2

Transverse Sections of the Spinal Cord

The spinal cord is perhaps the most simply arranged part of the CNS. Its basic structure, indicated in a schematic drawing of the eighth cervical segment (Figure 2–1), is the same at every level—a butterfly-shaped core of gray matter surrounded by white matter. An often indistinct central canal in the middle of the butterfly is the remnant of the lumen of the embryonic neural tube.

The extensions of the gray matter posteriorly and anteriorly are termed the posterior and anterior (dorsal and ventral) horns. The zone where the two horns meet is the intermediate gray. At every level, the posterior horn is capped by a zone of closely packed small neurons, the substantia gelatinosa. Beyond this, there are level-to-level variations in the configuration of the spinal gray (Figure 2–2). For example, the motor neurons that innervate skeletal muscle are located in the anterior horns, so these horns expand laterally in lumbar and lower cervical segments to accommodate the many motor neurons required for the muscles of the lower and upper extremities. Other examples are indicated in Figure 2–2. When studied in detail, the spinal gray matter can be partitioned into a series of 10 layers (Rexed's laminae), as indicated on the right side of Figure 2–1. Some of these laminae have clear functional significance. For example, lamina II corresponds to the substantia gelatinosa, which plays an important role in regulating painful and thermal sensations.

Spinal white matter contains pathways ascending to or descending from higher levels of the nervous system, as well as nerve fibers interconnecting different levels of the spinal cord. The horns of the gray matter divide the white matter into posterior, lateral, and anterior funiculi. In contrast to the level-to-level variations in the gray matter, the total amount of white matter increases steadily at progressively higher spinal levels. Moving rostrally, the ascending pathways enlarge as progressively more fibers are added to them; the descending pathways do the same because fewer fibers have left them.

Information travels to and from the spinal gray matter in the dorsal and ventral roots. The dorsal roots convey the central processes of afferents with cell bodies in dorsal root ganglia. As the roots approach the spinal cord, they break up into filaments, each of which sorts itself into a medial division, containing the large-diameter afferents, and a lateral division, containing the small-diameter afferents. This is the beginning of two great streams of somatosensory information that travel rostrally in the CNS. The large fibers, primarily carrying information about touch and position, send branches into multiple levels of the gray matter and may send a branch rostrally in the posterior funiculus. The small fibers, primarily carrying information about pain and temperature, traverse a distinctive area of the white matter (Lissauer's tract) and end more superficially in the posterior horn. Subsequent connections of both classes of afferents are reviewed in Chapter 8.

In this chapter (as in all chapters in this atlas), only the largest and best-known spinal structures and pathways are indicated. Many others are either known to exist in humans or inferred from animal studies. In many cases, however, their functional significance is not well understood.

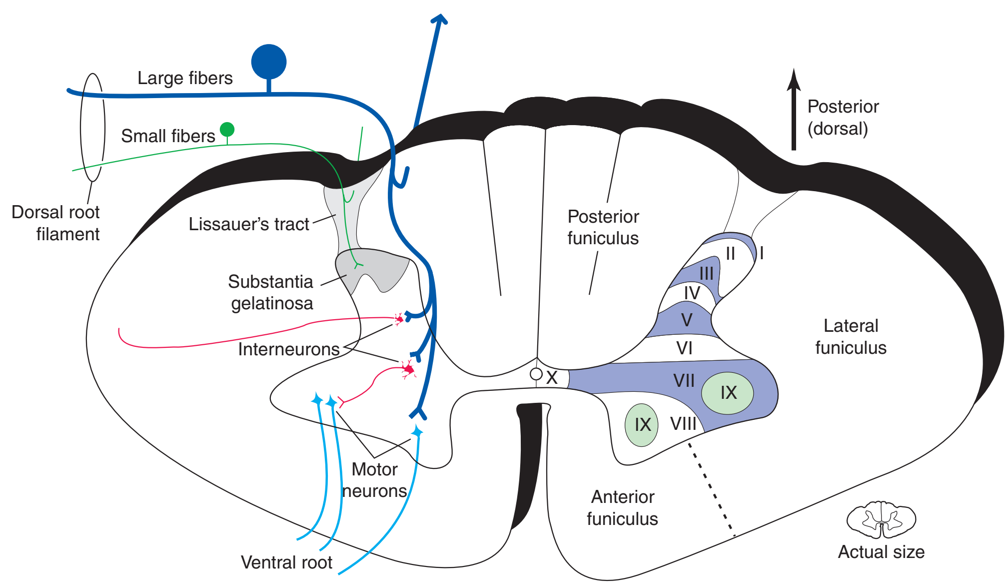
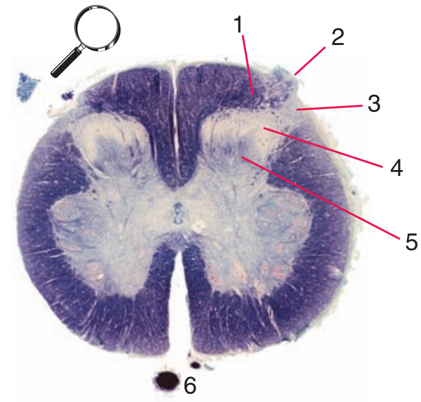


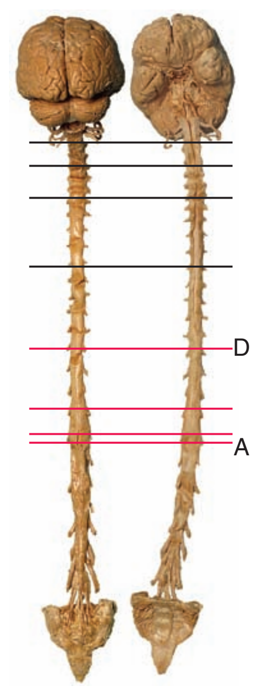
Figure 2–1 Schematic drawing of the spinal cord at the level of the eighth cervical segment. *(Modified from Nolte J: The human brain, ed 5, St. Louis, 2002, Mosby.)*

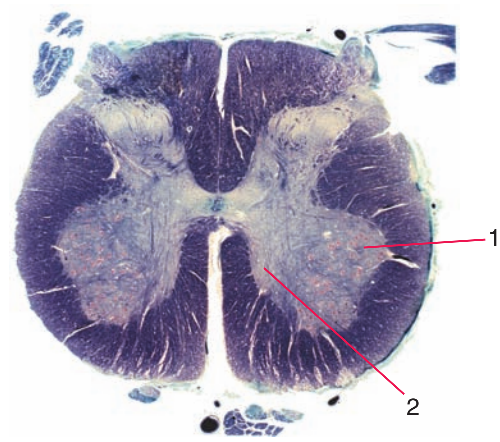
Figure 2–2 **A–H,** Cross sections of a spinal cord at eight different levels.

A, The fourth sacral segment (S4). Several features common to all spinal levels can be seen. The substantia gelatinosa *(4)* caps the posterior horn *(5).* Also, afferent fibers entering through dorsal rootlets *(2)* sort themselves into small-diameter fibers that move laterally and enter Lissauer's tract *(3)* and large-diameter fibers that enter more medially *(1)* at the edge of the posterior funiculus. (This sorting occurs at all spinal levels and can be seen in all of the sections in this series.) Little white matter is present in any of the funiculi because most fibers either have already left descending pathways or have not yet entered ascending pathways. The anterior spinal artery *(6)* is cut in cross section as it runs longitudinally near the anterior median fissure of the cord. Shown enlarged in Figure 2–3.

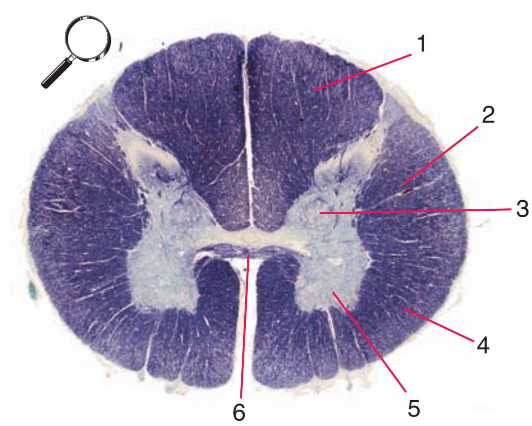


B, The fifth lumbar segment (L5). This segment is in the lumbar enlargement (which extends from about L2 to S3) and has anterior horns that are enlarged, primarily in their lateral aspects *(1),* to accommodate motor neurons for leg and foot muscles. Motor neurons located more medially *(2)* in the anterior horn innervate more proximal muscles, in this case hip muscles.





C, The second lumbar segment (L2). The posterior funiculus *(1)* is larger because ascending fibers carrying touch and position information from the lower limb have been added. The lateral funiculus is also larger, reflecting increased numbers of descending fibers in the lateral corticospinal tract *(2)* and ascending fibers in the spinothalamic tract *(4).* This section is at the rostral end of the lumbar enlargement, so the anterior horn *(5)* no longer is enlarged laterally. Clarke's nucleus *(3),* which extends from about T1 to L3 and contains the cells of origin of the posterior spinocerebellar tract, makes its appearance. The anterior white commissure *(6),* a route through which axons can cross the midline, is present at this and all other spinal levels. Shown enlarged in Figure 2–4.



D, The tenth thoracic segment (T10). The posterior *(1)* and anterior *(4)* horns are slender, corresponding to the relative dearth of sensory information arriving at this level and the relatively small number of motor neurons needed. Sympathetic preganglionic neurons form a lateral horn *(3)* containing the intermediolateral cell column, a characteristic feature of thoracic segments. Clarke's nucleus *(2)* is still apparent. Shown enlarged in Figure 2–5.

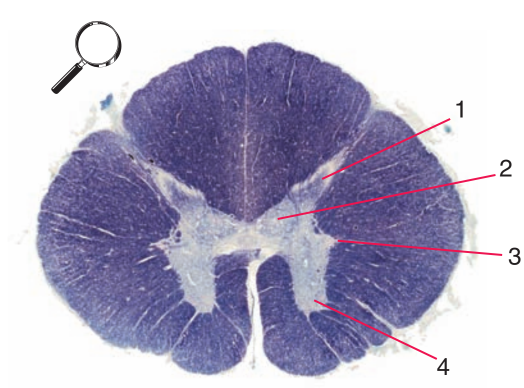
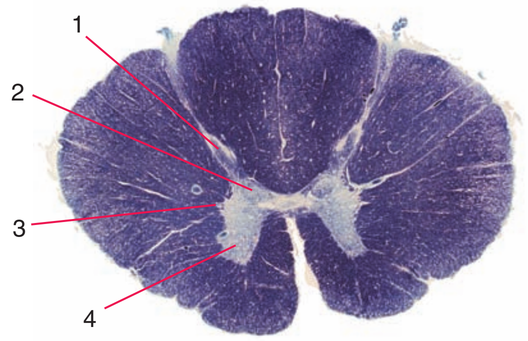
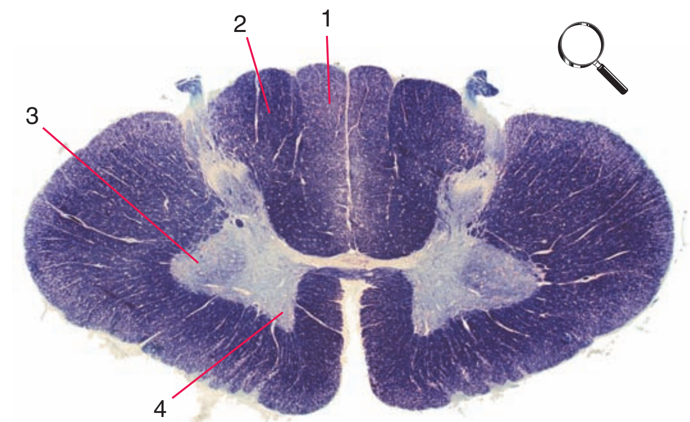
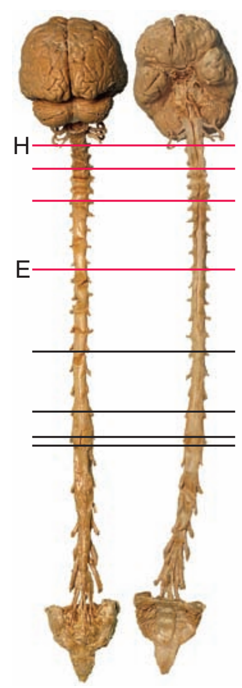


Figure 2–2 (Continued) Cross sections of a spinal cord.

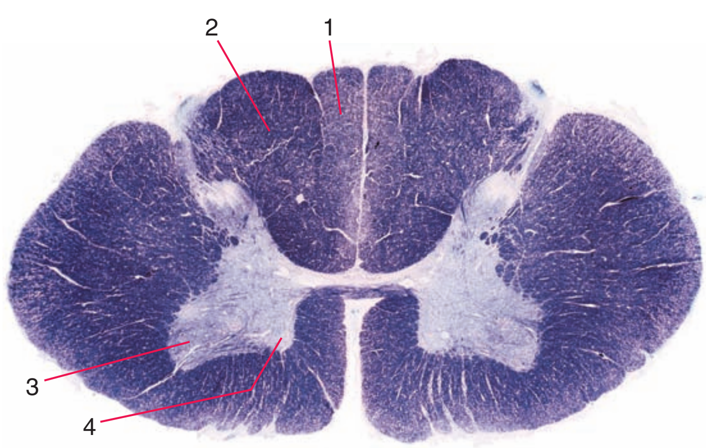


E, The fifth thoracic segment (T5). The posterior *(1)* and anterior *(4)* horns are even more slender, reflecting the relative paucity of sensory information arriving from the trunk and the relatively small number of motor neurons required by trunk muscles. Clarke's nucleus *(2),* although smaller, is still present, as is the lateral horn *(3).*

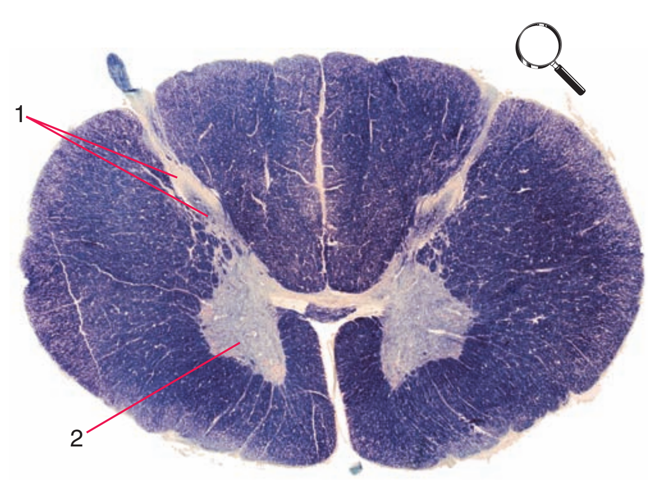




F, The eighth cervical segment (C8), near the caudal end of the cervical enlargement (C5 to T1). The posterior funiculus is subdivided by a partial glial partition into fasciculus gracilis *(1),* conveying touch and position information from the lower limb, and fasciculus cuneatus *(2),* conveying touch and position information from the upper limb. The anterior horn is enlarged, primarily in its lateral aspect *(3),* to accommodate motor neurons for hand and forearm muscles. Motor neurons in more medial parts of the anterior horn *(4)* innervate more proximal muscles, such as the triceps. Shown enlarged in Figure 2–6.



G, The fifth cervical segment (C5), still in the cervical enlargement. As in the previous section, the posterior funiculus is subdivided into fasciculus gracilis *(1)* and fasciculus cuneatus *(2),* and the anterior horn includes an expanded lateral region *(3)* (here containing motor neurons for forearm muscles) and the more medial area *(4)* that is present at all spinal levels (and at this level innervates shoulder muscles).



H, The third cervical segment (C3), rostral to the cervical enlargement. The posterior horn *(1)* is more slender, reflecting the smaller amount of afferent input arriving from the neck. The anterior horn *(2)* is no longer enlarged laterally. The area of white matter is larger, however, than in any other section in this series, reflecting the near-maximal size of ascending and descending pathways. Shown enlarged in Figure 2–7.

Figure 2–3 Fourth sacral segment (S4).

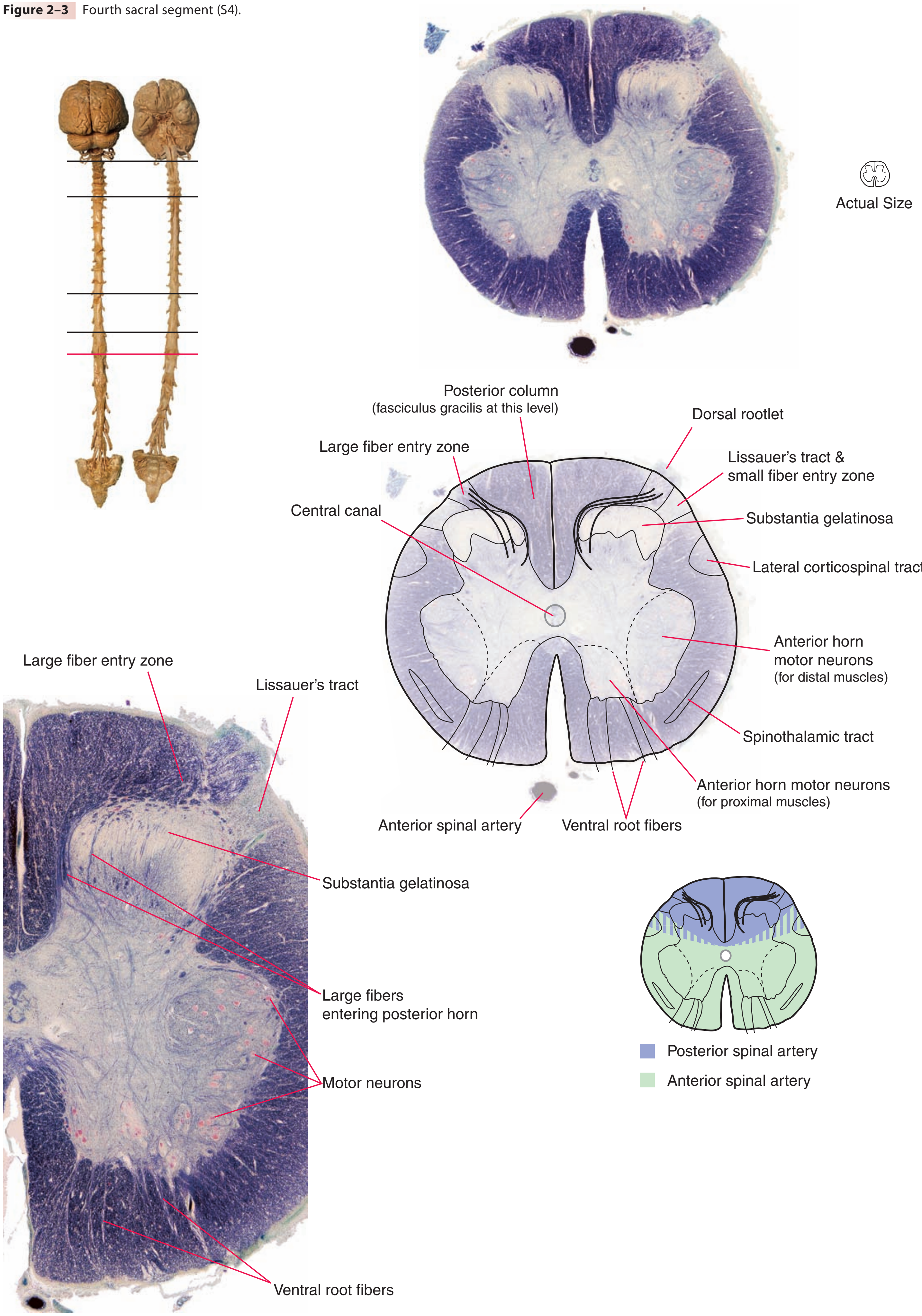
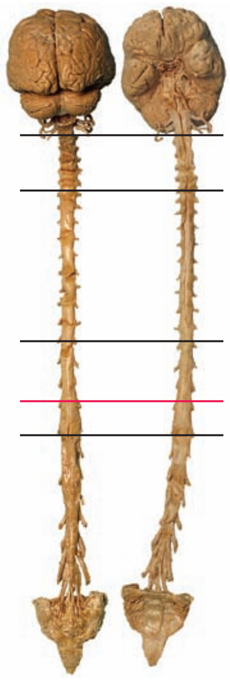
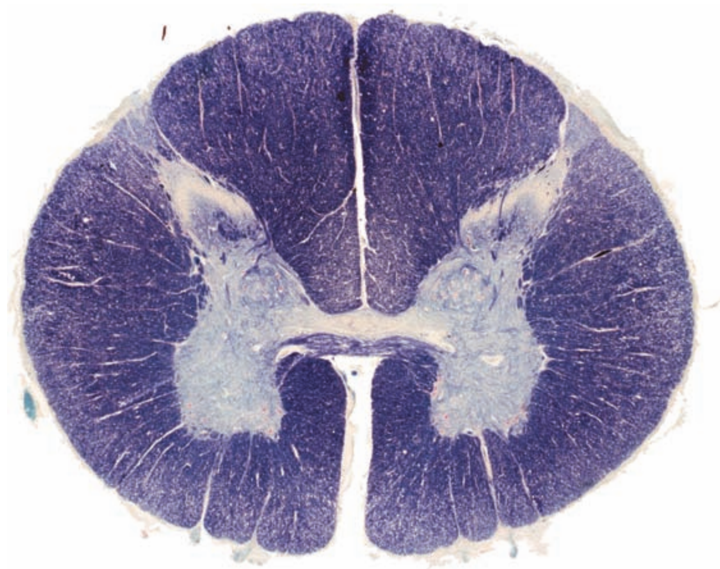
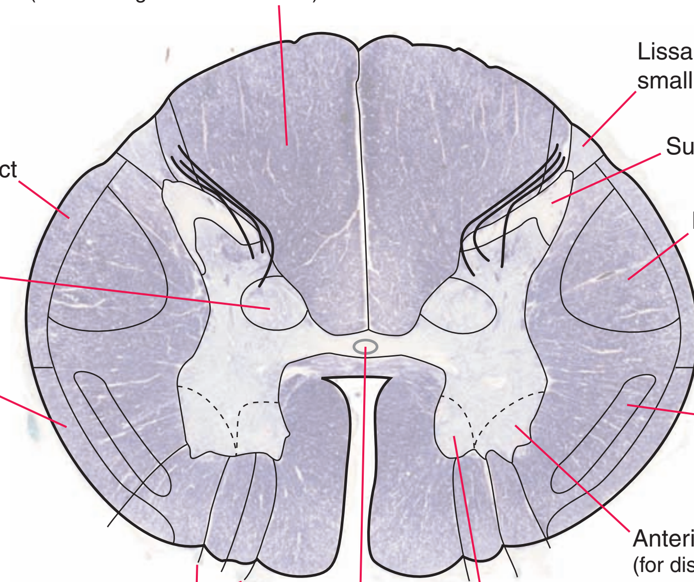
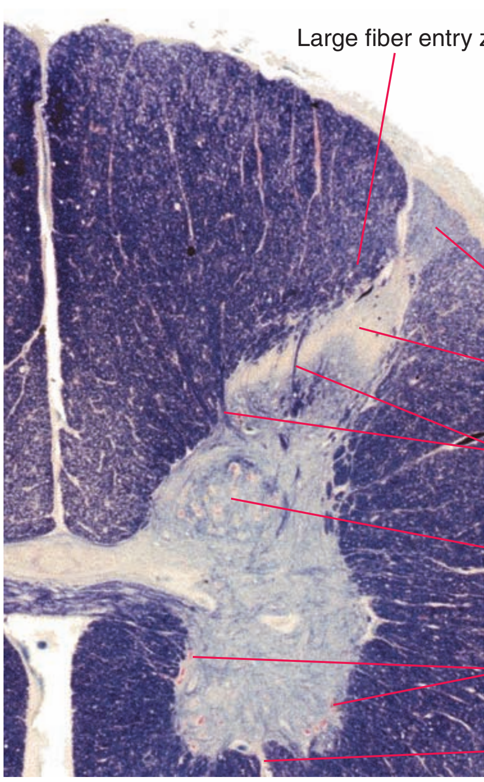


Figure 2–4 Second lumbar segment (L2).









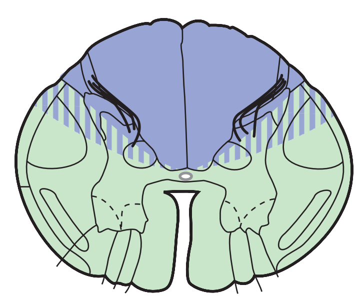


Figure 2–5 Tenth thoracic segment (T10).

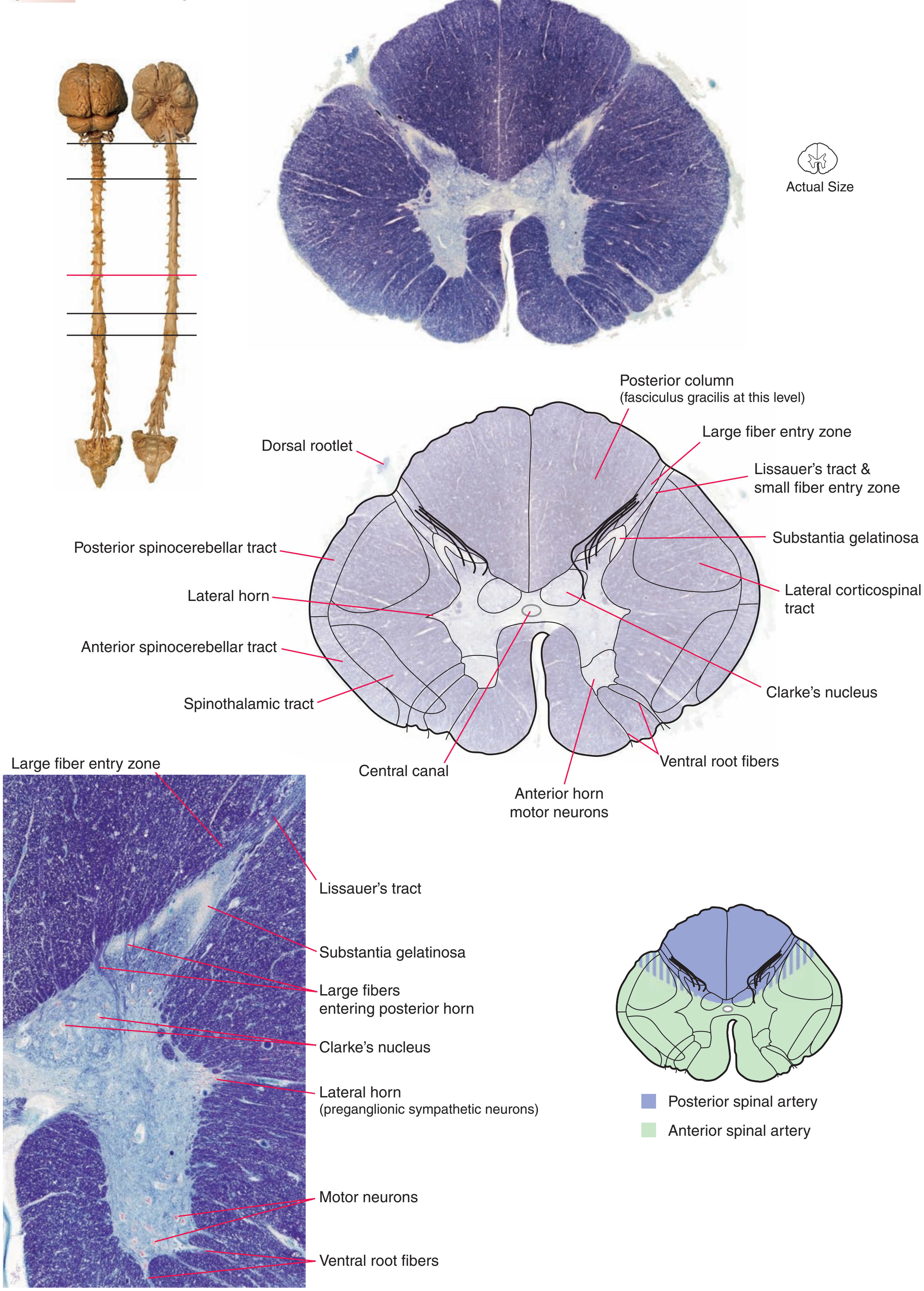


Figure 2–6 Eighth cervical segment (C8).

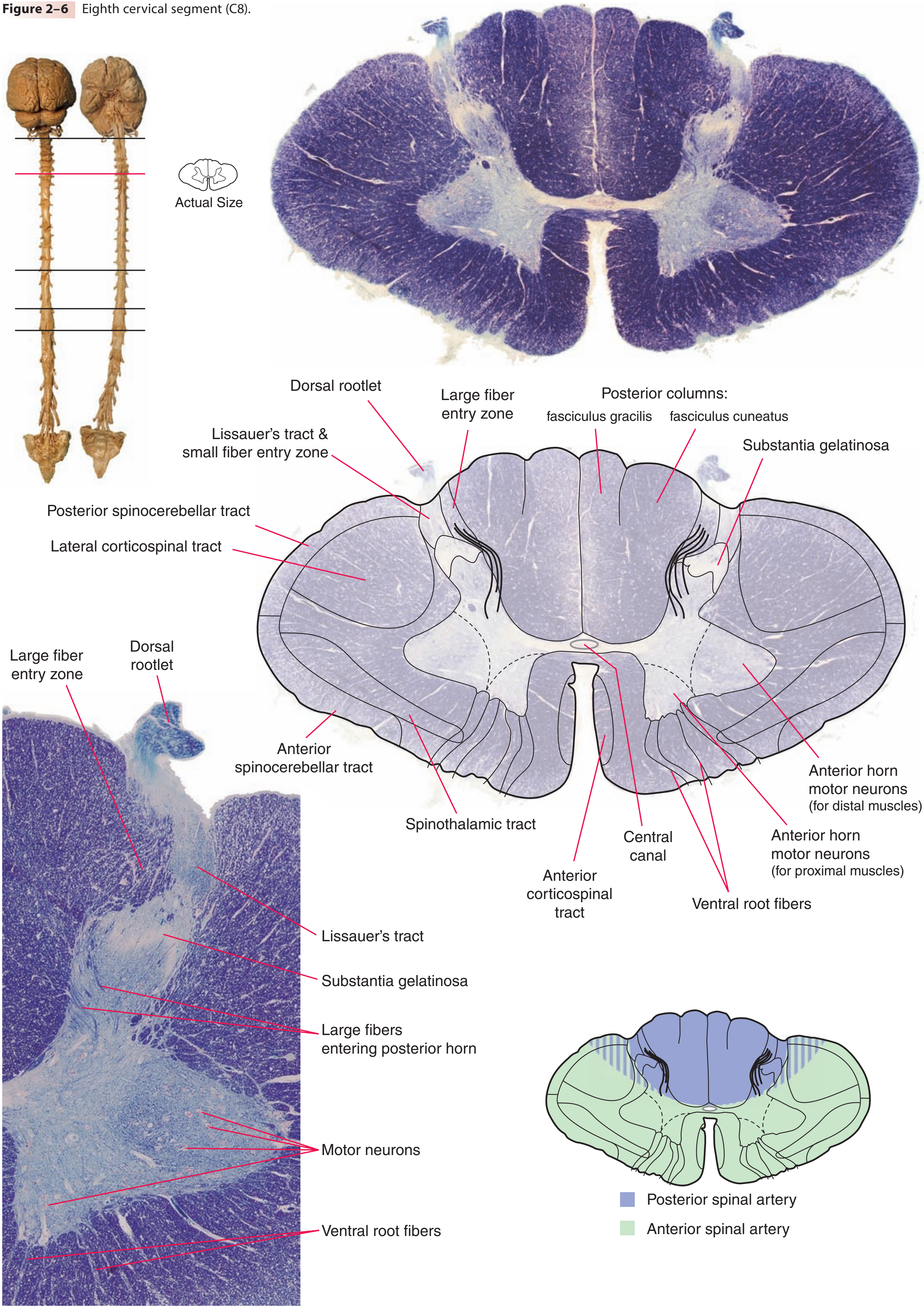


Figure 2–7 Third cervical segment (C3).