LUMBAR, SACRAL, & COCCYGEAL VERTEBRAE

CN: Use the same colors as were used on the previous two plates for T, L, E, F, A, S, and Co (1) Begin with the three large views of lumbar vertebrae. (2) Color the different planes of articular facets (3) Color the four views of the sacrum and coccyx Note that the central portion of the median section receives the vertebral canal color (E').

LUMBAR VERTEBRA L

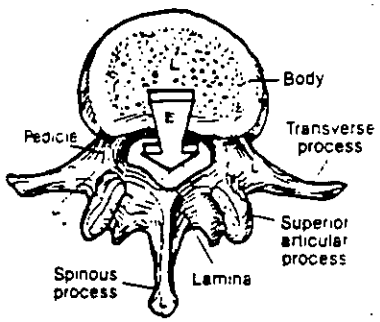
VERTEBRAL FORAMEN F

VERTEBRAL CANAL E'

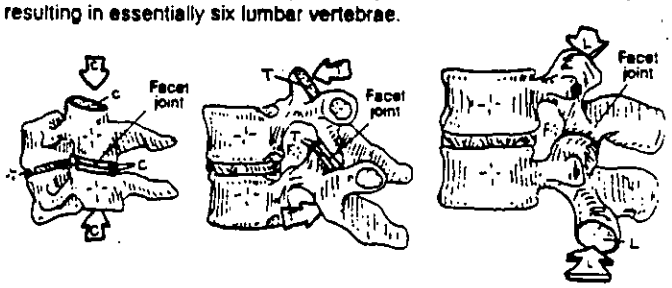
INTERVERTEBRAL FORAMEN F

INTERVERTEBRAL DISC A

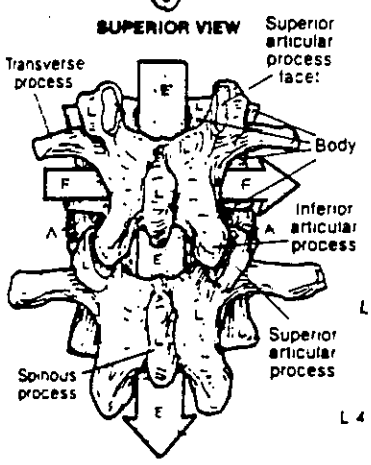
The five *lumbar vertebrae* are the most massive of all the individual vertebrae, their thick processes securing the attachments of numerous ligaments and muscles/tendons. Significant flexion and extension of the lumbar and lumbosacral motion segments, particularly at L4-L5 and L5-S1, are possible. At 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. Transiting nerve roots/sheaths take up only about 50% of the volume of these foramina. *Disc* and facet degeneration is common in the L4-5 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.

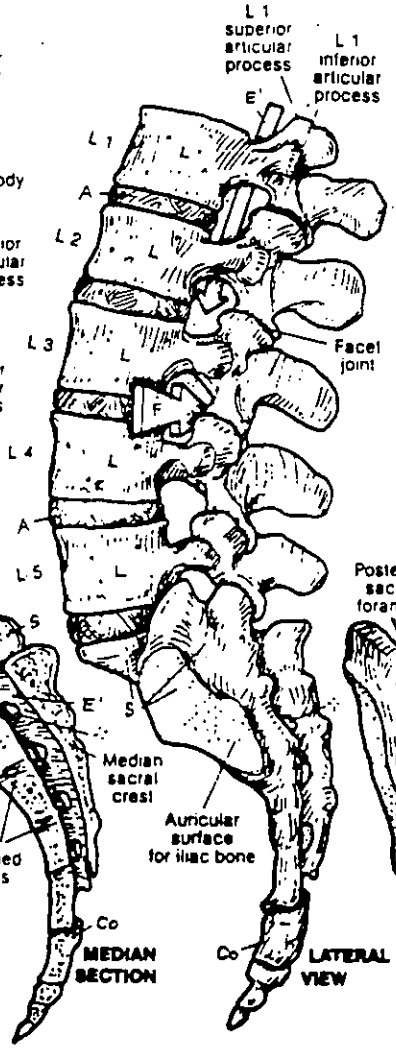


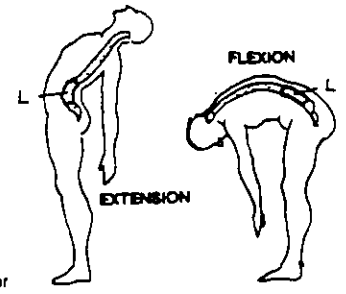
PLANES OF ARTICULAR FACETS: CERVICAL C THORACIC T LUMBAR L

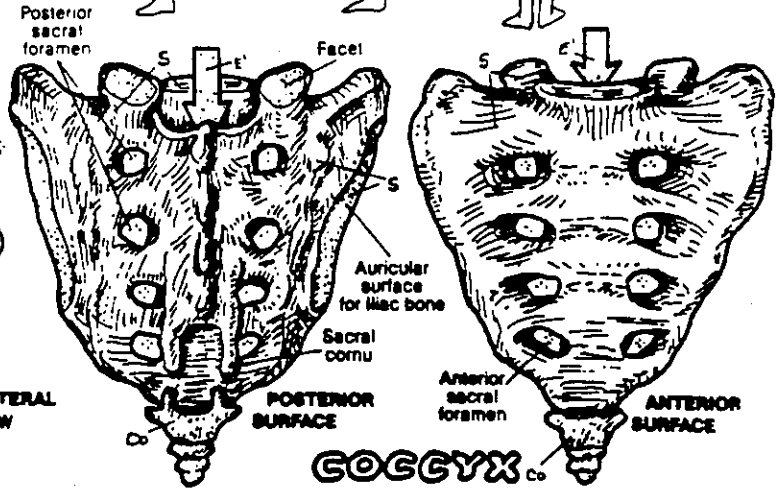


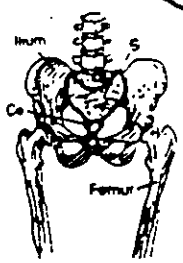
The planes (orientation) of the articular facets determine the direction and influence the degree of motion segment movement. The plane of the *cervical facets* is angled coronally off the horizontal plane about 30°. Considerable freedom of movement of the cervical spine is permitted in all planes (sagittal, 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.











SACRUM S

COCCYX Co

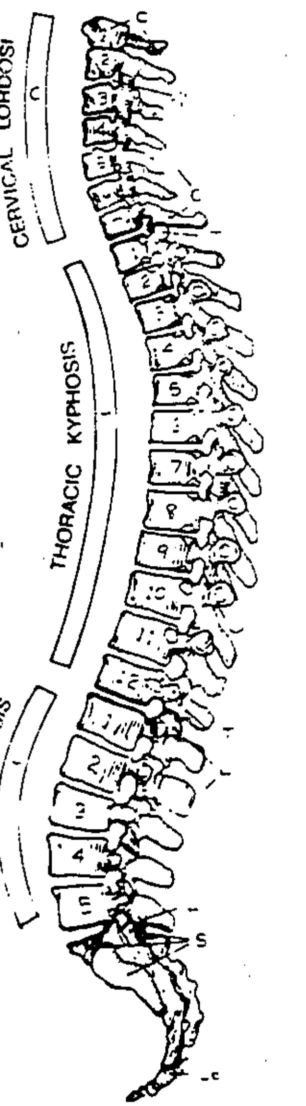
The *sacrum* consists of five fused vertebrae; the intervertebral discs are largely replaced by bone. The sacral (vertebral) canal contains the terminal sac of the dura mater (dural sac, thecal sac) to S2 and the sacral nerve roots, which transit the sacral foramina. The sacrum joins with the ilium of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

CN Use gray for D, yellow for H, and light colors for the rest, especially C, T, L, S, and Co. (1) Begin with regions of the column and the three examples of vertebral disorders at lower left. (2) Color the motion segment and its role in flexion and extension. (3) Color the vertebral foramina and canal. (4) Color the example of a protruding intervertebral disc pressing on a spinal nerve.

REGIONS:

CERVICAL C
THORACIC T
LUMBAR L
SACRAL S
COCCYGEAL Co

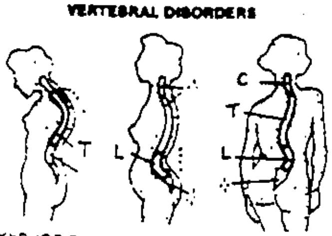


The vertebral column has 24 individual vertebrae arranged in *cervical, thoracic*, and *lumbar* regions; the *sacral* and *coccygeal* vertebrae are fused (sacrum/coccyx). Numbers of vertebrae in each region are remarkably constant; rarely S1 may be free or L5 may be fused to the sacrum (transitional 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.

Vertebral 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.

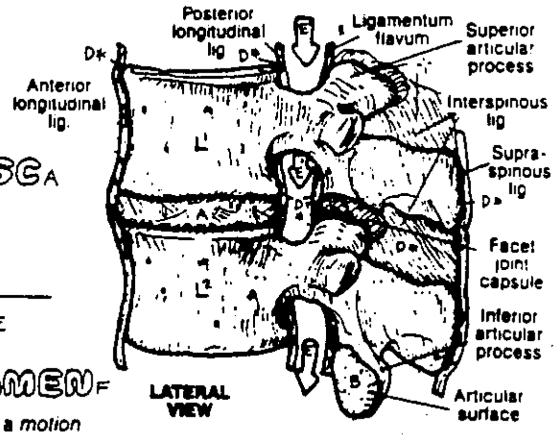
VERTEBRAL DISORDERS



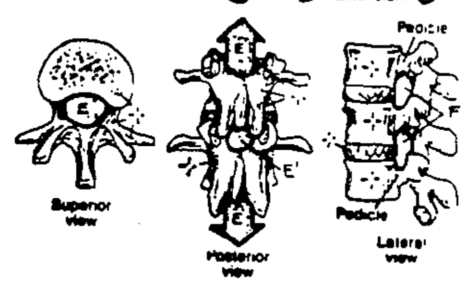
MOTION SEGMENT:*

VERTEBRA L
JOINTS:
INTERVERTEBRAL DISC A
POSTERIOR (FACET) B
LIGAMENT D*
VERTEBRA L²

VERTEBRAL FORAMEN E
VERTEBRAL CANAL E'
INTERVERTEBRAL FORAMEN F



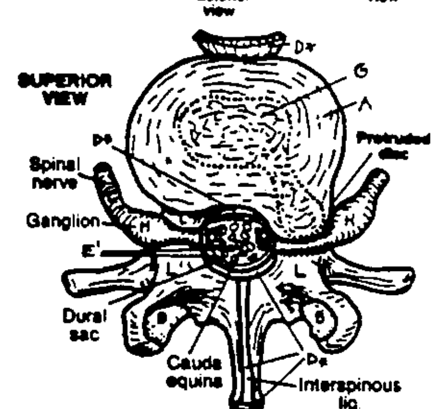
Each pair of individual, unfused vertebrae constitutes a *motion segment*, the basic movable unit of the back. Combined movements of motion segments underlie movement of the neck, middle and low back. Each pair of vertebrae in a motion segment, except C1-C2, is attached by three joints: a partly movable, *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.



INTERVERTEBRAL DISC A

ANNULUS FIBROSUS A'
NUCLEUS PULPOSUS G
SPINAL NERVE H

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.



BRACHIAL PLEXUS & NERVES TO THE UPPER LIMB

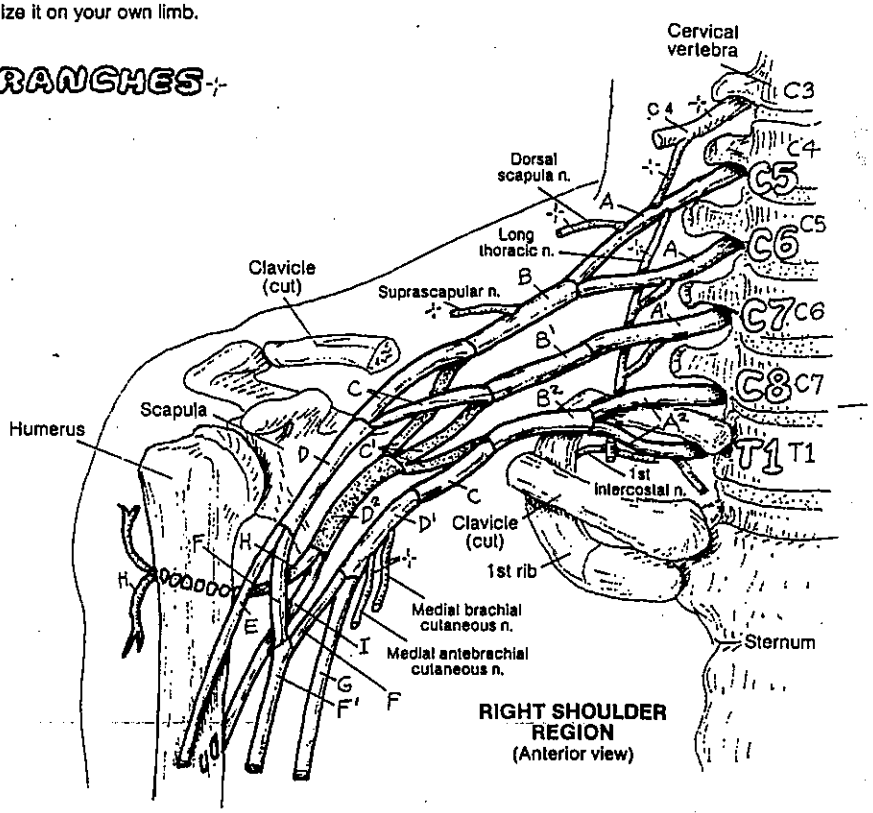
CN: Use light colors for A–D. (1) In the upper illustration, color the letters and numbers identifying the five roots of the brachial plexus. Note but do not color the small branches of the plexus as you color the plexus itself. Note in the lower illustration that the entire plexus is colored gray. (2) As you color each of the major nerves arising from the plexus, color it in the lower illustration as well. As you color each nerve, try to visualize it on your own limb.

BRACHIAL PLEXUS & MAJOR BRANCHES

ROOTS C5, C6 A
UPPER TRUNK B
ROOT C7 A'
MIDDLE TRUNK B'
ROOTS C8, T1 A²
LOWER TRUNK B²

ANTERIOR DIVISION C
LATERAL CORD (C5-C7) D
MUSCULOCUTANEOUS N. E
BR. TO MEDIAN N. F
MEDIAL CORD (C8-T1) D'
BR. TO MEDIAN N. F
MEDIAN N. F'
ULNAR N. G

POSTERIOR DIVISION (C5-T1) C'
POSTERIOR CORD D²
AXILLARY N. (C5-C6) H
RADIAL N. (C5-T1) I

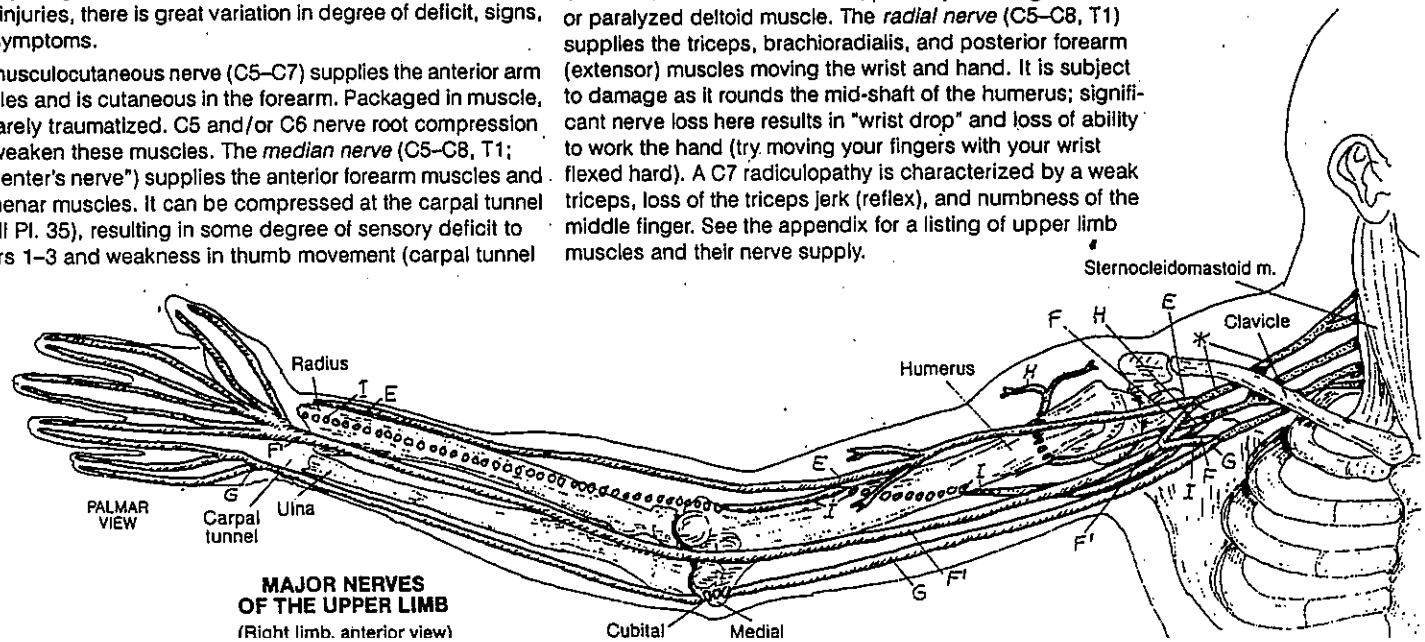


The major nerves to the structures of the upper limb arise from the brachial plexus, formed from the anterior rami of spinal nerves C5–T1 (plus or minus one level). These rami form the *roots of the plexus*. In the pattern illustrated, further branching and joining of fibers in the neck, supraclavicular area, and axilla result in the formation of the five major nerves of the upper limb.

The brachial plexus is subject to injury (plexopathy) from excessive stretching or traction (e.g., rapid, forceful pulling of the upper limb) and compression (e.g., long-term placement of body weight on axillary or armpit cushions of crutches). In such injuries, there is great variation in degree of deficit, signs, and symptoms.

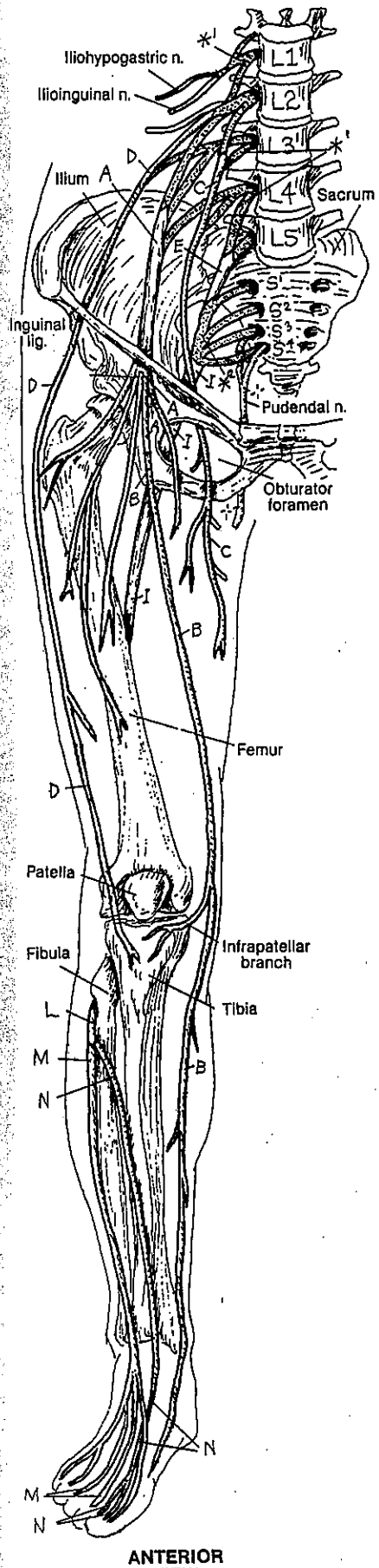
The musculocutaneous nerve (C5–C7) supplies the anterior arm muscles and is cutaneous in the forearm. Packaged in muscle, it is rarely traumatized. C5 and/or C6 nerve root compression can weaken these muscles. The *median nerve* (C5–C8, T1; "carpenter's nerve") supplies the anterior forearm muscles and the thenar muscles. It can be compressed at the carpal tunnel (recall Pl. 35), resulting in some degree of sensory deficit to fingers 1–3 and weakness in thumb movement (carpal tunnel syndrome). Similar complaints can be associated with a C6 nerve root compression.

The ulnar nerve (C8–T1; "musician's nerve") supplies certain muscles of the forearm and most intrinsic muscles of the hand. It is subject to trauma as it rounds the elbow in the cubital tunnel, possibly resulting in ulnar-side finger pain, hand weakness, or abnormal little finger position. Similar complaints can be associated with a C8 nerve root compression. The *axillary nerve* (C5–C6) wraps around the neck of the humerus to supply deltoid and teres minor. It is vulnerable in fractures of the humeral neck, possibly resulting in a weak or paralyzed deltoid muscle. The *radial nerve* (C5–C8, T1) supplies the triceps, brachioradialis, and posterior forearm (extensor) muscles moving the wrist and hand. It is subject to damage as it rounds the mid-shaft of the humerus; significant nerve loss here results in "wrist drop" and loss of ability to work the hand (try moving your fingers with your wrist flexed hard). A C7 radiculopathy is characterized by a weak triceps, loss of the triceps jerk (reflex), and numbness of the middle finger. See the appendix for a listing of upper limb muscles and their nerve supply.



MAJOR NERVES OF THE UPPER LIMB
(Right limb, anterior view)

LUMBAR PLEXUS & NERVES TO THE LOWER LIMB



CN: Use a bright color for J. (1) Begin with the anterior view. Color the lumbar and sacral plexuses gray; note that they have been dotted for easy identification. Note the longest branch of the femoral nerve: saphenous nerve. (2) Color the posterior view, which includes almost entirely the sciatic nerve and its branches. The heel of the foot has been lifted to view the plantar nerves.

LUMBAR PLEXUS (L1–L4) *1
- FEMORAL N. A
  - SAPHENOUS N. B
- OBTURATOR N. C
- LAT. FEMORAL CUTAN. N. D

LUMBOSACRAL TRUNK (L4–L5) E

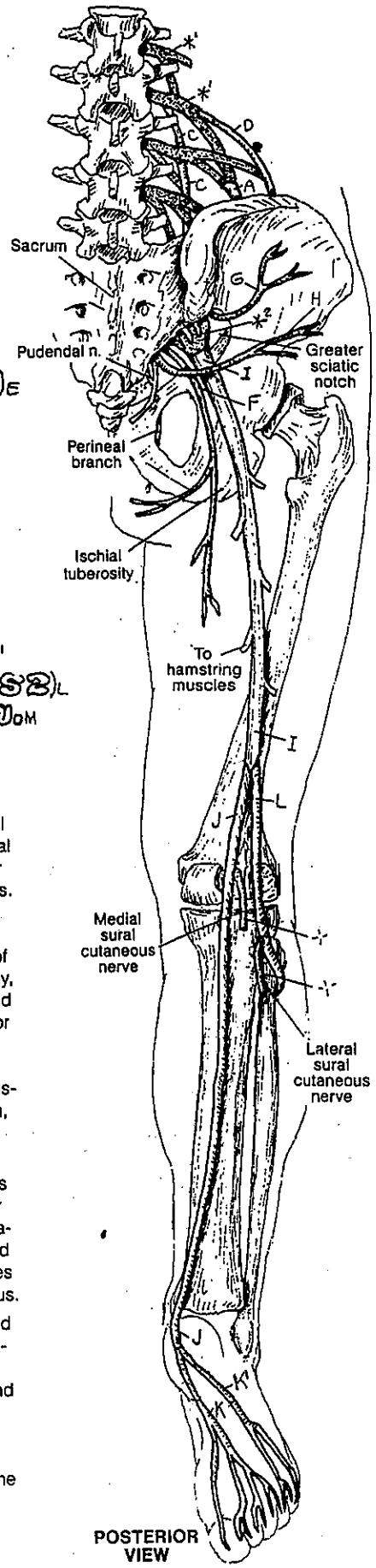
SACRAL PLEXUS (L4–S4) *2
- POST. FEMORAL CUTAN. N. F
- SUPERIOR GLUTEAL N. G
- INFERIOR GLUTEAL N. H

SCIATIC N. (L4–S3) I
- TIBIAL N. (L4–S3) J
  - MED. & LAT. PLANTAR N. K'
- COMMON FIBULAR N. (L4–S2) L
  - SUPERFICIAL FIBULAR N. M
  - DEEP FIBULAR N. N

The lumbar plexus, formed from the anterior rami of L1–L4 spinal nerves, is located against the muscles of the posterior abdominal wall. The *femoral nerve* (L2–L4) passes through the psoas major muscle in its descent, emerging lateral to the muscle in the pelvis. As the nerve passes under the inguinal ligament, it lies on the muscle's anterior surface. The femoral nerve breaks up into a leash of nerves in the proximal thigh, supplying the four heads of the quadriceps femoris muscle and the sartorius muscle. Medially, the cutaneous *saphenous nerve* descends to the medial knee and beyond to the ankle. In mid-thigh, it passes through the adductor canal into the posterior femoral compartment, with the femoral artery and vein (recall Plate 63). The *obturator nerve* (L2–L4) passes along the lateral pelvic wall on the obturator internus muscle. It penetrates the obturator foramen to enter the medial thigh, supplying the adductor muscles. Both femoral and obturator nerves are subject to trauma or compression within the pelvis.

The lumbosacral trunk (L4, L5) joins with the sacral spinal nerves to form the *sacral plexus* (L4–S4). From this plexus, the *superior gluteal nerve* (L4, L5, S1) passes through the greater sciatic foramen, above the piriformis muscle, to supply gluteus medius (and sometimes minimus). The *inferior gluteal nerve* (L5, S1, S2) comes into the gluteal region above piriformis to supply gluteus maximus.

The sciatic nerve joins the posterior femoral cutaneous nerve and the inferior gluteal nerve to pass through the greater sciatic foramen under the piriformis muscle, deep to gluteus maximus (but not innervating it). It descends between the ischial tuberosity and the greater trochanter of the femur. Within the posterior femoral compartment, above the knee, the sciatic nerve splits into the tibial and common *fibular (peroneal) nerves*. The *tibial nerve* supplies the posterior leg muscles and the plantar muscles of the foot. The common fibular nerve supplies the lateral leg muscles (superficial fibular nerve) and the muscles of the anterolateral leg compartment (deep fibular nerve).



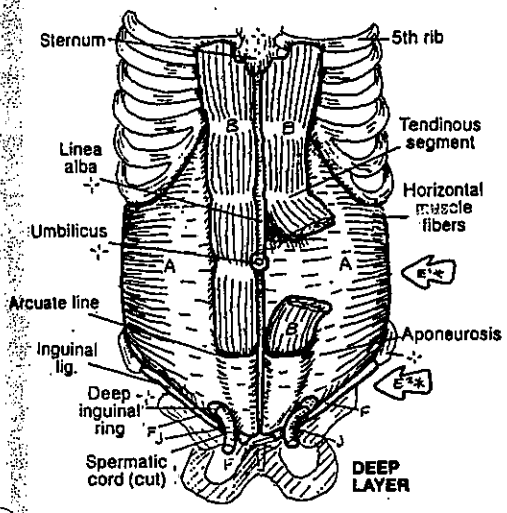
MUSCLES OF ANTERIOR ABDOMINAL WALL & INGUINAL REGION

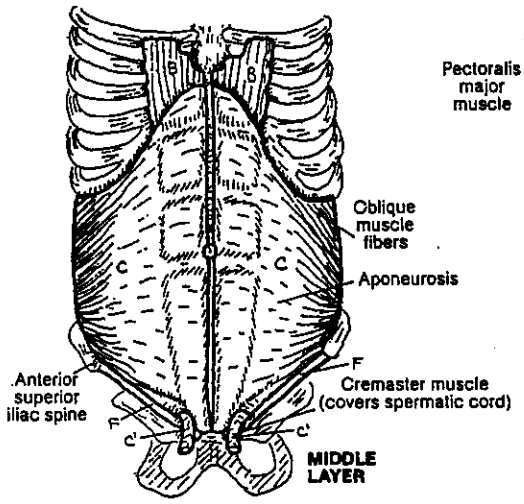
CN: Use a dark color for J and bright ones for B and I. (1) Color the 3 layers of the abdominal wall. (2) Color the sheath of the rectus abdominis in the lower left illustration gray. Color the two locator arrows gray in this and the upper illustration. (3) Beginning with J and K, and followed by H, color the coverings of the spermatic cord.

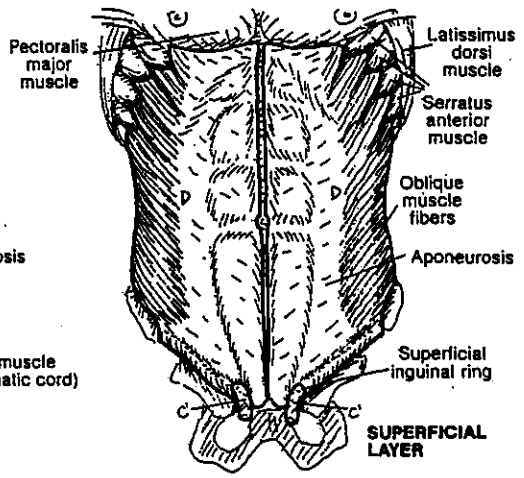
ANTERIOR ABDOMINAL WALL

- TRANSVERSUS ABDOMINIS A
- RECTUS ABDOMINIS B
- INTERNAL OBLIQUE C
- EXTERNAL OBLIQUE D

The anterior abdominal wall consists of three layers of flat muscles, the tendons (aponeuroses) of which interlace in the midline, and a vertically oriented pair of segmented muscles that are ensheathed incompletely by the aponeuroses of the three flat muscles (*sheath of the rectus abdominis*). The flat muscles arise from the lateral aspect of the torso (inguinal ligament, iliac crest, thoracolumbar fascia, lower costal cartilages, ribs). The lowest fibers of *external oblique* roll inwardly to form the *inguinal ligament*. These three muscles act to compress the abdominal contents during expiration, urination, and defecation. They assist in maintaining pressure on the curve of the low back, resisting "sway back" (excess lumbar lordosis) and extension of the low back.

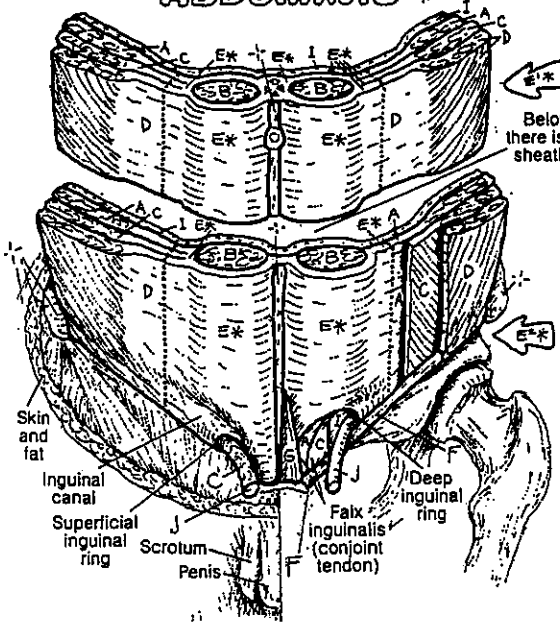




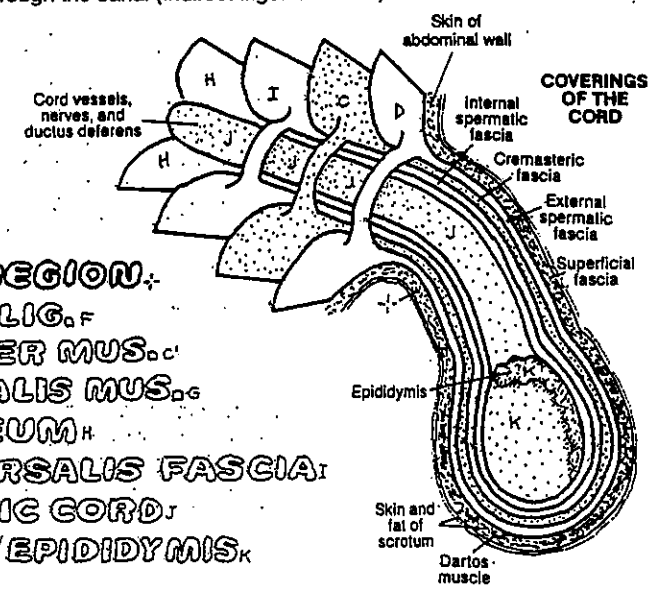


Each segmented rectus abdominis muscle arises from the pubic crest and tubercles and inserts on the lower costal cartilages and xiphoid process (sternum). They are flexors of the vertebral column. The *sheath of the rectus* varies in its extent, running from deep to superficial from below upward, as illustrated. Below the arcuate line, no muscle contributes to its posterior layer (E^{2*}); in the middle, all three flat aponeuroses contribute equally to the sheath (E^{1*}); above, the anterior sheath is formed from external oblique; posteriorly, the rectus contacts the costal cartilages.

SHEATH OF RECTUS ABDOMINIS E*



The inguinal region is the lower medial part of the abdominal wall, characterized by a canal with inner (deep) and outer (superficial) openings or rings. This canal carries the *spermatic cord* (ductus deferens and its vessels, testicular vessels, lymphatics) in the male and the round ligament of the uterus in the female. The testes and spermatic cords "descend" (by differential growth) into outpocketings of the anterior abdominal wall, collectively called the scrotum. In their descent, they push in front of them layers of fibers from the three flat muscles of the abdominal wall and their aponeuroses, much as a finger might push against four layers of latex to form a four-layered finger glove. These are the coverings of the cord: internal, cremasteric, and external spermatic fasciae. The lower fibers of internal oblique are unique in that they continue in loops around the spermatic cord as the cremaster muscle; the two are connected by cremasteric fascia. The canal area is a weak point, subject to protrusions of fat or intestine (hernias) from within the abdominal cavity, either directly through the wall (direct inguinal hernia) or indirectly through the canal (indirect inguinal hernia).



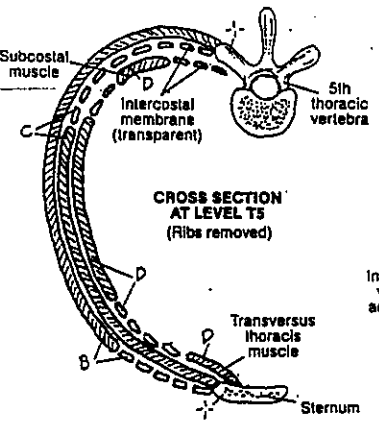
INGUINAL REGION

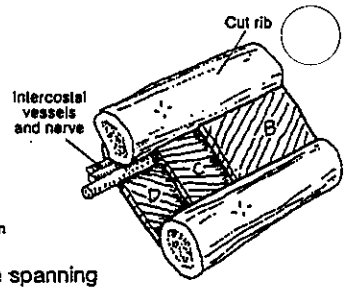
- INGUINAL LIG. F
- CREMASTER MUS. C'
- PYRAMIDALIS MUS. G
- PERITONEUM H
- TRANSVERSALIS FASCIA I
- SPERMATIC CORD J
- TESTIS / EPIDIDYMIS K

See 74, 75, 76, 169

MUSCLES OF THORAX & POSTERIOR ABDOMINAL WALL

CN: Use blue for E and red for G. (1) You may wish to darken the underside of the diaphragm (A) in the anterior view. Do not confuse the arcuate ligaments with the 12th rib. (2) In the cross-sectional view at upper right, color the broken lines that represent transparent, membranous portions of the intercostal muscles.





INTERCOSTAL MUSCLE FIBER ORIENTATION

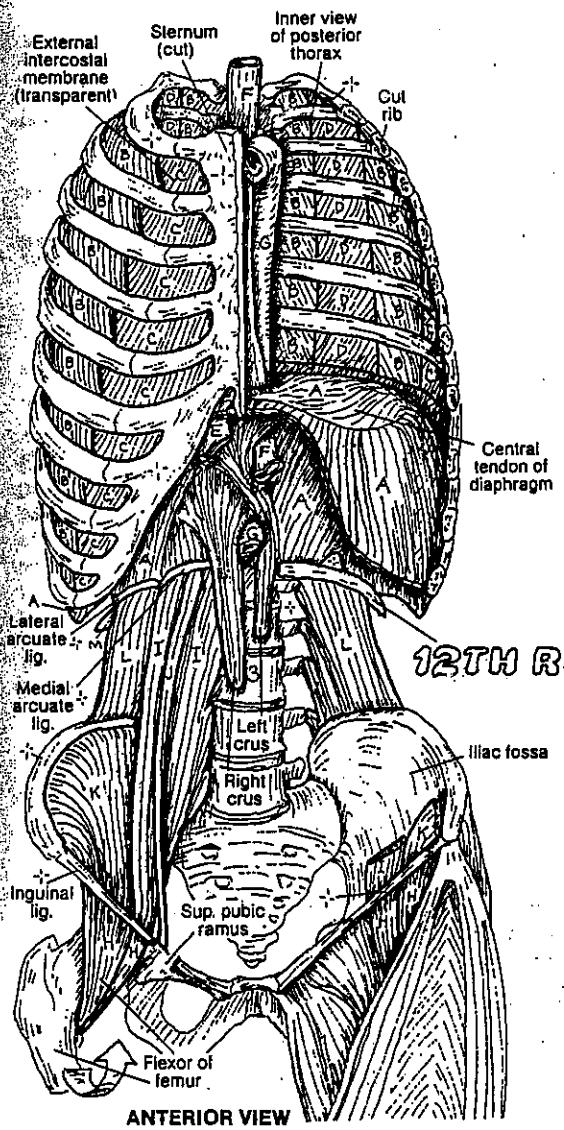
THORAX MUSCLES

THORACIC DIAPHRAGM A
EXTERNAL INTERCOSTAL B
INTERNAL INTERCOSTAL C
INNERMOST INTERCOSTAL D

The thoracic diaphragm is a broad, thin muscle spanning the thoracoabdominal cavity; the illustration shows much of its origin (all except the lower six ribs).

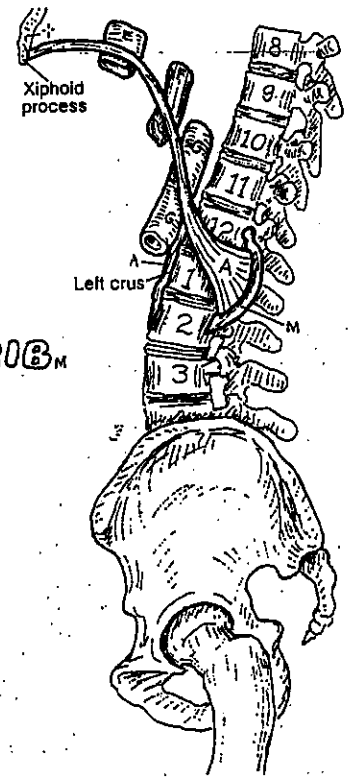
The left and right halves of the diaphragm insert into each other (central tendon). The diaphragm is responsible for 75% of the respiratory air flow. Openings (hiatuses) in the diaphragm provide passage for major transiting structures.

The intercostal muscles alter the dimensions of the thoracic cavity by collectively moving the ribs, resulting in 25% of the total respiratory effort. The specific function of each of these muscles, with respect to fiber orientation, is not understood. The innermost intercostals are an inconstant layer, and here include the transversus thoracis and subcostal muscles.

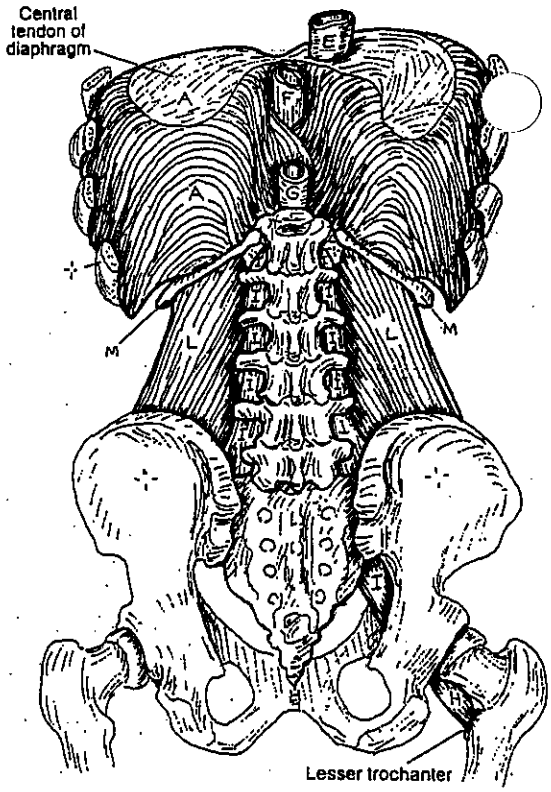


ANTERIOR VIEW

INFERIOR VENA CAVA E
ESOPHAGUS F
AORTA G



LATERAL VIEW



POSTERIOR VIEW

POSTERIOR ABDOMINAL WALL MUSCLES

ILIOPSOAS H
PSOAS MAJOR I MINOR J
ILIACUS K
QUADRATUS LUMBORUM L

The tendons of iliacus and psoas major converge to a single insertion (*iliop*[illegible] iliopsoas, a strong flexor of the hip joint, is a powerful flexor of the lumbar ve[illegible] brae; a weak psoas may contribute to low back pain. *Quadratus lumborum* is an extensor of the lumbar vertebrae (bilaterally) and a lateral flexor unilaterally. It functions in respiration by securing the 12th rib. Immediately anterior to these muscles is the retroperitoneum (see Plate 147).