The vertebral column has 24 individual vertebrae arranged in cervical, thoracic, and lumbar regions, the sacral and coccygeal vertebrae are fused (sacrum/coccyx). Numbers of vertebrae in each region are remarkably constant; rarely S1 may be free or L5 may be fused to the sacrum (transitional vertebrae). The seven mobile cervical vertebrae support the neck and the 3-4 kg (6-8 lb) head. The cervical spine is normally curved (cervical lordosis) secondary to the development of postural reflexes about three months after birth. The 12 thoracic vertebrae support the thorax, head, and neck. They articulate with 12 ribs bilaterally. The thoracic spine is congenitally curved (kyphosis) as shown. The five lumbar vertebrae support the upper body, torso, and low back. The column of these vertebrae is curved (lumbar lordosis) due to the onset of walking at 1-2 years of age. The sacrum is the keystone of a weightbearing arch involving the hip bones. The sacral/coccygeal curve is congenital. The variably numbered 1-5 coccygeal vertebrae are usually fused, although the first vertebra may be movable.

Ventral curvatures may be affected (usually exaggerated) by posture, activity, obesity, pregnancy, trauma, and/or disease; these conditions are named the same as the normal curves. There may normally be a slight lateral curvature to the spine often due to dominant handedness; a significant, possibly disabling, lateral curve (scoliosis) may occur for many reasons.

Each pair of individual, unfused vertebrae constitutes a motion segment, the basic movable unit of the back. Combined movements of motion segments underlie movement of the neck, middle and low back. Each pair of vertebrae in a motion segment, except C1-C2, is attached by three joints: a partly movable, intervertebral disc anteriorly, and a pair of gliding synovial facet (zygapophyseal) joints posteriorly. Ligaments secure the bones together and encapsulate the facet joints (joint capsules). The vertebral or neural canal, a series of vertebral foramina, transmits the spinal cord and related coverings, vessels, and nerve roots. Located bilaterally between each pair of vertebral pedicles are passageways, each called an intervertebral foramen, transmitting spinal nerves, their coverings/vessels, and some vessels to the spinal cord.

The intervertebral disc consists of the annulus fibrosus (concentric, interwoven collagenous fibers integrated with cartilage cells) attached to the vertebral bodies above and below, and the more central nucleus pulposus (a mass of degenerated collagen, proteoglycans, and water). The discs make possible movement between vertebral bodies. With aging, the discs dehydrate and thin, resulting in a loss of height. The cervical and lumbar discs, particularly, are subject to early degeneration from one or more of a number of causes. Weakening and/or tearing of the annulus can result in a broad-based bulge or a localized (focal) protrusion of the nucleus and adjacent annulus; such an event can compress a spinal nerve root as shown.
III. SKELETAL SYSTEM

CEVICAL AND THORACIC VERTEBRAE

CN: Use red for M and use the same colors as were used on Plate 21 for C and T. Use dark colors for N, O, and P. (1) Begin with the parts of a cervical vertebra. Color the atlas and axis and note they have been given separate colors to distinguish them from other cervical vertebrae. (2) Color the parts of a thoracic vertebra and then the thoracic portion of the vertebral column. Note the three different facet/demifacet colors.

CERVICAL VERTEBRA

BODY
PEDICLE
TRANSVERSE PROCESS
ARTICULAR PROCESS
LAMINA
SPINOSUS PROCESS

SUPERIOR VIEW

The small seven cervical vertebrae support and move the head and neck, supported by ligaments and strap-like paracervical (paraspinal) muscles. The ring-shaped atlas (C1) has no body; thus there are no weight-bearing discs between the occiput and C1, and between C1 and C2 (the axis). Head weight is transferred to C3 by the large articular processes and facets of C1 and C2. The atlanto-occipital joints, in conjunction with the C3-C7 facet joints, permit a remarkable degree of flexion/extension ("yes" movements). The dens of C2 projects into the anterior part of the C1 ring, forming a pivot joint, enabling the head and C1 to rotate almost 90° ("no" movements). Such rotational capacity is permitted by the relatively horizontal orientation of the cervical facets. The C3-C6 vertebrae are similar; C7 is remarkable for its prominent spinous process, easily palpated. The posterior directed cervical curve and the extensive paracervical musculature preclude palpation of the other cervical spinous processes. The vertebral arteries, en route to the brain stem, pass through foramina of the transverse processes of the upper six cervical vertebrae. These vessels are subject to stretching injuries with extreme cervical rotation of the hyperextended neck. The cervical vertebral canal conducts the cervical spinal cord and its coverings (not shown). The C4-5 and C5-6 motion segments are the most mobile of the cervical region and are particularly prone to disc/facet degeneration.

The twelve thoracic vertebrae—characterized by long, slender spinous processes, heart-shaped bodies, and nearly vertically oriented facets—articulate with ribs bilaterally. In general, each rib forms a synovial joint with two demifacets on the bodies of adjacent vertebrae and a single facet on the transverse process of the lower vertebra. Variations of these costovertebral joints are seen with T1, T11, and T12.

THORACIC VERTEBRA

BODY
FACET
DEMFACET
TRANSVERSE FACET
RIB
LIGAMENT

See 21, 23

Cranium
Mastoid process
C 1
C 2
C 3
C 4
C 5
C 6
C 7
Vertebra prominens

LATERAL VIEW

ATLAS
AXIS

Facet for occipital condyle
Transverse foramen
Posterl arch
Posterior tubercle
Superior articular process
Inferior articular process

MOVTMENT

"NO"

"YES"

MOVEMENT

ROTATION

FLEXION/EXTENSION

TYPICAL CERVICAL (C4) VERTEBRA

TYPICAL THORACIC (T12) VERTEBRA

Superior articular process
Inferior articular process

Outline of rib

LATERAL/
SUPERIOR VIEW

Transverse facet
The five lumbar vertebrae are the most massive of all the individual vertebrae, their thick processes securing the attachments of numerous ligaments and muscles/tendons. Significant flexion and extension of the lumbar and lumbosacral motion segments, particularly at L4–L5 and L5–S1, are possible. About L1, the spinal cord terminates and the cauda equina (bundle of lumbar, sacral, and coccygeal nerve roots; see Plate 21) begins. The lumbar intervertebral foramina are large. Transmitting nerve roots/sheaths take up only about 50% of the volume of these foramina. Disc and facet degeneration is common in the L4–S5 and L5–S1 segments; reduction of space for the nerve roots increases the risk of nerve root irritation/compression (radiculitis/radiculopathy). Occasionally, the L5 vertebra is partially or completely fused to the sacrum (sacralized L5). The S1 vertebra may be partially or wholly non-fused (lumbarized S1), resulting in essentially six lumbar vertebrae.

The planes (orientation) of the articular facets determine the direction and influence the degree of motion segment movement. The plane of the cervical facets is angled coronally off the horizontal plane about 30°. Considerable freedom of movement of the cervical spine is permitted in all planes (sagittal, coronal, horizontal). The thoracic facets lie more vertically in the coronal plane, and are virtually non-weightbearing. The range of motion here is significantly limited in all planes, less so in rotation. The plane of the lumbar facets is largely sagittal, resisting rotation of the lumbar spine, transitioning to a more coronal orientation at L5–S1. The L4–L5 facet joints permit the greatest degree of lumbar motion in all planes.

The sacrum consists of five fused vertebrae; the intervertebral discs are largely replaced by bone. The sacral (vertebral) canal contains the terminal sac of the dura mater (dural sac, thecal sac) to S2 and the sacral nerve roots, which transit the sacral foramina. The sacrum joins with the ilium of the hip bone at the auricular surface, forming the sacroiliac joint.

The sacrum and the ilia of the hip bones form an arch for the transmission and distribution of weightbearing forces to the heads of the femora. It is a strong arch, and the sacrum is its keystone. The coccyx consists of 2–4 tiny individual or partly fused, rudimentary vertebrae. The first coccygeal vertebra is the most completely developed.
The bony thorax is the skeleton of the chest, representing a fairly mobile set of structures important to respiration and harboring the heart, lungs, and other significant organs. The superior thoracic aperture (thoracic inlet, often incorrectly termed thoracic outlet in a clinical context) transmits the esophagus, trachea, nerves, and important ducts and vessels. The inferior thoracic aperture is virtually sealed by the diaphragm. The space between ribs is the intercostal space, and contains three layers of muscle and fasciae, and intercostal vessels and nerves. Collective rib movement is responsible for about 25% of the respiratory effort.

The fibrocartilaginous joint between the manubrium and the body of the sternum (sternal angle, sternomanubrial joint) makes subtle hinge-like movements during respiration. The xiphoid makes a fibrocartilaginous (xiphisternal) joint with the body of the sternum.

The sternum is frequently cancellous bone containing red marrow. The costal cartilages, representing unossified cartilage models of the anterior ribs, articulate with the sternum by gliding-type synovial joints (sternocostal joints; except for the first joint, which is not synovial). All ribs form synovial joints with the thoracic vertebrae (costovertebral joints). Within each of these joints, the rib (2 through 9) forms a synovial joint with a demifacet of the upper vertebral body and with a demifacet of the lower body (costocoracoid joints). In addition, the tubercle of the rib articulates with a cartilaginous facet at the tip of the transverse process of the lower vertebra (costotransverse joint). Ribs 1, 10, 11, 12 each join with one vertebra instead of two; ribs 11 and 12 have no costotransverse joints. True ribs (1–7) articulate directly with the sternum. Ribs 8–12 are called false ribs; ribs 8–10 articulate indirectly with the sternum (via cartilages connecting to the 7th costal cartilage); ribs 11 and 12 (also called floating ribs) end in the muscular abdominal wall.