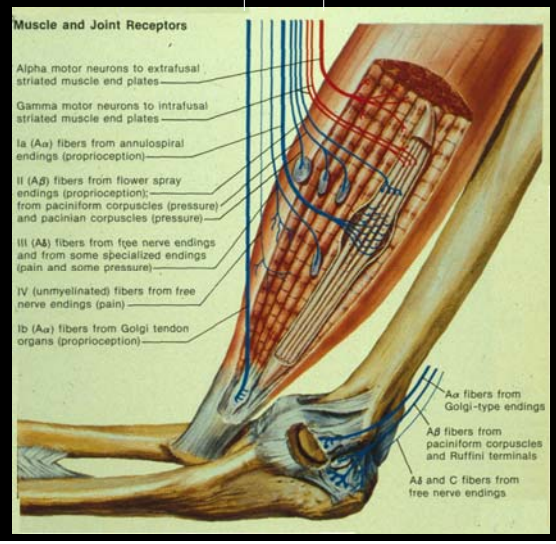
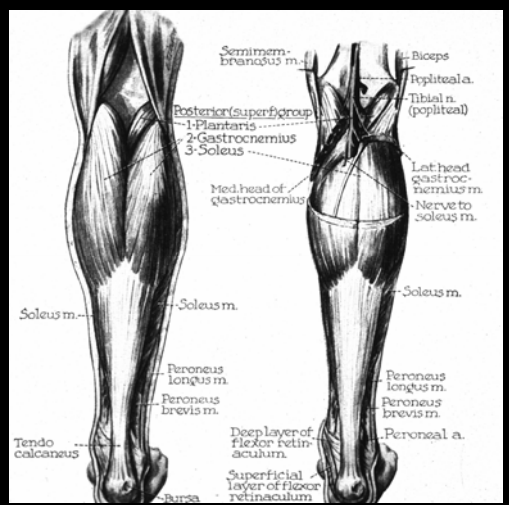
Muscle Receptors and Motor Control

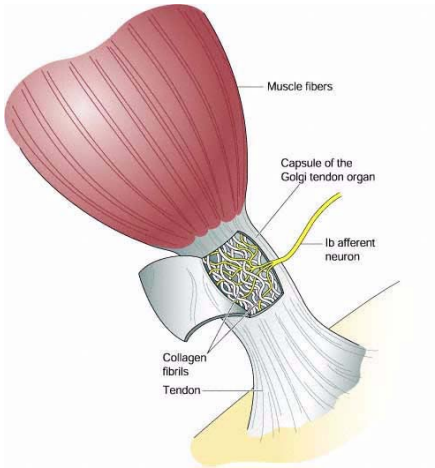
Muscle Nerve





Innervation of the Soleus Muscle of the Cat

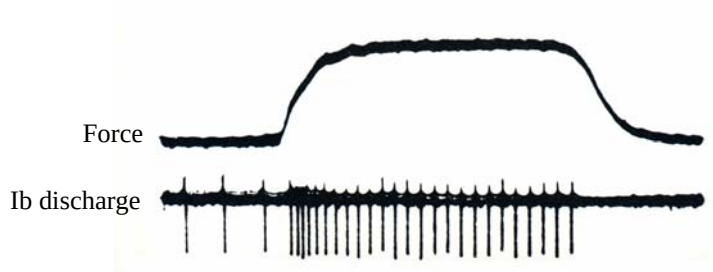
AFFERENT #	Fiber type	Target
50	Ia fibers	50 spindle primary endings
40	Ib fibers	45 Golgi tendon organs
50	II fibers	50 spindle secondary endings
[200-400	IV fibers	pain, vasculature]
EFFERENT		
150	alpha motor neurons	25,000 extrafusal muscle fibers
100	gamma motor neurons	300 intrafusal fibers in 50 spindles



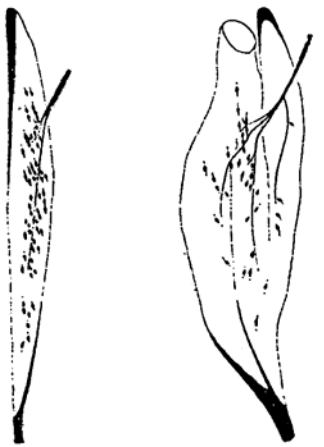
The GTO is "in series" with the muscle. It can be activated by contraction of the muscle or by pulling on the tendon.

BCP p. 456

Effect of Contraction of a Single Motor Unit



The GTO (Ib) provides a signal related to **muscle force**.

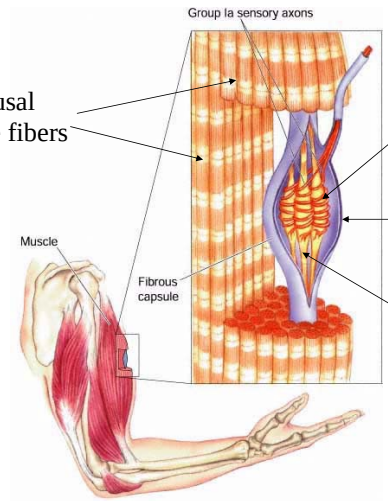


Soleus

Lat. Gastrocnemius

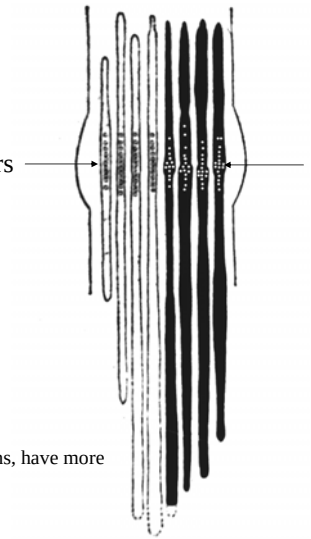
Muscles used for fine control (e.g. muscles of hand and neck) have relatively more spindles (#/gram) than other muscles.

BCP p. 452



Latin *fusus* = spindle

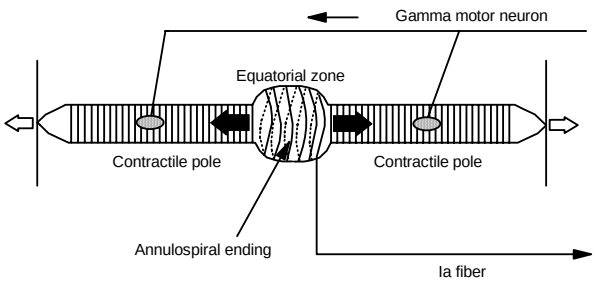
The spindle is situated 'in parallel' with the extrafusal fibers. Stretching the muscle stretches the spindle.

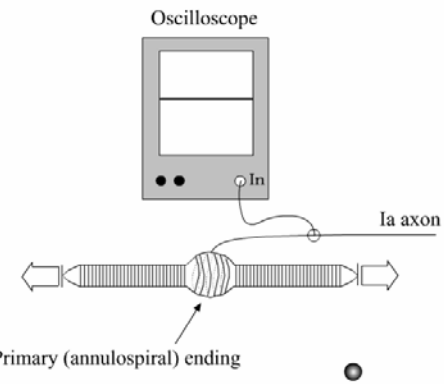


Muscle fibers, unlike neurons, have more than one nucleus – they are **multinucleated**.

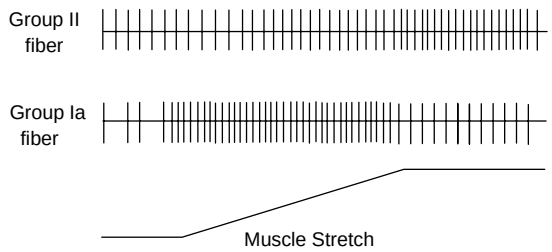
Ia fibers
Primary
"annulospiral" endings

ype II fibers
econdary ("flower spray") endings

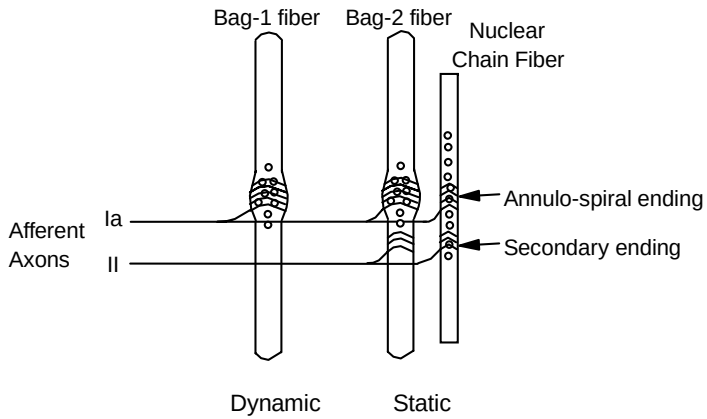




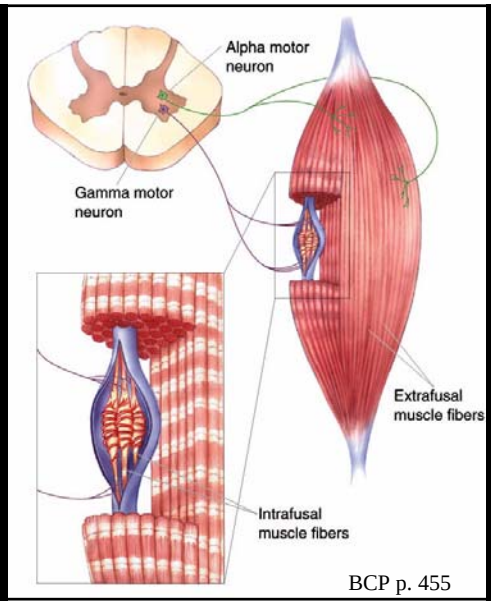
The Ia axon is sensitive to muscle **stretch** (length)



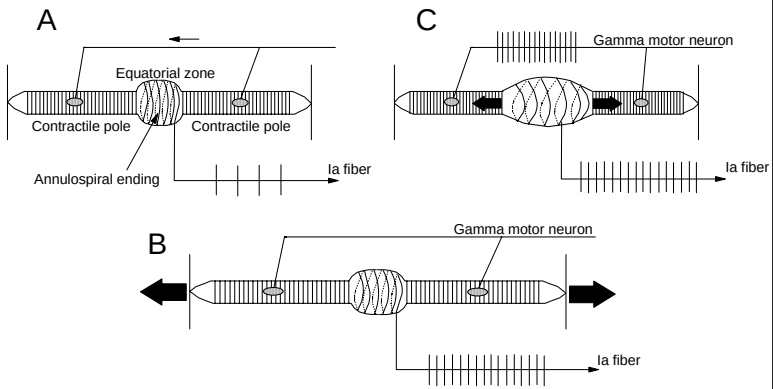
Muscle spindle afferents provide signals related to *muscle length* (static aspect) and *rate-of-change of length* (dynamic aspect).



Dynamic vs static transduction properties appear to depend on the physical characteristics of the intrafusal muscle fibers rather than the nerve terminals.

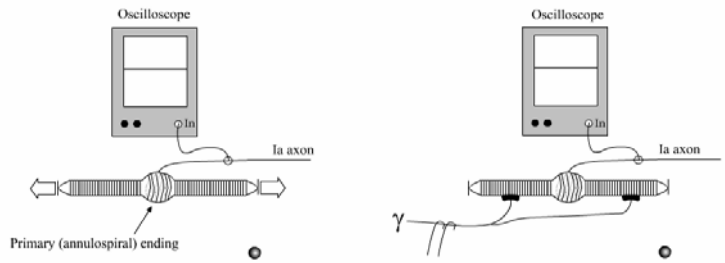


BCP p. 455

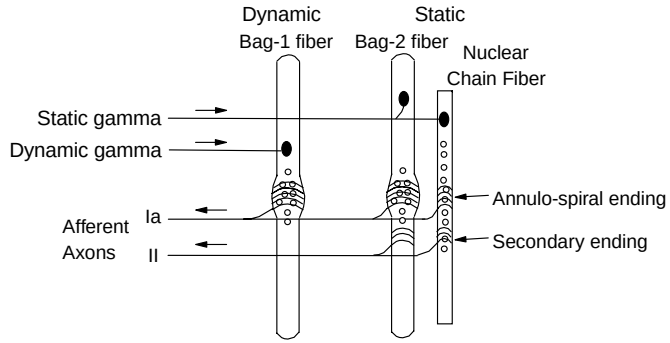


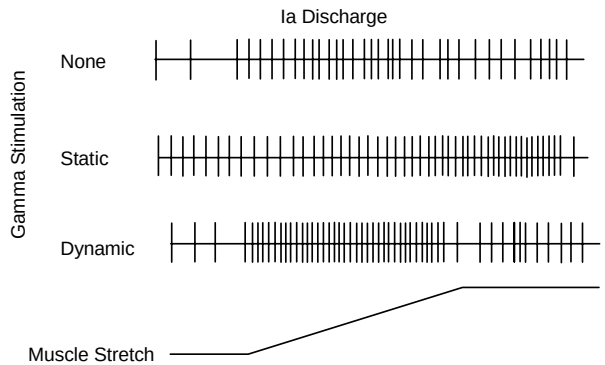
Gamma motor neuron activity is said to “bias” the spindle, i.e. make it more sensitive or more active at a given length.

Intrafusal fibers do not generate action potentials. Their contraction is modulated by temporal summation of end-plate potentials



Static and Dynamic Gamma Motor Neurons

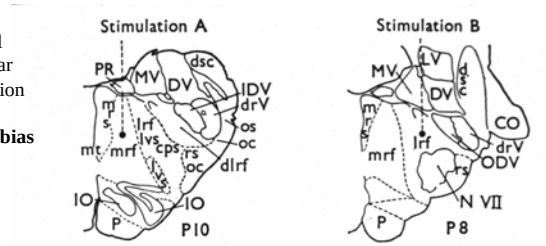




Note: To interpret the Ia input in terms of muscle length, the CNS must take account of the gamma activity or *gamma bias*. It must use some kind of **efference copy** for this.

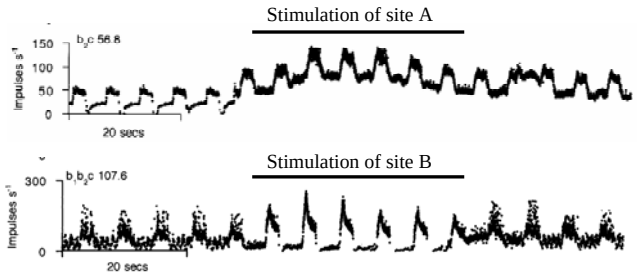
Medial reticular formation

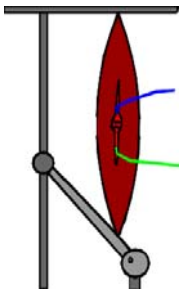
Static bias

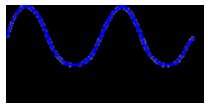


Lateral reticular formation

Dynamic bias

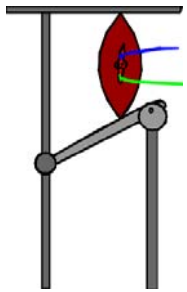


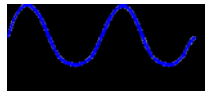




Muscle length
(stretched)

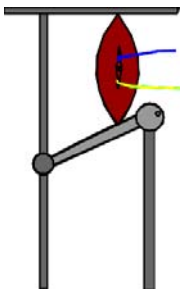
Ia output

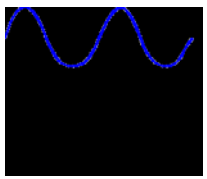


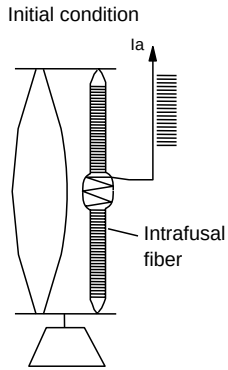


Muscle length

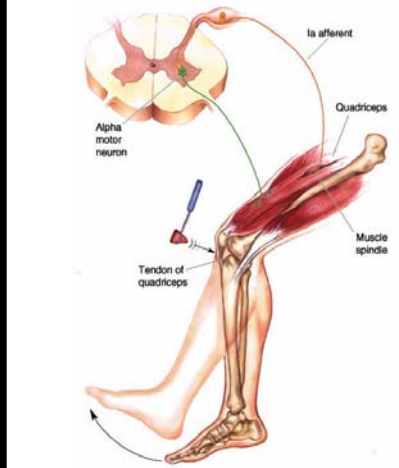
Ia output

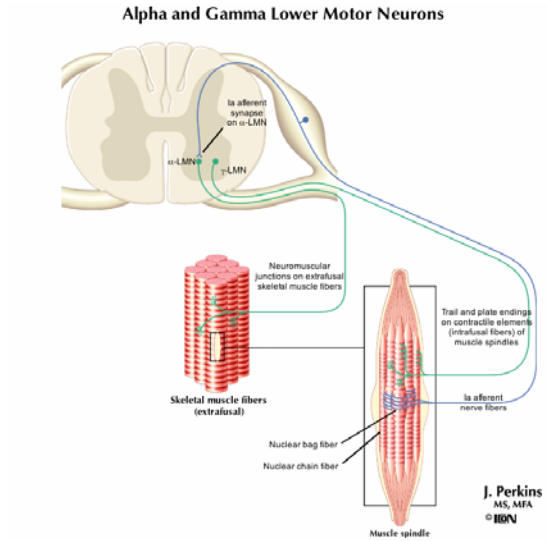




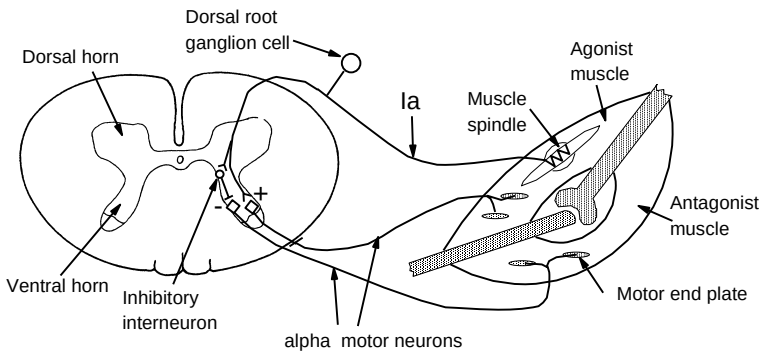


Coactivation of alphas and gammas allows the spindle to adjust its length to the changing length of the muscle



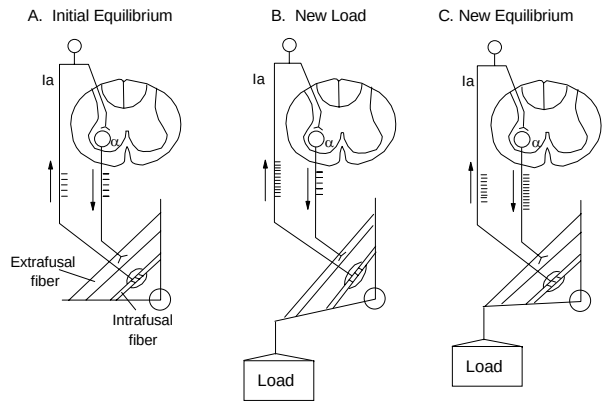


Myotatic Reflex and Reciprocal Innervation (Inhibition)

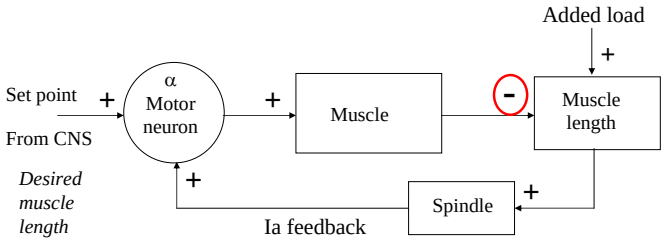


Note that the gamma motor neurons are not targets of the Ia input.

Myotatic Reflex and Automatic Load Management



The myotatic reflex as a regulator of muscle length



With respect to muscle length, the Ia feedback is negative because an increase in spindle output results in a decrease in muscle length.

The myotatic reflex contributes to the stiffness of the muscle, i.e. its resistance to lengthening.

Increasing the sensitivity of the spindle by gamma bias would increase the 'stiffness' of the reflex.

Spasticity: Hypertonia, Hyperreflexia

The Myotatic Reflexes are Hyperexcitable

Hyperreflexia of Leg and Arm

Spasticity can result from abnormally high gamma activity.

Because this has its effect via the Ia afferents, spasticity goes away if the dorsal roots are cut.