

## INTRODUCTION TO REFLEXES

### A. Characteristics

1. simple, stereotyped motor responses to sensory stimuli
2. generally involuntary, but sometimes can be influenced by voluntary input
3. do not require conscious perception

### B. Anatomical Elements

1. sensory endings
2. afferent neurons
3. integration center (involves synapses)
4. efferent neurons
5. motor structures

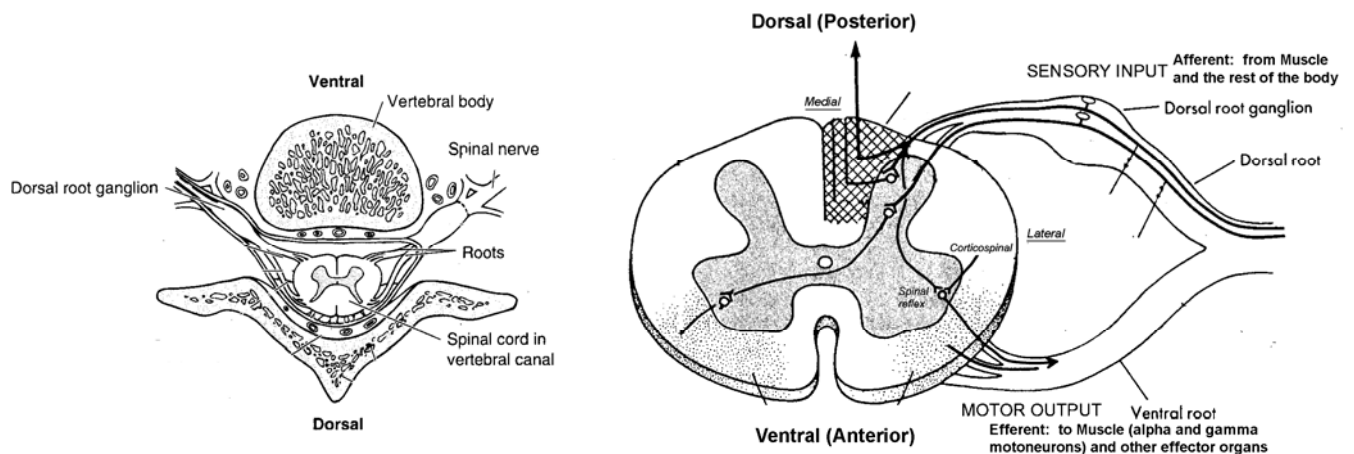
### C. Physiological Description

1. initiating stimulus
2. motor action
3. role in body function

## SPINAL REFLEXES

### A. Anatomical Elements

1. Sensory endings: various, depending upon the reflex
2. Afferent neurons: sensory neurons, cell bodies in the dorsal root ganglia, enter the spinal cord in the dorsal roots
3. Integration center: spinal cord
4. Efferent neurons: motoneurons, cell bodies in the ventral horn of the spinal cord, leave the cord in the ventral roots; generally large, myelinated motor neurons termed alpha motoneurons
5. Motor structures: skeletal muscle, cardiac muscle, smooth muscle, secretory glands



## SPINAL REFLEXES (continued)

Note: Upon spinal cord section, these are the only motor responses remaining below level of spinal cord transection (but note cerebral dominance in humans, *encephalization*, and *spinal shock* -- temporary depression of spinal reflexes following section)

Note: There are similar reflexes in the head region, except that (1) the afferent neurons are in certain cranial nerves and their cell bodies are in cranial nerve ganglia; (2) efferent motor neuron axons travel in certain cranial nerves and their cell bodies are in the brain; and (3) the integration centers are in the brain stem (medulla, pons, and midbrain)

### B. Main Reflexes Involving Skeletal Muscle (Somatic Reflexes)

1. flexion (withdrawal) reflex
2. crossed extension reflex
3. myotatic (stretch) reflex
4. inverse myotatic (clasp-knife) reflex

### FLEXION (WITHDRAWAL) & CROSSED EXTENSION REFLEX

#### A. Stimulus and Response

1. Stimulus: noxious (painful) stimulus
2. Response
  - a. ipsilateral: flexion-withdrawal of affected region from stimulus
  - b. contralateral: extension of limb

#### B. Pathway

1. Afferent endings: cutaneous and deep pain receptors, also touch and joint receptors
2. Spinal organization
  - a. ipsilateral (same side): make connections with interneurons that facilitate flexor motoneuron pool and inhibit extensor motoneuron pool
  - b. contralateral (opposite side): crossed pathway exciting extensors

#### C. Role: protective; withdrawal from injurious stimulus

## SKELETAL MUSCLE SENSORY ORGANS

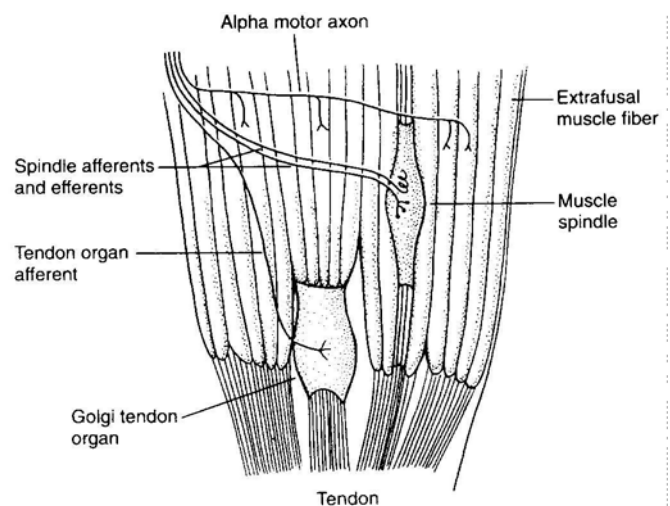
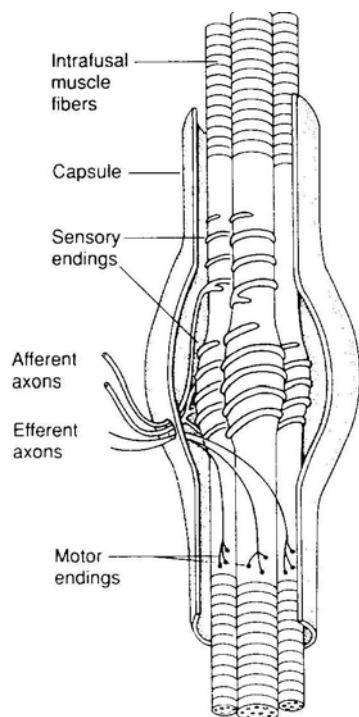
### A. Muscle Spindle

1. consist of 7-8 intrafusal fibers
2. embedded in muscle, interspersed among regular (extrafusal) muscle fibers
3. contractile elements at poles (ends), but not in center
4. sensory endings
  - a. primary (annulospiral)
    - 1) innervated by large, myelinated axons, Group Ia
    - 2) partially adapting
  - b. secondary (flower spray)
    - 1) innervated by medium sized myelinated axons, Group II
    - 2) slowly adapting
5. efferent fibers
  - a. small motor nerve fibers, gamma motoneurons
  - b. innervate the contractile poles of spindle
  - c. when poles contract, central (non-contractile) center of intrafusal fiber is stretched
  - d. do not contribute to the tension developed on the muscle as a whole
6. adequate stimulus for sensory endings
  - a. mechanoreceptors, discharge when stretched
  - b. discharge when muscle stretched (sense muscle length)
  - c. also discharge when stretched by gamma efferent discharge

### B. Tendon Organ (Golgi)

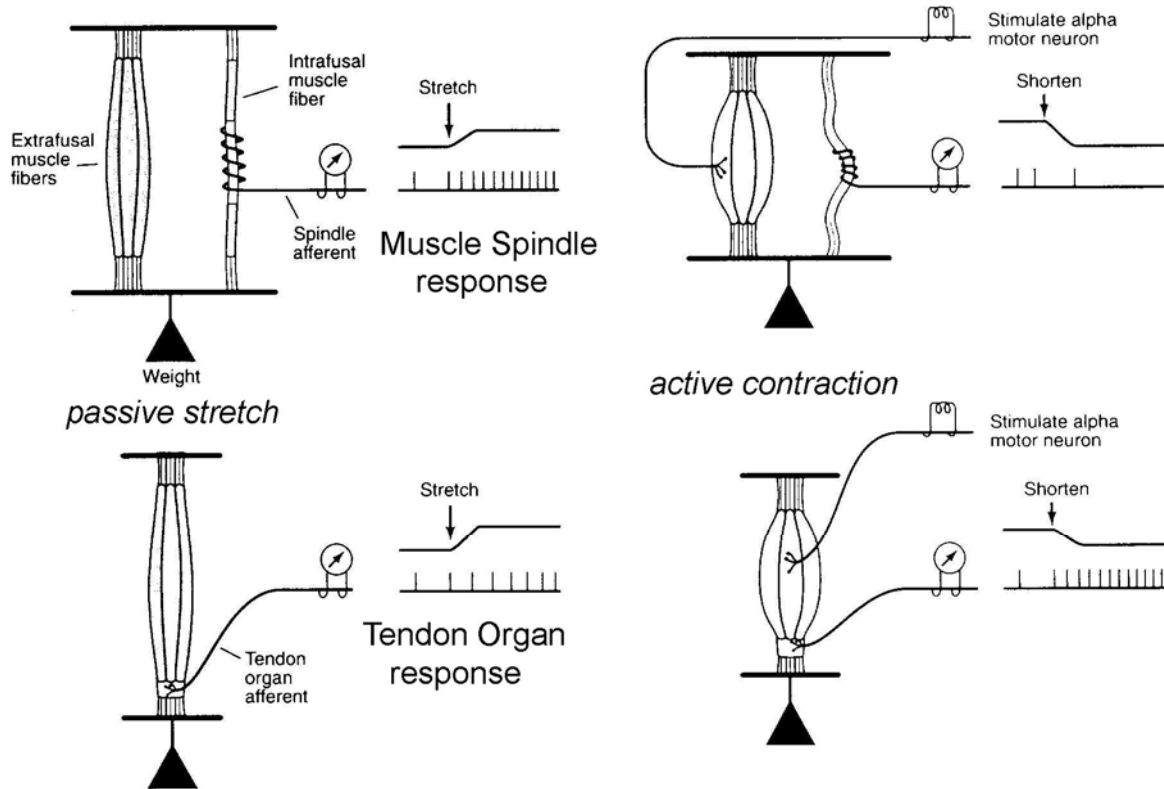
1. located at muscle-tendon junction
2. mechanoreceptor; stimulated by increase in muscle tension

- C. Role: **Proprioceptors**, since they provide information to the CNS concerning the position and state of the musculoskeletal system



SKELETAL MUSCLE SENSORY ORGANS (continued)

Summary of Response Properties



STRETCH (MYOTATIC) REFLEX

A. Stimulus and Response

1. Stimulus: stretch (lengthening) of skeletal muscle
2. Response
  - a. active contraction of stretched muscle
  - b. facilitation (increased motoneuron sensitivity) of muscle's synergists
  - c. inhibition (decreased sensitivity) of muscle's antagonists

B. Pathway

1. Sensory endings: muscle spindles of stretched muscle, innervated by Group IA and Group II axons
2. Afferent pathway: enter spinal dorsal root, along with other afferent fibers

Note: afferent fibers also have branches that ascend to the brain (contribute to conscious proprioception) and synaptic connections that ascend to the cerebellum (contribute to motor coordination)

## STRETCH (MYOTATIC) REFLEX

### B. Pathway (continued)

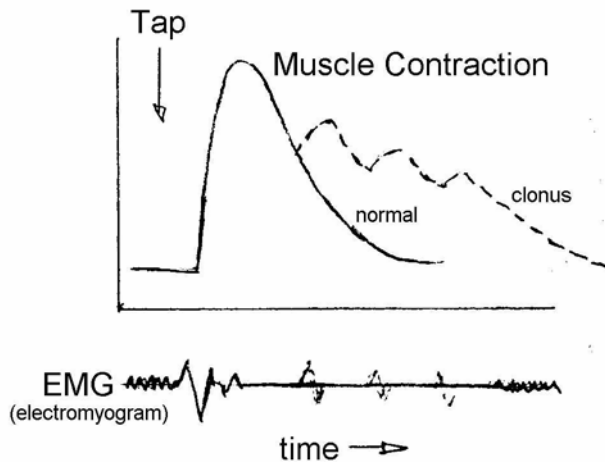
3. Spinal organization
  - a. monosynaptic excitatory connections with alpha motoneurons of stretched muscle
  - b. monosynaptic facilitation connections with alpha motoneurons of synergists of stretched muscle
  - c. excitatory connection with interneurons, that in turn make inhibitory connections with alpha motoneurons of antagonists of stretched muscle
4. Efferent pathway: exit ventral root, go to skeletal muscle
5. Motor structure: skeletal muscle

### C. Roles

1. Posture
2. Muscle tone

### D. Clinical Evaluation

1. Tendon tap: brief muscle stretch to elicit synchronous discharge of dynamic muscle spindle endings; results in brief contraction (normal response)



2. Assessment of tone by passive movement of limb

Notes:

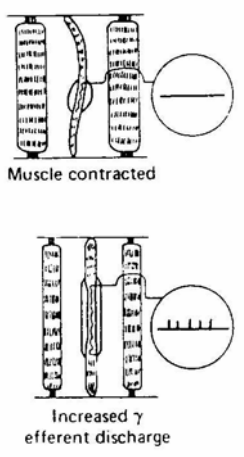
Hypereflexia: excess response, may involve clonus (multiple twitches in response to a single stimulus); component of spasticity

Hyporeflexia: below normal response

### STRETCH (MYOTATIC) REFLEX

#### E. Role of Gamma-efferent system (small motor system, fusimotor system)

1. Keep muscle spindle afferents within their sensitive range (prevent “unloading” upon muscle contraction) by activation when muscle contracts



2. Sets general sensitivity of reflex response; influenced by descending motor pathways

#### INVERSE MYOTATIC REFLEX (Clasp-knife reflex)

##### A. Stimulus and Response

1. Stimulus: increase muscle tension
2. Response
  - a. inhibit motoneurons of muscle from which the stimulus arises
  - b. inhibit synergists
  - c. facilitate antagonists

##### B. Pathway

1. Afferent endings: tendon organs, innervated by Group IB fibers
2. Afferent pathway: enter dorsal root along with other afferent fibers
3. Spinal organization
  - a. excitatory synapses on interneurons
  - b. interneurons make inhibitory synapses with alpha motoneurons of muscle and its synergists and excitatory synapses with antagonists

##### C. Role

1. normal contractions: balances forces developed by motor units
2. maximum tension: protective; prevent muscle-tendon injury by inhibiting contraction when muscle tension becomes too great (clasp-knife action)