Spinal Cord Functions & Spinal Reflexes

Prof. Faten Zakareia

Professor & Consultant Clinical Neurophysiology

Dept. of Physiology

College of Medicine & KKUH

King Saud University

OBJECTIVES:

UPON COMPLETION OF THIS LECTURE, STUDENTS SHOULD BE ABLE TO:

- Describe the physiological functions of the spinal cord
- Describe the organization of the spinal cord for motor functions
- Identify the spinal reflex and reflex arc components
- Classify reflexes (superficial ,deep; monosynpolysynaptic synaptic & polysynaptic)
- Describe withdrawal reflex & crossed extensor reflex
- Recognize the general properties of spinal cord reflexes

REFERENCE BOOK/gyton chapter 54&46 and review of human physiology by ganong (last edition)

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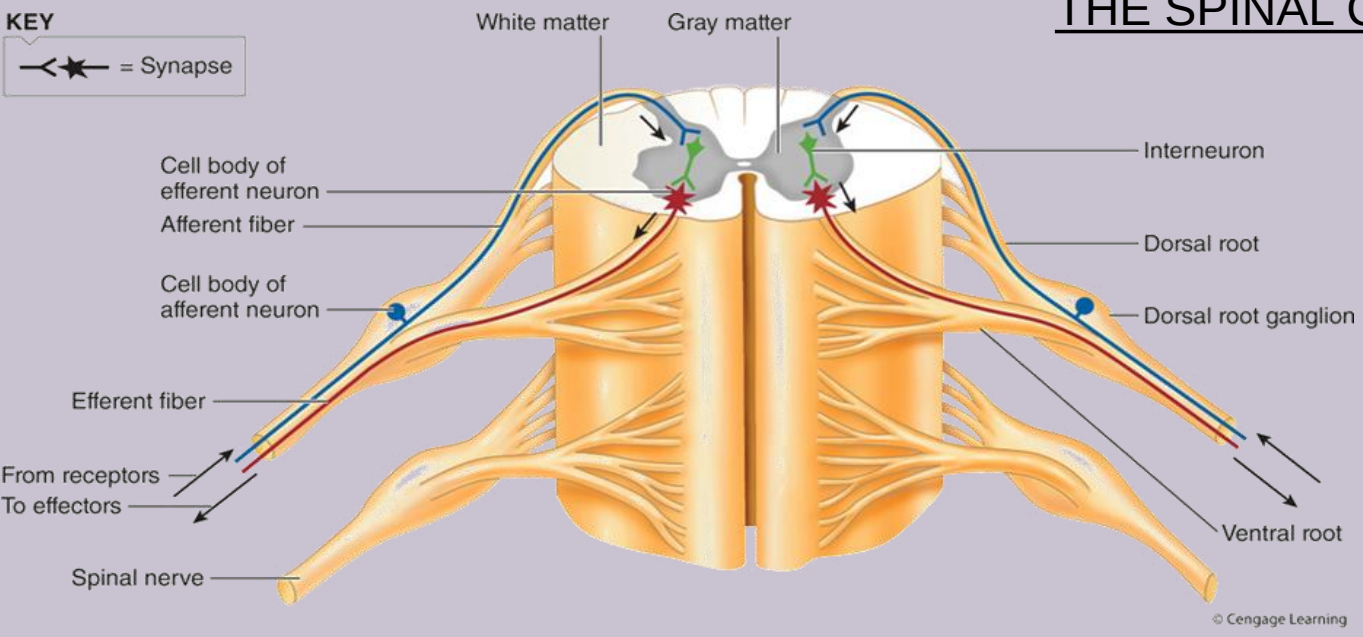
THE SPINAL CORD



THE SPINAL CORD HAS 31 PAIRS OF SPINAL NERVES
EACH SPINAL NERVE HAS HAS VENTRAL & DORSAL ROOTS :

- **THE DORSAL(POSTERIOR) ROOT CONTAINS AFFERENT (SENSORY) FIBERS COMING FROM RECEPTORS .**
- **THE CELL BODY OF THESE NEURONS IS LOCATED IN DORSAL (POSTERIOR) ROOT GANGLION (DRG)**

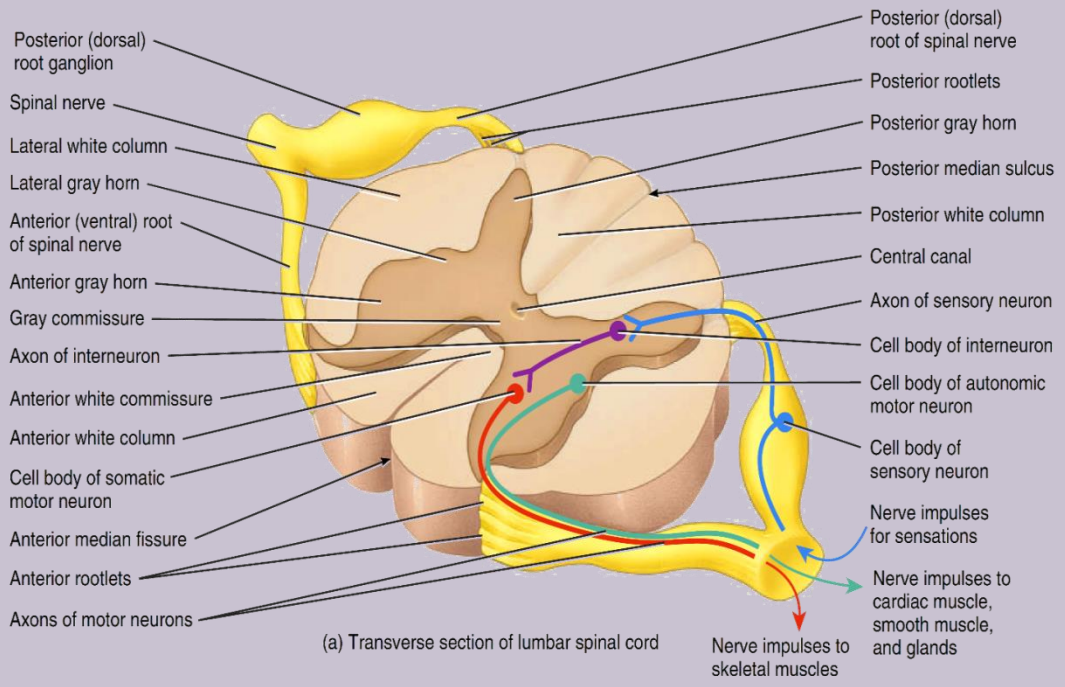
- **THE VENTRAL(ANTERIOR) ROOT CARRIES EFFERENT (MOTOR) FIBERS**
- **THE CELL-BODY OF THESE MOTOR FIBRES IS LOCATED IN THE VENTRAL (ANTERIOR) HORN OF THE SPINAL CORD**

GREY MATTER | NUCLEI

IN THE GREY MATTER OF THE SPINAL CORD AND BRAIN, CLUSTERS OF NEURONAL CELL BODIES FORM FUNCTIONAL GROUPS CALLED NUCLEI

SENSORY NUCLEI RECEIVE INPUT FROM RECEPTORS VIA SENSORY NEURONS

MOTOR NUCLEI PROVIDE OUTPUT TO EFFECTOR TISSUES VIA MOTOR NEURONS



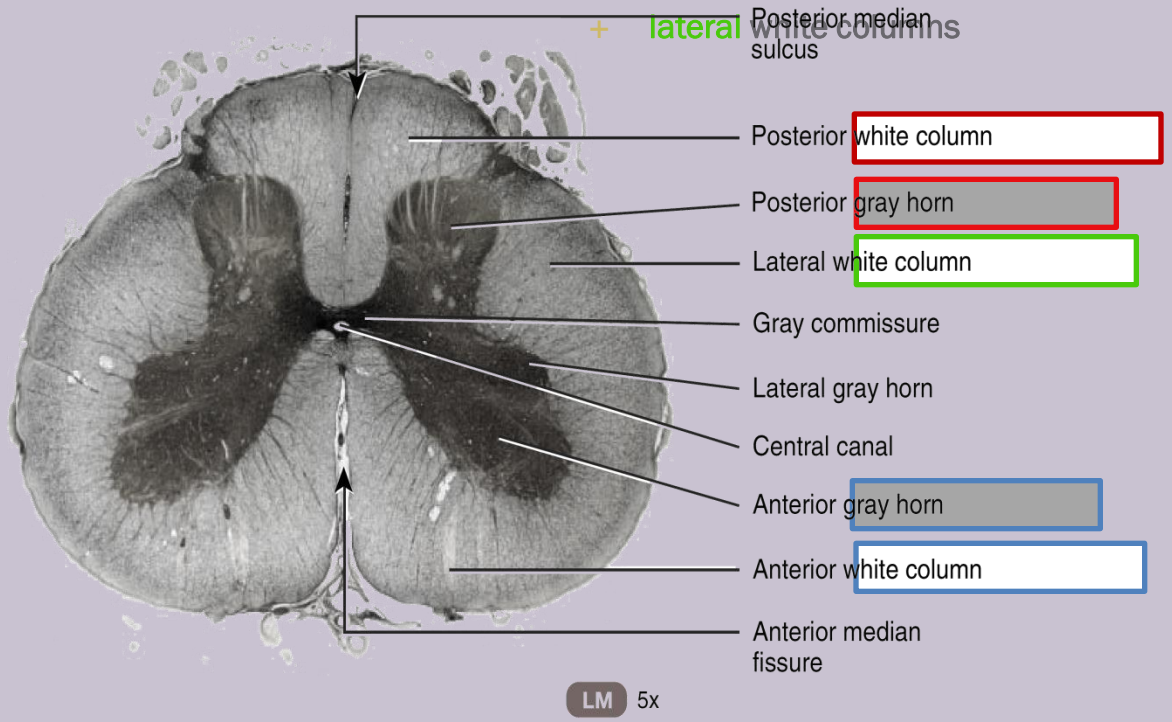
THE POSTERIOR GREY HORN CONTAINS AXONS OF SENSORY NEURONS AND CELL BODIES OF INTERNEURONS

THE LATERAL GREY HORN CONTAINS CELL BODIES OF AUTONOMIC MOTOR NEURONS;

THE ANTERIOR GREY HORN CONTAINS CELL BODIES OF SOMATIC MOTOR NEURONS.

WHITE MATTER

- The anterior and posterior grey horn matter on each side
- White matter is divided into three bi columns:
  - anterior (*ventral*) white columns,
  - posterior (*dorsal*) white columns,
  - lateral white columns



EACH COLUMN IN TURN CONTAINS DISTINCT BUNDLES OF AXONS HAVING A COMMON ORIGIN OR DESTINATION AND CARRYING SIMILAR INFORMATION.

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, WHEREAS 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.**

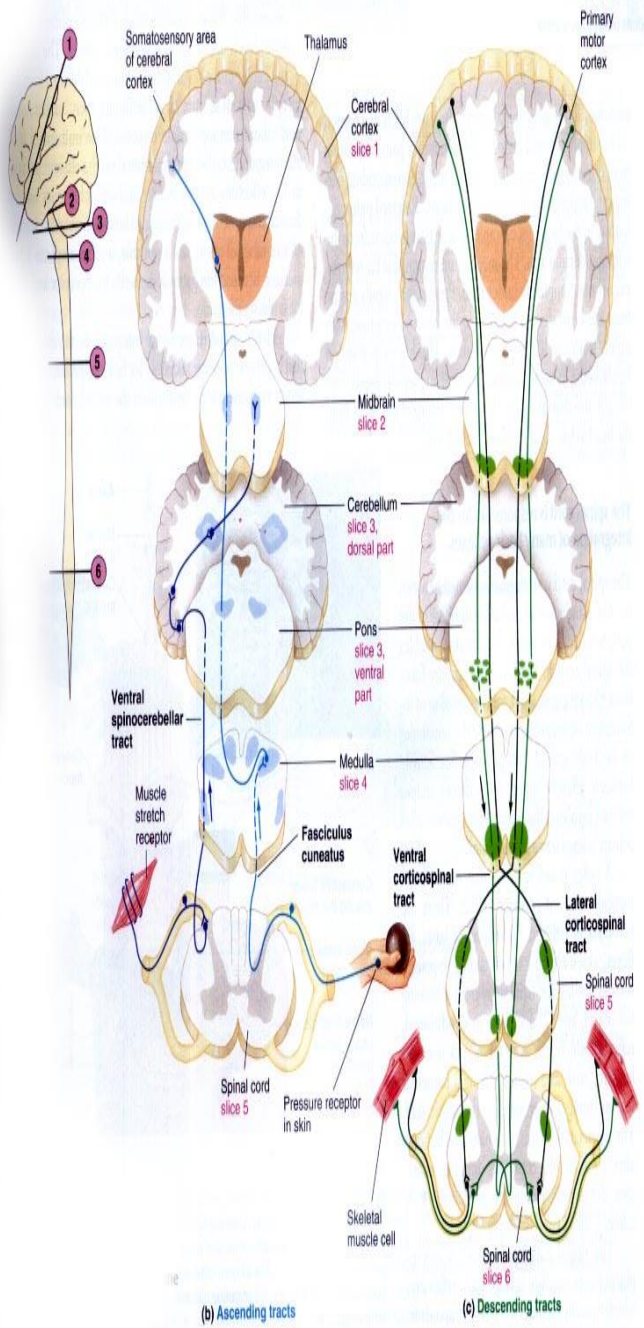
SENSORY AND MOTOR TRACTS OF THE SPINAL CORD ARE CONTINUOUS WITH SENSORY AND MOTOR TRACTS IN THE BRAIN.

Functions of the Spinal Cord

1-Gateway and conduction pathway for all tracts

2-Center of Spinal Cord Reflexes (Somatic & Autonomic)

3-Gateway for Pain control systems



Spinal cord functions(cont----)

1-Gateway and conduction pathway for all tracts

The two-way traffic pathways along the spinal cord

A-Sensory signals from receptors enter the cord through the sensory (posterior) roots, then every sensory signal travels to two separate destinations:

1-One branch of the sensory nerve terminates in the sensory neurons of the gray matter of the dorsal horn and elicits local segmental cord reflexes

2-Another branch transmits signals to higher levels in the cord , or to the brain stem, or even to the cerebral cortex through spinal ascending sensory tracts as:_

-Dorsal Column Tracts (Gracile &Cuneate)

-Lateral Spinothalamic Tract & Anterior Spinothalamic Tract.

-Spinocerebellar Tracts

B- Motor signals & brain motor commands pass through descending motor tracts & motor neurons to spinal efferent motor nerves to skeletal muscles to excute motor functions

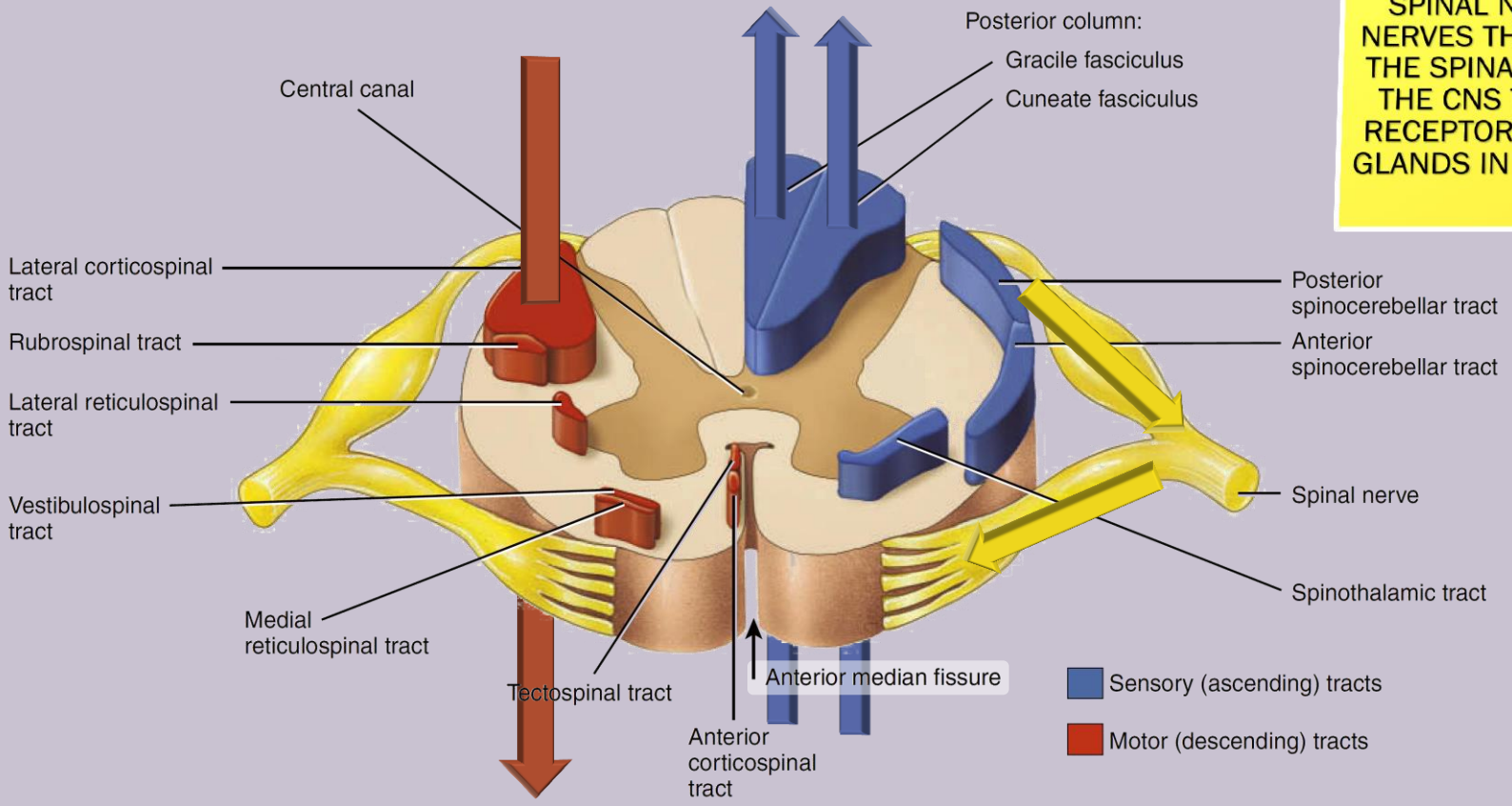
OBJECTIVE: APPRECIATE THE TWO-WAY TRAFFIC ALONG THE SPINAL CORD

THE WHITE MATTER OF THE SPINAL CORD CONTAINS SENSORY AND MOTOR TRACTS

SENSORY TRACTS ARE THE "HIGHWAYS" FOR CONDUCTION OF SENSORY NERVE IMPULSES TOWARD THE BRAIN

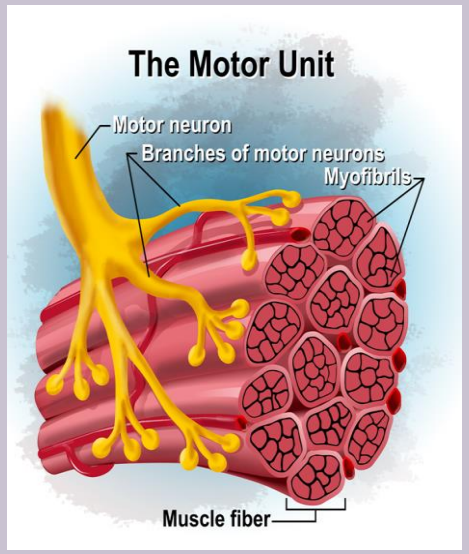
MOTOR TRACTS ARE THE "HIGHWAYS" FOR CONDUCTION OF MOTOR NERVE IMPULSES FROM THE BRAIN TOWARD EFFECTOR TISSUES

SPINAL NERVES AND THE NERVES THAT BRANCH FROM THE SPINAL CORD CONNECT THE CNS TO THE SENSORY RECEPTORS, MUSCLES, AND GLANDS IN ALL PARTS OF THE BODY.



THE ORGANIZATION OF THE SPINAL CORD FOR MOTOR FUNCTIONS(ANTERIOR HORN CELLS& INTERNEURONS& NEURONAL POOLS)

- Anterior Horn Cells: ***alpha motor neurons*** and ***gamma motor neurons.***
- Located in each segment of the anterior horns of the cord gray matter , several thousand neurons that are 50 to 100 percent larger than others *neurons , the send motor fibers to innervate the skeletal muscle.*



- ***1-Alpha motor neurons:_***
- -They give rise to large type A alpha (Aa) motor nerve
- fibers, 14 micrometers in diameter; innervate the large
- skeletal muscle fibers called extrafusal fibers

-Q-What is the motor unit?

2-Gamma motor neurons:-

Along with the alpha motor neurons,are smaller *gamma motor neurons*

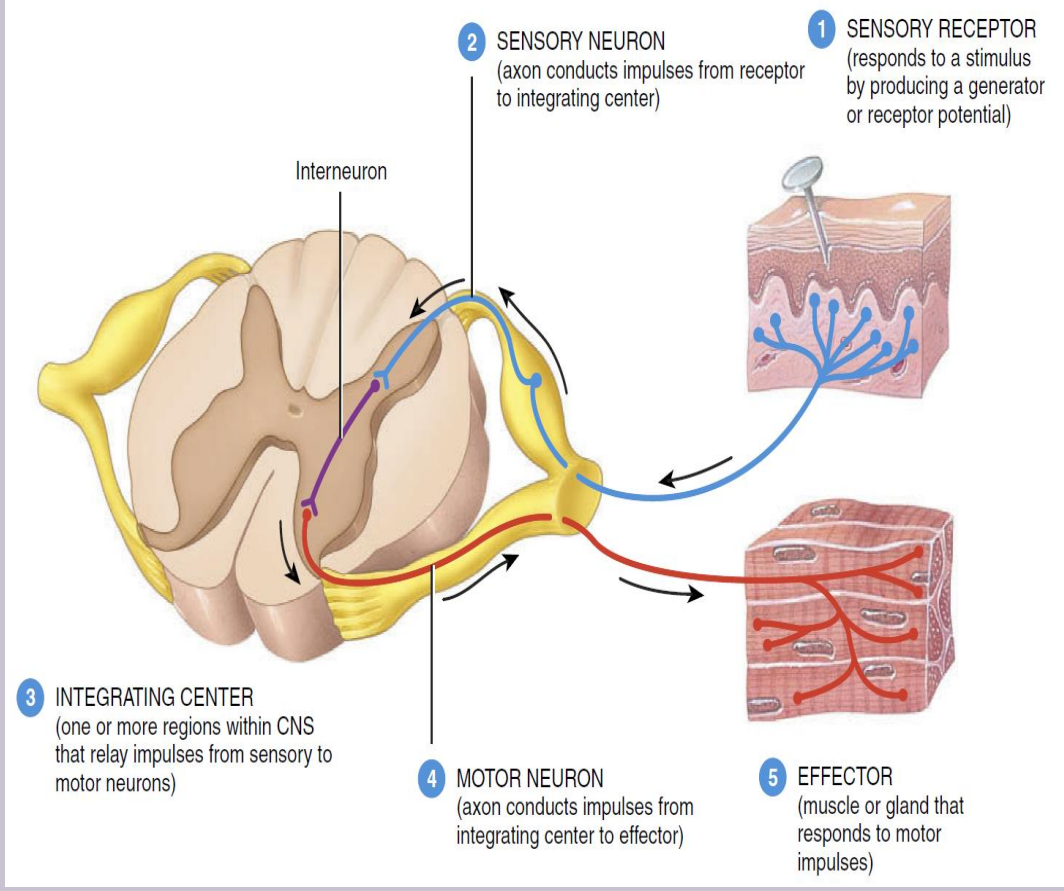
-They transmit impulses through much smaller type A gamma motor nerve fibers, 5 micrometers in diameter, which go to special skeletal muscle fibers called intrafusal fibers

Spinal reflexes

What is a reflex?

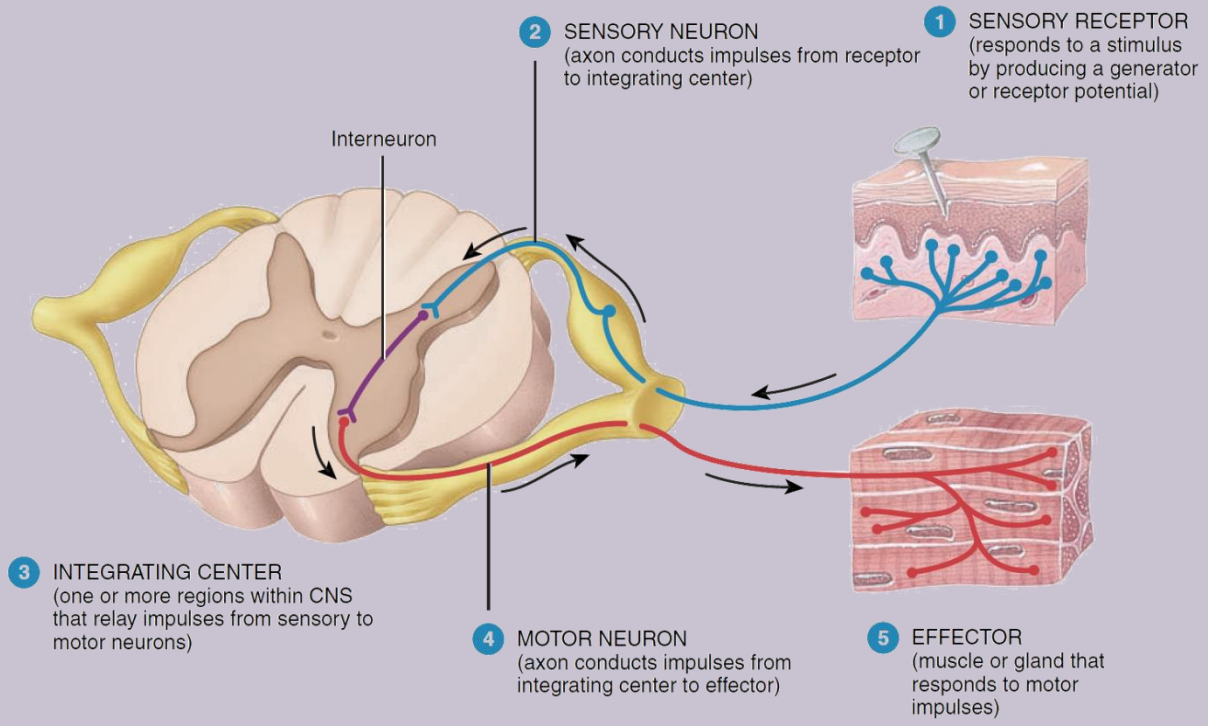
-Functional unit of CNS, rapid, automatic ,involuntary response to a stimulus

-example/pinprick causes withdrawal. R



The reflex arc & its components

REFLEX ARC IS THE PATHWAY FOLLOWED BY NERVE IMPULSES THAT PRODUCE A REFLEX (REFLEX CIRCUIT)



A REFLEX ARC INCLUDES FIVE FUNCTIONAL COMPONENTS

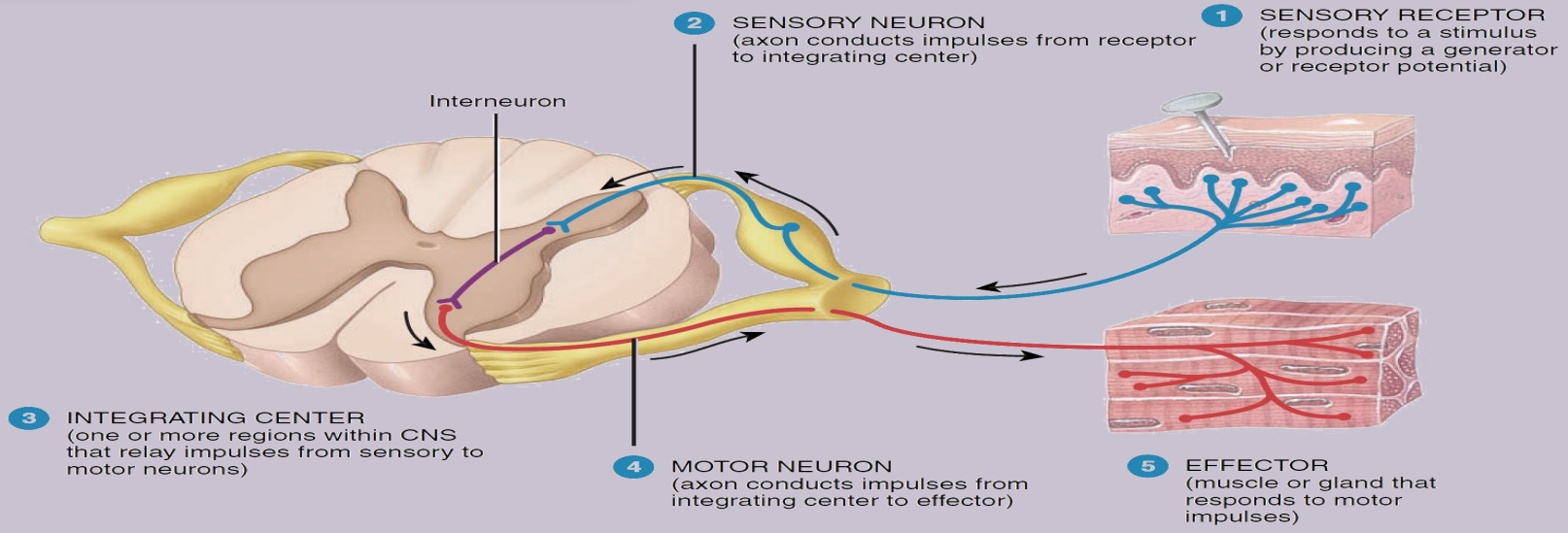
- SENSORY RECEPTOR
- SENSORY NEURON
- INTEGRATING CENTER
- MOTOR NEURON
- EFFECTOR

COMPONENTS OF REFLEX ARC

1-SENSORY RECEPTOR |

IF A GENERATOR POTENTIAL REACHES THE THRESHOLD LEVEL OF DEPOLARIZATION, IT WILL TRIGGER ONE OR MORE NERVE IMPULSES IN THE SENSORY NEURON

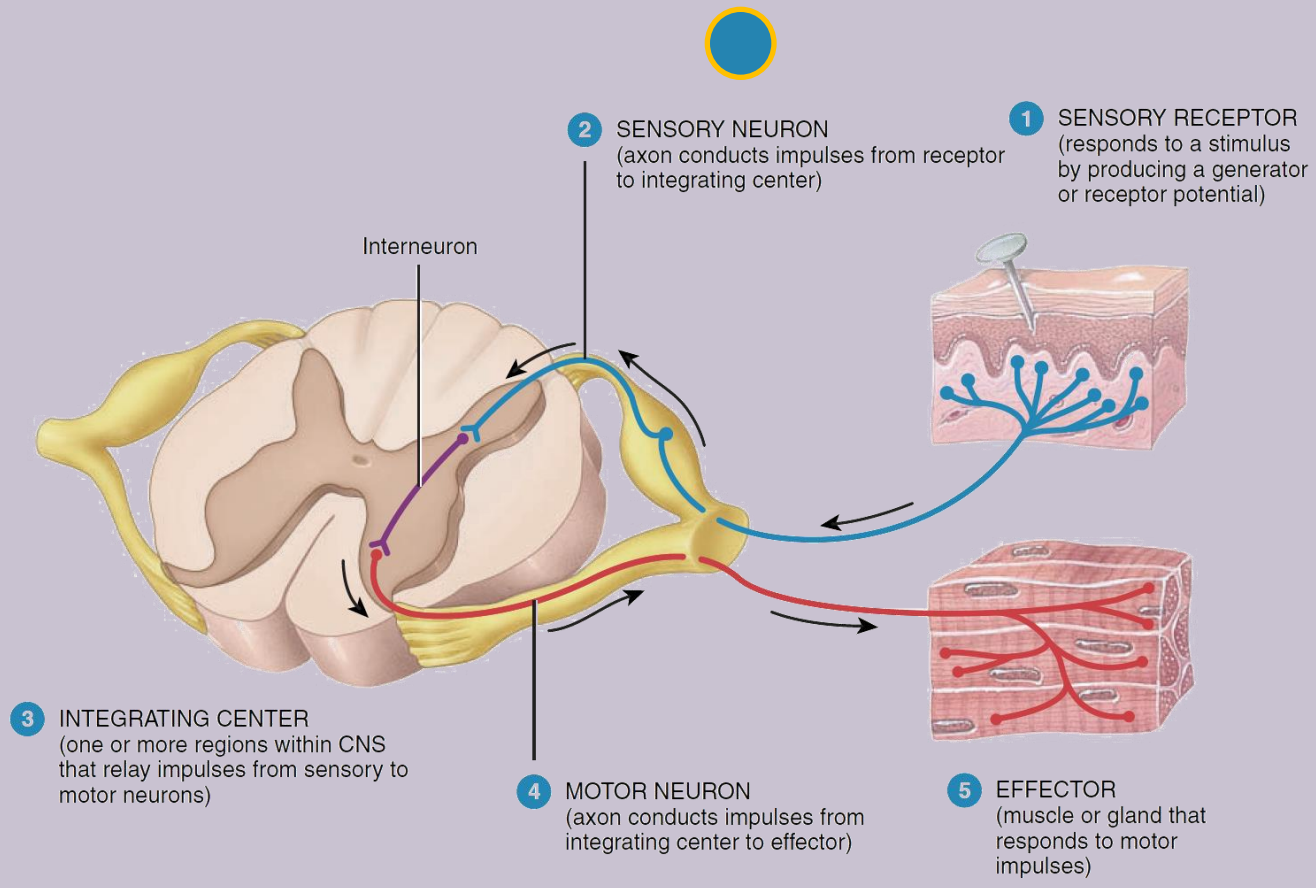
IT RESPONDS TO A SPECIFIC STIMULUS—A CHANGE IN THE INTERNAL OR EXTERNAL ENVIRONMENT—BY PRODUCING A GRADED POTENTIAL CALLED A GENERATOR (OR RECEPTOR) POTENTIAL



SENSORY NEURON |2|

THE NERVE IMPULSES PROPAGATE FROM THE SENSORY RECEPTOR ALONG THE AXON OF THE SENSORY NEURON TO THE AXON TERMINALS, WHICH ARE LOCATED IN THE GRAY MATTER OF THE SPINAL CORD OR BRAIN STEM.

RELAY NEURONS SEND NERVE IMPULSES TO THE AREA OF THE BRAIN THAT ALLOWS CONSCIOUS AWARENESS THAT THE REFLEX HAS OCCURRED.OR IT SEND TO MOTOR NEURON OR INTERNEURON



INTEGRATING CENTRE|3|

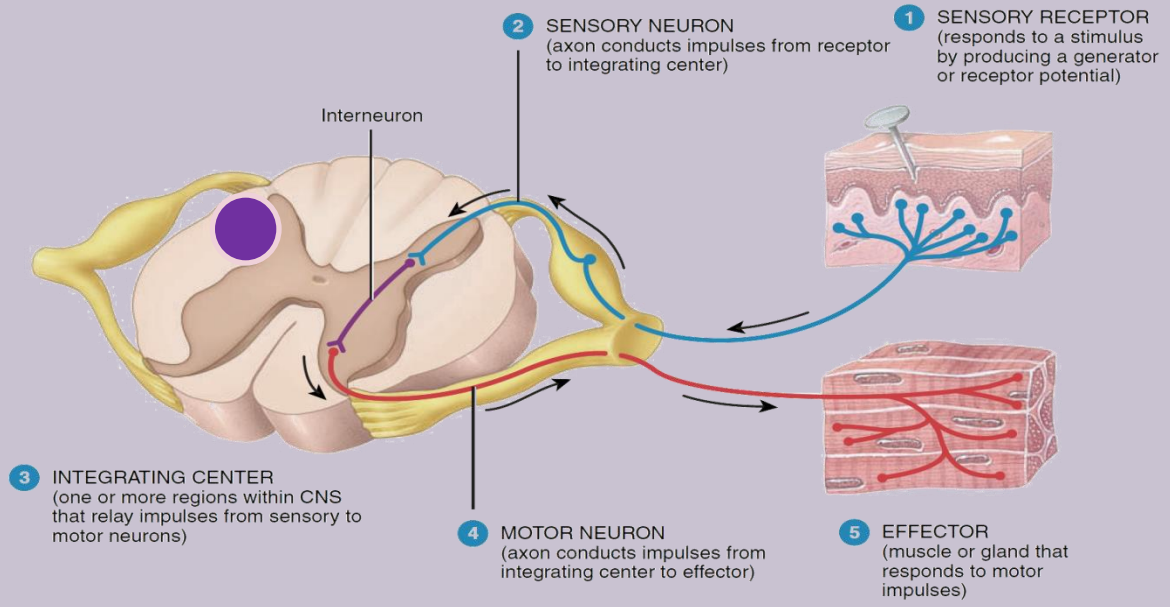
ONE OR MORE N EURONS GRAY MATTER WITHIN THE SPINAL CORD ACTS AS AN INTEGRATING CENTER.

IN THE SIMPLEST TYPE OF REFLEX, THE INTEGRATING CENTER IS A SINGLE SYNAPSE BETWEEN A SENSORY NEURON AND A MOTOR NEURON.

A REFLEX PATHWAY HAVING ONLY ONE SYNAPSE IN THE CNS IS TERMED A MONOSYNAPTIC REFLEX ARC

MORE OFTEN, THE INTEGRATING CENTER CONSISTS OF ONE OR MORE INTERNEURONS, WHICH MAY RELAY IMPULSES TO OTHER INTERNEURONS AS WELL AS TO A MOTOR NEURON.

A POLYSYNAPTIC REFLEX ARC INVOLVES MORE THAN TWO TYPES OF NEURONS AND MORE THAN ONE CNS SYNAPSE.



- Interneurons & interneuron pool

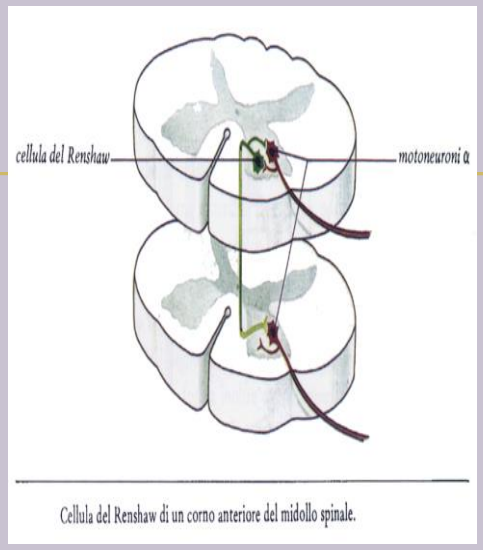
- Interneurons are present in the gray matter in the dorsal horns, the anterior horns, and the intermediate areas between them.
- -These cells are about 30 times as numerous as the anterior motor neurons, small and highly excitable, often exhibiting spontaneous activity

- Different types of neuronal circuits are found in the interneuron pool **(parallel and reverberating circuits).**

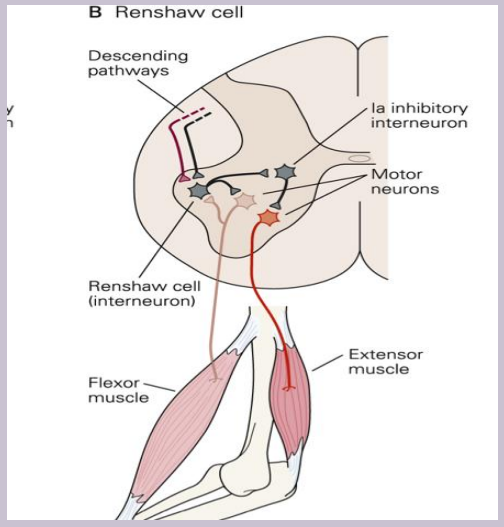
- They are **(excitatory or inhibitory).**

Renshaw Cells :-

- - Small interneurons located in the anterior horns of the spinal cord, in close association with the motor neurons.
- - AHCs axon leaves the body of the neuron, sends collateral branches to adjacent Renshaw cells.
- - These inhibitory cells transmit inhibitory signals to the surrounding motor neurons by Lateral inhibition.
- -This lateral inhibition helps to **focus or sharpen the signals from each motor neuron**



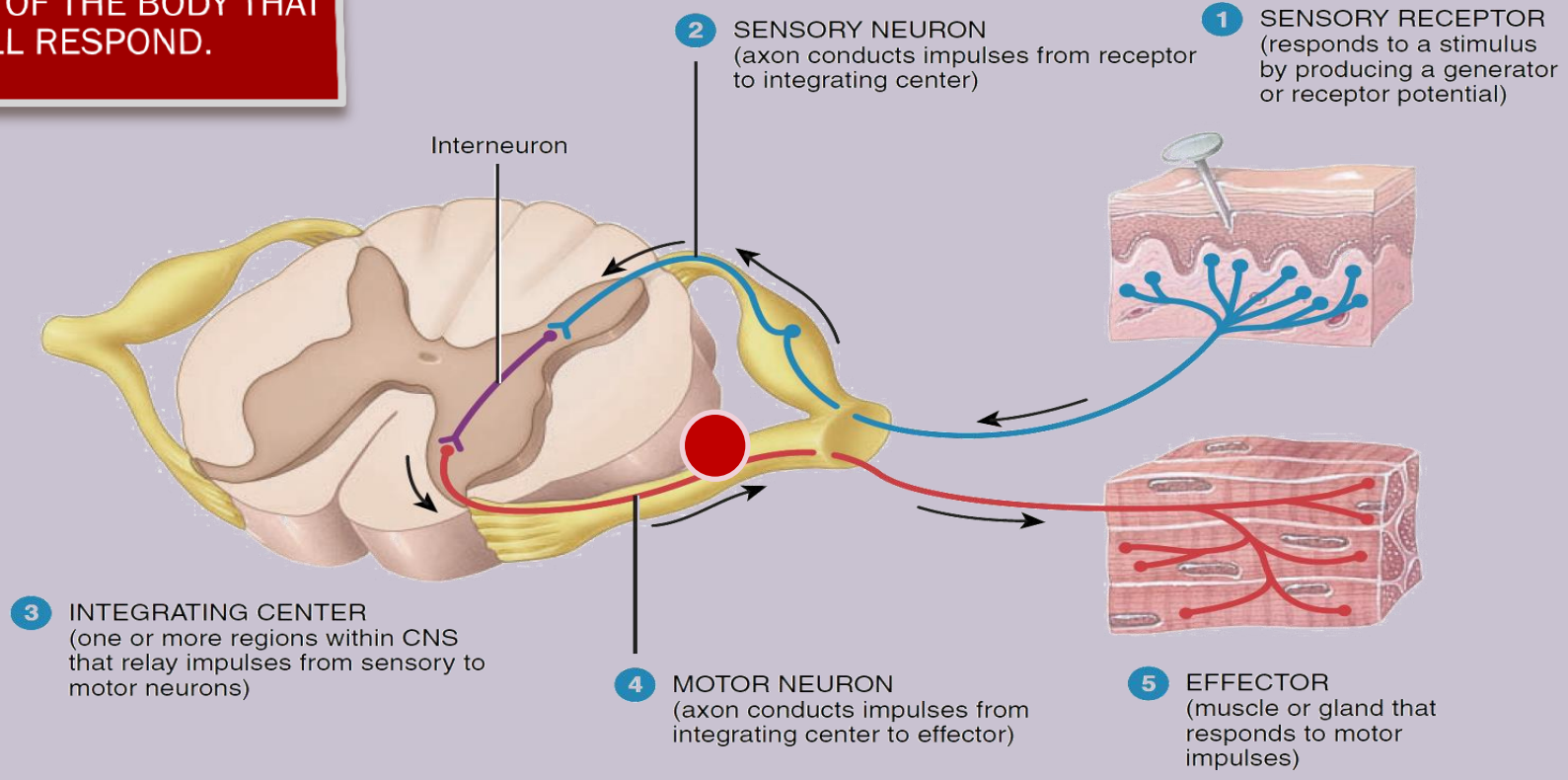
Cellula del Renshaw di un corno anteriore del midollo spinale.



MOTOR NEURON|4|

-EFFERENT NEURON

IMPULSES TRIGGERED BY THE INTEGRATING CENTER PROPAGATE OUT OF THE CNS ALONG A MOTOR NEURON TO THE PART OF THE BODY THAT WILL RESPOND.



-These are Anterior Horn Cells (Motor neurons) of spinal cord supplying skeletal muscle:

1. **alpha motor neurons :- large cells, with large mylinated fibres (axons) form 70% of ventral root - supply extrafusal muscle fibres (2/3 Of skeletal muscle fibers)**

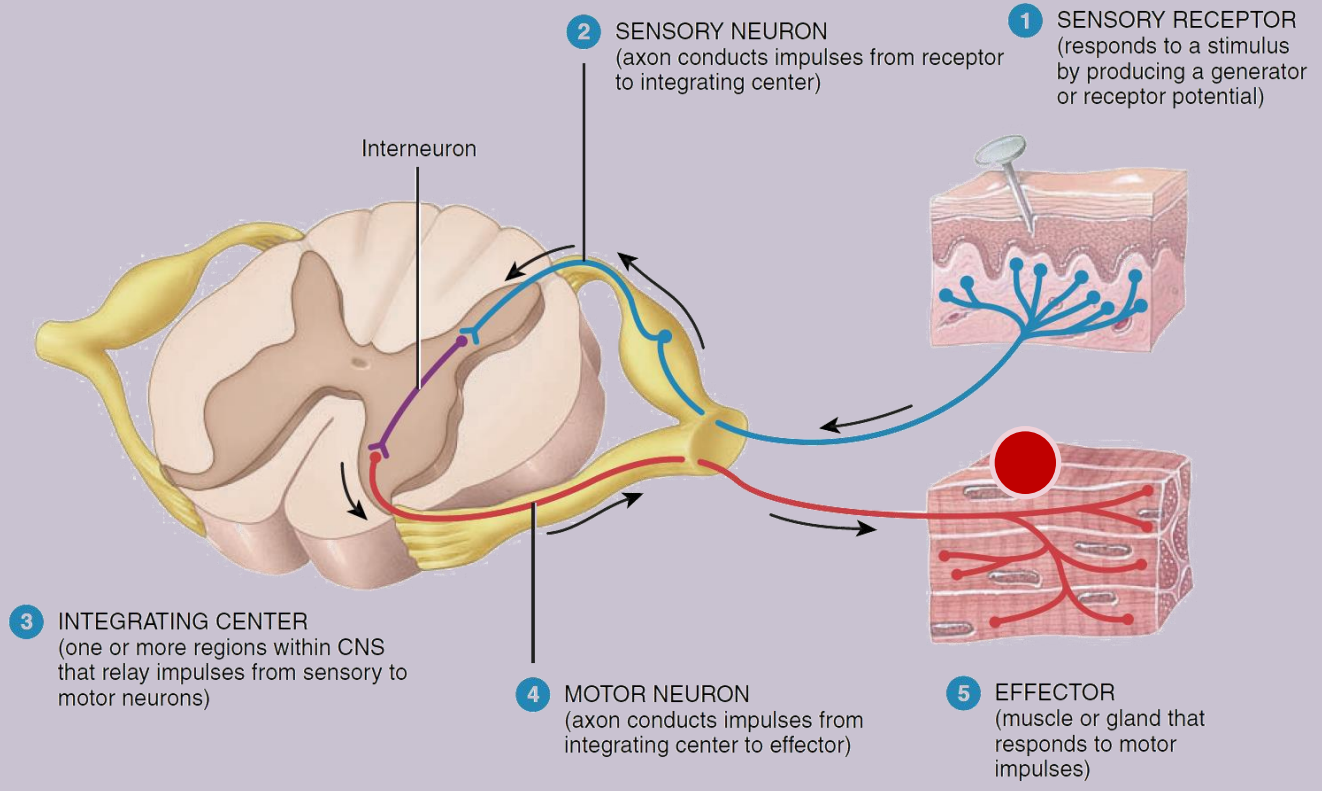
2. **Gamma motor neurons :- smaller cells- with small axons form 30 % of ventral root - supply intrafusal muscle fibres (muscle spindles=1/3 Of skeletal muscle fibers)**

EFFECTOR|5|

THE PART OF THE BODY THAT RESPONDS TO THE MOTOR NERVE IMPULSE, SUCH AS A MUSCLE OR GLAND, IS THE EFFECTOR.

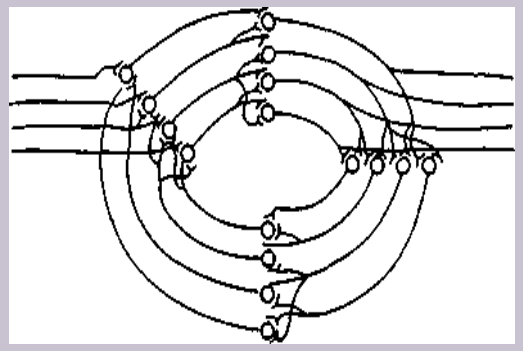
ITS ACTION IS CALLED A REFLEX.

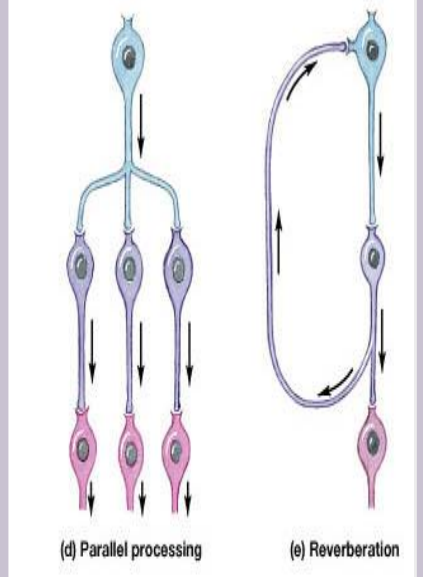
IF THE EFFECTOR IS SKELETAL MUSCLE, THE REFLEX IS A SOMATIC REFLEX. IF THE EFFECTOR IS SMOOTH MUSCLE, CARDIAC MUSCLE, OR A GLAND, THE REFLEX IS AN AUTONOMIC (VISCERAL) REFLEX.



NEURONAL POOL CIRCUITS

1- PARALLEL
2-REVERBRATING

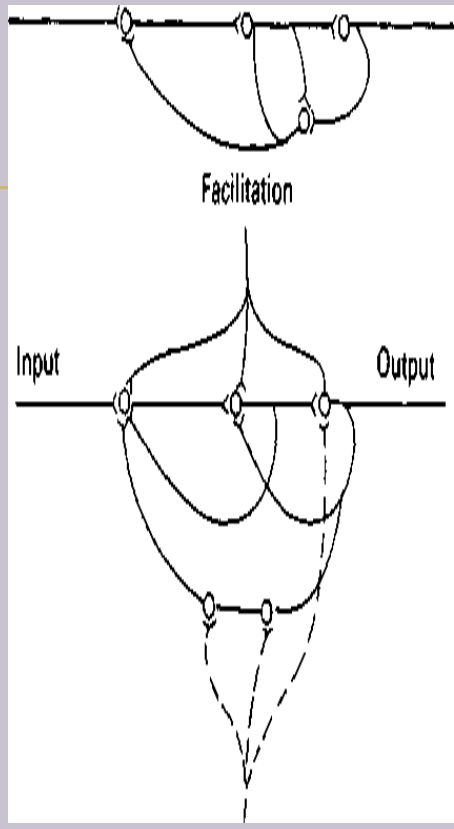


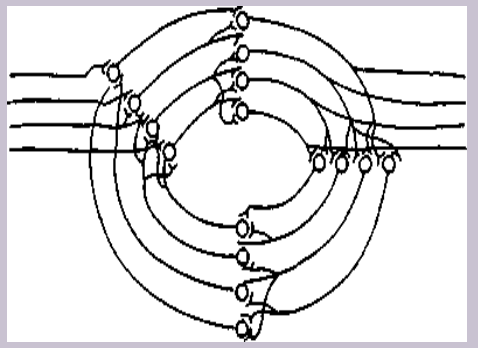


1-Parallel circuits //afferent and efferent are parallel to each other (input parallel to output)

4-Reverberatory *Circuit*

- *1-.The simplest reverberatory circuits* involves only a single neuron, the out put neuron sends a collateral nerve fiber back to its own dendrites or soma to restimulate the input neuron itself & so the circuit may discharge repetitively for a long time and causes **signal prolongation** –
- -Amore complex circuits in which both facilitatory and inhibitory fibers involved on the reverberating circuit.
- A facilitatory signal enhances the intensity and frequency of reverberation, whereas an inhibitory signal depresses or stops the reverberation.
- - Most reverberating pathways are constituted of many parallel fibers





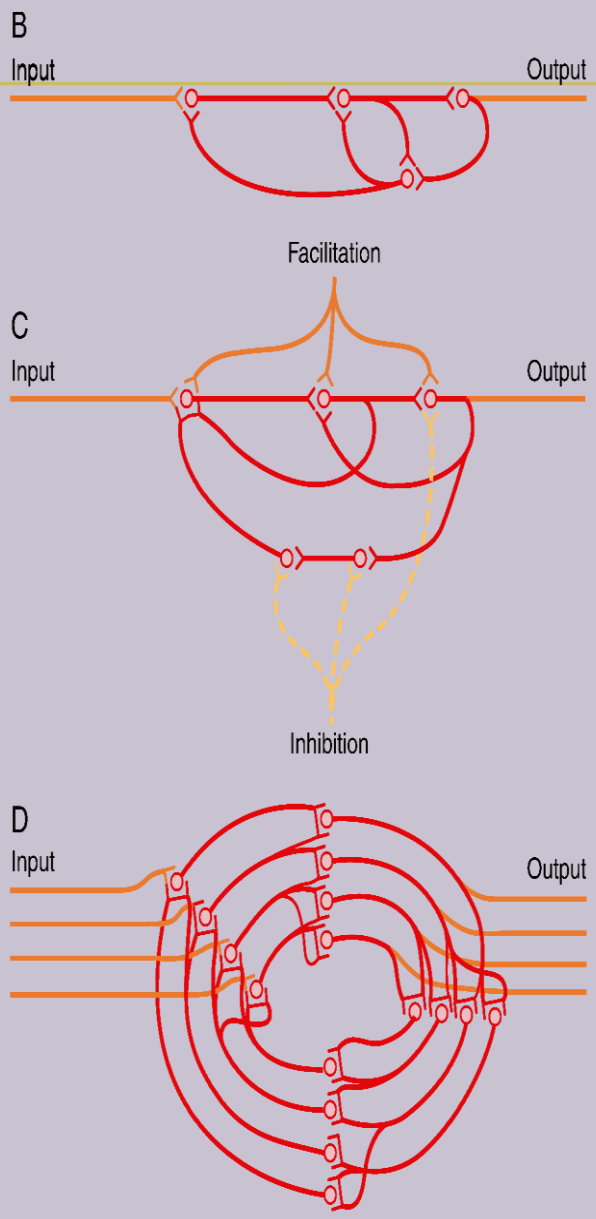
B SHOWS A FEW ADDITIONAL NEURONS IN THE FEEDBACK CIRCUIT, WHICH CAUSES A LONGER DELAY BETWEEN INITIAL DISCHARGE AND THE FEEDBACK SIGNAL.

C SHOWS A STILL MORE COMPLEX SYSTEM IN WHICH BOTH FACILITATORY AND INHIBITORY FIBRES INTERACT IN THE REVERBERATING CIRCUIT.

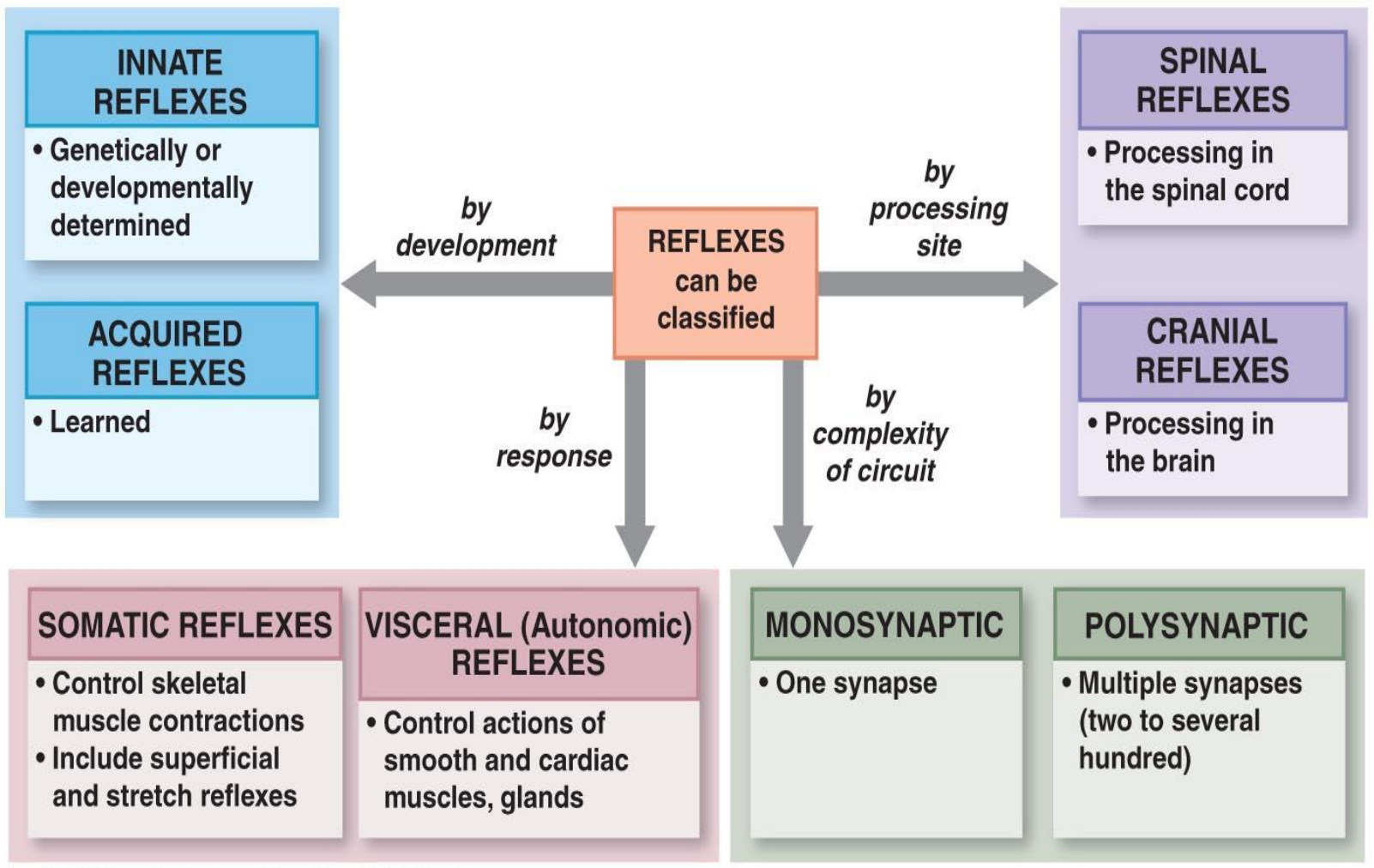
- A FACILITATORY SIGNAL ENHANCES THE INTENSITY AND FREQUENCY OF REVERBERATION,
- AN INHIBITORY SIGNAL DEPRESSES OR STOPS THE REVERBERATION.

D SHOWS THAT MOST REVERBERATING PATHWAYS ARE CONSTITUTED OF MANY PARALLEL FIBRES.

- IN SUCH A SYSTEM, THE TOTAL REVERBERATING SIGNAL CAN BE EITHER WEAK OR STRONG, DEPENDING ON HOW MANY PARALLEL NERVE FIBRES ARE MOMENTARILY INVOLVED IN THE REVERBERATION.



Classification of reflexes



DESCRIBE THE GENERAL PROPERTIES OF *REFLEXES* AND THEIR NEURONAL POOLS SUCH AS

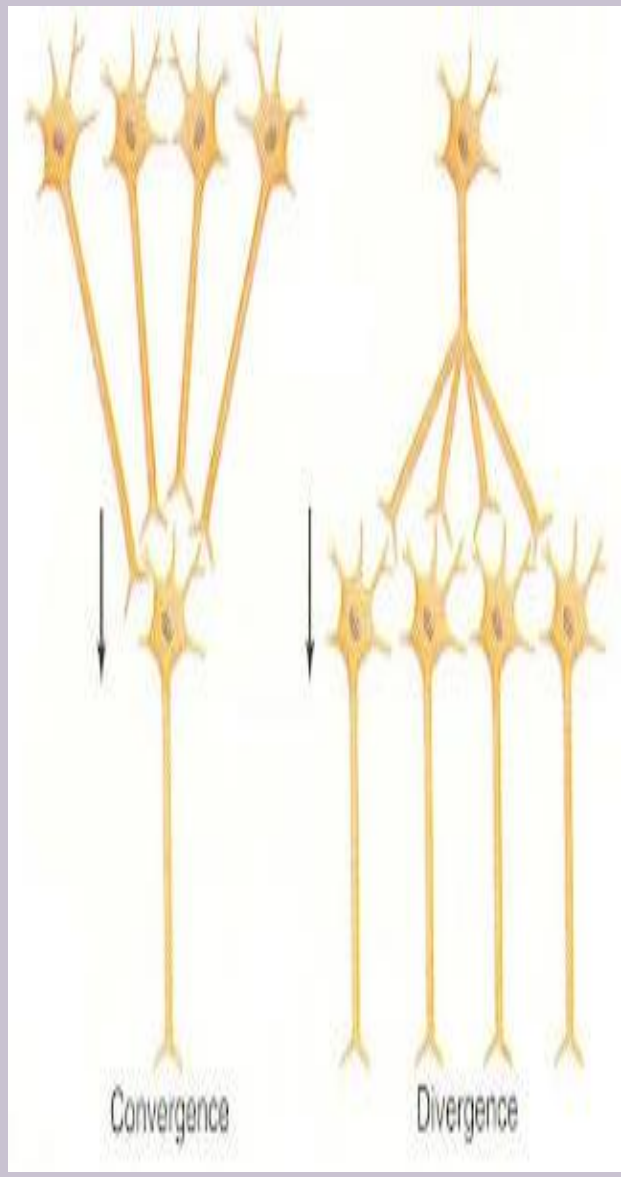
CONVERGENCE	DIVERGENCE	IRRADIATION
RECRUITMENT	REVERBERATING CIRCUITS	AFTER-DISCHARGE
MINIMAL SYNAPTIC DELAY	CENTRAL DELAY	REFLEX TIME

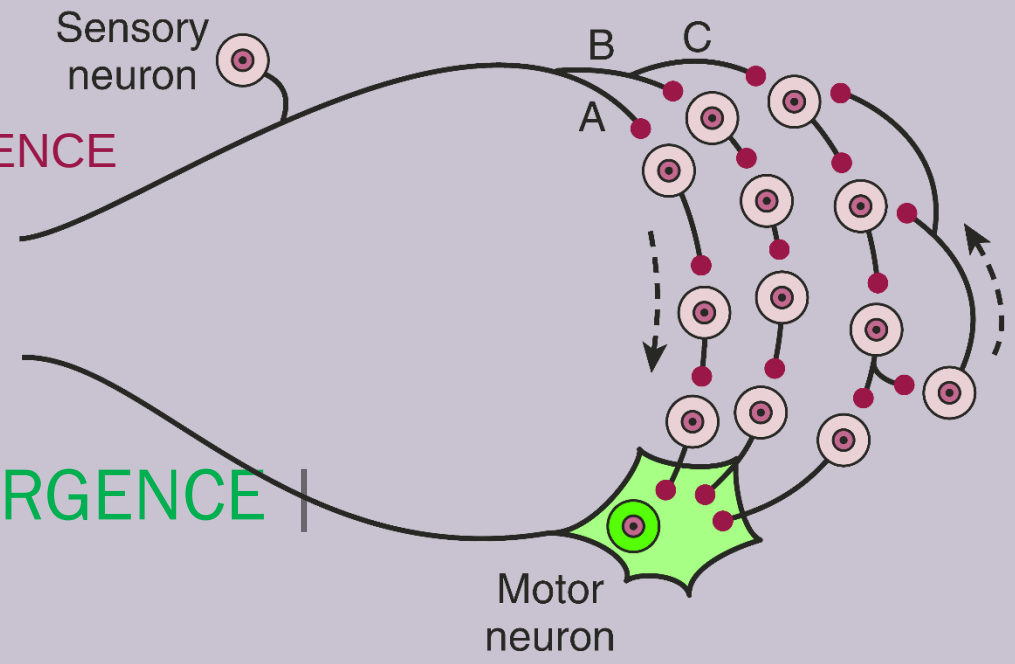
- **DIVERGENCE&CONVERGENCE**
- **Sensory afferent enter spinal cord via dorsal(posterior) root, as they enter the neuronal pool undergo:**

1- Divergence help to spread a single stimulus to a wide area of the spinal cord, it is important for weak signals entering a neuronal pool to excite far greater numbers of nerve fibers leaving the pool.

2-Convergence :- signals from multiple inputs uniting to excite a single neuron multiple action potentials converging on the neuron from multiple terminals provide enough spatial summation to bring the neuron to the threshold required for discharge.

(multiple stimuli summate & collect together at the same time)





- CONVERGENCE

OUTPUT FROM ONE NEURON ONTO MANY.

EACH POSTSYNAPTIC NEURON RECEIVES INPUT FROM THE SAME PRESYNAPTIC NEURON, BUT MAY REACT TO IT DIFFERENTLY.

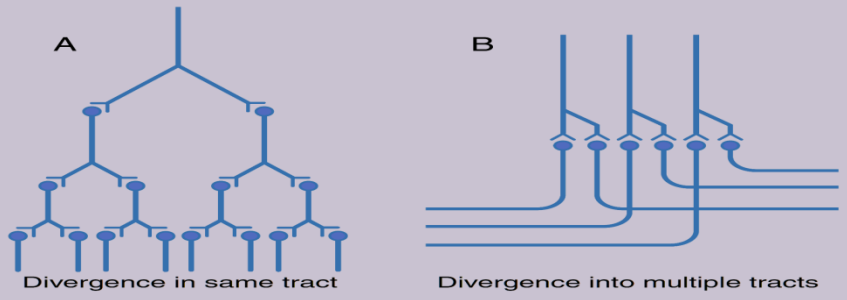
IN A DIVERGENT NEURAL CIRCUIT, THE AXON OF ONE NEURON BRANCHES TO SEND INFORMATION TO MULTIPLE TARGET NEURONS.

DIVERGENT OUTPUT ALLOWS THE SAME SIGNAL TO REACH MANY DIFFERENT NEURONS.

1-DIVERGENCE

A | DIVERGENCE WITHIN A PATHWAY TO CAUSE AMPLIFICATION OF THE SIGNAL

B | DIVERGENCE INTO MULTIPLE TRACTS TO TRANSMIT THE SIGNAL TO SEPARATE AREAS.

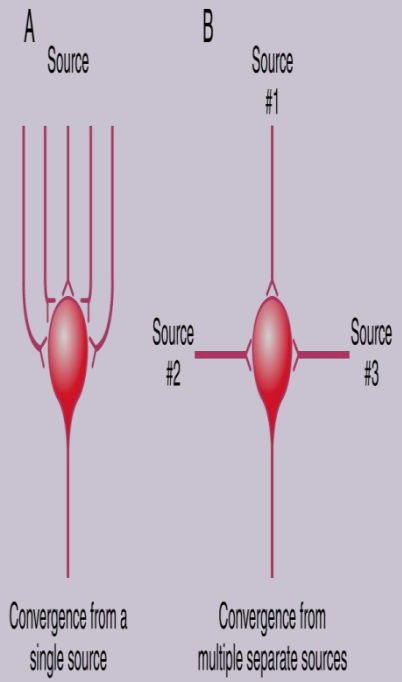


2-CONVERGENCE

CONVERGENCE OF MULTIPLE INPUT FIBRES ONTO A SINGLE NEURON.

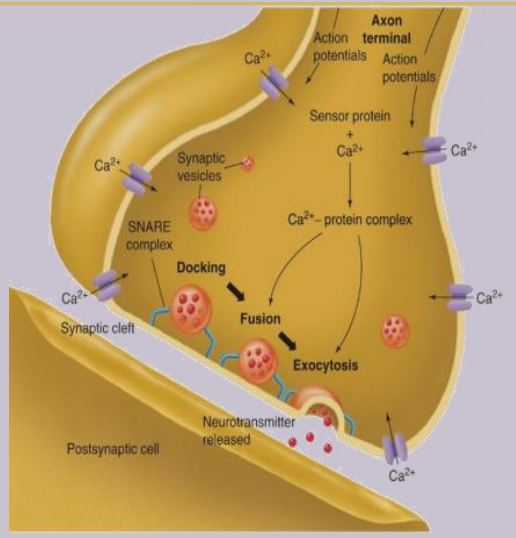
A | MULTIPLE INPUT FIBRES FROM A SINGLE SOURCE

B | INPUT FIBRES FROM MULTIPLE SEPARATE SOURCES



5-AFTER-DISCHARGE:-

- A signal entering a pool causes a prolonged output discharge of AHCs called **afterdischarge,** lasting a few millisec-onds to as long as many minutes after
- the incoming signal is over.

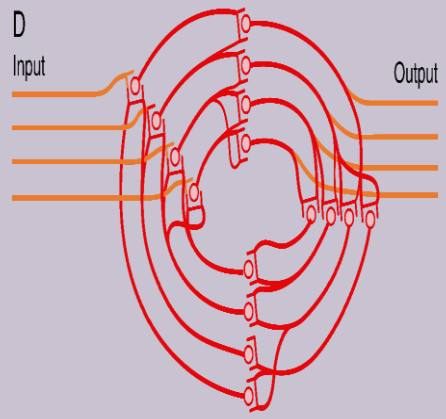


- After- discharge occurs due to the following:-

- **1-Synaptic After-discharge.**

When excitatory synapses discharge on the surfaces of dendrites or soma of a neuron, a postsynaptic electrical potential (PSP) develops in the neuron and lasts for many milliseconds.

--it can continue to excite the neuron, causing it to transmit a series of repetitive discharges, this cause maintained reflex action & response continue for some time after cessation of stimulus)



- **2- Reverbrating circuits** restimulate AHCs

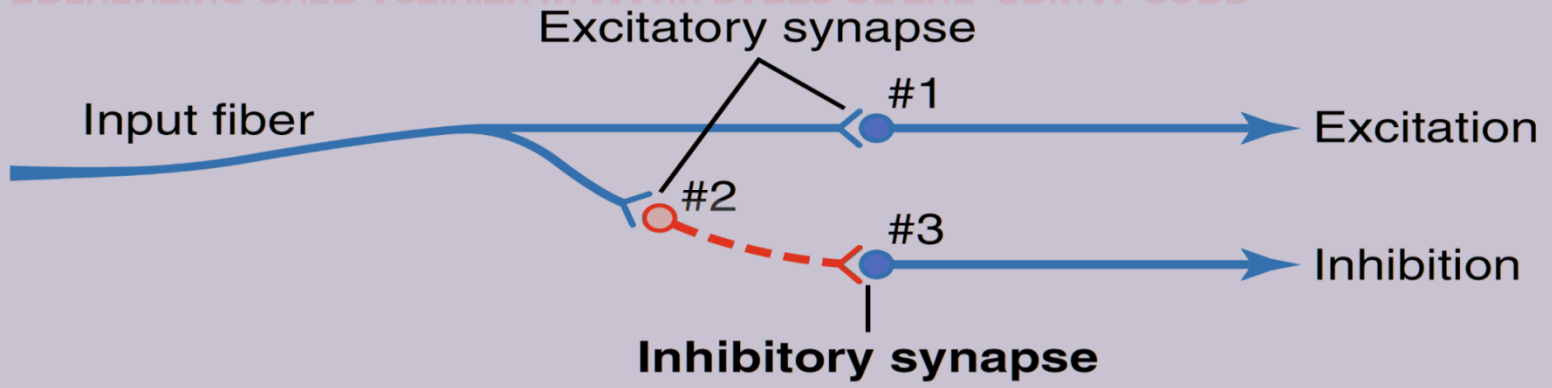
3-Reciprocal inhibition circuits

-stimulation of flexors muscle accompanied by inhibition of extensors through inhibitory interneurons , the neuronal circuit that causes this reciprocal relation is called reciprocal innervation

-reflex contraction of an agonist muscle is accompanied by inhibition of the antagonist.

-the input fibre excites the excitatory output pathway, but it stimulates an intermediate *inhibitory neuron* (neuron 2), which secretes a different type of transmitter substance to inhibit the second output pathway from the pool.

-PREVENTING OVER ACTIVITY IN MANY PARTS OF THE SPINAL CORD.



6-SYNAPTIC DELAY (CENTRAL DELAY)

-Is the time of reflex to pass through neurons of the spinal cord

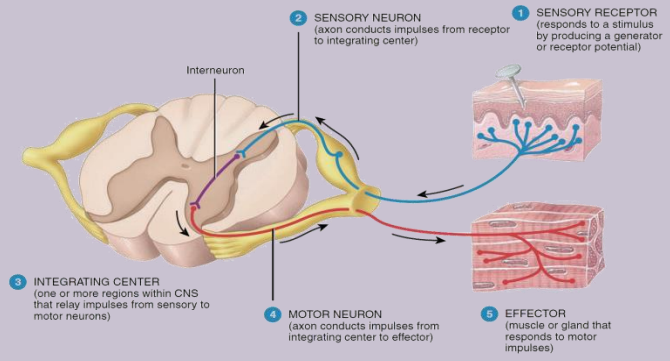
-

- the minimal period of time required for transmission of a neuronal signal from a presynaptic neuron to a postsynaptic neuron is the **SYNAPTIC DELAY**.

-Equals 0.5 ms /synapse (it is long in polysynaptic reflex).
- it is > 2 MS in the withdrawal reflex (polysynaptic reflex)

-NUMBER OF SYNAPSES IN A REFLEX = CENTRAL DELAY / 0.5MS

-for knee jerk it equals 0.6 msc = one synapse



Reaction time = reflex time = central delay + time spent in conduction of impulses along the afferent and efferent nerves

THE TIME BETWEEN THE APPLICATION OF THE STIMULUS AND THE RESPONSE IS CALLED THE **REACTION TIME**

IN HUMANS, THE REACTION TIME FOR A STRETCH REFLEX SUCH AS THE KNEE JERK IS 19–24 MS.

THE CONDUCTION VELOCITIES OF THE AFFERENT AND EFFERENT FIBRE TYPES ARE KNOWN AND THE DISTANCE FROM THE MUSCLE TO THE SPINAL CORD CAN BE MEASURED

- THIS IS RESPONSIBLE FOR MOST OF THE REACTION TIME

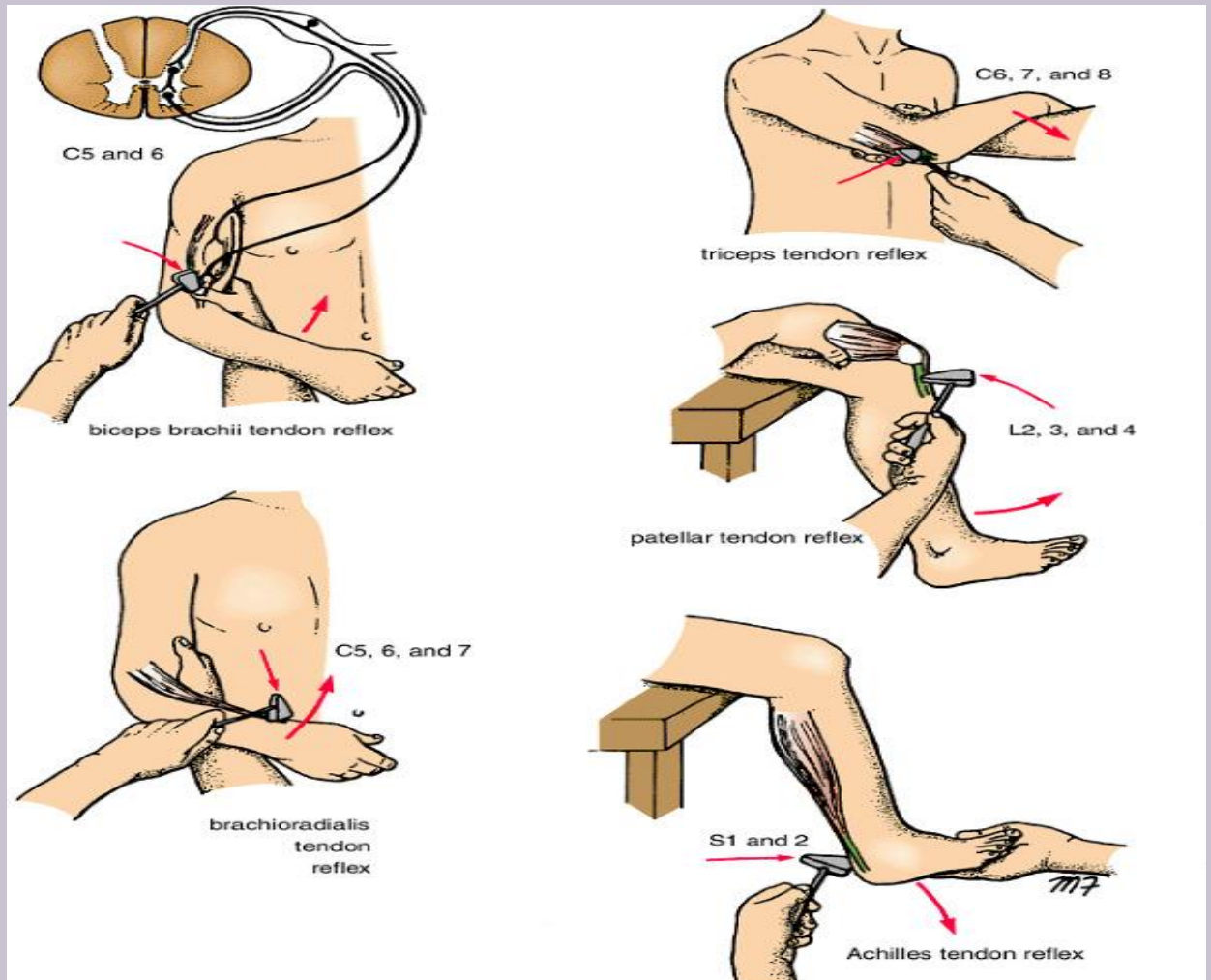
Types of spinal reflexes

-According to number of neurons:-

- **Monosynaptic**
  - Sensory axon (afferent)synapse directly with anterior horn cell- (No interneuron)

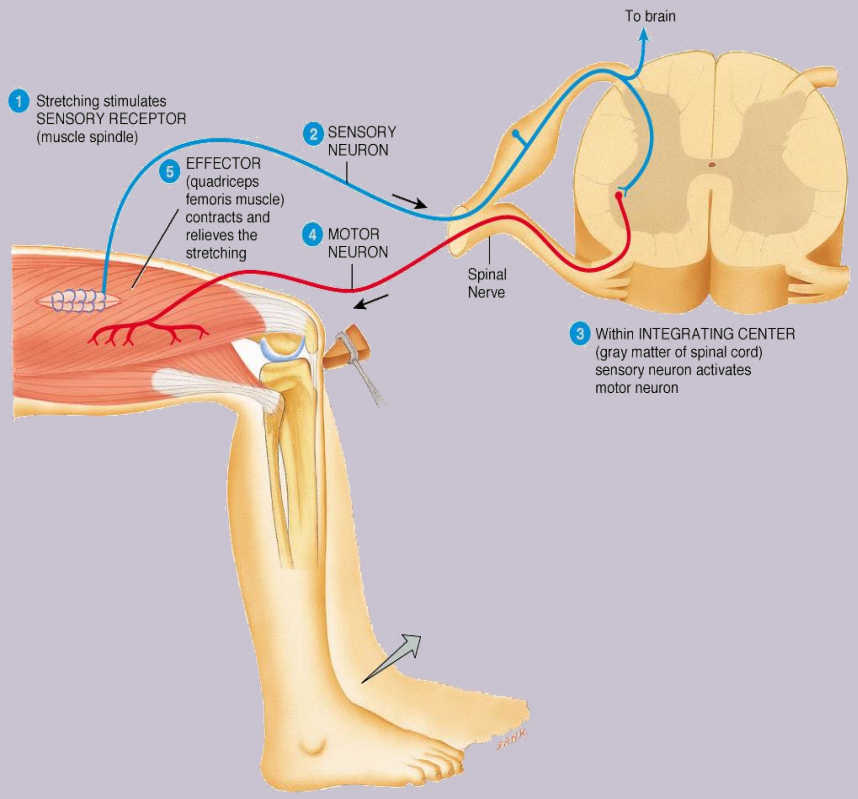
    Ex.Stretch reflex
- **Polysynaptic**
  - Sensory axon (afferent)synapse with one or more interneuron

    Ex.Withdarwal,abdominal reflexes, visceral,planter reflex


C5 and 6
biceps brachii tendon reflex
C6, 7, and 8
triceps tendon reflex
L2, 3, and 4
patellar tendon reflex
C5, 6, and 7
brachioradialis
tendon
reflex
S1 and 2
Achilles tendon reflex

MONOSYNAPTIC REFLEXES

As knee reflex



IN THE SIMPLEST TYPE OF REFLEX, THE INTEGRATING CENTER IS A SINGLE SYNAPSE BETWEEN A SENSORY NEURON AND A MOTOR NEURON.

WHEN A REFLEX ARC CONSISTS OF ONLY TWO NEURONS IN AN ANIMAL (ONE SENSORY NEURON, AND ONE MOTOR NEURON), IT IS DEFINED AS MONOSYNAPTIC.

Classification of reflexes

-According to site of the receptor:-

(A)Deep Reflexes:- by stimulation of receptors deep in muscle and tendons

(1) Stretch Reflexes (Tendon jerks) ,they are monosynaptic : such as knee-jerk (patellar reflex) and ankle jerk .

The receptor for all these is the muscle spindle (is located deep within the muscle itself

(2) Inverse Stretch Reflex (Golgi Tendon organ reflex) , polysynaptic :

The receptor is called Golgi Tendon Organ present deep in the muscle tendon

Also there are

-Extensor Standing/Posture/Stepping

• Rhythmic Walking/Scratching

(B) Superficial Reflexes

Are polysynaptic reflexes . The receptor are superficial in the skin . Examples are

Withdrawal, abdominal reflexes and plantar reflex

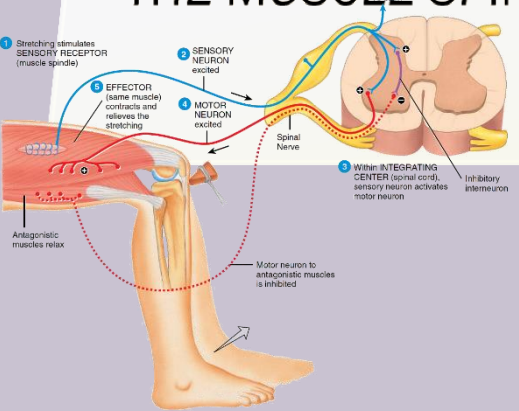
©Visceral(autonomic)-by stimulation of receptors in wall of viscera

As Micturition, defecation

SUPERFICIAL AND DEEP REFLEXES

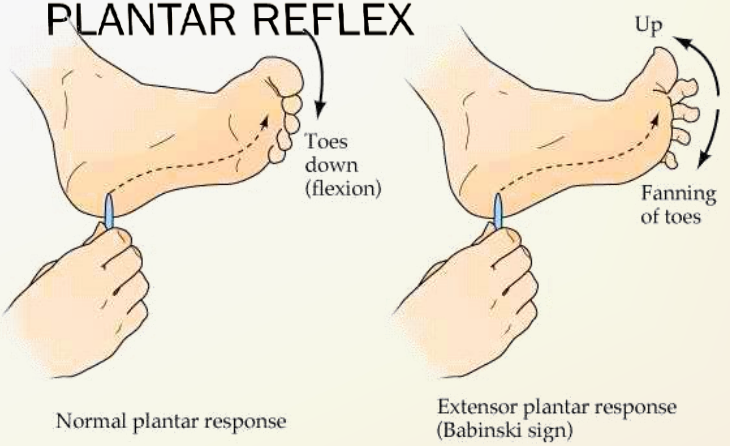
DEEP REFLEXES

- BY STIMULATION OF RECEPTORS DEEP IN MUSCLE AND TENDONS
- EXAMPLES ARE
  - STRETCH REFLEXES (TENDON JERKS)
  - KNEE-JERK (PATELLAR REFLEX)
  - ANKLE JERK .
- THE RECEPTORS FOR THESE ARE THE MUSCLE SPINDLE



SUPERFICIAL REFLEXES

- THE RECEPTORS ARE SUPERFICIAL IN THE SKIN .
- EXAMPLES ARE WITHDRAWAL, ABDOMINAL REFLEXES AND PLANTAR REFLEX



Withdrawal reflex(flexor reflex) (nociceptive reflex)

-A **superficial polysynaptic** reflex

Stimulation of pain receptors of hand(a pin- prick, heat, or a wound)>>>>>> **impulses to SC in A delta or C fibres >>>>>>> interneurons pool >> motor neurons >> stimulate hand flexor muscles >>move the hand away from the injurious stimulus.**

characterised by :

- It involve the following basic types of circuits:

1- diverging circuits to spread the reflex to the necessary muscles for withdrawal;

(2) ***Reciprocal inhibition*** *circuits*

-Stimulation of flexors muscle accompanied by inhibition of extensors through inhibitory interneurons

*****-Reflex contraction of an agonist muscle is accompanied by inhibition of the antagonist.**

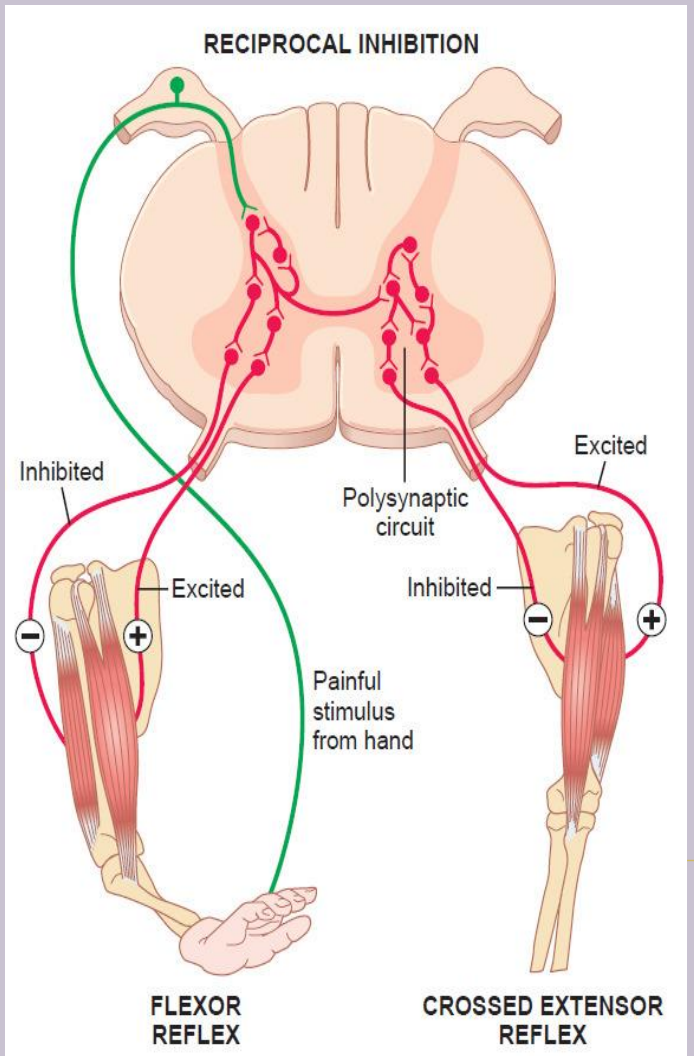
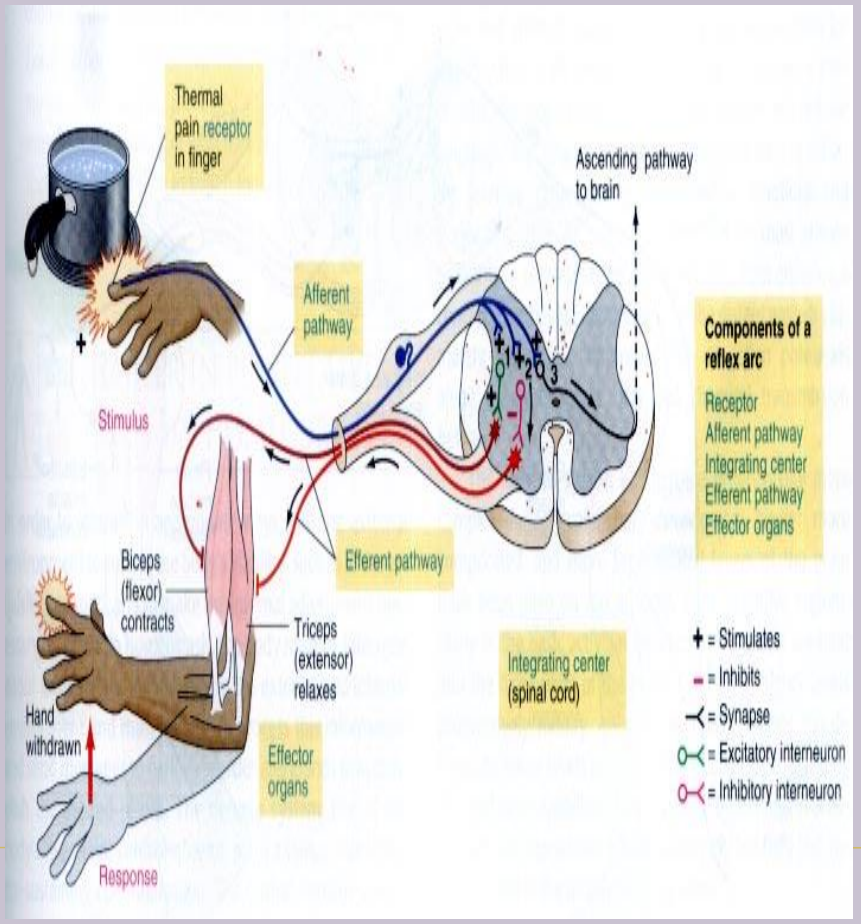


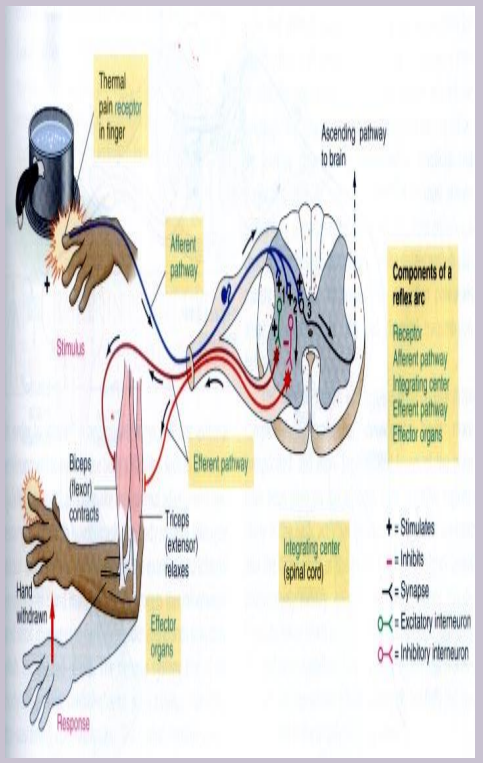
Figure 55-9. Flexor reflex, crossed extensor reflex, and reciprocal inhibition.



3- RECRUITMENT :

-Maintained repetitive stimulation of afferent nerve in a reflex causes **Gradual** activation of more number of motor neurons (AHCS)

Cause/ 1-different conduction velocities of afferents
2-different number of interneurons with short & long pathways to the motor neurons (AHCs)



Motor unit recruitment :

If a repetitive &stronger stimulus is maintained, there will be Gradual increase in the force of the muscle contraction until the maximum force is reached , due to gradual recruitment/activation of more and more motor neurons

4- After-discharge CIRCUITS:-

Circuits to cause afterdischarge lasting many fractions of a second after the stimulus is over.

-The duration of afterdischarge depends on the intensity of the sensory stimulus that elicited the reflex

Cause/

-Presence of reverberating circuit & synaptic after-discharge restimulate AHCs

-Value /prolong the protective response of reflex

5- **IRRADIATION :-** **- spread of impulses up & down to different segments and motor neurons in the S.C**

A strong stim in sensory afferent irradiate to many segments of S.C due to divergence

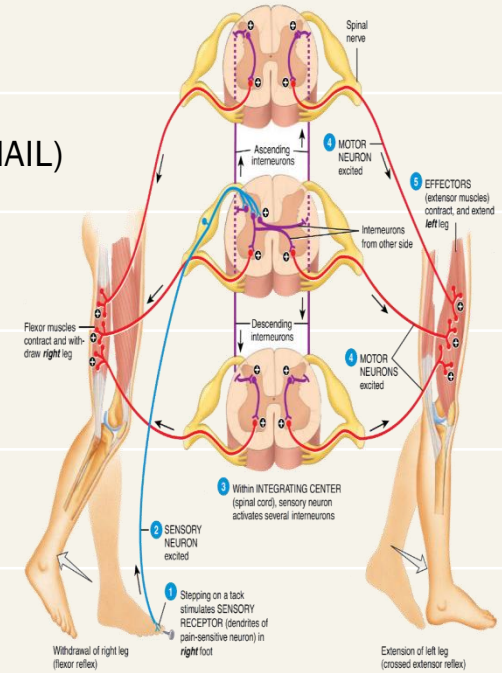
******The extent of the response in a reflex depends on the intensity of the stimulus.**

- **Weak stim-----irradiates to small number of neurons ,**
  so it causes weak flexion of limb

- **Strong stim---- irradiates to large number of neurons ,**
  so it causes strong withdrawal of affected limb &
  extension of opposite limb.(as in crossed extensor reflex)

THE WITHDRAWAL REFLEX |

REFLEX	FLEXOR REFLEX OR WITHDRAWAL REFLEX	
CLINICAL TEST | STIMULUS	SHARP PAINFUL STIMULUS (STEPPING ON NAIL)	
RESPONSE	LIMB IS RAPIDLY WITHDRAWN	
SENSORY RECEPTOR	CUTANEOUS SKIN AND PAIN RECEPTORS	
SYNAPSES INVOLVED	POLYSYNAPTIC (VIA INTERNEURON)	
EFFECTS ON MUSCLE	CONTRACTS FLEXOR MUSCLE	
OTHER EFFECTS	RELAXES (-) EXTENSOR MUSCLE OF SAME LIMB	REVERSE EFFECT ON OPPOSITE LIMB (CROSS EXTENSOR REFLEX)
FUNCTION	PROTECTIVE – WITHDRAWAL FROM PAINFUL STIMULUS	CROSS EXTENSOR AIDS IN MAINTAINING POSTURE WHEN OPPOSING LEG IS LIFTED



https://musom.marshall.edu/anatomy/grosshom/allppt/pdf/Spinalreflexes.pdf

IRRADIATION AND RECRUITMENT

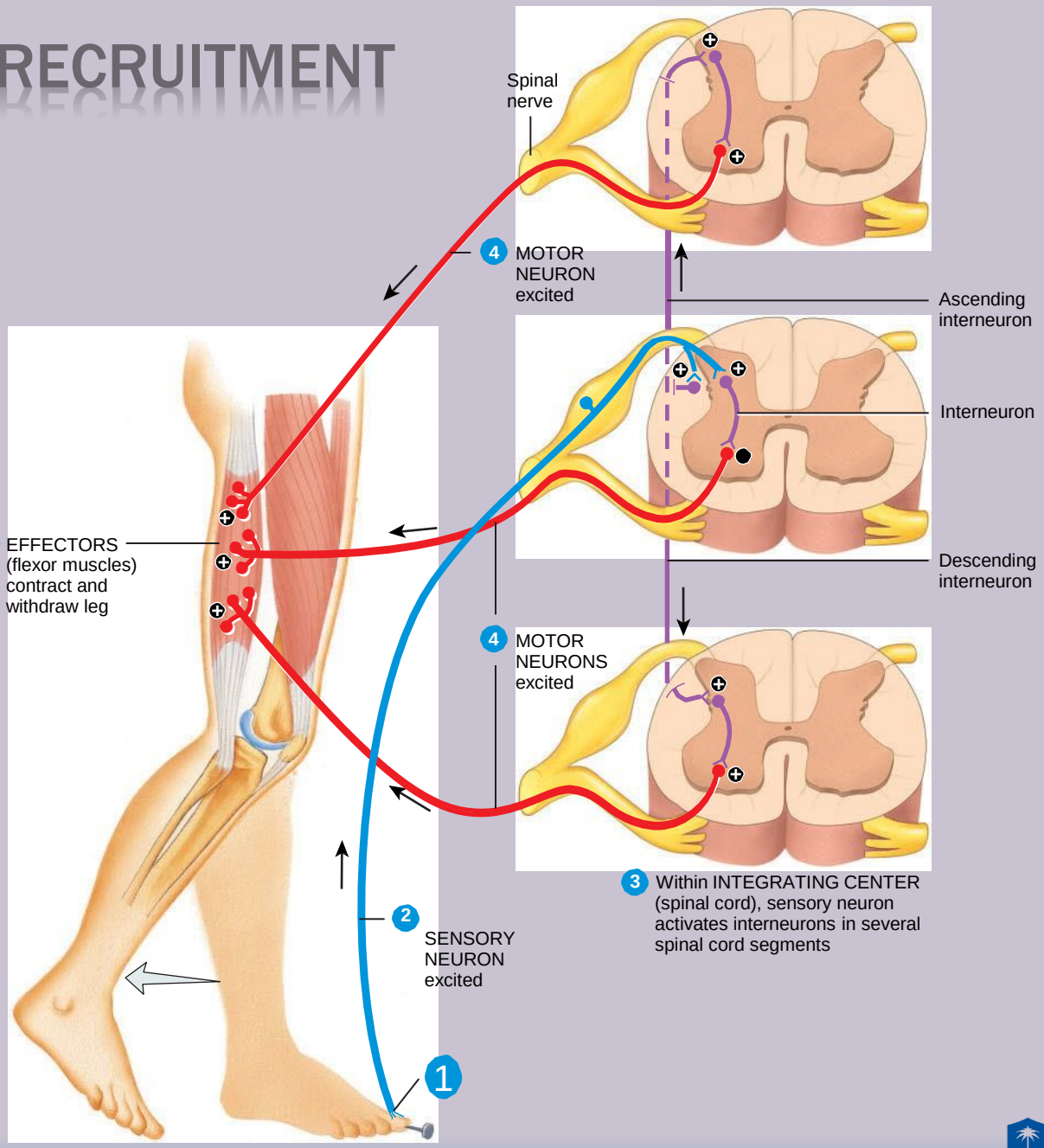
STRONG STIMULI CAN GENERATE ACTIVITY IN THE INTERNEURON POOL THAT SPREADS

Irradiation

THIS SPREAD OF EXCITATORY IMPULSES UP AND DOWN THE SPINAL CORD TO MORE AND MORE MOTOR NEURONS IS CALLED **IRRADIATION** OF THE STIMULUS

Rfcruitmebt

THE gradual INCREASE IN THE NUMBER OF ACTIVE MOTOR UNITS IS CALLED **RECRUITMENT** OF MOTOR UNITS



Crossed Extensor Reflex:-

-While pushing the body away from the injurious agent by withdrawal R ,the **crossed extensor reflex** in the other limb supporting the body weight against gravity.

-Flexion and withdrawal of the stimulated limb >> extension of the opposite limb >> occurs with strong stimulus **why?**

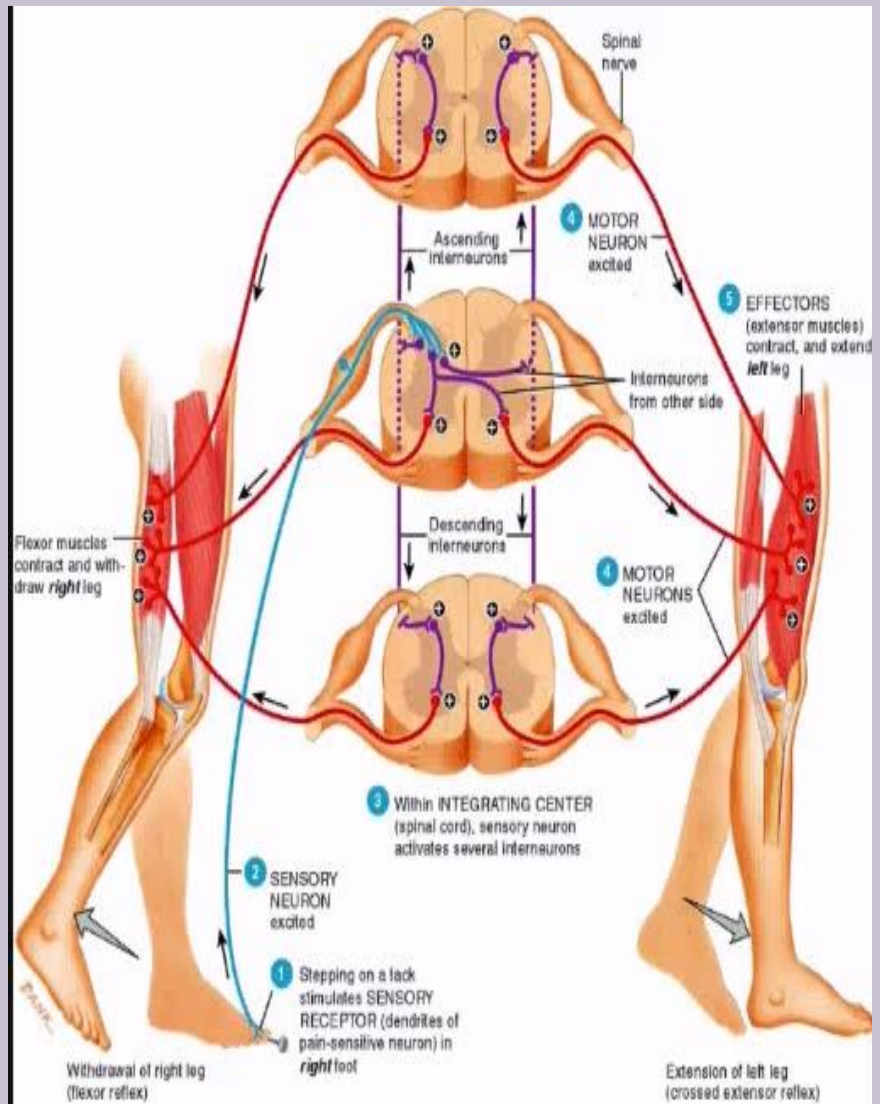
- -Signals from sensory neurons as it activates withdrawal reflex in the stimulated limb, signals cross to the opposite side of the cord by irradiation& divergence to excite excitatory interneurons to activate motor neurons of extensor muscles neurons & send collaterals to inhibitory interneurons to inhibit motor neurons of the flexors(all in the other limb)
-
- -It does not begin until 200 to 500 milliseconds after onset of the initial pain stimulus, because many interneurons are involved in the circuit between the incoming sensory neuron and the motor neurons of the opposite side of the cord
- -After the painful stimulus is removed, the crossed extensor reflex has a prolonged afterdischarge, results from reverberating circuits .
- This of benefit in holding the pained area of the body away from the painful object & support balance.

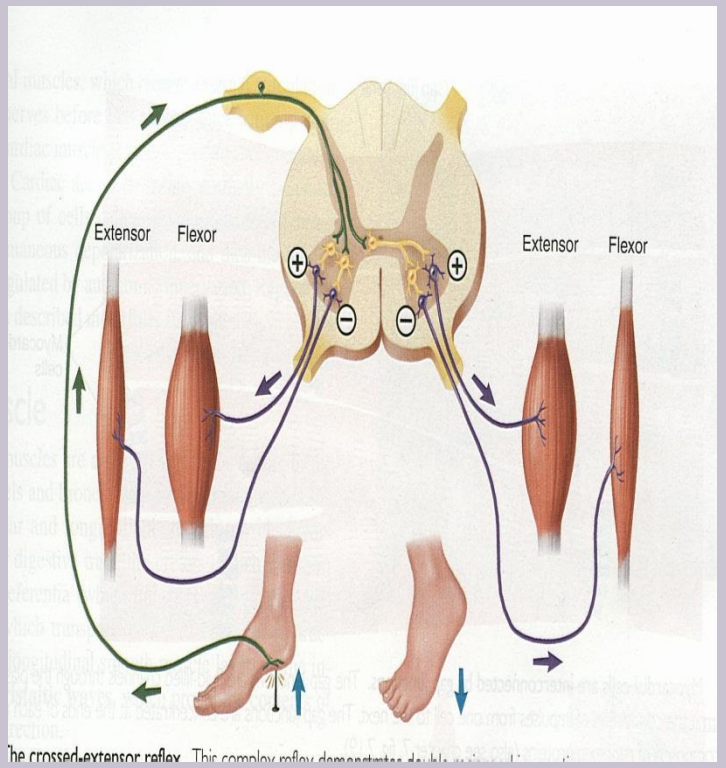
- Mostly in the lower limb to support balance.

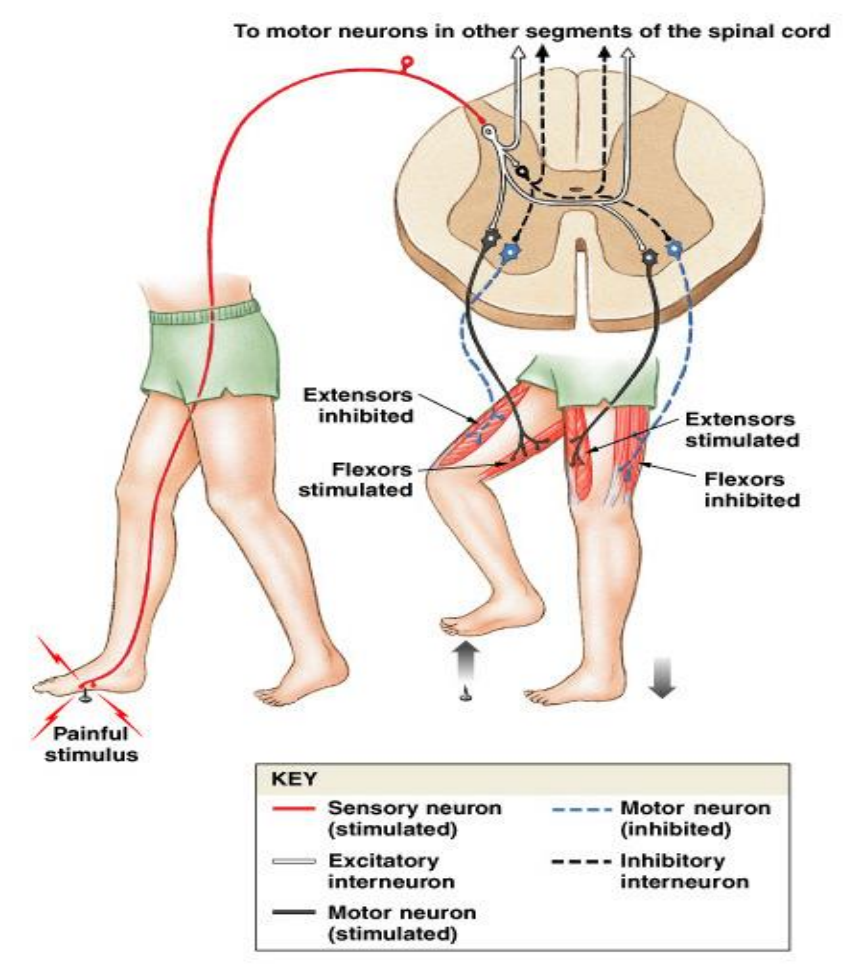
-Reciprocal innervations occurs also in crossed **extensor reflex. How?**

-flexors in the opposite limb are inhibited while extensors are excited because while pushing the body away from the injurious agent by withdrawal R ,the **crossed extensor reflex** supporting the body weight against gravity

Crossed extensor reflex






To motor neurons in other segments of the spinal cord
Extensors inhibited
Flexors stimulated
Extensors stimulated
Flexors inhibited
Painful stimulus
KEY
Sensory neuron (stimulated)
Motor neuron (inhibited)
Excitatory interneuron
Inhibitory interneuron
Motor neuron (stimulated)