AL MUSTAQBAL UNIVERSITY

College of Medicine / First Year

ANATOMY

(L5) Nervous System & The Axilla Region

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Learning Objectives

Nervous System & Axilla Region

By the end of this lecture, students should be able to:

1. **Differentiate** anatomically and functionally between the **central and peripheral nervous systems**.
2. **Identify** the structural components of a neuron and **distinguish** between **gray matter and white matter**.
3. **Describe** the organization and functions of the **gray matter columns of the spinal cord**.
4. **List** the **meninges** of the CNS and state their protective roles.
5. **Define and differentiate** the terms **nucleus, ganglion, tract, and nerve**.
6. **Describe** the formation and branches of a **typical spinal nerve**, including dorsal and ventral roots and rami.
7. **Differentiate** between the **somatic and autonomic nervous systems**, including the **two-neuron autonomic pathway**.
8. **Compare** the **sympathetic and parasympathetic divisions** with respect to anatomical origin and function.
9. **Define** the axilla and **identify its boundaries and contents**.
10. **Apply** axillary anatomy to **common clinical conditions**, particularly lymph node involvement and neurovascular injury.

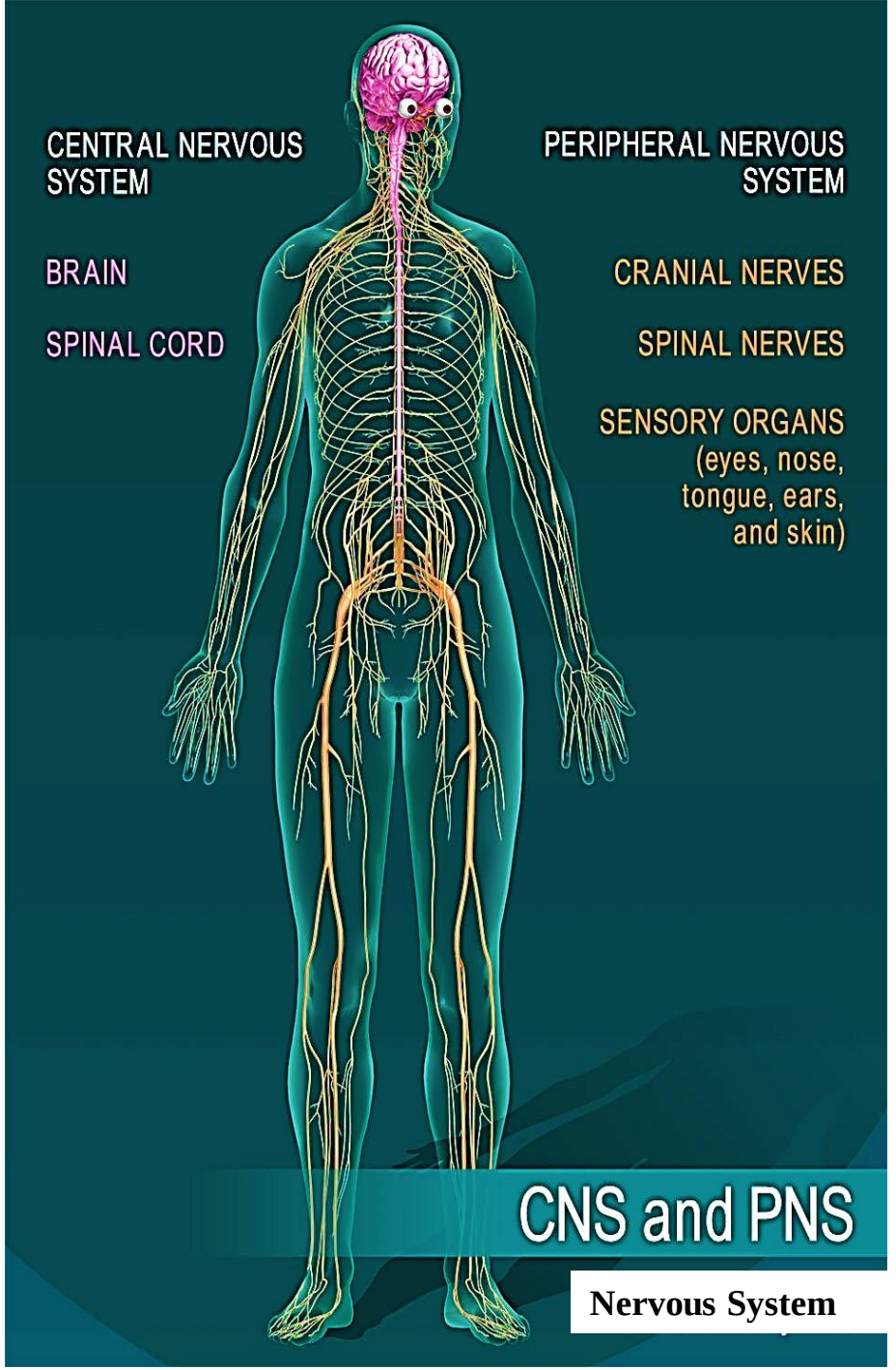
Nervous System

The nervous system, together with the endocrine system, controls and integrates the activities of the different parts of the body. The nervous system is divided into two main parts:

The Central Nervous System (CAN), which consists of the brain and spinal cord, and

The Peripheral Nervous System (PNS), which consists of a paired series of cranial and spinal nerves and their associated ganglia.

Functionally, the nervous system can be further divided into the **somatic nervous system** and the **autonomic nervous system**. The somatic nervous system acts upon the body's external environment, primarily through the actions of skeletal muscles, and uses mostly voluntary responses toconsciously perceived sensory signals from the body wall and limbs. The autonomic nervous system (ANS) acts upon the body's internal environment, primarily through the actions of smooth muscle, cardiac muscle, and glands, and uses mostly involuntary responses to sensory signals that are not consciously perceived.



Nervous System

The Nervous System

Central Nervous System (CNS)

- brain and spinal cord
- receives sensory input via PNS sensory nerves
- processes/interprets sensory input (interneurons)
- sends response to effectors (muscles and glands) via motor nerves

Peripheral Nervous System (PNS)

- cranial and spinal nerves extending from brain and spinal cord
- connects CNS to entire body

Autonomic

- cranial and spinal nerves connecting CNS to heart, stomach, intestines, and glands
- controls unconscious activities

Parasympathetic

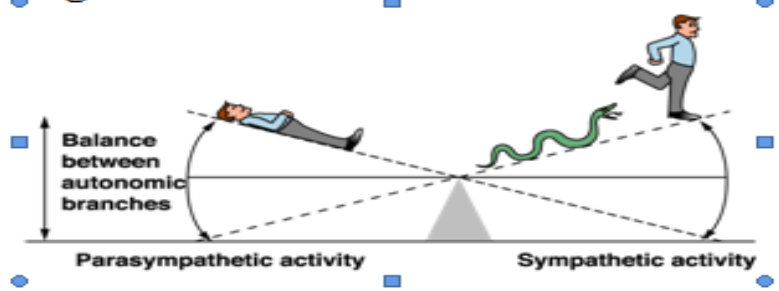
- decreases heart rate, bronchiole dilation, blood glucose, blood to skeletal muscle, bladder
- increases digestion, pupil size, urinary output
- "rest and digest"

Sympathetic

- decreases digestion, pupil size, urinary output
- increases heart rate, bronchiole dilation, blood glucose, blood to skeletal muscle, pupil size
- "fight or flight"

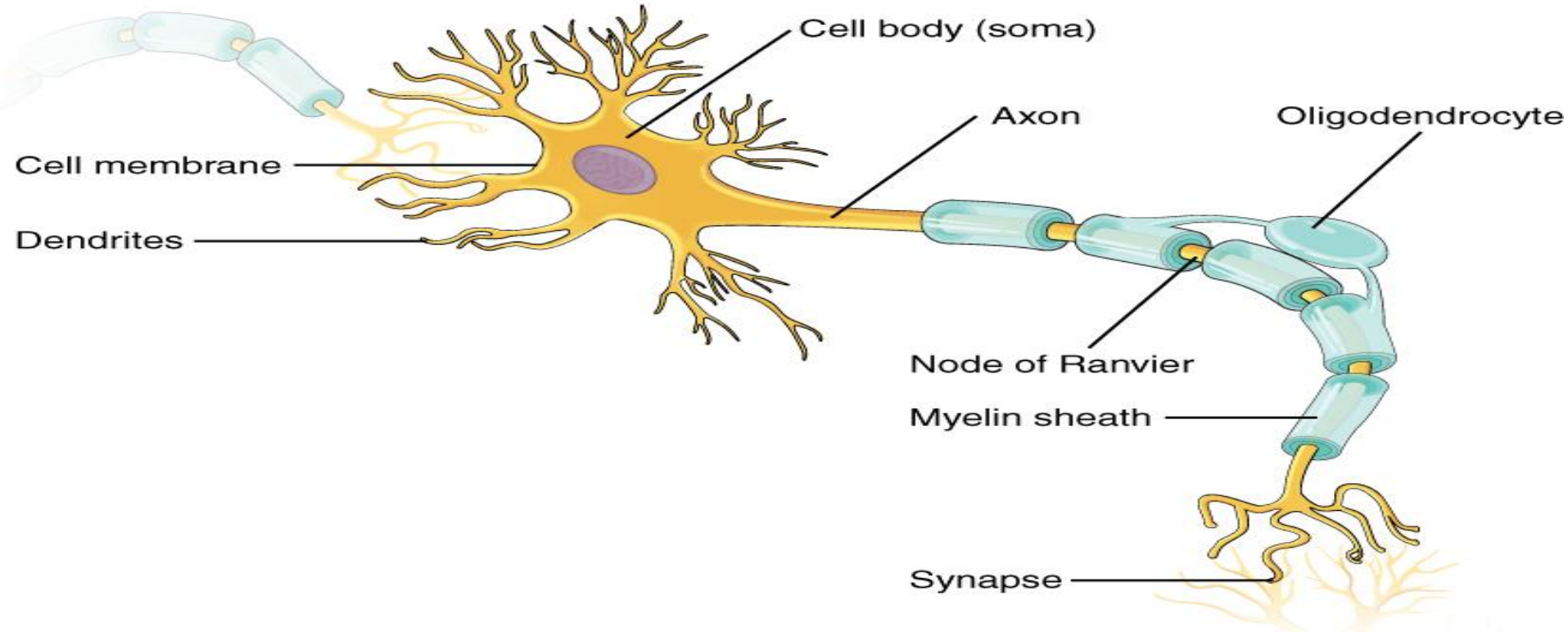
Somatic

- cranial and spinal nerves connecting CNS to skin and skeletal muscles
- oversees conscious activities

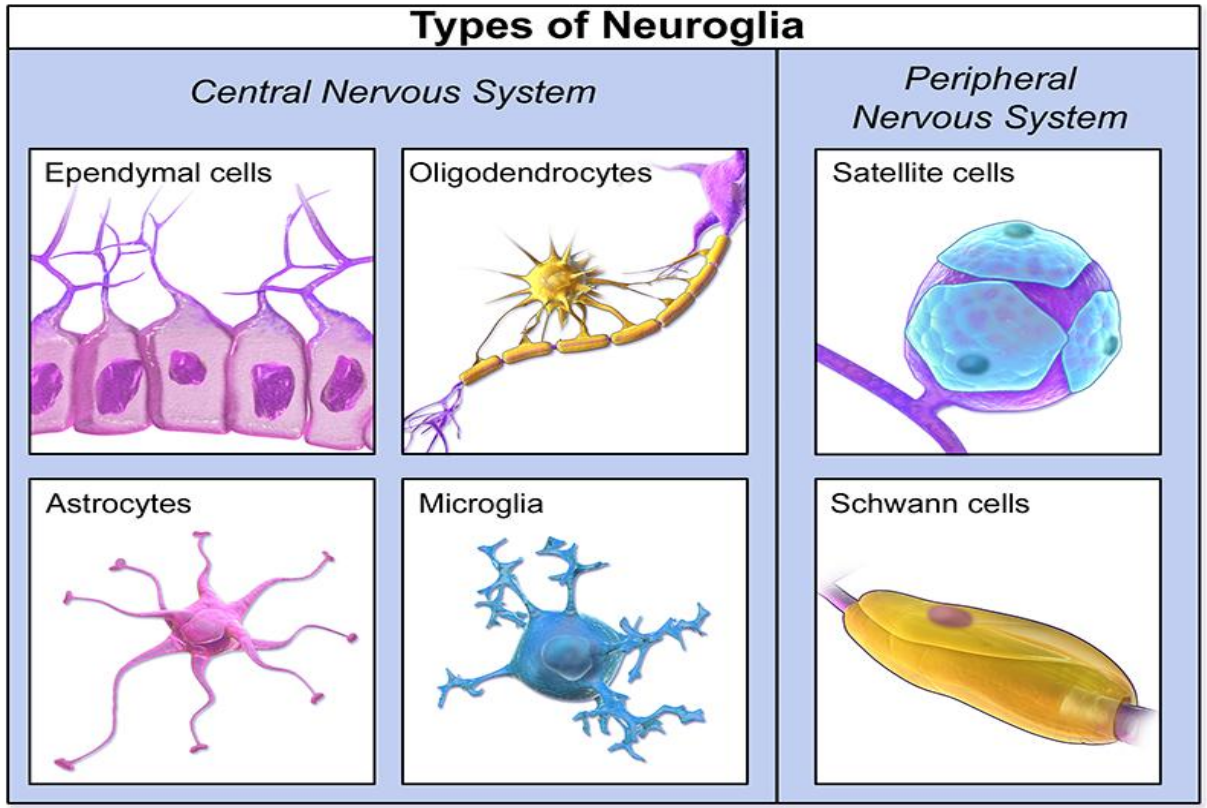


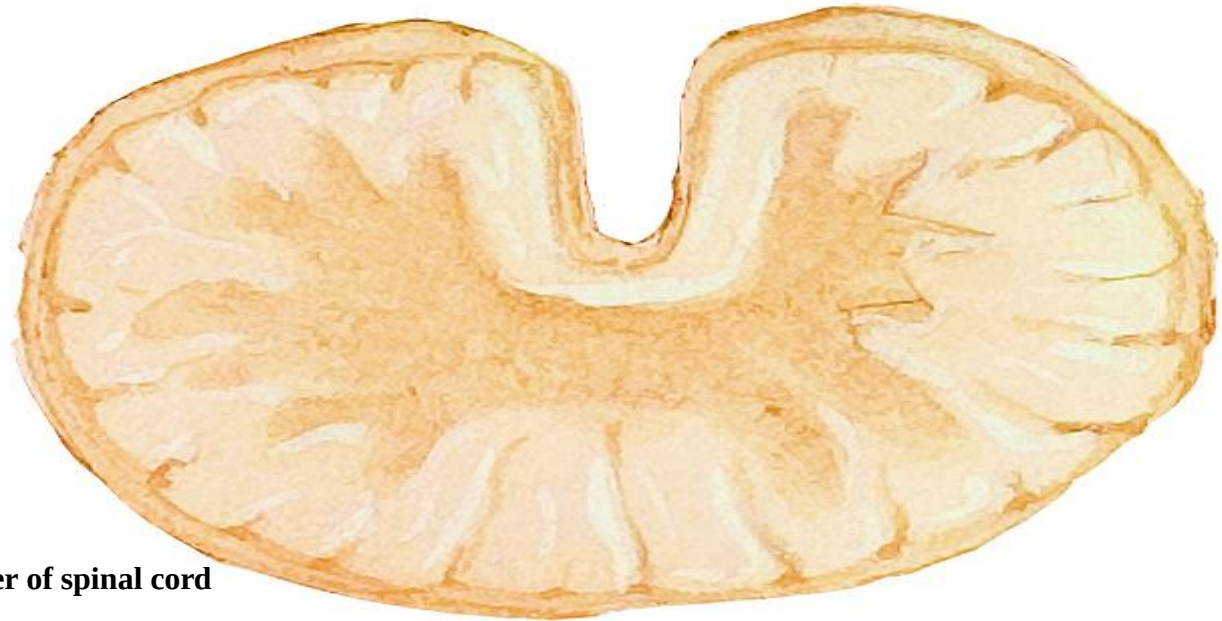
Central Nervous System

The central nervous system (CNS) is composed of large numbers of nerve cells and their processes, supported by specialized tissue called **neuroglia**. **A neuron** is an individual nerve cell, including all its processes. Each neuron has three main components: the cell body and two types of processes termed **dendrites** and an **axon**. Dendrites typically conduct nerve impulses toward the cell body and are the short processes of the cell body. The axon usually conducts impulses away from the cell body and dendrites and is the longest process of the cell body. Cell bodies within the CNS are mostly located in clusters termed nuclei.



The interior of the CNS is organized into gray and **white matter**. Gray matter consists largely of **nerve cell bodies** embedded in **neuroglia**. White matter consists largely of **nerve processes (axons)** and blood vessels embedded in **neuroglia**. Gray matter and white matter are so named because of their relative color tones in fresh tissue. The large population of myelinated nerve processes in white matter gives that tissue a relatively white, glistening color. Conversely, the large population of nonmyelinated cell bodies in gray matter presents a relatively dull, grayish color. In **the spinal cord**, the gray matter is organized in a characteristic **H-shaped (or butterfly-shaped)** pattern. Paired posterior (dorsal) and anterior (ventral) gray horns extend along the length of the cord. Paired lateral gray horns bulge out in the thoracic and upper lumbar portions of the cord. A central canal containing **cerebrospinal fluid** runs the internal length of the CNS.





H-shaped (or butterfly-shaped) of gray matter of spinal cord

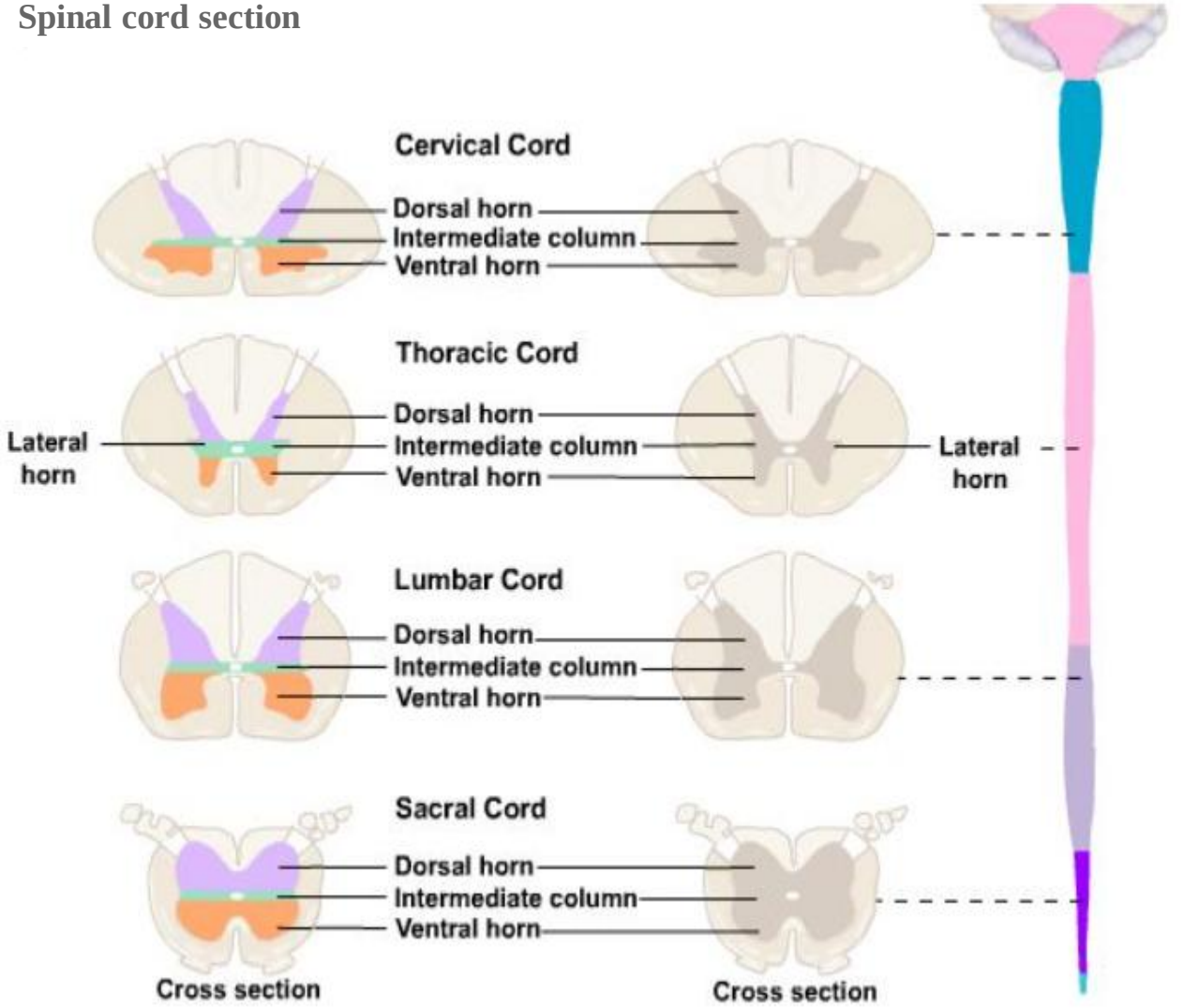
The Four Columns of Grey Matter: The grey matter is organized based on the type of information it processes. These columns extend the length of the cord (though some are more prominent in certain segments):

Dorsal Horn (Posterior Column): Primarily contains sensory (afferent) neurons. It receives incoming signals from the body regarding touch, pain, and temperature.

Intermediate Column (Intermediate Zone): Located between the dorsal and ventral horns. It contains interneurons that bridge sensory and motor signals and plays a major role in integrating spinal reflexes.

Lateral Horn (Intermediolateral Column): Contains autonomic motor neurons. This horn is only prominent in the thoracic and upper lumbar segments (T1–L2) for the sympathetic nervous system, and in the sacral segments (S2–S4) for the parasympathetic system.

Ventral Horn (Anterior Column): Contains somatic motor (efferent) neurons. These are the "lower motor neurons" that send axons out to stimulate skeletal muscles.

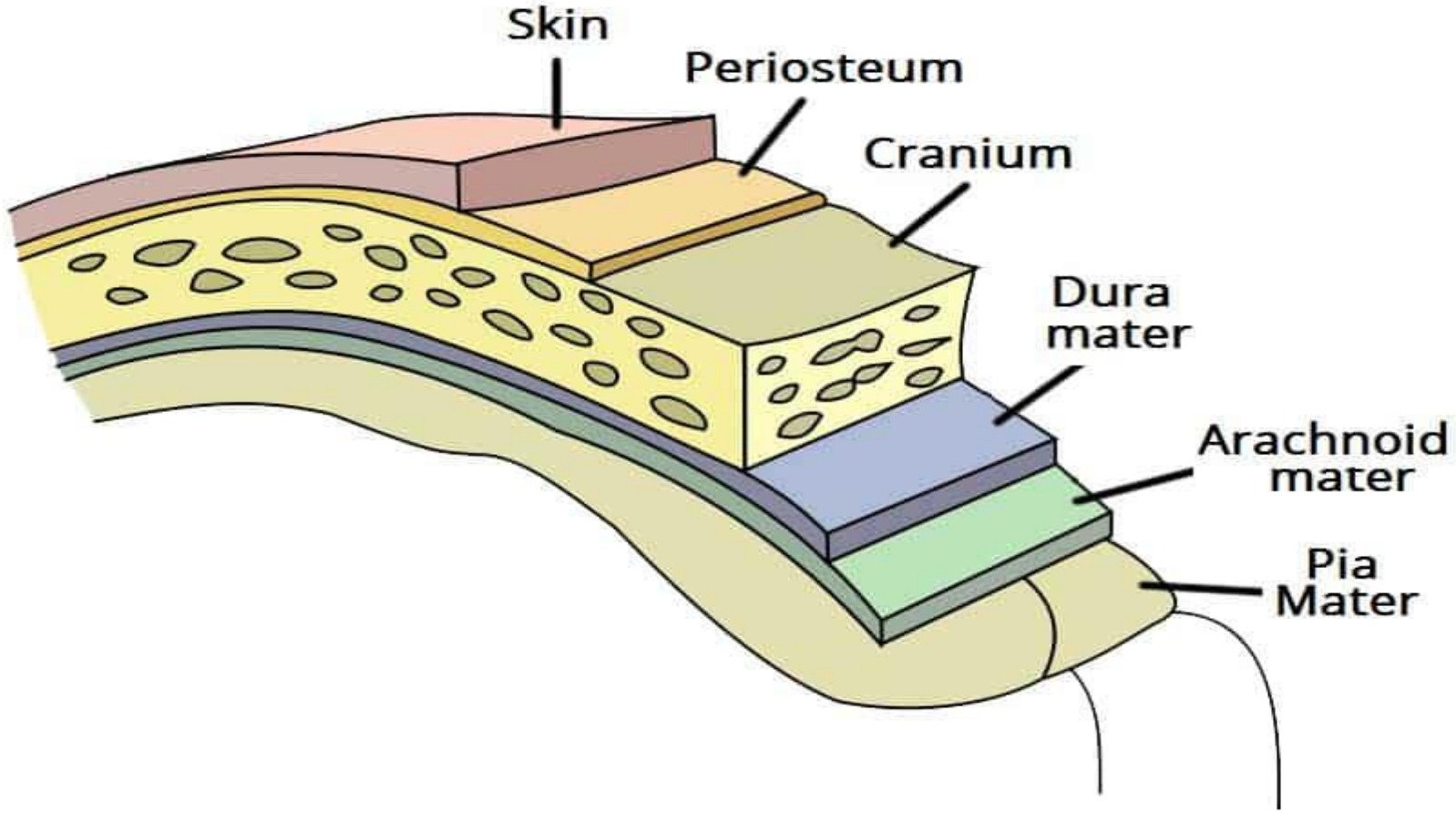


Feature	Dorsal Horn	Intermediate Column	Lateral Horn	Ventral Horn
Primary Function	Somatic/Visceral Sensory	Integration/Reflexes	Autonomic Motor	Somatic Motor
Target/Source	From Skin/Organs	Internal Processing	To Heart/Glands/Smooth Muscle	To Skeletal Muscle
Presence	Entire Cord	Entire Cord	T1-L2 and S2-S4	Entire Cord

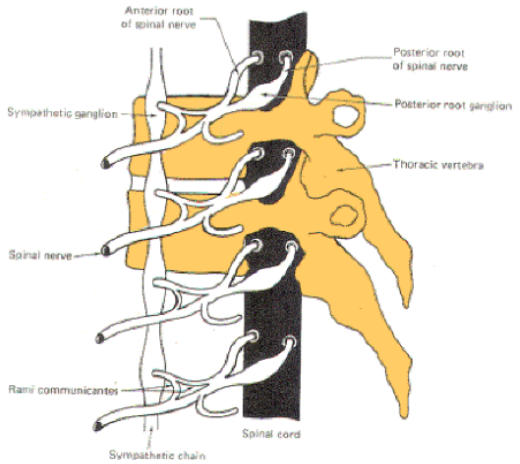
Three membranes (meninges) surround the entire CNS (brain plus spinal cord): **the dura mater** is the most external membrane; **the arachnoid mater** is the middle membrane; and the **pia mater** is the innermost layer. The meninges serve to protect, anchor, and stabilize the CNS and also contain a surrounding sac of cerebrospinal fluid.

Neurons : also called nerve cells, are electrically excitable cells that are the main functional units of the nervous system. Their function is to transmit nerve impulses, and they are the only type of human cells that can carry out this function

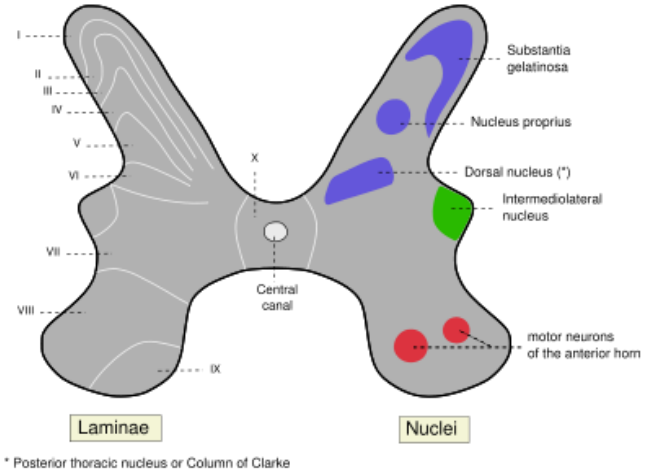
Neuroglia support and protect neurons



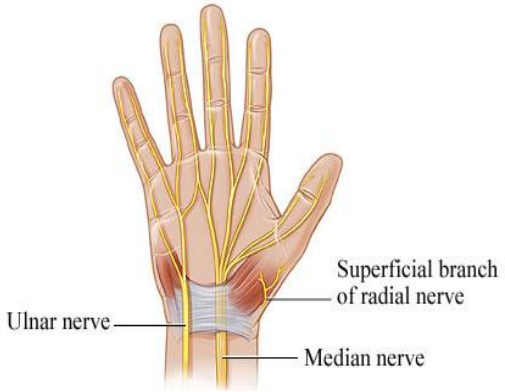
Common Terms



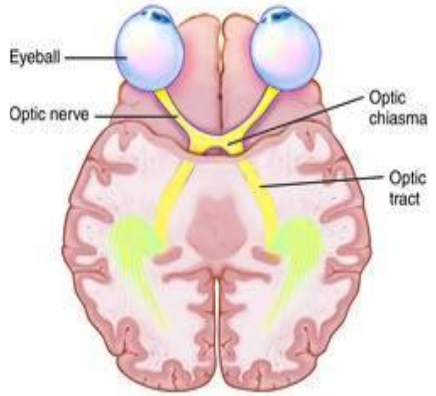
Ganglion
A group of neurons outside the CNS



Nucleus
A group of neurons within the CNS



Nerve
A group of nerve fibers (axons) outside the CNS



Tract
A group of nerve fibers (axons) within the CNS

Peripheral Nervous System

The peripheral nervous system consists of **the cranial and spinal nerves** and their associated ganglia. **A ganglion** is a cluster of neuron cell bodies located outside the CNS. In dissection, the cranial and spinal nerves appear as grayish white cords.

Cranial Nerves

The 12 pairs of cranial nerves branch off the brain and upper spinal cord and pass through openings (foramina) in the skull. All the cranial nerves are distributed in the head and neck except cranial nerve (CN) X (vagus nerve), which also supplies structures in the thorax and abdomen.

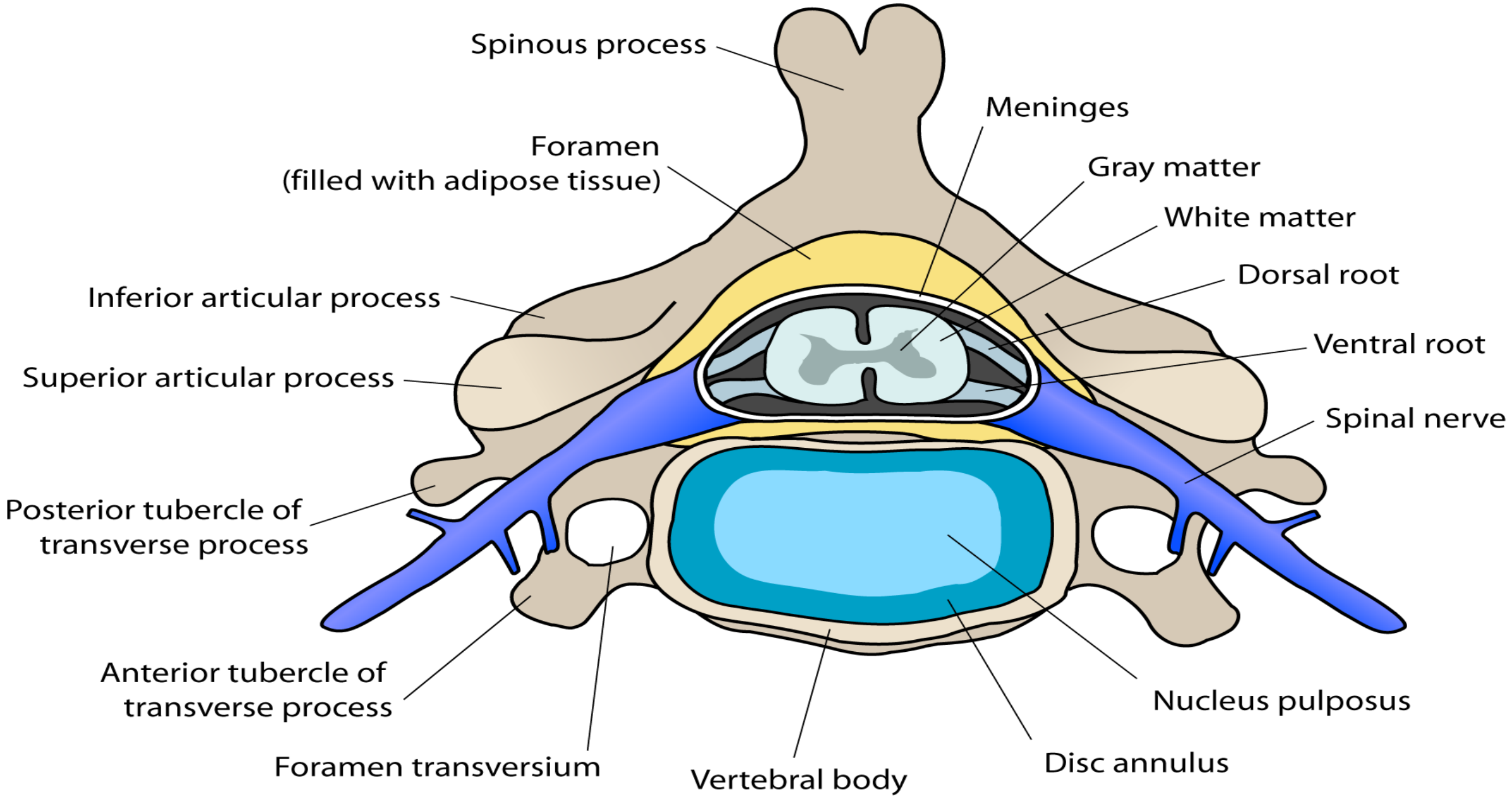
Spinal Nerves: Anatomically, a **spinal nerve** is a "**mixed" nerve**, meaning it carries both sensory and motor information. There are **31 pairs of spinal nerves** that emerge from the spinal cord to provide the primary communication link between the central nervous system and the rest of the body.

1. Structure and Formation: Every spinal nerve is formed by the union of two distinct **"roots"** that emerge from the spinal cord.

Dorsal Root (Posterior): Contains sensory (afferent) fibers. These carry signals like touch, pain, and temperature from the body to the brain. **Dorsal RootGanglion:** A visible swelling on the dorsal root that contains the cell bodies of these sensory neurons.

Ventral Root (Anterior): Contains motor (efferent) fibers. These carry commands from the brain and spinal cord to muscles and glands.

The Mixed Nerve: The dorsal and ventral roots join together at the intervertebral foramen (the opening between vertebrae) to form the **actual spinal nerve**. Because it contains both types of fibers, it is called a "mixed" nerve.


Spinous process
Meninges
Foramen
(filled with adipose tissue)
Gray matter
White matter
Dorsal root
Inferior articular process
Ventral root
Superior articular process
Spinal nerve
Posterior tubercle of
transverse process
Anterior tubercle of
transverse process
Nucleus pulposus
Foramen transversium
Vertebral body
Disc annulus

2. Branching (Rami): Almost immediately after forming and exiting the vertebral column, the spinal nerve splits into branches called rami (singular: ramus):

Branch	Function
Dorsal Ramus	Supplies the deep muscles and skin of the back.
Ventral Ramus	Much larger; supplies the front and sides of the trunk, as well as all the limbs. These often join together to form complex networks called plexuses (like the Brachial Plexus for the arm).

In addition to the anterior and posterior rami, the spinal nerves give a

Meningeal Branch	Re-enters the vertebral canal to innervate the vertebrae, ligaments, and meninges.
Rami Communicantes	Small branches that connect to the sympathetic chain (part of the autonomic nervous system).

Classification by Region

Spinal nerves are named based on the level of the vertebral column from which they emerge:

8 Cervical (C1–C8): Head, neck, diaphragm, and arms.
12 Thoracic (T1–T12): Chest and upper abdominal muscles.
5 Lumbar (L1–L5): Lower back, hips, and fronts of legs.
5 Sacral (S1–S5): Pelvic organs, buttocks, and backs of legs.
1 Coccygeal (Co1): Tailbone area.

Note: Although there are only 7 cervical vertebrae, there are 8 cervical nerves because the first pair exits above the C1 vertebra, and the eighth pair exits below the C7 vertebra

Typical Spinal Nerve.

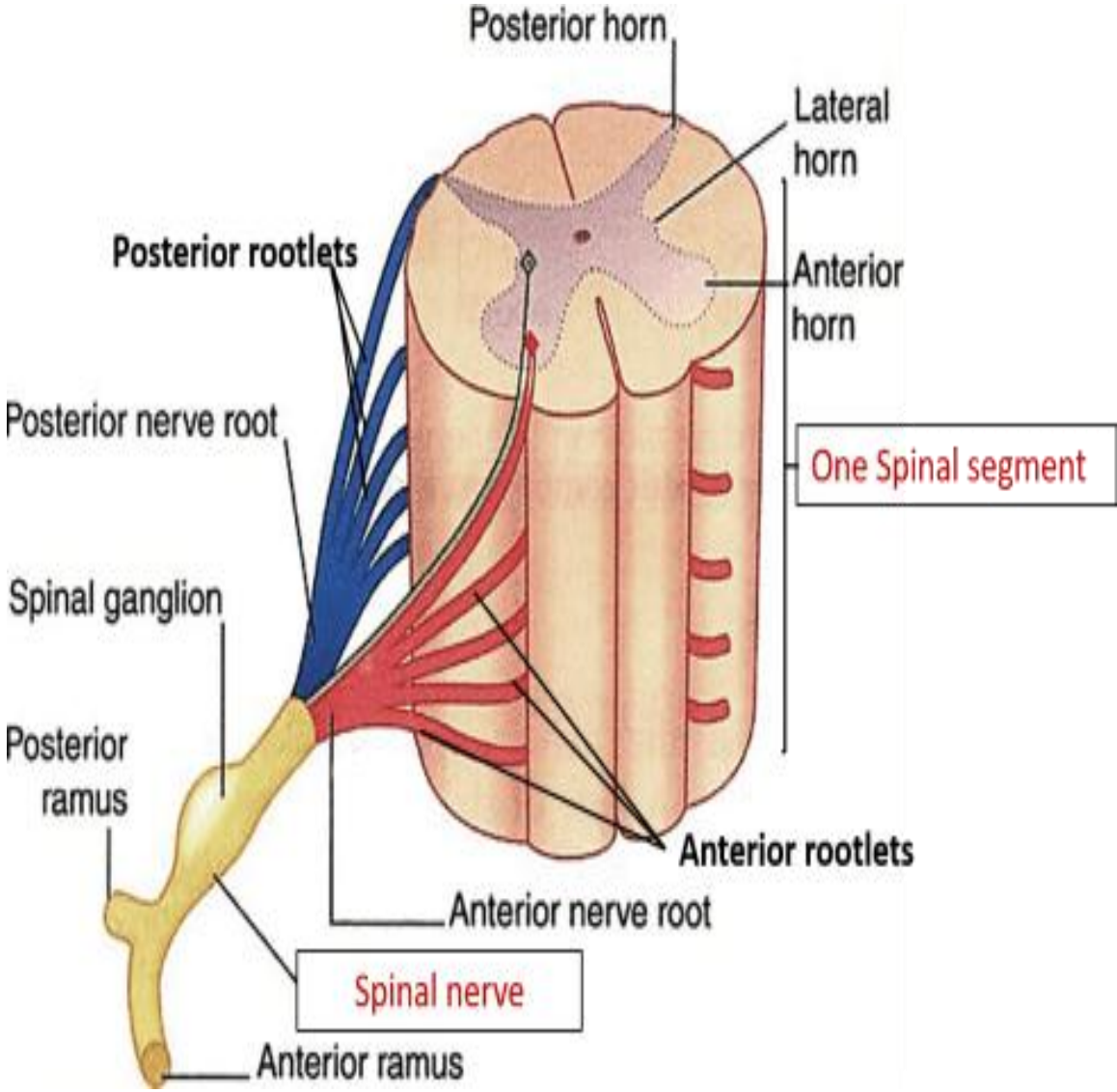
•Thoracic spinal nerves are the examples of typical spinal nerves. Unlike cervical, lumbar and sacral nerves , they do not form plexus.

• Each spinal nerve is attached to a part of spinal cord called **spinal segment** via anterior and posterior roots which in turn have 1-8 rootlets.

•**Anterior root is motor** and comprises of axons of neuron located in the anterior horn (motor neurons) and lateral horn in T1-L1 spinal segments (preganglionic sympathetic neurons) and in S2-S4 spinal segments (preganglionic parasympathetic neurons)

•**Posterior root is sensory** and has a swelling called dorsal root ganglion consisting of neuronal cell bodies of sensory fibers.

•The two roots join together to form the **spinal nerve trunk** which in turn divides into large anterior ramus and small posterior ramus (**ramii contain both sensory and motor fibers**).



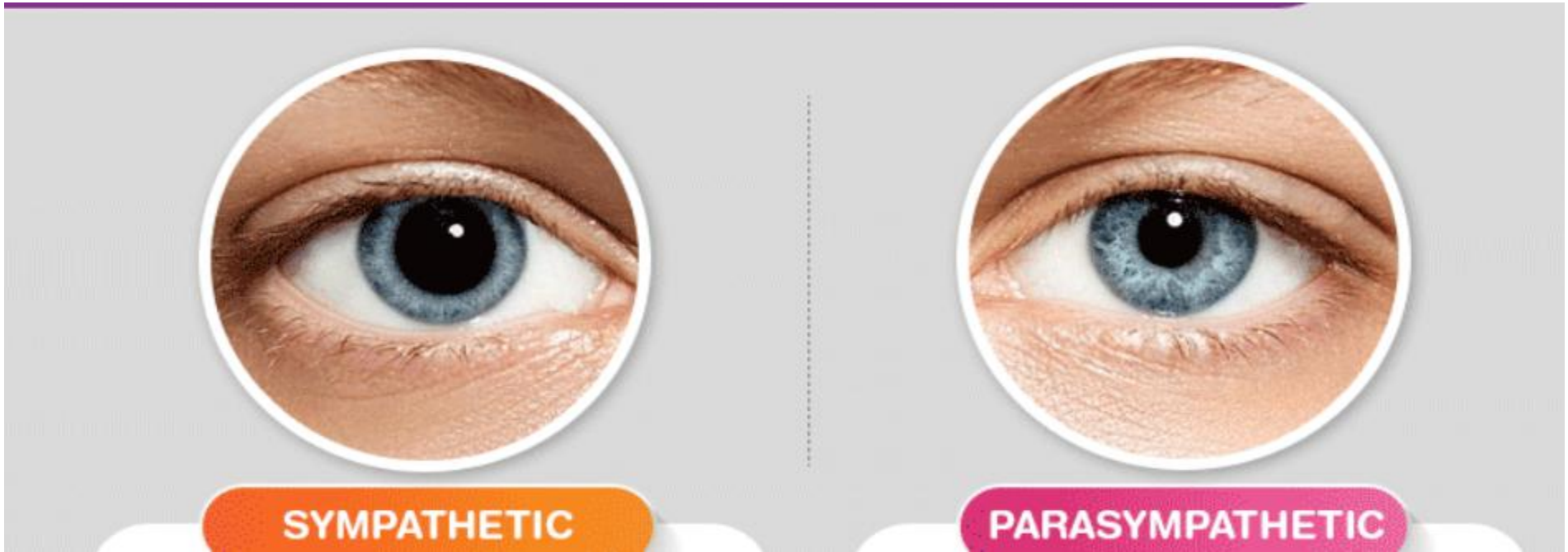
Autonomic Nervous System

The autonomic nervous system (ANS) is the part of the nervous system concerned with motor control of smooth muscle cardiac muscle, and glands throughout the body. **The hypothalamus** of the brain controls the ANS and integrates the activities of the autonomic and neuroendocrine systems, thus preserving homeostasis in the body. The ANS is distributed throughout the central and peripheral nervous systems. The somatic and ANS differ in several significant ways. The fundamental anatomical difference between the Somatic Nervous System (SNS) and the Autonomic Nervous System (ANS) lies in how many neurons it takes to get the signal from the Central Nervous System (CNS) to the target organ.

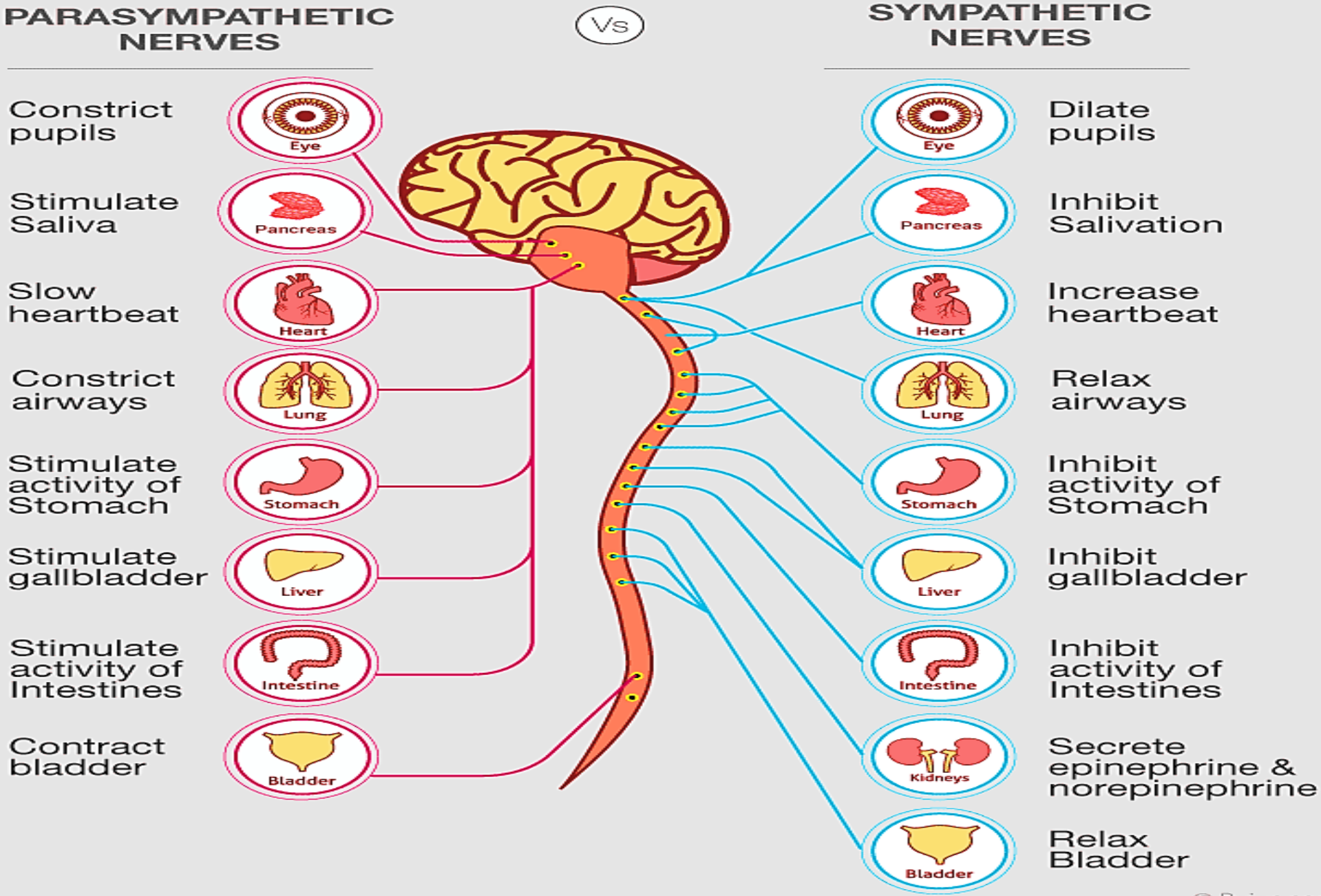
1. **Somatic Nervous System:** The One-Neuron Pathway: In the somatic system (which controls skeletal muscle), there is no "middleman." A single, long motor neuron carries the signal all the way from the spinal cord to the muscle. **Origin:** The cell body of the motor neuron is located in the ventral horn of the spinal cord's gray matter. **Pathway:** Its axon exits the spinal cord and travels directly to the skeletal muscle without synapsing (connecting) with any other neurons along the way. **Neurotransmitter:** It always releases **Acetylcholine (ACh)** at the Neuromuscular Junction (NMJ) to trigger contraction.

2. Autonomic Nervous System: The Two-Neuron Pathway: In the ANS (which controls smooth muscle, cardiac muscle, and glands), the signal must pass through a "relay station" called an **autonomic ganglion**. This requires a chain of two neurons: **Neuron 1**: **The Preganglionic** Neuron. The cell body is located in the CNS (either the brainstem or the lateral horn of the spinal cord).Its axon travels out of the CNS to an autonomic ganglion. **Neuron 2: The Postganglionic** Neuron. The cell body is located inside the autonomic ganglion (outside the CNS).Its axon travels the rest of the way to the target organ (the effector). The "two-neuron" setup of the ANS allows for integration and coordination outside of the brain. A single preganglionic neuron can synapse with many postganglionic neurons, allowing one signal from the brain to cause a widespread response (like the "fight or flight" rush that hits your whole body at once) .

The ANS is divided into two parts: the sympathetic division and the parasympathetic division. Overall, sympathetic activity prepares the body for emergency, whereas parasympathetic activity aids in recovery. The sympathetic and parasympathetic divisions often function as **antagonistic systems**, that is, they produce activities in opposition to one another. For example, sympathetic activity produces accelerated heart rate, bronchodilation, decreased peristalsis in the gut tube, closing of the sphincters, relaxation of the general bladder wall, and dilation of the pupils. Conversely, parasympathetic activity results in decelerated heart rate, bronchoconstriction, increased gut peristalsis, opening of sphincters, contraction of the bladder wall, and constriction of the pupils. However, the two divisions may function as **complementary (synergistic) systems**. For example, in normal sexual function, parasympathetic activity produces erection, and sympathetic activity results in ejaculation. Additionally, one division may function **independently** of the other—sympathetic stimulation activates sweat gland secretion, but parasympathetics play no role in sweat gland activity.

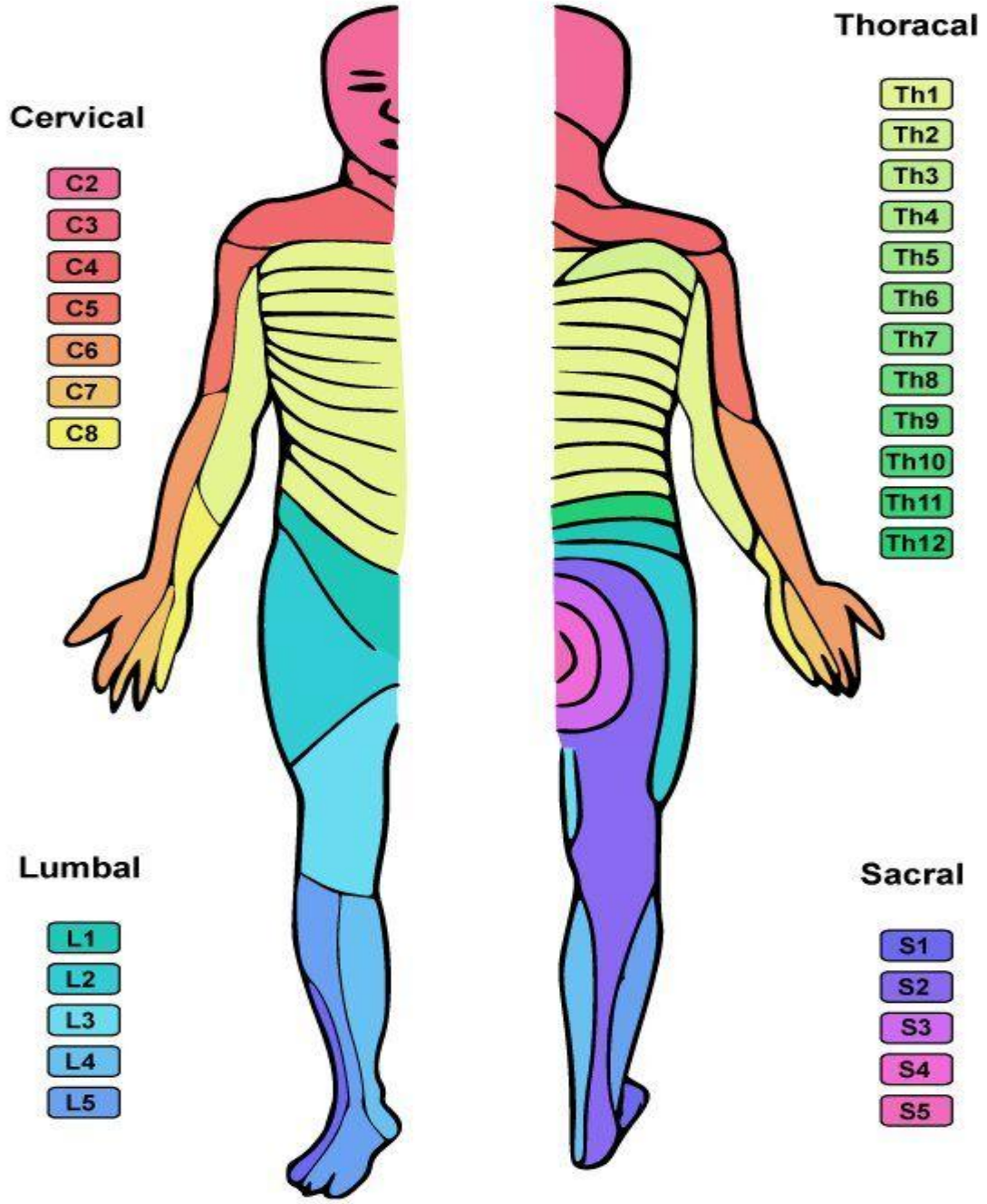


DIFFERENCE BETWEEN SYMPATHETIC AND PARASYMPATHETIC



Dermatomes: Segmental Innervation of Skin

Each spinal nerve (and therefore each segment of the spinal cord) innervates a specific area of skin in a highly organized fashion. A **dermatome** is the area of skin supplied by the somatic sensory fibers of a single spinal nerve. On the trunk, the dermatomes form a relatively simple bandlike pattern. In the limbs, arrangement of the dermatomes is more complicated because of the embryonic rotations that take place as the limbs grow out from the body wall. Adjacent dermatomes overlap considerably, especially on the trunk. At least three contiguous spinal nerves must be sectioned to produce complete anesthesia in any one dermatome.



The Axilla

The axilla is a pyramid-shaped space below the glenohumeral joint that is the passageway for nerves and vessels to pass into the upper arm. The axilla has a base, an apex, and 4 walls (anterior, medial, lateral, posterior)

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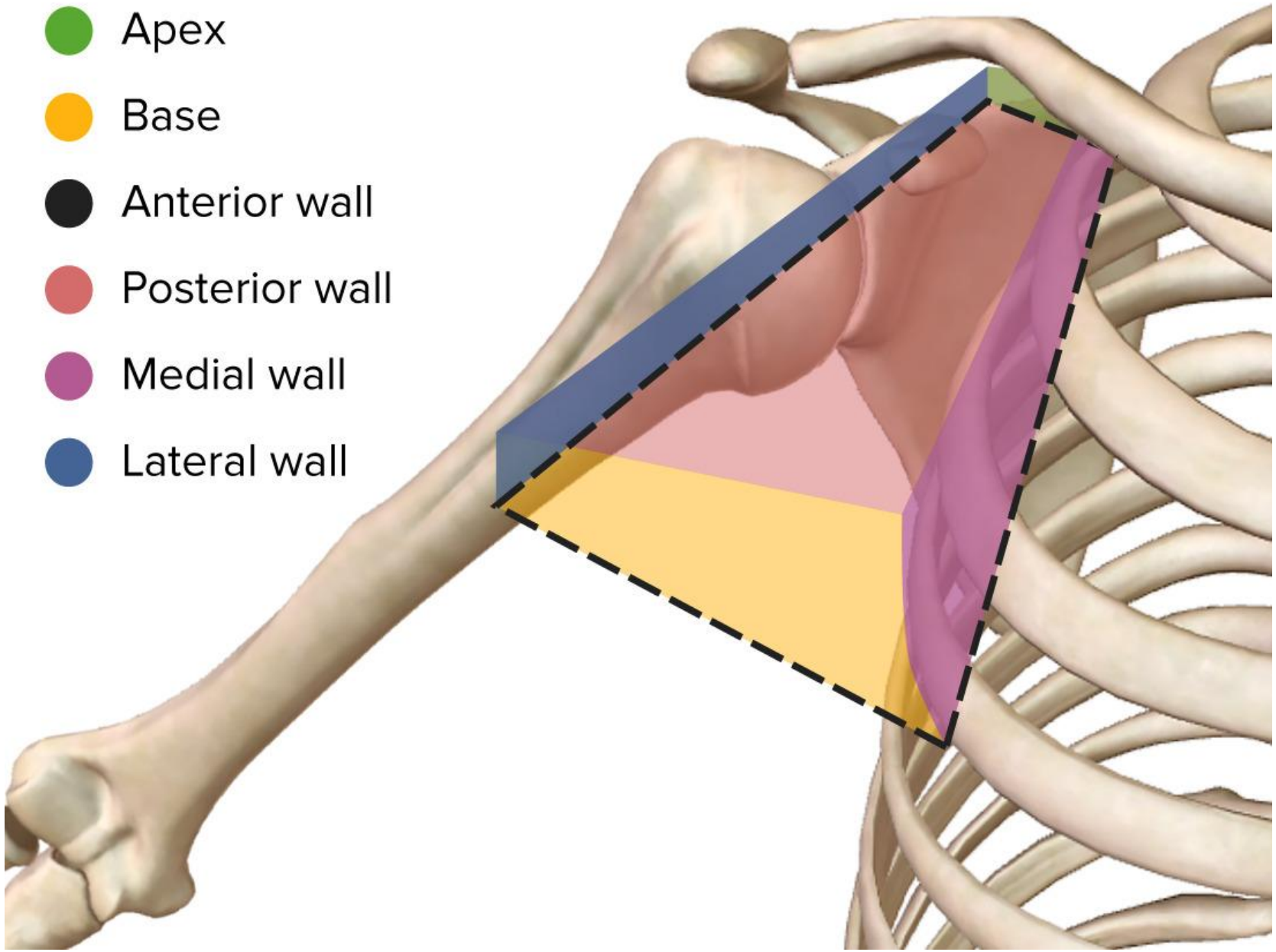
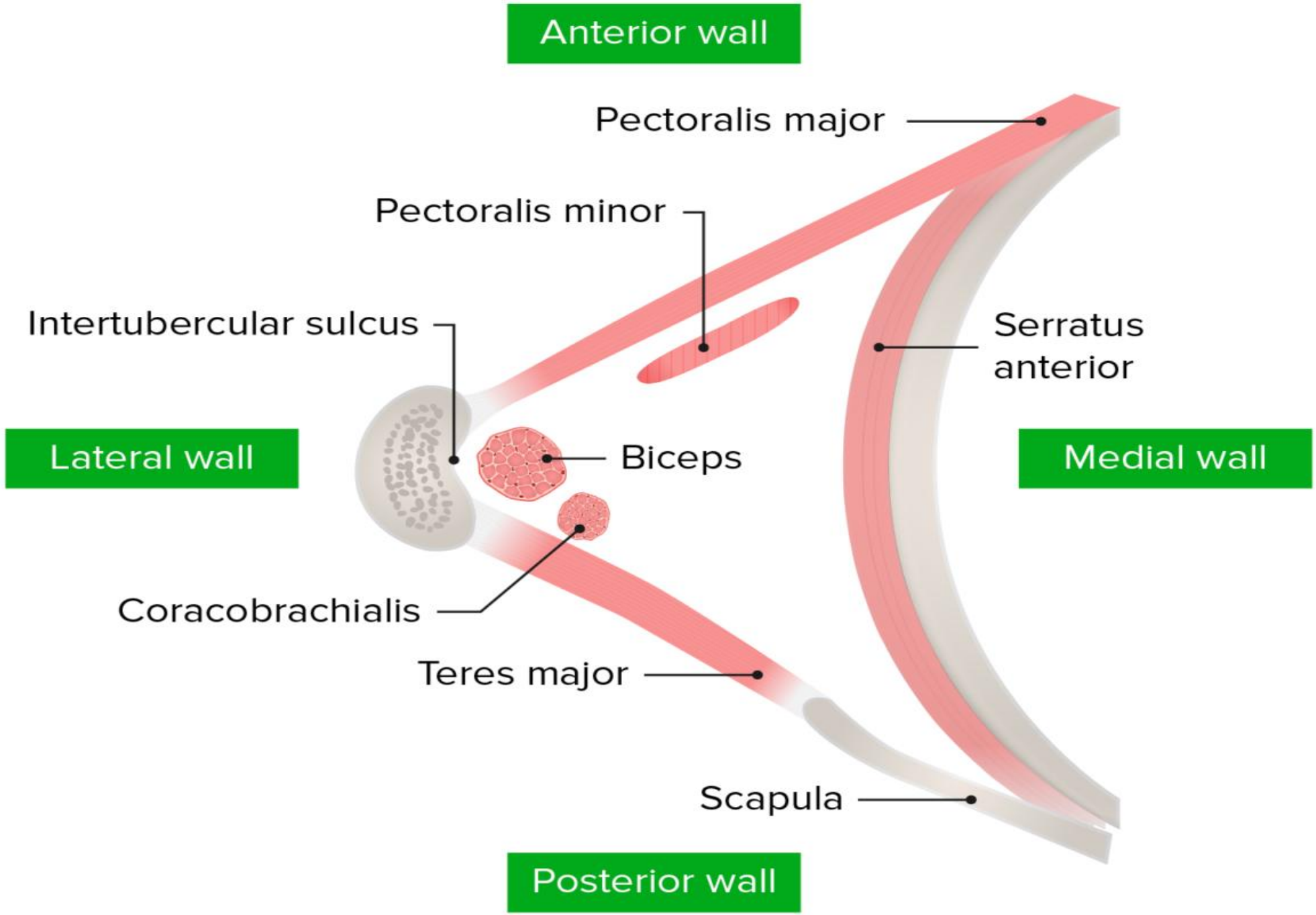


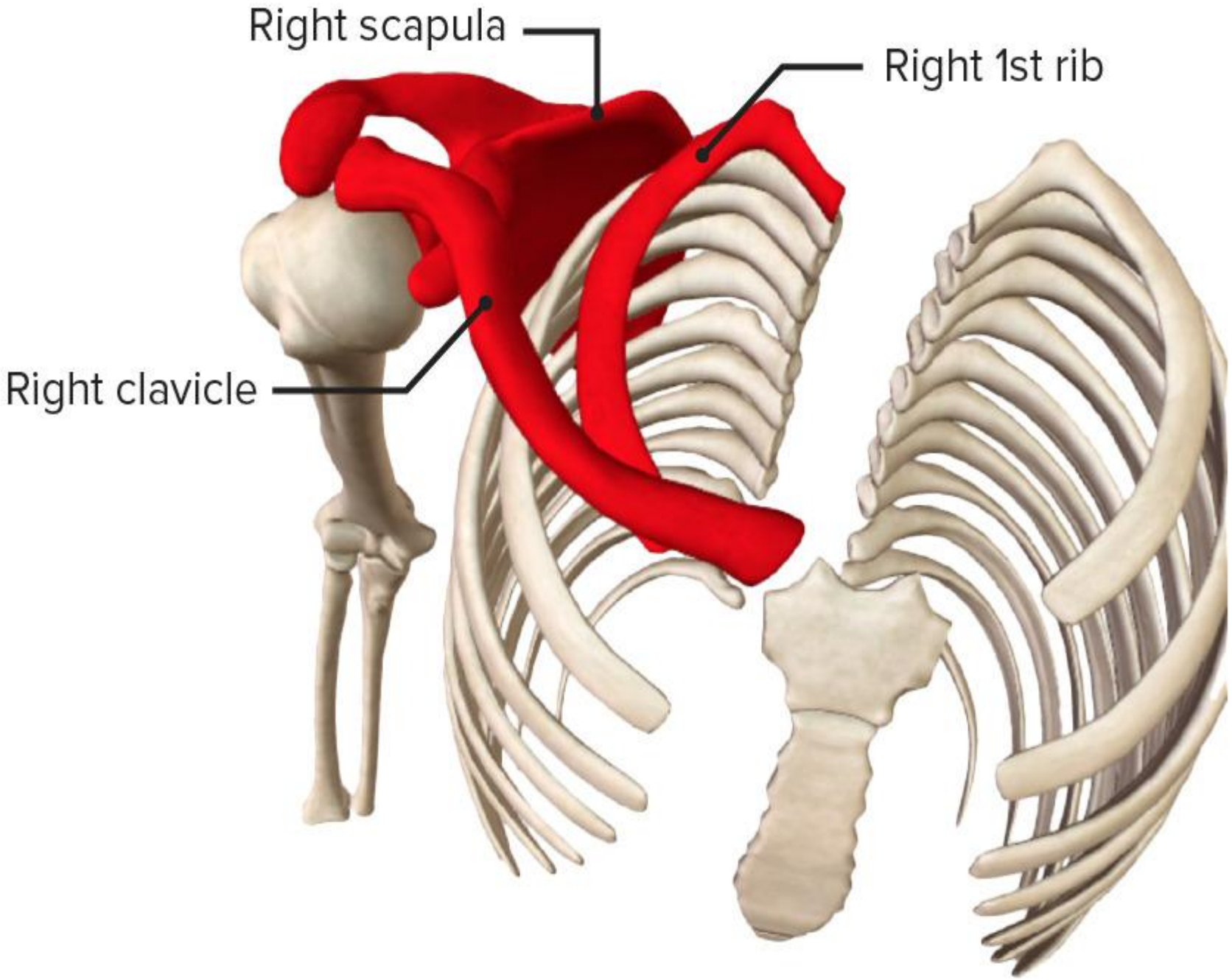

Anterior wall
Pectoralis major
Pectoralis minor
Intertubercular sulcus
Serratus anterior
Lateral wall
Biceps
Medial wall
Coracobrachialis
Teres major
Scapula
Posterior wall

Axillary Borders

- **Anterior wall:** Pectoralis major and minor muscles and clavipectoral fascia
- **Posterior wall:** Latissimus dorsi, teres major, and subscapularis muscles
- **Lateral wall:** Humerus, short head of biceps brachii muscle, and coracobrachialis muscle
- **Medial wall:** Upper five ribs, their intercostal muscles, and adjacent serratus anterior muscle
- **Base:** hair and sweat gland–bearing axillary skin and Axillary fascia
- **Apex** *(cervicoaxillary canal):* Superior border of scapula, 1st rib, and clavicle

Apex (axillary inlet):

It is called **Cervicoaxillary canal.** between the 1st rib, superior border of the scapula, and clavicle. The apex houses various vessels and nerves, including the axillary artery and its branches, the axillary vein and its tributaries, the branches of the brachial plexus, and the axillary lymph nodes



Contents

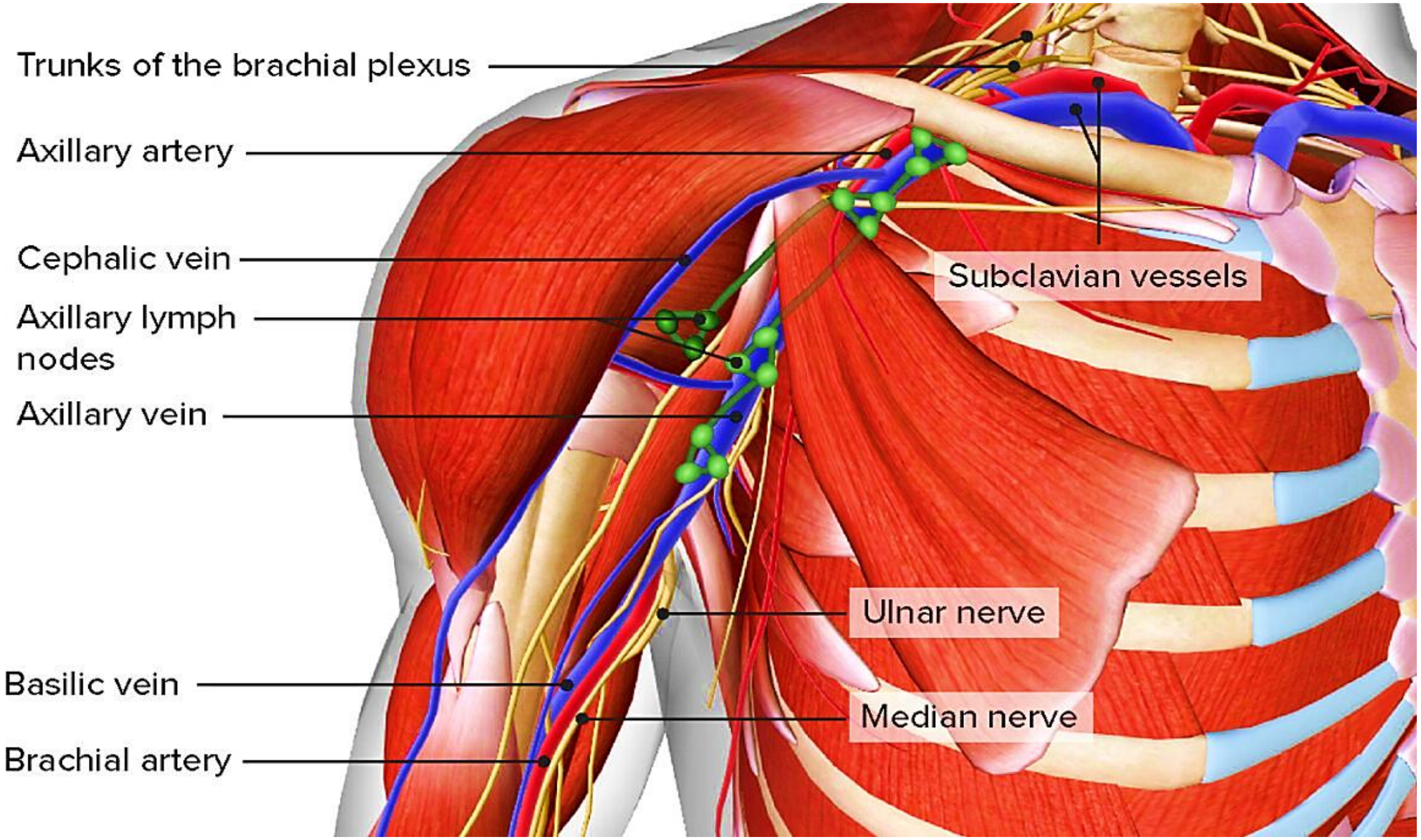
The contents of the axilla region include muscles, nerves, vessels, and lymphatics:

- **Axillary artery** – the main artery supplying the upper limb. It is commonly referred as having three parts; one medial to the pectoralis minor, one posterior to pectoralis minor, and one lateral to pectoralis minor.

- **Axillary vein** – the main vein draining the upper limb. It is formed by the brachial veins and basilic vein, and receives the cephalic vein as a major tributary.

- **Brachial plexus** – a network of spinal nerves (C5–T1) that gives rise to the peripheral nerves supplying the upper limb.

- **Axillary lymph nodes** – a group of lymph nodes that filter lymph drained from the upper limb, breast, and pectoral region

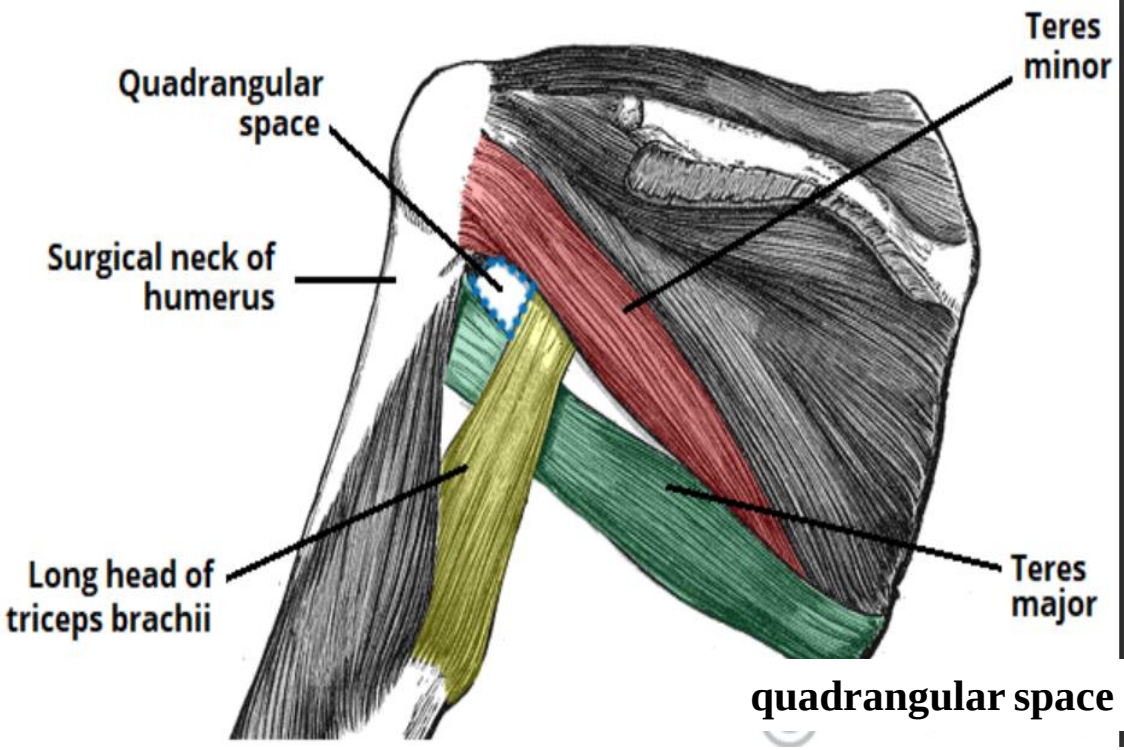

Trunks of the brachial plexus
Axillary artery
Cephalic vein
Axillary lymph nodes
Axillary vein
Basilic vein
Brachial artery
Subclavian vessels
Ulnar nerve
Median nerve

Passageways Exiting the Axilla
There are three main routes by which structures leave the axilla.

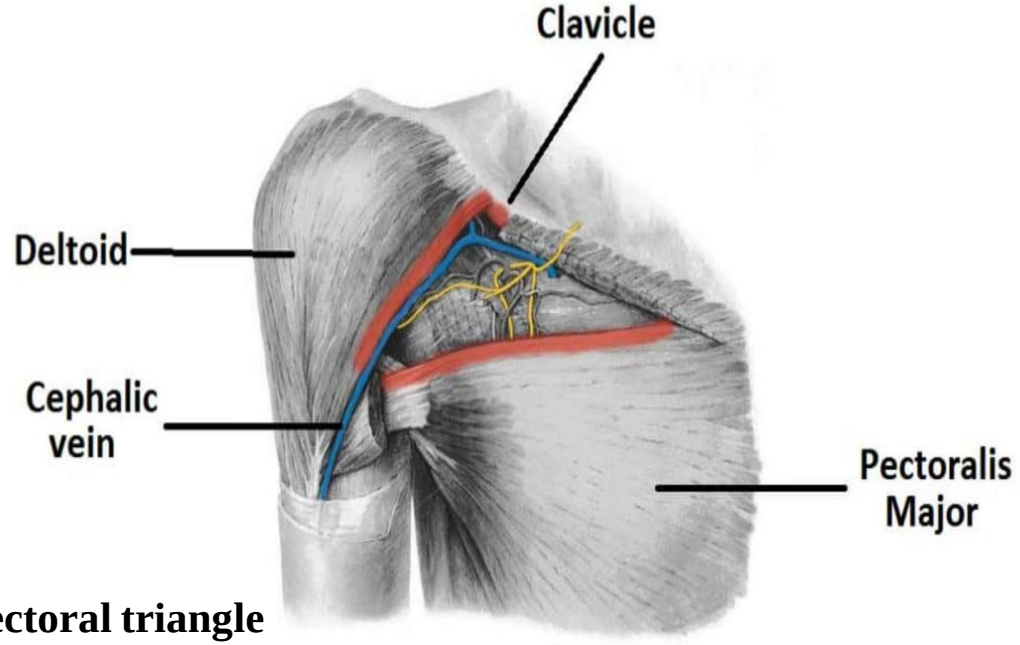
The main route of exit is immediately inferiorly and laterally, into the **upper limb**. The majority of contents of the axilla region leave by this method.

Another pathway is via the **quadrangular space**. This is a gap in the posterior wall of the axilla, allowing access to the posterior arm and shoulder area. Structures passing through include the axillary nerve and posterior circumflex humeral artery, a branch of the axillary artery.

The last passageway is the **clavipectoral triangle**, which is an opening in the anterior wall of the axilla. It is bounded by the pectoralis major, deltoid, and clavicle. The cephalic vein enters the axilla via this triangle



quadrangular space



clavipectoral triangle

CLINICAL RELEVANCE

Thoracic Outlet Syndrome

The apex of the axilla region is an opening between the clavicle, first rib and the scapula. In this apex, the vessels and nerves may become **compressed** between the bones – this is called thoracic outlet syndrome.

Common causes of **thoracic outlet syndrome** include:

- **Trauma** – e.g. fractured clavicle.
- **Repetitive movements** – seen commonly in occupations that require lifting of the arms.
- **Cervical rib** – an extra rib which arises from the seventh cervical vertebra.

It often presents with **pain** in the affected limb (the distribution of pain is dependent on which nerve is compressed), tingling, muscle weakness and discolouration.

Lymph Node Biopsy

Approximately 75% of lymph from the **breast** drains into the axilla lymph nodes, so can be biopsied if breast cancer is suspected. If breast cancer is confirmed, the axillary nodes may need to be removed to prevent the cancer spreading. This is known as **axillary clearance**. During this procedure, the long thoracic nerve may become damaged, resulting in winged scapula.

THANK YOU!