphoresis is uncommon. Many older adults who have heart attacks die suddenly (Box 3-2).

If severe atherosclerotic occlusion of the coronary arteries is detected before MI, angioplasty, stent placement, or coronary bypass surgery may be performed. The age and overall health of the individual are considered before any of these surgical procedures are attempted. MI caused by an embolus that is detected quickly can be treated using thrombolytic agents such as streptokinase or tissue plasminogen activator, but the use of these drugs may increase the risk for stroke.

Occlusion of the coronary arteries decreases the flow of nutrients and oxygen to the myocardium. Total oxygen deprivation results in myocardial tissue necrosis. Cardiac tissue necrosis is irreversible. The types of problems experienced after an MI depend on the location and extent of the damage to the heart muscle. Mild damage may not be associated with symptoms and may be detectable on the electrocardiogram only. This type of infarction is often referred to as a *silent* heart attack. Moderate damage may limit a person's physical activity. Extensive damage or damage to a critical area of the heart may result in death.

Box 3-2 Signs and Symptoms of Myocardial Infarction (Heart Attack) in Older Adults

1. Sudden-onset dyspnea
2. Chest discomfort (not crushing pain)
3. Anxiety and confusion
4. Syncope
5. Decreased urine production
6. Diaphoresis (uncommon)

Coronary Valve Disease

The valves of the heart become less pliant over time. In addition, calcium deposits may develop on the valves, preventing them from sealing completely. This can result in mitral valve prolapse, mitral regurgitation, and, ultimately, congestive heart failure (CHF). Symptoms of mitral valve prolapse include chest pain, palpitations, fatigue, and dyspnea. Calcium deposits on the valves roughen the lining and increase the risk for clot formation in the chambers of the heart and in the blood vessels.

Cardiac Arrhythmias

Cardiac arrhythmias, including ventricular arrhythmias, atrial fibrillation, and conduction disturbances, are increasingly common with aging. Heart block is a common conduction disturbance caused by disruption of the electrical conduction system of the heart. This disruption can be caused by fibrotic tissue infiltration or MI. Sinus node dysfunction, sometimes called *sick sinus syndrome*, is the primary conduction disorder seen in older adults. This condition causes a disturbance in the rate and rhythm of heart contraction, resulting in symptoms such as lightheadedness, fatigue, palpitations, and syncope. When the disturbance is severe, an artificial pacemaker may be used to regulate cardiac activity.

Congestive Heart Failure

CHF is primarily a problem of the aging population. It is estimated that more than two million people suffer from this disorder, resulting in almost one million hospitalizations each year. The term *congestive heart failure* is descriptive of the disease process: The patient's lungs are often congested, and edema appears because the heart's pumping action is ineffective. CHF is not a single disease but rather a syndrome that accompanies and results from many other disorders. A variety of cardiovascular diseases can contribute to the development of CHF. Coronary artery disease, MI,

hypertension, valve disease, and cardiac infection or inflammation may increase the risk for CHF. Diseases of other body systems, including bronchitis, emphysema, asthma, hyperthyroidism, liver disease, kidney disease, and anemia, can also lead to CHF. Metabolic changes and fluid and electrolyte imbalances seen with malnutrition can lead to CHF. Excessive sodium intake with fluid retention increases the risk for CHF. The effects of alcohol, digoxin, hormones, some antineoplastics, corticosteroids, and NSAIDs can directly or indirectly lead to CHF.

CHF is associated with a wide range of symptoms, depending on the type and severity of the underlying disease. Mild **chronic CHF** tends to have a slow, insidious onset. Older adults who experience mild symptoms such as dyspnea, orthopnea, or paroxysmal nocturnal dyspnea often decrease their activity spontaneously. They may not recognize these symptoms as serious and may attribute them to "slowing down" with aging. Many older adults do not seek medical attention until they have serious problems and are unable to perform even minimal activities (Box 3-3). **Acute CHF** can result in severe pulmonary congestion or cardiogenic shock and is often fatal in older adults. Chronic CHF can become acute CHF with increased physical or emotional stress. People with CHF are more susceptible to fluid and electrolyte imbalances, infections, and renal or liver failure.

Medical management of CHF includes dietary restriction of sodium to decrease fluid retention, administration of diuretics (e.g., furosemide) to reduce fluid overload, administration of cardiotonic medications (e.g., digoxin) to increase the pumping efficiency of the heart, and planned levels of activity designed to reduce cardiac workload. Use of medical devices, including pacemakers, left ventricle assist devices, and implanted sensors, is increasingly common.

Cardiomegaly

Although aging does not routinely affect the size of the heart, many older adults do develop **cardiomegaly**, or enlargement of the heart, which is often related to CHF. As we age, the muscular wall of the left ventricle thickens. Because arteries and veins lose elasticity with age, the heart must pump harder to move blood through the vessels. The muscles of the left ventricle hypertrophy in an attempt to improve the output of blood from the heart to meet the body's tissue demands for oxygenated blood.

The right side of the heart may also hypertrophy. Right-sided enlargement is a result of increased resistance in the pulmonary circulation. When one side of the heart is weakened, the other side is soon affected.

Box 3-3 Signs and Symptoms of Congestive Heart Failure

1. Dyspnea (shortness of breath) with exertion
2. Orthopnea (dyspnea at rest when recumbent)
3. Coughing or wheezing with exertion or at rest
4. Fatigue, weakness, or generalized muscle weakness with minimal exertion
5. Peripheral edema
6. Weight gain without an increase in food intake (as a result of fluid retention)
7. Nausea, vomiting, or anorexia
8. Paroxysmal nocturnal dyspnea (extreme orthopnea during sleep)

Peripheral Vascular Disease

Vessel changes with aging can lead to mild or severe problems. In arteriosclerosis, the walls of the arteries become less elastic and plaque forms in the lumen, further restricting blood flow. Excessive plaque is often related to lifestyle factors or to other disease conditions, most commonly obesity, high cholesterol intake, cigarette smoking, and DM. If the lumen becomes too narrow, blood flow to peripheral sites, particularly the lower extremities, may be restricted. This decreased blood flow deprives the tissue of oxygen and nutrients and causes ischemia. If the lumen is completely obstructed, tissue death may result.

An early symptom of arterial occlusive disease is pain. **Intermittent claudication,** which manifests as a cramping pain in the legs during or after walking, is common with diminished peripheral circulation. Severe circulatory impairment can result in tissue necrosis that requires amputation.

Acute occlusion may occur if a thrombus or embolus obstructs the blood vessel. Sudden pain, pallor, pulselessness, loss of sensation, or a change in body temperature should be assessed and reported promptly.

Occlusive Peripheral Vascular Problems

Thrombus formation (clotting) in the lumen of a vein is a common problem, particularly in older adults who are immobile. These clots can form quickly because of sluggish blood flow within the vessels. Increasing the patient's activity and using antiembolism stockings help prevent problems related to venous stasis or pooling.

Thrombi form most often in the veins of the lower extremities, where they irritate and inflame the vessel and cause thrombophlebitis. Signs of thrombophlebitis include edema, swelling, warmth over the affected area, aching, cyanosis or pallor, and a positive Homans' sign (pain induced by dorsiflexing the foot of the affected leg).

Medical management of thrombophlebitis typically includes rest, elevation of the affected leg, application of elastic stockings or wraps, administration of analgesics, anticoagulant therapy, and sometimes application of heat.

If a thrombus breaks loose from the vein and travels in the circulatory system, it is referred to as an **embolus.** Emboli can be life-threatening. They are particularly dangerous if they reach small blood vessels in the lungs or brain, where they can occlude the blood supply to vital tissues.

Varicose Veins

Varicose veins are seen when blood pools in the veins and dilates or stretches them. The decrease in vascular muscle tone that occurs with aging increases the risk for this. Varicosities are most often seen as a twisting discoloration in the superficial veins of the lower extremities. Older adults who are obese, are inactive, or spend a great deal of time standing are more likely to have varicosities. The risk for inflamed varicosities increases with age.

Varicosities can result in leg cramps or a dull, aching pain in the legs. Patients can reduce or prevent related problems by avoiding constricting garments such as garters or rolled stockings, by refraining from sitting with crossed legs, by increasing activity, by resting with the legs elevated, and by wearing elastic stockings that promote venous return.

Aneurysm

Aneurysm, the pouching or ballooning of arteries, is common in older adults who suffer from arteriosclerotic blood vessel changes. Older adults with a history of angina, MI, or CHF are at increased risk for developing aneurysms. As parts of the muscular walls of the arteries develop plaque and become rigid, other areas of the vessels stretch, dilate, and weaken. The walls of the dilated areas become thin and prone to rupture.

Aneurysms of the abdominal aorta are most common in older adults. These are sometimes observed as a pulsating mass near the umbilicus, or navel. Patients may have abdominal pain and GI complaints. Aneurysms can also develop in peripheral and cerebral blood vessels. Thrombi can form in aneurysms and block the flow of blood. Rupture of an aneurysm results in massive, life-threatening hemorrhage. Early detection and surgical repair of the damaged area provide the best chance for survival.

Hypertensive Disease

Hypertension is prevalent in the older-adult population. It is estimated that more than 50% of persons older than 65 years of age have some form of hypertensive disorder. Hypertension is categorized as **essential** (primary) or **secondary.** Essential hypertension, the more common form, has no known cause. Many factors, including heredity, diet, obesity, stress, smoking, increased serum cholesterol levels, and abnormal sodium transport, are known to contribute to essential hypertension. Secondary hypertension occurs as a result of a coexisting disease process or other known cause. Renal, vascular, and endocrine pathologic conditions are among the most common causes of secondary hypertension.

Essential hypertension tends to have a gradual onset and is often asymptomatic until complications arise. Most often, hypertension is discovered during a routine physical examination. It is diagnosed based on two elevated blood pressure determinations on three separate days. A reading of 140/90 mm Hg is considered the upper limit of normal in adults, but some physicians consider slightly higher readings normal in adults older than 60 years of age.

Essential hypertension cannot be cured, but it can be treated. Treatment includes nonpharmacologic approaches such as rest, smoking cessation, use of stress-reduction techniques, weight loss, and dietary-sodium restriction. Pharmacologic approaches typically include administration of oral diuretics and β-blockers. The person experiencing hypertension must be monitored continuously to determine the effectiveness of therapy. Treatment of secondary hypertension is directed at the underlying pathologic condition.

THE HEMATOPOIETIC AND LYMPHATIC SYSTEMS

Body fluids distribute essential protective factors, nutrients, oxygen, and electrolytes throughout the body. The two major fluids of the body are blood and lymph. These fluids flow through the body within two parallel circulatory systems.

BLOOD

Blood flows within the heart and vessels of the cardiovascular system. The general functions of blood include **transportation** of nutrients, waste products, blood gases, and hormones; regulation of fluid-electrolyte balance, acid-base balance, and body temperature; and **protection** against pathogenic attack by the WBCs and against excessive blood loss through clotting mechanisms.

Blood is 91% to 92% liquid; the remaining 8% to 9% is solid. The liquid of the blood is called **plasma.** As a liquid, plasma is a substance in which many other substances can dissolve and be transported, including nutrients (e.g., glucose, amino acids, and lipids), electrolytes (e.g., sodium, potassium, calcium, and chloride), hormones, vitamins, antibodies, and waste products. Carbon dioxide is carried in the plasma as bicarbonate ion. Plasma contains a variety of proteins. **Albumin,** the most abundant plasma protein, is important in the maintenance of **osmotic pressure** needed to regulate blood pressure and volume. In the **fibrinogen** component are prothrombin, fibrinogen itself, and other clotting factors that circulate until they are required by the body. **Globulins** function as transport agents for lipids and fat-soluble vitamins;

the γ-globulin fraction is composed of antibodies that provide immunity from pathogens. The solid portion of the blood is composed of three types of blood cells: RBCs, WBCs, and platelets.

Erythrocytes

Erythrocytes, or RBCs, live for approximately 120 days; therefore, the body produces new RBCs throughout life. They are formed in the red bone marrow by **stem cells,** which undergo mitosis. For mitosis to occur, and thus for RBCs to form, vitamin B_{12} and folic acid are necessary for deoxyribonucleic acid (DNA) synthesis. For maturation, the RBCs need adequate amounts of protein and iron.

When RBCs become old and fragile, they are removed from the circulation by the **reticuloendothelial cells** of the spleen, liver, and red bone marrow. Their iron is reused in new RBCs formed by the red marrow. Excess iron is stored in the liver for later use. The **heme** portion of the RBC is converted to bilirubin in the reticuloendothelial system and is then processed by the liver. The liver secretes the bilirubin, or **bile pigment,** with the other components of bile, into the duodenum for use in digestion. This bile pigment helps give stool its characteristic brown color. If excessive numbers of RBCs are destroyed or if the liver does not function adequately, excessive amounts of bilirubin remain in the circulation. High bilirubin levels result in jaundice, a yellow discoloration of the sclera of the eyes and of the skin of light-skinned individuals.

Leukocytes

Leukocytes, or WBCs, have protective functions: They destroy dead or damaged tissue, detoxify foreign proteins, protect from infectious disease, and function in the immune response. WBCs are produced in the lymphatic tissue of the spleen, lymph nodes, thymus, and red bone marrow. The five types of WBCs are **neutrophils, eosinophils, basophils, lymphocytes,** and **monocytes.**

Platelets

Platelets, more properly called **thrombocytes,** are not whole cells but pieces of cells. They are produced when large cells called **megakaryocytes** fragment and enter the circulation. Platelets, which remain in circulation for approximately 10 days, play an important role in the blood's clotting mechanism.

LYMPH SYSTEM

The lymph and circulatory systems are parallel and interdependent. In fact, the lymph system is sometimes considered part of the circulatory system because it is responsible for returning fluids from the tissues to the circulation. The major components of the immune system—lymphocytes and antibodies—are formed by the lymph system to protect the body from pathogenic microorganisms, malignant cells, and foreign proteins. The lymph system consists of the lymph vessels, fluid, nodes, and nodules; the spleen; and the thymus gland.

Lymph Vessels, Fluid, and Nodes

Lymph vessels are located in most tissue spaces. These permeable vessels absorb fluid and proteins from the tissues. Muscular compression on the vessels moves this fluid through a series of lymph nodes and nodules that trap and phagocytize foreign materials before the fluid enters the circulatory system at the subclavian veins. Lymph nodes and nodules also produce lymphocytes and monocytes and phagocytize pathogens.

Spleen and Thymus

The spleen is responsible for producing lymphocytes and monocytes, which enter the bloodstream. It also contains fixed **plasma cells,** which produce antibodies to foreign antigens, and fixed macrophages, which phagocytize pathogens and other foreign substances in the blood. Although people can survive without a spleen, they may be more susceptible to certain bacterial infections, including pneumonia.

The thymus, which is located behind the thyroid gland, is large in fetuses and infants. The embryonic bone marrow and the spleen produce the initial **T lymphocytes,** or T cells, which are responsible for recognition of foreign antigens and for cell-mediated immunity. The thymus shrinks with age, but once the T cells are established in the spleen and lymph nodes, they are self-perpetuating.

Lymphocytes and Immunity

B lymphocytes, or B cells, are also produced in the embryonic bone marrow. These cells are responsible for the recognition of antigens located on a foreign cell and for humoral immunity. In humoral immunity, T cells and B cells often cooperate: Sensitized **helper T cells** detect antigens and induce the B cells to produce antibodies, which are then found in the globulin portion of plasma. When the antigen has been destroyed, **suppressor T cells** reduce helper T-cell activity and stop the immune process. Conversely, in cell-mediated immunity, antibodies are not produced. Instead, activated T cells divide into memory T-cells (which recognize the pathogen) and killer T cells (which destroy bacteria by disrupting their cell membranes).

EXPECTED AGE-RELATED CHANGES

The characteristics of blood change somewhat as a person ages (see Table 3-5). Plasma viscosity increases slightly and is most often related to a general decrease in total body fluid. Blood cell production in the bone

Table 3-5 Hematopoietic and Lymphatic Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Increased plasma viscosity	Increased risk for vascular occlusion
Decreased red blood cell production	Increased incidence of anemia
Decreased mobilization of neutrophils	Less effective phagocytosis
Increased immature T cells response	Decreased immune response
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO HEMATOPOIETIC AND LYMPHATIC CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Monitor laboratory tests, including Hgb, Hct, WBC, and differential.	Report abnormal findings promptly to physician.
Assess nutritional intake for adequacy of protein, iron and vitamins	Administer nutritional supplements as ordered.

marrow decreases slightly, resulting in a small decrease in total RBCs and WBCs. Unless extreme physiologic stress or disease is present, blood levels of RBCs, WBCs, and platelets remain within normal limits.

The number of T cells in the body does not appear to decrease with aging, but more of the cells are immature. The ratio of helper cells to suppressor cells is increased. These T-cell changes lead to a diminished immune response. Consequently, older adults are at greater risk for developing infections, particularly respiratory and urinary tract infections (UTIs). Older adults are also at increased risk for acquiring nosocomial infections. Studies have shown that women older than 55 years of age have limited antibody titers to tetanus toxoid, raising questions about changes in humoral immunity with aging. If the ability to produce antibodies is affected by aging, changes in immunization practices for the aging population may be necessary.

Changes in the immune response may modify the usual signs and symptoms of infection. Such changes may be difficult to recognize in older adults: Body temperature may not become significantly elevated until the infection is severe, and pain may not be present to indicate infection. Some examples include the following: (1) Older adults with pneumonia may not have a fever or chills; (2) dysuria is often absent in older adults with UTIs; (3) pain may be absent with peritonitis or appendicitis, even though the individual is obviously ill; and (4) the physiologic response of older adults to tuberculosis skin testing may be delayed or less intense than that of younger individuals.

COMMON DISORDERS SEEN WITH AGING

Anemia

Anemia is defined as inadequate levels of RBCs or insufficient hemoglobin. The most commonly observed anemias in older adults are iron-deficiency anemia, pernicious anemia, and folic acid–deficiency anemia.

Iron-deficiency anemia results from inadequate nutritional intake, blood loss, malabsorption, or increased physiologic demand. Pernicious anemia is associated with decreased intake or absorption of vitamin B_{12}. Folic acid–deficiency anemia is usually caused by poor nutrition, chronic alcohol abuse, or malabsorption syndromes such as Crohn's disease. Anemia is common in the older adult population, and these problems are explored further in other chapters.

Leukemia

Leukemia is the result of excessive production of immature WBCs. There are both acute and chronic varieties, and leukemia is also classified by the type of abnormal cells present. Other blood disorders (e.g., anemia) and hemorrhage (related to a decrease in the number or function of platelets) are commonly seen with leukemia. **Chronic lymphocytic leukemia** is the form most often seen in older adults. Approximately 75% of those diagnosed with chronic lymphocytic leukemia are older than age 60. Depending on the stage of the disease and the patient's overall health, life expectancy may vary from a few to as many as 20 years after diagnosis.

THE GASTROINTESTINAL SYSTEM

Food and fluids containing the nutrients needed for survival normally enter the body through the GI tract. Although it is possible to live without food for several days, the cells require a regular supply of nutrients to support their normal physiologic activities.

As appealing as a banana split, turkey dinner, or bowl of strawberries may be to us, these foods are useless to our cells until they are broken down into simple, usable forms by the GI system. The GI tract prepares food for digestion. It then digests, processes, and absorbs the nutrients, which are used by the cells of the body. The GI system also stores and discards wastes and plays a major role in maintaining fluid balance by absorbing water. After we chew and swallow food, we do not need to think about its further processing, because the GI system takes care of removing the nutrients and discarding the waste. However, in unusual situations, the GI tract can be bypassed by administering specially prepared nutrients directly into the bloodstream (parenteral nutrition, or hyperalimentation).

The GI tract begins at the mouth and ends at the anus. Each part of the GI tract performs its own distinct functions.

ORAL CAVITY

Food normally enters the body through the mouth and is prepared for digestion in the **oral cavity.** The teeth mechanically process food by biting, tearing, grinding, and chewing it, a process called **mastication.** The normal adult has 28 to 32 permanent teeth with shapes and sizes that vary depending on their function. The incisors are used to bite, the **canines** to tear, and the **premolars** and **molars** to chew and grind. Each tooth is composed of a crown, which is the part visible above the gingiva (gum), and a **root,** which is imbedded in a socket in either the mandible or maxilla of the jaw. The periodontal membrane lines the tooth socket and holds the teeth in place. The crown of the tooth is protected by an extremely hard casing called **enamel.** The **pulp cavity** of the tooth contains blood vessels and nerve endings.

TONGUE

The tongue is a highly flexible structure controlled by and composed primarily of skeletal muscle. **Papillae,** which contain the taste buds, are located on the upper surface of the tongue. Cranial nerves control the movement of the tongue and carry the impulses for the perception of taste. The tongue aids in mechanical digestion by positioning food between the teeth and mixing it with saliva in the oral cavity.

SALIVARY GLANDS

Three pairs of **salivary glands** excrete saliva into the oral cavity. Saliva is composed primarily of water but also contains the enzyme **amylase,** which begins the digestion of starch. Saliva production normally increases in response to the sight or smell of food. Inadequate amounts of saliva result in a dry mouth and in difficult swallowing. When adequately mixed with saliva, food reaches a consistency that makes it more suitable for chemical digestion. The tongue lifts against the hard palate, pushing the bolus of food to the pharynx at the back of the oral cavity. From here, the bolus of food enters the esophagus.

ESOPHAGUS

Once in the **esophagus,** food is moved by a process called *peristalsis,* a wavelike motion of the smooth musculature that propels material through the entire GI tract. The esophagus is a hollow muscular tube that passes from the pharynx through the flat layer of diaphragm muscle and to the stomach. The esophagus is located above the diaphragm, and the stomach is located immediately below the diaphragm. The lower esophageal sphincter, also called the *cardiac sphincter,* is at approximately the same level as the diaphragm, where the esophagus meets the stomach. It allows food to enter the stomach but prevents the stomach contents from moving backward (refluxing) into the esophagus.

STOMACH

The **stomach** is a muscular sac in which both mechanical and chemical digestion take place. The stomach is lined with mucous membrane, which helps prevent damage to the muscle walls. Special stomach glands secrete mucus; others secrete enzymes, intrinsic factor, and hydrochloric acid. This mixture of enzymes and acids is called **gastric juice,** or **digestive juice.** The pyloric sphincter at the distal end of the stomach retains the bolus of food and the digestive juices within the stomach, where they can be churned, mixed, and further broken down for later digestion and absorption. Once the food has been processed in the stomach, it is referred to as **chyme.** After adequate mixing, small amounts of chyme are released through the pyloric sphincter into the small intestine.

SMALL INTESTINE

The **small intestine** is more than 20 feet long and is divided into three segments called the **duodenum,** the **jejunum,** and the **ileum** (in order of progression away from the stomach). Additional substances are added to chyme in the small intestine to complete digestion. Intestinal digestive glands secrete intestinal juice, which is alkaline and contains many enzymes. The common bile duct and pancreatic duct converge and enter the duodenum at the sphincter of Oddi. **Bile,** which is produced in the liver and stored in the gallbladder, breaks down fat by **emulsifying** it. **Pancreatic juice** contains enzymes that break down proteins. The pancreas also produces sodium bicarbonate; when released into the duodenum, it neutralizes the hydrochloric acid from the stomach. After all of these chemicals have acted on the material in the GI tract, the process of digestion is completed, and the nutrients are in elementary forms (e.g., glucose and amino acids) that can be used by the cells of the body.

Absorption of nutrients occurs primarily in the small intestine. Special **villi,** projections of the lining of the small intestine that are rich in capillaries and lymphatic vessels, increase the surface area of the lining. As the digested nutrients pass over these villi, they are absorbed into the blood and lymph by the capillary network and lymphatics.

Once the nutrients have been absorbed, undigested material and water are propelled into the large intestine by peristalsis. A structure called the **ileocecal valve** is located between the ileum of the small intestine and the cecum of the large intestine. This structure prevents waste products from moving backward into the small intestine.

LARGE INTESTINE

The **large intestine** is approximately 5 feet long and is divided into segments called the **ascending, transverse, descending,** and **sigmoid colon** and the rectum.

The major functions of the large intestine are absorption of water, minerals, and vitamins, and storage and elimination of indigestible wastes.

As the **effluent,** or discharge of waste products, moves through the large intestine, water is absorbed and the mass becomes increasingly solid in consistency. It is stored in the sigmoid and descending colon. When peristalsis causes the effluent to enter the rectum, its presence there triggers the defecation reflex, in which strong peristaltic movements propel the mass from the rectum and through the anus. Another reflex-like action occurs when the stomach is distended with food, stimulating vigorous peristalsis of the rectum and a desire to defecate. The internal anal sphincter is an involuntary muscle that relaxes when the rectum is full. The external anal sphincter, which is usually under voluntary control after 2 to 3 years of age, may be contracted to prevent defecation. When the external sphincter relaxes, wastes are eliminated from the large intestine.

EXPECTED AGE-RELATED CHANGES

Over time, changes in the GI tract can interfere with normal digestion (Table 3-6). In the oral cavity, gingival tissue may recede and the periodontal bonds that hold the teeth in place may loosen. If the teeth are not structurally sound, the ability to bite and chew can be impaired. Good oral hygiene can slow these changes. It is no longer considered normal for older adults to lose some or all of their teeth, which was common in the past.

Dental caries (cavities) can soften the enamel and expose nerves in the tooth pulp. The resulting pain can decrease the ability and the desire to eat.

Esophageal dilation and problems related to swallowing may be observed with aging. Commonly, the **gag reflex** is depressed in older adults, even in those without neurologic problems. This can lead to episodes of choking and to aspiration. The tone of sphincter muscles, particularly the lower esophageal sphincter, may decrease, increasing the incidence of esophageal reflux or heartburn.

In the stomach, atrophy of the gastric glands may result in a decreased production of intrinsic factor and hydrochloric acid; this, in turn, can interfere with normal digestion and absorption of nutrients. These changes can contribute to anemia and other malabsorptive problems. A decrease in gastric mucus production leads to risk for injury and bacterial penetration into the systemic circulation. Decreases in gut-associated lymphoid tissue can have an effect on immune response. Peristalsis of the intestine slows with aging, increasing the likelihood of constipation and the incomplete elimination of feces during a single bowel movement.

Table 3-6 Gastrointestinal Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Increased dental caries and tooth loss	Decreased ability to chew normally; decreased nutritional status
Decreased thirst perception	Increased risk for dehydration and constipation
Decreased gag reflex	Increased incidence of choking and aspiration
Decreased muscle tone at sphincters	Increased incidence of heartburn (esophageal reflux)
Decreased saliva and gastric secretions	Decreased digestion and absorption of nutrients
Decreased gastric motility and peristalsis	Increased flatulence, constipation, and bowel impaction
Decreased liver size and enzyme production	Decreased ability to metabolize drugs leading to increased risk for toxicity
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO GASTROINTESTINAL CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess oral cavity for dentition, condition of mucous membranes and hygiene.	Educate regarding importance of good oral hygiene; stress need for adequate fluid intake. Dental referral as necessary.
Assess swallow and gag reflexes.	Encourage posture that facilitates swallowing. Consult with speech therapy for swallow studies and safe dietary regimen.
Monitor weight changes.	Weigh at least one time per month, more often if fluid balance issues present.
Assess intake of nutrients and fluid.	Educate regarding recommended dietary intake. Establish calorie count and intake and output if problems are suspected.
Assess bowel sounds and bowel elimination patterns.	Establish bowel routines. Teach importance of adequate fluid, fiber, and activity. Administer laxatives, stool softeners, suppositories, or enemas as needed to prevent constipation and impaction.

COMMON DISORDERS SEEN WITH AGING

Hiatal Hernia

A **hiatal hernia** is the protrusion of the stomach into the thoracic cavity through the esophageal opening in the diaphragm (see Figure 3-8). Men older than 50 years of age are most likely to experience problems with hiatal hernias, and as many as 40% to 60% of those 60 years of age or older may be affected. Some demonstrate no symptoms; others complain of severe distress that may be intermittent or continuous. Reflux episodes usually occur after meals, especially when the person lies down to rest immediately after eating. Complaints may include sour stomach, heartburn, or generalized epigastric distress. Sometimes the symptoms can resemble an angina attack. As mentioned, hiatal problems are most likely to occur after meals or when the person is at rest; in contrast, angina attacks are most likely to occur with physical exertion. Vital signs do not normally change in response to problems with hiatal hernias.

Gastroesophageal reflux disease is a major problem that can occur with hiatal hernias. With gastroesophageal reflux disease, the gastric contents move backward into the esophagus, where they increase the risk for aspiration. This can present serious concerns in older adults who have diminished gag or cough reflexes. Occasionally, the hernia through the diaphragm is reduced surgically, but typical treatment involves the use of antacids, histamine$_2$ antagonists, proton pump inhibitors, and dietary modifications. Fatty foods, carbonated beverages, alcohol, and foods that contain caffeine or caffeine-like substances (e.g., coffee, cola, and chocolate) should be avoided to reduce problems with reflux. Smaller, more frequent meals are often beneficial because overeating is likely to enlarge the stomach and cause it to bulge into the diaphragm. It is recommended that food and fluids be restricted after the normal evening meal, and affected persons should avoid lying down too soon after eating. In severe cases, the head of the bed may need to be elevated during sleep to reduce the risk for aspiration.

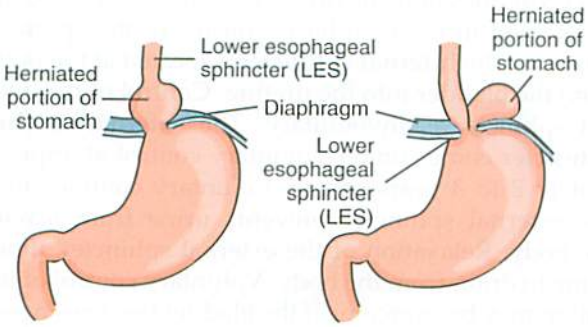

FIGURE 3-8 Hiatal hernia. A, Sliding hernia. B, Paraesophageal hernia.

Gastritis and Ulcers

Chronic atrophic gastritis is an inflammatory change in the mucous membranes of the stomach in which the mucosa becomes thin and abnormally smooth and may develop hemorrhagic patches. All or parts of the stomach may be involved.

Both **gastric** and **duodenal ulcers** can occur with aging, but gastric ulcers are more common. Many factors contribute to the development of gastric ulcers. Behaviors such as smoking or alcohol ingestion, physical trauma such as surgery or fractures, disease processes such as pneumonia, and psychological stress resulting from hospitalization or nursing home placement can increase the risk for ulcers. A bacterium, *Helicobacter pylori*, has been implicated as the cause of some gastric ulcers. Drug-induced ulcers related to the use of iron supplements, aspirin, and NSAIDs are particularly common in older adults.

Peptic ulcers in older adults do not cause the classic epigastric pain that is seen in younger people. Older adults suffering from ulcers are more likely to complain of generalized pain and to exhibit a decreased activity level, decreased appetite, and weight loss. Vomiting, melena, and generalized signs of anemia may result from gastric bleeding. If a gastric ulcer progresses to the point of perforation, severe hemorrhage can result. If the person has already been weakened by occult bleeding, hemorrhage may be serious enough to result in death.

Early recognition and reporting of symptoms by the nurse is important so that treatment can be started before serious problems occur. Medical treatment of ulcers in older adults is generally preferred to surgical correction (Box 3-4).

Diverticulosis and Diverticulitis

Diverticula are small pouches or sacs that develop because of weaknesses in the intestinal mucosa. Between 30% and 40% of persons older than age 50 have some diverticula, and the incidence of **diverticulosis** increases with each decade of life. Most people with diverticula experience no symptoms, and there is no specific treatment unless symptoms occur. The patient

Box 3-4 Medical Treatment of Ulcers

- Dietary modifications, including avoidance of alcohol, caffeine, and other suspect foods that tend to irritate the problem or increase hydrochloric acid production
- Avoidance of tobacco, which stimulates acid release
- Administration of antacids to reduce acidity
- Administration of histamine H_2-blocking agents, such as famotidine, cimetidine and ranitidine, to prevent ulcer formation or to promote ulcer healing
- Stress-reduction programs
- Administration of proton pump inhibitors such as omeprazole and lansoprazole

should continue to eat a normal diet with adequate fluids and roughage. If rectal bleeding occurs, medical intervention is necessary to determine the source.

Diverticulitis involves inflammation of one or more diverticula. This inflammation may result in bowel obstruction, perforation, or abscess formation. In cases of severe diverticulitis, the patient may need to be hospitalized. Oral intake of food is restricted and intravenous fluids are administered to give the diseased area an opportunity to "rest." Surgical correction, including bowel resection or colostomy, may be required if conservative medical treatment is unsuccessful. As many as 25% of elderly people who have diverticulitis require surgery.

Cancer

The incidence of **colon cancer** begins to increase at 40 years of age and peaks between the ages of 60 and 75. Carcinoma of the colon is more common in women, whereas carcinoma of the rectum is more common in men. Any changes in bowel elimination should be viewed with suspicion, especially signs of obstruction or bleeding. Routine screening for rectal cancer is recommended for those older than 40 years of age.

Hemorrhoids

Hemorrhoids, sometimes called **piles** by older adults, are common at all ages but may be particularly troublesome to older patients. People with chronic constipation and obese people are most likely to have problems with hemorrhoids. Pain and small amounts of bright red blood at the rectum are common complaints. Most patients with hemorrhoids do not require surgery. Diet changes, stool softeners, or bulk laxatives are usually effective in reducing problems related to constipation and hemorrhoids.

Rectal Prolapse

Bulging of the rectum through the anus is most likely to occur in women older than age 60, especially those who have given birth to many children. Some form of medical intervention may be needed if this condition causes distress. Surgery may be performed to strengthen the musculature. Insertion of a wire loop at the anal sphincter may be attempted in very old people.

THE URINARY SYSTEM

The urinary system consists of two kidneys, two ureters, the urinary bladder, and the urethra. The urinary system supports homeostasis by eliminating wastes and excessive fluid from the body. The kidneys continuously filter the blood and selectively save or eliminate water, electrolytes, and wastes. Those substances not reabsorbed by the kidneys are eliminated from the body as urine.

KIDNEYS

The kidneys are two bean-shaped organs located on each side of the spine behind the peritoneal lining of the abdomen and at the lower edge of the rib cage. The left kidney is usually located slightly higher than the right kidney. Each kidney is surrounded by an adipose tissue pad and is further protected from trauma by the muscles of the back. Within each kidney is a maze of nearly a million **nephrons,** the functional portion of the kidney. Blood is filtered in the glomerulus of the nephron, and this filtrate is destined to become urine. This highly vascular organ receives blood from the renal artery, which branches off the abdominal aorta. Blood returns to the circulation through the renal vein, which connects to the inferior vena cava. Adequate blood flow to the kidneys is very important; any condition that decreases renal blood flow interferes with normal kidney function.

The kidneys play an important role in fluid and electrolyte balance and acid-base balance in the body. They remove nitrogenous wastes, excess glucose, and drug metabolites from the bloodstream. They also help regulate blood pressure. The kidneys typically produce between 1 and 2 L of urine every 24 hours. If excessive fluid is lost elsewhere (e.g., in perspiration or diarrhea), urine output normally decreases. Excessive fluid or alcohol intake tends to increase urine production. A single kidney can meet the needs of the entire body.

URETERS AND BLADDER

The **ureters** are tubes of smooth muscle that allow urine to drain from each kidney into the bladder. When the body is upright, urine drains by means of gravity. Pressure of the enlarging bladder against the lower portion of the ureter keeps the ureter closed and prevents urine from flowing back toward the kidneys.

The **bladder** is a hollow muscular sac located below the peritoneum and normally entirely within the pelvic cavity. The bones of the pelvis protect the bladder from trauma. In women, the bladder is located anterior to the uterus; in men, it is superior to the prostate gland.

The muscular wall of the bladder is lined with a mucous membrane and is capable of stretching to hold large volumes of urine (up to 1000 mL or more). Urine is retained in the bladder by means of the sphincter muscles. The **internal sphincter** is located at the outlet from the bladder into the urethra. Control of the internal sphincter is involuntary. The **external urethral sphincter** comes under voluntary control at approximately 2 to 3 years of age. Voluntary contraction of the external sphincter prevents urine from leaving the body. Relaxation of the external sphincter allows urine to drain from the body. Voluntary control of urination may be overcome if the bladder becomes overly enlarged with urine. In adults, the urge to urinate

typically occurs when urine volume in the bladder reaches approximately 200 to 400 mL.

The urethra is a tubelike passage that leads from the bladder to the outside of the body. At the point of exit, it is referred to as the *urinary meatus*. The female urethra is 1 to 1.5 inches long; the male urethra is 7 to 8 inches long. The urethra is part of the reproductive system in men and is used to transport semen as well as urine; however, ejaculation and urination cannot take place at the same time. The prostate gland surrounds the urethra. Although this normally causes no problems, an enlarged prostate can interfere with urination.

CHARACTERISTICS OF URINE

Urine is approximately 95% water, with the remainder composed of waste products and salts. The specific gravity (which measures the amount of solids dissolved in water) of urine is normally maintained within close limits. A specific gravity of 1.010 to 1.025 is considered normal. Dilute urine has a low specific gravity, and concentrated urine has a high specific gravity. Urine is normally clear, and its color ranges from pale yellow to dark amber. It may be alkaline or acidic, depending on the diet of the individual. High-protein diets tend to make the urine more acidic; vegetarian diets tend to lead to alkaline urine. Acidic urine is less compatible with bacterial growth than is alkaline urine and may help reduce the risk for a UTI.

EXPECTED AGE-RELATED CHANGES

The kidneys decrease in size from approximately 400 g at age 40 to only 250 g by age 80. By age 70, they lose approximately one-third of their efficiency and they lack functional reserve. Despite this, the kidneys usually are able to remove wastes adequately to maintain normal blood levels. As a person ages (Table 3-7), the number of functional units or nephrons decreases. In addition, the kidneys lose mass and decrease in size. Vascular changes, such as those that occur with atherosclerosis or arteriosclerosis, lead to decreased blood supply to the kidneys. Decreased blood flow results in an altered **glomerular filtration rate.** At 90 years of age, the glomerular filtration rate can be as little as half of what it was at age 20. The **blood urea nitrogen** remaining in the blood increases significantly with age, from a normal of 10 to 15 mg/dL in young adulthood to 21 mg/dL by age 70.

The nephrons and collecting system of the aging body are less sensitive to the effects of antidiuretic hormone. Less sodium and water are reabsorbed and more potassium is lost, resulting in the production of a less concentrated urine with aging.

Aging results in reduced urinary bladder size, which leads to decreased **bladder capacity** (i.e., the volume of urine the bladder can hold before a person experiences the urge to void). Many older people need to void when only 100 mL of urine is present. In addition, overactivity of the detrusor muscle can result in contraction of the bladder before the bladder is full. Either or both of these factors can lead to the urinary urgency and frequency that is common in older adults. To further aggravate the situation, loss of muscle tone can impair voluntary control of the external sphincter muscle. Atonic muscular changes may also occur in the wall of the bladder. Loss of tone may result in reduced urinary stream, incomplete or unsuccessful voiding, continuous dribbling of urine, or urinary retention with overflow voiding (a condition in which the person voids frequently but never completely empties the bladder). Urinary retention contributes to the risk for UTIs, especially in older adults, because retained urine is a good medium for bacterial growth.

Table 3-7 Urinary Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased number of functional nephrons	Decreased filtration rate with decrease in drug clearance
Decreased blood supply	Decreased removal of body wastes; increased concentration of urine
Decreased muscle tone	Increased volume of residual urine
Decreased tissue elasticity	Decreased bladder capacity
Delayed or decreased perception of need to void	Increased incidence of incontinence
Increased nocturnal urine production	Increased need to awaken to void or episodes of nocturnal incontinence
Increased size of prostate (male)	Increased risk for infection; decreased stream of urine; increased hesitancy and frequency of urination
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO URINARY CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Monitor for signs of drug toxicity.	Promptly notify physician of relevant observations.
Assess for urinary frequency.	Palpate bladder after voiding or use Doppler to determine whether bladder is emptying completely.
Assess for signs and symptoms of urinary tract infection.	Obtain a urine specimen for analysis.
Assess frequency and timing of episodes of incontinence.	Establish a toileting schedule based on assessment data.

The prostate gland enlarges with age. Most men older than 60 years of age experience some degree of prostate gland enlargement as a result of **benign prostatic hyperplasia** or cancer. Because it surrounds the urethra, an enlarged prostate gland can compress and narrow the passageway, which, in turn, causes problems with voiding. Hesitancy, frequency, the inability to maintain a steady stream of urine, and urinary retention are common indicators of prostatic hypertrophy.

COMMON DISORDERS SEEN WITH AGING

Urinary Incontinence

Urinary incontinence, the involuntary loss of urine, is not a routine or normal occurrence with aging. Incontinence may occur as a result of physiologic changes, other medical problems such as UTIs, neurologic problems, or changes in the ability to function. Several classifications of medication can contribute to incontinence. Urinary incontinence is discussed in greater detail in Chapter 18.

Urinary Tract Infection

The incidence of UTIs increases significantly with age. Only 3% of women in their forties experience UTIs, whereas close to 15% experience UTIs by age 60. Men also develop UTIs, but they are less common in men and develop at an older age. Both the normal changes of aging and the increased incidence of health problems contribute to this increased incidence of UTIs (Box 3-5).

Chronic Renal Failure

An increasing number of people older than 70 years of age are being treated with dialysis for chronic renal failure. This was an age-restricted treatment in the past; however, today many older adults receive life-prolonging hemodialysis or peritoneal dialysis, depending on their needs and their physician's judgment.

Box 3-5 Risk Factors for Urinary Tract Infections

- Inadequate or improper hygiene related to difficulty in cleansing after toileting
- Urinary stasis and incomplete emptying of bladder resulting from physiologic changes and decreased mobility
- Coexisting diseases such as diabetes, hypertension, stroke, and dementia
- Medical interventions, including catheterization and repeated use of antibiotics (which can lead to resistant strains of bacteria)
- Increased exposure to microorganisms in hospitals or extended-care facilities

Chronic renal failure may be a result of other chronic health conditions such as hypertension, DM, chronic UTIs, or urinary tract obstructions. It may also result from acute renal failure caused by hypovolemia, hypotension, or antibiotic toxicity.

The symptoms of chronic renal failure are extensive and often mimic those of other conditions. These symptoms include changes in urine output, muscle weakness, edema, nausea and vomiting, itchy and dry skin, and numerous neurologic symptoms. Blood tests reveal significant changes, particularly elevated levels of blood urea nitrogen and creatinine.

THE NERVOUS SYSTEM

The nervous system processes and controls body functions and links us with the outside world. Through the nervous system, we perceive sensations and detect changes in our environment. We store information about the world within the nervous system and use this information to respond to the world. A functioning nervous system is necessary for survival. Internally, the nervous system and the endocrine system maintain homeostasis.

Many of the functions of the nervous system (e.g., regulation of heartbeat and body temperature) occur at an unconscious level. Other activities, such as writing, working with tools, or singing, can be done with conscious thought and effort only. Some activities, such as breathing, occur unconsciously but can also be controlled consciously. The nervous system functions at an unconscious or reflex level at birth; neurologic control is gained with maturation. With advanced age, the nervous system becomes prone to deterioration and is susceptible to many types of injury and illness. Because of the serious consequences of age-related neurologic problems, it is important to examine this system in greater detail.

The nervous system is composed of highly specialized cells called **neurons.** Each neuron consists of a **cell body,** which contains the cell nucleus; multiple **dendrites,** which are fibers that transmit impulses (messages) to the cell body; and one **axon,** which carries impulses away from the cell body.

Nerve impulses are electrochemical in nature. An impulse travels through the neuron by fast-moving ion shifts across progressive segments of the cell membrane until it reaches the end of the axon. Axons and dendrites do not touch each other. A small gap called a **synapse** separates these structures. Special chemicals called **neurotransmitters** are released by the axon to stimulate a **receptor site** on another nerve cell. This allows the nerve impulse to move from one nerve cell to another. When the receptor has been stimulated, the neurotransmitter activity is halted by an inactivating chemical that stops prolonged transmission of impulses. In the peripheral nervous

system, the most common neurotransmitters are **acetylcholine** and norepinephrine. In the central nervous system, dopamine, serotonin, and **norepinephrine** are important. Each neurotransmitter has a specific inactivator.

The nervous system consists of two major divisions: the central nervous system and the peripheral nervous system.

CENTRAL NERVOUS SYSTEM

The **central nervous system** is composed of the **brain** and the spinal cord. The brain is the master integrator of the nervous system. Thought, decision making, behavior, and all life processes are controlled by the various segments of the brain.

Medulla

The **medulla oblongata** extends from the spinal column to the pons of the brain. This area controls many vital functions, including heart rate, constriction of blood vessels (which affects blood pressure), and respiration. Reflex centers for coughing, vomiting, swallowing, and sneezing are also located in this area. Severe trauma to this area of the brain is life threatening.

Pons and Midbrain

The **pons** also exerts control over respiratory patterns and works with the medulla to regulate breathing rhythm. The **midbrain** integrates visual and auditory reflexes and helps maintain balance and equilibrium.

Cerebellum

The **cerebellum** works to coordinate body movement at an unconscious level. It allows excitation of muscles by neurons higher in the brain while it inhibits unnecessary impulses; thus, it enables smooth movements without jerkiness. Picking up a cup of coffee and bringing it to your mouth in a coordinated way is an example of the activity of the cerebellum. If you had to think consciously of all of the individual movements to accomplish this activity, the coffee would be cold before you could drink it.

Hypothalamus

The **hypothalamus,** a small area of the brain above the pituitary gland, is the coordinating center for the autonomic nervous system. It also secretes releasing and inhibiting hormones that affect the secretions of the pituitary gland (such as growth-hormone-releasing factor) and thus results in various effects on the endocrine system. Other hormones are produced in the hypothalamus, move to the pituitary, and are released by that gland, including antidiuretic hormone and oxytocin. The hypothalamus regulates body temperature, controls food intake, and is involved with visceral responses such as the increased heart rate that occurs with anger.

Cerebrum

The **cerebrum** is the largest part of the human brain. It is divided into lobes, which are named according to the cranial bones under which they lie. Because of the manner in which nerve impulses are routed in the central nervous system, the left lobes control the right side of the body and the right lobes control the left side of the body—they function **contralaterally.** The **frontal lobes** control voluntary motor activity, judgment, planning, organization, problem solving, and behavior regulation. **Broca's area,** which controls the movements related to speech, is found on the left frontal lobe in right-handed individuals. The **parietal lobes** interpret impulses and sensations from the skin and muscles. In addition, they are responsible for facial, shape, and color recognition. Taste sensation overlaps both the parietal and temporal lobes of the brain. The **temporal lobes** receive auditory (hearing) and olfactory (smelling) impulses and are devoted to new memory, learning, music, and emotions. The occipital lobes deal with vision, depth perception, and three-dimensional perception.

PERIPHERAL NERVOUS SYSTEM

The **peripheral nervous system** consists of the cranial and the spinal nerves and includes the **somatic nervous system** and the **autonomic nervous system.** The peripheral nervous system is a relay system that detects changes in both the internal and external environments and relays this information to the central nervous system. It also transmits impulses from the brain and spinal cord to the appropriate end organs. To prevent messages from short-circuiting each other in the peripheral nervous system and to speed impulse conduction, the axons of many types of nerves are surrounded by **Schwann cells,** which form the protective **myelin sheath.** Probably because of the myelin sheath, injured peripheral nerves can be surgically repaired or they may even regenerate spontaneously if the damage is not too severe. Neurons in the central nervous system lack this guiding sheath; if damaged, they usually die.

EXPECTED AGE-RELATED CHANGES

Many cellular changes have been observed in the aging brain, including a reduction in its size and weight resulting from a decrease in the volume of the cerebral cortex. There is approximately a 3% reduction in brain tissue in each decade from age 50 to 90. Brain shrinkage has been linked to a decrease in the number of functional cortical neurons (Table 3-8). Mental function is often changed as these cells are lost or undergo functional changes. Cerebral blood flow decreases with aging because of the gradual accumulation of fatty deposits (i.e., **arteriosclerosis**). Decreased blood flow also results in a slower rate of cerebral metabolism. A progressive decrease in the

Table 3-8 Neurologic Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased number of brain cells	Slowed thought processes, decreased ability to respond to multiple stimuli and tasks
Decreased number of nerve fibers	Decreased reflexes, decreased coordination, decreased proprioception
Decreased amounts of neuroreceptors	Decreased perception of stimuli
Decreased peripheral nerve function	Decreased motor responses, increased risk for ischemic paresthesia in extremities
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO NEUROLOGIC CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess alertness level, cognition, and functional abilities.	Report abnormal findings to physician. Refer for neurologic evaluation.
Assess balance and reflexes.	Educate regarding safety precautions and use of assistive devices. Structure tasks to reduce confusion; allow adequate time to perform tasks.

number of branches and the connections between dendrites occurs over time. Studies of neurotransmitters show that serotonin levels increase with aging, and norepinephrine levels decrease. Levels of monoamine oxidase, which metabolizes catecholamines, increase. In the peripheral nervous system, the velocity of nerve conduction decreases as much as 30% between 20 and 90 years of age.

Because of these physiologic changes, motor responses take longer in older individuals. Simple actions such as walking and talking often become slower with age. Reflex movements become sluggish, and reactions are slowed. Some loss of coordination is common. Tasks that require quick perception of stimuli and highly coordinated responses (e.g., driving in rush-hour traffic) may pose a risk to those with significant neurologic loss. Many aging people recognize these changes and modify their lifestyles to avoid potentially dangerous situations.

COMMON DISORDERS SEEN WITH AGING

Parkinson's disease

Parkinson's disease, also called **paralysis agitans,** is a progressive, degenerative disorder of the central nervous system. The cause of Parkinson's disease is unknown. Specific neurons in the brain that produce the neurotransmitter dopamine are lost. Symptoms usually begin after age 40 years and appear gradually. The incidence of Parkinson's disease increases in older age groups.

People suffering from Parkinson's disease may manifest a variety of symptoms. The initial signs of the disease tend to be unilateral and include slight tremors on one side, in addition to a more general weakness and slowing down. As the disease progresses, these tremors become typical and obvious when the person is at rest, decrease with conscious movement, and are totally absent during sleep. Emotional stress or fatigue often worsens the tremors. Later in the course of the disease, both sides of the body become affected. Tremor increases, the body becomes more rigid, and movements become slower. The face takes on a flat, open-mouthed, masklike expression, and eye blinking decreases in frequency. Speech slows and may be unclear. Swallowing may be affected. Many have trouble either starting to walk or stopping once they have begun. Gait changes, and the affected individual appears to lean forward and walk with short, shuffling steps that occur faster and faster until the person almost runs in an attempt to avoid falling. It is common for people with Parkinson's disease to fall both forward and backward, because with increasing rigidity they lose the ability to compensate for shifts in their center of gravity. In severe cases, the affected person may become extremely rigid and unable to move.

Changes in mental processes may accompany physical changes. Although intelligence is not consistently affected by the disease, as many as 50% of persons suffering from parkinsonism experience some form of **dementia** late in the disease. Personality changes, frustration, and depression are common.

Medical treatment aimed at decreasing the symptoms of Parkinson's disease includes medications such as levodopa (combined with carbidopa), amantadine, bromocriptine, and anticholinergic drugs. These medications may allow less severely affected individuals to function almost normally. Unfortunately, the effects of these drugs lessen over time, or the symptoms worsen. Various combinations of medications are often ordered to maximize benefit. Because stress worsens the symptoms, it is particularly important to minimize frustration and emotional upset in these individuals. Neurosurgery may be performed in selected situations to decrease tremors and enhance functional ability.

Dementia

Dementia is a general term for a permanent or progressive organic mental disorder. Dementia is characterized by personality changes; confusion; disorientation; deterioration of intellectual functioning; and impaired control of memory, judgment, and impulses. Dementia can be a result of drug intoxication, trauma, disease processes, hormonal imbalances, and vitamin deficiencies. Some forms are treatable and

reversible, particularly when an early diagnosis is made. Other forms do not respond to any known form of treatment. The most common form of dementia is Alzheimer's disease. Other forms include the following:

- **Vascular dementia,** or multi-infarct dementia, is the second most common form of dementia. It results from hemorrhage or ischemic brain lesions, is more common in men than in women, and is most common after age 70. Signs of depression are common, and sufferers may be suicidal. Onset of vascular dementia is sudden, as opposed to the gradual onset of Alzheimer's disease, and usually follows an episode of reduced blood flow to the brain tissue. Persons with hypertension or other types of cerebrovascular disease are most likely to develop this form of dementia. Risk for vascular dementia can be reduced by identifying and treating factors that contribute to the development of vascular disease, including high lipid (cholesterol) levels, elevated homocysteine levels, high blood pressure, smoking, and obesity.
- **Dementia with Lewy bodies** (DLB) is caused by microscopic deposits in the brain (Lewy bodies) that cause damage to nerve cells. In addition to classic symptoms of dementia, visual hallucinations are characteristic of this form of dementia. Many individuals with this form of dementia develop Parkinson-like symptoms, including slowness, limb and facial stiffness, and tremors.
- **Frontotemporal dementia,** formerly called *Pick's disease,* is a fairly uncommon form of dementia caused by the degeneration of the frontal and temporal lobes of the brain. This form of dementia is more likely to affect individuals under age 65.

Alzheimer's Disease

Alzheimer's disease (or **senile dementia, Alzheimer's type**), is the most common form of dementia and is typically seen in individuals older than 60 years of age. From age 65 onward, the incidence of Alzheimer's disease doubles approximately every 5 years. By age 85 as many as 50% of the population is affected. It is estimated that 4.5 million elderly men and women are affected in the United States and 24 million people worldwide. Researchers estimate that 81 million people worldwide will be affected by Alzheimer's disease or another form of dementia by 2040.

Cultural Considerations

Alzheimer's Disease

- Alzheimer's symptoms begin, on average, 7 years earlier in U.S. Latinos than in non-Latino whites. The incidence of Alzheimer's disease and related dementias in the Latino community is expected to increase dramatically during the first half of this century, rising from 200,000 today to over 1.3 million by 2050.
- A disproportionate number of African Americans suffer from Alzheimer's disease. African Americans were found to be three times more likely to develop Alzheimer's disease than Americans of European extraction. More accurate testing that is adapted to cultural differences provides better assessment of cognitive changes.
- Japanese-American men have a higher prevalence of Alzheimer's disease than do similar groups of men living in Japan. Among the Americans of Japanese descent, 9.3% were suffering from dementia of all causes and 5.4% had Alzheimer's disease.

Alzheimer's is a chronic, progressive, degenerative disease in which large numbers of brain cells and tissues are affected by atrophy, beta-amyloid plaques, and neurofibrillary tangles. The brain level of the neurotransmitter acetylcholine decreases, leading to a disturbed ability to reason and retain new information. Levels of norepinephrine and dopamine are also decreased in Alzheimer's disease.

The disease progresses from mild forgetfulness to a total loss of function. It is suspected that changes in the brain may begin up to 20 years before obvious symptoms are noticed. The disease follows a somewhat predictable course with increased severity of symptoms (see Box 10-5). The time from diagnosis to death ranges from the average of 8 years to more than 20 years (Figure 3-9). The financial and social costs of Alzheimer's disease are staggering, as evidenced by the following:

- The Alzheimer's Association and the National Institute on Aging estimate that the current cost of caring for individuals who suffer from Alzheimer's disease is at least $100 billion.
- An additional $65 billion is spent by businesses to cover the direct cost of health care, lost productivity, absenteeism, and worker replacement.
- The average lifetime cost of care for an individual with Alzheimer's disease is $174,000, although this may be higher in some parts of the country.

The cause of Alzheimer's disease is unknown. Some even question whether it is a single disease or whether varied forms exist. Extensive research is taking place

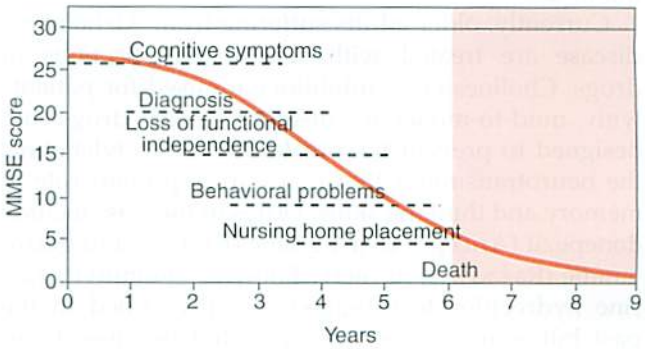

FIGURE 3-9 Typical Progression of Alzheimer's disease.

worldwide to identify a cause so that a cure can then be found. Genetics is believed to be a risk factor for the development of Alzheimer's disease. Children of people with Alzheimer's disease have four times the risk for developing the disease. The apolipoprotein E (ApoE) gene has been implicated as a risk factor; however, everyone has apolipoprotein E. It is estimated that about 15% of the population has the genetic form of ApoE, which increases the risk for Alzheimer's disease. The fact that a person has the affected gene does not mean that person will develop the disease, but the risk is greater.

Other factors implicated in Alzheimer's include inflammatory processes, immunologic changes, elevated glucose levels such as those found with diabetes, severe hypertension, and traumatic head injuries. In addition to physiologic factors, scientists are studying diet, exercise, educational level, social activity patterns, and environmental factors to determine whether any identifiable lifestyle factors may contribute to the problems or help reduce the incidence or severity of the disease.

Physical examination and laboratory tests are typically performed to rule out reversible causes of dementia such as **hypothyroidism** or vitamin B_{12} deficiency. Empirical diagnosis is made based on the evaluation of behavioral changes; psychometric testing to measure memory, attention, and problem solving; and brain scans such as CT or PET.

Until very recently, no definitive diagnostic test for Alzheimer's disease existed. The only way to confirm the diagnosis was a postmortem examination of the brain tissues. In 2010 researchers in Belgium identified specific proteins that could not only be used diagnostically, but also had a high predictive significance for the development of this form of dementia. Spinal fluid levels that are low in beta amyloid proteins and high in tau proteins are highly indicative of Alzheimer's. Identified changes in these protein levels may precede the first classic symptoms of the disease by a decade. These tests are still in the research stage and are not available to the public. Much more work needs to be done. These studies and others offer promise of earlier detection, better treatment, and hope for a cure for this devastating illness.

Currently, older adults suffering from Alzheimer's disease are treated with several classifications of drugs. Cholinesterase inhibitors are used for patients with mild-to-moderate disease. These drugs are designed to prevent the breakdown of acetylcholine, the neurotransmitter that plays an important role in memory and thinking skills. Drugs in the class include donepezil (Aricept), rivastigmine (Exelon), and galantamine (Razadyne, formerly known as Reminyl). Tacrine hydrochloride (Cognex) was prescribed in the past but is no longer recommended because it can cause liver damage.

Another drug, memantine (Namenda), has been approved to treat moderate-to-severe Alzheimer's disease. This drug is believed to work by regulating the level of glutamate, a neurotransmitter that helps the brain process, store, and retrieve information. Drugs specific to Alzheimer's treatment are often supplemented with antidepressants, anxiolytics, and antipsychotics, which are prescribed based on behavioral or psychotic symptoms that frequently coexist with Alzheimer's symptoms.

Alternative Treatments for Alzheimer's Disease. Vitamins C and E, coenzyme Q10, selenium, ginkgo biloba, hyperazine A, and coral calcium have been recommended as "natural" remedies for the treatment of Alzheimer's disease. Doses are varied and have not been evaluated by the Food and Drug Administration for effectiveness or safety. Additionally many of the elderly, particularly those diagnosed with Alzheimer's disease have lower than normal levels of melatonin. Melatonin, a hormone secreted by the pineal gland, plays a role in sleep rhythms. There is potential but limited evidence that melatonin, which is available over the counter, or possibly new drugs that have more targeted responses might provide some benefits by improving sleep patterns and decreasing the incidence of the behavioral changes seen at the end of the day called "sundowning." Since "natural" remedies can interact with prescription medication these substances should only be used under the direction of the physician.

Clinical trials are being conducted to determine the benefits of a passive vaccine containing manufactured antibodies designed to change blood levels of beta-amyloid. Other research is focused on a vaccine designed to use antibodies to directly attack beta-amyloid plaques. Yet another group of researchers have identified a compound called *AF267B* that they believe will affect both the plaque and tangles classically observed in Alzheimer's disease. Perhaps one of these research projects or some other scientific breakthrough will bring an end to the scourge of Alzheimer's disease.

Transient Ischemic Attack

Transient ischemic attacks (TIAs) are brief episodes of cerebrovascular insufficiency that are usually the result of obstruction of the cerebral blood vessels. Such obstruction is usually caused by an embolus or atherosclerotic plaque. TIAs occur most commonly in middle-aged and older people.

TIAs occur without warning. Most episodes last a few minutes only, but some may persist as long as 24 hours. A person may have several attacks within a day or may go for months without experiencing another attack. A variety of symptoms may indicate a TIA. Common symptoms include blurred, tunnel, or double vision; blindness; vertigo; transient numbness and weakness; aphasia or slurred speech; and gait

disturbances. The person generally remains conscious throughout the attack. The symptoms of TIAs disappear spontaneously and do not cause permanent neurologic damage.

TIAs may be warnings of an impending stroke, but this is not necessarily the case. Some individuals who suffer from TIAs never have a stroke.

Cerebrovascular Accident

A cerebrovascular accident (CVA), commonly called a *stroke*, is a disturbance of the blood supply to the brain. Most CVAs are related to atherosclerosis, hypertension, diabetes, or a combination of these. They can occur at any age, but they most commonly affect individuals older than age 65. CVAs are often fatal and are a leading natural cause of death in the United States. The likelihood of CVA fatality increases with advanced age. CVAs occur slightly more often in men than in women. African Americans are affected more often than other groups, possibly because there is a higher incidence of hypertension in the African-American population. Even when they are not fatal, CVAs are a leading cause of disability.

Several specific types of CVAs exist, categorized by the process that disturbs the blood flow: (1) cerebral infarction, caused by either an embolus or a thrombus, (2) cerebral insufficiency, resulting from atherosclerotic changes that restrict blood flow, or (3) cerebral hemorrhage, caused by weakened vessels or aneurysms that rupture spontaneously or as a result of hypertension.

If a CVA is suspected, care is directed at supporting essential life functions—maintaining an open airway, providing adequate oxygenation, and preventing trauma. Hospitalization is necessary during the acute post-CVA phase. The need for rehabilitation or extended care is determined by the physician and is based on the individual's particular situation. The onset of a CVA may be sudden, or symptoms may progress gradually. The nature of symptoms varies with the type of CVA, the area of the brain that is affected, and the extent of the damage (Boxes 3-6 and 3-7). Because the two sides of the brain serve very different functions, the symptoms depend on which side is affected. Effects of CVAs are contralateral: Damage to the right hemisphere affects the left side of the body; damage to the left hemisphere affects the right side of the body. Some individuals manifest mild symptoms, whereas in others the symptoms are more severe. A few victims of CVA recover completely, but most have some lingering deficits. Most improvement occurs within the first 6 months after a CVA. Any deficit lasting longer than 6 months is likely to be permanent. Recurrence of CVAs is common, and each occurrence is likely to cause additional problems.

Box 3-6 Signs and Symptoms of Right Brain Hemisphere Damage

- Left hemiparesis (weakness of the left arm and/or leg)
- Impaired sense of humor
- Disorientation to time, place, and person
- Difficulty recognizing people
- Visual/spatial problems, including loss of depth perception
- Neglect of the left visual field (may not see objects or hazards on the left side of body)
- Loss of impulse control (may strike out, cry, or shout if upset)
- Unaware of neurologic function loss (may try to stand or walk despite hemiparesis)
- Poor judgment (may deny illness or problems or tend to overestimate the ability to perform activities)
- Inappropriate responses (may smile continually or demonstrate euphoric behavior even in serious or tragic situations)
- Confabulation (may make up detailed but inaccurate explanations to compensate for memory losses, which can be very believable to persons who are not aware of the facts)

Box 3-7 Signs and Symptoms of Left Brain Hemisphere Damage

- Right hemiparesis (weakness of the right arm and/or leg)
- Language disturbances:
  Aphasia—defective or absent language skills that may be expressive (motor), in which words cannot be formed; receptive (sensory), in which language is not understood; or mixed, in which both processes are affected
  Agraphia—loss of the ability to write
  Alexia—inability to comprehend written words; reading problems
- Neglect of the right visual field (may not see objects or hazards on the right side of body)
- Behavior changes (slow, cautious, and anxious when attempting new activities)
- Mood changes (tendency toward worry or depression; verbalization of feelings of worthlessness or guilt; anger and frustration)

THE SPECIAL SENSES

The special senses, including sight, hearing, balance, smell, and taste, are integrally connected to the central nervous system by the cranial nerves. The other senses include touch, pressure, and proprioception, which is the awareness of body movement and position in space. These senses are the means by which we gather information from the world around us and about our relationship to this world. The special senses provide our first line of protection against hazards in the environment. Unless all of these senses function properly and provide us with good information, we are at risk for suffering from these hazards.

It is important to understand the visual and auditory changes that occur with aging, because these changes may have serious implications for safety. A great deal of the information in the world that we receive and respond to comes to us through our senses of sight and hearing. We may think older adults are confused or senile, when actually their sensory perceptions are merely impaired because of the changes associated with aging.

THE EYES

The **eyes** are two globe-shaped structures located in the orbits of the skull on each side of the nose. Because the eyes are so important, they have surrounding structures designed to protect them from both physical and biologic hazards.

The **eyelids** are controlled by skeletal muscle and are lined with a smooth mucous membrane called the **conjunctiva.** The eyelids can close; thus, they and the eyelashes located on their margins provide protection from dust and flying debris. Tears are produced by the **lacrimal glands** located at the upper and outer corners of the eye. These glands lubricate the eye, prevent particles of debris from scraping the surface, and inhibit the growth of bacteria by means of the enzyme **lysozyme.** Tears leave the eye at the medial corner through the **lacrimal sac** and the nasolacrimal duct that drains into the nose.

The eye itself is composed of three layers. The outermost layer, the **sclera** (commonly called the *white of the eye*), is composed of fibrous connective tissue and supports the inner structures of the eye. The anterior part of the sclera is the **cornea,** a transparent structure that **refracts,** or bends, light rays. The sclera contains small capillaries that are sometimes visible on its surface. The cornea does not contain any capillaries or nerves.

The middle layer of the eye, the **choroid,** contains pigments that absorb light and keep the interior of the eye dark. The choroid is highly vascular and supplies nourishment to the surrounding tissue. Located in the anterior portion of the choroid are the **iris** (the colored portion), the **pupil** (an opening in the iris through which light enters the eye), the **lens** (a transparent oval disk), and the **ciliary body** (muscles that change the shape of the lens to refract light waves). The lens does not contain any capillaries or nerves.

The innermost layer of the eye is the **retina.** This structure covers the posterior two-thirds of the eye and contains the visual receptors, highly specialized structures called **rods** and **cones.** These receptors use chemical changes in their pigments to detect light. Cones are most abundant near the center of the retina. They detect color and discriminate among different colors based on the wavelength of the incoming light. Rods are more abundant near the periphery of the retina and detect the presence or absence of light. Vitamin A is essential to the formation of the pigment in the rods that enables their response. Rods are important for vision when there is limited light. Nerves in the retina transmit messages from the rods and cones to the optic nerve, which sends the information to the vision centers of the brain. The macula lutea (yellow spot) is a small area, less than 2 mm in size, located near the center of the retina that provides us with sharp central vision.

The greatest part of the eye mass is made up of two fluid-filled cavities. The small **anterior cavity** is located between the cornea and the lens, and it contains **aqueous humor,** a fluid formed by capillaries in the choroid. This fluid passes from the **posterior chamber** through the pupil to the **anterior chamber,** and it supplies the nourishment for the lens and cornea, which do not have a blood supply. Because aqueous humor is produced continuously, some must be absorbed or the amount of fluid becomes excessive. Normally, absorption takes place through small veins located at the juncture of the iris and cornea. The presence of excess fluid increases the pressure within the anterior chamber. The posterior cavity of the eye, the **vitreous,** is much larger and contains a gelatinous substance called the **vitreous humor.** Vitreous humor holds the retina in contact with the choroid of the eye.

REFRACTION

The eye functions much like a camera. Light waves enter the eye through the cornea and then pass through the aqueous humor, lens, and vitreous humor to the retina. When light waves strike the retina, they stimulate the receptors in the cones and rods. The rods react chemically to the amount of light and regulate nerve impulses to the brain based on this information. Different cones respond to different wavelengths of light rays (different colors) and thus determine the perceived color of objects. Based on information gathered from the rods and cones, the image projected on the retina is translated into nerve impulses by the retina, which then sends the information through the optic nerves to the visual centers of the cerebral cortex in the **occipital region.** The optic nerves from both eyes meet at the **optic chiasm** just under the pituitary gland. At the optic chiasm, the medial fibers (from the image on the part of the retina closest to the nose) cross to the opposite side of the brain, whereas the lateral fibers (from the outside part of the retina) do not cross. This allows visual centers on both sides of the brain to process messages from both eyes and is important for binocular vision. Because of position, each eye "sees" things somewhat differently from the other and sends slightly different messages to the brain. The brain receives messages from both eyes, correlates the information, and makes sense of it. Binocular vision is also important for **depth perception,** the sense of how far you are from another person or object.

For information to be received accurately, all of the eye's structures must function together to focus the light rays. The shape of the lens is controlled by the ciliary body, whose muscles relax or contract to change the shape of the lens so that it can bend the light waves correctly and bring an object into clear focus. This change in lens shape is called **accommodation.**

EXPECTED AGE-RELATED CHANGES

Refractive errors, or errors in focusing ability, occur when the cornea is misshapen or when the lens cannot appropriately change shape to focus images.

With aging, many structural and functional changes may occur in the eye (see Table 3-9). The eyelids become less elastic and sag. Eyelashes tend to be shorter, thinner, and in some cases, absent. A grayish haze of the peripheral cornea, **arcus senilis** (Figure 3-10), develops with aging and is more common in dark-skinned persons.

FIGURE 3-10 Arcus senilis.

Legal blindness is defined as visual acuity of 20/200 or less in the worse eye, even with the best correction or a visual field extent of less than 20 degrees in diameter. Vision impairment is defined as having vision worse than 20/40 with correction. The rate of legal blindness and visual impairment increases significantly in later years of life, particularly after age 75. According to research done by the National Eye Institute, blindness affects blacks more than whites or Hispanics, whereas Hispanics have higher rates of visual impairment than people of other races.

Refractive errors are the most common visual problem in the United States. Most people older than 50 years of age experience some degree of farsightedness, also called *hyperopia* or *presbyopia,* which literally means "elderly eye." Refractive errors become increasingly common as the ciliary muscles lose their ability to contract easily, and progressive rigidity of the lens restricts accommodation. A combination of these changes makes it increasingly difficult to focus on close objects, perform detailed close work, or read. Presbyopia is usually corrected by the use of contact lenses or eye glasses that help the aging person focus on close objects. Laser surgery is also an option for some individuals.

Astigmatism, a malformation of the cornea, causes blurring of images at all distances. People of all ages can have astigmatism, but younger people compensate for it by quickly refocusing the blurred and unblurred images. When this ability decreases with aging, astigmatism appears to worsen. Corrective lenses help with this.

A decrease in tear production is common in older adults because the volume of body fluids and secretions decreases with age. An 80-year-old person produces only 25% of the tears he or she produced during the teenage years. Environmental factors such as central heating, dry climate, and wind or air pollution can further aggravate the problem. Many older adults complain of dry, burning, or itching eyes caused by friction from the lids or from small particles of debris. The decline in tear production also reduces the

Table 3-9 Vision Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased number of eyelashes	Increased risk for eye injury
Decreased tear production	Increased risk for eye irritation
Increased discoloration of lens	Decreased color perception
Decreased tissue elasticity	Increased blurring
Decreased muscle tone	Decreased diameter of pupil; increased refractive errors; decreased night vision; increased sensitivity to glare, decreased peripheral vision
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO VISUAL CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess for signs of irritation, inflammation, and dryness.	Encourage regular use of synthetic tear preparations to help reduce irritation due to inadequate tear production.
Assess visual acuity.	Encourage or schedule regular professional eye examinations. Educate regarding importance of adequate light with minimum glare. Explain importance of using eye glasses appropriately for reading or distance, particularly when driving.
Assess ability to detect objects within the environment.	Provide adequate lighting and contrast in colors to highlight important structures such as the edge of stairs, light fixtures, faucets, etc.

antibacterial protection provided by enzymes and can lead to decreased resistance to bacterial eye infections.

Older adults may have poor **dark adaptation** responses and may experience a decrease in the ability to adjust from light to darkness and darkness to light. **Night blindness,** the inability to see well at night or in dim light, grows increasingly common with aging.

Color vision and the ability to detect changes in color contrast are affected by aging. The lens of the eye tends to yellow with age, possibly leading to misperception of colors. All dark colors may be perceived as black, and subtle differences in shades may not be detectable. Younger people who find "blue-haired women" amusing should look at them through a lens that is slightly tinted yellow. Amazingly, the hair looks clean and white.

Peripheral vision and depth perception often decrease with aging. It is important to recognize these changes because they significantly increase the risk for accidents and injuries.

Another common occurrence with aging is **floaters.** Many older adults report seeing flecks, spots, cobwebs, or brilliant crystals within their eyes. These are harmless but can be frustrating because they interfere with many visual activities such as reading, sewing, or doing other detailed work.

COMMON DISORDERS SEEN WITH AGING

Blepharitis

Blepharitis, a chronic inflammation of the eyelids, is one of the most common disorders of the eye. Symptoms of blepharitis include burning, itching, and sensitivity to light. Discomfort is often worse on awakening. Blepharitis can be caused by *Staphylococcus* bacteria, by sebaceous gland dysfunction, or in conjunction with skin conditions such as seborrhea or rosacea. There is no definitive cure for this disorder, but treatment can reduce the severity of the problem. Common treatment includes the use of warm compresses, eyelid massage, lid scrubs, and the use of antibiotic ointments. Dietary intake of antioxidants has been proposed as being of some benefit.

Diplopia

Diplopia, or double vision, is not normal and indicates some disturbance of the nervous system that requires further investigation by a physician.

Cataracts

Cataracts, which cause a clouding of the lens of the eye, are increasingly common with aging. Studies done in the United States show that 5% of people between 52 and 62 years of age develop cataracts. By age 75 to 85, the incidence of cataracts increases to 46%. Factors that increase the risk for cataracts include (1) female gender, (2) sunlight exposure, (3) myopia, (4) steroid use, (5) tobacco exposure, (6) eye trauma, and (7) diabetes. Cataracts develop over time and result in progressive, painless loss of vision. The amount of vision loss depends on the degree of lens opacity and the area of the lens that is affected. Vision in bright light or glare may be particularly difficult with certain types of cataracts. Individuals with cataracts require frequent changes in eyeglass prescriptions while the cataract matures. When vision is severely affected, surgical removal of the cataract or the lens is the medical treatment of choice. Today, this surgery is common and, in most cases, can be performed on an outpatient basis. Once the cataract is removed, vision is corrected by means of surgically implanted lenses, contact lenses, or cataract glasses.

Glaucoma

Glaucoma is a disease characterized in most cases by increased fluid pressure (intraocular pressure) within the eye that may result in damage to the retina. Initially, peripheral vision is affected. Tunnel vision and, eventually, permanent blindness may result. The incidence of **glaucoma** increases with age. Additional risk factors include family history, diabetes, African-American ancestry, hypertension, and steroid use.

Persons with glaucoma seldom experience obvious symptoms, so serious damage usually occurs before the disease is even recognized. However, a test for increased intraocular pressure can be performed easily. The test for glaucoma is simple, painless, and takes only minutes. It is normally part of a routine ophthalmic examination, and everyone older than 40 years of age should be tested routinely for glaucoma. Early detection and treatment can delay progression of the disease. Medications, surgery, and laser therapy can be used to treat glaucoma, but any damage already done cannot be reversed.

Age-Related Macular Degeneration and Retinal Detachment

The **macula,** the small area in the center of the retina where visual acuity is best, is susceptible to damage and destruction. **Age-related macular degeneration** (AMD) occurs most often in people over age 50. The incidence of this disorder increases significantly after age 75 and is more common in women. It is more common in fair-haired, blue-eyed individuals and those who smoked or had excessive exposure to sunlight. The exact cause of macular degeneration remains unknown, but two types of the disorder have been identified. The atrophic form, also called *dry AMD,* is a result of inadequate nutrient supply or waste removal resulting from vascular changes. When cells atrophy or die, the macula is damaged and central vision is significantly diminished. Vision is restricted but not totally lost, because noncentral vision remains. Although not scientifically proven, antioxidants such as vitamins C and E,

beta carotene, lycopene, and zinc supplements appear to have some protective, if not therapeutic, benefits. Use of these substances, particularly in megadoses, should be done under the direction of a physician only.

The neovascular form of macular degeneration, also called *wet AMD,* results from abnormal growth of tiny blood vessels under the retina. These vessels ruin vision by leaking fluid and blood, which cause the retina to become swollen and distorted. This form is more likely to cause severe vision loss. Laser surgery or microsurgery may be attempted to seal leaking vessels, slow their growth, and prevent further vision loss.

Circulatory changes in the blood vessels of the eyes are common with DM, resulting in a condition called **diabetic retinopathy.** This condition is characterized by the hemorrhaging of small blood vessels into the vitreous humor and has effects similar to neovascular macular degeneration (i.e., loss of vision). Patients with diabetes are two to three times more likely to develop blindness resulting from retinopathy. Retinopathy is related not to age but rather to the severity and duration of hyperglycemia. More diabetic retinopathy is seen in older adults because of the higher incidence of diabetes with aging.

Normal shrinkage of the eye and changes in the consistency of the vitreous humor are common with aging and may result in **retinal detachment,** which is the separation of the retina from the choroid. Any or all of these changes can result in the loss of central vision.

THE EARS

The ear is composed of three distinct portions: **outer ear, middle ear,** and **inner ear.** The two main functions of the ear are the detection of sound and the maintenance of balance.

The outer ear consists of the visible curved structure, called the **pinna,** or **auricle,** and the **external ear canal.** The pliable auricle is made of cartilage. The size or shape of the external ear has little influence on hearing.

The middle ear begins at the **eardrum,** or **tympanic membrane.** This transparent membrane stretches across the end of the ear canal and separates it from an air-filled chamber called the **middle ear.** Air pressure in the middle ear is controlled through the **Eustachian tube,** which connects the middle ear to the nasopharynx. Attached to the tympanic membrane is a series of three small bones, the **malleus** (hammer), **incus** (anvil), and **stapes** (stirrup). Sound waves enter the ear through the external ear canal and cause the tympanic membrane to vibrate. This, in turn, causes movement of the three small bones, which then transmit the vibrations to the **oval window,** the opening into the inner ear.

The inner ear is a complex, fluid-filled structure that has several functions. A portion called the **cochlea** contains the hearing receptors, which consist of hair cells with fine movable projections that are set in motion when sound waves reach their fluid surroundings. When these hairs move, impulses are carried through the auditory nerve (a cranial nerve) to the midbrain and then to the temporal lobe of the brain, where the sound is heard.

Other specialized hair cells are found elsewhere in the inner ear: the vestibule and the **semicircular canals.** Hair cells from these structures transmit information in response to gravity, change of position, and motion through the cranial nerves. The central nervous system processes this information and maintains equilibrium.

EXPECTED AGE-RELATED CHANGES

Just as other body tissues become thinner with age, so does the tympanic membrane (Table 3-10). The small muscles that support the membrane show signs of atrophy with advanced age. Arthritic changes affect the joints between the small bones of the middle ear, and hair cells in the inner ear often deteriorate.

Table 3-10 Auditory Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased tissue elasticity	Decreased ability to distinguish high-frequency sounds
Decreased joint mobility	Decreased hearing ability
Decreased ceruminous cells in external ear canal	Increased risk for cerumen impaction causing conductive hearing loss
Atrophy of vestibular structures and in the inner ear	Increased problems with balance; decreased number of hair cells
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO AUDITORY CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess hearing and balance.	Refer for audiometric testing as needed.
Inspect ear canal for cerumen impaction.	Administration of prophylactic drops may reduce likelihood of impaction formation. Irrigation may be needed if impaction is present.
Assess functioning of hearing aid if used.	Check that batteries are working and that device is not plugged with cerumen. Keep an amplifying device on each patient care unit to use with hard of hearing individuals who do not have a functional hearing aid.
Assess for social isolation or behavioral background noise.	Encourage socialization in areas without excessive changes.

Presbycusis, defined as an alteration in the hearing capacity related to aging, affects an estimated 13% of people older than 65 years of age. Men appear to be more affected by this problem than women. The aging person with presbycusis loses the ability to perceive tones of higher frequencies. Speech sounds such as *s, sh, ch,* and soft *t* may not be audible, so the aging person may hear only parts of spoken words. Simple words such as *cat, hat, sat,* and *that* may all sound the same. If other noises are present in the environment, sounds become even less distinct. The aging individual may have difficulty sorting out words and making sense of what is being said.

COMMON DISORDERS SEEN WITH AGING

Otosclerosis

Otosclerosis, a hardening or fixing of the stapes to the oval window, interferes with sound wave transmission into the inner ear. This condition occurs slightly more often in women than in men. Surgical correction is possible.

Tinnitus

Tinnitus, or ringing in the ears, is commonly reported by aging people. Tinnitus may be a result of trauma to the ear, pressure from cerumen against the eardrum, otosclerosis, presbycusis, or Ménière's disease. Tinnitus can also be caused by certain medications.

Deafness

Deafness, the inability to hear sounds fully, may be temporary or permanent, depending on the cause. Deafness can be unilateral, affecting one ear only, or bilateral, affecting both ears.

Conductive hearing loss occurs when something interferes with transmission of the sound waves. A plug of **cerumen** (earwax) in the external canal, rupture or scarring of the eardrum, the presence of fluid or an infection in the middle ear, or any condition that interferes with movement of the small bones of the middle ear may result in conductive hearing loss or deafness.

Nerve or sensorineural deafness occurs when either the receptors in the inner ear or the cranial nerves are damaged or destroyed. Some antibiotics and viral infections can cause nerve deafness. Chronic exposure to loud noise can speed up the degeneration of the hair cells. Many young people today are experiencing significant hearing loss from excessive exposure to extremely loud music, and this will have serious implications as they age. Work-related noise has also been shown to have negative effects on hearing. Many aging individuals who worked in foundries or other noisy places may have suffered employment-related hearing loss. The Occupational Safety and Health Administration now requires employers to protect employees from excessive exposure to loud noise on the job.

Central deafness is caused by trauma or disease in the temporal lobes of the brain. This may be a result of tumors, CVA, or injury. Central deafness is not common.

Ménière's Disease

Ménière's disease is a fairly common chronic disorder of the inner ear observed in people older than 40 or 50 years of age. Persons suffering from this disorder experience severe vertigo (not simple dizziness) to the point that they may be unable to stand or walk. They may also report nausea, tinnitus, hearing loss, and a sensation of pressure in the ear. Diaphoresis, vomiting, and **nystagmus** (rapid, involuntary eye movement) may also be observed. Episodes generally appear suddenly and may last for minutes or hours. The frequency of attacks is unpredictable. Ménière's disease tends to affect one ear, and it can result in nerve deafness that sometimes persists even if treatment relieves the other symptoms.

TASTE AND SMELL

The receptors for our sense of taste are located in the papillae, or taste buds, on the superior surface of the tongue. In these papillae are chemical receptor cells that are sensitive to salty, sweet, sour, and bitter chemicals. When mixed with moisture such as saliva or water, food releases chemicals that are detected by these receptors. Foods get their subtle flavors by their unique interaction with various receptors. The detection of odors occurs when the olfactory receptors in the upper nasal cavities respond to airborne chemicals. When vapors escape from food or other volatile substances, they enter the nose and stimulate the receptors.

Information from both taste and smell receptors is then transported to the nervous system through the cranial nerves. When these senses are intact and functioning well, many people salivate and can "taste" a meal while it is being prepared. Without a sense of smell, food has little flavor. Most of us have had severe nasal congestion from colds or allergies, and have found that without smell, food has either a strange taste or no taste at all. Some individuals with chronic nasal congestion report ongoing problems with appetite because food has little flavor or appeal. People with permanent damage to the olfactory senses report a permanent change in taste (hypogeusia) that often results in a loss of appetite. Alterations in taste sensation may also be a side effect of brain tumors, gingival disease, periodontitis, systemic disorders such as DM or hypothyroidism, and medications. Research is being conducted to determine the correlation between loss of smell and the onset of Alzheimer's disease.

Table 3-11 Olfactory Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased number of papillae on tongue	Decreased ability to taste
Decreased number of nasal sensory	Decreased ability to receptors and to detect smells
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO OLFACTORY CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess ability to smell and taste.	Teach importance of storing food properly. Keep drugs and chemicals separated from foods.

EXPECTED AGE-RELATED CHANGES

With aging, there is a decrease in the number of functional receptors in both the nasal cavities and papillae on the tongue (Table 3-11). By age 60 it is estimated that half of adults will experience some alteration in smell and taste. The changes in taste particularly affect the receptors for sweet and salty tastes. Because salt enhances the flavor of food, older adults often add salt in an attempt to add flavor. Complaints of flavorless food are common even if the food seems well seasoned and tasty to younger individuals. Good oral hygiene, better food preparation, and flavor enhancers are sometimes helpful in improving taste.

The term **burning mouth syndrome** is used to describe the oral sensation of burning or tingling. This may be associated with a vitamin B deficiency, inadequate saliva production, allergies, GERD, trauma, and diabetes.

THE ENDOCRINE SYSTEM

The endocrine system and the nervous system perform the major integrating and regulating functions of the body. The endocrine glands secrete chemical substances called **hormones** to regulate body processes. Hormones are secreted directly into the capillaries of the bloodstream, where they circulate until they reach their target organs and cause specific effects. Some endocrine glands produce a single hormone; others produce several different hormones. Some hormones have one target organ only; others target multiple organs. The production of hormones is regulated by a negative feedback process in which the endocrine glands constantly monitor the effects of hormones circulating in the system. If the effect is adequate, the gland decreases production. If it is inadequate, the gland increases production. The process of regulation is similar to a system consisting of a thermostat and a furnace in a home. When the temperature reaches that for which the thermostat is set, the thermostat signals the furnace to stop producing heat. If the temperature drops below the preset level, the thermostat signals the furnace to produce more heat. In a highly complex manner, the endocrine glands constantly monitor the effects and the levels of the many hormones circulating in the body and increase or decrease production as needed to meet body demands.

PITUITARY GLAND

The pituitary gland is often referred to as the *master gland* of the body because of the many functions it regulates. It is located within the skull cavity and is connected directly to the hypothalamus. There are two major segments of the pituitary gland: the **anterior pituitary** and the **posterior pituitary.** The posterior pituitary is the site of connection between the nervous system and the endocrine system. The posterior pituitary hormones are actually produced in the hypothalamus of the brain and are stored in the posterior pituitary until needed. The major secretion of the posterior pituitary gland is the **antidiuretic hormone.** This hormone maintains fluid balance in the body by causing the kidneys to reabsorb fluid; in the absence of the antidiuretic hormone, the kidneys excrete more fluid. By controlling fluid balance, the antidiuretic hormone aids in the maintenance of blood pressure. Oxytocin, another hormone of the posterior pituitary gland, stimulates the contraction of the uterus during childbirth and ejection of milk from the breast during lactation.

The anterior pituitary produces many hormones. **Growth hormone** increases the rate of protein synthesis and aids in the transport of amino acids to cells. In adults, this hormone also participates in fat release from adipose tissue and the use of this fat as an energy source. **Thyroid-stimulating hormone** stimulates the normal growth and activity of the thyroid gland. Adrenocorticotropic hormone (corticotropin) stimulates the activity of the adrenal cortex. **Gonadotropic hormones** include follicle-stimulating hormone and **luteinizing hormone,** which are responsible for the maturation and function of the gonads, and **prolactin,** which supports lactation.

THYROID GLAND

The **thyroid gland** surrounds the trachea and is located just below the larynx (voice box). The major hormones produced by the thyroid gland are **thyroxin,** triiodothyronine, and **calcitonin.** The thyroid hormones triiodothyronine and thyroxin increase the rate of metabolism; regulate the metabolism of fat, carbohydrates, and protein in the cells; and increase body temperature. They also affect cardiac, neurologic, and musculoskeletal functions. The function of calcitonin is to keep calcium and phosphate within the bone matrix.

PARATHYROID GLANDS

The **parathyroid glands** are located on the posterior surface of the lobes of the thyroid gland. **PTH,** an antagonist of calcitonin, stimulates the movement of calcium and phosphorus from the bones into the blood.

PANCREAS

The **pancreas** is both an exocrine and an endocrine gland. It functions as an exocrine gland during digestion. The endocrine secretions of the pancreas are produced by α cells and β cells in the islets of Langerhans. The α cells produce glucagon, which stimulates the liver to convert glycogen to glucose. The β cells produce insulin, which increases the permeability of cell membranes and enables the cells to use glucose, amino acids, and fatty acids.

ADRENAL GLANDS

The **adrenal glands** are located on the top of each kidney. The **adrenal medulla** is the inner portion of the gland, and the **adrenal cortex** is the outer portion. The adrenal medulla secretes **epinephrine** and norepinephrine, which are the major neurotransmitters of the sympathetic portion of the autonomic nervous system. Thus, hormone release from the adrenal medulla has effects similar to those of the sympathetic nervous system. These hormones help the body cope with stressors by decreasing functions that are not required for the fight-or-flight response and by increasing cardiac activity, blood pressure, release of energy reserves, and other functions necessary for survival when faced with danger.

The adrenal cortex releases **mineralocorticoids, glucocorticoids,** and small amounts of sex hormones. The mineralocorticoid aldosterone is important in the regulation of fluid and electrolyte balance and the maintenance of blood pressure. The glucocorticoid **cortisol** is involved in the conversion of glycogen to glucose and in antiinflammatory activities. DHEA, dehydroepiandrosterone, is a hormone that the body can convert into estrogen and testosterone. Production of this hormone increases dramatically at puberty and peaks in the mid twenties. Levels then decrease over the years so only about 20% remains by age 70. Use of this hormone and its analog DHEA-S, dehydroepiandrosterone sulfate, has been evaluated as possible treatment for aging or at least for some of the negative consequences of aging. Most scientific studies have shown no significant benefits.

OVARIES AND TESTES

The **testes** and **ovaries** secrete the hormones involved in sexual maturation and function. The primary hormones secreted by the ovaries are **estrogen** and progesterone. These hormones are responsible for maturation of the ova, stimulation of the uterine endometrium, and the development of the secondary female sexual characteristics. The testes secrete the major male sex hormone, **testosterone,** which is responsible for the maturation of sperm and for the development of the secondary male sexual characteristics.

EXPECTED AGE-RELATED CHANGES

With aging, a variety of changes occurs in the endocrine function (Table 3-12). The pituitary gland continues to produce adequate levels of critical hormones throughout life. It produces less growth hormone as we age, leading to a decrease in muscle mass. In recent studies, the growth hormone was administered to older men, who then showed significant increases in muscle mass. Growth hormone is expensive, may have undesirable side effects, and is currently an investigational drug.

A decrease in the production of thyroid-stimulating hormone is seen in some older adults. Basal metabolic rate begins to decrease in young adulthood and continues to decrease gradually throughout the remainder of life. Because lean body mass also decreases, the overall metabolic rate does not change significantly. In response to a decreased thyroid function, some older people become more sensitive to cooler temperatures.

Table 3-12 Endocrine Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Decreased pituitary secretions (growth hormone)	Decreased muscle mass
Decreased production of thyroid-stimulating hormone	Decreased metabolic rate
Decreased insulin production or increased insulin resistance	Increased risk for type 2 diabetes mellitus
Decreased production of parathyroid hormone	Increased blood calcium levels (seen with osteoporosis)
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO ENDOCRINE CHANGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Monitor laboratory values, paying special attention to minerals such as calcium and sodium levels and blood glucose.	Educate patient regarding dietary needs and self-testing of blood glucose.
Assess for body temperature, weight, hair distribution or behavioral changes which may indicate endocrine imbalance.	Notify physician of assessment findings.

Studies of parathyroid function reveal conflicting information. PTH appears to decrease with age, except in cases of osteoporosis, where it appears to increase. Elevated levels of PTH may lead to increased blood calcium levels. This is of concern particularly for older women, who may manifest symptoms of confusion, kidney stones, and osteoporosis.

Pancreatic function appears to decrease with aging; however, barring the onset of some form of DM, its function remains adequate to meet normal body functioning.

Adrenal function is not altered significantly with advancing age. Adequate hormone levels are produced to meet bodily needs.

The levels of gonadotropic hormones decrease more significantly in women than in men. After menopause, estrogen and progesterone production drops significantly. As the production of female sex hormones decreases with aging, some changes in secondary sexual characteristics may be observed, such as the development of facial hair and genital atrophy. Studies indicate that estrogen depletion in postmenopausal women has negative effects on bone density, cardiovascular function, memory, and cognition (see the Complementary and Alternative Therapies box). Because production of the male hormone testosterone decreases gradually with aging, changes are gradual and often indistinguishable.

Complementary and Alternative Therapies

Hormone Replacement Therapy and Human Growth Hormone

Research is being done to determine the safety and effectiveness of various hormone replacement therapies (HRTs) in slowing or reversing common physiologic changes seen with aging. Estrogen replacement therapy, long thought to prevent cardiac problems and osteoporosis, vaginal discomfort, and skin changes in women, has recently come under scrutiny. Research shows that HRT does not protect the heart as once believed (American College of Obstetricians and Gynecologists, 2002). In fact, it has been shown to increase the risk for many problems, including the following:

- Cardiac disease
- Blood clots
- Liver and gallbladder disease
- Hypertension
- Cancer

Human growth-hormone therapy, which can cost up to $15,000 per year, has been marketed as a "cure" for aging. Proponents say that it is a veritable "fountain of youth" that provides the following benefits:

- Increased muscle mass
- Increased bone mass
- Improved energy by expanding cardiac and pulmonary function
- Extended life span

In fact, some propose that growth-hormone replacement therapy should start earlier in life to produce maximal benefits. Opponents state that this therapy is not a panacea. They believe it is essential to consider the risks and side effects of growth-hormone therapy, which include the following:

- Fluid retention
- Increased blood pressure
- Increased incidence of cancer

Use of hypothalamic hormones is now under study, but no conclusive information is available.

Supplementary use of DHEA and DHEA-S has shown little or no conclusive evidence of anti-aging benefits. Short-term use has not shown significant adverse effects but long-term use has not been proven safe. A physician should be consulted before use.

COMMON DISORDERS SEEN WITH AGING

Diabetes Mellitus

The incidence of DM increases with age. The likelihood of acquiring diabetes doubles with each decade of life. The American Diabetes Association cites that in 2009 about 23% of persons older than 60 years of age have diabetes, primarily type 2. Other studies indicate that 43% of those diagnosed with diabetes were older than age 85.

DM is a disease with multiple causes that is characterized by abnormal metabolism of carbohydrates, protein, and fats, resulting in elevated plasma glucose levels. Long-term complications include retinopathy (resulting in a loss of vision), nephropathy (resulting in renal failure), peripheral neuropathy (resulting in foot ulcers and amputation), autonomic neuropathy (resulting in GI, genitourinary, and cardiovascular symptoms and sexual dysfunction), atherosclerotic vascular problems (resulting in an increased incidence of cardiovascular, cerebrovascular, and peripheral vascular disease), hypertension, cognitive changes, and periodontal disease.

The most current classification system categorizes DM according to its etiology, or cause. The first category, **type 1** diabetes mellitus, is defined as being a result of either autoimmune destruction of the β cells of the pancreas or unknown idiopathic causes. The second category, **type 2** diabetes mellitus, results from a combination of resistance to insulin action and inadequate compensatory insulin secretion. In the third category, **other specific types** of DM are identified by their unique etiologies, including genetic defects or syndromes, exocrine diseases of the pancreas, diseases of the endocrine system, drugs or chemicals, infections, or other uncommon immune-mediated disorders. A fourth category, **gestational** diabetes mellitus, exists only during pregnancy. This classification system replaces the older system (insulin-dependent diabetes mellitus, or IDDM, and noninsulin-dependent diabetes mellitus, or NIDDM), which was based on the treatment method used.

Diagnosis of DM is made based on symptoms and on the determination of elevated plasma glucose levels. A casual (no specific relation to meals) plasma glucose level of 200 mg/dl or higher, particularly

when symptoms are present, warrants further testing. This can be done using the oral glucose tolerance test or the fasting plasma glucose (FPG) level (no calorie intake for at least 8 hours). The FPG level is the more commonly accepted test because it is less costly and less time-consuming. FPG levels less than 110 mg/dl are classified as normal. FPG levels between 110 and 126 mg/dl are classified as impaired fasting glucose. FPG levels of 126 mg/dl or higher warrant a provisional diagnosis of diabetes. Abnormal results must be confirmed on a subsequent day to make the diagnosis.

Type 1 Diabetes Mellitus. Type 1 DM can occur at any age, but its onset is usually before age 25. Approximately 10% to 15% of people with diabetes have type 1 DM. Type 1 DM typically has a sudden onset, but it may occur slowly, depending on the rate at which the pancreatic β cells are destroyed. People suffering from type 1 DM produce little or no insulin because of β-cell destruction. Absolute lack of insulin production results in excessively high levels of glucose in the blood (hyperglycemia) and leads to the classic symptoms of diabetes. Symptoms include **polyuria** (excessive and frequent urination), **polydipsia** (excessive thirst), and **polyphagia** (excessive appetite). Even with increased food and fluid intake, the person with type 1 DM may lose weight.

The patient with type 1 DM is prone to further metabolic problems. When the body is unable to use glucose because of inadequate insulin production, starvation at the cellular level occurs. The body may attempt to meet cell needs by using fat or muscle as a source of fuel. This results in an accumulation of **ketones** (by-products of incomplete metabolism of fatty acids) in the bloodstream. As the blood ketone level increases, the acid-base balance is altered, the blood becomes too acidic, and a condition called **ketoacidosis** occurs. The body attempts to maintain acid-base balance through the compensatory systems of the kidneys and lungs. When a severe imbalance occurs, **ketonuria** may occur, and acetone (or "apple pie") breath may be detected. Severe acidemia can result in a deep and rapid pattern of breathing called **Kussmaul's respirations.** If not recognized and treated, type 1 DM results in death.

Type 1 DM requires continuous, careful monitoring and medical supervision. Treatment involves a careful balance of diet, insulin therapy, exercise, and stress management. Each patient requires an individualized program that meets his or her particular needs.

Changes in diet or activity, infections, and stress can easily cause problems for the patient with type 1 diabetes. The plasma glucose levels of a patient receiving insulin therapy must be monitored closely. Plasma glucose levels may be determined by the laboratory or by a variety of self-testing devices. Any significant changes in plasma glucose levels should be reported promptly to the physician.

Patients with type 1 diabetes who live independently must be taught the importance of following the prescribed balance of diet, insulin, and exercise. They should be strongly urged to call the doctor immediately if they have any signs of infection, particularly any infection that results in vomiting. Special medical identification bracelets or necklaces are advisable. Such devices can help ensure that proper care is provided in emergencies.

Type 2 Diabetes Mellitus. The form of DM that is most often observed in older adults is type 2 DM, which accounts for 85% to 90% of all persons with diabetes. This form of DM is more commonly observed in individuals who are older than 40 years of age, who are obese, or whose family history includes type 2 DM. The symptoms of type 2 DM are usually mild and unrecognized by an aging person. Diagnosis often occurs during routine medical visits or when the person seeks medical attention for visual disturbances, delayed wound healing, or recurrent vaginal or yeast infections.

With type 2 DM, the individual may have normal or even elevated levels of insulin. Despite these normal levels, glucose does not enter the cells normally. It is suspected that a problem with the receptor sites on the cells prevents normal cellular functioning in these individuals.

Physicians prefer to control type 2 DM by dietary means. Weight loss is encouraged because it often results in a spontaneous decrease in plasma blood glucose levels. If diet alone is not successful, oral hypoglycemic agents may be prescribed. When under physical stress resulting from infection or surgery, persons with type 2 DM may experience abnormally high plasma glucose levels. In these cases, the classic symptoms of DM may occur, and the person may require insulin administration to maintain normal plasma glucose levels. Once these levels are normal and the stressor is removed, insulin administration is typically discontinued. Plasma glucose levels should be monitored frequently to ensure that they remain within normal limits.

Long-term glycemic control is monitored using the glycated hemoglobin A1C. An A1C of 7% or less is desirable. Good glucose control has been shown to reduce the risk of vascular complications.

Hypoglycemia

Hypoglycemia is a potentially serious problem for people receiving insulin or oral hypoglycemic agents. Classic signs of hypoglycemia include headache, nausea, weakness, tremors or trembling sensations, pallor, anxiety, irritability, tachycardia, sweating, and hunger. Many of these symptoms can be easily missed or misinterpreted in the older adult population. If hypoglycemia is suspected, the plasma glucose level should be measured promptly. Treatment is based on the specific plasma glucose level. Those with levels of

40 to 60 mg/dl respond best to foods such as milk and crackers, and those with levels of 20 to 40 mg/dl respond best to refined carbohydrates such as honey, juice, or sugar. If unconscious, the patient is treated with an intramuscular injection of glucagon or an intravenous infusion of 50% glucose. Individuals who are prone to hypoglycemia should be taught to carry a carbohydrate source, such as hard candy or glucose tablets.

Hypothyroidism

Reduced function of the thyroid gland, called *primary hypothyroidism,* is more common in older than in younger persons. The symptoms of hypothyroidism include cold intolerance, dry skin, dry and thin body hair, constipation, depression, and lack of energy. Because many of these changes are commonly observed with aging, the changes may not be recognized as signs of hypothyroidism. Diagnosis is made by means of blood tests. Treatment of hypothyroidism with very high levels of thyroid hormone has been shown to reduce bone density in older women but not in older men.

THE REPRODUCTIVE AND GENITOURINARY SYSTEMS

In both men and women, the genital and urinary systems are located close to each other. As mentioned previously, many structures in men are used for both the sexual and elimination functions. In women, the structures of elimination are completely separate from those of reproduction.

FEMALE REPRODUCTIVE ORGANS

The primary female sexual organs include the **ovaries, fallopian tubes, uterus,** and **vagina.** These structures, which are necessary for normal human reproduction, are located in the pelvic cavity between the bladder and the bowels. It is important to visualize their location to understand the symptoms that may occur if the size, shape, or position of these organs changes. During the reproductive years, the ovaries produce the hormones estrogen and progesterone. Under the influence of these hormones, the ova mature in the ovaries, and the endometrium of the uterus changes in vascularity to support a possible pregnancy. When a woman reaches menopause (sometime between 45 and 60 years of age), the hormonal function of the ovaries decreases and then ceases. This physiologic timing of the end of reproduction probably developed because it increased the likelihood that the mother would live to see her children reach maturity. Recent technology and extensive medical intervention can allow pregnancies to occur after menopause, but the number of women who choose to become pregnant this late in life is probably not significant. Most women who reach menopause are either resigned or delighted to reach the end of the reproductive stage.

MALE REPRODUCTIVE ORGANS

The male organs of reproduction consist of the **testes,** a series of ducts and glands, and the **penis,** which contains the passageway by which **sperm,** the male sex cells, leave the body in the **ejaculate.** The testes are suspended in a tissue sac called the **scrotum,** which hangs between the thighs. The testes produce the hormone **testosterone,** which is responsible for the production and maturation of sperm. Testosterone is also responsible for the secondary sex changes in men, including body hair patterns, voice changes, and muscle development. A series of ducts and glands provides additional fluid volume to the ejaculate and adds nutrients needed for sperm maturation and development. The **prostate gland** is located just below the urinary bladder. The prostate produces an alkaline secretion that increases sperm motility, and it contracts to aid in the ejaculation of sperm.

EXPECTED AGE-RELATED CHANGES

Changes in Women

Several significant changes occur with menopause (Table 3-13). Production of progesterone and estrogen diminishes. There is no longer the need to produce ova to be fertilized, and there is no need to prepare a site to support a pregnancy. Other changes related to the decline in hormones are not as desirable. Along with other body tissue, the tissues of the external female reproductive organs atrophy as a result of vascular changes. The tissues of the reproductive organs become less elastic, and the amount of subcutaneous tissue decreases. This results in a flattening of the tissue of the external genitalia, or labia, and often the amount and distribution of pubic hair decreases. Vaginal epithelial tissue becomes thinner and less vascular. The tissue of the vagina is drier and more alkaline, and fewer **rugae** (folds) are present within the vagina. The uterus, cervix, ovaries, and fallopian tubes decrease in size and may be difficult to palpate on examination. The decrease in hormone production and resulting tissue changes may lead to more fragile, more easily irritated vaginal tissue. Decreased vaginal secretions may lead to **vaginitis,** which can cause vulvar soreness and pruritus or painful intercourse (called **dyspareunia**). Once menopause has occurred, vaginal bleeding is considered abnormal. Older women who receive estrogen supplements may experience fewer reproductive tissue changes, and, in some cases, the lining of the uterus responds to these supplemental hormones. Vaginal bleeding may occasionally be observed in these women.

The breasts are part of the secondary female sexual organs. Because of the decrease in hormones with aging, breast tissue atrophies. As supporting muscle tissue atrophies, the breasts tend to sag and decrease in size.

Table 3-13 Reproductive Changes Associated With Aging

PHYSIOLOGIC CHANGE	RESULTS
Female	
Decreased estrogen levels	Decreased vaginal secretions
Decreased tissue elasticity	Decreased pubic hair; increased vaginal tissue fragility; increased tissue irritation; decreased size of uterus; decreased vaginal length and width; decreased size of vaginal opening; increased pain with intercourse (dyspareunia); decreased breast tissue mass
Increased vaginal alkalinity	Increased risk for infection
Male	
Decreased testosterone levels	Decreased amount of facial and pubic hair
Decreased circulation	Decreased rate and force of ejaculation; decreased speed gaining an erection
NURSING ASSESSMENTS AND CARE STRATEGIES RELATED TO REPRODUCTIVE CHARGES	
NURSING ASSESSMENTS	**CARE STRATEGIES**
Assess for signs and symptoms of infection or inflammation.	Report unusual vaginal discharge to physician. Administer treatment as prescribed.
Assess factors that may interfere with sexual activity.	Discuss normal physiologic changes and the possible effects of medications on sexual function. Educate females regarding use of artificial lubrication. Possible referral of males to physician for pharmacologic treatment of erectile dysfunction.

Changes in Men

Male age-related changes in the reproductive system are less noticeable because testosterone continues to be produced into old age, although the amount tends to decrease. Men even in their late eighties have successfully fathered children.

With aging, there is some change in the size and firmness of the testes. The penis retains the ability to become erect, although it may take longer and require more stimulation. Once achieved, erection may last longer than at a younger age. Ejaculations tend to be slower and less forceful in aging men and may not occur during each sexual encounter, particularly if intercourse is frequent.

Enlargement of the scrotum may indicate problems with the testes or part of the duct system. The penis should remain free from any tissue changes, and the presence of ulcers, nodules, or other changes is abnormal. The prostate gland commonly enlarges with age. Most aging men experience some degree of prostate enlargement. The signs and symptoms most often experienced include urinary frequency, hesitancy, dysuria, decreased force when voiding, dribbling, nocturia, increased incidence of UTIs, and decreased force during ejaculation. In cases of **benign prostatic hyperplasia,** surgical intervention such as a **transurethral prostatectomy** may help reduce the symptoms.

COMMON DISORDERS SEEN WITH AGING

Uterine Prolapse

Prolapse of the uterus (into the vagina) is commonly observed in older women. This is particularly a problem for those who have had many pregnancies or for those who delivered children with little medical assistance. Most often, the first signs of uterine prolapse involve changes in either urine or bowel elimination. Urinary frequency, urinary retention, recurrent UTIs, back pain, and constipation may be symptoms. In some cases, the cervix and uterus may prolapse through the vagina and be observed protruding outside of the vulva. Surgical correction of this condition may be required.

Vaginal Infection

Change in vaginal pH may lead to increased incidence of vaginal infections, particularly **yeast infections.** This is most often manifested by increased vaginal discharge, irritation, odor, and itching.

Breast Cancer

The risk for **breast cancer** does not disappear with increased age. Breast cancer continues to be a major cause of cancer deaths in women, and the incidence of this form of cancer continues to increase with age. It is important that regular breast examinations (including mammography) continue as a woman ages. Any sign of dimpling; masses; nipple retraction; or breast drainage, discharge, or bleeding is suspicious and requires further medical attention.

Prostate cancer

There are no obvious changes in function to indicate the presence of **prostate cancer.** Therefore, it is important for aging men to have regular medical examinations. A skilled physician who palpates the prostate may detect changes that indicate malignancy. Prostatic cancer is a major cause of death in aging men.