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PHYSIOLOGY OF THE PROPRIOCEPTORS IN BALANCE & ITS PATHWAYS

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OBJECTIVES

At the end of this lecture you should be able to:

- ▶ Identify the major sensory pathways
- ▶ Describe the components, processes and functions of the sensory pathways
- ▶ Appreciate the dorsal column system in conscious proprioception
- ▶ Describe the pathway of spinocerebellar tract in unconscious proprioception from muscles, tendons and joints
- ▶ Differentiate between sensory and motor ataxia



PROPRIOCEPTION

Latin proprius, meaning "one's own", "individual" and perception, is the sense of the relative position of neighbouring parts of the body and strength of effort being employed in movement.

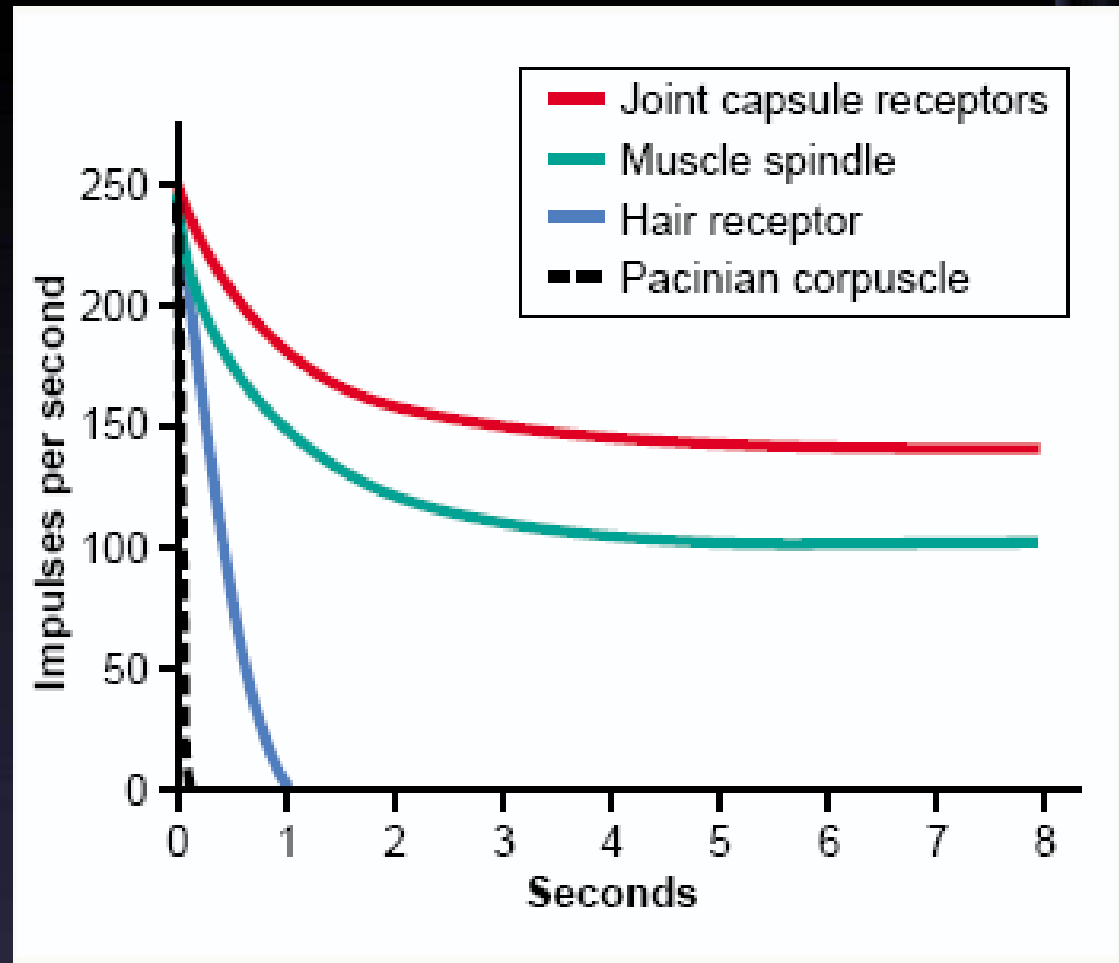
exteroception, by which one perceives the outside world

interoception, by which one perceives pain, hunger, etc., and the movement of internal organs.

MECHANORECEPTORS: which detect mechanical compression or stretching of the receptor or of tissues adjacent to the receptor

Adaptation of Receptors

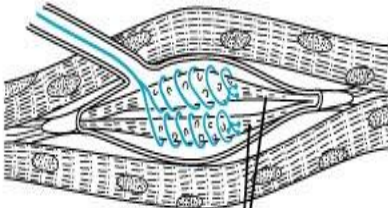
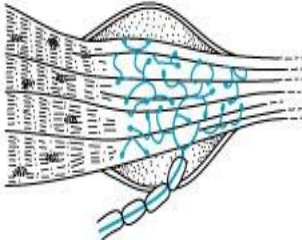
When a continuous sensory stimulus is applied, the receptor responds at a high impulse rate at first and then at a progressively slower rate until finally the rate of action potentials decreases to very few or often to none at all.



TABLE

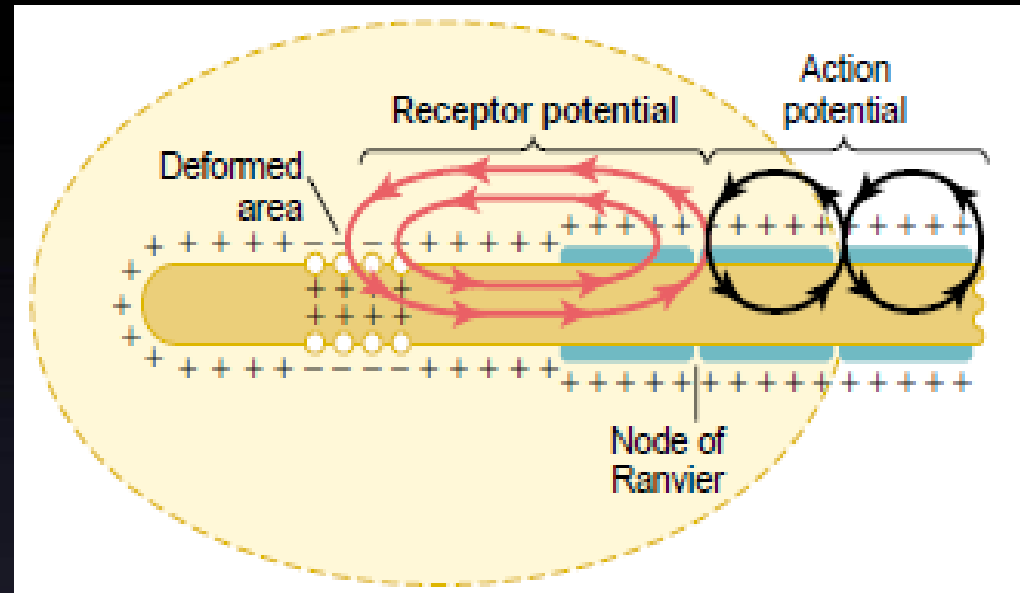
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General Sensory Receptors Classified by Structure and Function *(continued)*

Structural Class	Illustration	Functional Class According to Location (L) and Stimulus Type (S)	Body Location
PROPRIOCEPTORS			
Muscle spindles	 <p data-bbox="577 922 755 962">Intrafusal fibers</p>	L: Proprioceptors S: Mechanoreceptors (muscle stretch)	Skeletal muscles, particularly those of the extremities
Golgi tendon organs		L: Proprioceptors S: Mechanoreceptors (tendon stretch)	Tendons
Joint kinesthetic receptors (Pacinian and Ruffini endings, free nerve endings, and receptors resembling Golgi tendon organs)		L: Proprioceptors S: Mechanoreceptors and nociceptors	Joint capsules of synovial joints

Receptor Potential of the Pacinian Corpuscle

For joint position and vibration sensation (Also Ruffini's Endings)



- The receptor potential produced by compression induces a local circuit of current flow that spreads along nerve fiber.
- The frequency of repetitive action potentials transmitted from sensory receptors increases approximately in proportion to the increase in receptor potential

Types of proprioception

1- conscious proprioception reach the level of cerebral cortex sensory area via dorsal column tract.

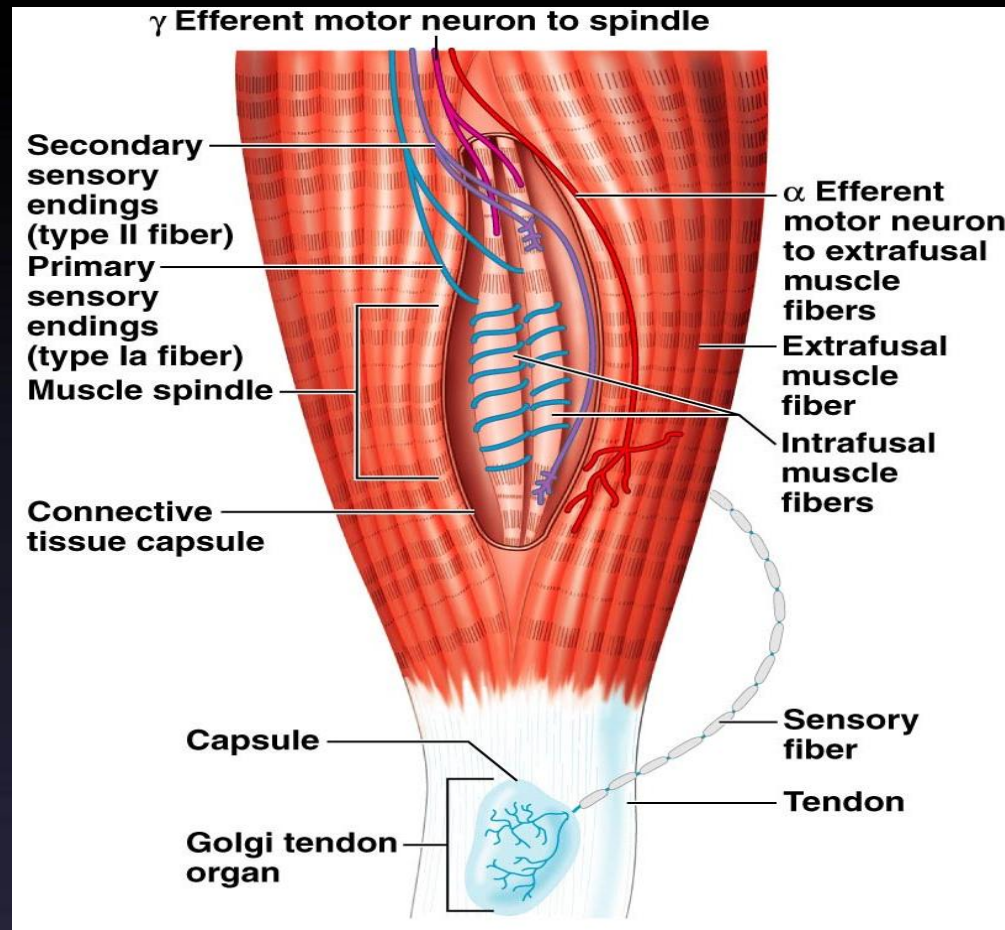
2- Unconscious proprioception reach the level of cerebellum via spinocerebellar tracts

Where is the location of these tracts?

Three Types of Proprioceptors

- **Muscle spindles** – measure the changing length of a muscle
 - Imbedded in the perimysium between muscle fascicles
- **Golgi tendon organs** – located near the muscle-tendon junction
 - Monitor tension within tendons
- **Joint kinesthetic receptors**
 - Sensory nerve endings within the joint capsules

Structure of Proprioceptors



NERVE FIBERS CLASSIFICATION

- **Type A**
 - Alpha
 - Beta
 - Gamma
 - Delta
- **Type C**

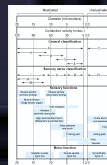
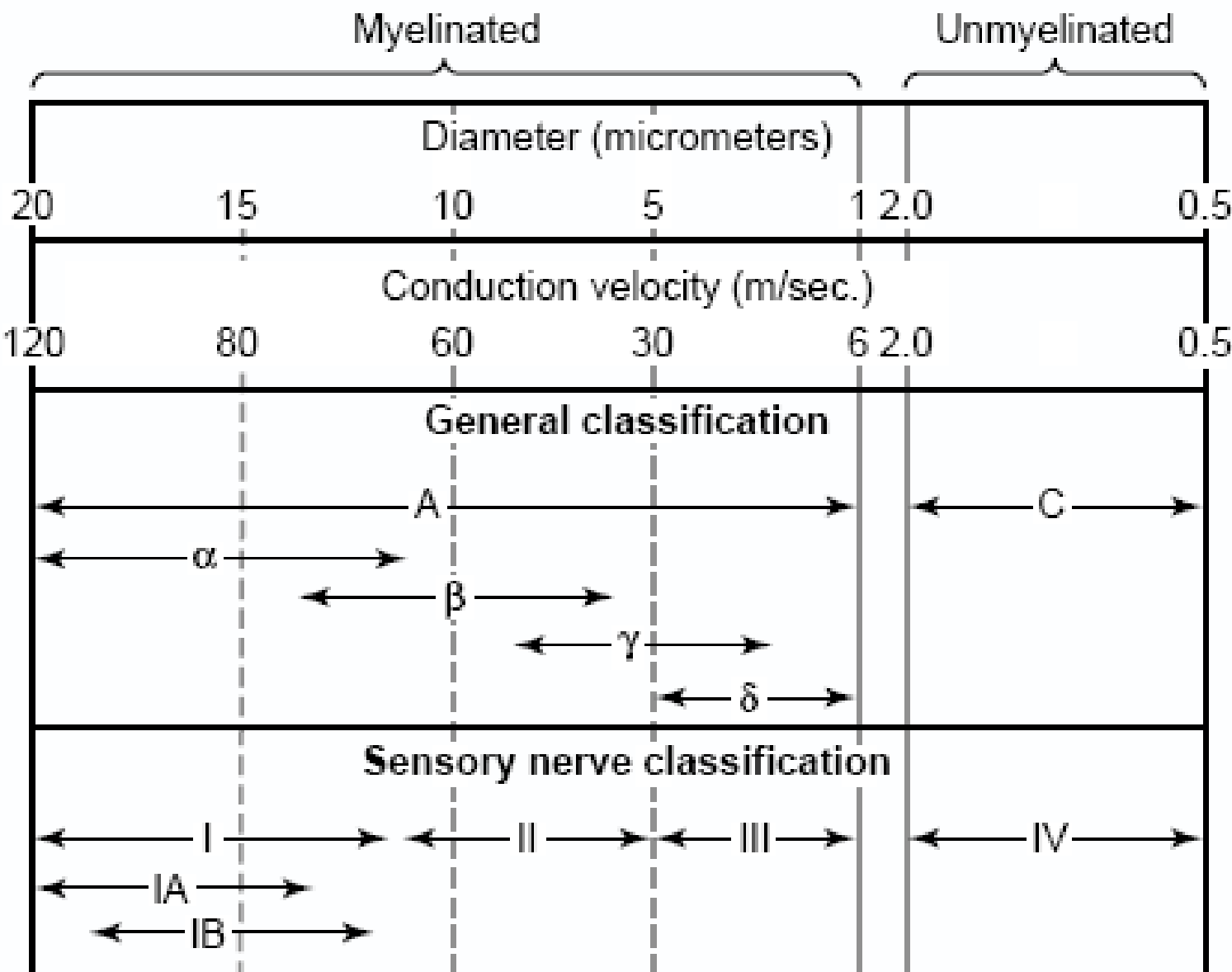


TABLE 4-1 Types of mammalian nerve fibers.

Fiber Type	Function	Fiber Diameter (μm)	Conduction Velocity (m/s)	Spike Duration (ms)	Absolute Refractory Period (ms)
A α	Proprioception; somatic motor	12–20	70–120		
A β	Touch, pressure	5–12	30–70	0.4–0.5	0.4–1
A γ	Motor to muscle spindles	3–6	15–30		
A δ	Pain, temperature	2–5	12–30		
B	Preganglionic autonomic	<3	3–15	1.2	1.2
C, Dorsal root	Pain, temperature	0.4–1.2	0.5–2	2	2
C, Sympathetic	Postganglionic sympathetic	0.3–1.3	0.7–2.3	2	2

SPINAL CORD TRACTS

Sensory information from receptors throughout most of the body is relayed to the brain by means of ascending tracts of fibers that conduct impulses up the spinal cord.

When the brain directs motor activities, these directions are in the form of nerve impulses that travel down the spinal cord in descending tracts of fibers.

Ascending Tracts (Sensory)

Descending Tracts (Motor)

SENSORY TRACTS

- **DORSAL COLUMN SYSTEM**
- **ANTEROLATERAL SYSTEM**

Each system carries different types of sensations which are known as MODALITIES like pain, temperature, fine touch, crude touch, vibration, proprioception etc

1. Dorsal column pathway- carries signal of fine touch, pressure, vibration , stereognosis and proprioception,
2. Spinothalamic pathway- carries signals of pain, temperature, deep pressure, and coarse touch.
- 3,4- Posterior and anterior spinocerebellar pathways- carry subconscious proprioception. Dorsal gray horn- to lateral column- to medulla oblongata- to pons – to cerebellum.

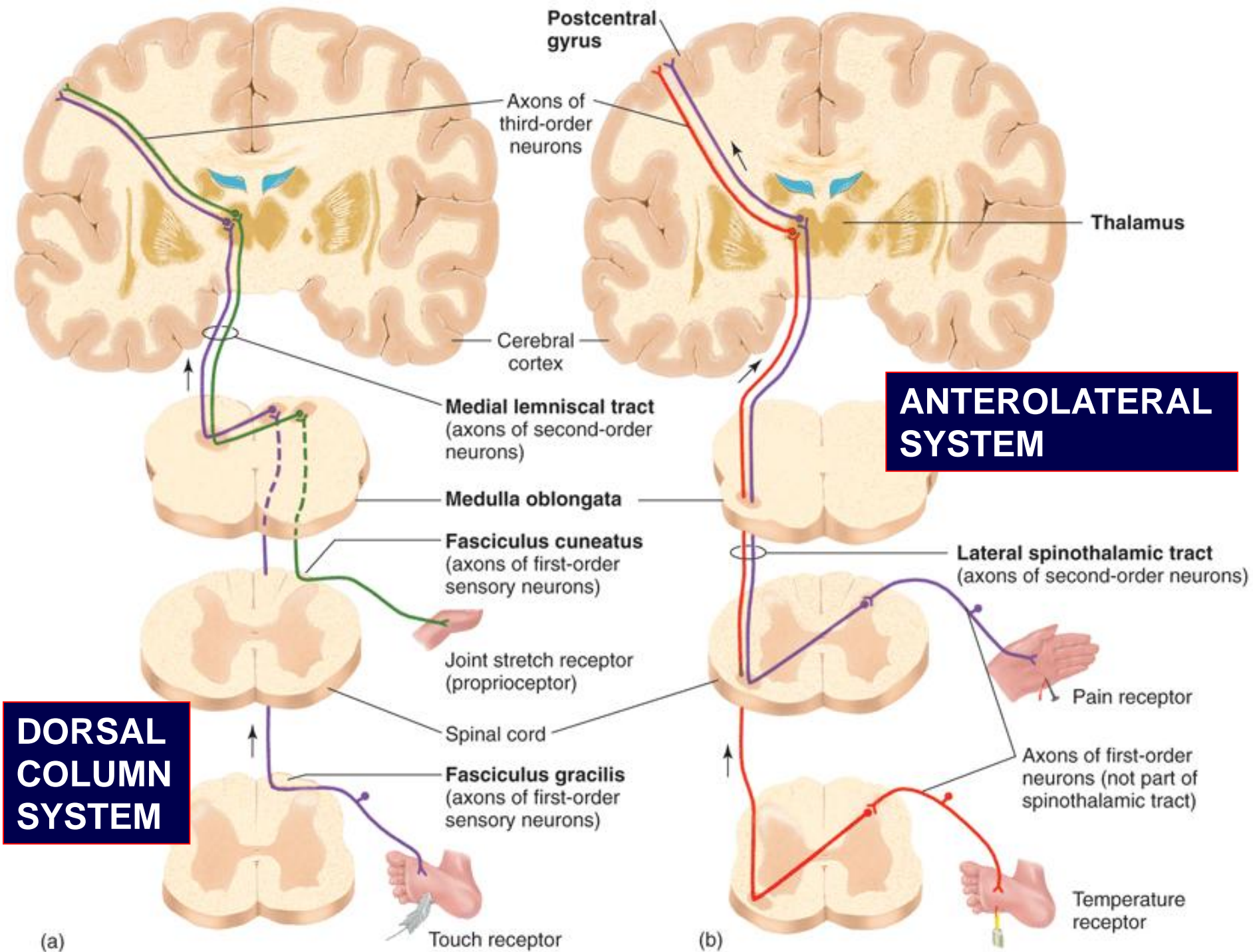
DORSAL COLUMN MEDIAL LEMNISCAL SYSTEM

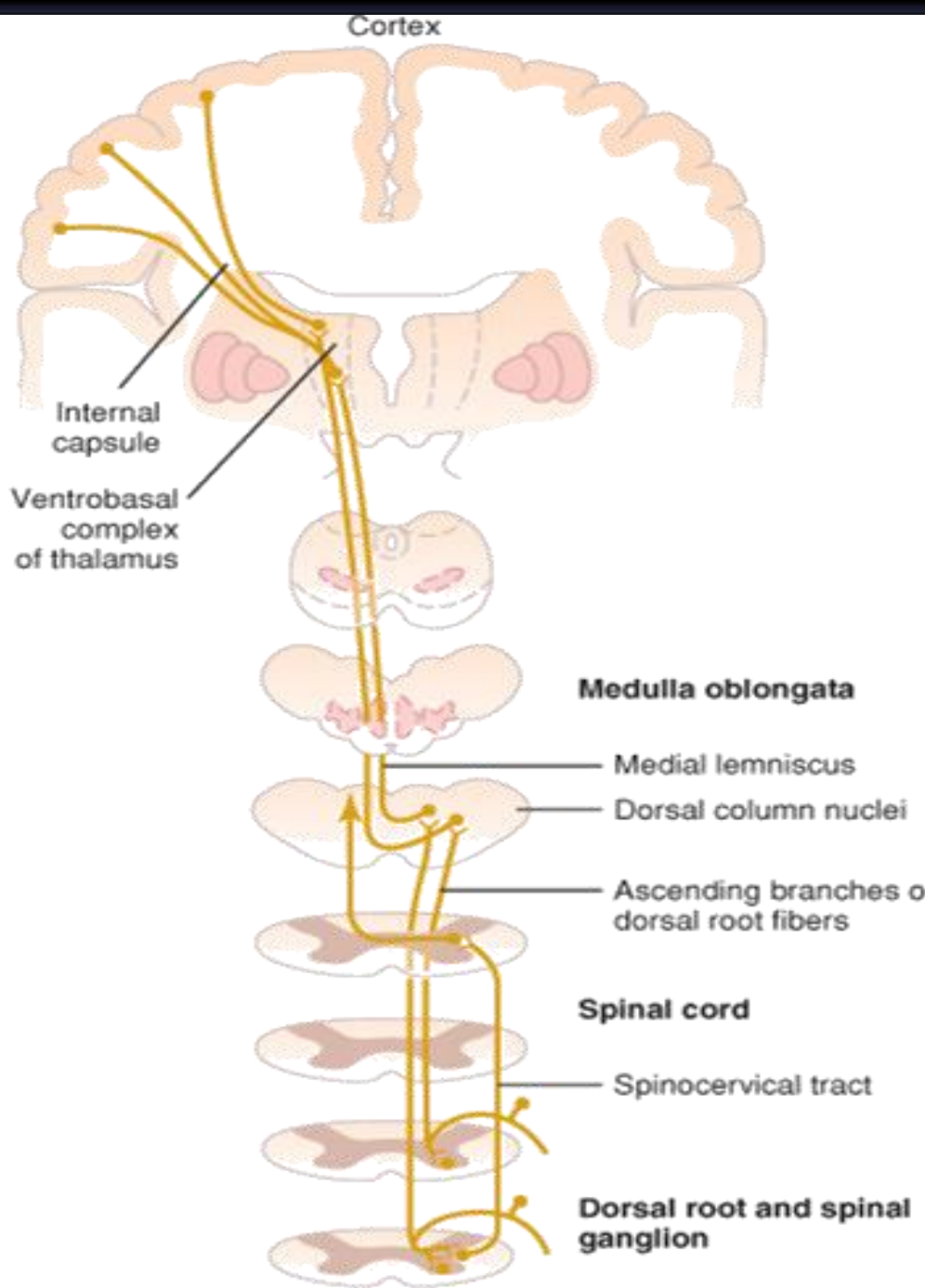
1. Touch sensations requiring a high degree of localization of the stimulus
2. Touch sensations requiring transmission of fine gradations of intensity
3. Phasic sensations like vibratory sensations
4. Sensations that signal movement against skin
5. **Joints Position sensations (Proprioception)**
6. Pressure sensations requiring fine degrees of judgment of intensity
7. Stereognosis

ANTEROLATERAL SYSTEM

Ventral & lateral spinothalamic tracts

- 1. Pain**
- 2. Thermal sensations, (warmth & cold)**
- 3. Crude touch and pressure sensations
capable only of crude localizing ability
on the surface of the body**
- 4. Tickle and itch sensations**
- 5. Sexual sensations**

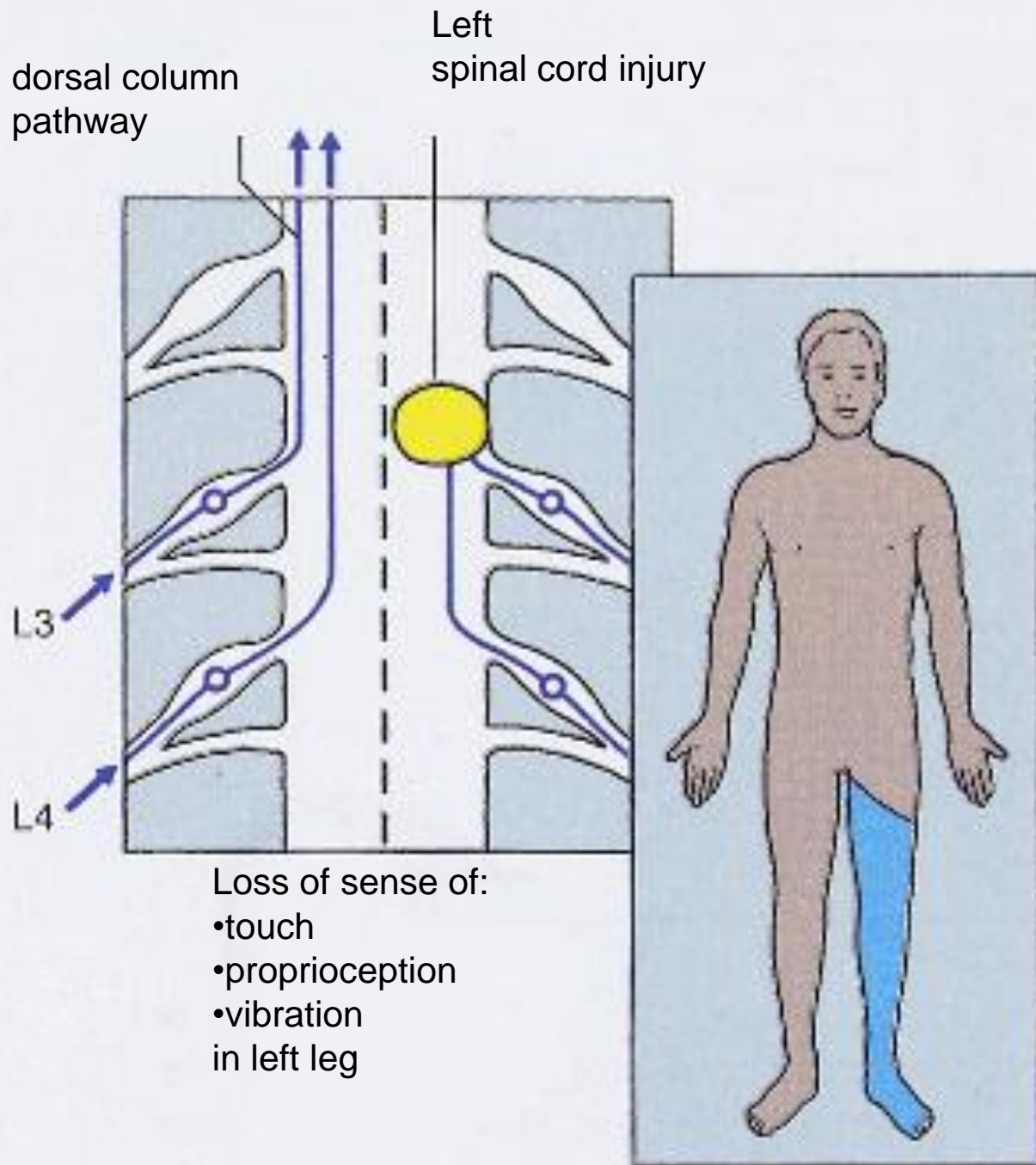




PROPRIOCEPTION FROM HEAD

In this pathway through the brain stem, each medial lemniscus is joined by additional fibers from the sensory nuclei of the trigeminal nerve; these fibers subserve the same sensory functions for the head that the dorsal column fibers subserve for the body.

Dorsal column damage



Dorsal column damage

- **Sensory ataxia**
- **Patient staggers; cannot perceive position or movement of legs**
- **Visual clues help movement**

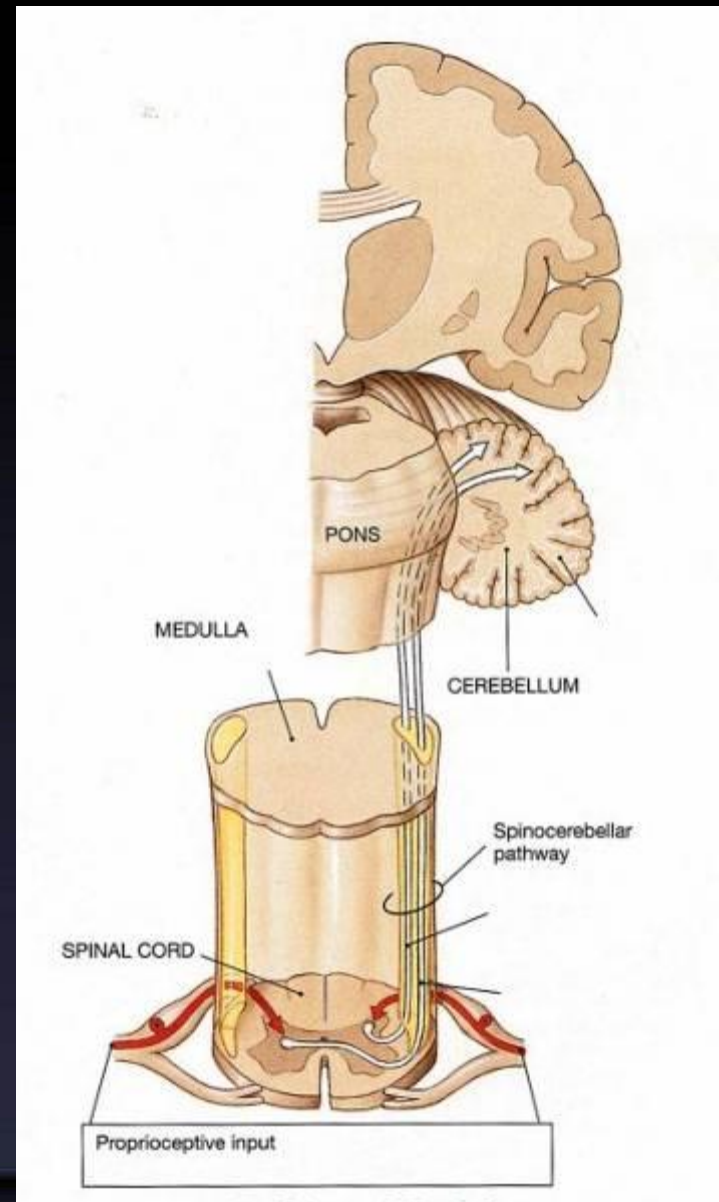
Positive Romberg test

The test depends on the integrity of proprioception from the joints of the legs.



Spinocerebellar pathway

- Carries subconscious proprioception signals
- Receptors in muscles & joints
- 1st neuron: enters spinal cord through dorsal root
- 2nd neuron: ascends to cerebellum
- No 3rd neuron to cortex



Spinocerebellar tract damage

- **Cerebellar ataxia**
 - Clumsy movements
 - Incoordination of the limbs (intention tremor)
 - Wide-based, reeling gait (ataxia)
 - Alcoholic intoxication produces similar effects!

Ataxia and Gait Disturbances

- **Pathophysiology**
 - Result from any condition that affects the central and peripheral nervous systems
 - **Ataxia: Types**
 - Motor ataxia
 - Sensory ataxia

Ataxia and Gait Disturbances

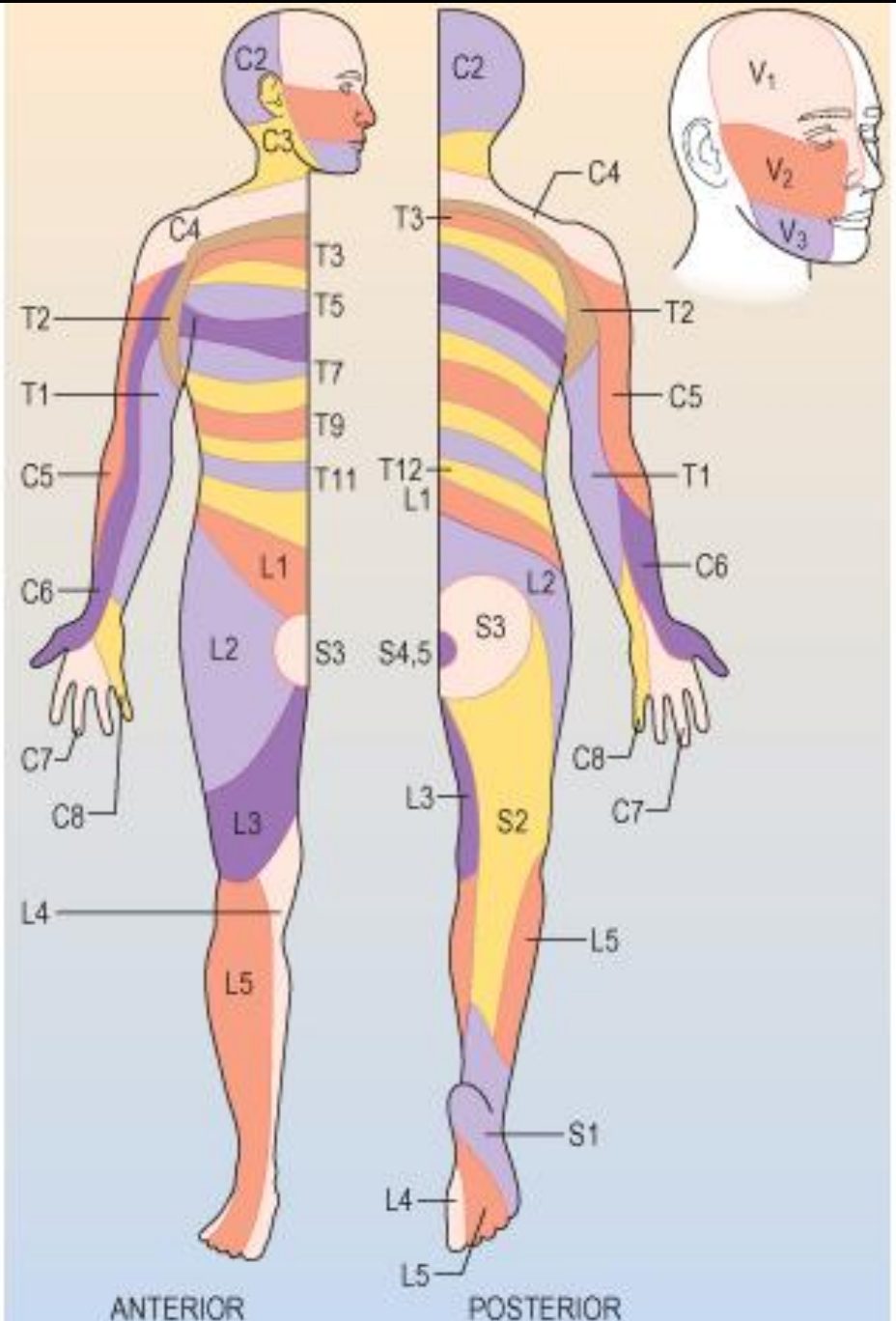
- **Motor Ataxia**

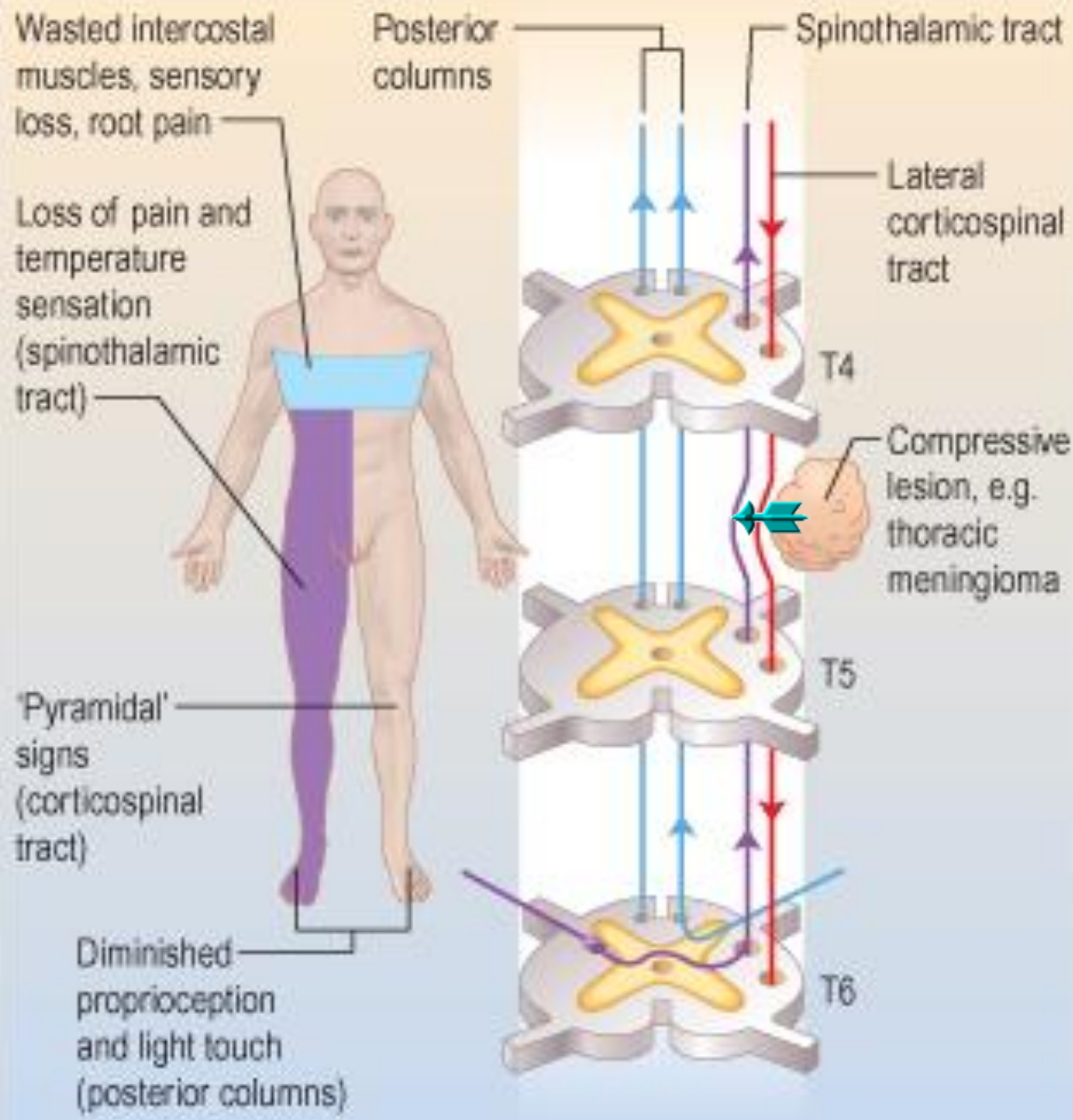
- **Caused by cerebellar disorders**

- **Intact sensory receptors and afferent pathways**
 - **Integration of proprioception is faulty**
 - **Midline cerebellar lesions cause truncal ataxia**
 - **Lateral cerebellar lesions cause limb ataxia**
 - **Thalamic infarcts may cause contralateral ataxia with sensory loss**

Dermatomes

Dermatome
is area on
skin supplied
by a single
spinal nerve





Brown Sequard syndrome

HEMISECTION OF SPINAL CORD

Ipsilateral Loss:

- Fine touch, Vibration, Proprioception (Dorsal Column)
- Leg Ataxia (Dorsal Spinocerebellar)
- Spastic Paresis below lesion (Lat Corticospinal)
- Flaccid Paralysis (Vent horn destruction)
- Dermatomal Anesthesia (Dorsal Horn destruction)

Contralateral Loss:

- Loss of pain and temp (lat Spinothalamic)
- Loss of crude touch and Pressure (Vent Spinothalamic)
- Minor Contralat Muscle Weakness (Vent Corticospinal)
- Leg Ataxia (Vent Spinocerebellar)

SENSORY ATAXIA

- **Peripheral sensory lesions (e.g. polyneuropathy) cause ataxia because there is loss of the sense of joint position - proprioception. Broad-based, high-stepping, stamping gait develops.**
- **This ataxia is made worse by removal of additional sensory input (e.g. vision) and is worse in the dark. First described in sensory ataxia of tabes dorsalis, this is the basis of**
- **Romberg's test. Ask the patient to close the eyes while standing: observe whether the patient becomes unstable (and prevent falling).**

THANKS

