accountable for addressing a large majority of personal healthcare needs, developing a sustained partnership with patients, and practicing within the context of family and community."[5]

- *Secondary care*. Provided by PTs in a wide range of settings, including acute care and rehabilitation hospitals, outpatient clinics, home health, and school systems.
- *Tertiary care*. Provided by PTs in highly specialized, complex, and technology-based settings (e.g., heart and lung transplant services, burn units) or in response to the requests of other healthcare practitioners for consultation and specialized services (e.g., for individuals with spinal cord lesions or closed head trauma).

PTAs, under the direction and supervision of the PT, are the only individuals who assist a PT in the provision of selected interventions.

☑ KEY POINT

The APTA House of Delegates (HOD) first authorized the training of PTAs at the 1967 Annual Conference by adopting the policy statement *Training and Utilization of the Physical Therapist Assistant*. In 1977, the Commission on Accreditation in Education (CAE), the precursor to the Commission on Accreditation in Physical Therapy Education (CAPTE), was established and recognized by the U.S. Department of Education and by the Council on Postsecondary Accreditation. The activities of the CAE included accreditation of programs for PTAs.

☑ KEY POINT

Supervision of the PTA is governed by several factors including the following:

- APTA standards.
- Individual state and federal laws regulating practice acts, including administrative rules for practice. Supervision of the PTA may be spelled out separately from other support personnel, or the PTA may be included in language that defines supervision for all support personnel. When state laws do not delineate supervision requirements, PTs and PTAs should rely on the APTA guidelines. State regulations always supersede the APTA guidelines.
- Specifications of entitlement programs, such as Medicare.

It is the responsibility of the PT to examine the patient; evaluate the data and identify problems; determine the diagnosis, prognosis, and POC; and implement the POC (intervention).[1] (See Chapter 6 and Chapter 8.)

The PTA may help the PT with the initial examination, gathering specific data that the PT requests (**TABLE 1.1**). Following the initial examination, the PT evaluates the results of data collection and makes a judgment about data value. The PTA does not interpret the results of the initial examination. The PT establishes the goals or outcomes to be accomplished by the POC and treatment plan, and the PT and PTA perform the patient's interventions with the PTA performing selected interventions as directed by the PT. The PTA must always recognize when involvement of the PT is warranted.

☑ KEY POINT

The PTA is responsible for data collection; establishing and enhancing rapport, trust, and confidence with the patient; carrying out the PT's POC, assisting in the management of the patient by providing proper patient supervision, educating the patient, communicating with the PT; recording the patient's progress or lack of progress since the initial examination and evaluation, and providing clinical observation during treatment sessions. The PTA also may ask the PT to perform a reexamination as appropriate.

☑ KEY POINT

When performing data collection, it is important for the PTA to consider why a change in patient status has occurred. For example, when the PTA is using a goniometer to measure a patient's knee range of motion and finds that the patient is unable to perform the last 5 degrees of extension, the PTA should begin thinking about the possible reasons why the patient is unable to achieve full knee extension (e.g., swelling, pain, contracture, etc.). However, the PTA is obligated to consult with the supervising PT before making any changes outside of the POC.

Strong interpersonal communication between the patient and the PTA, together with keen observation skills, are needed for the PTA to function effectively and efficiently in conjunction with the PT. Sharp observation involves the PTA closely monitoring the

TABLE 1.1 Essential Data Collection Skills for the PTA Carrying Out an Orthopaedic Plan of Care

Aerobic Capacity and Endurance
Measures standard vital signs
Recognizes and monitors responses to positional changes and activities
Observes and monitors thoracoabdominal movements and breathing patterns with activity

Anthropometrical Characteristics
Measures height, weight, length, and girth

Arousal, Mentation, and Cognition
Recognizes changes in the direction and magnitude of patient's state of arousal, mentation, and cognition

Assistive, Adaptive, Orthotic, Protective, Supportive, and Prosthetic Devices
Identifies the individual's and caregiver's ability to care for the device
Recognizes changes in skin condition while using devices and equipment
Recognizes safety factors while using the device

Gait, Locomotion, and Balance
Describes the safety, status, and progression of a patient while engaged in gait, locomotion, and balance

Integumentary Integrity
Recognizes absent or altered sensation
Recognizes normal and abnormal integumentary changes

Joint Integrity and Mobility
Recognizes normal and abnormal joint movement

Muscle Performance
Measures muscle strength by manual muscle testing
Observes the presence or absence of muscle mass
Recognizes normal and abnormal muscle length
Recognizes changes in muscle tone

Pain
Administers standardized questionnaires, graphs, behavioral scales, or visual analog scales for pain
Recognizes activities, positioning, and postures that aggravate or relieve pain or altered sensations

Posture
Describes resting posture in any position
Recognizes alignment of trunk and extremities at rest and during activities

Range of Motion
Measures functional range of motion
Measures range of motion using a goniometer

Applicable Standards
Adjusts interventions within the POC established by the PT in response to patient clinical indications and reports this to the supervising PT

Recognizes when an intervention should not be provided due to changes in the patient's status, and reports this to the supervising PT

Reports any changes in the patient's status to the supervising PT

Recognizes when the direction to perform an intervention is beyond that which is appropriate for a PTA and initiates clarification with the PT

Participates in educating patients and caregivers as directed by the supervising PT

Provides patient-related instruction to patients, family members, and caregivers to achieve patient outcomes based on the plan of care established by the PT

Takes appropriate action in an emergency situation

Completes thorough, accurate, logical, concise, timely, and legible documentation that follows guidelines and specific documentation formats required by state practice acts, the practice setting, and other regulatory agencies

Participates in discharge planning and follow-up as directed by the supervising PT

Reads and understands the healthcare literature patient's response to any of the interventions, and taking the necessary action to alert the supervising PT. In addition, much of what the PTA does involves sound decision-making (see Chapter 8) based on the recognition of subtle or profound changes in a patient's status, results from the vital signs (see Chapter 6), and correct interpretation of patient reports of items such as pain, fatigue, shortness of breath, and dizziness that may need to be reported to the PT.

Appearance

The appearance of the clinician is important to project a professional image. With each interaction, the patient is, consciously or subconsciously, formulating an opinion about the clinic environment and the entire clinical staff, from the receptionist to all members of the rehabilitation team. These patient observations continue throughout each session irrespective of whether a staff member is interacting directly with the patient, conversing with another patient, or communicating with another staff member. The patient also is likely to notice any nonverbal cues, such as voice volume, postures, mannerisms, gestures, and eye contact. Nonverbal cues are especially important as they often are performed subconsciously and can be misinterpreted. (See Chapter 6.) Most clinical facilities have a dress code in addition to a mandatory name tag. A dress code is designed to not offend patients or other members of the rehabilitation team and typically includes instructions on how to achieve the following:

- To prevent overexposure of the clinician. Most clinics do not allow the staff to wear clothing that exposes their midriff or armpits. Some clinics have strict guidelines for the number and location of exposed piercings and tattoos, hair color, and the use of nail polish.
- To prevent injury to a patient or staff member from jewelry, such as dangling earrings, necklaces, or bracelets.

The Rehabilitation Team

The responsibility for the patient's care is shared by the entire rehabilitation team, of which the PTA is a vital member (**TABLE 1.2**). As with the remainder of the team, the PTA must be responsible and accountable. The responsibility for the patient's care, however,

TABLE 1.2 Potential Key Members of the Orthopaedic Rehabilitation Team

Personnel	Function
Orthopaedic surgeon	Concerned with conditions involving the musculoskeletal system. Orthopaedic surgeons use both surgical and nonsurgical approaches to treat musculoskeletal trauma, sports injuries, degenerative diseases, infections, tumors, and congenital disorders.
Physiatrist	A physician specializing in physical medicine and rehabilitation, certified by the American Board of Physical Medicine and Rehabilitation. The primary role of the physiatrist is to diagnose and treat patients with disabilities involving musculoskeletal, neurological, cardiovascular, or other body systems.
Primary care physician (PCP)	A practitioner, usually an internist, general practitioner, or family medicine physician, providing primary care services and managing routine healthcare needs. Most PCPs serve as gatekeepers for managed-care health organizations, providing authorization for referrals to other specialty physicians or services, including physical therapy.
Chiropractor (DC)	A doctor trained in the science, art, and philosophy of chiropractic. A chiropractic evaluation and treatment provides a structural analysis of the musculoskeletal and neurological systems of the body. According to chiropractic doctrine, abnormal function of these two systems may affect function of other systems in the body.

(continues)

and cancellous (also referred to as trabecular) bone. The adult human skeleton is composed of 80 percent cortical bone and 20 percent cancellous bone.

- *Cortical (compact) bone*. Dense and robust, it is found in the outer shell of the diaphysis of long bones and where it surrounds the marrow space. The osteon, or Haversian system, the most complex type of cortical bone, is the fundamental functional unit of much compact bone. Osteon is the name given to the complex arrangement of bone around the vascular channels that are circumferentially surrounded by lamellar bone. During normal activity, cortical bone sustains loads well, so that the bone bends but does not sustain permanent deformation (elastic deformation). However, repetitively sustained loads over a short period can produce changes in the bone shape (plastic deformation).
- *Cancellous (trabecular) bone*. Porous and honeycomb-like, it is therefore less dense than cortical bone and is typically found in the epiphyseal and metaphyseal regions of long bones as well as throughout the interior of short bones. Cancellous bone is significantly more metabolically active than cortical bone.

☑ KEY POINT

The strength of a bone is related directly to its density. Bone mineral density (BMD) is the amount of bone mineral in bone tissue. Compared to cortical bone, cancellous bone has a greater surface area but is less dense, softer, weaker, and less stiff, and therefore more prone to fracture. Dual energy X-ray absorptiometry (DXA) is most commonly used to measure BMD as it determines the amount of mineral measured per unit area or volume of bone tissue. A more sophisticated method, which can better distinguish healthy microarchitecture of bone from suboptimal bone, is high-resolution peripheral quantitative computed tomography (HR-pQCT).[14]

There are three types of bone cells:

- *Osteoblasts*. Responsible for bone formation and the synthesis of type I collagen.
- *Osteocytes*. Control extracellular concentrations of calcium and phosphorus. Osteocytes are, in essence, osteoblasts that are embedded within the newly formed mineralized bone matrix, and are actively involved with the maintenance of the bony matrix.
- *Osteoclasts*. Responsible for bone resorption. An increased number of osteoclasts is characteristic of diseases with increased bone turnover.

The function of a bone is to provide support, enhance leverage, protect vital structures, provide attachments for both tendons and ligaments, and store minerals, particularly calcium.

☑ KEY POINT

Based on location, bones can be classified as follows (**FIGURE 2.3**):

- *Axial skeleton*. Bones of the skull, vertebral column, sternum, and ribs
- *Appendicular skeleton*. Bones of the pectoral girdle (including the scapula and clavicle), pelvic girdle, and limbs

Blood Supply to Bone

Bone has a rich vascular supply, receiving 5 to 10 percent of the cardiac output. The blood supply varies with different types of bones, but blood vessels are especially abundant in areas that contain red bone marrow. The following vessels supply the long bones:

- *Diaphyseal nutrient artery*. The most significant supply of arterial blood to a long bone
- *Metaphyseal and epiphyseal arteries*. Supply the ends of bones
- *Periosteal arterioles*. Supply the outer layers of cortical bone

The large irregular, short, and flat bones receive a superficial blood supply from the periosteum, and frequently from large nutrient arteries that penetrate directly into the medullary bone. It is important to note that fractures, internal fixation devices, prosthetic joint implants, and external fixation devices devitalized the microcirculation of the cortical–periosteal and the endosteal portion of the bone, which can lead to either nonunion and/or bone infections.

Bone inherently recognizes and responds to external loading, and its mechanoreceptors can stimulate osteogenesis. However, for osteogenesis to take place, any stress applied to the bone must be variable, dynamic, and progressive—static loading does not cause osteogenesis.[14,16] A fundamental principle of bone formation and adaptation is that physical deformation of the bone directly stimulates bone formation.[14]

☑ KEY POINT

Bone remodeling is a lifelong process that involves the replacement of old bone by new bone based on the functional demands of the mechanical loading according to Wolff's law. (See Chapter 4.)

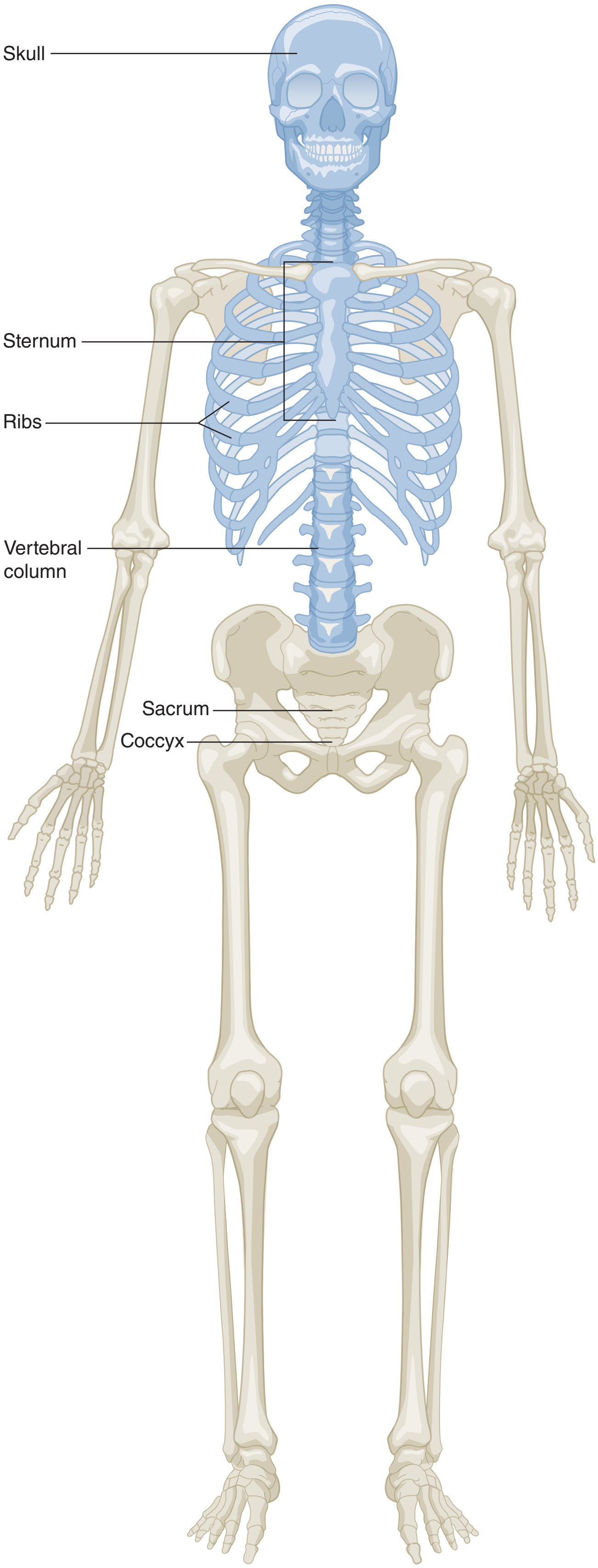

FIGURE 2.3 The axial (shaded) and appendicular skeleton.

Articular Cartilage

The formation of articular (hyaline) cartilage tissue, commonly called gristle, usually precedes the development of bone. Articular cartilage is a highly organized viscoelastic material composed of cartilage cells called *chondrocytes* (5 percent), water (65 to 80 percent), and an ECM. The ECM contains proteoglycans (10 to 15 percent), lipids, water, and dissolved electrolytes. Articular cartilage is devoid of any blood vessels, lymphatics, and nerves.[17] It covers the ends of long bones with synovial joints and, along with the synovial fluid that bathes it, provides a smooth, almost frictionless articulating surface. Articular cartilage is avascular and has no inherent ability to stimulate, regulate, or organize intrinsic repair. (See Chapter 4.)

☑ KEY POINT

- Articular cartilage is the most abundant cartilage within the body.
- Most of the bones of the body form first as articular cartilage and later become bone in a process called *endochondral ossification*.

Articular cartilage distributes the joint forces over a large contact area, dissipating the forces associated with the load. The standard thickness of articular cartilage is determined by the contact pressures across the joint—the higher the peak pressures, the thicker the cartilage.[18] This distribution of forces allows the articular cartilage to remain healthy and fully functional throughout decades of life.

☑ KEY POINT

The patella has the thickest articular cartilage in the body.

Articular cartilage may be grossly subdivided into four distinct zones with differing cellular morphology, biomechanical composition, collagen orientations, and structural properties (**FIGURE 2.4**).

Fibrocartilage

Fibrocartilage consists of a blend of white fibrous tissue and cartilaginous tissue. The white fibrous tissue provides flexibility and toughness, and the cartilage tissue provides elasticity.

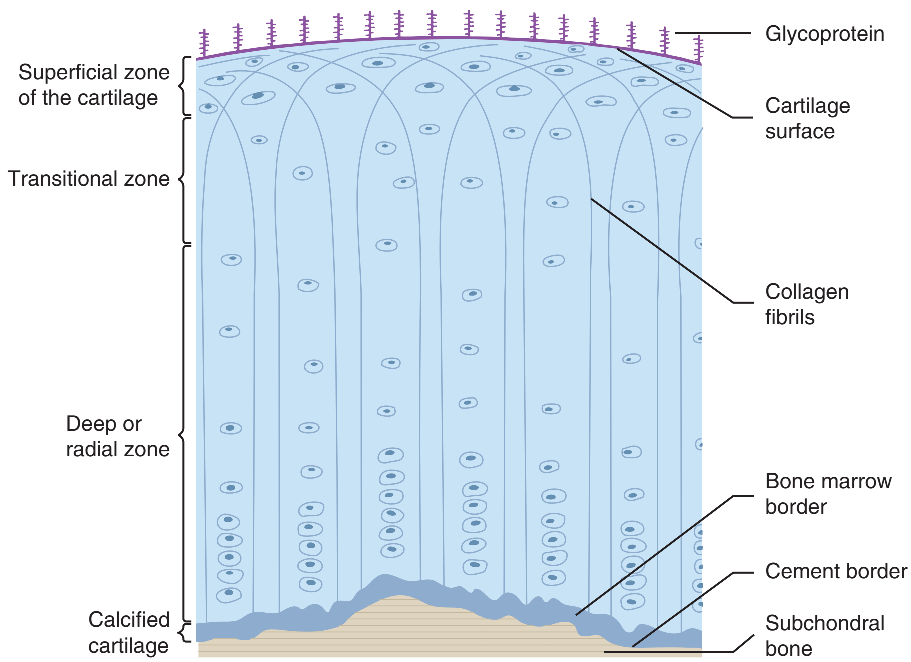

FIGURE 2.4 Articular layers of cartilage.

Meniscus

The meniscus is a specialized viscoelastic fibrocartilaginous structure capable of load transmission, shock absorption, stability, articular cartilage lubrication, and proprioception.[18] The collagen fibers of the menisci are arranged parallel to the peripheral border in the deeper areas, and are more radially-oriented in the superficial region. The radially oriented fibers provide structural rigidity, and the deep fibers resist tension. Menisci tend to be found in noncongruent joints, such as the knee. The pathology of the knee meniscus and implications for the PTA are described in Chapter 24.

Intervertebral Disk

An intervertebral disk (IVD) is located between adjacent vertebrae in the spine and represents the largest avascular structure in the body.[19] In the human spinal column, the combined heights of the IVDs account for approximately 20 to 33 percent of the total length of the spinal column.[19] The human vertebral column is designed to provide structural stability while affording full mobility as well as protection of the spinal cord and axial neural tissues.[20] The presence of an IVD not only permits motion of the segment in any direction up to the point that the disk itself is stretched but also allows for a significant increase in the weight-bearing capabilities of the spine.[21] IVDs are composed of three parts: the annulus fibrosus (AF), the vertebral end plate, and a central gelatinous mass, called the nucleus pulposus (NP).

Three main types of structural disruption are recognized: herniation, protrusion, and prolapse. (See Chapter 19.)

Joints

A joint represents the junction between two or more bone ends. Joints are regions where bones are capped and surrounded by connective tissues that hold the bones together and determine the type and degree of movement between them.[21] Joints are typically classified as synovial, fibrous, or cartilaginous (**TABLE 2.4**).

> **☑ KEY POINT**
>
> An amphiarthrosis, a joint formed primarily by fibrocartilage and hyaline cartilage, plays an important role in shock absorption. An example of an amphiarthosis is the IVD of the spine.

Every synovial joint contains at least one “mating pair” of articular surfaces—one convex and one concave. If only one pair exists, the joint is called simple; more than one pair it is called compound. If a disk is present, the joint is termed complex. Synovial joints have five distinguishing characteristics: joint cavity, articular cartilage, synovial fluid, synovial membrane, and a fibrous capsule (**FIGURE 2.5**). Synovial joints can be broadly classified according to structure or analogy (**FIGURE 2.6**) into the following categories:[22]

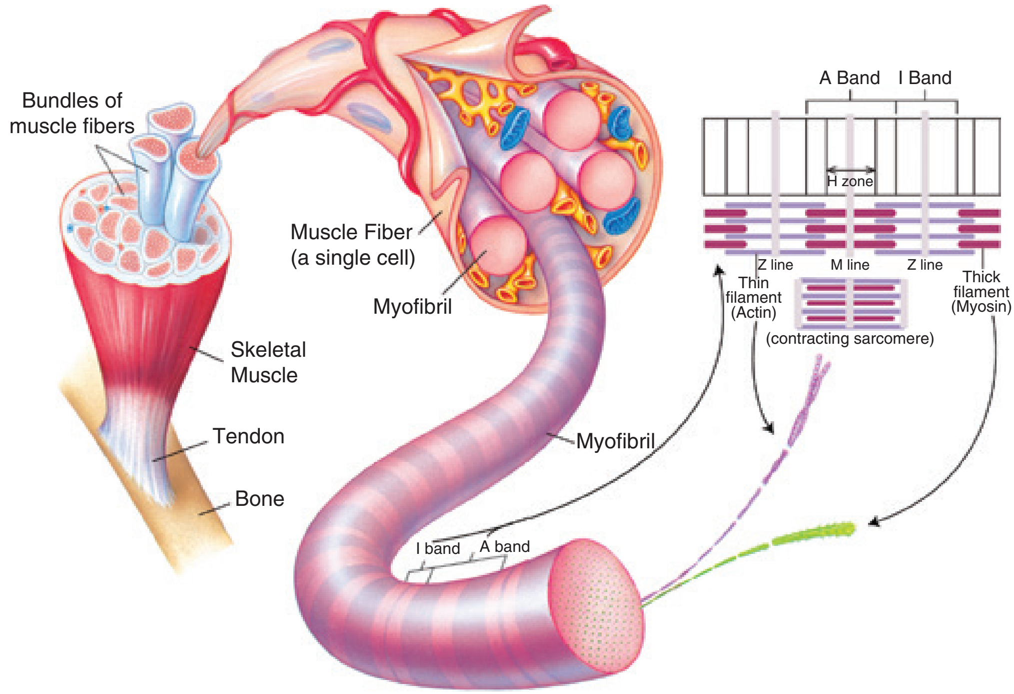

FIGURE 2.8 Contractile machinery.

but the width of the A band remains unchanged.[28] This shortening of the sarcomeres is not produced by a shortening of the actin and myosin filaments, but by a sliding of actin filaments over the myosin filaments, which pulls the Z lines together.

Structures called *myosin cross-bridges* connect the actin and myosin filaments (refer to Figure 2.8). The myosin filaments contain two flexible, hinge-like regions, which allow the cross-bridges to attach and detach from the actin filament. During contraction, the cross-bridges attach and undergo power strokes, which provide the contractile force. During relaxation, the cross-bridges detach. The attaching and detaching is asynchronous so that some are attaching while others are detaching. Thus, at any moment, some of the cross-bridges are pulling while others are releasing. The regulation of cross-bridge attachment and detachment is a function of two proteins found in the actin filaments: tropomyosin and troponin (**FIGURE 2.9**). Tropomyosin attaches directly to the actin filament, whereas troponin is attached to the tropomyosin rather than directly to the actin filament. Tropomyosin and troponin function as the switch for muscle contraction and relaxation. In a relaxed state, the tropomyosin physically blocks the cross-bridges from binding to the actin. For contraction to take place, the tropomyosin must be moved.

Each muscle fiber is innervated by a somatic motor neuron. One neuron, and the muscle fibers it innervates constitutes a motor unit or functional unit of the muscle. Each motor neuron branches as it enters the muscle to innervate a number of muscle fibers. The area of contact between a nerve and a muscle fiber is known as the motor end plate or neuromuscular junction (NMJ). The release of a chemical, acetylcholine, from the axon terminals at the NMJs causes electrical activation of the skeletal muscle fibers. When an action potential propagates into the transverse tubule system (narrow membranous tunnels formed from and continuous with the sarcolemma), the voltage sensors on the transverse tubule membrane signal the release of Ca^{2+} from the terminal cisternae portion of the sarcoplasmic reticulum (a series of interconnected sacs and tubes that surround each myofibril).[28] The released Ca^{2+} then diffuses into the sarcomeres and binds to troponin, displacing the tropomyosin and allowing the actin to bind with the myosin cross-bridges. At the end of the contraction (the neural activity and action potentials cease), the sarcoplasmic reticulum actively accumulates Ca^{2+} and muscle relaxation occurs. The return of Ca^{2+} to the sarcoplasmic reticulum involves active transport, requiring the degradation of adenosine triphosphate (ATP) to adenosine diphosphate (ADP).[28] (See Chapter 11.)

☑ KEY POINT

Because sarcoplasmic reticulum function is closely associated with both contraction and relaxation, changes in its ability to release or sequester Ca^{2+} markedly affect both the time course and magnitude of force output by the muscle fiber.[1]

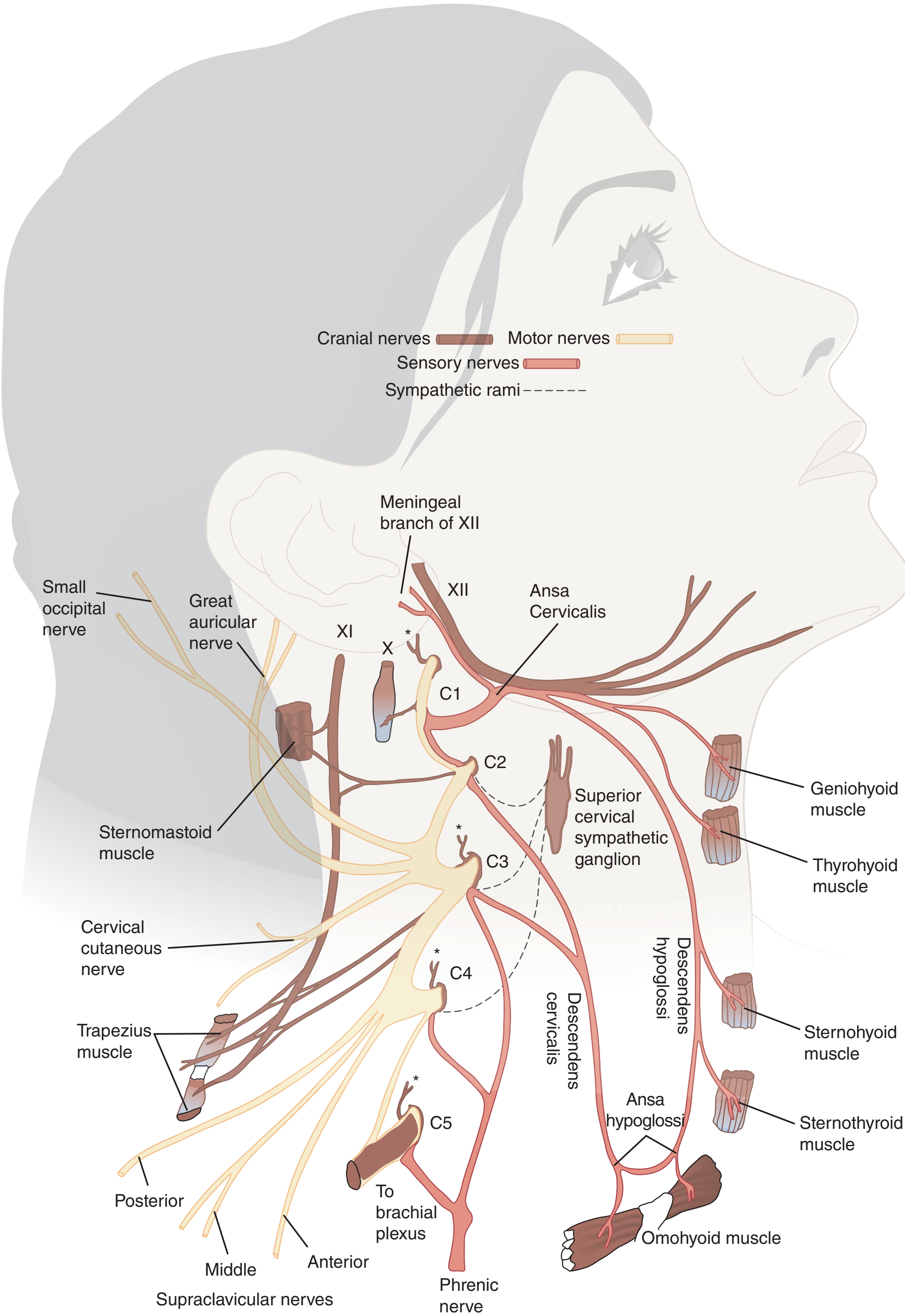

FIGURE 3.5 The cervical plexus.

*To adjacent vertebral musclature

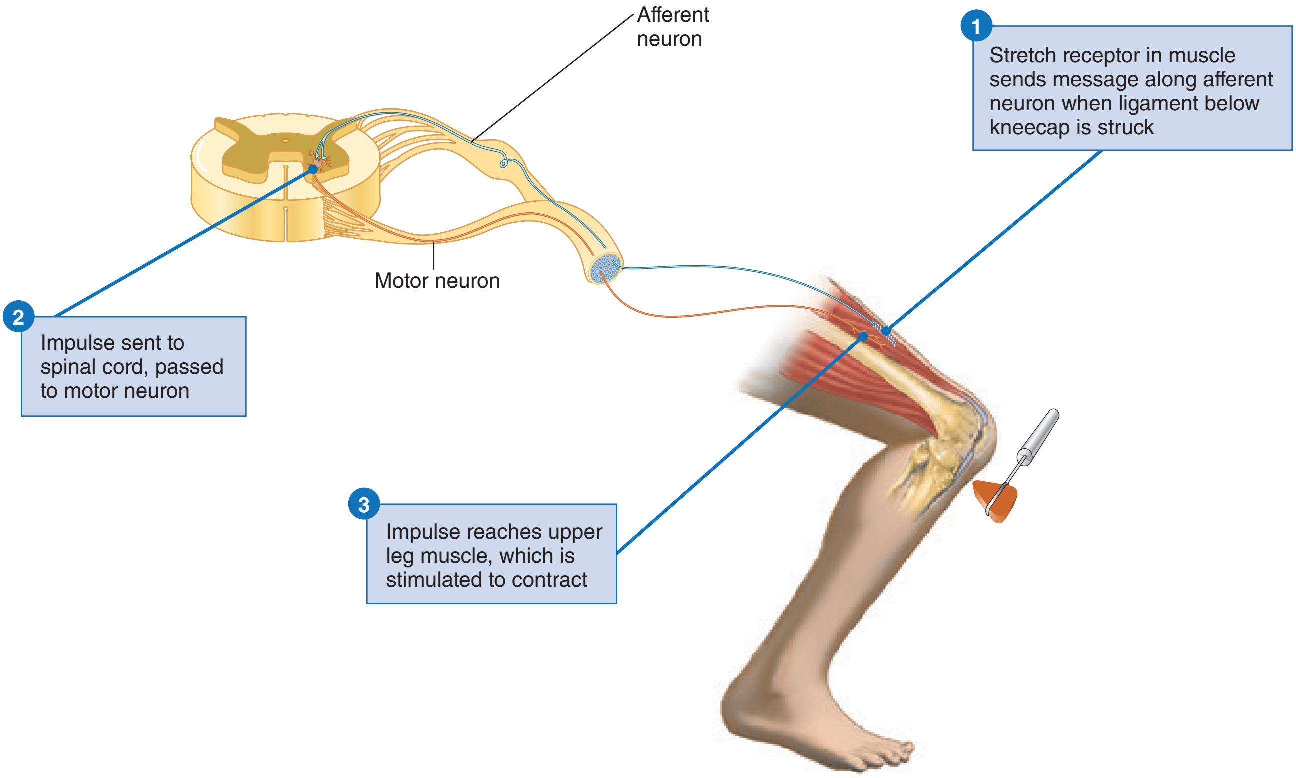

FIGURE 3.10 The stretch reflex.

which comprises CN II, III, IV, and VI, assists in balance control by providing input about the position of the head or the body in space.

The stretch reflex is a preprogrammed response of the body to a stretch stimulus in the muscle (**FIGURE 3.10**). When a muscle spindle (refer to Box 3.1) is stretched, an impulse is immediately sent to the spinal cord and a response to contract the muscle is received (**FIGURE 3.11**). Because the impulse only has to go to the spinal cord and back, and not all the way to the brain, it is a rapid impulse. It generally occurs in 1 to 2 milliseconds. This is designed as a protective measure for the muscles, to prevent tearing. At the same time, the stretch reflex has an inhibitory aspect to the antagonist muscles. When the stretch reflex is activated the impulse is sent from the stretched muscle spindle and the motor neuron is split so that the signal to contract can be sent to the stretched muscle, while a signal to relax can be sent to the antagonist muscles. The stretch reflex is very important in posture. It helps maintain proper posturing because a slight lean to either side causes a stretch in the spinal,

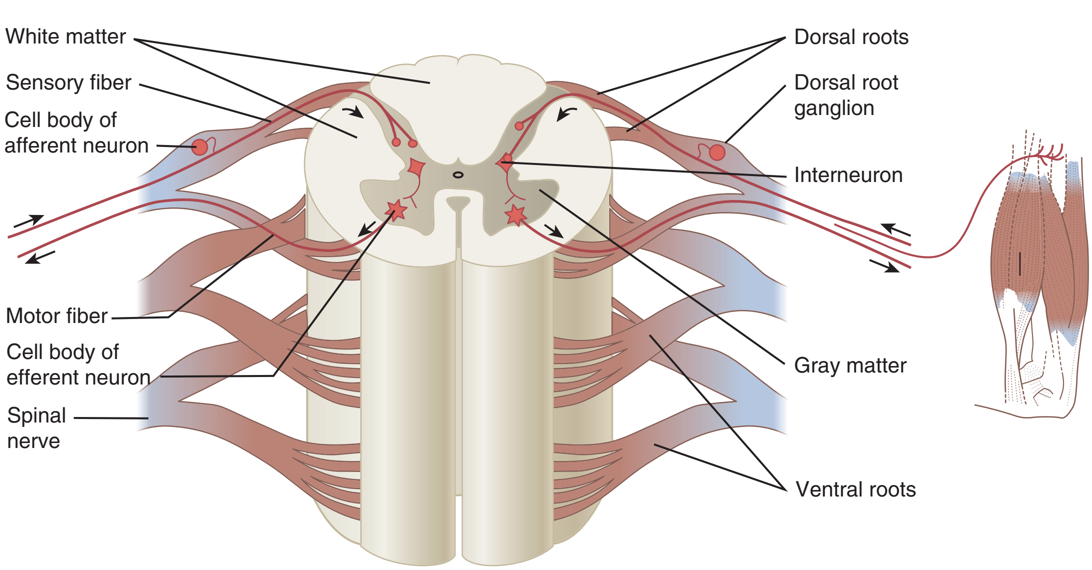

FIGURE 3.11 The muscle spindle and golgi tendon organ.

hip, and leg muscles to the other side, which is quickly countered by the stretch reflex in a constant process of adjustment and maintenance.

☑ KEY POINT

In contrast to muscle spindles, which are sensitive to changes in muscle length, Golgi tendon organs (GTOs) detect and respond to changes in muscle tension that are caused by passive stretch or muscular contraction (refer to Box 3.1).

Lesions of the Nervous System

As with all neuromusculoskeletal structures, the nervous system is prone to injury through trauma or disease. The resultant signs and symptoms depend on the location and extent of the injury.

Upper Motor Neuron Lesion

Upper motor neurons (UMN) are located in the white columns of the spinal cord and the cerebral hemispheres. An upper motor neuron lesion is a lesion of the neural pathway above the anterior horn cell or motor nuclei of the cranial nerves. It is important that the physical therapist assistant (PTA) be aware of the signs and symptoms associated with UMN lesions because they can be subtle but constitute a medical emergency. An example of a sudden UMN lesion is a cerebrovascular accident (CVA). The results of other UMN lesions that can be encountered in the clinical setting are spinal cord injury (SCI), traumatic brain injury (TBI), and Parkinson's disease. A UMN lesion can be characterized as follows:

- *Nystagmus.* An involuntary loss of control of the conjugate movement of the eyes (about one or more axes).
- *Dysphasia.* A problem with vocabulary that results from a cerebral lesion in the speech areas of the frontal or temporal lobes.
- *Ataxia.* Often most marked in the extremities. In the lower extremities, it is characterized by the so-called drunken-sailor gait pattern, with the patient veering from one side to the other and having a tendency to fall toward the side of the lesion. Ataxia of the upper extremities is characterized by a loss of accuracy in reaching for, or placing, objects. Although ataxia can have several causes, it generally suggests CNS disturbance.
- *Spasticity.* A motor disorder characterized by a velocity-dependent increase (resistance increases with velocity) in tonic stretch reflexes with exaggerated tendon jerks.
- *Vertical diplopia.* A patient report of "double vision" or seeing two images, one atop or diagonally displaced from the other.[29]
- *Dysphonia.* Presents as a hoarseness of the voice. Usually no pain is reported. Painless dysphonia is a common symptom of a condition called Wallenberg's syndrome (difficulty with swallowing, speaking, or both, caused by interrupted blood supply to parts of the brain).[30]
- *Hemianopia.* This finding, a loss in half of the visual field, is always bilateral.
- *Ptosis.* A pathologic depression of the superior eyelid such that it covers part of the pupil.
- *Miosis.* The inability to dilate the pupil. It is one of the symptoms of Horner's syndrome.[31]
- *Dysarthria.* A previously undiagnosed change in articulation.
- *Aphasia.* An acquired language disorder in which there is an impairment of any language modality. This may include difficulty in producing or comprehending spoken or written language (**TABLE 3.7**).
- *Apraxia.* A disorder caused by damage to specific areas of the cerebrum, characterized by loss of the ability to execute or carry out learned purposeful movements.
- *Perceptual dysfunction.* A compromised ability to attain awareness or understanding of sensory information.
- *Visual-spatial deficits.* Visual-spatial deficits manifested as poor visual recall, faulty space perceptions, a poor sense of directionality, and a poor comprehension of visually presented material.

☑ KEY POINT

Spasticity can occur as a result of a new or enlarged CNS lesion, a genitourinary tract dysfunction (e.g., infection, obstruction), and/or gastrointestinal disorder (e.g., bowel impaction, hemorrhoids), venous thrombosis, fracture, muscle strain, or pressure ulcers in those patients who already have a UMN lesion.

☑ KEY POINT

The symptoms of Horner's syndrome include miosis, ptosis, exophthalmos, facial reddening, and anhidrosis.

If Horner's syndrome is suspected, the patient immediately should be returned or referred to a physician for further examination and not treated again until the cause is found to be relatively benign.