The Spinal Cord

•In addition to relaying information to and from the brain, the spinal cord integrates an processes information on its own.

i.e.- A reflex controlled in the spinal cord, not in the brain, makes you drop a scalding-hot frying pan after you have accidentally grabbed it.

Gross Anatomy of The Spinal Cord (SC)

the spinal cord's major contributions are:

1. it conducts PNS sensory data to the brain & motor response info to the PNS

2. It is capable of making decisions which are collectively known as spinal reflexes

- The SC is structurally & functionally integrated w/ the brain

Anatomy

•SC is ≈ 45 cm (18 in) long; max width of 1.4 cm (½ in)

•There is a groove along the dorsal and anterior surfaces

•The amount of gray matter is largest in the sections of the SC that deal w/ sensory and motor control in the limbs. These areas of the spine are enlarged.

•**Cervical Enlargement** innervates shoulder girdle & upper limbs and the **Lumbar Enlargement** innervates the pelvic girdle & lower limbs.

•The entire spine can be divided into 31 segments based on origin of spinal nerves (similar to vertebral labels) C_3 is 3rd cervical segment, etc.

•Each segment is associated w/ a dorsal root, dorsal root ganglion, and ventral root.

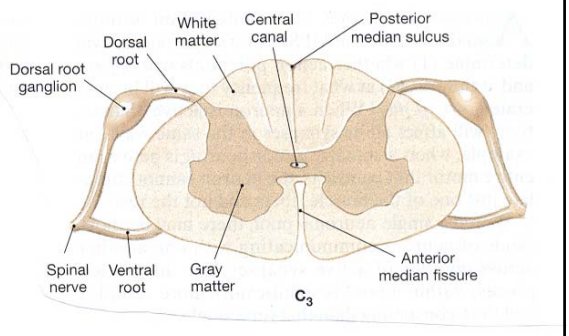
Contents

Dorsal root ganglion: neuron cell bodies

Dorsal root: sensory axon/dendrites

Ventral root: motor axons

•Dorsal & ventral root ganglia join distally to form spinal nerves. Spinal nerves are classified as mixed nerves, because they contain both afferent (sensory) and efferent (motor) fibers



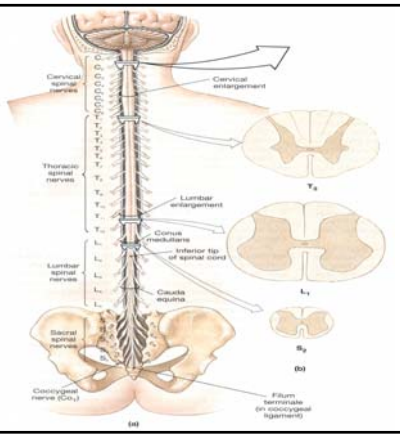
•Cervical series spinal nerves take their names from the vertebra that follows them, except SNC_8 (there are only 7 cervical vertebrae)

•Thoracic, lumbar & sacral spinal nerves take their name from the vertebra that immediately proceeds them.

•The SC elongates until age 4, when the spine keeps growing, but the SC does not!

*This is why they can do a spinal tap……

•The actual solid spine ends at **L_1**, the rest of the spinal nerves are filaments that hang down and resemble a horse's tail, so they were given the name **cauda equina**.



Spinal Meninges

•A series of specialized membranes that surround the spine to protect the delicate neural tissues.

•Provide stability

•Provide shock absorption

•Carry blood vessels that service the spinal cord

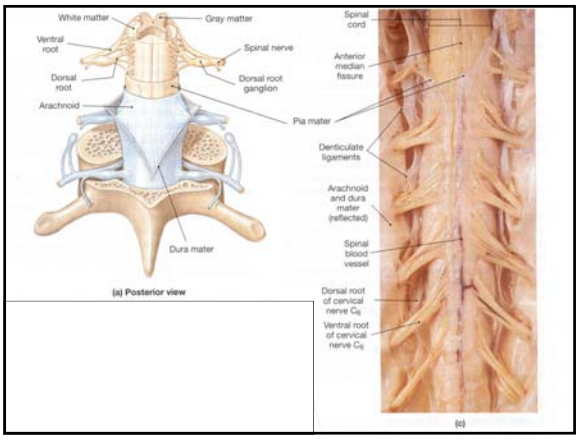
There are 3 menigeal layers

1. Dura mater

2. Arachnoid

3. Pia mater

- at the foramen magnum these 3 layers are continuous with the cranial meninges



Bacterial or Viral Infection can cause a serious inflammation called <u>Meningitis</u>

•Cause a disruption of blood or CSF fluid flow

•This damages or kills neural or glial cells in the affected area

•May start as spinal or cerebral but eventually the whole meningeal complex is involved

•Very small children are affected most often, but they have the best recovery rate. Adults who contract meningitis often die [they ignore the initial symptoms until its too late].

The Dura Mater (tough mother)

•Tough & fibrous

•Forms outermost covering of the spinal cord

•Dense collagen fibers run the length of the SC

•Between the dura mater and the vertebrae is a space called the **<u>epidural space</u>**.

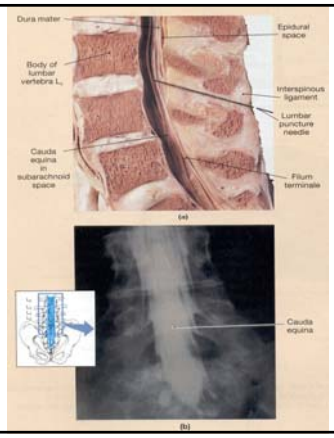
Epidural space contains:

a. loose CT

b. blood vessels

c. padding of adipose tissue

•Injections of an anesthetic in the epidural space affects only the spinal nerves near the injection, and result in a temporary sensory & motor paralysis known as **<u>epidural block</u>**. Option for child birth.



The Arachnoid (arachnoid mater)

•The arachnoid is the middle layer surrounding the spinal cord.

•It is in direct contact with the dura mater and has **arachnoid trabeculae** (a delicate network of collagen & elastic fibers) which extends into the **sub-arachnoid space**.

•Sub-arachnoid space is filled w/ CSF

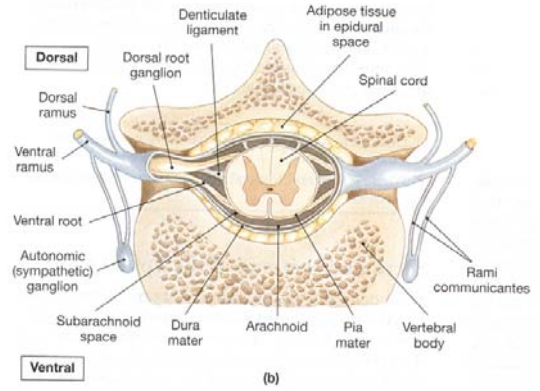
The Pia Mater

•Most inner meningeal layer

•Blood vessels that service the spinal cord are found here.

•The pia mater is firmly bound to the neural tissue of the spinal cord.

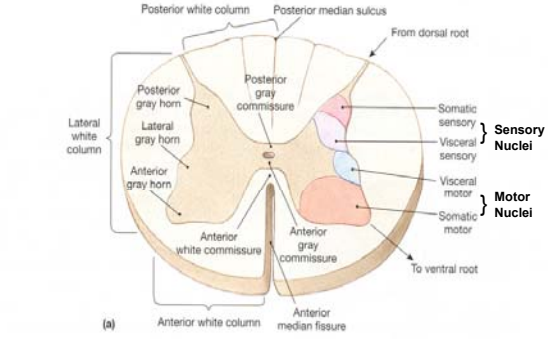
•The spinal meninges accompany the dorsal and ventral roots as they pass through the intervertebral foramina.



Sectional Anatomy of the Spinal Cord

•Anterior median fissure and posterior median sulcus mark the division btn. left and right sides of the spinal cord.

•"The butterfly faces forward"



•The outside of the spinal cord is superficial white matter.
(large #'s of myelinated & unmyelinated axons)

•The "butterfly" is the gray matter (cell bodies of neurons, glial cells, and unmyelinated axons)

•The projections of gray matter are called **horns**.

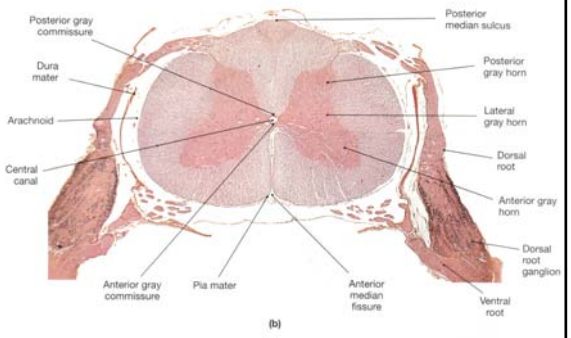
White Matter

•Is organized into **columns** (or funiculi) posterior, anterior, & lateral.

•The axons are organized into **tracts** (fasciculi). Same size nerves, carrying same type of signal at same speed in same direction to the same place.

•**Ascending tracts** relay information from the spinal cord to the brain.

•**Descending tracts** carry information from the brain to the spinal cord.



Spinal Nerves

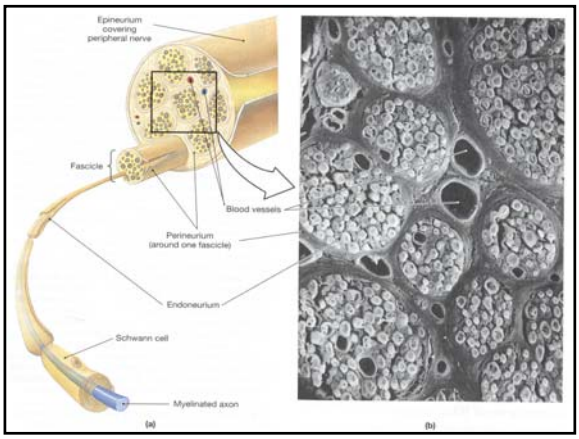
3 layers of CT:

a) epineurium- outermost layer

b) perineurium- bundles axons (fascicles)

c) endoneurium- innermost layer, surrounds individual axons

•Form just lateral to the intervertebral foramen where dorsal and ventral roots unite.



Peripheral Distribution of Spinal Nerves

A typical spinal nerve has (T_1-L_2):

•A **white ramus** (containing myelinated axons) preganglionic

•A **gray ramus** (containing unmyelinated fibers that innervate glands and smooth muscles in the body wall or limbs) postganglionic

•Gray & White Rami are collectively termed **rami communicantes,** communicating branches.

•The 1st branch from the spinal nerve carries visceral motor fibers to a nearby **autonomic ganglion** of the sympathetic division of the ANS (inc. metabolic rate & inc. alertness).

•A **dorsal ramus** (providing sensory and motor innervation to the skin and muscles of the back)

•A **ventral ramus** (supplying the ventrolateral body surface, structures in the body wall and the limbs)

•Postganglionic fibers innervating visceral organs in the thoracic cavity form a series of separate **sympathetic nerves**.

*each has sensory & motor functions some are visceral, some somatic.

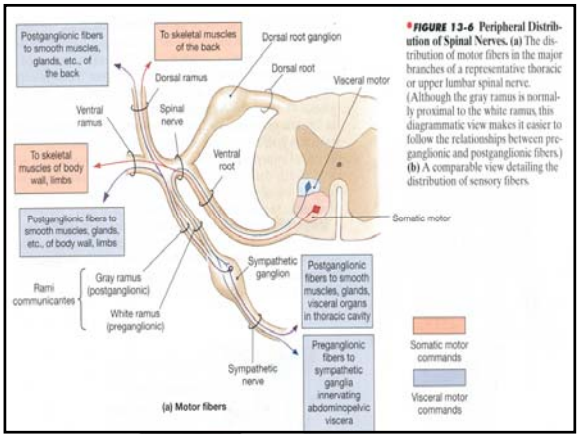
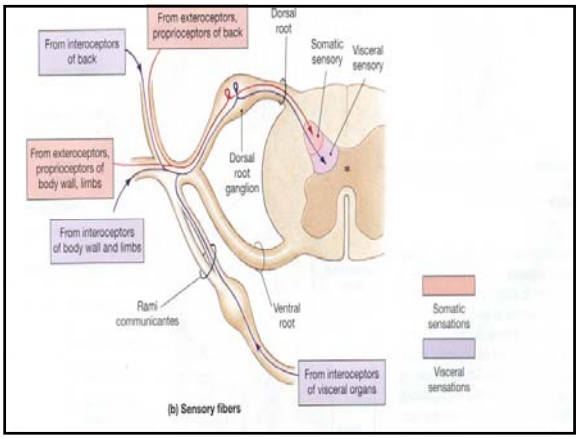


FIGURE 13-6 Peripheral Distribution of Spinal Nerves. (a) The distribution of motor fibers in the major branches of a representative thoracic or upper lumbar spinal nerve. (Although the gray ramus is normally proximal to the white ramus, this diagrammatic view makes it easier to follow the relationships between preganglionic and postganglionic fibers.) **(b)** A comparable view detailing the distribution of sensory fibers.

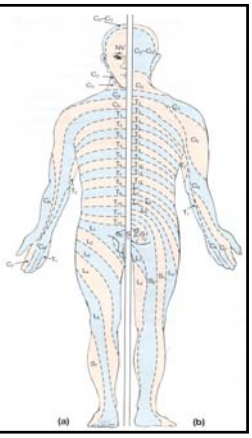


•Each pair of spinal nerves monitors a specific region of the <u>body surface</u> (this region is called a **dermatome**).

•Damage or infection of spinal nerve → characteristic loss of sensation

(**shingles**: virus that effects dorsal root ganglia)

Dermatomes



Shingles

Nerve Plexuses

•A **nerve plexus** is an interwoven bundle of nerve trunks (basically a bunch of spinal nerves that have connected)

•**Peripheral nerve palsies** or **peripheral neuropathies** occur as regional losses of sensory and motor function as a result of nerve trauma or compression (“my arm fell asleep”)

Spinal Nerves

$C_1 – C_5$: cervical nerve plexus

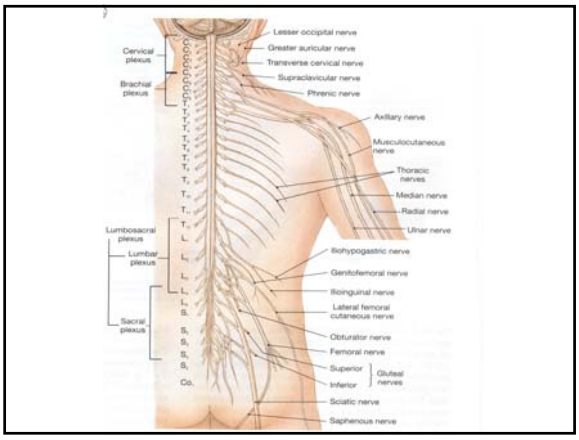
$C_6 – T_{11}$: brachial nerve plexus

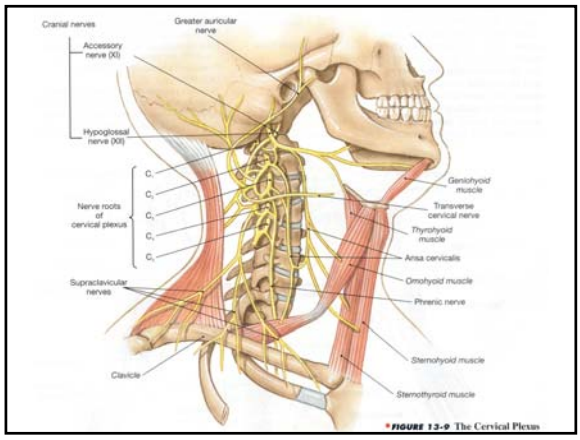
$T_{12} – S_5$: lumbrosacral plexus

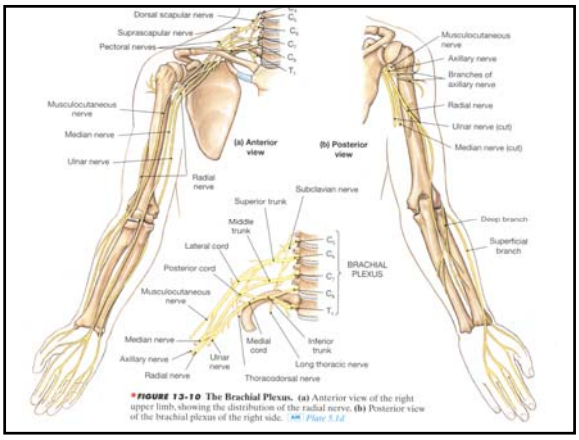
↓

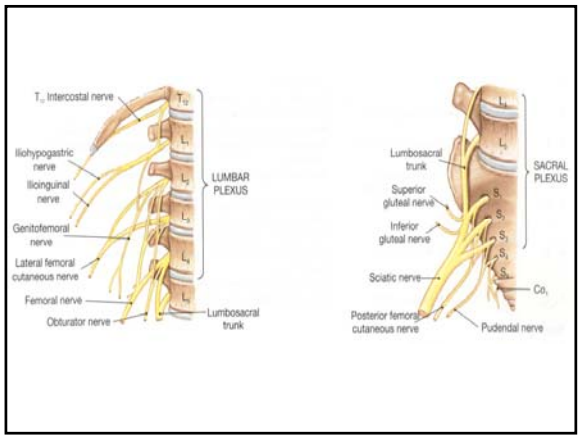
$T_{12} – L_4$ lumbar plexus

$L_5 – S_5$ sacral plexus









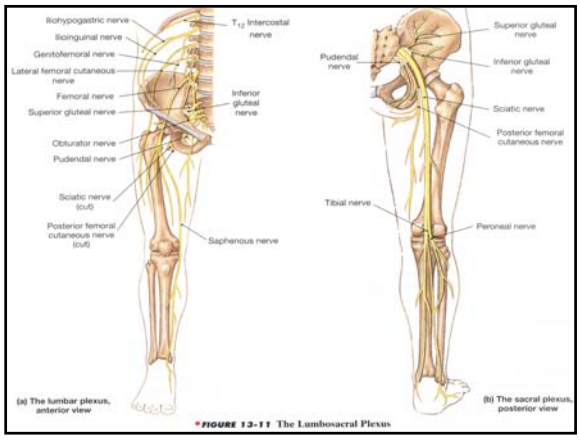


*FIGURE 13-11 The Lumbosacral Plexus

An Introduction to Reflexes

•Reflexes are rapid, automatic responses to specific stimuli.

•Reflexes strive to preserve homeostasis

•Reflex responses show very little variability

(same stimulus produces the same motor response)

Reflex Arc

•The wiring of a single reflex is called a reflex arc

•A reflex arc begins at the receptor and ends at the peripheral effector

Step 1: Arrival of a stimulus

Step 2: Activation of a sensory neuron

Step 3: Information processing

Step 4: Activation of a motor neuron

Step 5: Response of a peripheral effector

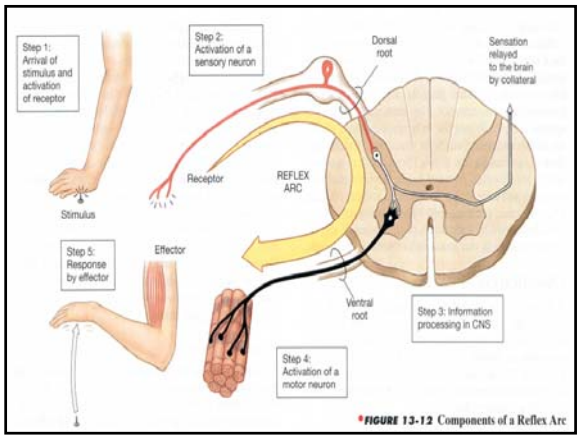
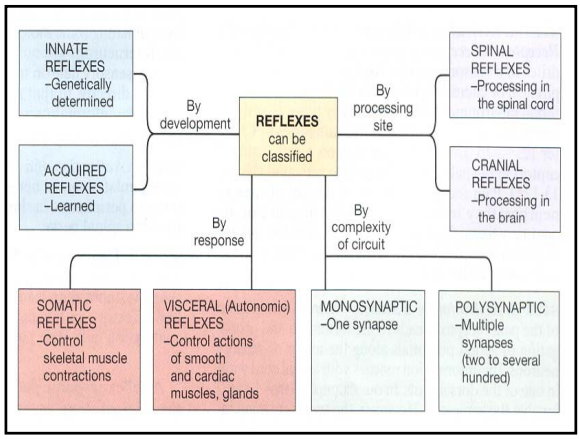
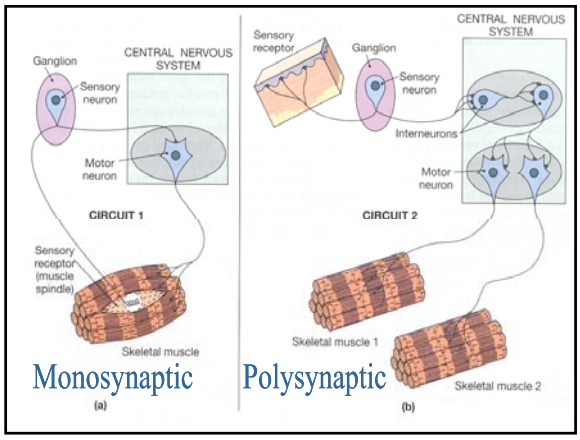
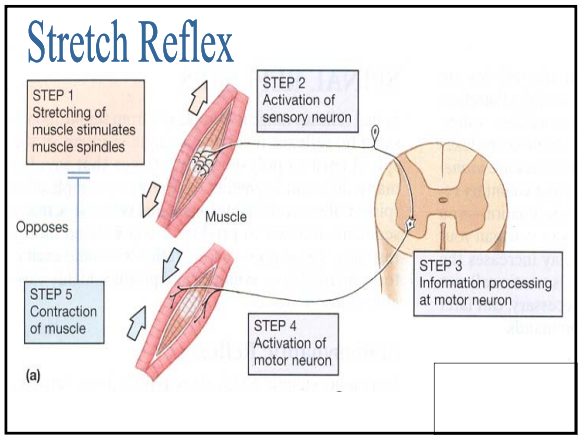
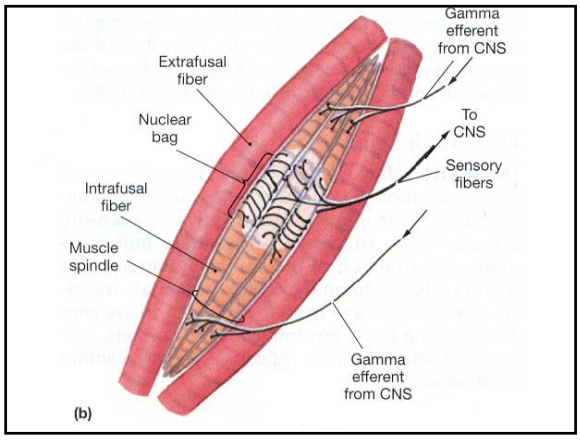


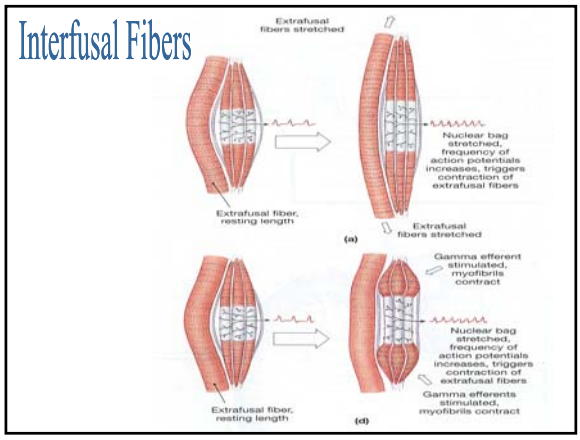
*FIGURE 13-12 Components of a Reflex Arc

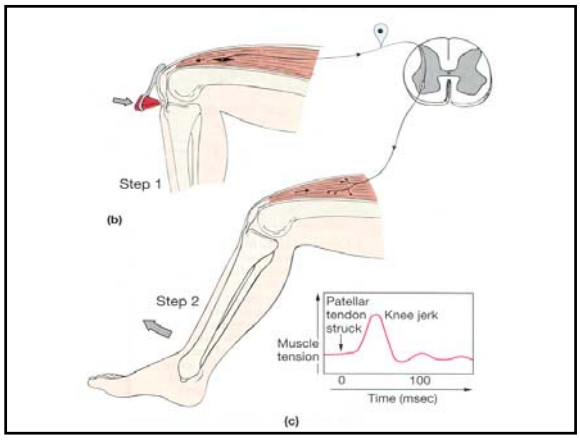


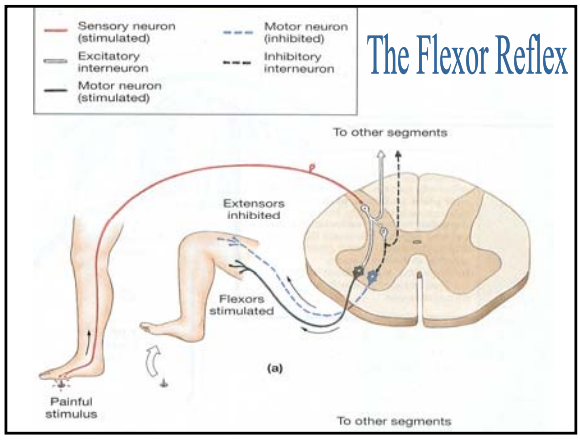

Ganglion
CENTRAL NERVOUS SYSTEM
Sensory neuron
Motor neuron
CIRCUIT 1
Sensory receptor (muscle spindle)
Skeletal muscle
Monosynaptic
(a)
Sensory receptor
Ganglion
CENTRAL NERVOUS SYSTEM
Sensory neuron
Interneurons
Motor neuron
CIRCUIT 2
Skeletal muscle 1
Skeletal muscle 2
Polysynaptic
(b)


Stretch Reflex
STEP 1
Stretching of muscle stimulates muscle spindles
STEP 2
Activation of sensory neuron
Opposes
Muscle
STEP 3
Information processing at motor neuron
STEP 5
Contraction of muscle
STEP 4
Activation of motor neuron
(a)

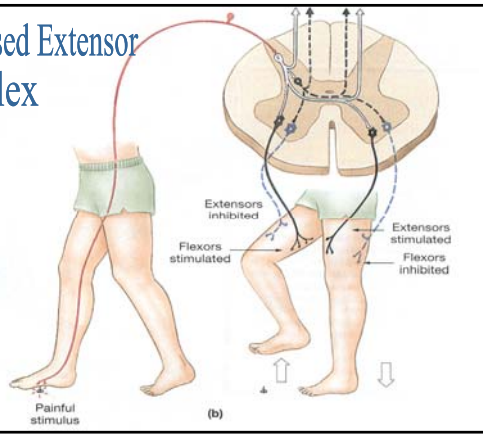

Gamma efferent from CNS
Extrafusal fiber
Nuclear bag
To CNS
Sensory fibers
Intrafusal fiber
Muscle spindle
Gamma efferent from CNS
(b)


Interfusal Fibers
Extrafusal fibers stretched
Nuclear bag stretched, frequency of action potentials increases, triggers contraction of extrafusal fibers
Extrafusal fiber, resting length
Extrafusal fibers stretched
(a)
Gamma efferent stimulated, myofibrils contract
Nuclear bag stretched, frequency of action potentials increases, triggers contraction of extrafusal fibers
Extrafusal fiber, resting length
Gamma efferents stimulated, myofibrils contract
(d)


Step 1
(b)
Step 2
Patellar tendon struck
Knee jerk
Muscle tension
0
100
Time (msec)
(c)


Sensory neuron (stimulated)
Excitatory interneuron
Motor neuron (stimulated)
Motor neuron (inhibited)
Inhibitory interneuron
The Flexor Reflex
To other segments
Extensors inhibited
Flexors stimulated
(a)
Painful stimulus
To other segments

Crossed Extensor Reflex



Babinski Reflex

FIGURE 13-18 The Babinski Reflexes. **(a)** The plantar reflex (negative Babinski reflex), a curling of the toes, is seen in normal adults. **(b)** The Babinski sign (positive Babinski reflex) occurs in the absence of descending inhibition. It is normal in infants but pathological in adults.

Spinal Cord Injuries

•Damage below T1, which lies at the base of the rib cage, causes paralysis and loss of sensation in the legs and trunk below the injury. Injury at this level usually does no damage to the arms and hands. Paralysis of the legs is called **paraplegia**.

•Damage above T1 involves the arms as well as the legs. Paralysis of all four limbs is called **quadriplegia** or tetraplegia.

•Cervical or neck injuries not only cause quadriplegia but also may cause difficulty in breathing. Damage in the lower part of the neck may leave enough diaphragm control to allow **unassisted** breathing.

•Patients with damage at C3 or above, just below the base of the skull, require **mechanical assistance** to breathe.