I. Proprioceptors

A. Definition

1. Provide information about the extent of muscle stretch (muscle spindles).
2. Provide information about the extent of muscle contraction (Golgi tendon organs).

B. Components

1. Muscle spindles: small intrafusal contractile organs with afferent and efferent neurons
2. Golgi tendon organs: small stretch receptors in tendons with afferent innervation only
II. Muscle spindles

A. Location and function

1. Muscle spindles are in parallel with myofibers (intrafusal).
2. Detect muscle stretch.

B. Structure

1. Small muscle fibers (4-7 mm long) that contain contractile proteins.
2. Have afferent and efferent fibers (fusimotor neurons).
3. Stretch of spindle signals muscle to contract (resists overstretching)
   b. Can be stimulated to contract when muscle relaxes by efferent motoneurons.
III. Golgi tendon organs

A. Location and function
1. Golgi tendon organs are in series with myofibers, embedded in tendons at ends of muscles.
2. Detect contraction (tension).

B. Structure
1. Approximately 0.7 mm long
2. Contain afferent fibers only
   a. Contraction of muscle signals muscle to relax – polysynaptic transmission.
   b. Inhibit skeletal muscle neuron pool in spinal cord.

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Fig. 8.10. A human muscle spindle demonstrated with the adenosine triphosphatase reaction. Large fibers in the center are type I, the small round fibers associated with them are type II. The capsule surrounding the intrafusal fibers can barely be seen with this reaction.

Fig. 13-9. — Semischematic representation of a Golgi tendon organ. This receptor is innervated by branches of a thick myelinated fiber (Ib) and also by some unmyelinated fibers (C fibers) (broken lines). The role of the Ib fibers is to convey tension information to the central nervous system. That of C fibers is less well understood, but it is believed that they may convey painful stimuli to the CNS. (Adapted from Barker, D., in Barker, D. [ed.]: Muscle Receptors [Hong Kong, China: Hong Kong University Press, 1962], p. 227.)
IV. Muscle spindles vs Golgi tendon organs

A. Muscle stretch increases discharge in muscle spindles
   1. Signals travel to spinal cord.
   2. Muscle is stimulated to contract; discharge in muscle spindle ceases.
   3. Muscle spindle contracts; discharges resume.

B. Muscle contraction increases discharge in Golgi tendon organs.
   1. Signals travel to spinal cord.
   2. Inhibitory neurons cause muscle to relax.

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**Fig. 13–3.**—Diagram of the effects of stretch and muscle contraction (extrafusal and intrafusal) on spindle afferent discharges. In all records, the upper traces represent the discharge from the spindle afferent fibers recorded through the R electrodes, and the lower traces are recordings of muscle tension registered through a strain gauge (R, hooked to the muscle tendon). In A, the muscle is at rest length. In B, stretch of the muscle is increased. In C, a single shock applied to the skeletal motor fibers (Sₘ) induces muscle twitch and a pause in the spindle discharge. Shortening of the muscle relaxes the spindle because the latter is in mechanical parallel with the extrafusal muscle fibers. In D, both the extrafusal and the intrafusal muscle fibers have been activated simultaneously by applying electric shocks to both skeletalmotor and fusimotor fibers—Sₘ and Sᵢ, respectively.

**Fig. 13–10.**—Mechanical model of the following anatomic arrangements: A, the muscle spindle (s) in mechanical parallel with the muscle fibers (e); and B, the Golgi tendon organ (T.O.) in series with the extrafusal muscle fibers. (Modified from Fulton, J. F., and Pi-Sunyer, J.: Am. J. Physiol. 83:554, 1928.) The bottom part of the illustration shows the afferent discharges and muscle tension changes during muscular contraction. In A, the upper record shows baseline (BL) discharge of a spindle afferent fiber. The lower record shows cessation of spindle discharge during a single muscle twitch. In B, the upper trace is a record from a single afferent fiber connected to a tendon organ of the same muscle; note the fiber is silent. The lower record in B shows that the tendon organ afferent fiber discharges during contraction of the muscle. (Drawn from Hunt, C. C., and Kuffler, S. W.: J. Physiol. 113:298, 1951.)