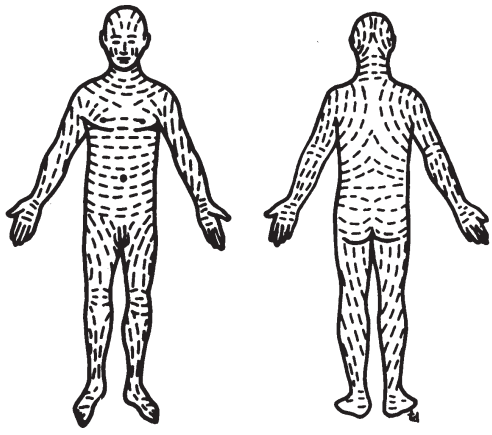
1 Introduction to Clinical Anatomy

Chapter Outline

SKIN

Lines of Cleavage

In the dermis, the bundles of collagen fibers are mostly arranged in parallel rows. A surgical incision through the skin made along or between these rows causes the minimum of disruption of collagen, and the wound heals with minimal scar tissue. Conversely, an incision made across the rows of collagen disrupts and disturbs it, resulting in the massive production of fresh collagen and the formation of a broad, ugly scar. The direction of the rows of collagen is known as the **lines of cleavage** (Langer's lines), and they tend to run longitudinally in the limbs and circumferentially in the neck and trunk (CD Fig. 1-1).



CD Figure 1-1 Cleavage lines of the skin.

A general knowledge of the direction of the **lines of cleavage** greatly assists the surgeon in making incisions that result in cosmetically acceptable scars. This is particularly important in those areas of the body not normally covered by clothing. A salesperson, for example, may lose his or her job if an operation leaves a hideous facial scar.

Skin Infections

The nail folds, hair follicles, and sebaceous glands are common sites for entrance into the underlying tissues of pathogenic organisms such as ***Staphylococcus aureus***. Infection occurring between the nail and the nail fold is called a **paronychia.** Infection of the hair follicle and sebaceous gland is responsible for the common **boil.** A **carbuncle** is a staphylococcal infection of the superficial fascia. It frequently occurs in the nape of the neck and usually starts as an infection of a hair follicle or a group of hair follicles.

Sebaceous Cyst

A sebaceous cyst is caused by obstruction of the mouth of a sebaceous duct and *may* be caused by damage from a comb or by infection. It occurs most frequently on the scalp.

Shock

A patient who is in a state of **shock** is pale and exhibits gooseflesh as a result of overactivity of the sympathetic system, which causes vasoconstriction of the dermal arterioles and contraction of the arrector pili muscles.

Skin Burns

The depth of a burn determines the method and rate of healing. A partial-skin-thickness burn heals from the cells of the hair follicles, sebaceous glands, and sweat glands as well as from the cells at the edge of the burn. A burn that extends deeper than the sweat glands heals slowly and from the edges only, and considerable contracture will be caused by fibrous tissue. To speed up healing and reduce the incidence of contracture, a deep burn should be grafted.

Skin Grafting

Skin grafting is of two main types: split-thickness grafting and full-thickness grafting. In a split-thickness graft the greater part of the epidermis, including the tips of the dermal papillae, are removed from the donor site and placed on the recipient site. This leaves at the donor site for repair purposes the epidermal cells on the sides of the dermal papillae and the cells of the hair follicles and sweat glands.

A full-thickness skin graft includes both the epidermis and dermis and, to survive, requires rapid establishment of a new circulation within it at the recipient site. The donor site is usually covered with a split-thickness graft. In certain circumstances the full-thickness graft is made in the form of a pedicle graft, in which a flap of full-thickness skin is turned and stitched in position at the recipient site, leaving the base of the flap with its blood supply intact at the donor site. Later, when the new blood supply to the graft has been established, the base of the graft is cut across.

FASCIAE

Fasciae and Infection

Knowledge of the arrangement of the deep fasciae often helps explain the path taken by an infection when it spreads from its primary site. In the neck, for example, the various fascial planes explain how infection can extend from the region of the floor of the mouth to the larynx.

SKELETAL MUSCLE

Muscle Attachments

The importance of knowing the main attachments of all the major muscles of the body need not be emphasized. Only with such knowledge is it possible to understand the normal and abnormal actions of individual muscles or muscle groups. How can one even attempt to analyze, for example, the abnormal gait of a patient without this information?

Muscle Shape and Form

The general shape and form of muscles should also be noted, since a paralyzed muscle or one that is not used (such as occurs when a limb is immobilized in a splint) quickly atrophies and changes shape. In the case of the limbs, it is always worth remembering that a muscle on the opposite side of the body can be used for comparison.

CARDIAC MUSCLE

Necrosis of Cardiac Muscle

The cardiac muscle receives its blood supply from the coronary arteries. A sudden block of one of the large branches of a coronary artery will inevitably lead to necrosis of the cardiac muscle and often to the death of the patient.

JOINTS

Examination of Joints

When examining a patient, the clinician should assess the normal range of movement of all joints. When the bones of a joint are no longer in their normal anatomic relationship with one another, then the joint is said to be **dislocated.** Some joints are particularly susceptible to dislocation because of lack of support by ligaments, the poor shape of the articular surfaces, or the absence of adequate muscular support. The shoulder joint, temporomandibular joint, and acromioclavicular joints are good examples. Dislocation of the hip is usually congenital, being caused by inadequate development of the socket that normally holds the head of the femur firmly in position.

The presence of cartilaginous discs within joints, especially weightbearing joints, as in the case of the knee, makes them particularly susceptible to injury in sports. During a rapid movement the disc loses its normal relationship to the bones and becomes crushed between the weightbearing surfaces.

In certain diseases of the nervous system (e.g., syringomyelia), the sensation of pain in a joint is lost. This means that the warning sensations of pain felt when a joint moves beyond the normal range of movement are not experienced. This phenomenon results in the destruction of the joint.

Knowledge of the classification of joints is of great value because, for example, certain diseases affect only certain types of joints. Gonococcal arthritis affects large synovial joints such as the ankle, elbow, or wrist, whereas tuberculous arthritis also affects synovial joints and may start in the synovial membrane or in the bone.

Remember that more than one joint may receive the same nerve supply. For example, the hip and knee joints are both supplied by the obturator nerve. Thus, a patient with disease limited to one of these joints may experience pain in both.

LIGAMENTS

Damage to Ligaments

Joint ligaments are very prone to excessive stretching and even tearing and rupture. If possible, the apposing damaged surfaces of the ligament are brought together by positioning and immobilizing the joint. In severe injuries, surgical approximation of the cut ends may be required. The blood clot at the damaged site is invaded by blood vessels and fibroblasts. The fibroblasts lay down new collagen and elastic fibers, which become oriented along the lines of mechanical stress.

BURSAE AND SYNOVIAL SHEATHS

Trauma and Infection of Bursae and Synovial Sheaths

Bursae and synovial sheaths are commonly the site of traumatic or infectious disease. For example, the extensor tendon sheaths of the hand may become inflamed after excessive or unaccustomed use; an inflammation of the prepatellar bursa may occur as the result of trauma from repeated kneeling on a hard surface.

BLOOD VESSELS

Diseases of Blood Vessels

Diseases of blood vessels are common. The surface anatomy of the main arteries, especially those of the limbs, is discussed in the appropriate sections of this book. The **collateral circulation** of most large arteries should be understood, and a distinction should be made between anatomic end arteries and functional end arteries.

All large arteries that cross over a joint are liable to be kinked during movements of the joint. However, the distal flow of blood is not interrupted because an adequate anastomosis is usually between branches of the artery that arise both proximal and distal to the joint. The alternative blood channels, which dilate under these circumstances, form the collateral circulation. Knowledge of the existence and position of such a circulation may be of vital importance should it be necessary to tie off a large artery that has been damaged by trauma or disease.

Coronary arteries are functional end arteries, and if they become blocked by disease (coronary arterial occlusion is common), the cardiac muscle normally supplied by that artery will receive insufficient blood and undergo necrosis. Blockage of a large coronary artery results in the death of the patient.

LYMPHATIC SYSTEM

Diseases of the Lymphatic System

The lymphatic system is often de-emphasized by anatomists on the grounds that it is difficult to see on a cadaver. However, it is of vital importance to medical personnel, since lymph nodes may swell as the result of infection, metastases, or primary tumor. For this reason, the lymphatic drainage of all major organs of the body, including the skin, should be known.

A patient may complain of a swelling produced by the enlargement of a lymph node. A physician must know the areas of the body that drain lymph to a particular node if he or she is to be able to find the primary site of the disease. Often the patient ignores the primary disease, which may be a small, painless cancer of the skin.

Conversely, the patient may complain of a painful ulcer of the tongue, for example, and the physician must know the lymph drainage of the tongue to be able to determine whether the disease has spread beyond the limits of the tongue.

NERVOUS SYSTEM

Segmental Innervation of the Skin

The area of skin supplied by a single spinal nerve, and therefore a single segment of the spinal cord, is called a **dermatome.** On the trunk, adjacent dermatomes overlap considerably; to produce a region of complete anesthesia, at least three contiguous spinal nerves must be sectioned. Dermatomal charts for the anterior and posterior surfaces of the body are shown in CD Figs. 1-2 and 1-3.

In the limbs, arrangement of the dermatomes is more complicated because of the embryologic changes that take place as the limbs grow out from the body wall.

A physician should have a working knowledge of the segmental (dermatomal) innervation of skin, because with the help of a pin or a piece of cotton he or she can determine whether the sensory function of a particular spinal nerve or segment of the spinal cord is functioning normally.

Segmental Innervation of Muscle

Skeletal muscle also receives a segmental innervation. Most of these muscles are innervated by two, three, or four spinal nerves and therefore by the same number of segments of the spinal cord. To paralyze a muscle completely, it is thus necessary to section several spinal nerves or to destroy several segments of the spinal cord.

Learning the segmental innervation of all the muscles of the body is an impossible task. Nevertheless, the segmental innervation of the following muscles should be known because they can be tested by eliciting simple muscle reflexes in the patient (CD Fig. 1-4):

- **Biceps brachii tendon reflex:** C5 and 6 (flexion of the elbow joint by tapping the biceps tendon)
- **Triceps tendon reflex:** C6, 7, and 8 (extension of the elbow joint by tapping the triceps tendon)
- **Brachioradialis tendon reflex:** C5, 6, and 7 (supination of the radioulnar joints by tapping the insertion of the brachioradialis tendon)
- **Abdominal superficial reflexes (contraction of underlying abdominal muscles by stroking the skin):** Upper abdominal skin T6–7, middle abdominal skin T8–9, and lower abdominal skin T10–12
- **Patellar tendon reflex (knee jerk):** L2, 3, and 4 (extension of the knee joint on tapping the patellar tendon)
- **Achilles tendon reflex (ankle jerk):** S1 and S2 (plantar flexion of the ankle joint on tapping the Achilles tendon)

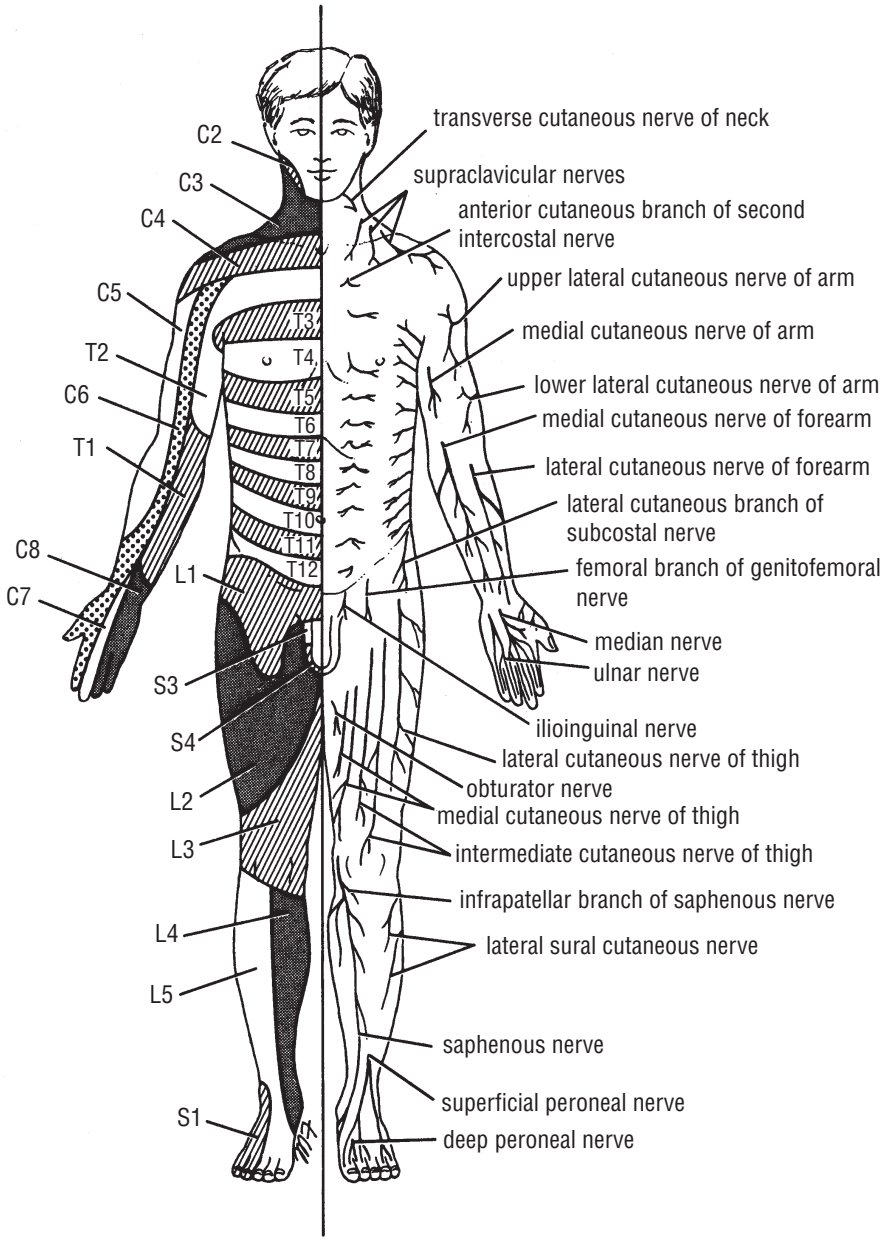
Clinical Modification of the Activities of the Autonomic Nervous System

Many drugs and surgical procedures that can modify the activity of the autonomic nervous system are available. For example, drugs can be administered to lower the blood pressure by blocking sympathetic nerve endings and causing vasodilatation of peripheral blood vessels. In patients with severe arterial disease affecting the main arteries of the lower limb, the limb can sometimes be saved by sectioning the sympathetic innervation to the blood vessels. This produces a vasodilatation and enables an adequate amount of blood to flow through the collateral circulation, thus bypassing the obstruction.

MUCOUS AND SEROUS MEMBRANES

Mucous and Serous Membranes and Inflammatory Disease

Mucous and serous membranes are common sites for inflammatory disease. For example, **rhinitis,** or the common



CD Figure 1-2 Dermatomes and distribution of cutaneous nerves on the anterior aspect of the body.

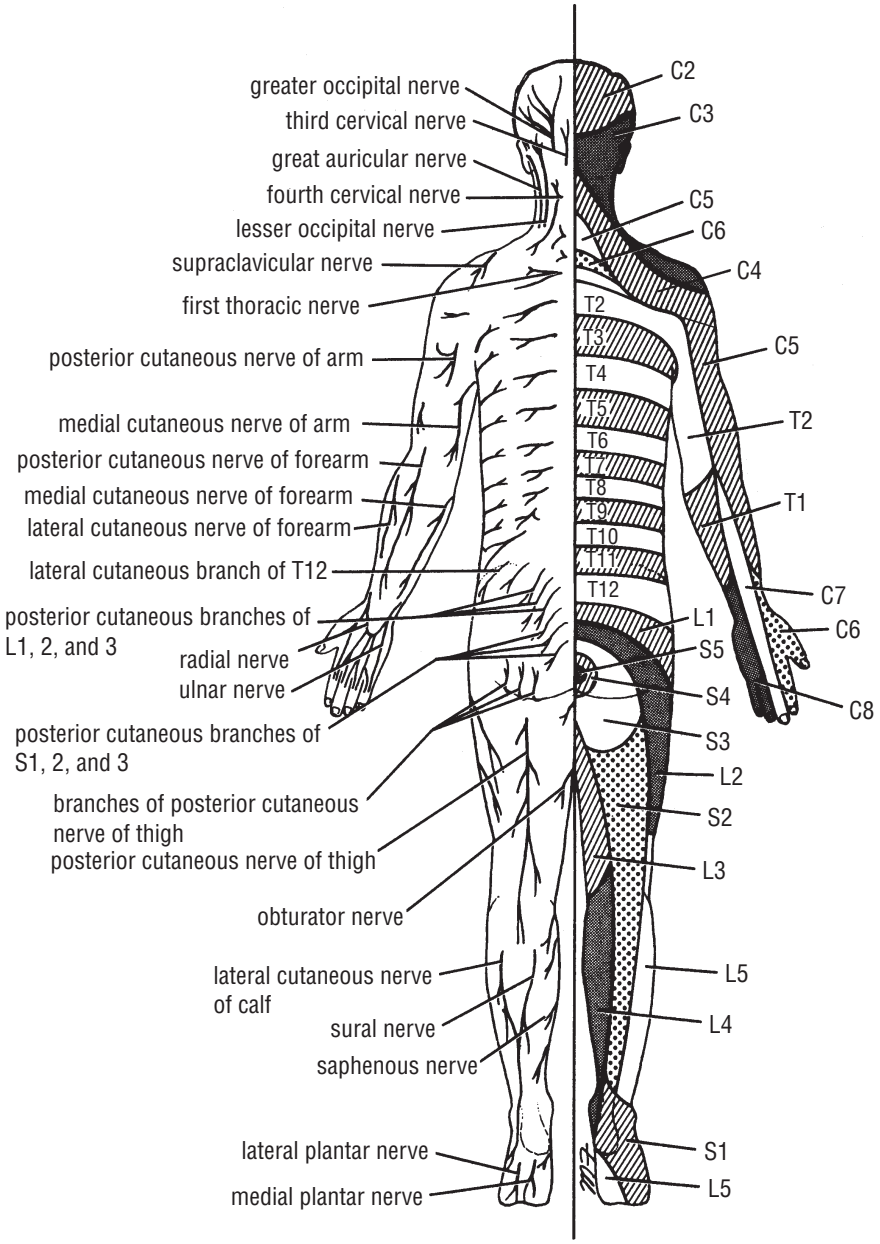
cold, is an inflammation of the nasal mucous membrane, and **pleurisy** is an inflammation of the visceral and parietal layers of the pleura.

BONES

Bone Fractures

Immediately after a **fracture,** the patient suffers severe local pain and is not able to use the injured part. Deformity may be visible if the bone fragments have been displaced relative to each other. The degree of deformity and the directions taken by the bony fragments depend not only on the mechanism of injury, but also on the pull of the muscles attached to the fragments. Ligamentous attachments also influence the deformity. In certain situations—for example, the ileum—fractures result in no deformity because the inner and outer surfaces of the bone are splinted by the extensive origins of muscles. In contrast, a fracture of the neck of the femur produces considerable displacement. The strong muscles of the thigh pull the distal fragment upward so that the leg is shortened. The very strong lateral rotators rotate the distal fragment laterally so that the foot points laterally.

Fracture of a bone is accompanied by a considerable hemorrhage of blood between the bone ends and into the



CD Figure 1-3 Dermatomes and distribution of cutaneous nerves on the posterior aspect of the body.

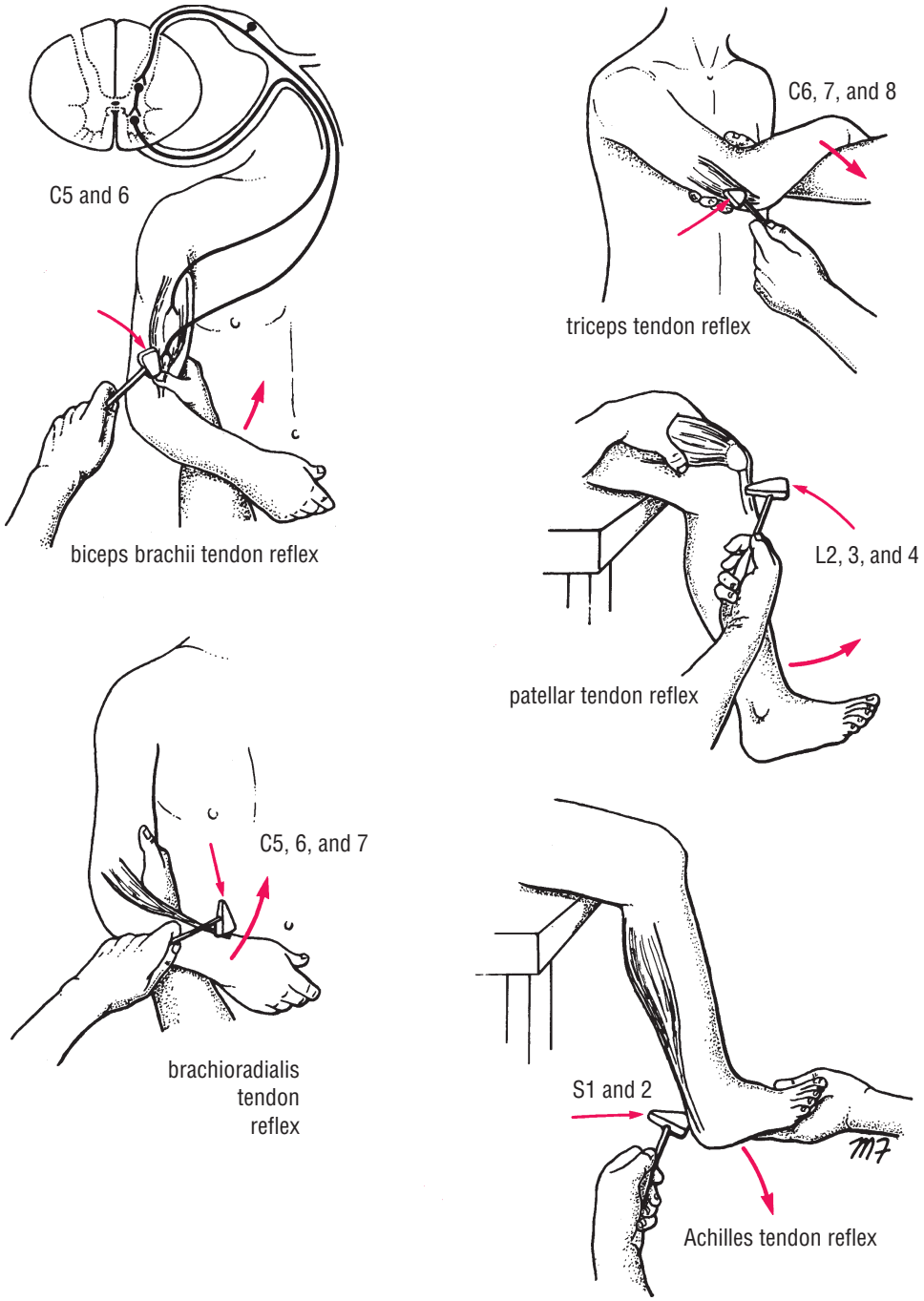
surrounding soft tissue. The blood vessels and the fibroblasts and osteoblasts from the periosteum and endosteum take part in the repair process.

Rickets

Rickets is a defective mineralization of the cartilage matrix in growing bones. This produces a condition in which the cartilage cells continue to grow, resulting in excess cartilage and a widening of the epiphyseal plates. The poorly mineralized cartilaginous matrix and the osteoid matrix are soft, and they bend under the stress of bearing weight. The resulting deformities include enlarged costochondral junctions, bowing of the long bones of the lower limbs, and bossing of the frontal bones of the skull. Deformities of the pelvis may also occur.

Epiphyseal Plate Disorders

Epiphyseal plate disorders affect only children and adolescents. The epiphyseal plate is the part of a growing bone concerned primarily with growth in length. Trauma, infection, diet, exercise, and endocrine disorders can disturb the growth of the hyaline cartilaginous plate, leading to deformity and loss of function. In the femur, for example, the proximal epiphysis can slip because of mechanical stress or excessive loads. The length of the limbs can increase excessively because of increased vascularity in the region of the epiphyseal plate sec-



CD Figure 1-4 Some important tendon reflexes used in medical practice.

ondary to infection or in the presence of tumors. Shortening of a limb can follow trauma to the epiphyseal plate resulting from a diminished blood supply to the cartilage.

CLINICAL SIGNIFICANCE OF SEX, RACE, AND AGE ON STRUCTURE

The fact that the structure and function of the human body change with age may seem obvious, but it is often overlooked; a child is just not a small adult. A few examples of such changes are given here:

1. In the infant, the bones of the skull are more resilient than in the adult, and for this reason fractures of the skull are much more common in the adult than in the young child.
2. The liver is relatively much larger in the child than in the adult. In the infant, the lower margin of the liver extends inferiorly to a lower level than in the adult. This is an important consideration when making a diagnosis of hepatic enlargement.
3. The urinary bladder in the child cannot be accommodated entirely in the pelvis because of the small size of the pelvic cavity and thus is found in the lower part of the abdominal cavity. As the child grows, the pelvis enlarges and the bladder sinks down to become a true pelvic organ.
4. At birth, all bone marrow is of the red variety. With advancing age, the red marrow recedes up the bones of the limbs so that in the adult it is largely confined to the bones of the head, thorax, and abdomen.
5. Lymphatic tissues reach their maximum degree of development at puberty and thereafter atrophy, so the volume of lymphatic tissue in older persons is considerably reduced.

Clinical Problem Solving Questions

Read the following case histories/questions and give the best answer for each.

A 45-year-old patient has a small, firm, mobile tumor on the dorsum of the right foot just proximal to the base of the big toe and superficial to the bones and the long extensor tendon but deep to the superficial fascia. The patient has a neurofibroma of a digital nerve.

1. The following information concerning the tumor is **correct**:
   A. It is situated on the lower surface of the foot close to the root of the big toe.
   B. It is attached to the first metatarsal bone.
   C. On palpation, it moves more freely from medial to lateral than from proximal to distal.
   D. It lies deep to the tendon of the extensor hallucis longus muscle.
   E. It is attached to the capsule of the metatarsophalangeal joint of the big toe.

A 31-year-old woman has a history of poliomyelitis affecting the anterior horn cells of the lower thoracic and lumbar segments of the spinal cord on the left side. On examination, she has severe right lateral flexion deformity of the vertebral column.

2. The following statement is **correct** about this case:
   A. The virus of poliomyelitis attacks and always destroys the motor anterior horn cells of the spinal cord.
   B. The disease resulted in the paralysis of the muscles that normally laterally flex the vertebral column on the left side.
   C. The muscles on the right side of the vertebral column are hyperactive.
   D. The right lateral flexion deformity is caused by the slow degeneration of the sensory nerve fibers originating from the vertebral muscles on the right side.

A 20-year-old woman severely sprains her left ankle while playing tennis. When she tries to move the foot so that the sole faces medially, she experiences severe pain.

3. What is the **correct** anatomic term for the movement of the foot that produces the pain?
   A. Pronation
   B. Inversion
   C. Supination
   D. Eversion

A 25-year-old man has a deep-seated abscess in the posterior part of the neck.

4. The following statement is **correct** concerning the abscess:
   A. The abscess probably lies superficial to the deep fascia.
   B. The deep fascia does not determine the direction of spread of the abscess.
   C. The abscess would be incised through a vertical skin incision.
   D. The lines of cleavage are not important when considering the direction of skin incisions.
   E. The abscess would be incised, if possible, through a horizontal skin incision.

A 40-year-old workman received a severe burn on the anterior aspect of his right forearm. The area of the burn exceeded 4 $in.^2$ (10 cm^2). The greater part of the burn was superficial and extended only into the superficial part of the dermis.

5. In the superficially burned area, the epidermis cells would regenerate from the following sites **except** which?
   A. The hair follicles
   B. The sebaceous glands
   C. The margins of the burn
   D. The deepest ends of the sweat glands

6. In a small area the burn penetrated as far as the superficial fascia; in this region, the epidermal cells would regenerate from the following sites **except** which?
   A. The ends of the sweat glands that lie in the superficial fascia
   B. The margins of the burn
   C. The sebaceous glands

In a 63-year-old man, a magnetic resonance imaging scan of the lower thoracic region of the vertebral column reveals the presence of a tumor pressing on the lumbar segments of the spinal cord. He has a loss of sensation in the skin over the anterior surface of the left thigh and is unable to extend his left knee joint. Examination reveals that the muscles of the front of the left thigh have atrophied and have no tone and that the left knee jerk is absent.

7. The following statements concerning this patient are correct **except** which?
   A. The tumor is interrupting the normal function of the efferent motor fibers of the spinal cord on the left side.
   B. The quadriceps femoris muscles on the front of the left thigh are atrophied.
   C. The loss of skin sensation is confined to the dermatomes L1, 2, 3, and 4.
   D. The absence of the left knee jerk is because of involvement of the first lumbar spinal segment.

A woman recently took up employment in a factory. She is a machinist, and for 6 hours a day she has to move a lever repeatedly, which requires that she extend and flex her right wrist joint. At the end of the second week of her employment, she began to experience pain over the posterior surface of her wrist and noticed a swelling in the area.

8. The following statements concerning this patient are correct **except** which?
   A. Extension of the wrist joint is brought about by several muscles that include the extensor digitorum muscle.
   B. The wrist joint is diseased.
   C. Repeated unaccustomed movements of tendons through their synovial sheaths can produce traumatic inflammation of the sheaths.
   D. The diagnosis is traumatic tenosynovitis of the long tendons of the extensor digitorum muscle.

A 19-year-old boy was suspected of having leukemia. It was decided to confirm the diagnosis by performing a bone marrow biopsy.

9. The following statements concerning this procedure are correct **except** which?
   A. The biopsy was taken from the lower end of the tibia.
   B. Red bone marrow specimens can be obtained from the sternum or the iliac crests.
   C. At birth, the marrow of all bones of the body is red and hematopoietic.
   D. The blood-forming activity of bone marrow in many long bones gradually lessens with age, and the red marrow is gradually replaced by yellow marrow.

A 22-year-old woman had a severe infection under the lateral edge of the nail of her right index finger. On examination, a series of red lines were seen to extend up the back of the hand and around to the front of the forearm and arm, up to the armpit.

10. The following statements concerning this patient are probably correct **except** which?
    A. Palpation of the right armpit revealed the presence of several tender enlarged lymph nodes (lymphadenitis).
    B. The red lines were caused by the superficial lymphatic vessels in the arm, which were red and inflamed (lymphangitis) and could be seen through the skin.
    C. Lymph from the right arm entered the bloodstream through the thoracic duct.
    D. Infected lymph entered the lymphatic capillaries from the tissue spaces.

Answers and Explanations

1. **C** is the correct answer. The tumor is a neurofibroma of a small digital nerve. This fact explains why the tumor is relatively superficial and moves with the digital nerve more freely from medial to lateral than from proximal to distal. A. The tumor is situated on the dorsum or upper surface of the foot. B. The tumor is mobile and not attached to the first metatarsal bone. D. The tumor lies superficial to the tendon of the extensor hallucis longus muscle. E. The tumor is mobile and is not attached to the capsule of the metatarsophalangeal joint.

2. **B** is the correct answer. The disease infected the anterior horn cells, whose axons supply the muscles that normally laterally flex the vertebral column on the left side. A. The virus of poliomyelitis attacks anterior horn cells in the spinal cord. The result may be death of the cells and muscle paralysis or, depending on the severity of the attack, the nerve cells may recover and the muscle paralysis may also recover. C. The muscles on the right side of the vertebral column are contracting normally against the paralyzed left-sided vertebral muscles. D. The sensory nerves of muscles are unaffected by the polio virus.

3. **B** is the correct answer. The movement of the foot so that the sole comes to face medially is called inversion (see text Fig. 1-3). For a full discussion of the movements of inversion and eversion of the foot at the subtalar and transverse joints of the foot, see text.

4. **E** is the correct answer. The abscess would be incised, if possible, through a horizontal skin incision along a line of cleavage (see CD Fig. 1-1). A. A deep-seated abscess in the neck usually lies deep to the superficial fascia and beneath the investing layer of deep cervical fascia. B. The arrangement of the deep fascia in the neck plays an important role in the direction of spread of a deep-seated abscess. C. The abscess would only be incised through a vertical incision if a horizontal incision along a line of cleavage was not possible. A vertical incision in the neck would result in an unsightly scar. D. The lines of cleavage (see CD Fig. 1-1) are very important when considering the direction of skin incisions. However, cosmetic concerns have to take second place in life-threatening situations.

5. **D** is the correct answer. In a superficial burn, the epidermal cells would regenerate from the hair follicles, the sebaceous glands, and the margins of the burn.

6. **C** is the correct answer. The sebaceous glands are located superficially (see text Fig. 1-4) and are destroyed in deep burns.

7. **D** is the correct answer. The patellar tendon reflex (knee jerk) involves L2, 3, and 4 segments of the spinal cord.

8. **B** is the correct answer. The wrist joint is not diseased in this patient. The swelling on the posterior surface of the wrist region was caused by the excessive production of fluid in the synovial sheaths of the extensor tendons secondary to repeated and excessive extensor movements, a condition called traumatic tenosynovitis.

9. **A** is the correct answer. In a 19-year-old boy, the bone marrow at the lower end of the tibia is yellow. A biopsy specimen of red marrow in an adult, who is suspected of suffering from leukemia, is easily obtained from the iliac crests or the sternum.

10. **C** is the correct answer. Lymph from the right upper limb enters the bloodstream through the right lymphatic duct.