

# INTRODUCTION TO THE NERVOUS SYSTEM: MAJOR DIVISIONS – CENTRAL NERVOUS SYSTEM

**SKULL**

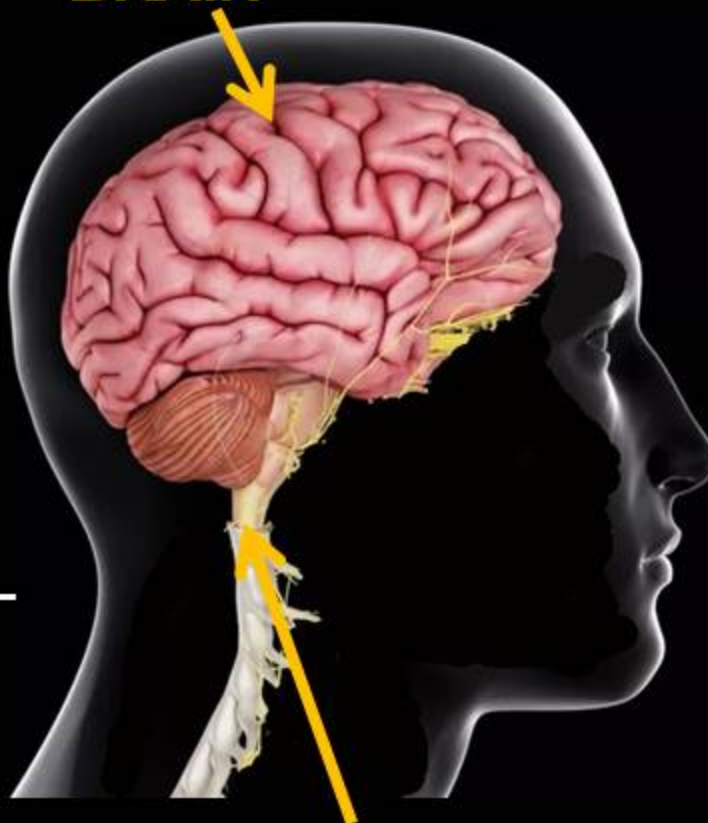


**Vertebrae**

**CRANIAL CAVITY –  
inside Skull**



**BRAIN**

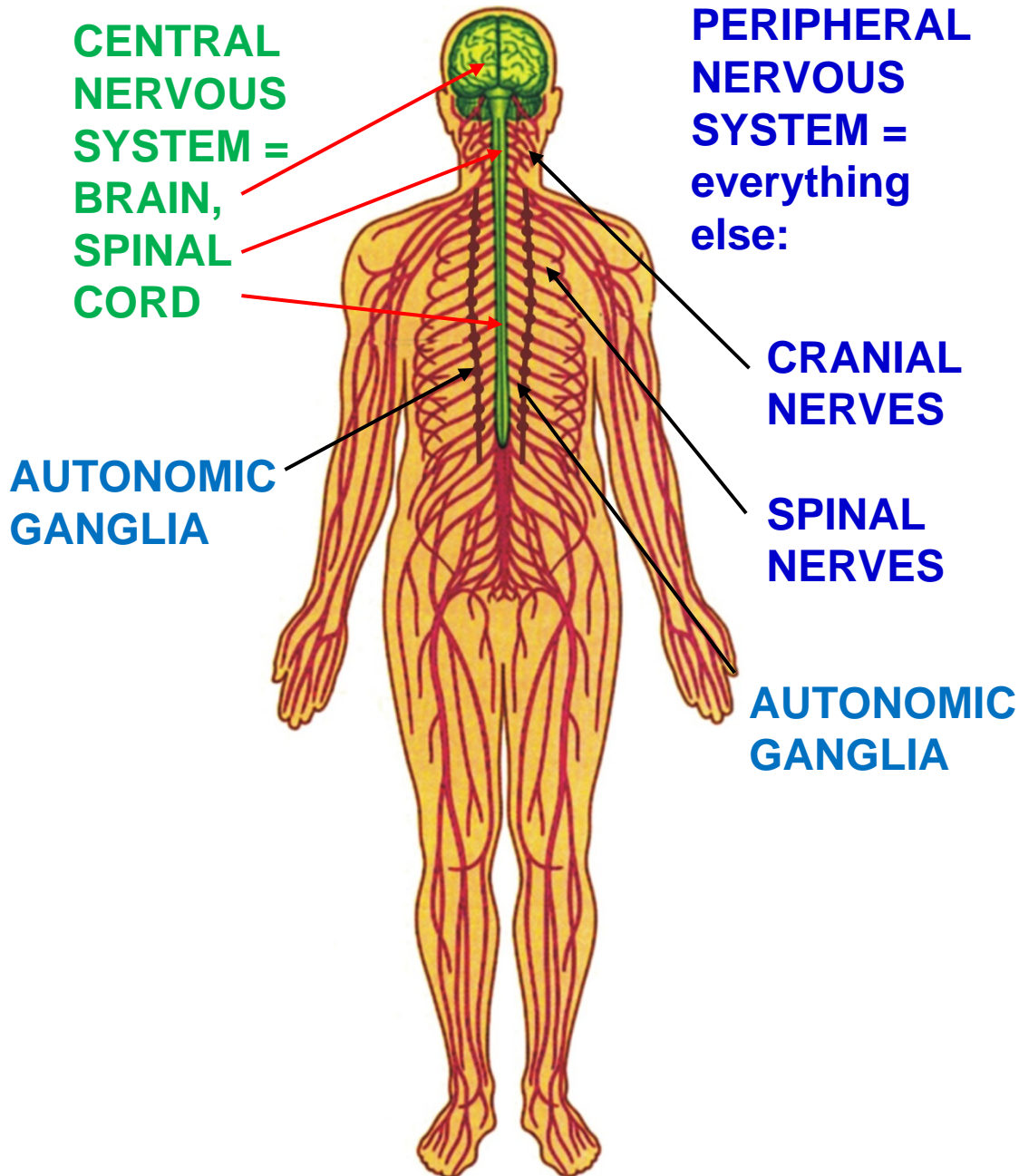


**SPINAL CORD**

**Most complicated system  
in human body; cessation of function = death**

**CENTRAL NERVOUS SYSTEM (CNS) -  
definition is precise; consists  
of BRAIN  
(contained in cranial cavity of  
skull) and SPINAL CORD  
(contained in vertebral canal  
inside column of vertebrae [back  
bones]).**

## INTRODUCTION: PERIPHERAL NERVOUS SYSTEM



**A. CENTRAL NERVOUS SYSTEM (CNS) – BRAIN and SPINAL CORD**

**B. PERIPHERAL NERVOUS SYSTEM (PNS) = EVERYTHING ELSE INCLUDING:**

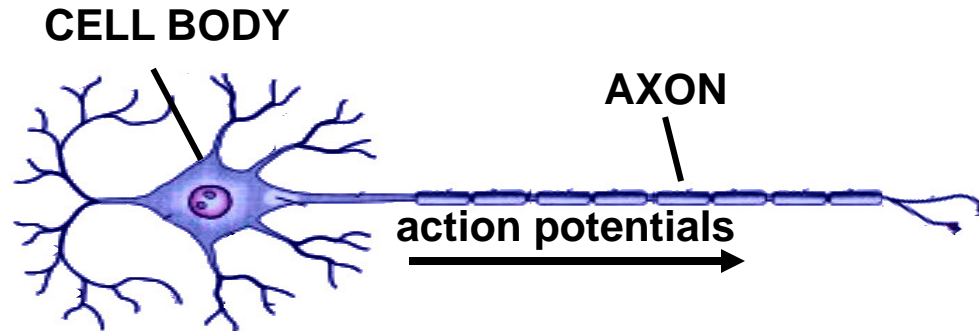
**1) NERVES - CRANIAL NERVES, SPINAL NERVES that carry signals to and from the CNS;**

**2) GANGLIA - collections of nerve cell bodies, including GANGLIA OF AUTONOMIC NERVOUS SYSTEM**

**3) SENSE ORGANS – ex. eye, sensory endings in skin, etc.**

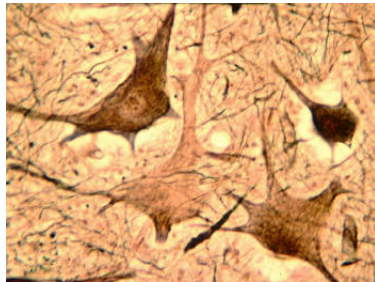
# INTRO: TERMINOLOGY OF GROUPS OF CELL BODIES AND AXONS

STRUCTURE  
OF NERVE  
CELL (NEURON)

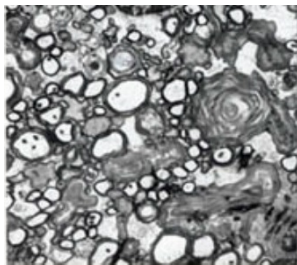


TERMINOLOGY OF GROUPS OF CELL BODIES AND AXONS DIFFERS  
IN CENTRAL (CNS) AND PERIPHERAL (PNS) NERVOUS SYSTEMS

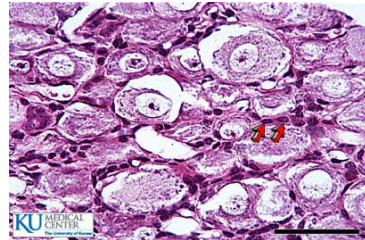
NUCLEI - in CNS



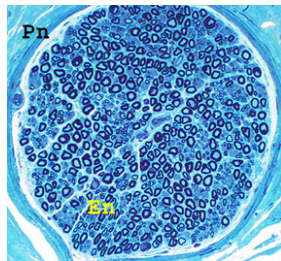
TRACTS - in CNS



GANGLIA - in PNS



NERVES - in PNS



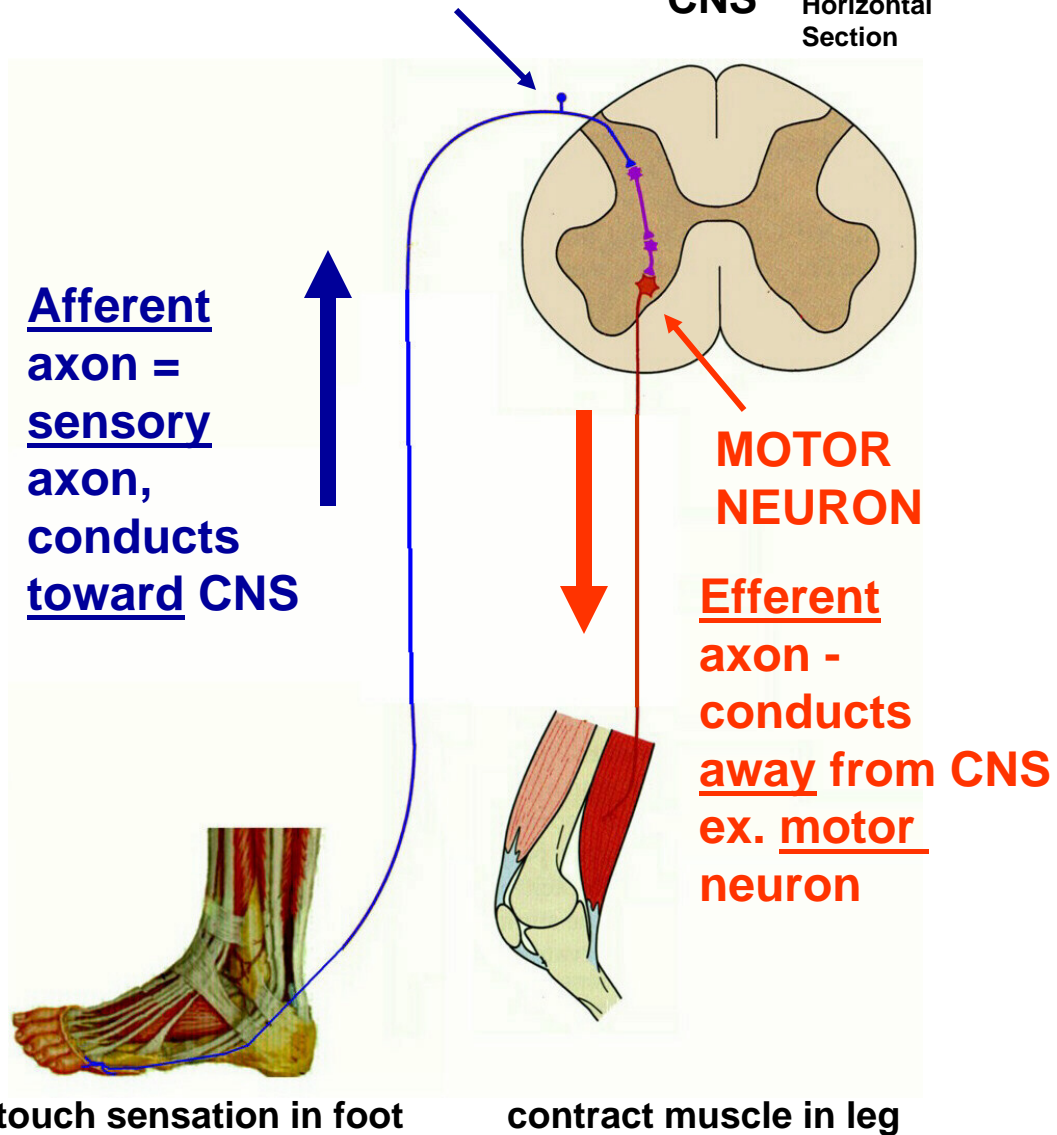
Groups of nerve  
cell bodies are  
called  
NUCLEI in CNS  
GANGLIA IN PNS

Groups of axons  
are called  
TRACTS in CNS  
NERVES in PNS

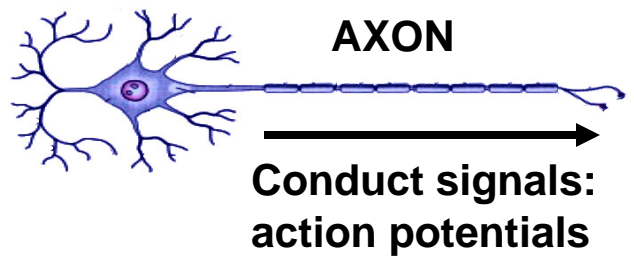
# TERMINOLOGY: AXONS IN PERIPHERAL NERVES

## SENSORY NEURON

View of Spinal Cord in Horizontal Section  
CNS



NEURON = nerve cell

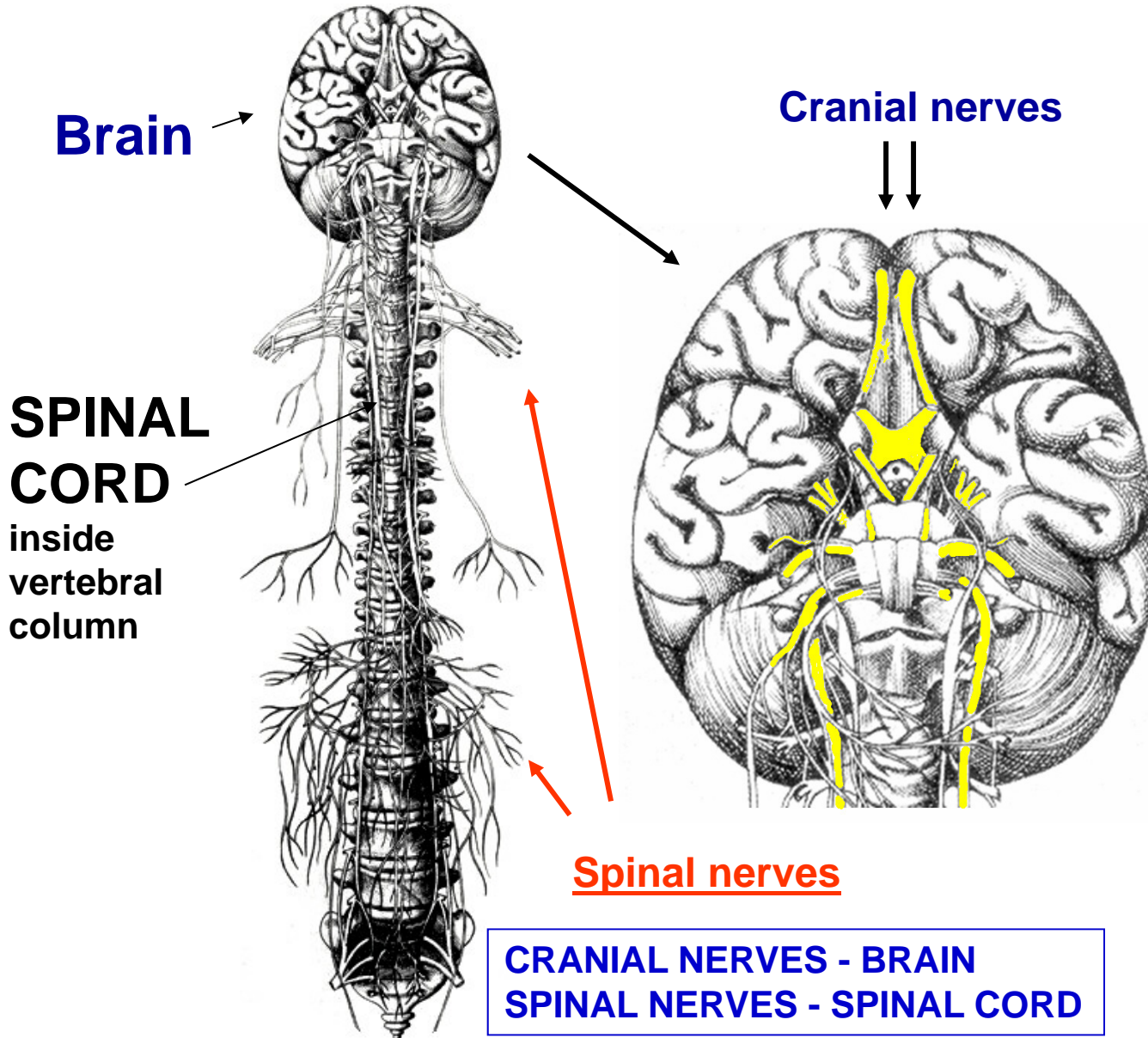


### a. Sensory axons

(Afferents) axons of sensory neurons that conduct signals **toward CNS** (ex. sensory neurons signaling touch, taste, pain, etc.)

**b. Motor axons** (Efferents) - axons of neurons that conduct signals **away from CNS**; most motor axons that cause contractions of skeletal muscles; **OTHER AXONS Visceral Motor (= AUTONOMICS**; pathway more complicated).

# TERMINOLOGY - TYPES OF NERVES: CRANIAL NERVES AND SPINAL NERVES



Spinal nerves and Cranial nerves are named for regions of nervous system they arise from/project to.

1. Cranial nerves - arise from/project to brain; there are 12 Cranial nerves
2. Spinal nerves - arise from project to spinal cord; there are typically 31 Spinal Nerve

# TERMINOLOGY - SOMATIC NERVOUS SYSTEM

## SOMATIC MOTOR NEURONS -

motor axons to skeletal muscles

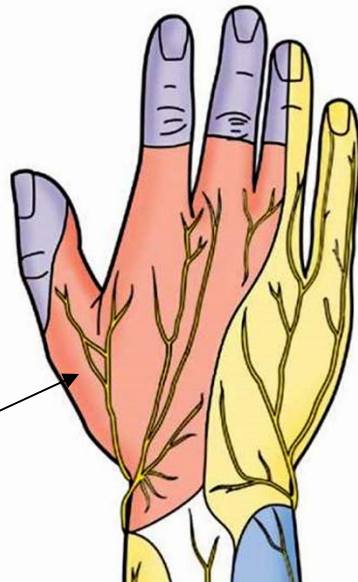
ex. muscles of hand



## SOMATIC SENSORY NEURONS -

sensory axons to skin ; also joints, body position

ex. skin of hand



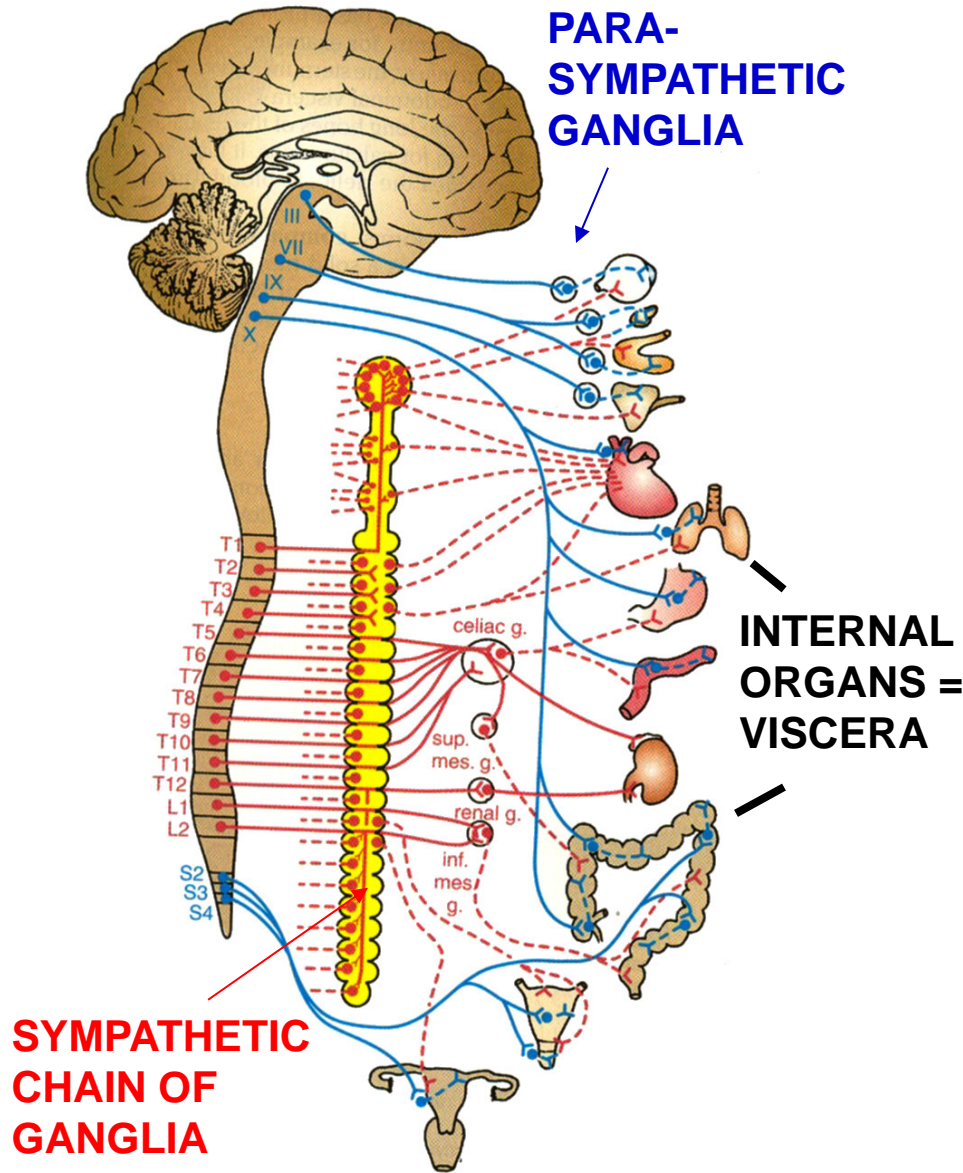
Major divisions of nervous system - terminology based upon function but very confusing

1. **Somatic Nervous system** - **voluntary, conscious** part of nervous system

a. **Somatic Motor** - control skeletal muscle; voluntary activities (ex. limb or eye movements, walking); voluntary actions.

b. **Somatic Sensory** - sensory neurons that innervate skin, joints; provide conscious sensation of touch, pressure, pain etc.

# TERMINOLOGY - AUTONOMIC = VISCERAL NERVOUS SYSTEM



Autonomic Nervous system = Visceral nervous system - **involuntary, unconscious** part of nervous system; (autonomic means self-regulating or AUTOMATIC).

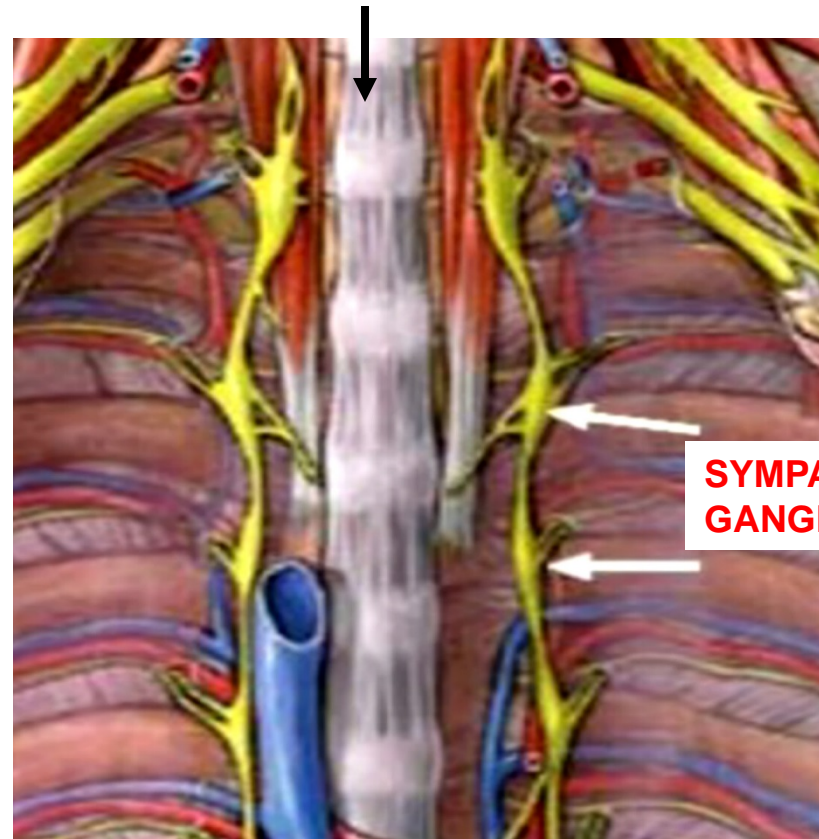
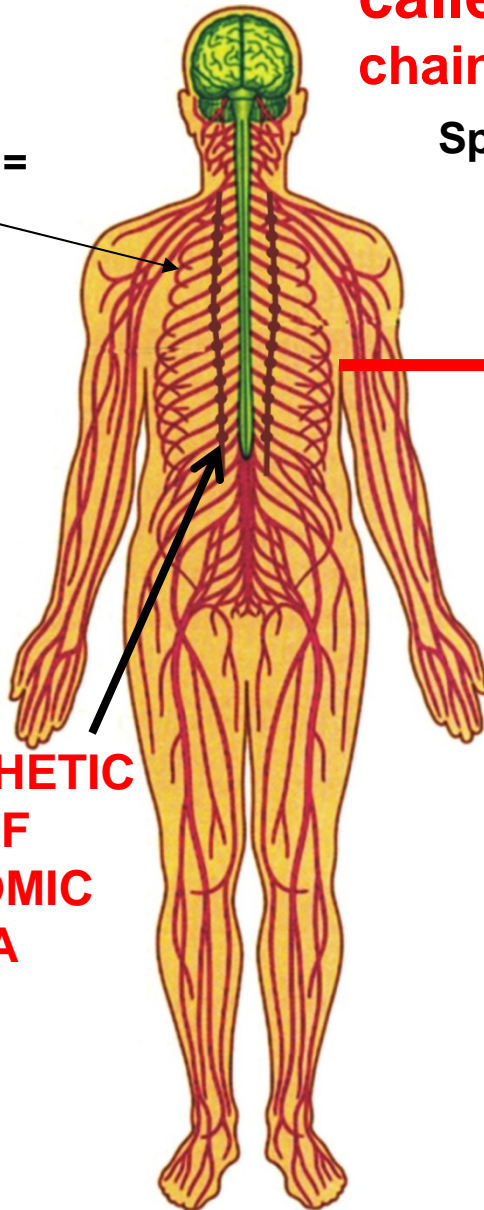
- Visceral Motor (parasympathetic and sympathetic) - control smooth and cardiac muscle, glands and internal organs; largely unconscious actions
- Visceral Sensory - sensory neurons that innervate internal organs, blood vessels; only provide imprecise localization of sensation and dull sense of pressure, pain, etc.

# SYMPATHETIC CHAIN OF GANGLIA - called Paravertebral Ganglia – (NOTE: chain is OUTSIDE of CNS; therefore, in PNS)

Spinal cord located inside of vertebrae (vertebral canal)

THORAX =  
CHEST

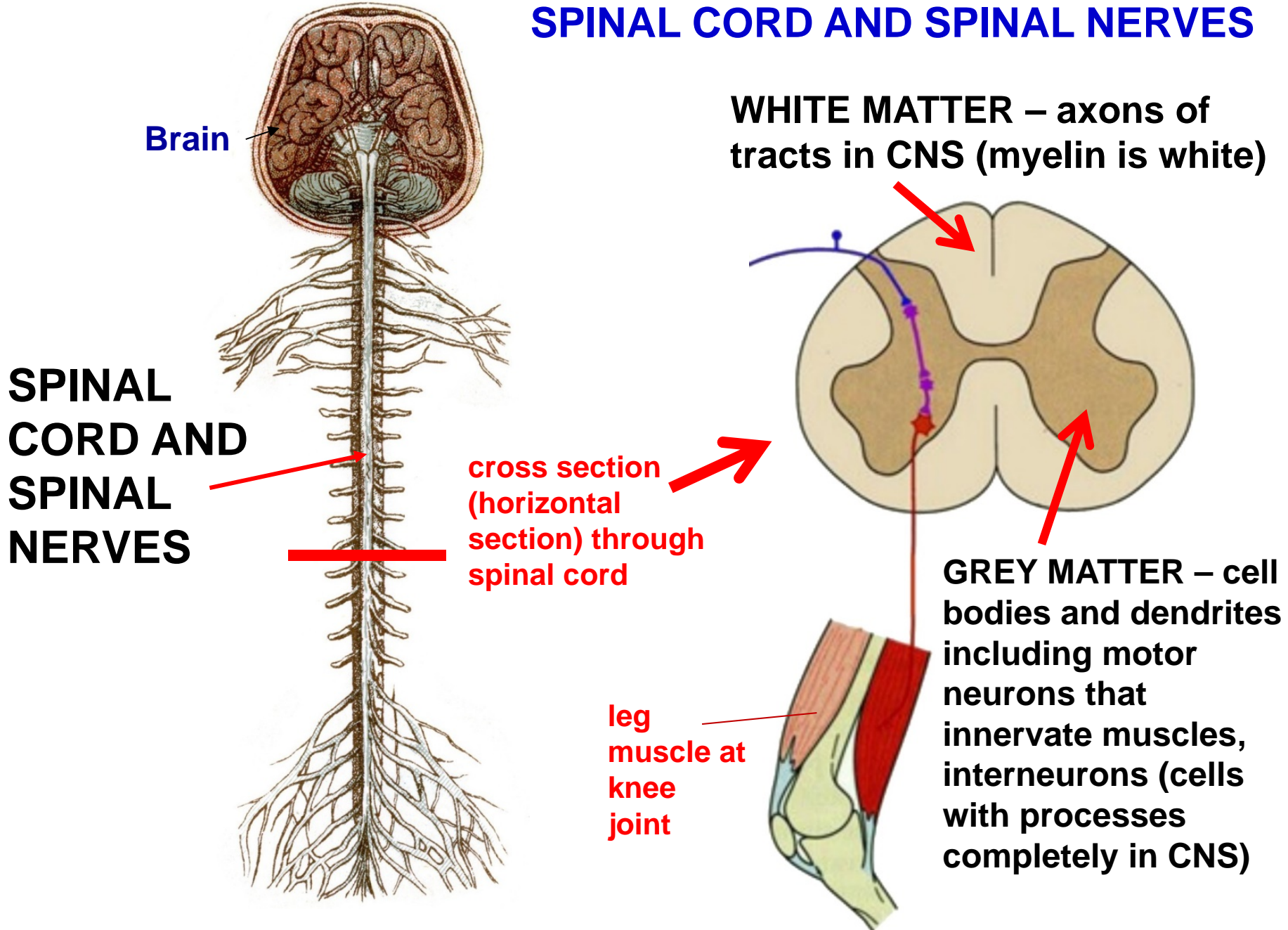
SYMPATHETIC  
CHAIN OF  
AUTONOMIC  
GANGLIA



View of the anterior side (front) of vertebrae  
(back bones) inside the thorax (chest cavity); chain of  
ganglia are on sides of vertebrae (paravertebral)



# SPINAL CORD AND SPINAL NERVES



Brain

**SPINAL  
CORD AND  
SPINAL  
NERVES**

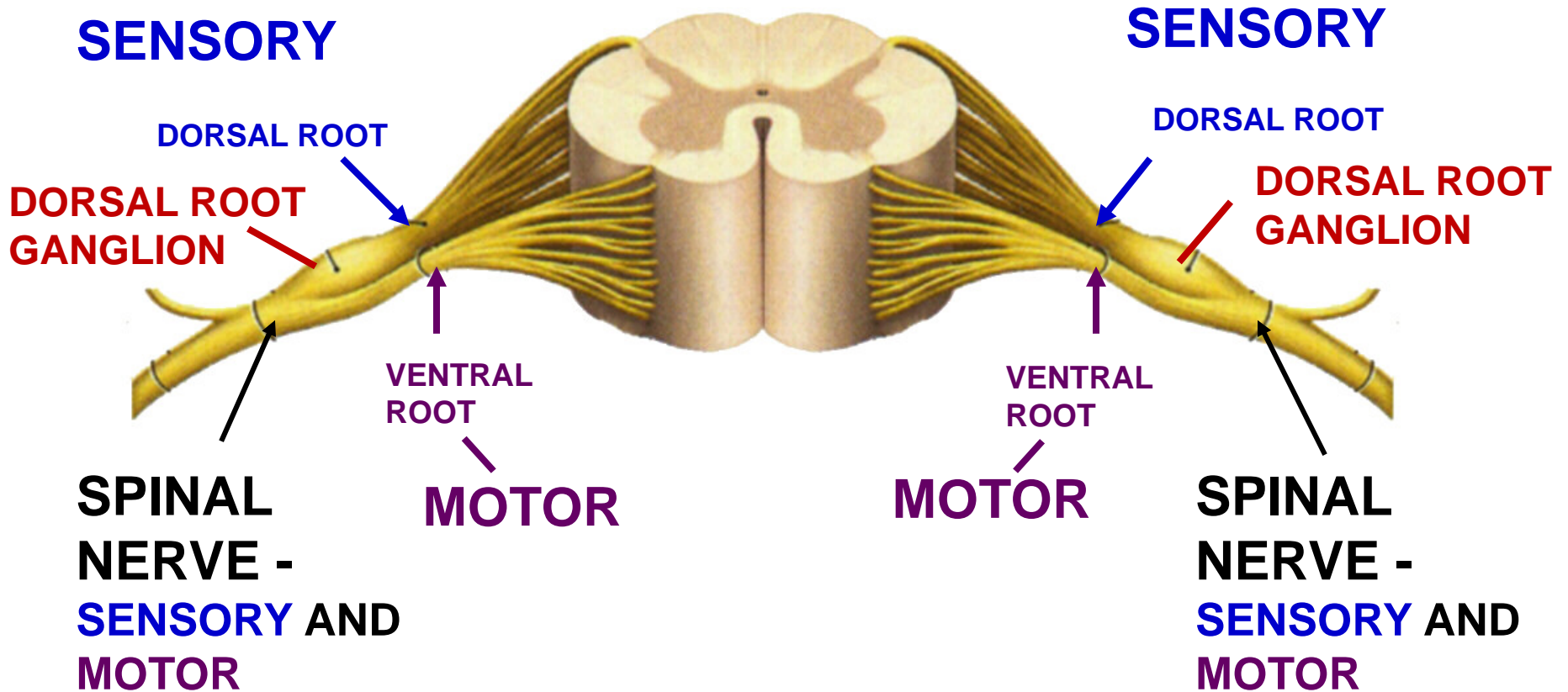
cross section  
(horizontal  
section) through  
spinal cord

**WHITE MATTER – axons of  
tracts in CNS (myelin is white)**

**GREY MATTER – cell  
bodies and dendrites  
including motor  
neurons that  
innervate muscles,  
interneurons (cells  
with processes  
completely in CNS)**

leg  
muscle at  
knee  
joint

# SPINAL NERVE FORMED FROM SENSORY AND MOTOR ROOTS



- Dorsal Roots; contain **sensory (afferent) axons**
- Ventral Roots; contain **motor (efferent) axons**

- Dorsal and Ventral roots unite to form a Spinal Nerve; which contains **sensory** and **motor axons**

- **DORSAL ROOT GANGLION** – contains cell bodies of sensory neurons

# SPINAL REFLEXES

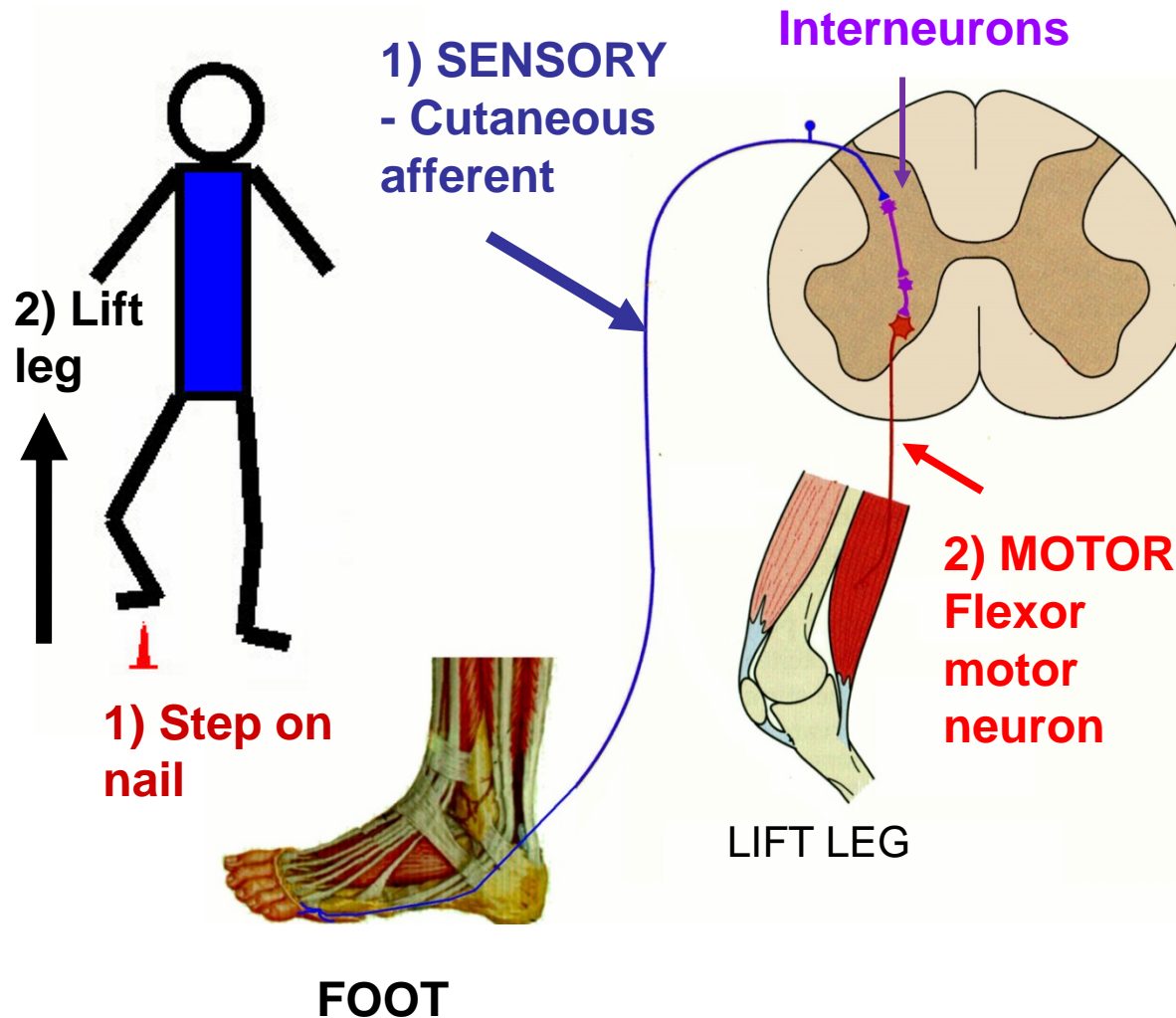
**SENSORY  
STIMULUS**



**MOTOR  
RESPONSE**

**Definition of a Reflex - stereotyped motor response to a specific sensory stimulus**

# 1) FLEXOR REFLEX: STEPPING ON A NAIL



## FLEXOR REFLEX

### 1) SENSORY STIMULUS

- foot steps on nail

### 2) MOTOR RESPONSE -

lift leg before foot is impaled by nail

### PATHWAY

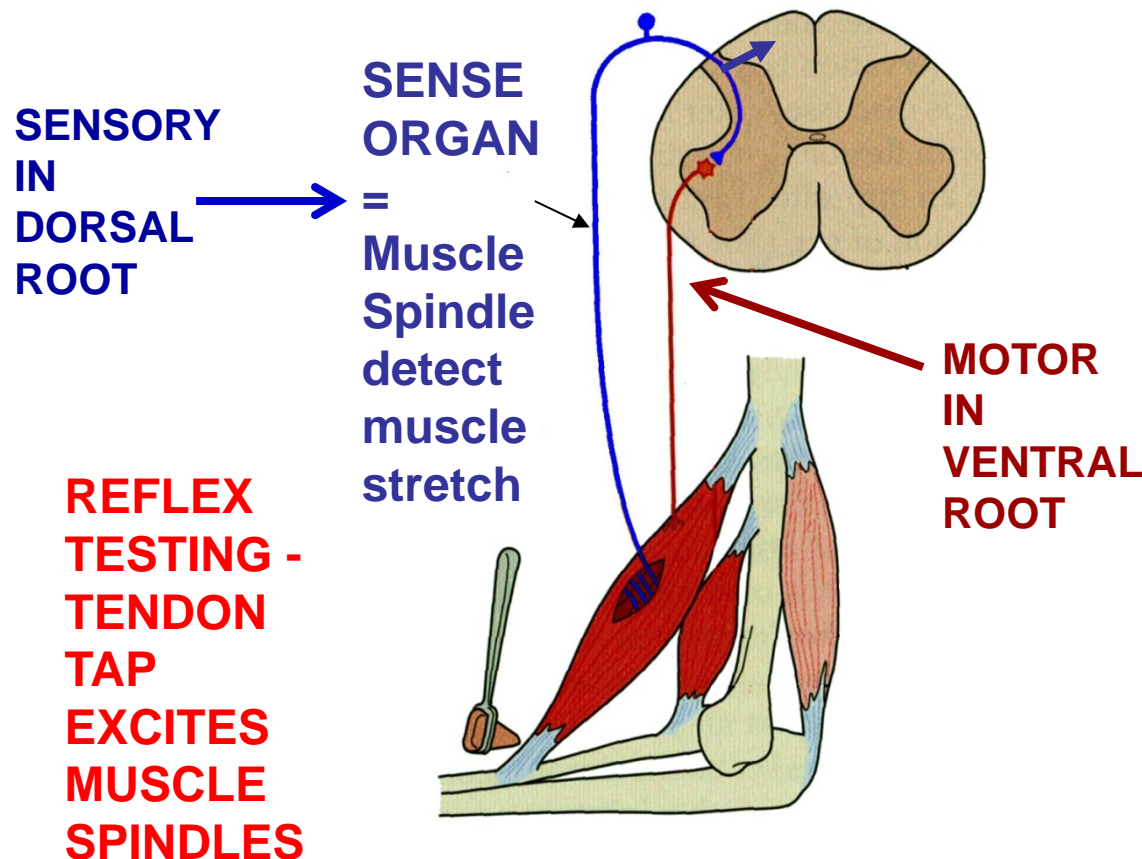
1) SENSORY NEURONS IN SKIN (CUTANEOUS)

detects pain

2) INTERNEURONS IN CNS - transmit signal

3) MOTOR NEURONS- activate Flexor muscles to lift leg

## 2) STRETCH (DEEP TENDON) REFLEXES - tapping on the tendon of a muscle stretches the muscle and reflexively causes it to contract – **CLINICALLY IMPORTANT**



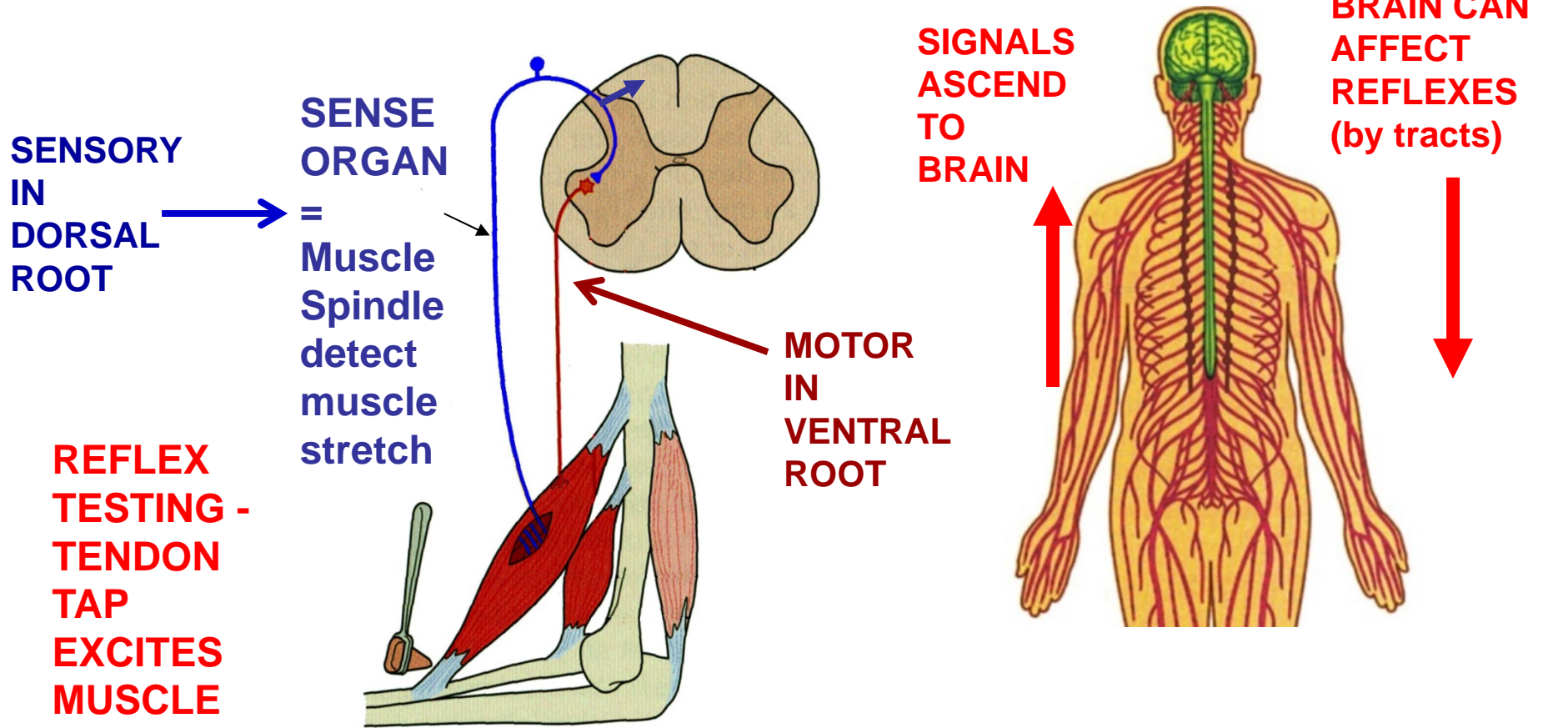
### STRETCH (DEEP TENDON) REFLEX

- 1) SENSORY STIMULUS - stretch of muscle
- 2) MOTOR RESPONSE - contract muscle that is stretch

#### PATHWAY

- 1) SENSORY Muscle spindle (sensory endings inside muscle) detect stretch
- 2) MOTOR NEURONS- activate motor neurons to muscle that is stretched

## 2) STRETCH (DEEP TENDON) REFLEXES - tapping on the tendon of a muscle causes the muscle to contract – **CLINICALLY IMPORTANT**



**SIGNALS FROM BRAIN AFFECT REFLEXES - damage to tracts (ex. Corticospinal tract) can INCREASE stretch reflexes (HYPERREFLEXIA)**

**NORMAL STRETCH (DEEP TENDON) REFLEXES - ELICIT BY TAPPING ON MUSCLE TENDON - CAUSES MUSCLE TO CONTRACT**

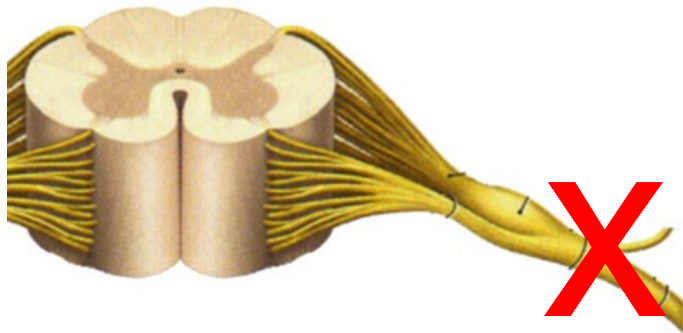
**NORMAL PATIENT**



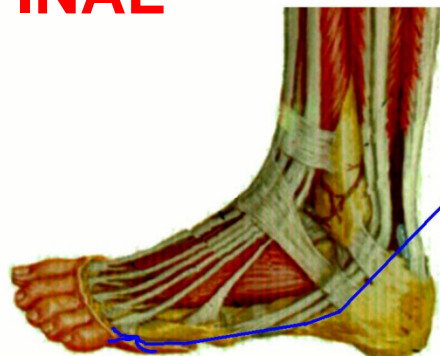
download videos from Zillanatomy: [https://www.zillanatomy.com/Pandemic\\_anatomy.htm](https://www.zillanatomy.com/Pandemic_anatomy.htm)

# DAMAGE (LESION) OF PNS

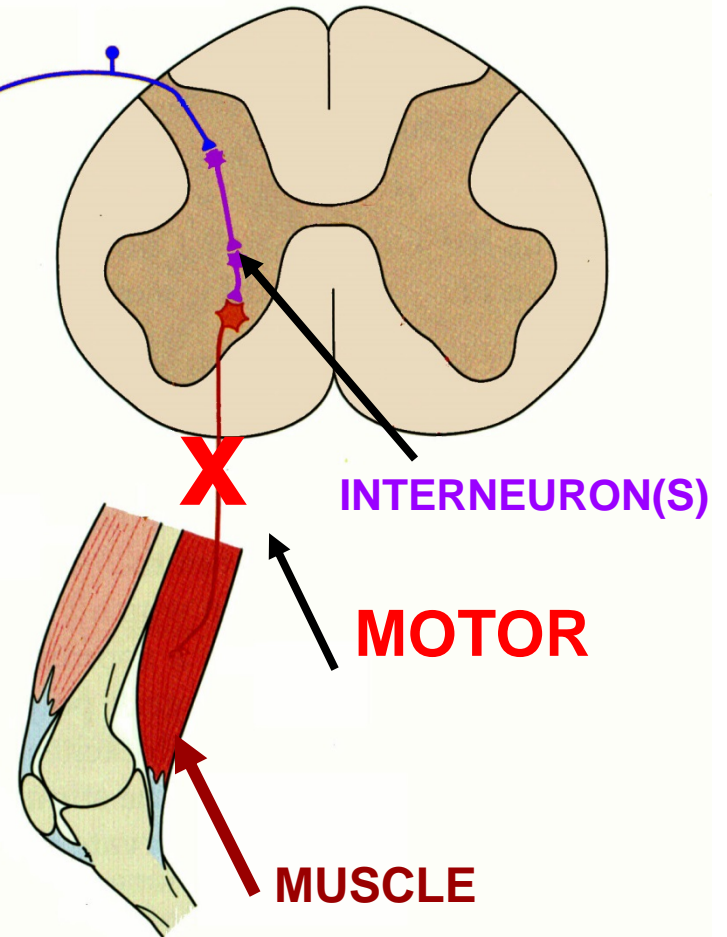
ex. COMPRESS  
SPINAL NERVE



DAMAGE SPINAL  
NERVE



SENSORY



INTERNEURON(S)

MOTOR

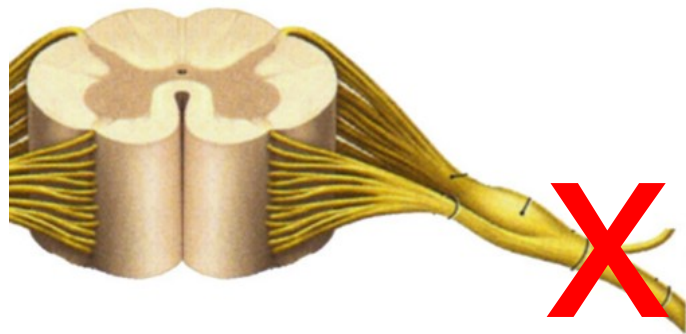
MUSCLE

SPINAL NERVE DAMAGE CAN AFFECT SENSORY AND  
MOTOR NEURONS



# DAMAGE (LESION) OF PNS

ex. COMPRESS  
SPINAL NERVE



**DAMAGE SPINAL  
NERVE**

## STRUCTURES AFFECTED:

- 1) Motor Neurons
- 2) Sensory neurons

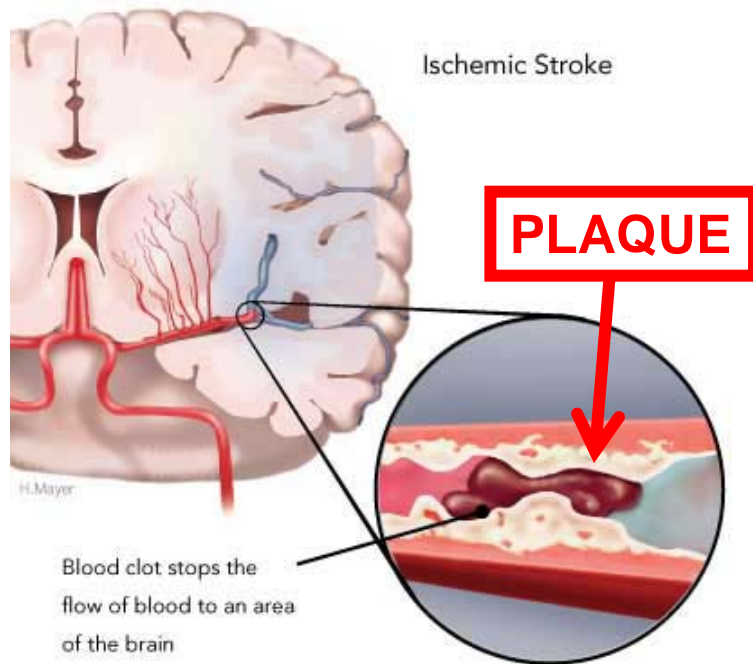
## SYMPTOMS

- 1) Muscle is completely paralyzed (Flaccid Paralysis) or partially paralyzed (weakness)
- 2) Sensory loss is complete (total numbness) or partial (paresthesia = 'pins and needles' sensation)
- 3) **DECREASED (HYPOREFLEXIA) OR NO (AREFLEXIA) STRETCH REFLEXES**

**SPINAL NERVE DAMAGE CAN AFFECT SENSORY  
AND MOTOR NEURONS**

# DAMAGE (LESION) OF CNS

ex. **STROKE** – blood supply to brain interrupted or reduced



**Note:** this illustrates an Ischemic stroke caused by a clot; other strokes are Hemorrhagic, caused by bleeding

## STRUCTURES AFFECTED:

Neurons and tracts in CNS; (tracts that generate voluntary muscle contractions also called Upper Motor Neurons; ex. Corticospinal Tract)

## SYMPTOMS

Disrupt voluntary control of movement and regulation of reflexes (remove inhibition):

1) No or weakened voluntary movements

**2) INCREASE STRETCH (DEEP TENDON) REFLEXES (HYPERREFLEXIA)**

**3) MANY OTHER SYMPTOMS**

**Causes - Example - Stroke**  
(interruption of blood supply to brain – can damage Corticospinal tract)

**STRETCH (DEEP TENDON) REFLEXES - ELICIT BY TAPPING ON MUSCLE TENDON - CAUSES MUSCLES TO CONTRACT**

**ABNORMAL - CHILD WITH CNS LESION (STROKE) - REFLEXES HYPERACTIVE ON RIGHT SIDE**



## MAJOR TAKE-HOME POINTS FROM THIS LECTURE

1- Know definitions of terms in Summary

2- Damage Spinal Nerve - Spinal nerves contain axons of sensory AND motor neurons; **damage** can produce Sensory deficits (numbness or paresthesias (tingling sensation) **AND** motor deficits (paralysis, weakness) depending upon extent of lesion. Also, spinal reflexes can be **DECREASED** or eliminated.

3- Damage Central Nervous system tracts - Can **decrease or eliminate voluntary movements**; however, spinal reflexes can still be elicited; damage to descending tracts (Corticospinal tract) **can INCREASE spinal stretch reflexes.**

# SUMMARY DEFINITIONS OF TERMS

## Definitions of Terms

Central nervous system (CNS) = brain and spinal cord

Peripheral nervous system (PNS) = all nerves, ganglia, sense organs outside CNS

Cranial nerves = nerves that arise from brain (there are 12 cranial nerves)

Spinal nerves = nerves that arise from spinal cord (there are 31 spinal nerves)

Afferent axons = axons of sensory neurons (conduct toward CNS)

Efferent axons = axons of motor neurons, neurons of autonomic nervous system; (conduct away from CNS)

Somatic = voluntary

Somatic efferents - axons innervate skeletal muscle;

Somatic afferents - sensory neurons innervate skin, joints muscles (also oral cavity and nasal cavity); sensory perception is precise

Visceral = involuntary

Visceral efferents (= AUTONOMICS) - innervate smooth muscle, glands, gut, blood vessels

Visceral afferents - sensory neurons innervate internal organs; sensory perception is imprecise

Reflex - a stereotyped motor (muscle) response to a specific sensory signal.

Flexor Reflex - sensory - stepping on nail; motor - lift leg

Stretch (Deep Tendon Reflex - sensory - stretch muscle (tap on tendon) activates Muscle Spindle sensor neurons; motor - muscle contracts.

# SUMMARY CHART: LESIONS OF PNS AND CNS - Symptoms are a direct consequence of Anatomy

## SUMMARY: INTRODUCTION TO LESIONS OF PNS AND CNS – Major symptoms and causes

Lesion	Structures Affected	Symptoms	Causes (Examples)
DAMAGE PNS (ex. Peripheral nerve injury, Flaccid Paralysis)	1) Motor Neurons = Motor neurons with axons that innervate skeletal muscles (also called Lower (Alpha) Motor Neuron Lesion, 2) Sensory neurons	1) Muscle is completely paralyzed (Flaccid Paralysis) or partially paralyzed (weakness) 2) Sensory loss is complete (total numbness) or partial (paresthesia = 'pins and needles' sensation) 3) STRETCH REFLEXES ARE REDUCED OR ABSENT	1) Compression of spinal nerve 2) MANY OTHER CAUSES
DAMAGE CNS (ex. Stroke = interrupt blood supply to parts of CNS)	Neurons and tracts in CNS - Descending tracts that generate voluntary muscle contractions are also called Upper Motor Neurons (ex. Corticospinal Tract)	Disrupt voluntary control of movement and regulation of reflexes (remove inhibition): 1) No or weakened voluntary movements 2) STRETCH REFLEXES CAN BE INCREASED (Hyper-reflexia) 3) MANY OTHER SYMPTOMS	Example - Stroke (interruption of blood supply to brain – can damage Corticospinal tract)

Note: Some diseases damage both CNS and PNS - (ex. ALS Amyotrophic Lateral Sclerosis)