POLYSYNAPTIC REFLEXES
- Lots of different pathways to the same motor neuron
- Some are shorter and some are longer, but all of them try to get to the same motor neuron
- Thus, there is sustained stimulation of the motor neuron (because of synaptic delay, some stimuli arrive late) and the reflex is prolonged
- Also, some of the pathways recur back on themselves and inhibit themselves, and so there is “reverberation” which eventually kills off the stimulus

Withdrawal reflex
- This is a reflex of withdrawing from a painful stimulus
- The ipsilateral flexor flexes, and the extensor relaxes
- With a strong stimulus, the contralateral body part undergoes the opposite: the extensor flexes, and the flexor relaxes
- This seems rooted in our past as quadruped animals: one limb flexes to withdraw from the nociceptive stimulus, and the other limb extends to support the body
- WITHDRAWAL REFLEXES ARE PREPOTENT: that is to say they override any other reflex activity going on at the time.
  o The stronger the noxious stimulus, the faster the reaction time because there the summation from more rapid action potentials is faster.
  o The stronger the stimulus, the more prolonged the response

GENERAL PROPERTIES OF ALL REFLEXES
- Adequate stimulus
  ▪ A reflex arc is set up to respond to a precise stimulus – this is the “adequate stimulus”
- Final common path
  ▪ All stimuli causing muscle contraction are eventually funneled through to the motor neuron
  ▪ That’s the final common path – numerous stimuli converge on them
- Central excitatory and inhibitory states
  ▪ There are subliminal fringe effects
  ▪ There is also prolonged changes to spinal excitability
  ▪ When the central excitatory state is massive, the stimulus propagates to many somatic and autonomic areas
  ▪ Thus a noxious stimulus in a paraplegic can cause prolonged extension-withdrawal responses, as well as urination, defecation, and sweating and blood pressure fluctuations (“mass reflex”)

References: Ganong Review of Medical physiology, 23rd ed, chapter 9
Effects of gamma-motor-neuron discharge
- When a muscle is voluntarily contracted, both alpha-motor-neurons and gamma-motor-neurons are firing. This means the spindle contracts in proportion with the muscle. This means also that the spindle remains sensitive to stretch, and can produce reflex adjustments.

Control of gamma-motor-neuron discharge
- These neurons are controlled by descending tracts from the brain.
- The sensitivity of the reflex arcs is adjusted this way.
- Anxiety increases muscle spindle sensitivity via the gamma-motor-neuron.
- The JENDRASSIK’s maneuver—pulling one’s hands apart with fingers held together tends to facilitate the knee jerk reflex; the reason being that the total gamma-motor-neuron firing is increased by afferent impulses from the hands.
- Noxious stimuli to the skin increase gamma-motor-neuron discharge to the ipsilateral flexor muscle spindles, while decreasing the discharge to the contralateral limb flexors. The opposite happens to the extensors.

Reciprocal innervation
- If you are going to flex a muscle, the opposite muscles across the joint need to relax.
- This is called “reciprocal innervation.”
- It happens because of post-synaptic inhibition of motor neurons of the opposing muscles.
- This is a bisynaptic reflex arc-a collateral from each Ia fiber passes to an interneuron in the spinal cord which inhibits the motor neuron of the antagonist muscle.

Inverse stretch reflex
- The muscle only responds to stretch with contraction up to a point.
- Eventually it gives up and relaxes.
- This is the “inverse stretch reflex”, or autogenic inhibition.
- The sensor responsible is the GOLGI TENDON ORGAN—it fires when the tendons are over-stretched.
- This is a netlike collection of knobby nerve endings among the fascicles of a tendon.
- These nerve fibers are Ib fast myelinated fibers.
- Stimulating them produces inhibitory post—synaptic potentials in the neurons which are responsible for contracting the muscle.
- It also produces excitatory post-synaptic potentials in the antagonist muscles.
- The Golgi organ is in series, not in parallel, with the muscle spindle—this means it will be activated by both passive stretch and by active contraction.
- Thus, it functions as a modifier, controlling muscle force in the same way as the muscle spindle controls muscle length.

Clonus
- The characteristic of a state where there is increased gamma-motor-neuron discharge.
- If you subject a muscle to a sudden sustained stretch, clonus will appear if gamma neurons are overactive.
- This might be because of decreased input from descending fibers to the Renshaw cells in the spinal cord, which are glycine-releasing inhibitory interneurons.

Muscle Tone
- Increased tone is due to hyperactive stretch reflexes—this is a hypertonic, “spastic” muscle.
- This demonstrates sequential stretch reflex activation followed by golgi organ relaxation.
- When a spastic arm is suddenly flexed, it puts up a lot of resistance.
- Then, if the pressure is maintained, it gives way because the Golgi organ reflex is activated, and there is relaxation; so the arm becomes flaccid.