Nervous system

CNS

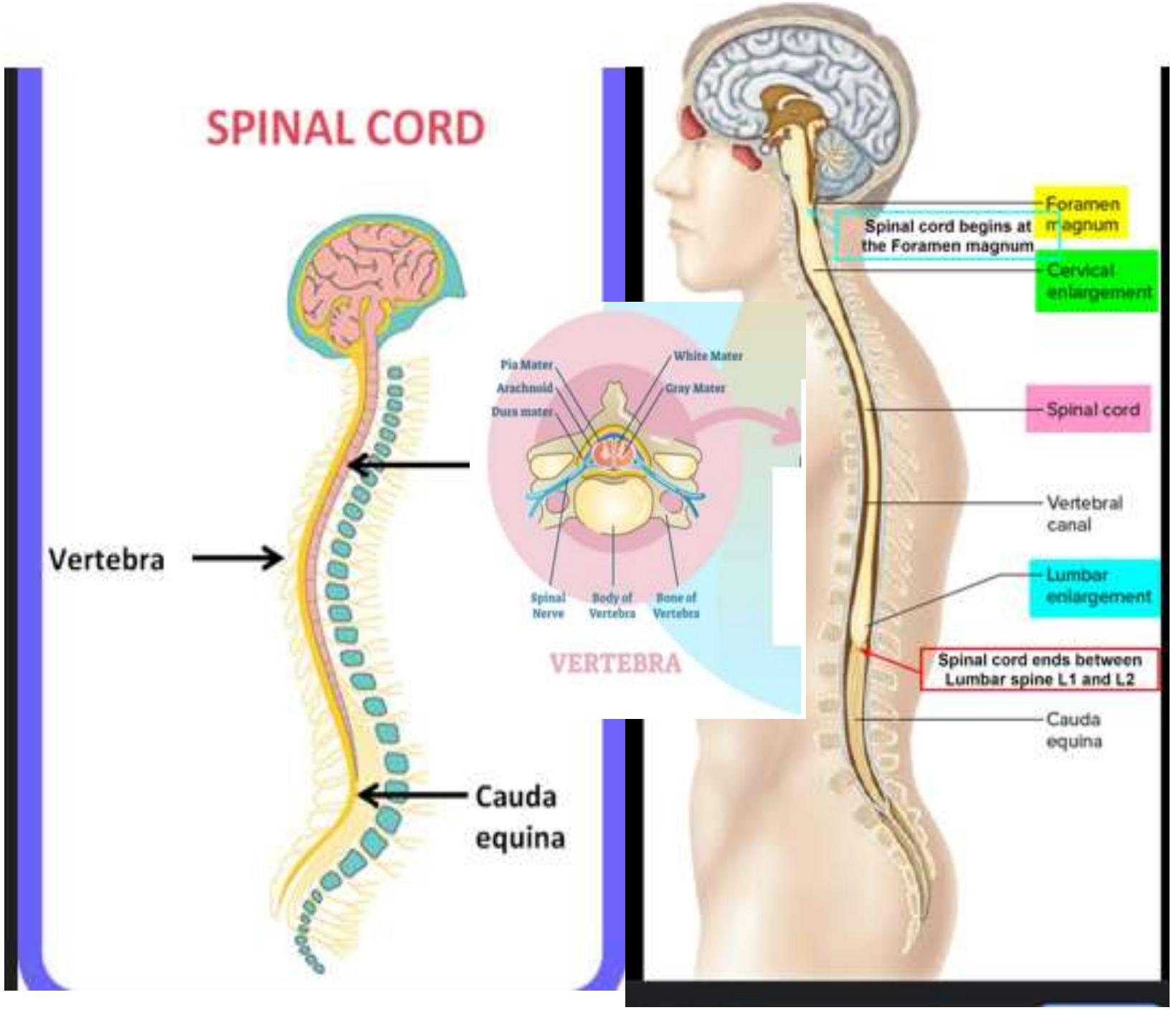
Lec. 10& 11

د. هدى جبار البديري

Prof - M. B. Ch. B - M. S. C .Medical Physiology

SPINAL CORD

- **O B J E C T I V E S**
- • Describe the functions of the major sensory and motor
- tracts of the spinal cord.
- • Describe the functional components of a reflex , spinal reflexes
- Sensory & motor system


SPINAL CORD
Vertebra
Cauda equina
Pia Mater
Arachnoid
Dura mater
White Mater
Gray Mater
Spinal Nerve
Body of Vertebra
Bone of Vertebra
VERTEBRA
Foramen magnum
Spinal cord begins at the Foramen magnum
Cervical enlargement
Spinal cord
Vertebral canal
Lumbar enlargement
Spinal cord ends between Lumbar spine L1 and L2
Cauda equina

Internal Anatomy of the Spinal Cord

A transverse section of the spinal cord reveals regions of white matter that surround an inner core of gray matter

The white matter of the spinal cord consists primarily of bundles of myelinated axons of neurons. Two grooves penetrate the white matter of the spinal cord and divide it into right and left sides:

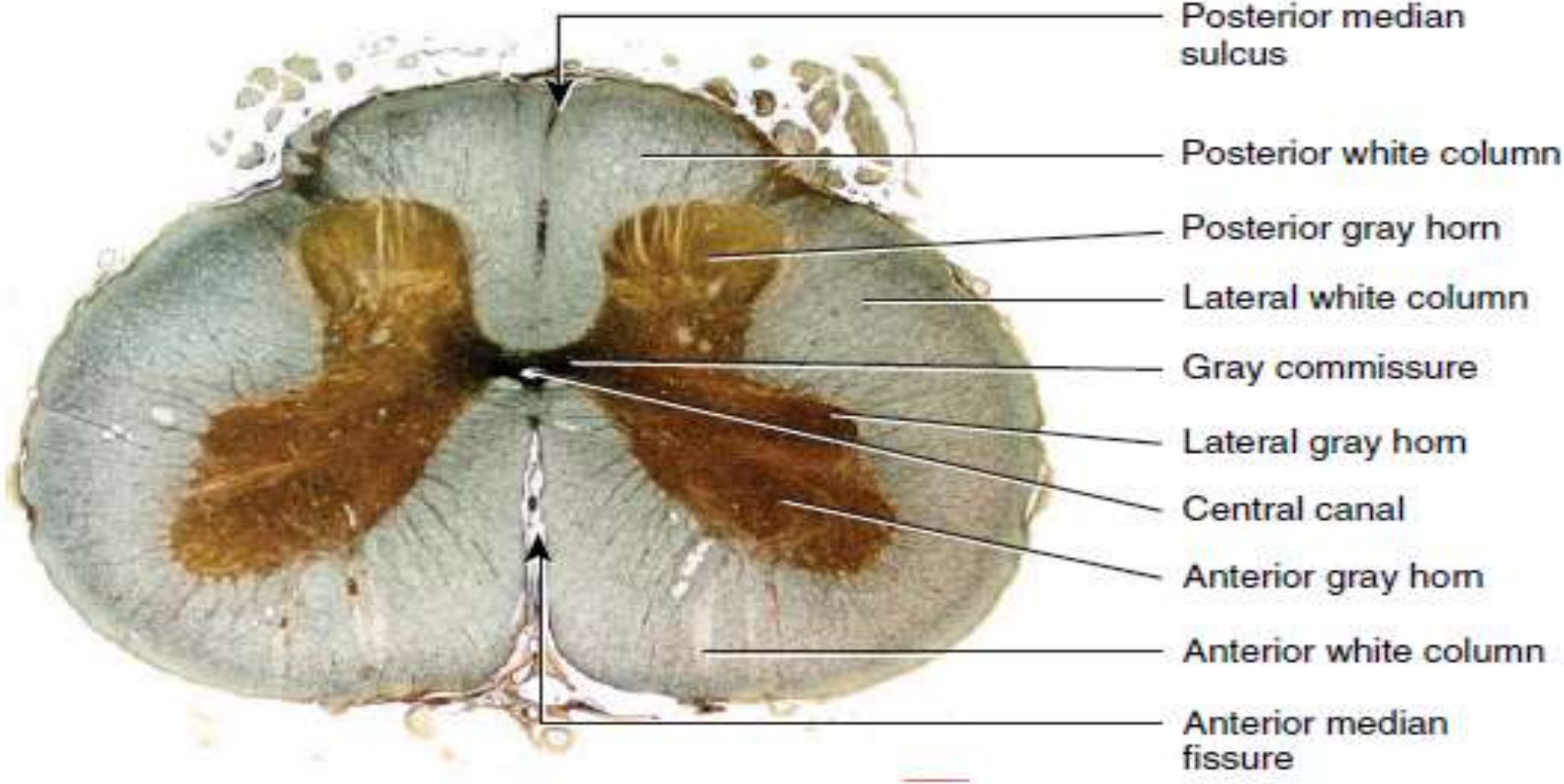
1-The anterior median fissure is a wide groove on the anterior (ventral) side.

2-The posterior median sulcus is a narrow furrow on the posterior (dorsal) side.

The gray matter of the spinal cord is shaped like the letter H or a butterfly; it consists of dendrites and cell bodies of neurons, unmyelinated axons, and neuroglia.

In the center of the gray commissure is a small space called the **central canal;** it extends the entire length of the spinal cord and is filled with cerebrospinal fluid. At its superior end, the central canal is continuous with the fourth ventricle in the medulla oblongata

Anterior to the gray commissure is the anterior (ventral) white commissure, which connects the white matter of the right and left sides of the spinal cord.



(b) Transverse section of lumbar spinal cord

The gray matter on each side of the spinal cord is subdivided into regions called horns

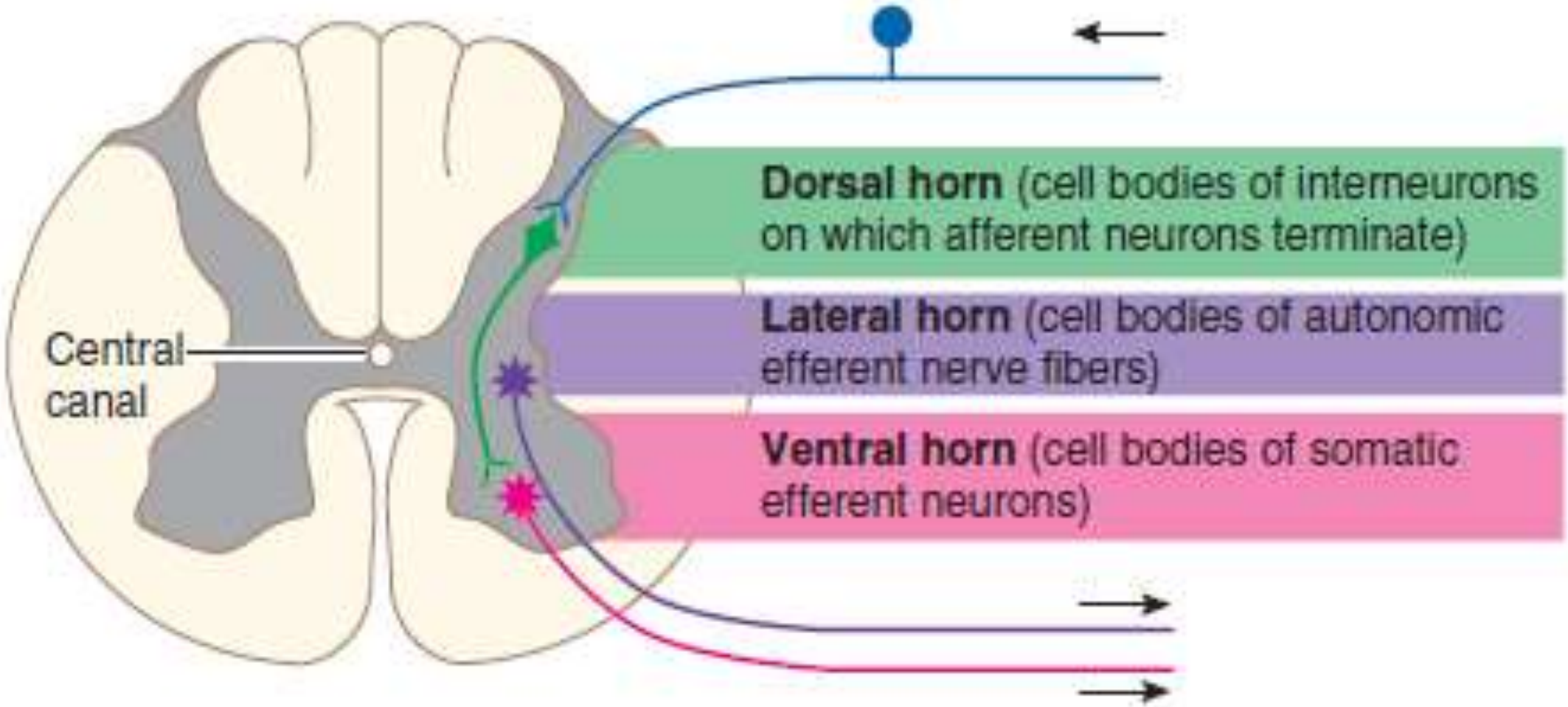
The posterior (dorsal) gray horns contain cell bodies of interneurons

On which incoming sensory neurons terminates . Recall that cell bodies of sensory neurons are located in the posterior (dorsal) root ganglion of a spinal nerve.

The anterior (ventral) gray horns contain somatic motor nuclei, which are clusters of cell bodies of somatic motor neurons that provide nerve impulses

for contraction of skeletal muscles.

The **lateral gray horns** are present only **in thoracic and upper lumbar segments** of the spinal cord. The lateral gray horns contain **autonomic motor nuclei**, which are clusters of cell bodies of autonomic motor neurons that regulate the activity of **cardiac muscle, smooth muscle, and glands**



Regions of the gray matter.

The white matter of the spinal cord, like the gray matter, is organized into regions. The anterior and posterior gray horns divide the white matter on each side into three broad areas called columns: (1) anterior (ventral) white columns, (2) posterior (dorsal) white columns, and (3) lateral white columns

Each column in turn contains distinct bundles of axons. These bundles, which may extend long distances up or down the spinal cord, are called **tracts.** Recall that tracts are bundles of axons in the CNS, Where as nerves are bundles of axons in the PNS. Sensory (ascending) tracts consist of axons that conduct nerve impulses toward the brain. Tracts consisting of axons that carry nerve impulses from the brain are called motor (descending) tracts.

Sensory and motor tracts of the spinal cord are continuous with sensory and motor tracts in the brain.

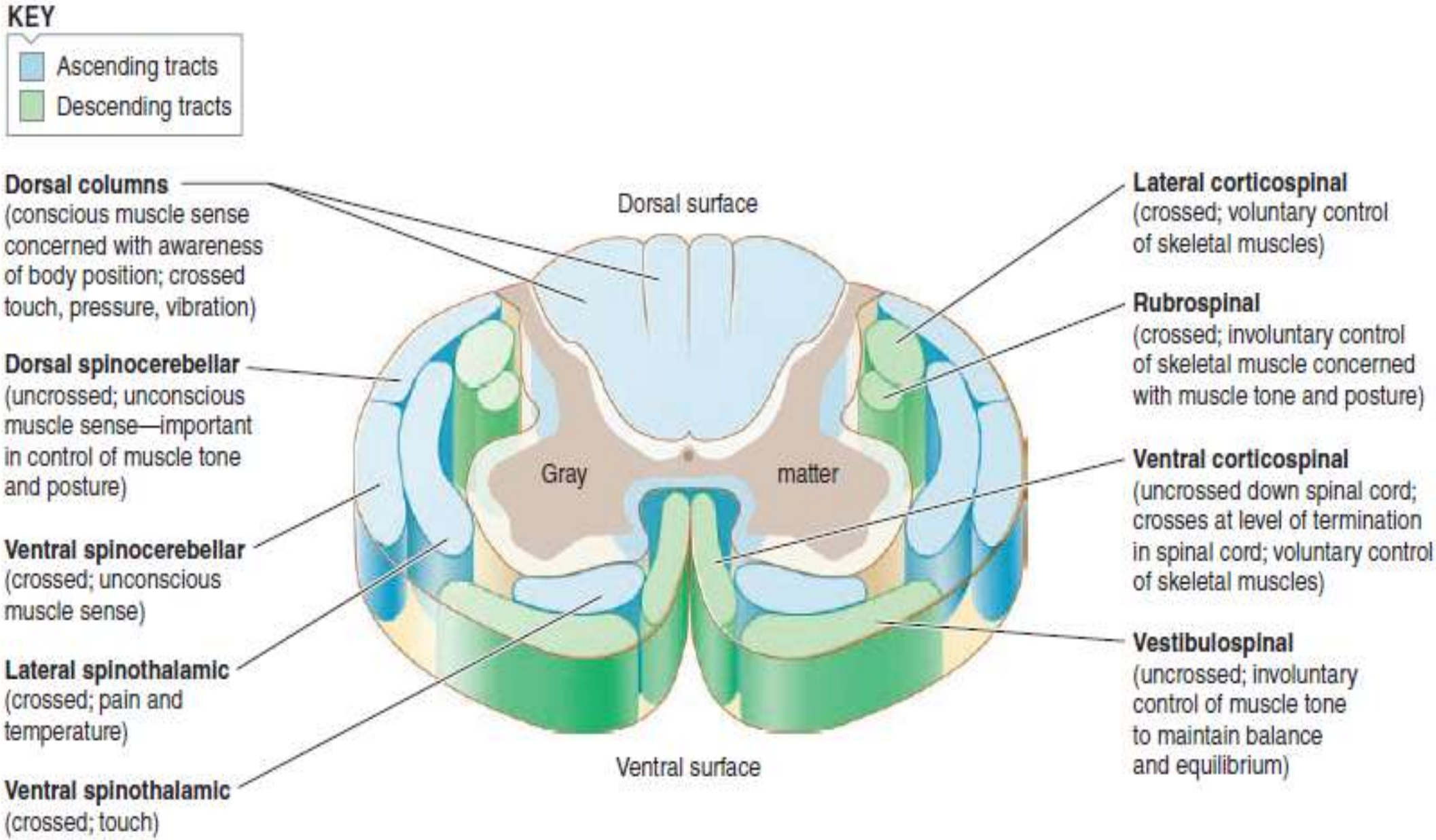
The white matter is organized into **tracts**, which are bundles of nerve fibers (axons of long interneurons) with a similar function. The bundles are grouped into **columns** that extend the length of the cord. Each of these tracts begins or ends within a particular area of the brain, and each transmits a specific type of information. Some are ascending (cord to brain) tracts that transmit to the brain signals derived from afferent input. Others are descending (brain to cord) tracts that relay messages from the brain to efferent neurons

The tracts are generally named for their origin and termination.

For example, the ventral spinocerebellar tract is an ascending pathway that originates in the spinal cord and runs

e.g. ventral spinocerebellar tract from muscle stretch receptors ---S.C(ventral part) ---spinocerebellum

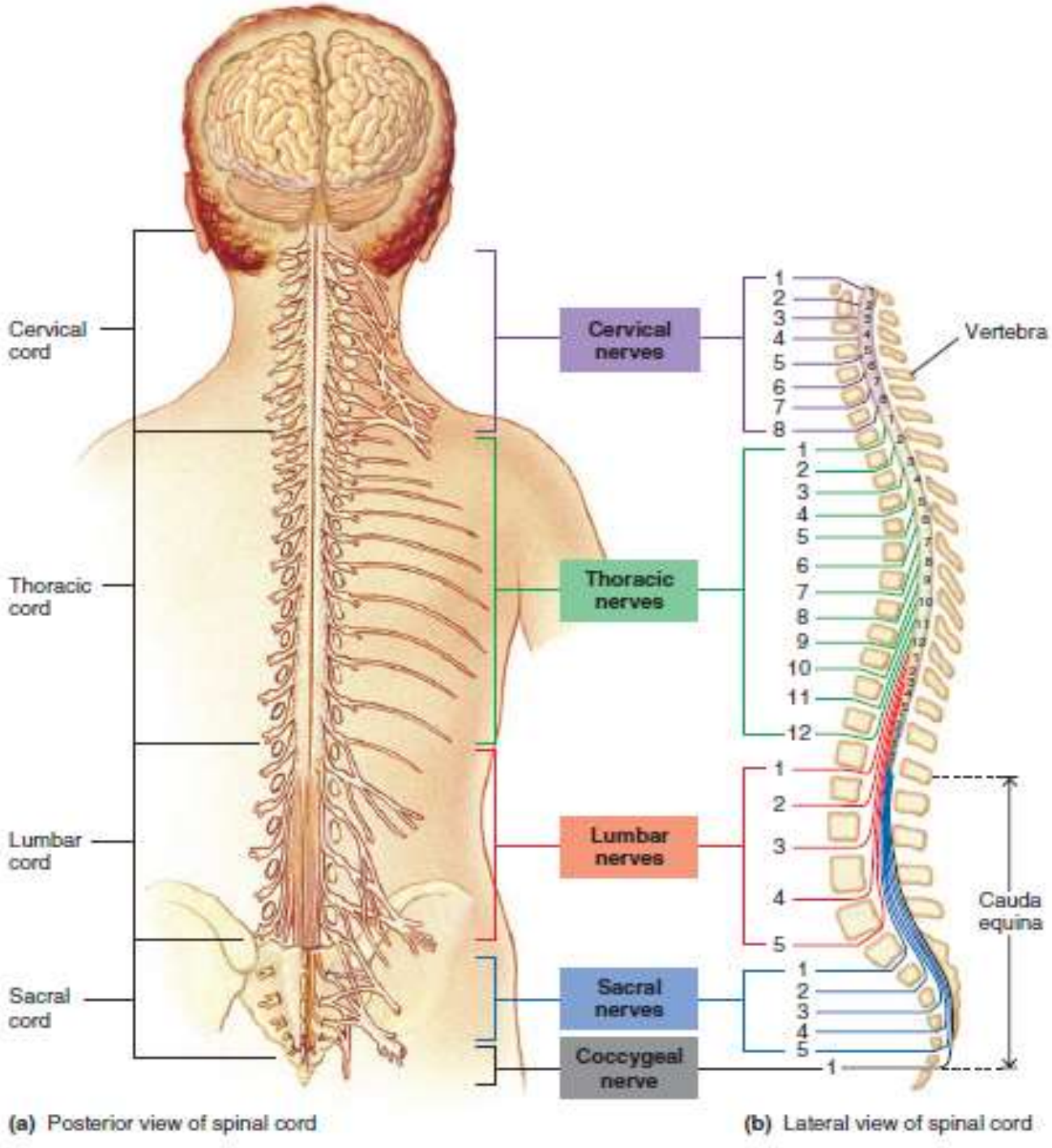
Ventral Corticospinal tract from motor region of the cerebral cortex ----S.C(vental) -----skeletal muscle

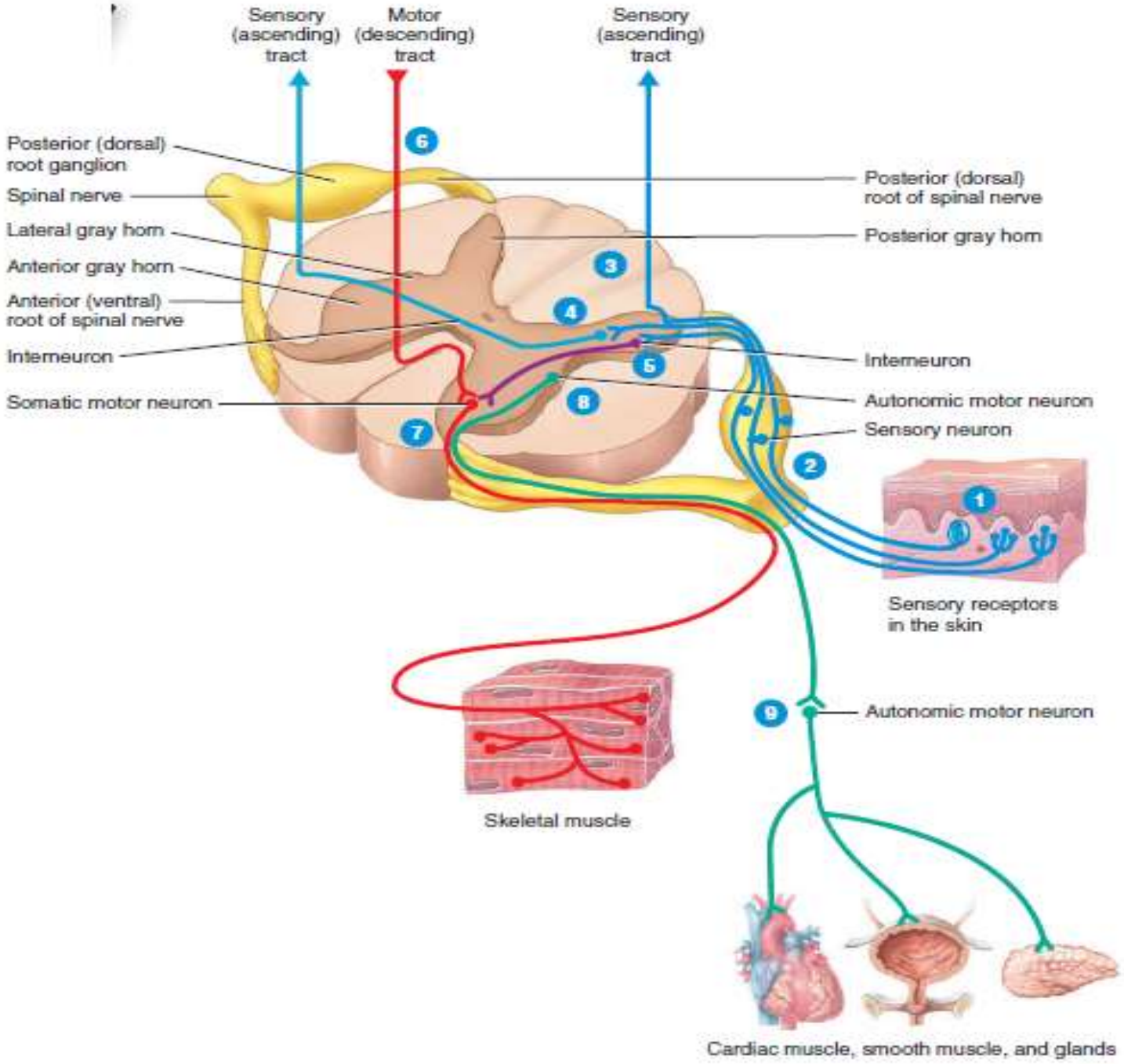

KEY
Ascending tracts
Descending tracts
Dorsal columns
(conscious muscle sense concerned with awareness of body position; crossed touch, pressure, vibration)
Dorsal spinocerebellar
(uncrossed; unconscious muscle sense—important in control of muscle tone and posture)
Ventral spinocerebellar
(crossed; unconscious muscle sense)
Lateral spinothalamic
(crossed; pain and temperature)
Ventral spinothalamic
(crossed; touch)
Dorsal surface
Gray
matter
Ventral surface
Lateral corticospinal
(crossed; voluntary control of skeletal muscles)
Rubrospinal
(crossed; involuntary control of skeletal muscle concerned with muscle tone and posture)
Ventral corticospinal
(uncrossed down spinal cord; crosses at level of termination in spinal cord; voluntary control of skeletal muscles)
Vestibulospinal
(uncrossed; involuntary control of muscle tone to maintain balance and equilibrium)

Spinal nerves carry both afferent and efferent fibers.

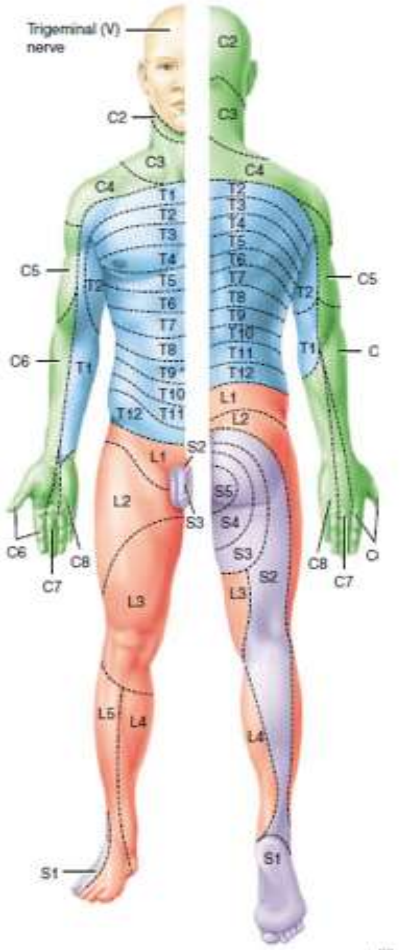
Spinal nerves connect with each side of the spinal cord by a dorsal root and a ventral root

Afferent Fibers carrying incoming signals from peripheral receptors enter the spinal cord through the dorsal root. The cell bodies for the afferent neurons at each level are clustered together in a dorsal root ganglion. (A collection of neuronal cell bodies located outside the CNS is called a ganglion, whereas a functional collection of cell bodies within the CNS is referred to as a nucleus or a center.) The cell bodies for the efferent neurons originate in the gray matter, and the efferent fibers carrying outgoing signals to muscles and glands exit through the ventral root. The dorsal and ventral roots at each level join to form a spinal nerve that emerges from the vertebral column.

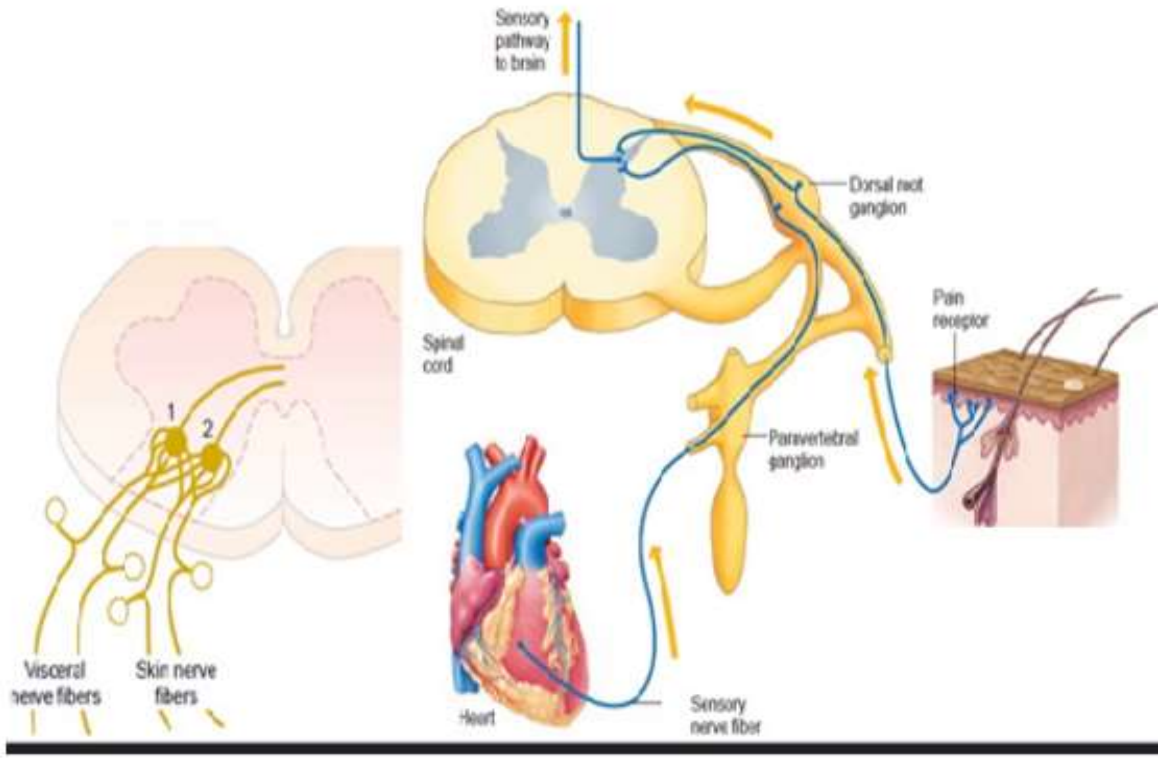

Cervical cord
Thoracic cord
Lumbar cord
Sacral cord
Cervical nerves
Thoracic nerves
Lumbar nerves
Sacral nerves
Coccygeal nerve
Vertebra
Cauda equina
(a) Posterior view of spinal cord
(b) Lateral view of spinal cord


Sensory (ascending) tract
Motor (descending) tract
Sensory (ascending) tract
Posterior (dorsal) root ganglion
Spinal nerve
Lateral gray horn
Anterior gray horn
Anterior (ventral) root of spinal nerve
Interneuron
Somatic motor neuron
Posterior (dorsal) root of spinal nerve
Posterior gray horn
Interneuron
Autonomic motor neuron
Sensory neuron
Sensory receptors in the skin
Skeletal muscle
Autonomic motor neuron
Cardiac muscle, smooth muscle, and glands
1
2
3
4
5
6
7
8
9

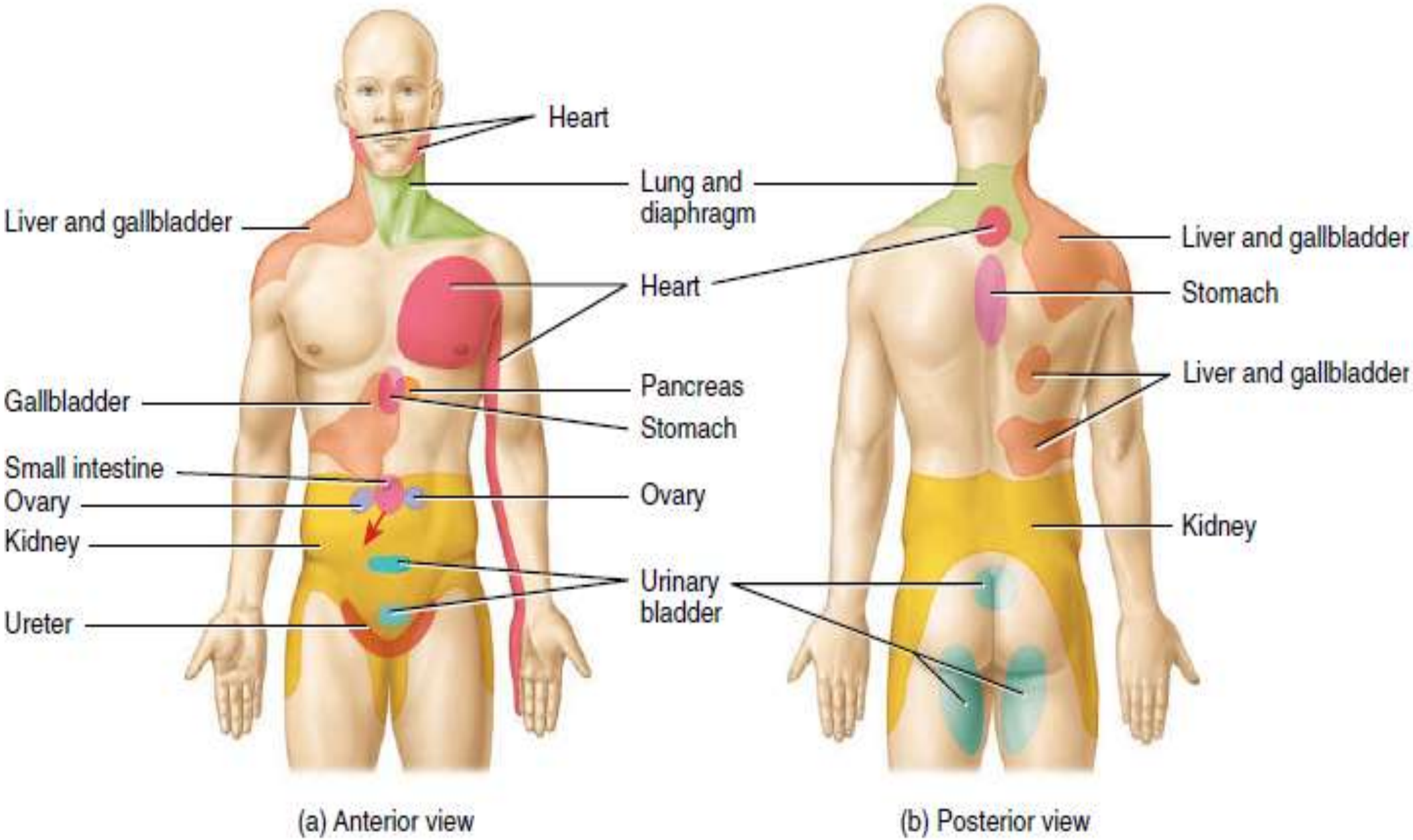
Dermatome



referred pain ?



Spinal nerves also carry fibers that branch off to supply internal organs, and sometimes pain originating from one of these organs is "referred" to the corresponding dermatome (surface region) supplied by the same spinal nerve. **Referred pain** For example, sensory fibers from the heart, the skin superficial to the heart, and the skin along the medial aspect of the left arm enter spinal cord segments T1 to T5. Thus, the pain of a heart attack typically is felt in the skin over the heart and along the left arm.


Heart
Lung and diaphragm
Liver and gallbladder
Heart
Pancreas
Gallbladder
Stomach
Small intestine
Ovary
Ovary
Kidney
Urinary bladder
Ureter
Liver and gallbladder
Stomach
Liver and gallbladder
Kidney
(a) Anterior view
(b) Posterior view

Each spinal nerve carries afferent sensory fibers from a particular region on the body surface called **dermatome**. The body surface can be mapped with multiple dermatomes, each one associated with a different spinal nerve

Shingles an infection of a sensory nerve fiber and the area of skin supplied by this fiber, is caused by varicella zoster virus, the same virus that causes **chicken pox**.

After a bout of chicken pox, some of the virus may survive and travel in sensory axons to dorsal root ganglia.

Functions of spinal cord

(1) serving as a link for **transmission of information** between the brain and rest of the body and

(2) integrating reflex activity between afferent input and efferent output **without** involving the brain.

REFLEXES (is for our survival)

A reflex is **any response** that occurs automatically **without** conscious effort

Classification of reflexes

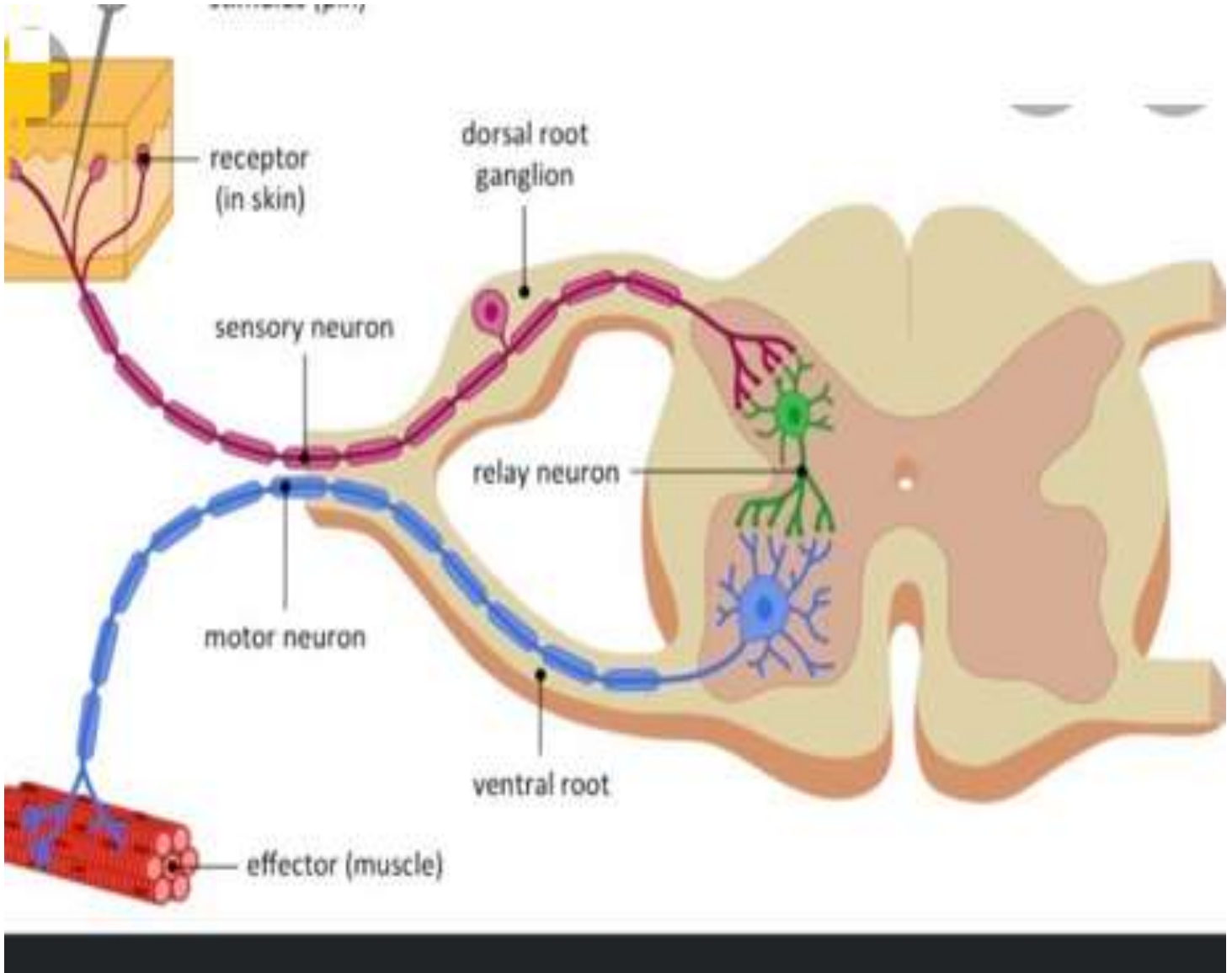
<table>
<tr><th>Development</th><th colspan="4">Response</th><th>Processing site</th><th>Complexity</th></tr>
<tr><td rowspan="2">Innate
Sucking reflex
Grasp reflex</td><td colspan="4">Somatic</td><td rowspan="2">Cranial reflex

-Pupillary light reflex
-Eye blinking reflex</td><td>Monosynaptic
Stretch reflex</td></tr>
<tr><td colspan="2">Superficial (superficial abdominal reflex</td><td colspan="2">deep (deep tendon reflex)</td><td rowspan="2">Polysynaptic
Deep tendon reflex</td></tr>
<tr><td rowspan="2">Acquired
Slamming brake in emergency</td><td colspan="4">Autonomic
Control action of</td><td rowspan="2">Spinal reflexes</td></tr>
<tr><td>Cardiac M.</td><td>Smooth m.</td><td colspan="2">Glands</td></tr>
</table>

reflex arc is the pathway of reflex travels , typically includes five basic components:

1. **Sensory receptor**
2. **Afferent pathway**
3. **Integrating center** processes all information available and then “makes a decision”
4. **Efferent pathway**
5. **Effector organ**

.



Somatic Spinal Reflexes

include the stretch reflex, the Golgi tendon reflex, the crossed extensor reflex, and the withdrawal reflex

Stretch reflex

- This type of reflex occurs via ***a monosynaptic* reflex** arc.
- can be elicited by tapping on tendons attached to muscles at the elbow, wrist , knee or ankle joints
- An example of a stretch reflex is the patellar reflex (knee jerk)
- Slight **stretching** of a muscle stimulates **sensory receptors** in the muscle called **muscle spindles**
- impulse propagate through somatic sensory neuron through the posterior root of the spinal nerve and into the spinal cord. In the spinal cord (integrating center), the sensory neuron makes an excitatory synapse with, and thereby activates, a motor neuron in the anterior gray horn along its axon,which extends from the spinal cord into the anterior root and through peripheral nerves to the stimulated muscle.
- In the reflex arc just described, sensory nerve impulses enter
- the spinal cord on the same side from which motor nerve impulses leave it. This arrangement is called an **ipsilateral reflex**

All monosynaptic reflex are ipsilateral

. An axon collateral (branch) from the muscle spindle sensory neuron also synapses with an inhibitory interneuron in the integrating center. In turn,

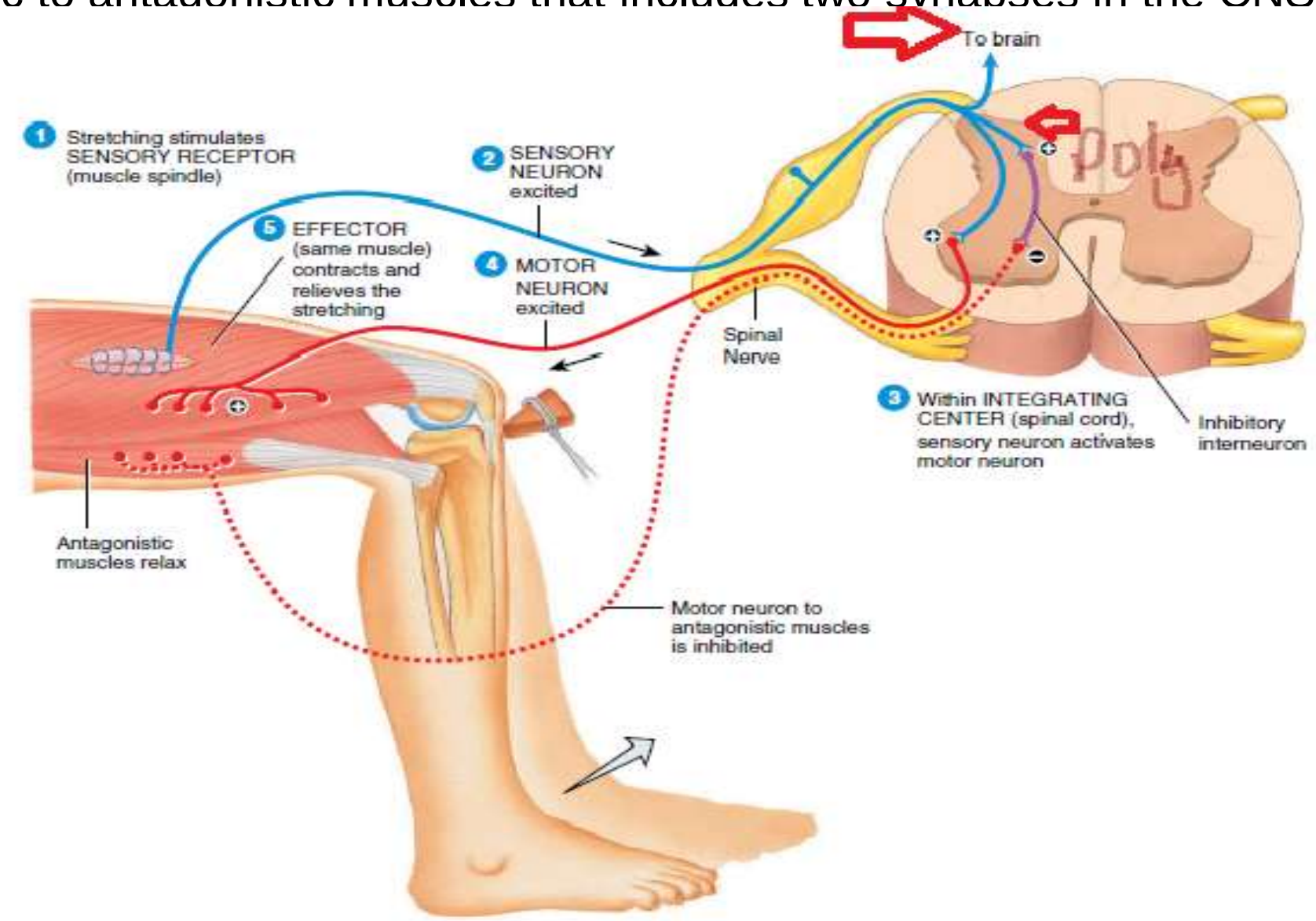
the interneuron synapses with and inhibits a motor neuron that normally excites the antagonistic muscles .Thus when the stretched muscle contracts during a stretch reflex, antagonistic muscles that oppose the contraction relax. This type of arrangement, in which the components of a neural circuit simultaneously cause contraction of one muscle and relaxation of its

antagonists, is termed **reciprocal innervation**

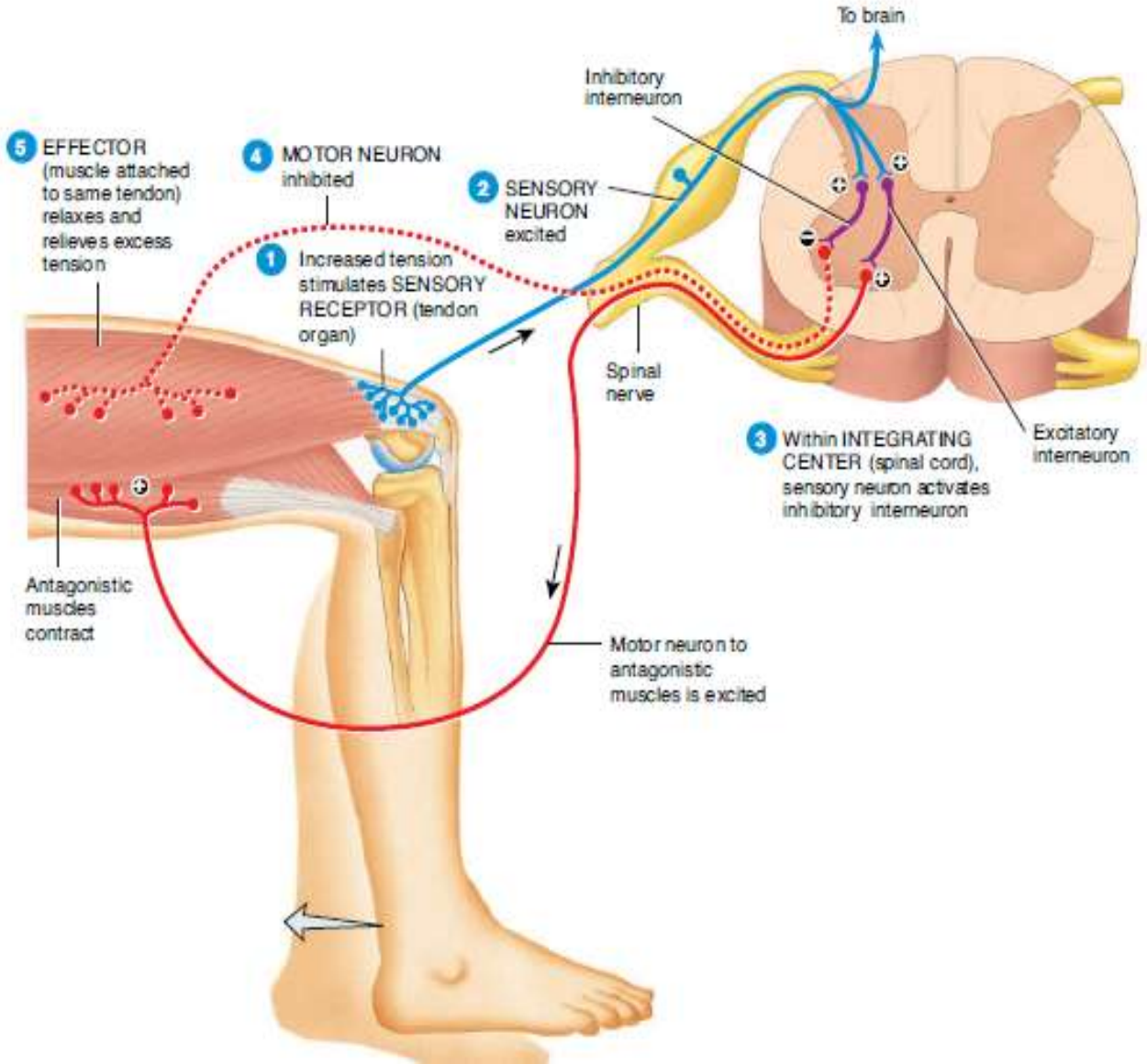
Axon collaterals of the muscle spindle sensory neuron also relay nerve impulses to the brain over specific ascending pathways.
In this way, the brain receives input about the state of stretch or contraction of skeletal muscles, enabling it to coordinate muscular movements. The nerve impulses that pass to the brain also allow conscious awareness that the reflex has occurred.

Stretch reflex Slight stretching of a muscle stimulates sensory receptors in the muscle called **muscle spindles , Stretch reflex.** This **monosynaptic** reflex arc has only one synapse in the CNS—between a single sensory neuron and asingle motor neuron.

A **polysynaptic** reflex arc to antagonistic muscles that includes two synapses in the CNS and one interneuron is al



Tendon reflex. The sensory receptors for this reflex are called **tendon** (*Golgi tendon*) **organs** ,This reflex arc is **polysynaptic (** more than one CNS synapse and more than two different neurons are involved in the pathway. The sensory neuron synapses with two interneurons. An inhibitory interneuron causes relaxation of the effector, and a stimulatory interneuron causes contraction of the antagonisti

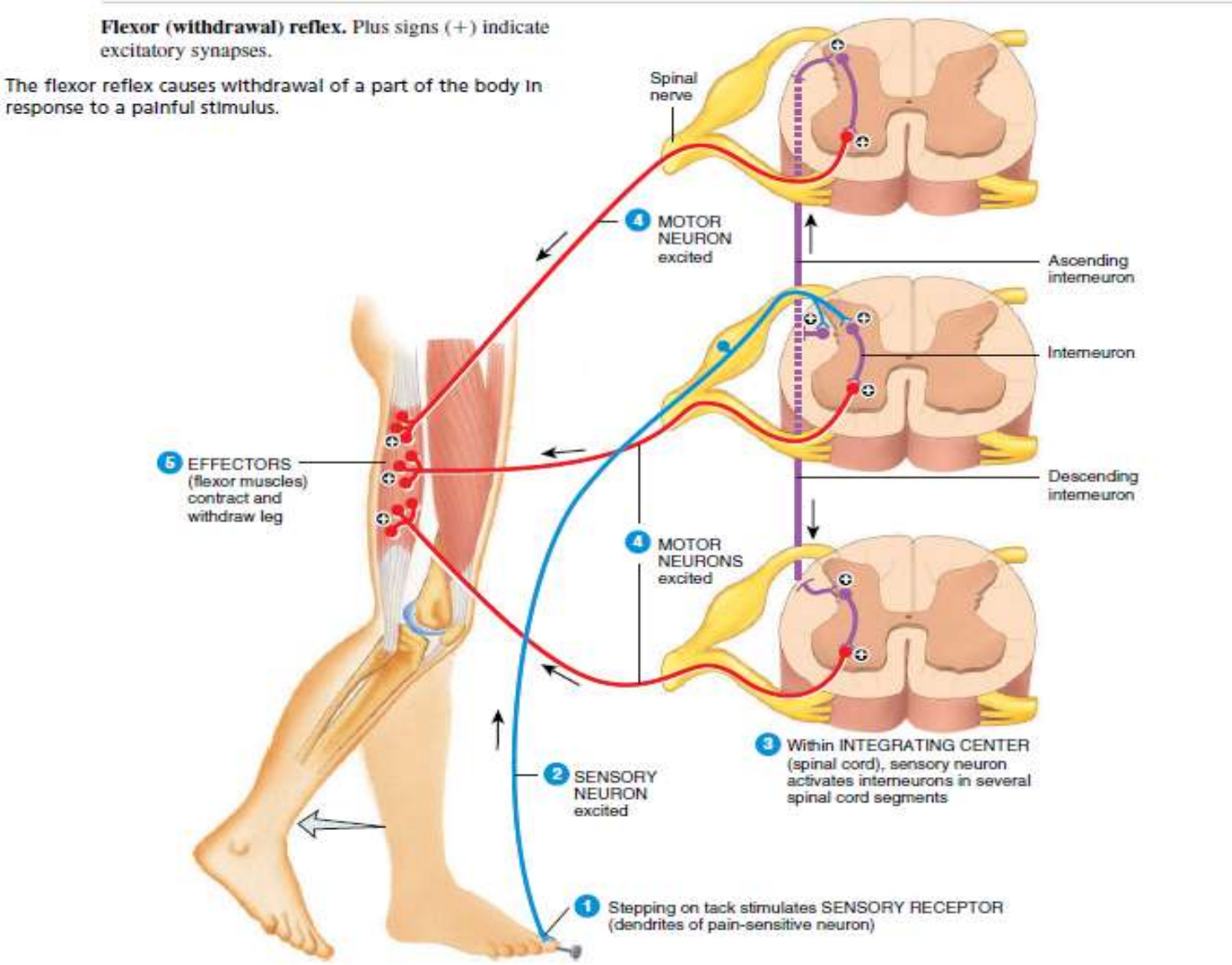


Flexor (withdrawal) reflex. **Is ipsilateral, polysynaptic ,intersegmental reflex arc** (group of muscle need to be contracted) .Through intersegmental reflex arcs, a single sensory neuron can activate several motor neurons, thereby stimulating more than

one effector,

Like stepping on a tack stimulates the dendr

(sensory receptor)of a pain-sensitive neuror



crossed extensor reflex to help you maintain your balance;

1. Stepping on a tack stimulates the sensory receptor of a pain sensitive

neuron in the right foot.

2. This sensory neuron then generates nerve impulses, which

propagate into the spinal cord.

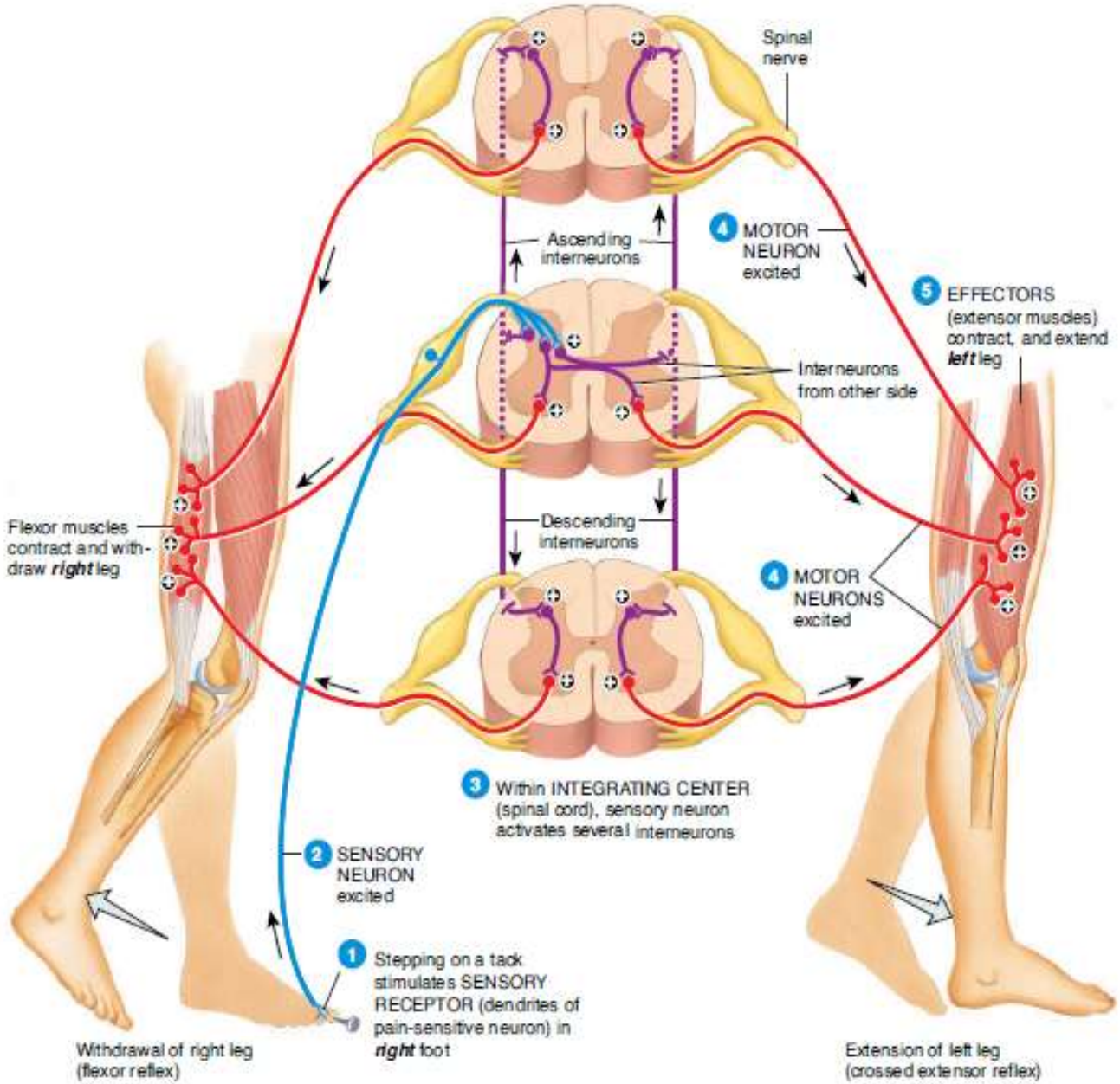
3 .Within the spinal cord (integrating center), the sensory neuron activates several interneurons that synapse with motor neurons on the left side of the spinal cord in several spinal cord segments. Thus, incoming pain signals cross to the opposite

side through interneurons at that level, and at several levels above and below the point of entry into the spinal cord.

4. The interneurons excite motor neurons in several spinal cord segments that innervate extensor muscles. The motor neurons in turn generate more nerve impulses, which propagate toward the axon terminals.

5 Acetylcholine released by the motor neurons causes extensor muscles in the thigh (effectors) of the unstimulated left limb

to contract, producing extension of the left leg. So **its contralateral reflex**


Spinal nerve
Ascending interneurons
4 MOTOR NEURON excited
5 EFFECTORS (extensor muscles) contract, and extend *left* leg
Interneurons from other side
Flexor muscles contract and withdraw *right* leg
Descending interneurons
4 MOTOR NEURONS excited
3 Within INTEGRATING CENTER (spinal cord), sensory neuron activates several interneurons
2 SENSORY NEURON excited
1 Stepping on a tack stimulates SENSORY RECEPTOR (dendrites of pain-sensitive neuron) in *right* foot
Withdrawal of right leg (flexor reflex)
Extension of left leg (crossed extensor reflex)

SENSORY& MOTOR SYSTEM

Senory system

sensation

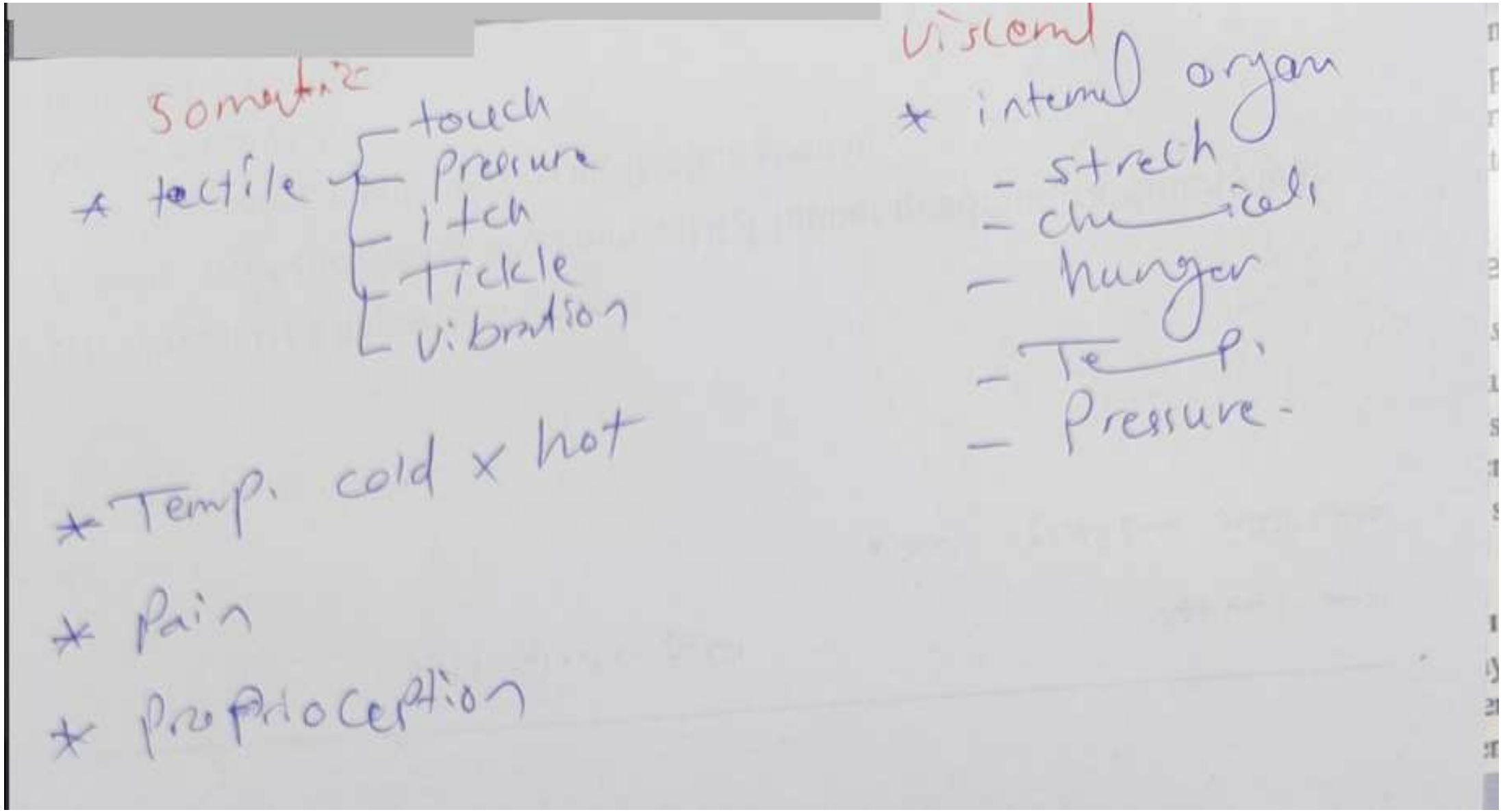
sensation is the conscious or subconscious awareness of changes in the external or internal environment.

The **nature of the sensation** and the **type of reaction** generated vary according to the **ultimate destination of nerve impulses that convey sensory information to the CNS**

Spinal cord , brain stem, cerebral cortex

perception is the conscious interpretation of sensations and is primarily a function of the cerebral cortex.

Sensation modality



The Process of Sensation

stimulus = **A sensory receptor** **responds only weakly or not at all to other stimuli**. This

characteristic of sensory receptors is known as **selectivity**.

.Transduction of the stimulus A sensory receptor *transduces* (converts) energy in a stimulus into a graded potential.

Generation of nerve impulses.

Integration of sensory input at particular region in CNS

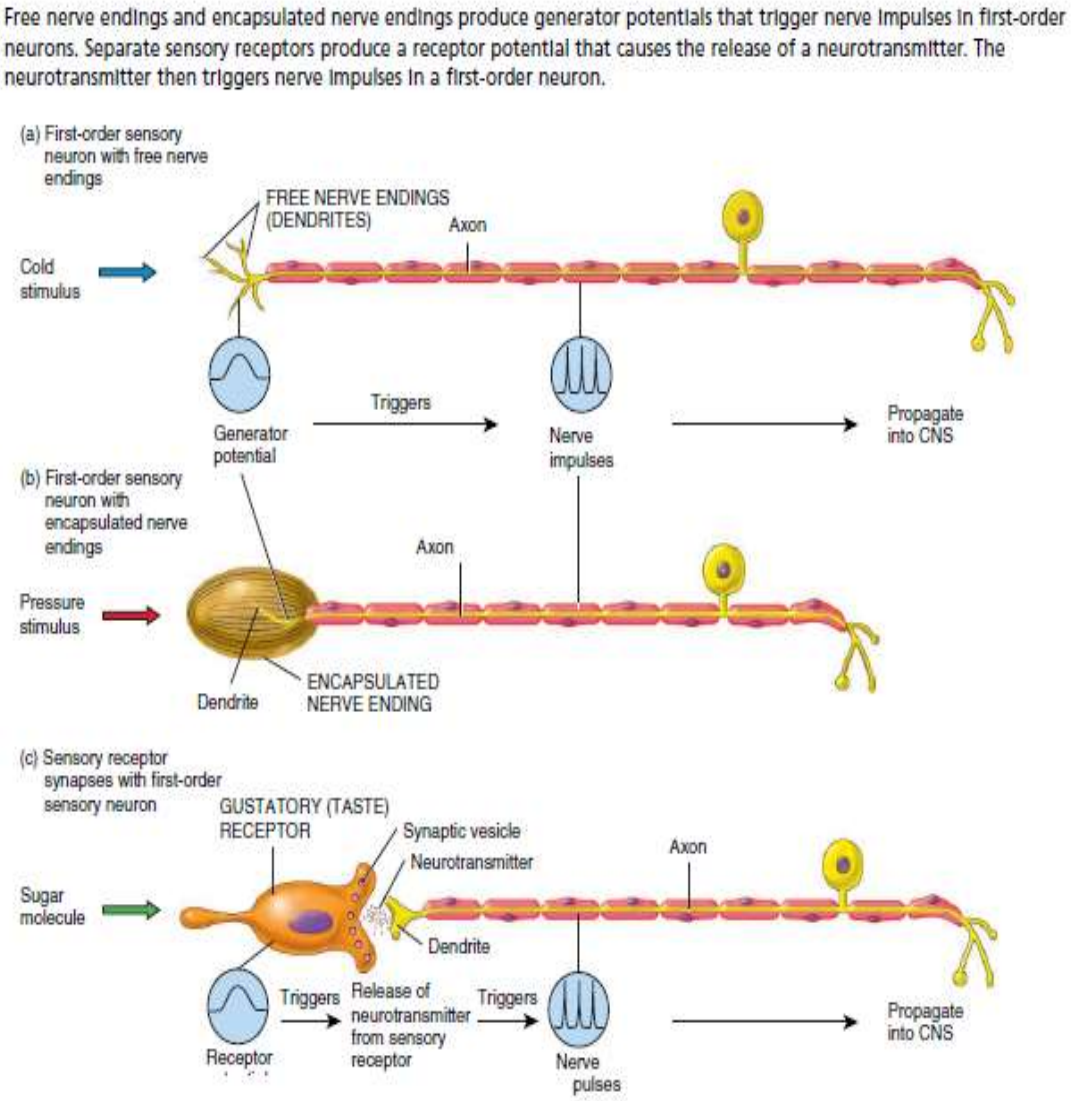
Classifications of receptors

1- MICROSCOPIC STRUCTURE

Free nerve endings Bare dendrites associated with pain, thermal, tickle, itch, and some touch sensations.

Encapsulated nerve endings
Dendrites enclosed in connective tissue capsule for pressure, vibration, and some touch sensations.

Separate cells Receptor cells synapse with fi rst-ordersensory neurons; located in retina of eye (photoreceptors), inner ear (hair cells), and taste buds of tongue (gustatory receptor cells).



2- receptor location and activating stimuli

Exteroceptors Located at or near body surface; sensitive to stimuli originating outside body; provide information about **external environment**; convey visual, smell, taste, touch, pressure, vibration, thermal, and pain sensations.

Interoceptors Located in blood vessels, visceral organs, and nervous system; provide information about **internal environment**; impulses usually are not consciously perceived but occasionally may be felt as pain or pressure.

Proprioceptors Located in muscles, tendons, joints, and inner ear; provide information about body position, muscle length and tension, position and motion of joints, and equilibrium (balance).

3- type of stimulus detected

Mechanoreceptors Detect mechanical stimuli; provide sensations of touch, pressure, vibration, proprioception, and hearing and equilibrium; also monitor stretching of blood vessels and internal organs.

Thermoreceptors Detect changes in temperature.

Nociceptors Respond to painful stimuli resulting from physical or chemical damage to tissue.

Photoreceptors Detect light that strikes the retina of the eye.

Chemoreceptors Detect chemicals in mouth (taste), nose (smell), and body fluids.

Osmoreceptors Sense osmotic pressure of body fluids.


THANK YOU