Chapter 54:

Motor Functions of the Spinal Cord

The Spinal Cord is More Than Just a Conduit for Nerve Fibers

- Neuronal circuits for walking and various reflexes are contained within the spinal cord.
- Higher brain centers activate and command these circuits.
  - walking
  - maintaining equilibrium

Motor Organization of the Spinal Cord

- Sensory fibers enter the cord and are transmitted to higher centers, or they synapse locally to elicit motor reflexes.
- Motor neurons are located in the anterior portion of the cord.
  - motor neurons are 50 - 100 % bigger than other neurons

Anterior Motor Neurons

- Alpha motor neurons
  - give rise to large type A alpha fibers (~14 microns).
  - stimulation can excite 3 - 100 ***extrafusal*** muscle fibers collectively called a motor unit
- Gamma motor neurons
  - give rise to smaller type A gamma fibers (~5 microns)
  - stimulation excites ***intrafusal fibers***, a special type of sensory receptor

Interneurons and Propriospinal Fibers

- Interneurons
  - 30 times as many as anterior motor neurons
  - small and very excitable
  - comprise the neural circuitry for the motor reflexes
- Propriospinal fibers
  - travel up and down the cord for 1 - 2 segments
  - provide pathways for multisegmental reflexes

Sensory Receptors of the Muscle

- Muscle Spindle
  - sense muscle length and change in length
- Golgi Tendon Organ
  - sense tendon tension and change in tension

The Muscle Spindle

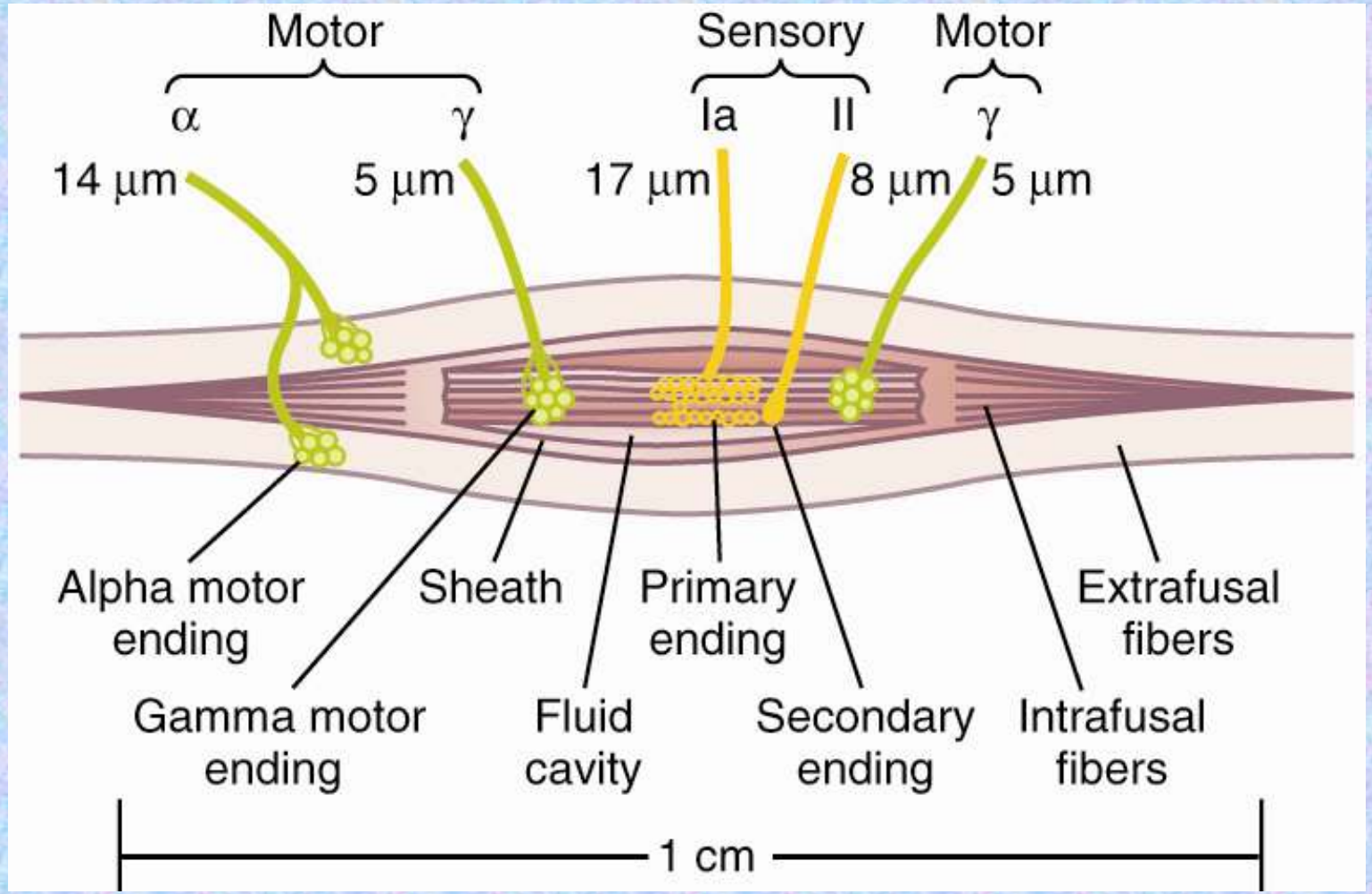


Figure 54-2

Static Response of the Muscle Spindle

- When the center of spindle is stretched *slowly* - the number of impulses generated by the primary and secondary endings increases in proportion to the *degree of stretch.*
- This is the '*static response*'.
- Function of the static nuclear bag and nuclear chain fibers.

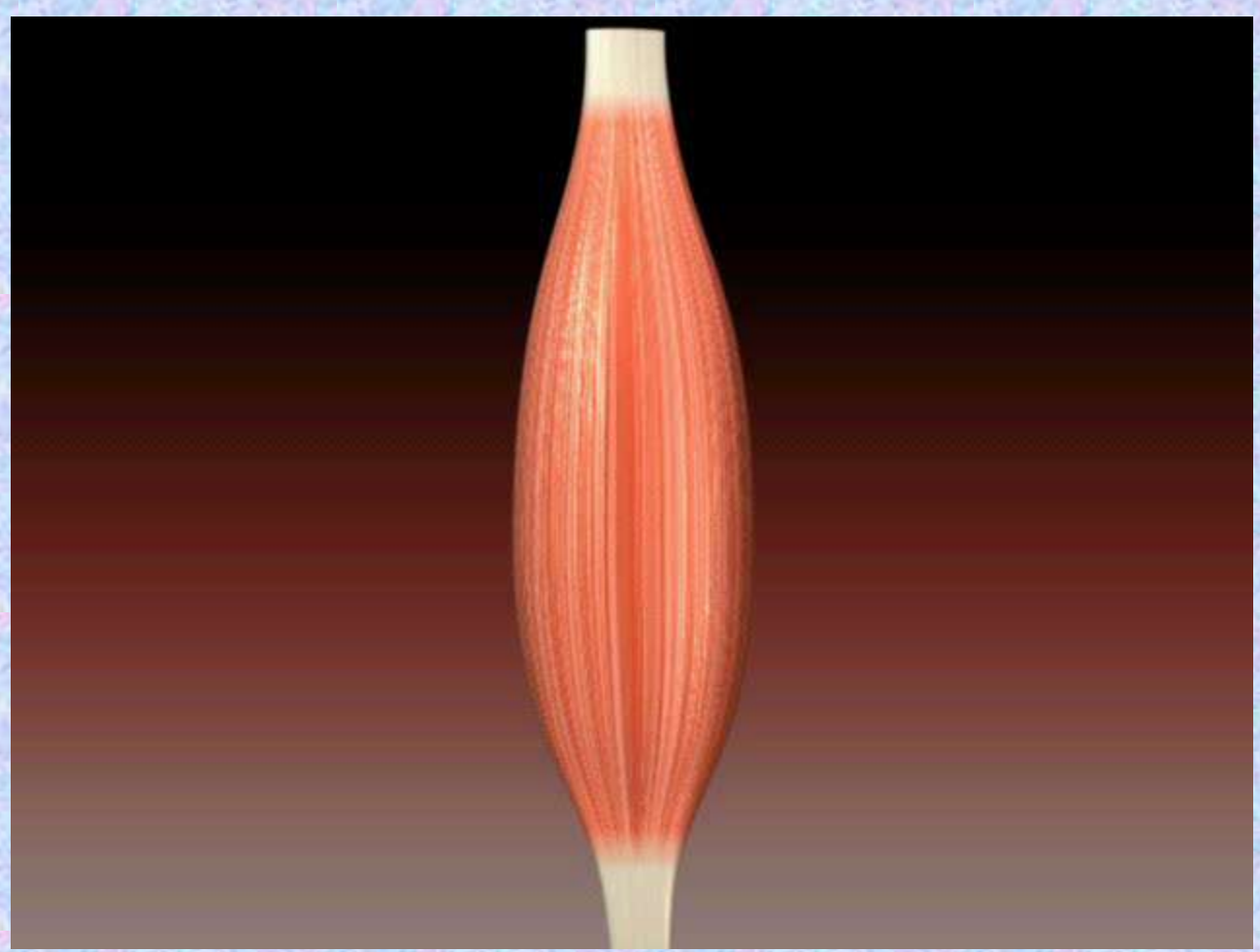
Dynamic Response of the Muscle Spindle

- When the center of the spindle is stretched *rapidly* - the number of impulses generated by the primary endings increases in proportion to the *rate of change* of the length.
- This is the '*dynamic response'*.
- Function of the dynamic nuclear bag fiber.

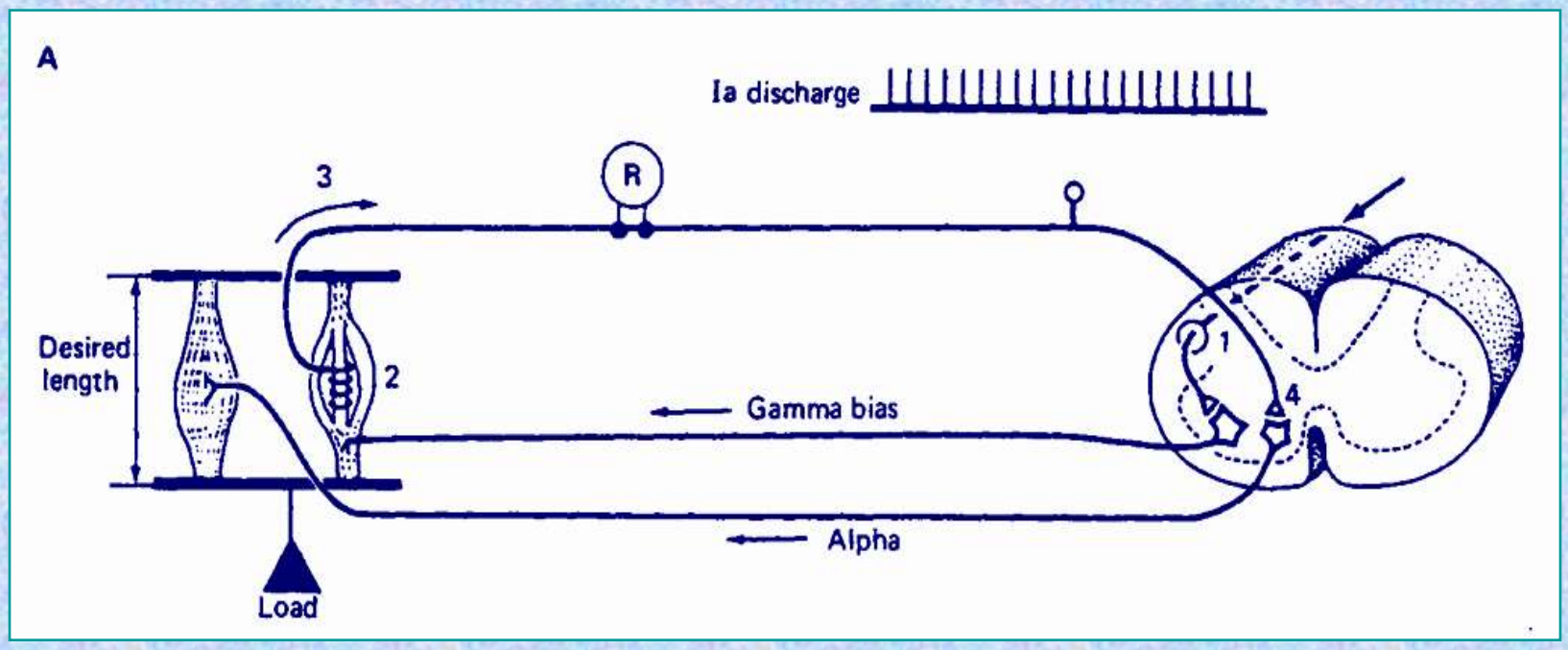
Physiologic Function of the Muscle Spindle

- Comparator of length between the intrafusal and extrafusal muscle fiber.
- Opposes a change in length of the muscle.
- When the muscle is stretched the spindle returns it to its original length.
- Leads to the stretch reflex.

Muscle Spindle Animation



Function of the Gamma System



- Spindle is normally tonically active as a result of input from higher brain centers.
- Controls the intensity of the stretch reflex.
- Performs a damping function by adjusting sensitivity.

Control of the Gamma Motor System (Fusimotor System)

- Gamma signal excited by the bulboreticular facilatory area of the brain stem.
- Secondarily by areas that send impulses to this area.
  - cerebellum, basal ganglia, cortex
- Little is known about the precise control of this system.

Clinical Application of the Stretch Reflex

- Knee jerk reflex
  - striking the patellar tendon with a hammer stretches the quadriceps muscle.
  - this initiates a stretch reflex which shortens the muscle and causes the knee to move forward.
- Can be done with almost any muscle.
- Index of the facilitation of the gamma efferents.
- Cortical lesions usually increase muscle stretch reflexes.

Golgi Tendon Reflex

- Mediated by the golgi tendon organ receptor located in the tendon.
- This receptor responds to tension.
- When the tension becomes too great the reflex inhibits the motor fibers attached to the tendon.
- Function is to equalize force among muscle fibers.

Transmission of Stretch Information to Higher Centers

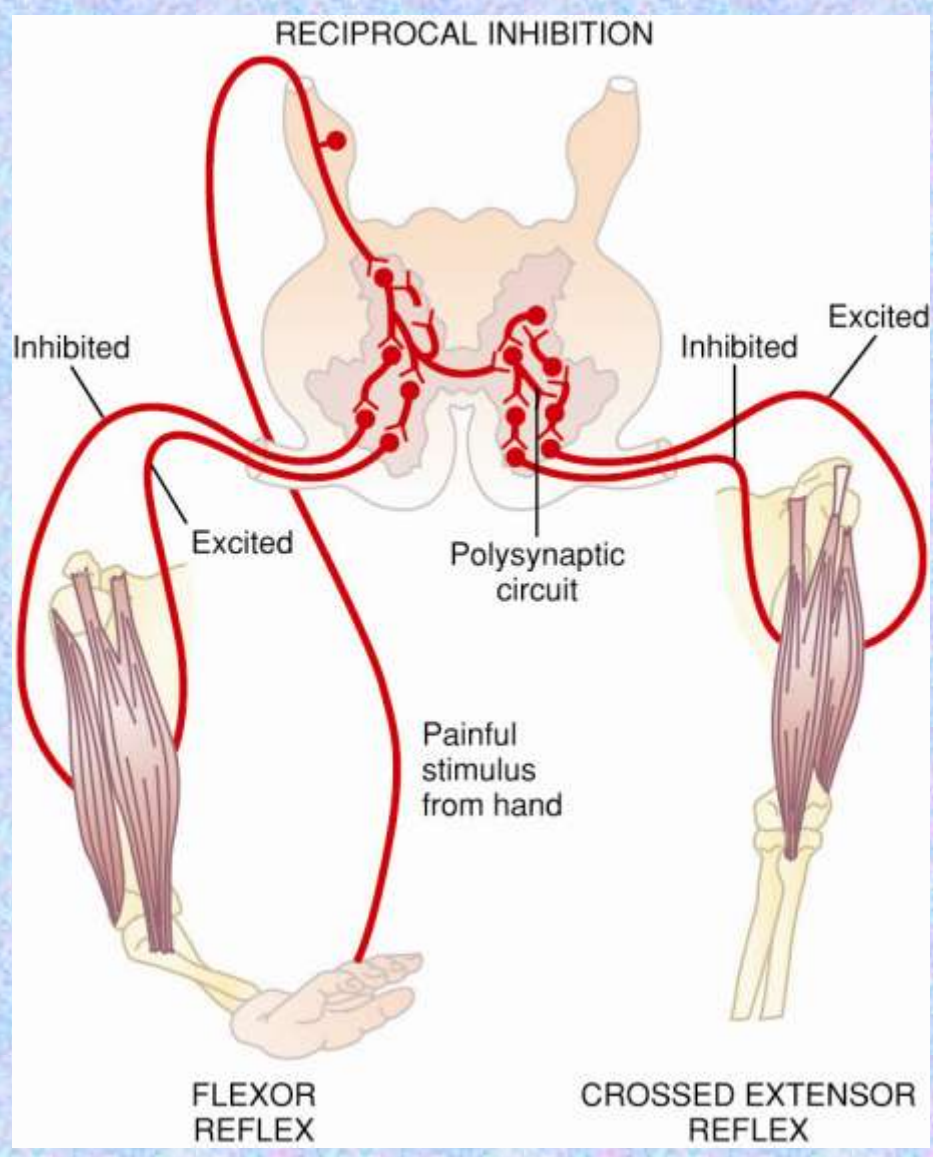
- Muscle spindle and golgi tendon signals are transmitted to higher centers.
- This informs the brain of the tension and stretch of the muscle.
- Information is transmitted at 120 m/sec.
- Important for feedback control of motor activity.

The Withdrawal Reflexes

- A painful stimulus causes the limb to automatically withdraw from the stimulus.
- Neural pathways for reflex:
  - nociceptor activation transmitted to the spinal cord
  - synapses with pool of interneurons that diverge the to the muscles for withdrawal, inhibit antagonist muscles, and activate reverberating circuits to prolong muscle contraction
  - duration of the afterdischarge depends on strength of the stimulus

Crossed Extensor Reflex

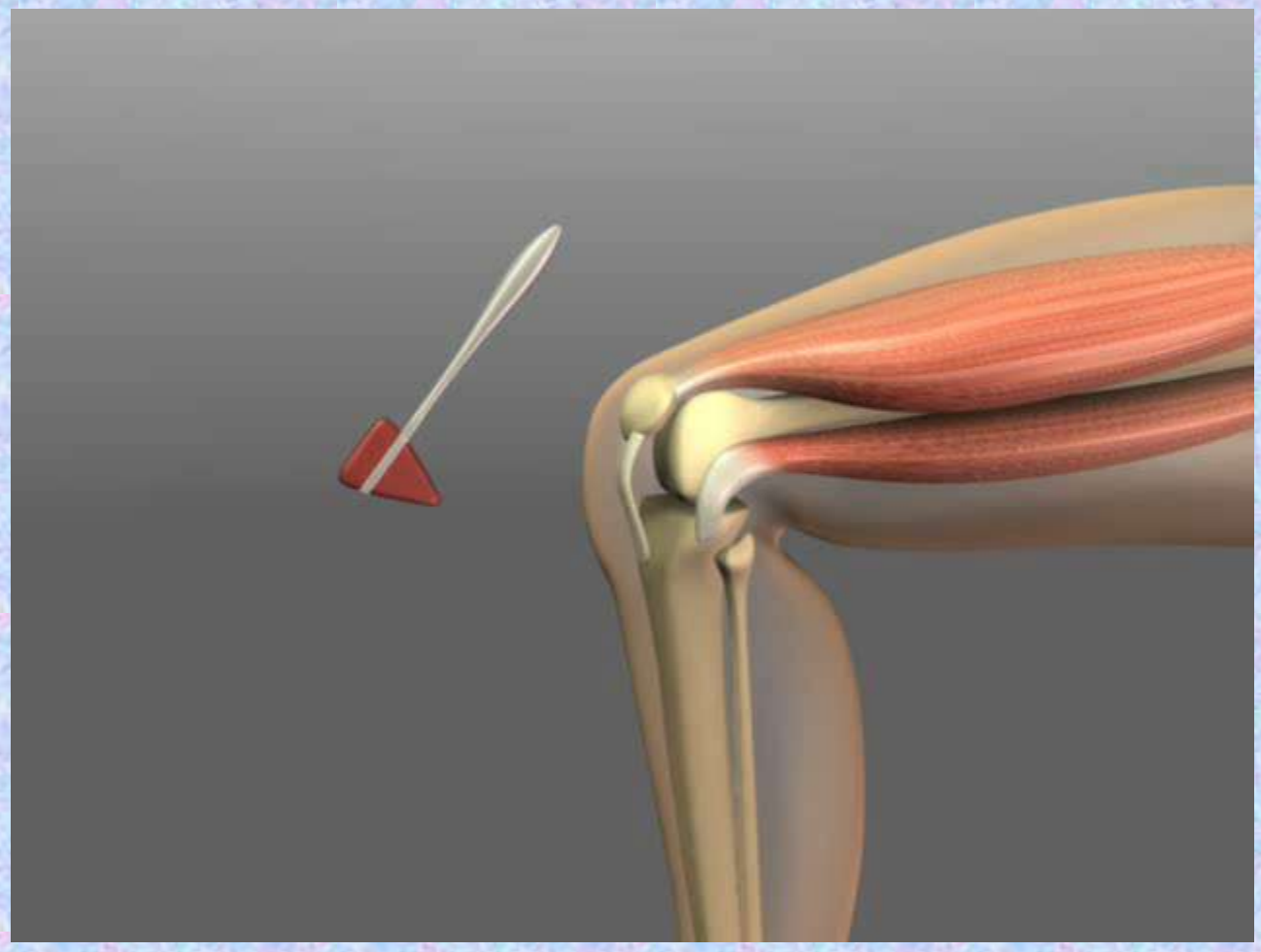
- Painful stimulus elicits a flexor reflex in affected limb and an extensor reflex in the opposite limb.
- Extensor reflex begins 0.2 - 0.5 seconds after the painful stimulus.
- Serves to push body away from the stimulus, also to shift weight to the opposite limb.



Neuronal Circuits for Withdrawal and Crossed Extensor Reflex

Figure 54-8

The Stretch Reflex



Other Reflexes for Posture and Locomotion

- Pressure on the bottom of the feet cause extensor reflex.
  - more complex than flexor-crossed extensor reflex
- Basic walking reflexes reside in the spinal cord.

Reflexes that Cause Muscle Spasm

- Pain signals can cause reflex activation and spasm of local muscles.
- Inflammation of peritoneum can cause abdominal muscle spasm.
- Muscle cramps caused by painful stimulus in muscle:
  - can be due to cold, ischemia, of overactivity
  - reflex contraction increases painful stimulus and causes more muscle contraction