Lab 2. Gross and Intrinsic Anatomy of the Spinal Cord B. Puder, Ph.D.

Objectives: At the end of this laboratory session you should be able to:

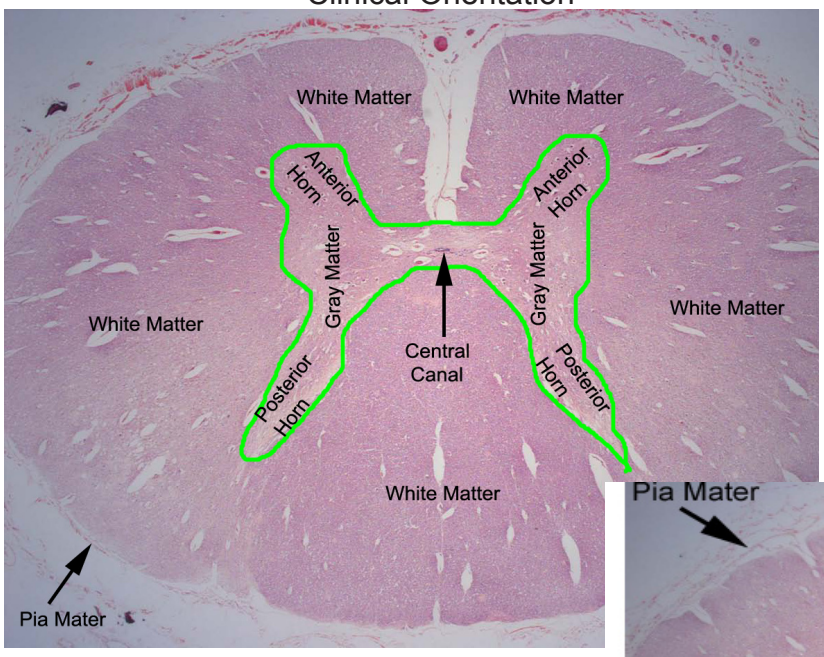
1. **Identify the gross anatomical structures of the spinal cord**
2. **Identify the intrinsic anatomical structures of the spinal cord**
3. **Trace/draw the following pathways: Anterolateral system, Posterior columns/medial lemniscus pathway, Voluntary motor pathway**
4. **List signs or symptoms including modality, side and body part affected when there is a lesion in one of the following pathways: Anterolateral system, Posterior columns/ Medial Lemniscus, Voluntary Motor Pathway.**

Materials required: Atlas and text diagrams, histological spinal cord sections, gross spinal cord, 4 transverse spinal cord sections

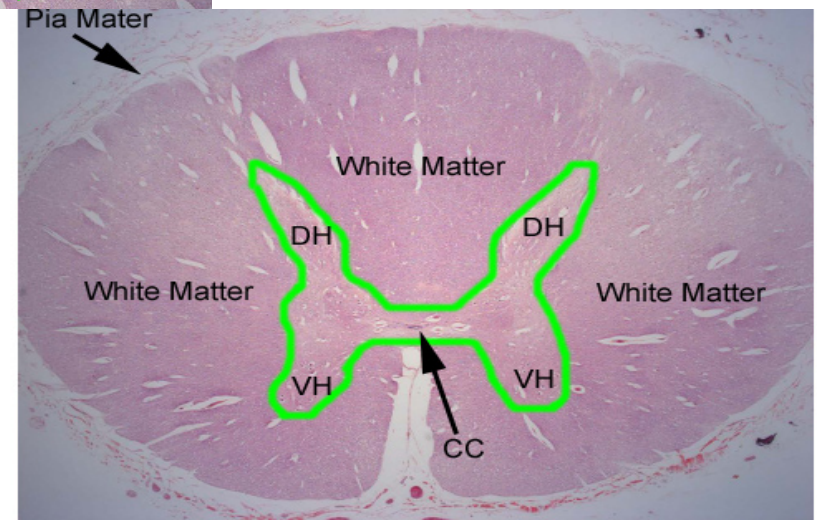
Histology of the Spinal Cord

Materials required: Digital histological images provided in this lab manual
Review the digital histological spinal cord images provided in this lab guide.
Identify the ***gray matter (neuronal cell bodies)*** from the ***white matter (axons).***
Within the ***gray matter***, identify the ***posterior and anterior horns***, and ***central canal***

Clinical Orientation



Anatomical Orientation

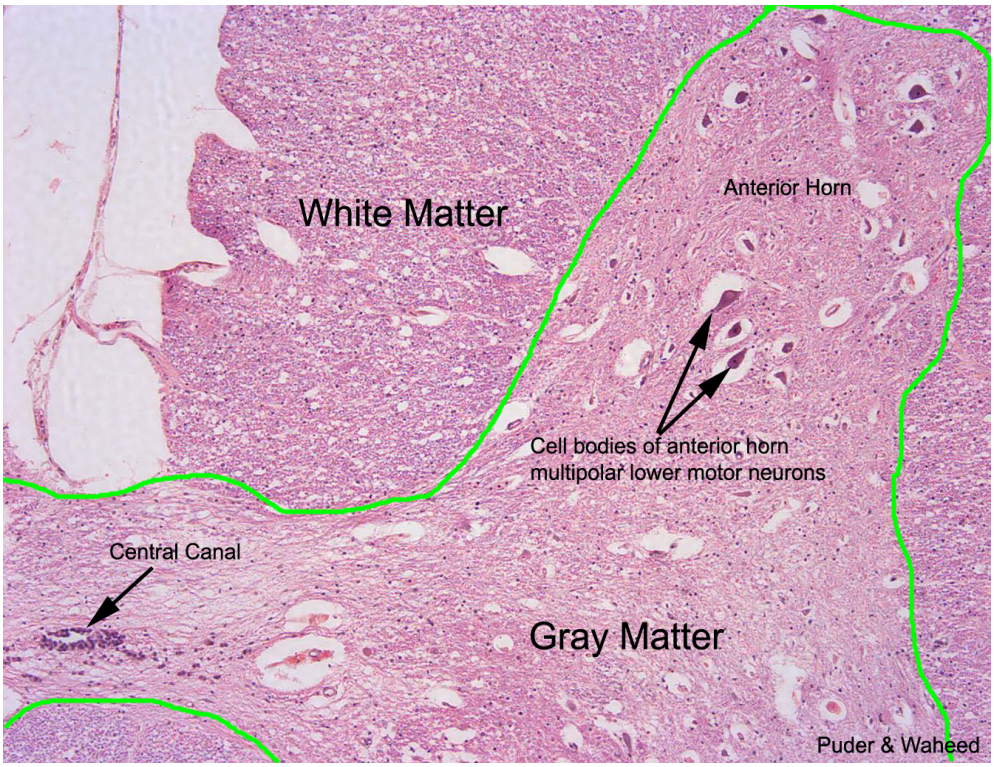


Cross section through thoracic spinal cord. ***The gray matter has 2 posterior (dorsal) horns.*** This is the area where peripheral sensory neurons enter and can synapse upon another neuron. There are also ***2 anterior (ventral) horns***. You will find cell bodies of motor neurons here and their axons will project out as anterior (ventral) roots to go out to the periphery. In the center of the gray matter is the ***central canal*** which is continuous with the ventricular system. The cells that make up the central canal are ***ependymal cells***. Surrounding the spinal cord is the most intimate layer of the meninges, the pia mater.

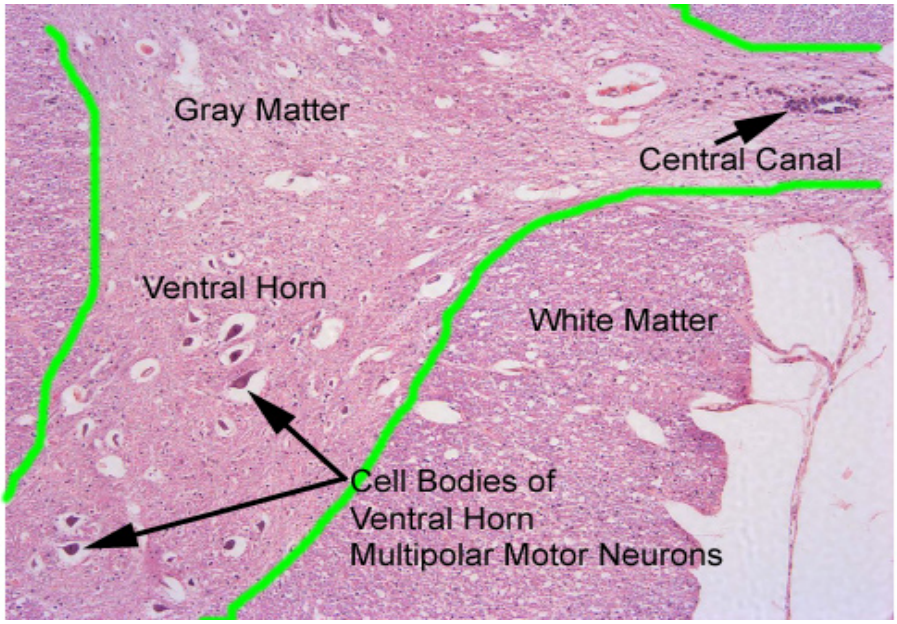
Neuronal cell bodies of the posterior horn are generally small and show few processes, (with the exception of the dorsal nucleus of Clarke). In contrast, many of the neurons of the anterior horn are very large and obviously multipolar. The cells of the intermediolateral nucleus of the lateral horn are intermediate in morphology. The smaller cells with the small oval nuclei are mostly glial cells and small internuncial neurons.

Note: You will not be required to identify nuclei or tracts in the spinal cord H&E stained histological images.
Identification of the nuclei and tracts will be required on the myelin stained transverse sections that appear later in this lab manual.

Clinical Orientation



Anatomical Orientation



High magnification view of the anterior horn of the spinal cord. Arrows point to cell bodies of large multipolar motor neurons (with this staining, it is difficult to see all the processes projecting from the cell body).

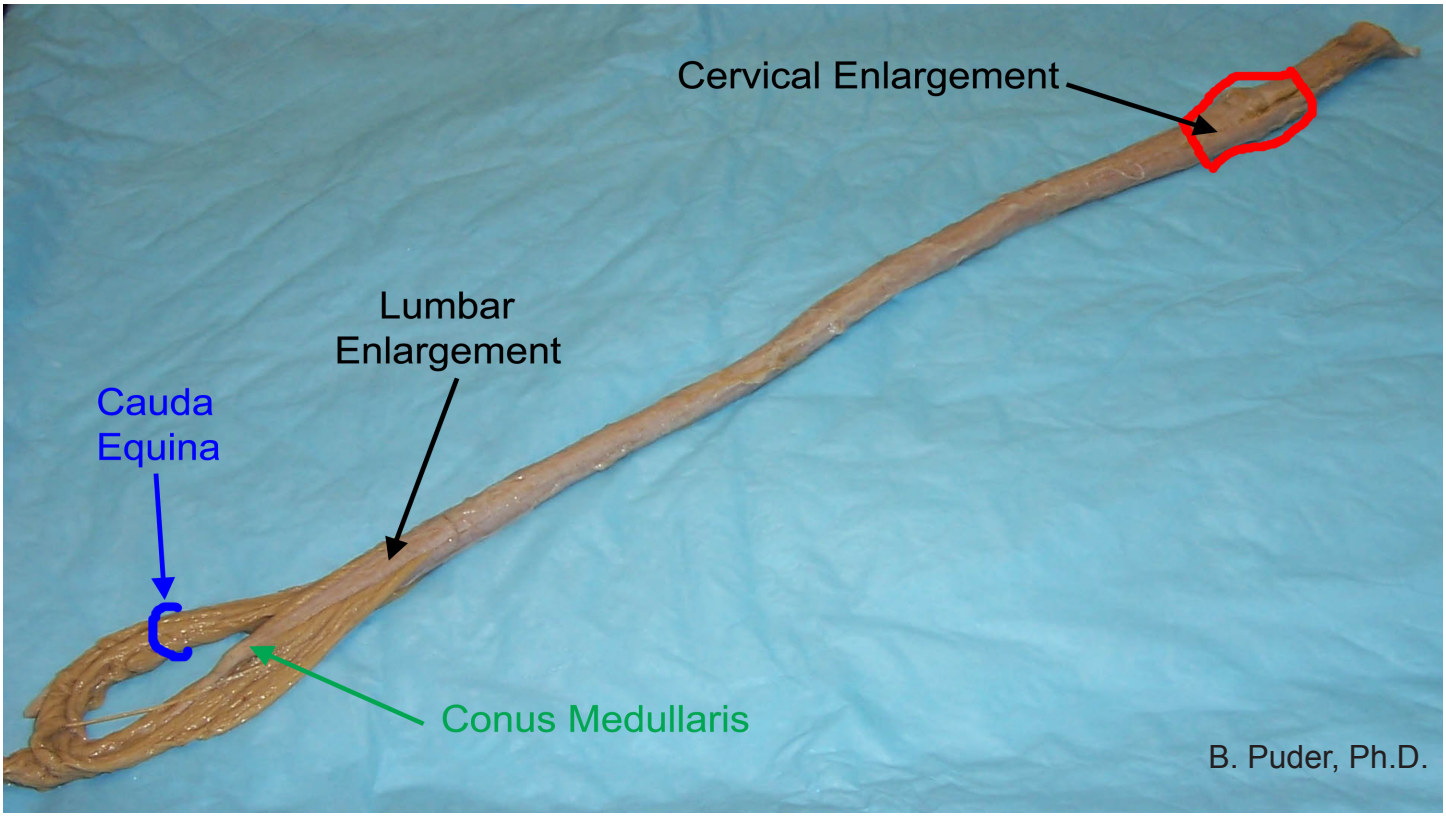
Gross Anatomy of the Spinal Cord

Materials required:
Gross spinal cord
Review the information related to the spinal cord, meninges, and the vertebral column as discussed in lecture.

Discuss at which vertebral level you will see the termination of the spinal cord and the dural sac.

Review the position of the spinal cord in the vertebral canal in the infant as compared to the adult.

Review the relationships and significance of the following structures:
cervical and lumbosacral enlargements
posterior and anterior rootlets and roots
cauda equina
conus medullaris



Intrinsic Anatomy of the Spinal Cord
Materials required:
Atlas, lab manual, 4 myelin stained transverse sections (digital images) of the spinal cord
Use the computers to project the spinal cord images onto the dry erase board. Use markers to label and identify the following nuclei and tracts.

Note: Some of the structures in the nervous system have poorly-defined morphological boundaries. Defining the boundaries between nuclei and tracts will require the use of your atlas and lab manual.

Examine all 4 myelin stained spinal cord sections to gain an appreciation of the size and shape of the spinal cord and the gray matter at various levels. You will be required to **identify each of the 4 sections from one another, i.e. cervical spinal cord from thoracic, lumbar, or sacral.**
You will not be required to identify specific spinal cord levels such as C4 or C5.

The following is a list of structures related to the gray matter of the spinal cord that you should identify. Remember, not all of these structures are present at all levels of the cord.

posterior and anterior horns
central canal (not usually patent in adults)
substantia gelatinosa
nucleus proprius
medial motor nucleus
lateral motor nucleus
lateral horns (thoracic level only)-- contains the intermediolateral nucleus
dorsal nucleus (of Clarke) (thoracic level only)
sacral parasympathetic nucleus (sacral level only)

The following is a list of structures to be identified in the white matter of the spinal cord.
Some are present only in the cervical cord.
posterior and anterior roots
posterior median fissure
anterior median fissure
posterior funiculus (columns)--contains the fasciculus gracilis (and fasciculus cuneatus if at T6 and above)
anterior funiculus (columns)
lateral funiculus (columns)
anterior white commissure
posterolateral fasciculus (tract of Lissauer)
fasciculus proprius (propriospinal tract)

The following is a list of tracts that are part of 3 major pathways that you must learn.
1. **Anterolateral system (lateral spinothalamic tract)** pain and temperature pathway
2. **Lateral corticospinal tract** = descending voluntary motor pathway

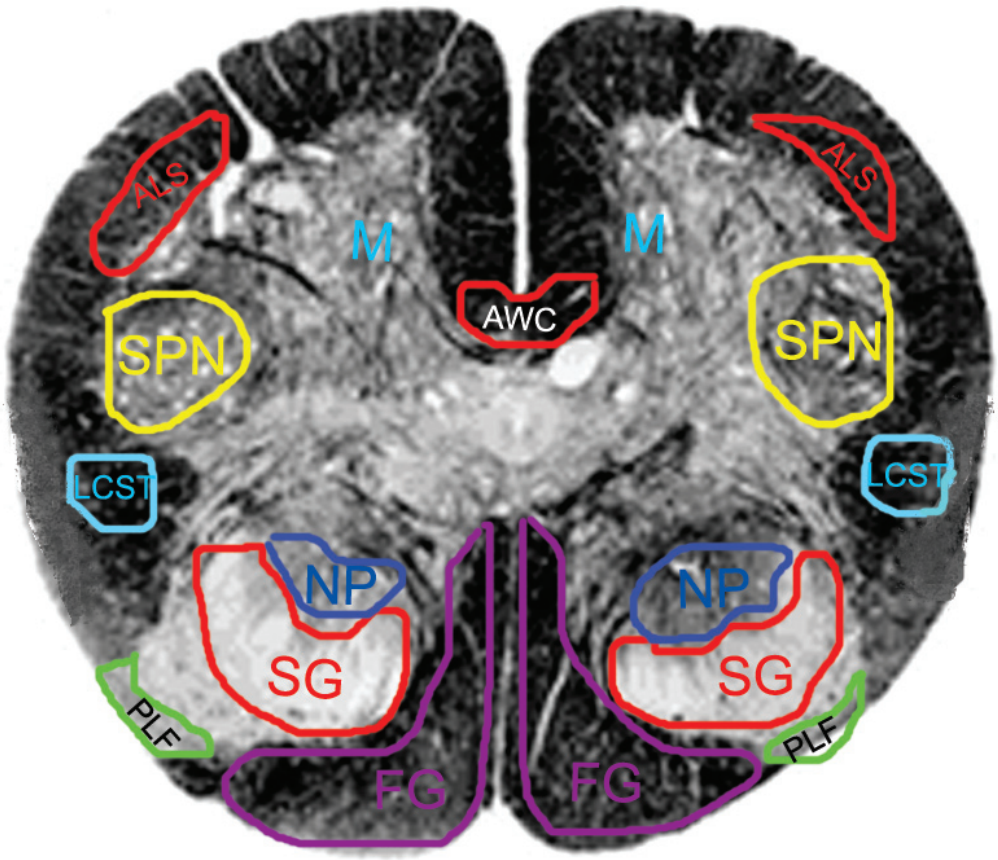
3A. Fasciculus cuneatus (part of posterior columns/medial lemniscus pathway) fine touch, vibratory sense from upper extremity

3B. Fasciculus gracilis (part of posterior columns/medial lemniscus pathway) fine touch, vibratory sense from lower extremity

Sacral Spinal Cord
Unlabeled and Labeled
Clinical Orientation

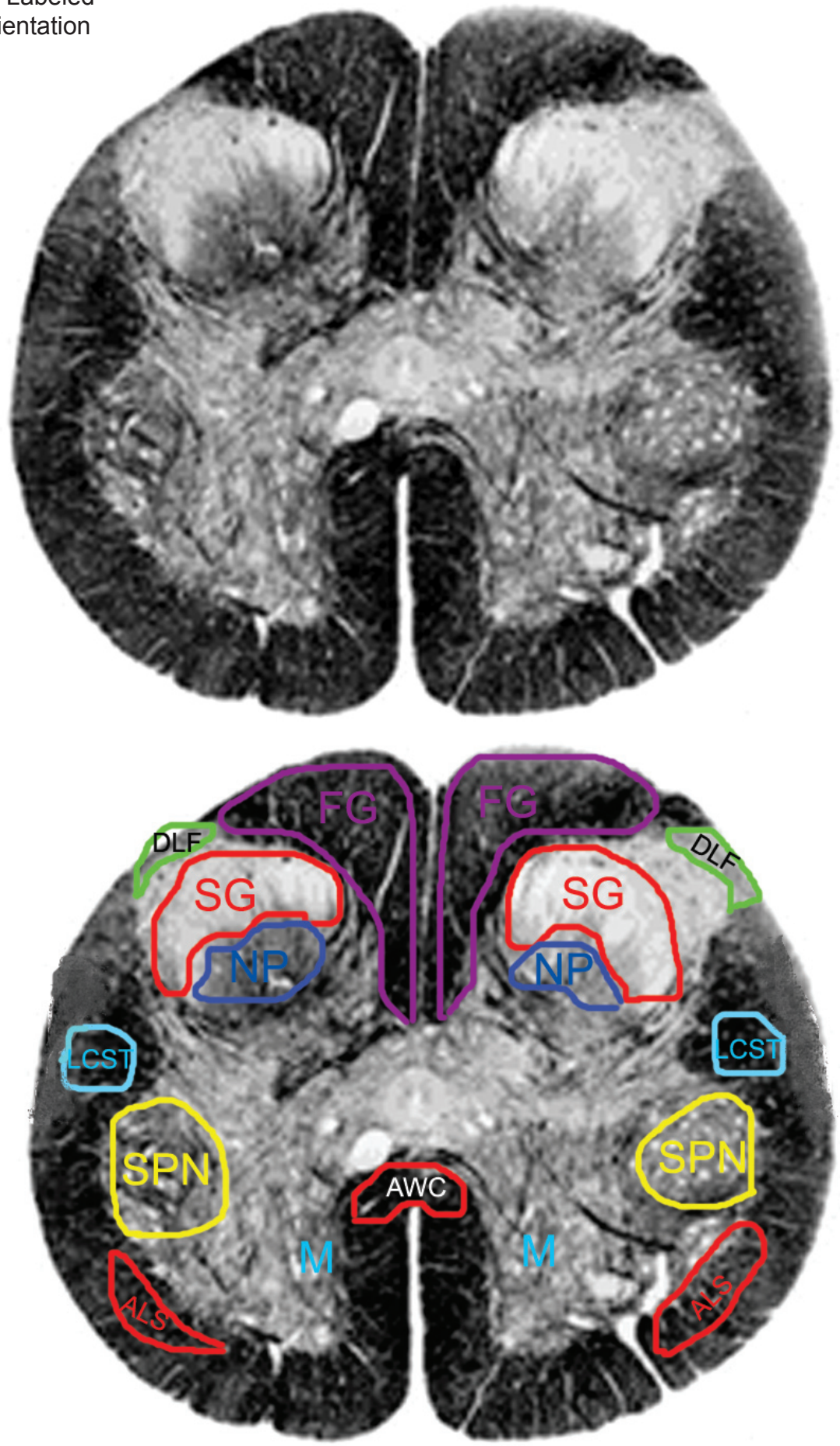
Anterior

Posterior



Abbreviation key is on
page 13 of lab manual

Sacral Spinal Cord
Unlabeled and Labeled
Anatomical Orientation

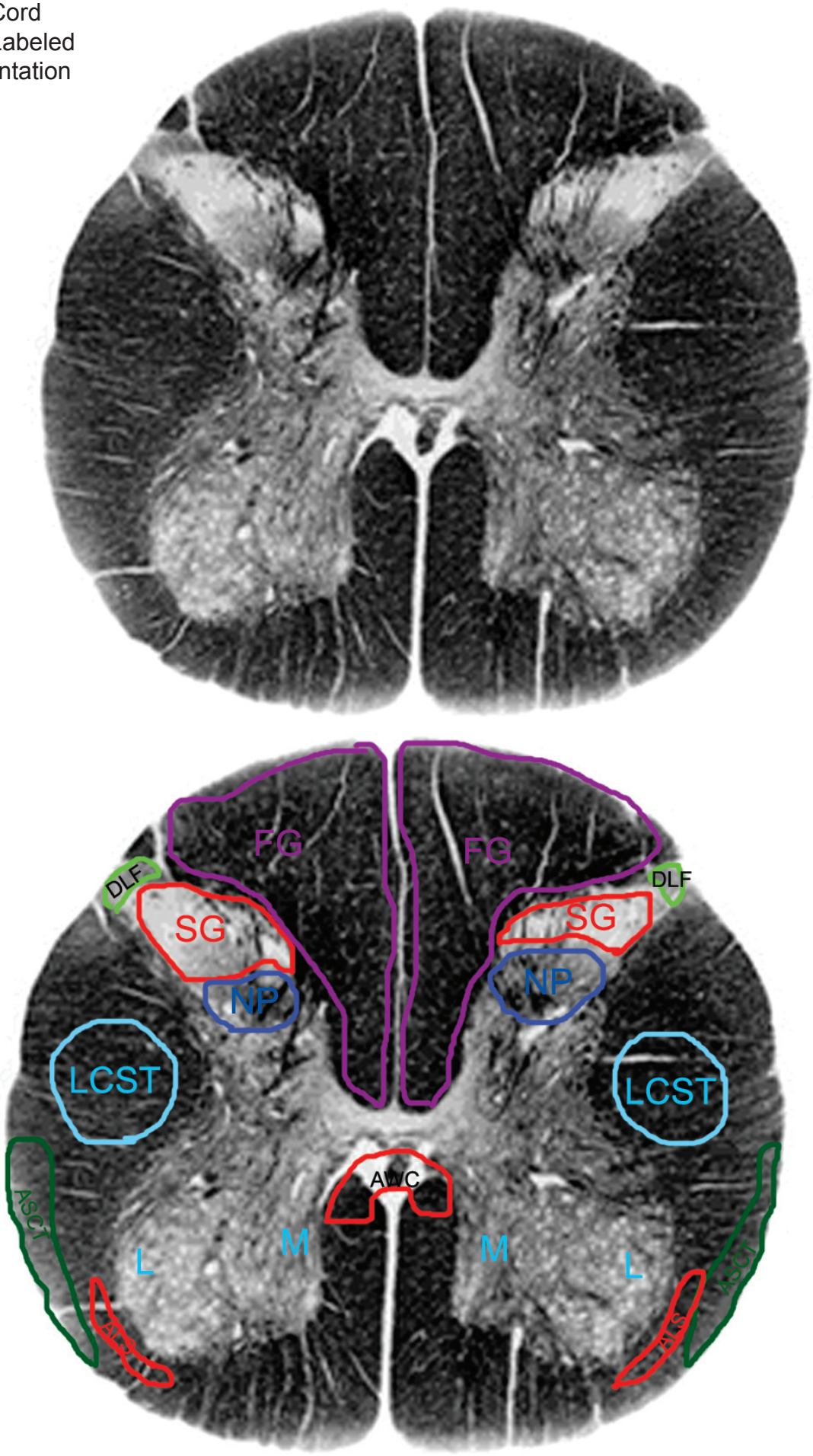


Lumbar Spinal Cord
Unlabeled and Labeled
Clinical Orientation

Anterior

Posterior

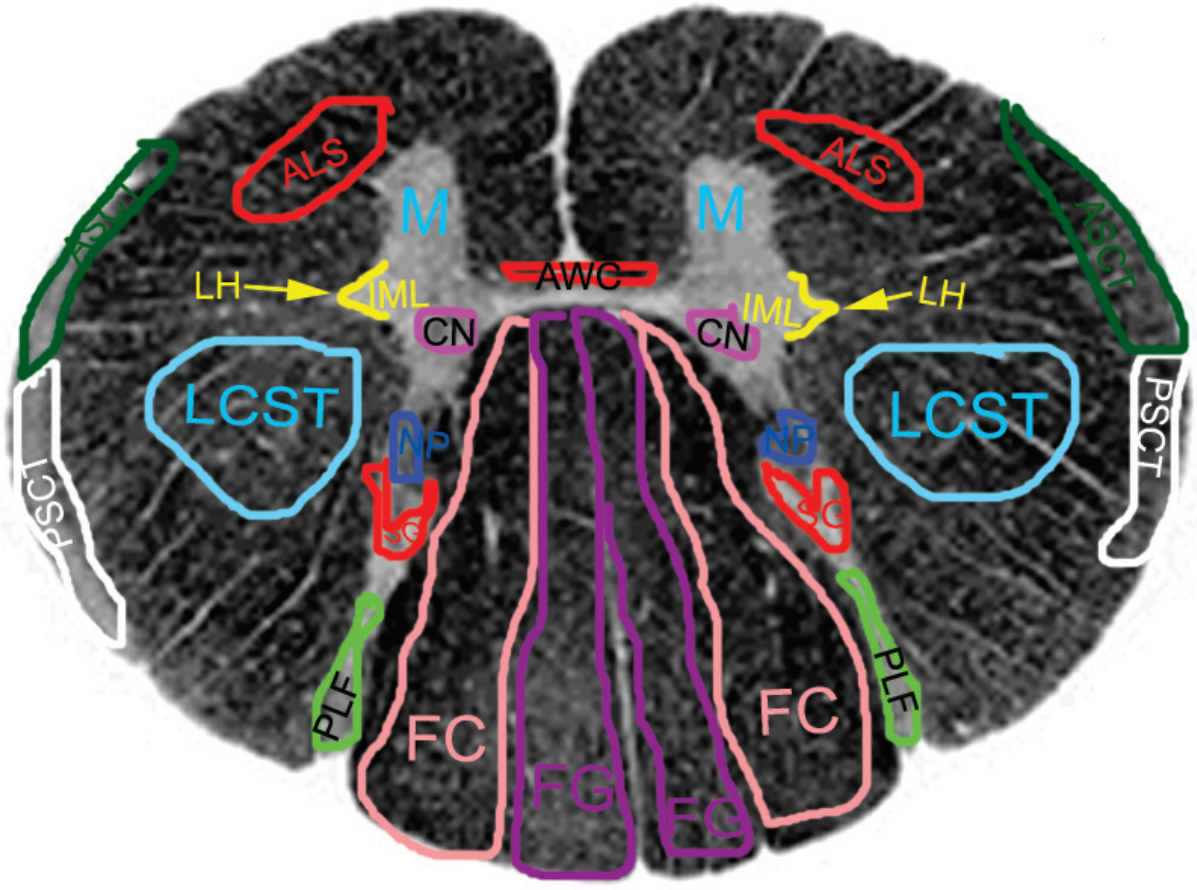
Lumbar Spinal Cord
Unlabeled and Labeled
Anatomical Orientation



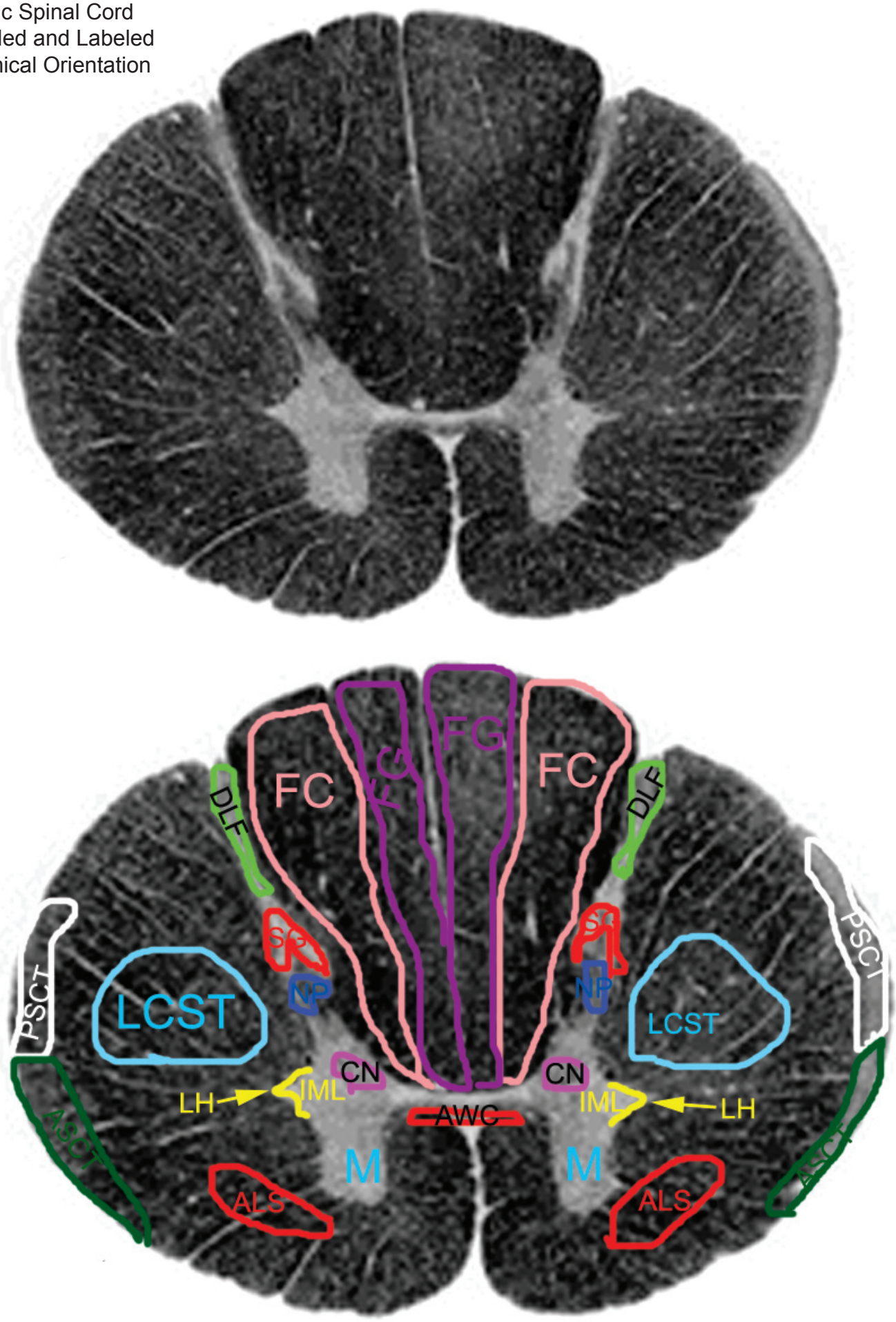
Thoracic Spinal Cord
Unlabeled and Labeled
Clinical Orientation

Anterior

Posterior



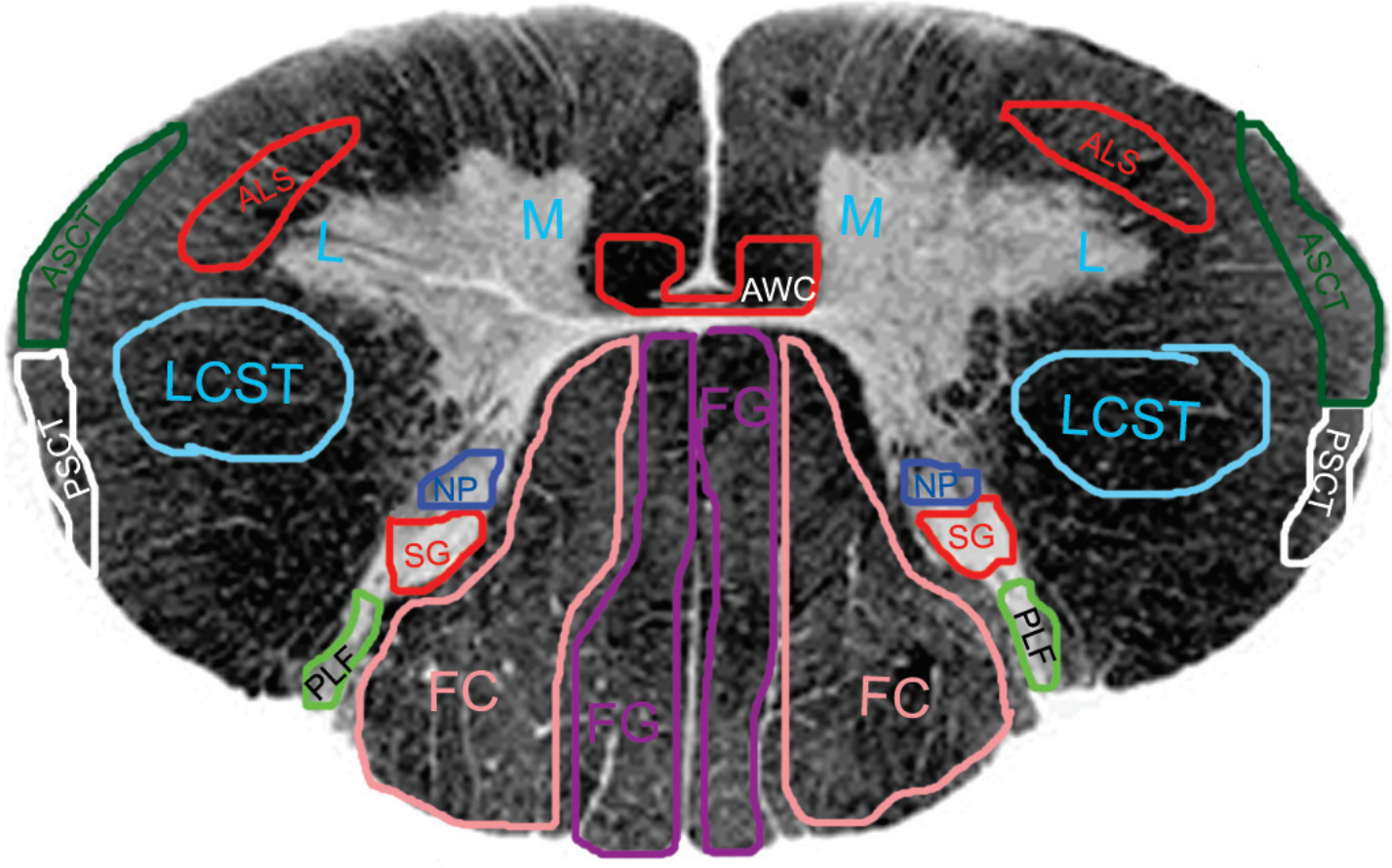
Thoracic Spinal Cord
Unlabeled and Labeled
Anatomical Orientation



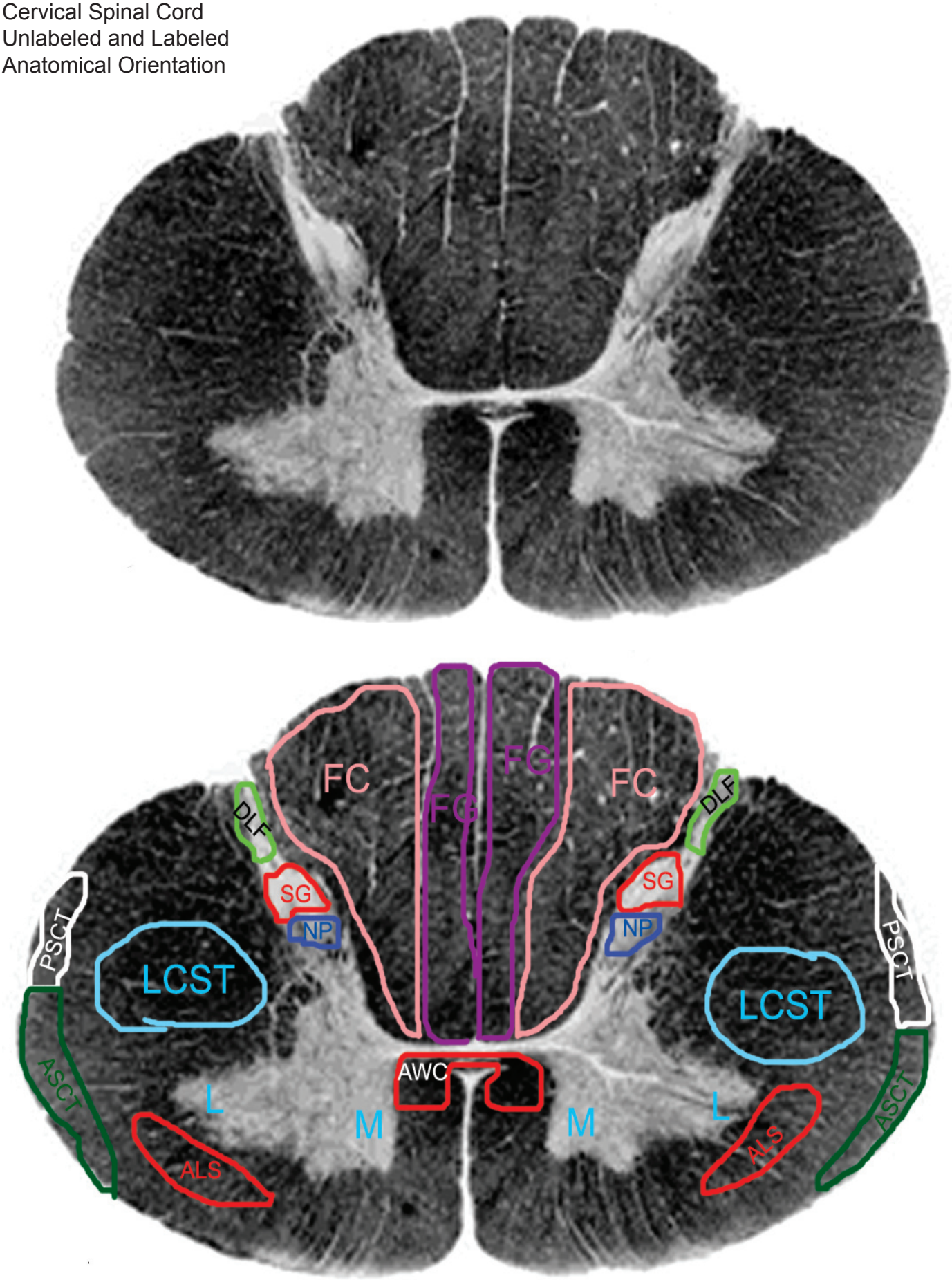
Cervical Spinal Cord
Unlabeled and Labeled
Clinical Orientation

Anterior

Posterior



Cervical Spinal Cord
Unlabeled and Labeled
Anatomical Orientation



Key to abbreviations on the labeled spinal cord sections

ALS = Anterolateral system (ascending pathway carrying pain and temperature info)

ASCT = Anterior spinocerebellar tract (ascending axons going to cerebellum)

AWC = Anterior white commissure (axons crossing to contralateral spinal cord carrying pain and temp

CN = Clarke's nucleus

DLF = Dorsolateral Fasciculus (same as Posterolateral Fasciculus - sensory fibers entering spinal cord)

FC = Fasciculus cuneatus (ascending axons carrying tactile, vibratory info from the upper extremity)

FG = Fasciculus Gracilus (ascending axons carrying tactile, vibratory info from the lower extremity)

IML = Intermediolateral nucleus (preganglionic sympathetic cell bodies)

LH = Lateral Horns (lateral protrusions that contain the IML)

L = Lateral lower motor neuronal cell bodies in the ventral (anterior) horn

LCST = Lateral corticospinal tracts (descending pathway containing axons of upper motor neurons)

M = Medial lower motor neuronal cell bodies in the ventral (anterior) horn

NP = Nucleus Proprious (sensory cell bodies in the dorsal horn)

PLF = Posterolateral Fasciculus (sensory fibers entering spinal cord)

PSCT = Posterior spinocerebellar tracts (axons going from spinal cord to cerebellum)

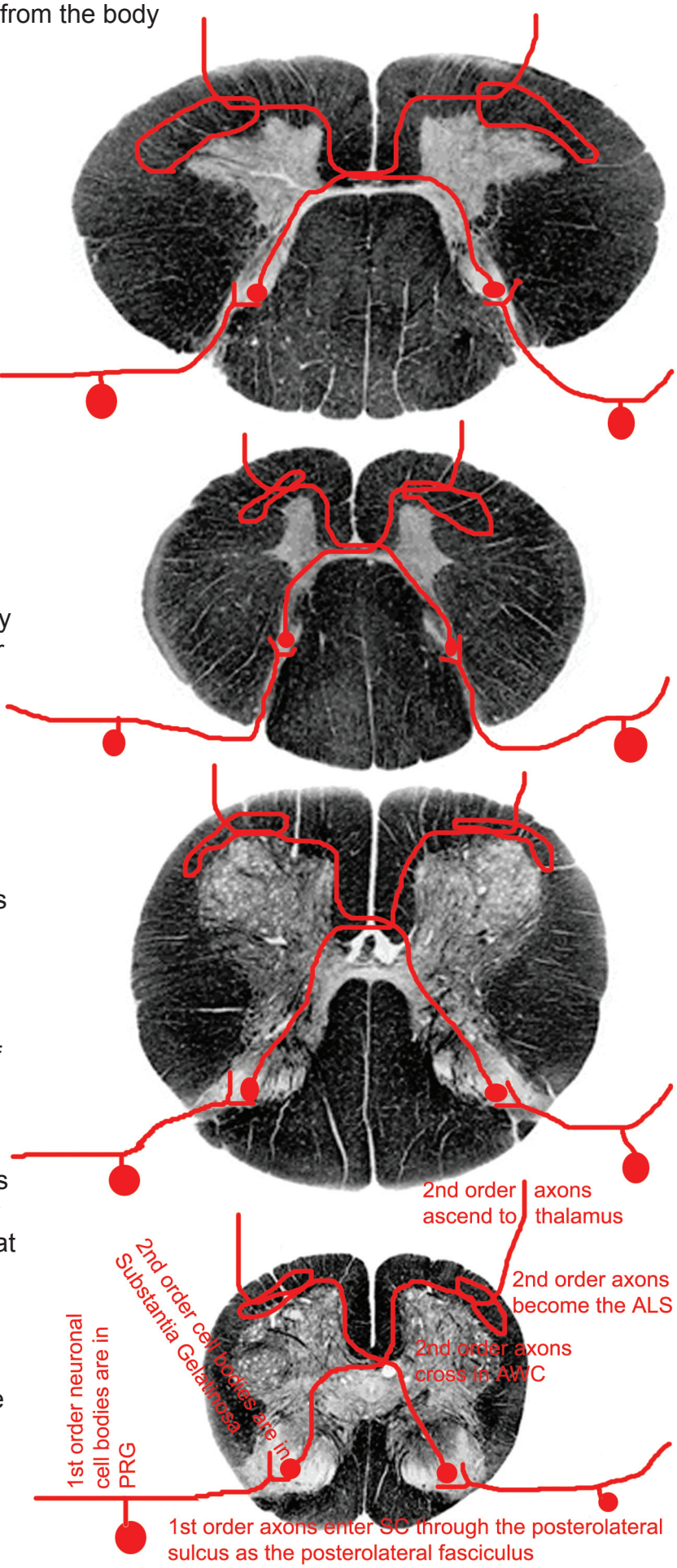
SG = Substantia Gelatinosa (cell bodies relaying pain and temp info to higher brain centers)

SPN = Sacral parasympathetic nucleus (preganglionic parasympathetic cell bodies)

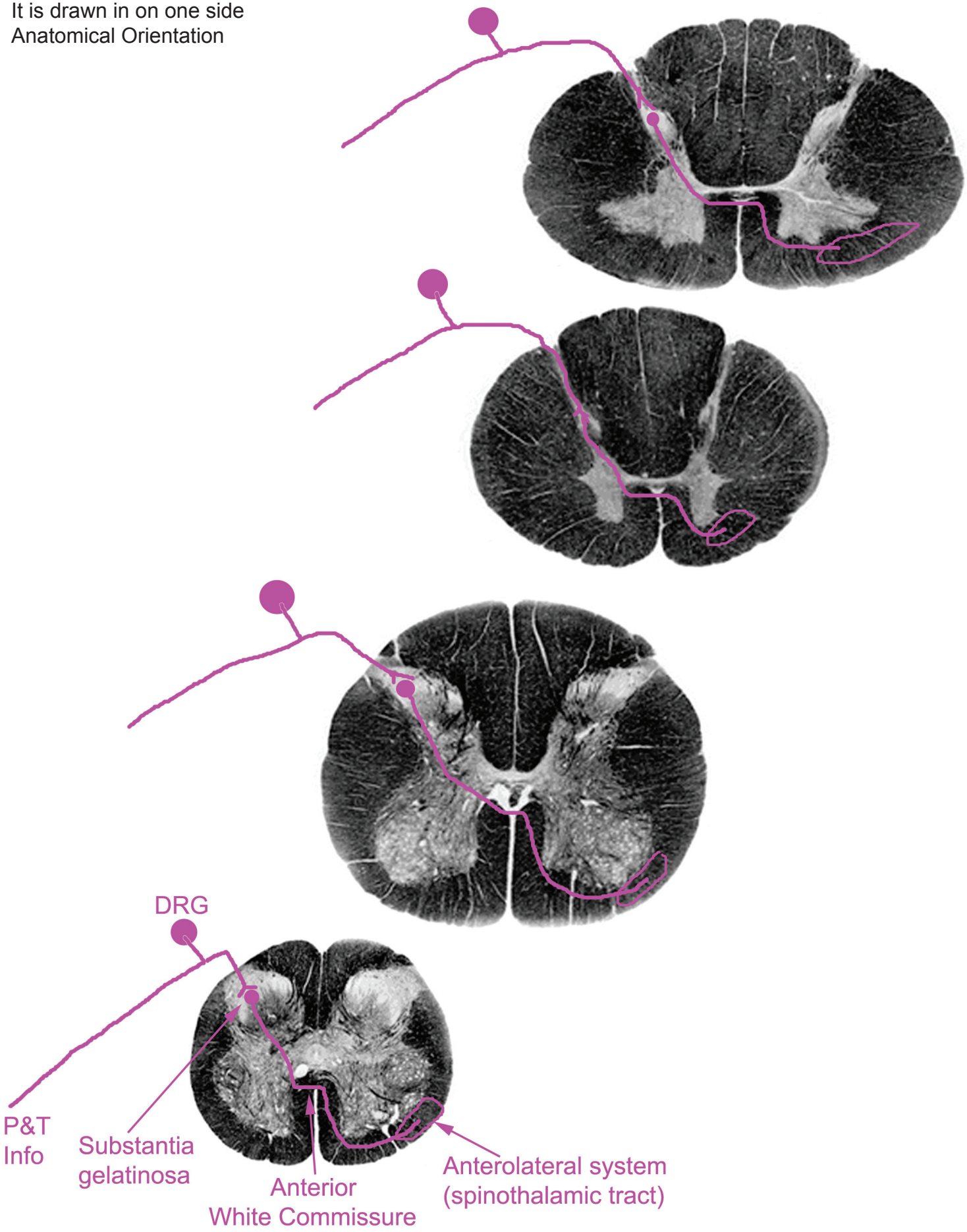
Anterolateral System
Pain and temperature from the body
Clinical Orientation

Second order axons will synapse on the VPL (ventral posterolateral nucleus) of the thalamus. The thalamic third order neurons will project their axons through the posterior limb of the internal capsule to synapse on the paracentral lobule (feet, legs)or post central gyrus (rest of the body). You will learn this pathway information later in this course.

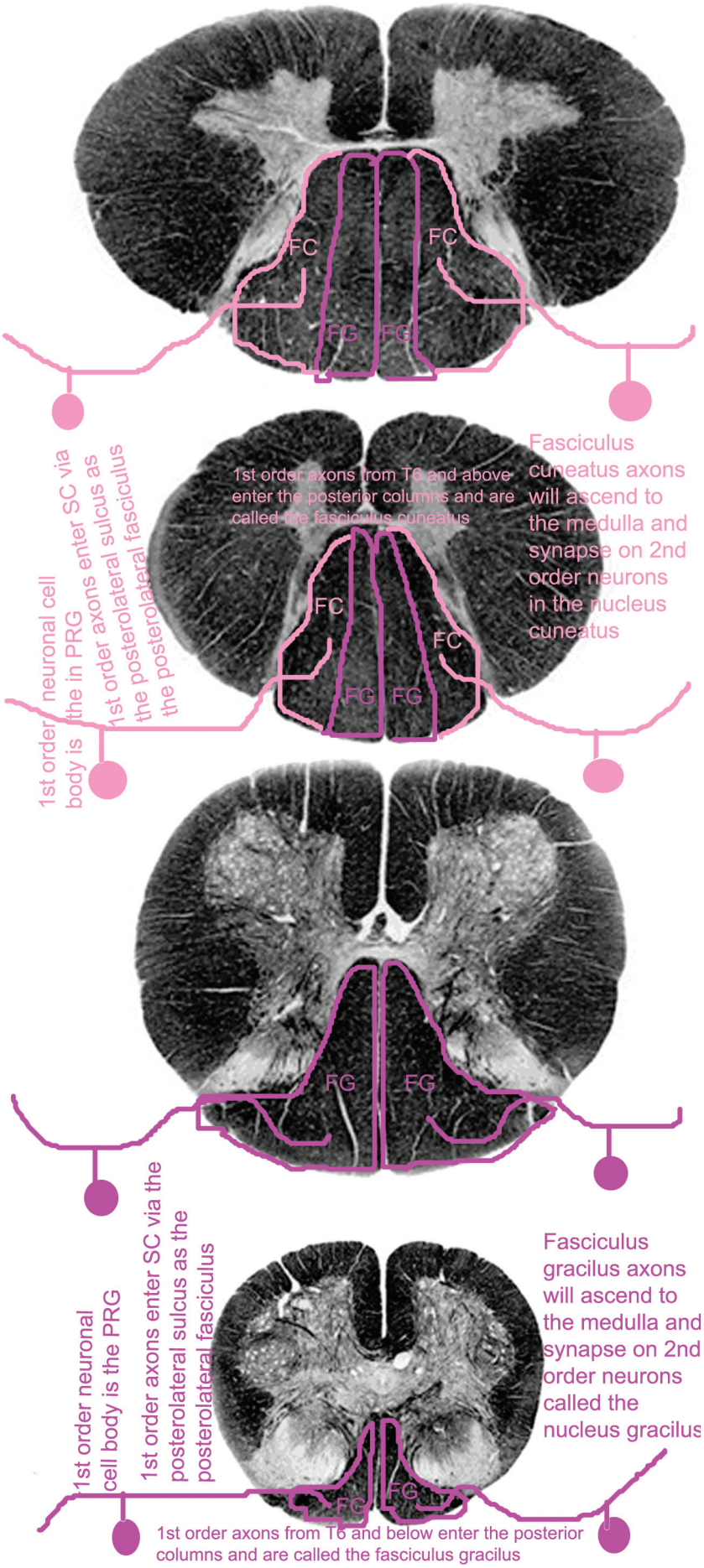
First order neurons relay the modalities of pain or temperature.
The cell bodies of first order neurons are located in the posterior root ganglia and first order axons project into the spinal cord as the posterolateral fasciculus at that specific spinal cord level.
First order axons will synapse in the substantia gelatinosa of the posterior horn (cell bodies of the second order neurons).
The second order axons will cross in the anterior white commissure at that specific level and the axons will become part of the spinothalamic tracts (anterolateral system) and ascend the spinal cord.



The Anterolateral system in the spinal cord.
It is drawn in on one side
Anatomical Orientation



Posterior columns/Medial lemniscus Pathway
Touch, vibration, proprioception from the body

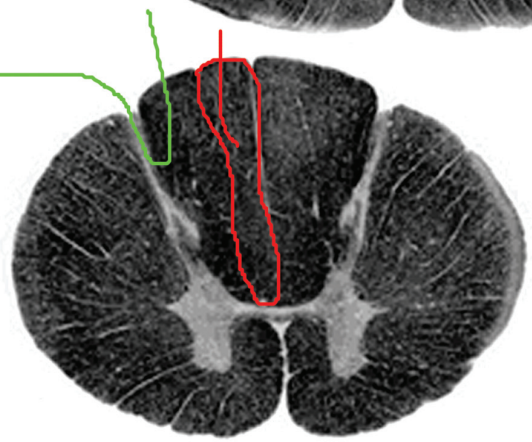


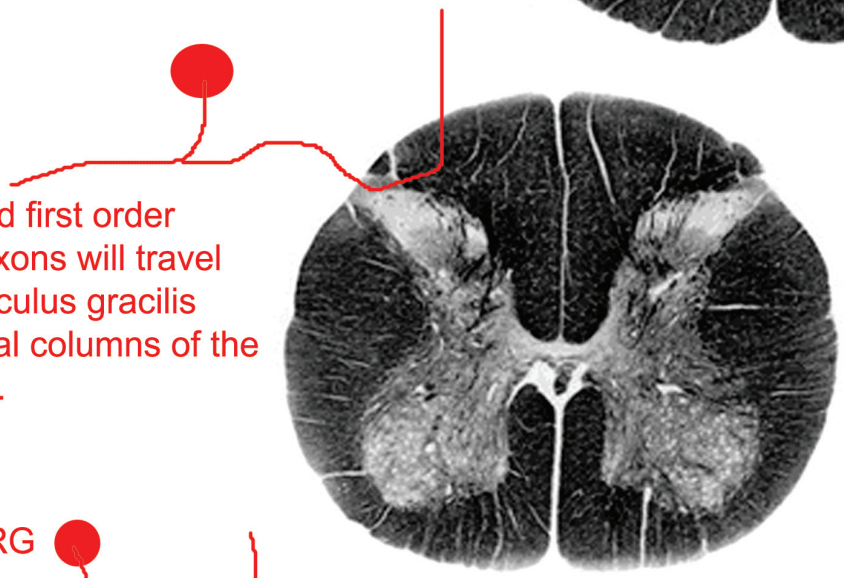
First order axons will synapse on second order neuronal cell bodies in the nucleus gracilus and nucleus cuneatus (in the medulla.)
These second order neuronal axons will decussate and project their axons as the medial lemniscus, which will travel up through the brainstem and synapse on the VPL of the thalamus.
The thalamic third order neurons will project their axons through the posterior limb of the internal capsule to synapse on the paracentral lobule (feet, legs) or post central gyrus (rest of the body).
You will learn this pathway information later in this course.

Posterior (dorsal) columns/medial lemniscus pathway
in the spinal cord.
Drawn in on one side only.
Anatomical Orientation

DRG

Green colored first order
neuronal axons will travel
in thefasciculus cuneatus
of the dorsal columns of the
spinal cord.





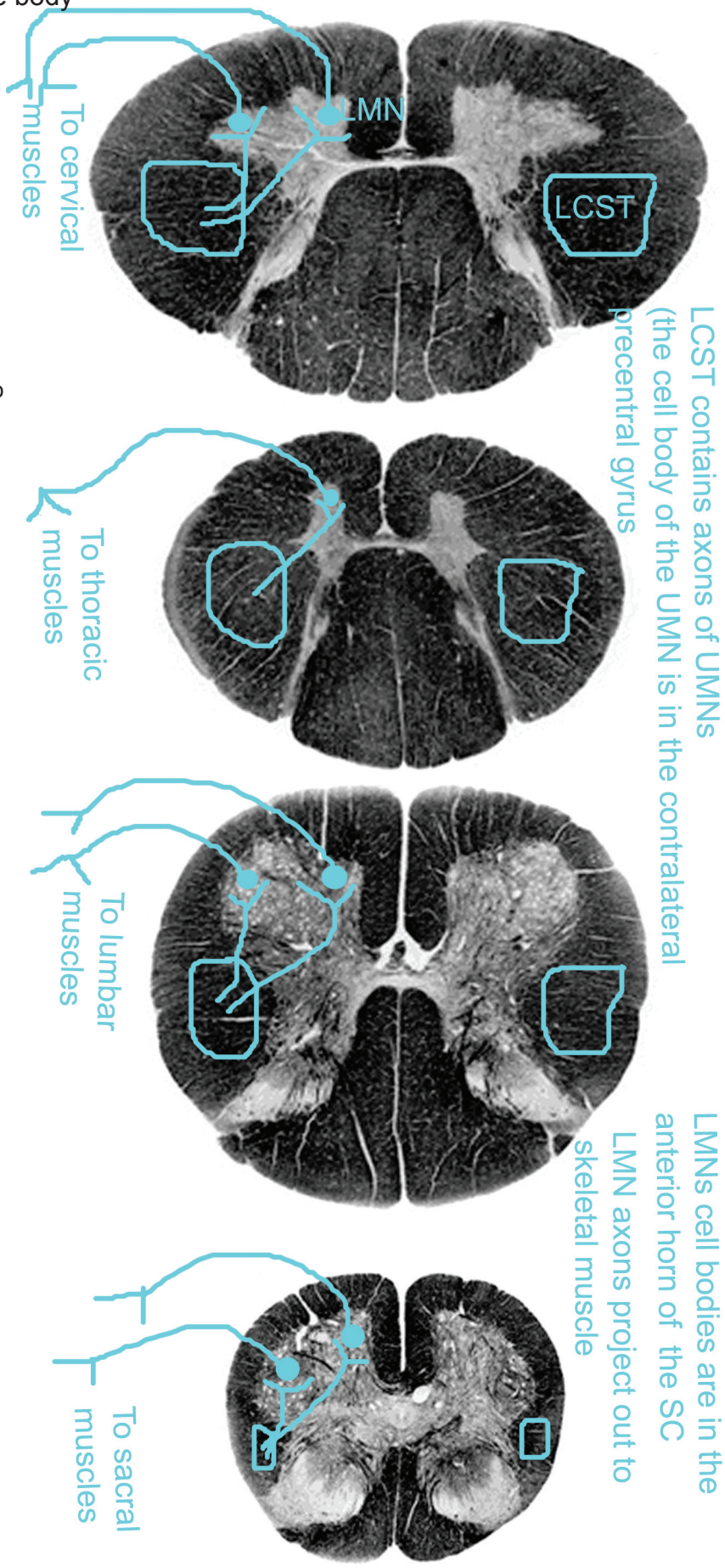
Red colored first order
neuronal axons will travel
in the fasciculus gracilis
of the dorsal columns of the
spinal cord.

DRG

Touch,
Vibratory sense
position sense

Voluntary Motor Pathway
to skeletal muscles of the body

Upper motor neuronal cell bodies are located in the precentral gyrus or paracentral gyrus and project their axons down through the posterior limb of the internal capsule, cerebral peduncles, anterior aspect of the pons, and pyramids of the medulla. At the caudal medulla, the upper motor neuronal axons will decussate and continue to descend in the lateral funiculus of the spinal cord. This tract in the spinal cord is called the lateral corticospinal tract (LCST). These upper motor neurons will synapse on lower motor neuronal cell bodies located in the anterior horn of the spinal cord. The lower motor neuronal axons will project out to innervate skeletal muscle at that myotome level. You will learn the complete details of this pathway later in this course.



LCST contains axons of UMNs (the cell body of the UMN is in the contralateral precentral gyrus

LMNs cell bodies are in the anterior horn of the SC
LMN axons project out to skeletal muscle

Voluntary motor pathway in the spinal cord
Anatomical Orientation

Lateral corticospinal tracts are the upper motor neuronal axons. They will synapse on the lower motor neuronal cell bodies in the ventral horn of the spinal cord. The lower motor neuronal axons will project out to innervate skeletal muscle.