

Figure 5.34 Ossification centers in the skeleton of a 12-week-old fetus are indicated by the darker areas. Lighter regions are still fibrous or cartilaginous.

the intervertebral discs rather than from modifications of the bony vertebrae and produce the S-shaped spine typical of the adult.

Most cases of abnormal spinal curvatures, such as scoliosis and lordosis (see Figure 5.18), are congenital, but some can result from injuries. The abnormal curvatures are usually treated by surgery, braces, or casts when diagnosed. Generally speaking, young, healthy people have no skeletal problems, assuming that their diet is nutritious and they stay reasonably active.

During youth, growth of the skeleton not only increases overall body height and size but also changes body proportions (Figure 5.35b). At birth, the head and trunk are approximately $1\frac{1}{2}$ times as long as the lower limbs. The lower limbs grow more rapidly than the trunk from this time on, and by the age of 10, the head and trunk are approximately the same height as the lower

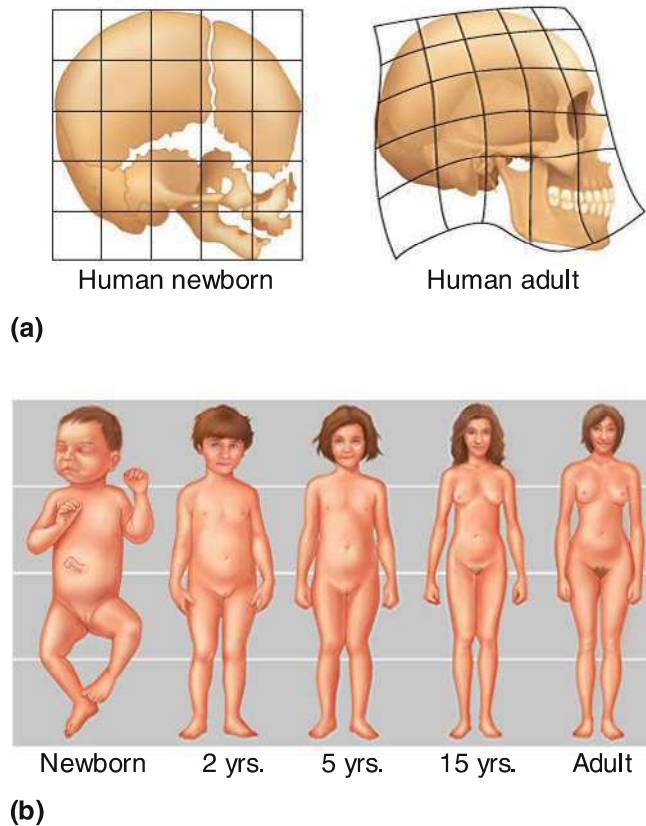


Figure 5.35 Differences in the growth rates for some parts of the body compared to others determine body proportions. (a) Differential growth transforms the rounded, foreshortened skull of a newborn to the sloping skull of an adult.

(b) During growth of a human, the arms and legs grow faster than the head and trunk, as shown in this conceptualization of different-aged individuals all drawn at the same height.

limbs and change little thereafter. During puberty, the female pelvis broadens in preparation for childbearing, and the entire male skeleton becomes more robust. Once adult height is reached, a healthy skeleton changes very little until late middle age. In old age, losses in bone mass become obvious.

It cannot be emphasized too strongly that bones have to be physically stressed to remain healthy. When we remain active physically and muscles and gravity pull on the skeleton, the bones respond by becoming stronger. By contrast, if we are totally inactive, they become thin and fragile. **Osteoporosis** is a bone-thinning disease that afflicts half of women over 65 and some 20 percent

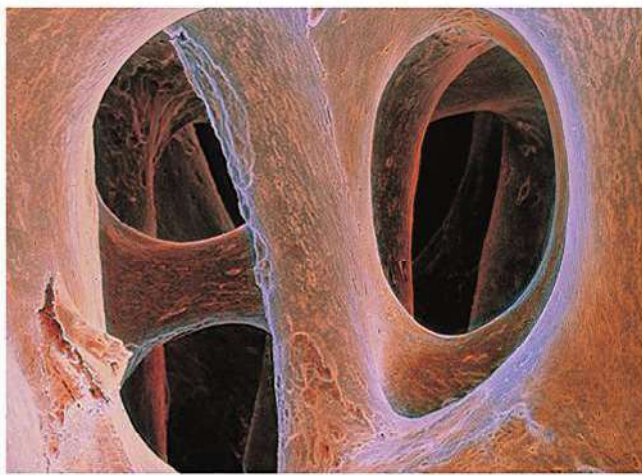


Figure 5.36 Osteoporosis. The architecture of osteoporotic bone, at top, is contrasted with that of normal bone, below.

of men over the age of 70. Osteoporosis makes the bones so fragile that even a hug or a sneeze can cause bones to fracture (**Figure 5.36**). The bones of the spine and the neck of the femur are particularly susceptible. Vertebral collapse frequently results in a hunched-over posture (kyphosis) familiarly known as dowager’s hump (**Figure 5.37**).

Estrogen helps to maintain the health and normal density of a woman’s skeleton, and the estrogen deficiency that occurs after a woman goes through menopause (“change of life,” when menstruation ceases) is strongly implicated as a cause of osteoporosis. Other factors that may contribute to osteoporosis are a diet poor in calcium and protein, lack of vitamin D, smoking, and insufficient weight-bearing exercise to stress the bones. Sadly, many older people feel that they are

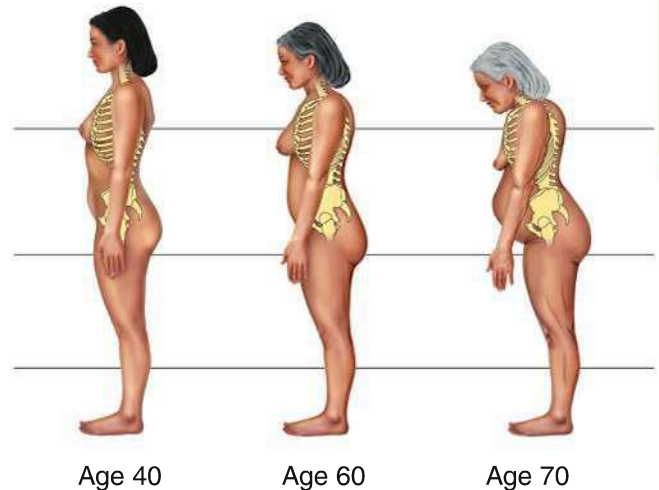


Figure 5.37 Vertebral collapse due to osteoporosis. Women with postmenopausal osteoporosis are at risk for fractures in the bones in their spine (vertebrae) as they age. Eventually these vertebrae tend to collapse, causing spinal curvature that causes loss of height, a tilted rib cage, a dowager’s hump, and a protruding abdomen.

helping themselves by “saving their strength” and not doing anything too physical. Their reward for this is *pathologic fractures* (breaks that occur spontaneously without apparent injury), which increase dramatically with age and are the single most common skeletal problem for this age group.

Advancing years also take their toll on joints. Weight-bearing joints in particular begin to degenerate, and *osteoarthritis* is common. Such degenerative joint changes lead to the complaint often heard from the aging person: “My joints are getting so stiff. . . .”

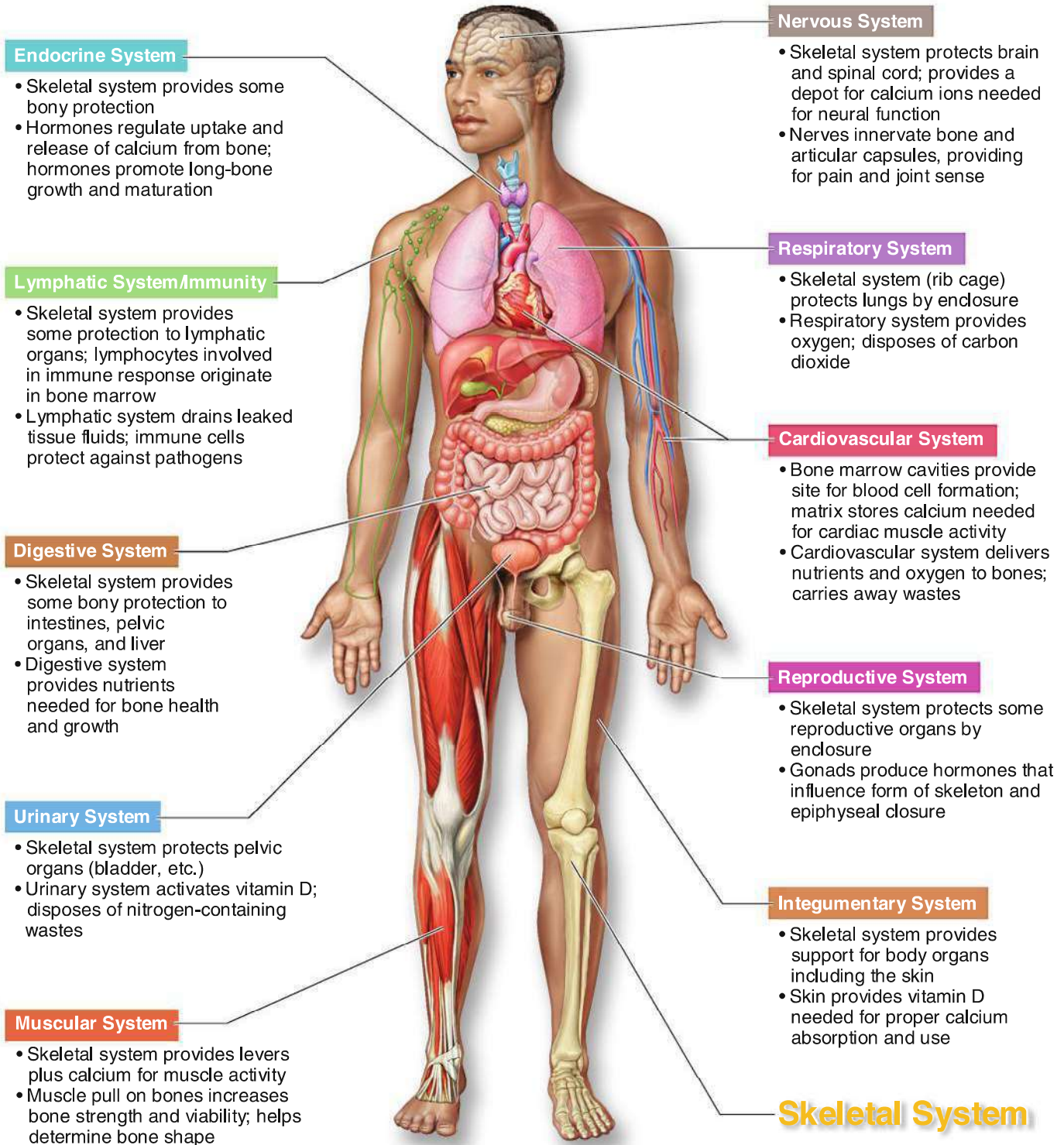
DID YOU GET IT ?

- 35.** Which spinal curvatures are present at birth?
- 36.** How does the shape of a newborn baby’s spine differ from that of an adult?
- 37.** Ninety-year-old Mrs. Pelky is groaning in pain. Her grandson has just picked her up and given her a bear hug. What do you think might just have happened to her spine, and what bone condition may she be suffering from?
- 38.** Which two regions of the skeleton grow most rapidly during childhood?

For answers, see Appendix D.

SYSTEMS IN SYNC

Homeostatic Relationships between the Skeletal System and Other Body Systems



Summary

➤ Access more review material and fun learning activities online—visit www.anatomyandphysiology.com and select Essentials of Human Anatomy & Physiology, 10th edition. In addition, references to Interactive Physiology are included below.

iP = Interactive Physiology

Bones: An Overview (pp. 134–145)

1. Bones support and protect body organs; serve as levers for the muscles to pull on to cause movement at joints; store calcium, fats, and other substances for the body; and contain red marrow, the site of blood cell production.
2. Bones are classified into four groups—long, short, flat, and irregular—on the basis of their shape and the amount of compact or spongy bone they contain. Bone markings are important anatomical landmarks that reveal where muscles attach and where blood vessels and nerves pass.
3. A long bone is composed of a shaft (diaphysis) with two ends (epiphyses). The shaft is compact bone; its cavity contains yellow marrow. The epiphyses are covered with hyaline cartilage; they contain spongy bone (where red marrow is found).
4. The organic parts of the matrix make bone flexible; calcium salts deposited in the matrix make bone hard.
5. Bones form on hyaline cartilage “models,” or fibrous membranes. Eventually these initial supporting structures are replaced by bone tissue. Epiphyseal plates persist to provide for longitudinal growth of long bones during childhood and become inactive when adolescence ends.
6. Bones change in shape throughout life. This remodeling occurs in response to hormones (for example, PTH, which regulates blood calcium levels) and mechanical stresses acting on the skeleton.
7. A fracture is a break in a bone. Common types of fractures include simple, compound, compression, comminuted, and greenstick. Bone fractures must be reduced to heal properly.

Axial Skeleton (pp. 145–157)

1. The skull is formed by cranial and facial bones. Eight cranial bones protect the brain: frontal,

occipital, ethmoid, and sphenoid bones, and the pairs of parietal and temporal bones. The 14 facial bones are all paired (maxillae, zygomatics, palatines, nasals, lacrimals, and inferior nasal conchae), except for the vomer and mandible. The hyoid bone, not really a skull bone, is supported in the neck by ligaments.

2. Skulls of newborns contain fontanelles (membranous areas), which allow brain growth. The infant's facial bones are very small compared to the size of the cranium.
3. The vertebral column is formed from 24 vertebrae, the sacrum, and the coccyx. There are 7 cervical vertebrae, 12 thoracic vertebrae, and 5 lumbar vertebrae, which have common as well as unique features. The vertebrae are separated by fibrocartilage discs that allow the vertebral column to be flexible. The vertebral column is S-shaped to allow for upright posture. Primary spinal curvatures present at birth are the thoracic and sacral curvatures; secondary curvatures (cervical and lumbar) develop after birth.
4. The bony thorax is formed from the sternum and 12 pairs of ribs. All ribs attach posteriorly to thoracic vertebrae. Anteriorly, the first 7 pairs attach directly to the sternum (true ribs); the last 5 pairs attach indirectly or not at all (false ribs). The bony thorax encloses the lungs, heart, and other organs of the thoracic cavity.

Appendicular Skeleton (pp. 158–165)

1. The shoulder girdle, composed of two bones—the scapula and the clavicle—attaches the upper limb to the axial skeleton. It is a light, poorly reinforced girdle that allows the upper limb a great deal of freedom. There are two shoulder girdles.
2. The bones of the upper limb include the humerus of the arm, the radius and ulna of the forearm, and the carpals, metacarpals, and phalanges of the hand.
3. The pelvic girdle is formed by the two coxal bones, or hip bones and the sacrum (which is actually part of the axial skeleton). Each hip bone is the result of fusion of the ilium, ischium, and pubis bones. The pelvic girdle is securely attached to the vertebral column, and the socket for the thigh bone is deep and heavily reinforced. This girdle receives the weight of the upper body and transfers it to the lower limbs. The female pelvis is lighter and broader than the male's; its inlet and outlet are larger, which reflects the childbearing function.

- The bones of the lower limb include the femur of the thigh, the tibia and fibula of the leg, and the tarsals, metatarsals, and phalanges of the foot.

Joints (pp. 165–173)

- Joints hold bones together and allow movement of the skeleton.
- Joints fall into three functional categories: synarthroses (immovable), amphiarthroses (slightly movable), and diarthroses (freely movable).
- Joints also can be classified structurally as fibrous, cartilaginous, or synovial joints depending on the substance separating the articulating bones.
- Most fibrous joints are synarthrotic, and most cartilaginous joints are amphiarthrotic. Fibrous and cartilaginous joints occur mainly in the axial skeleton.
- Most joints of the body are synovial joints, which predominate in the limbs. In synovial joints, the articulating bone surfaces are covered with articular cartilage and enclosed within the joint cavity by a fibrous capsule lined with a synovial membrane. All synovial joints are diarthroses.
- The most common joint problem is arthritis, or inflammation of the joints. Osteoarthritis, or degenerative arthritis, is a result of the “wear and tear” on joints over many years and is a common affliction of the aged. Rheumatoid arthritis occurs in both young and older adults; it is believed to be an autoimmune disease. Gouty arthritis, caused by the deposit of uric acid crystals in joints, typically affects a single joint.

Developmental Aspects of the Skeleton (pp. 173–175)

- Fontanelles, which allow brain growth and ease birth passage, are present in the skull at birth. Growth of the cranium after birth is related to brain growth; the increase in size of the facial skeleton follows tooth development and enlargement of the respiratory passageways.
- The vertebral column is C-shaped at birth (thoracic and sacral curvatures are present); the secondary curvatures form when the baby begins to lift its head and walk.
- Long bones continue to grow in length until late adolescence. By the age of 10, the head and trunk are approximately the same height as the lower limbs and change little thereafter.
- Fractures are the most common bone problem in elderly people. Osteoporosis, a condition of bone wasting that results mainly from hormone deficit or inactivity, is also common in older individuals.

Review Questions

Multiple Choice

More than one choice may apply.

- Which of the following are correctly matched?
 - Short bone—wrist
 - Long bone—leg
 - Irregular bone—sternum
 - Flat bone—cranium
- A passageway connecting neighboring osteocytes in an osteon is a
 - central canal.
 - lamella.
 - lacuna.
 - canaliculus.
 - perforating canal.
- Which of the following would you expect to be prominent in osteoclasts?
 - Golgi apparatus
 - Lysosomes
 - Microfilaments
 - Exocytosis
- Bone pain behind the external acoustic meatus probably involves the
 - maxilla.
 - ethmoid.
 - sphenoid.
 - temporal.
 - lacrimal.
- Bones that articulate with the sphenoid include
 - parietal.
 - vomer.
 - maxilla.
 - zygomatic.
 - ethmoid.
- Which humeral process articulates with the radius?
 - Trochlea
 - Greater tubercle
 - Lesser tubercle
 - Capitulum
 - Olecranon fossa
- The parts of the thoracic vertebrae that articulate with the ribs are
 - spinous process.
 - transverse process.
 - superior articular processes.
 - body.
 - pedicles.
- Which of the following bones or bone parts articulate with the femur?
 - Ischial tuberosity
 - Pubis
 - Patella
 - Fibula
 - Tibia

9. Which bone of the arm corresponds to the femur of the leg?
- Ulna
 - Humerus
 - Radius
 - Tibia
 - Fibula
10. At what stage of life do the lower limbs attain the same height as the head and trunk?
- At birth
 - By 10 years of age
 - At puberty
 - When the epiphyseal plates fuse
 - Never
11. Match the types of joints to the descriptions that apply to them. (More than one description might apply.)
- Fibrous joints
 - Cartilaginous joints
 - Synovial joints
- ___ 1. Have no joint cavity
- ___ 2. Types are sutures and syndesmoses
- ___ 3. Dense connective tissue fills the space between the bones
- ___ 4. Almost all joints of the skull
- ___ 5. Types are synchondroses and symphyses
- ___ 6. All are diarthroses
- ___ 7. The most common type of joint in the body
- ___ 8. Nearly all are synarthrotic
- ___ 9. Shoulder, hip, knee, and elbow joints
12. Match the bone markings listed on the right with their function listed on the left.
- | | |
|---|-------------------|
| 1. Attachment site for muscle or ligament | ___ a. Trochanter |
| 2. Forms a joint surface | ___ b. Condyle |
| 3. Passageway for vessels or nerves | ___ c. Foramen |
| | ___ d. Process |
| | ___ e. Facet |
| | ___ f. Tuberosity |
17. Which fracture types are most common in older people? Why are greenstick fractures more common in children?
18. Name the eight bones of the cranium.
19. With one exception, all skull bones are joined by sutures. What is the exception?
20. What facial bone forms the chin? The cheekbone? The upper jaw? The bony eyebrow ridges?
21. Name two ways in which the fetal skull differs from the adult skull.
22. How many vertebrae are there in each of the three superior regions of the vertebral column?
23. Diagram the normal spinal curvatures and then the curvatures seen in scoliosis and lordosis.
24. What is the function of the intervertebral discs? What is a slipped disc?
25. Name the major components of the thorax.
26. Is a floating rib a true or a false rib? Why are floating ribs easily broken?
27. Name the bones of the shoulder girdle.
28. Name all the bones with which the ulna articulates.
29. What bones make up each hip bone (coxal bone)? Which of these is the largest? Which has tuberosities that we sit on? Which is the most anterior?
30. Name the bones of the lower limb from superior to inferior.
31. Compare the amount of movement possible in synarthrotic, amphiarthrotic, and diarthrotic joints. Relate these terms to the structural classification of joints; that is, to fibrous, cartilaginous, and synovial joints.
32. Describe the structure of a synovial joint.
33. Professor Rogers pointed to the foramen magnum of the skull and said, "The food passes through this hole when you swallow." Some students believed him, but others said that this was a big mistake. What do you think? Support your answer.

Short Answer Essay

13. Name three functions of the skeletal system.
14. What is yellow marrow? How do spongy and compact bone look different?
15. Why do bone injuries heal much more rapidly than injuries to cartilage?
16. Compare and contrast the role of PTH (hormone) and mechanical forces acting on the skeleton in bone remodeling.
34. Yolanda is asked to review a bone slide that has been set up under a microscope. She sees concentric layers surrounding a central cavity or canal. Is this bone section taken from the diaphysis or the epiphyseal plate of the bone specimen?
35. List two factors that keep bones healthy. List two factors that can cause bones to become soft or to atrophy.



Critical Thinking and Clinical Application Questions

36. A 75-year-old woman and her 9-year-old granddaughter were in a train crash in which both sustained trauma to the chest while seated next to each other. X-ray images showed that the grandmother had several fractured ribs, but her granddaughter had none. Explain these surprisingly (?) different findings.
37. The pediatrician at the clinic explains to parents of a newborn that their son suffers from cleft palate. She tells them that the normal palate fuses in an anterior-to-posterior pattern. The child's palatine processes of the maxilla have not fused. Have his palatine bones fused normally?
38. After having a severe cold accompanied by nasal congestion, Helen complained that she had a frontal headache and the right side of her face ached. What bony structures probably became infected by the bacteria or viruses causing the cold?
39. Bernice, a 75-year-old woman, stumbled slightly while walking, then felt a terrible pain in her left hip. At the hospital, X rays revealed that the hip was broken. Also, the compact and spongy bone throughout her spine were very thin. What was her probable condition?
40. At work, a box fell from a shelf onto Bertha's acromial region. In the emergency room, the physician felt that the head of her humerus had moved into the axilla. What had happened to Bertha?
41. An X-ray image of the arm of an accident victim reveals a faint line curving around and down the shaft. What kind of fracture might this indicate?
42. Bone X rays are sometimes used to determine whether a person has reached his or her final height. What are the clinicians checking out?
43. A patient complains of pain starting in the jaw and radiating down the neck. When he is questioned further, he states that when he is under stress he grinds his teeth. What joint is causing his pain?
44. Dr. Davis is palpating Jane's vertebral column to determine whether she is beginning to exhibit scoliosis. What part or region of her vertebrae was he feeling as he ran his fingers along her spine?