

PSYCH 260

Action

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Prelude



Prelude



Announcements

- Exam 3 next Tuesday, November 16
- Grading
 - Best 3 of 4 quizzes
 - Best 3 of 4 exams
 - Blogs or paper

Today's Topics

- Wrap-up on somatosensation
- The neuroscience of action

Action

The neuroscience of action

- What types of actions are there?
- How are they produced?
 - By the muscles
 - By the nervous system

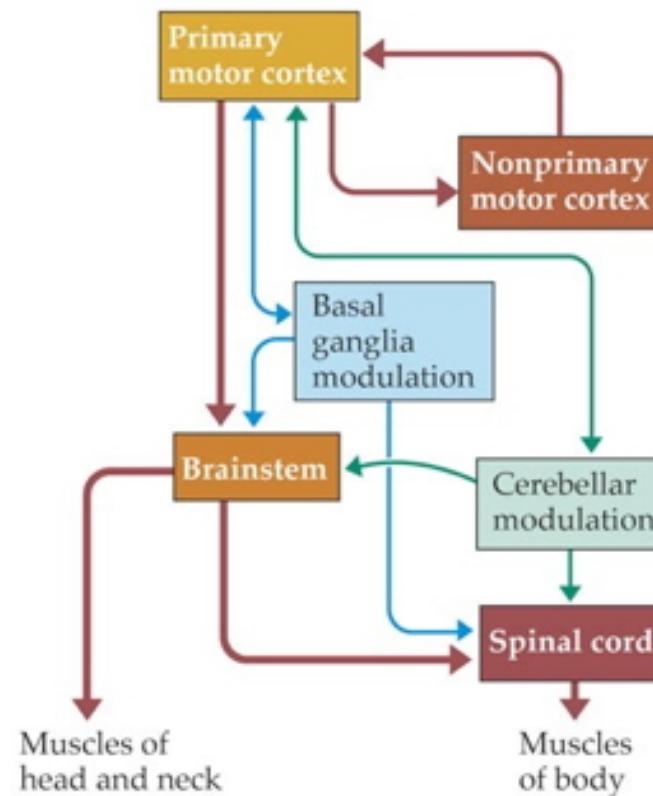
Remember

- Nervous system “output” includes
 - Movements
 - Autonomic responses
 - Endocrine responses

Types of actions

- Reflexes
 - Simple, highly stereotyped, unlearned, rapid
- vs. Planned or voluntary actions
 - Complex, flexible, acquired, slower
- Discrete (reaching) vs. rhythmic (walking)
- Ballistic (no feedback) vs. controlled (feedback)

Multiple, parallel controllers



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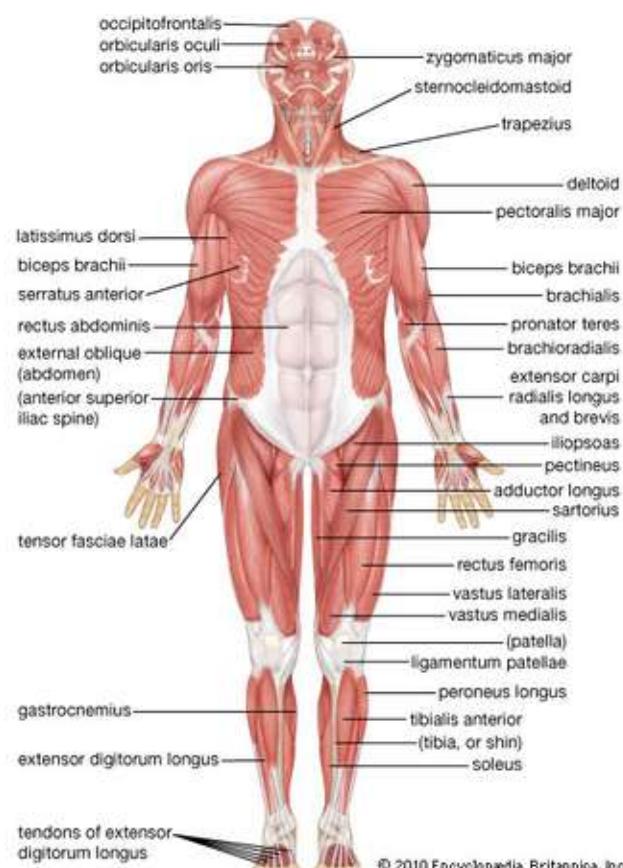
Key “nodes” in network

- Primary motor cortex (M1)
- Non-primary motor cortex
- Basal ganglia
- Brain stem
- Cerebellum
- Spinal cord

Muscle classes

- Axial
 - Trunk, neck, hips
- Proximal
 - Shoulder/elbow, pelvis/knee
- Distal
 - Hands/fingers, feet/toes

Muscles

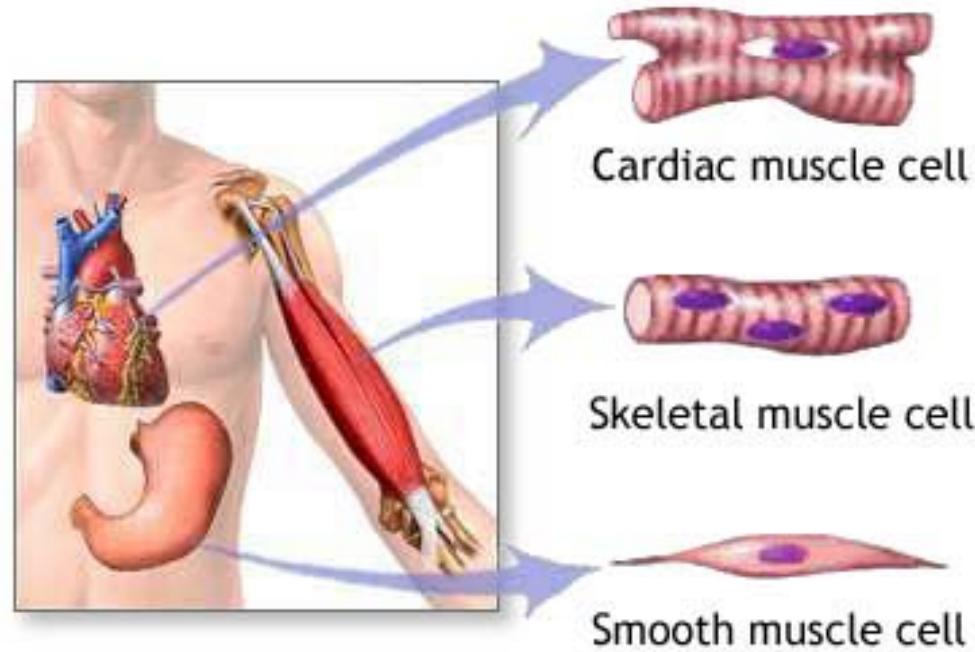


<https://cdn.britannica.com/s:700x450/20/55620-004-0B8EF544.jpg>

Muscle types

- Smooth
 - Arteries, hair follicles, uterus, intestines
 - Regulated by ANS (involuntary)
- Striated (striped)
 - Skeletal
 - Voluntary control, mostly connected to tendons and bones
- Cardiac

Muscle types



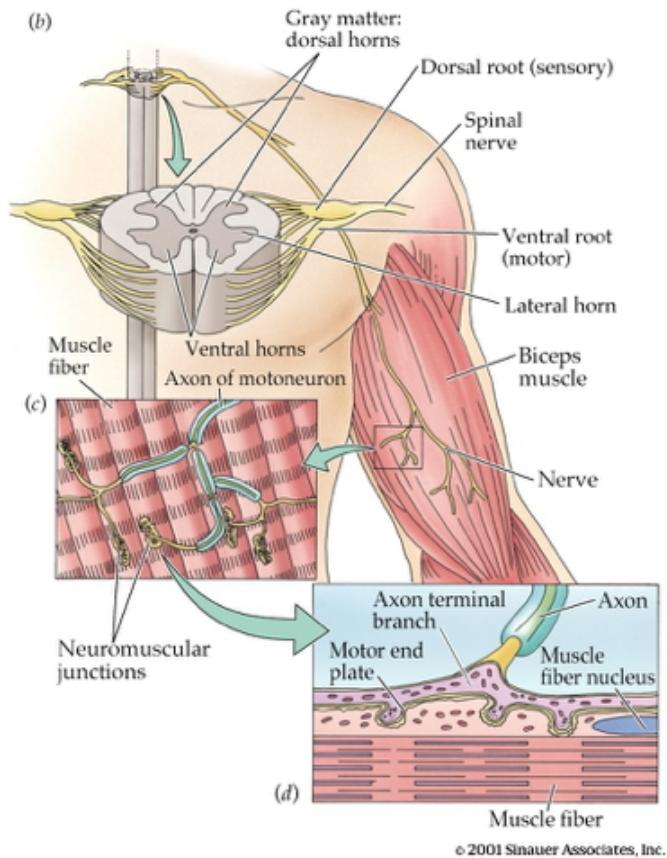
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<http://graphics8.nytimes.com/images/2007/08/01/health/adam/19917.jpg>

How skeletal muscles contract

- Motoneuron (ventral horn of spinal cord)
- Neuromuscular junction
 - Releases ACh

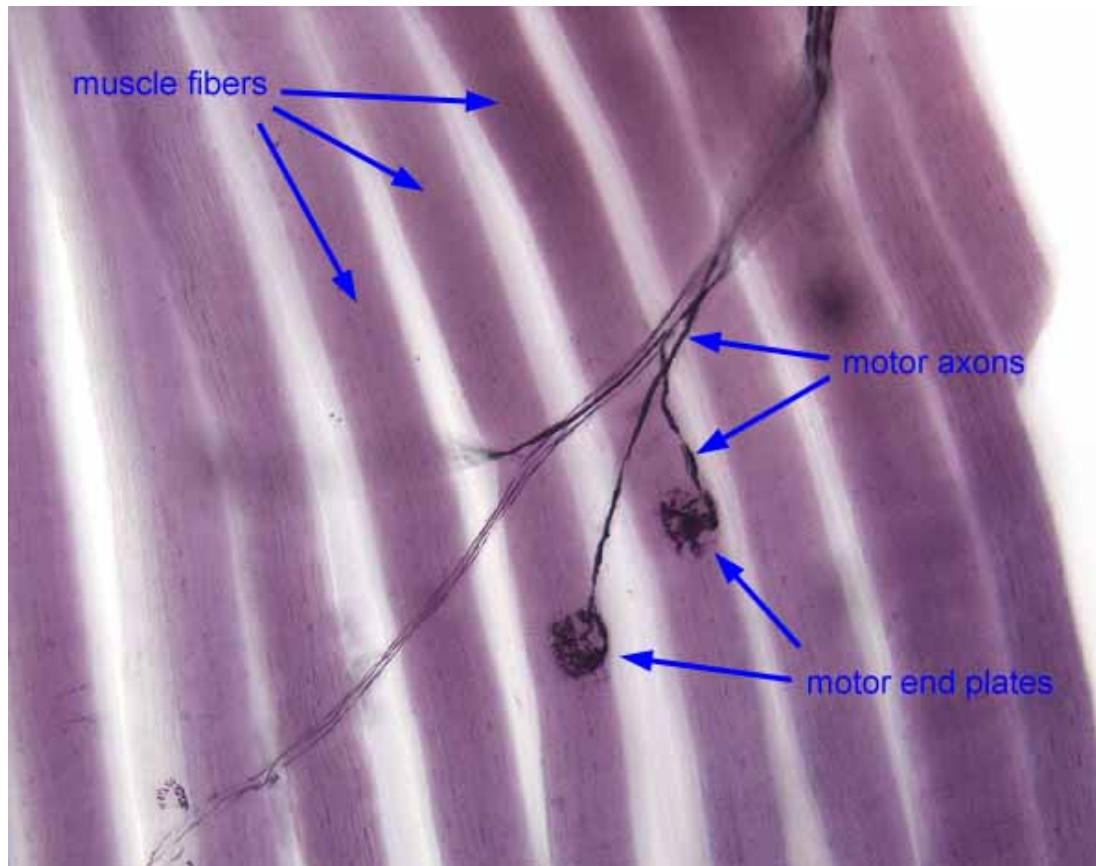
From spinal cord to muscle



How skeletal muscles contract

- Motor endplate
 - Contains nicotinic ACh receptor
 - Generates excitatory endplate potential
 - Muscle fiber depolarizes
 - Depolarization spreads along fiber
 - Causes release of Ca++ from stores inside muscle

Motor endplate



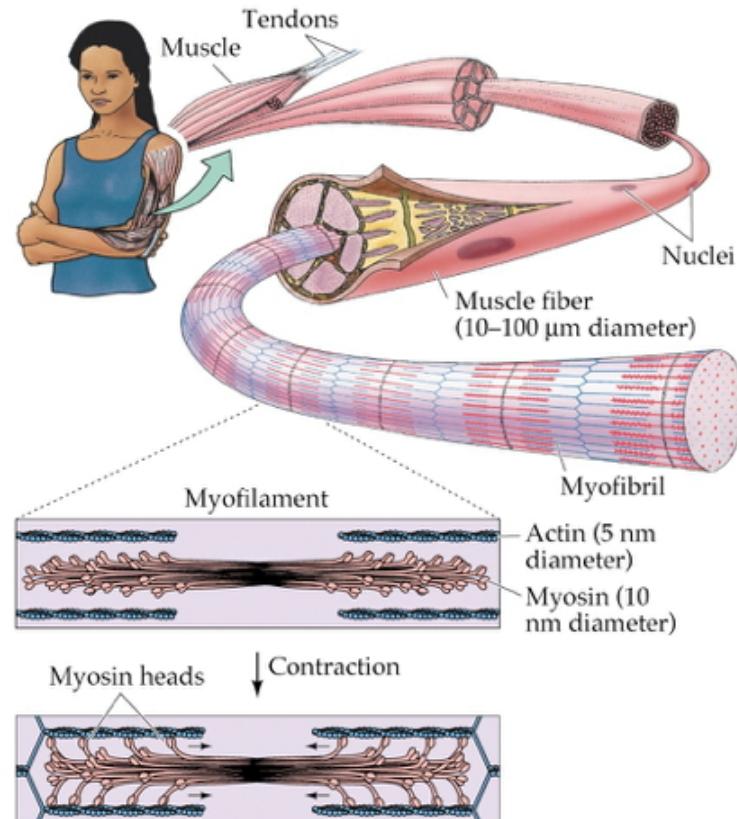
Anatomy of motor endplate



How skeletal muscles contract

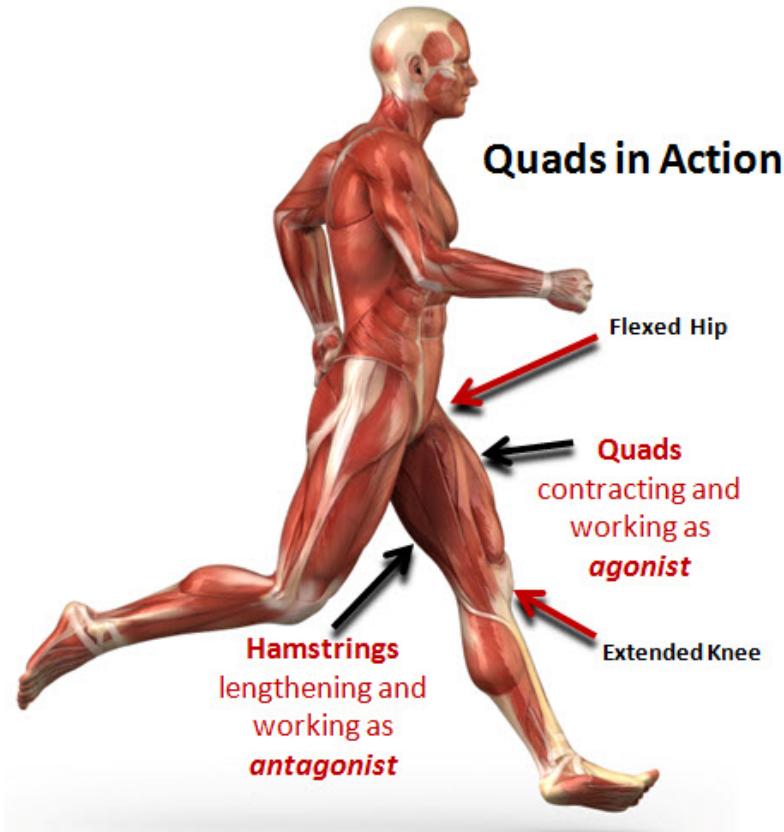
- Muscle fibers segmented in to sarcomeres
- Myofibrils (w/in sarcomere)
 - Paired actin & myosin proteins
 - “Molecular gears”
- Bind, move, unbind in presence of Ca^{++} plus energy source (ATP)

Anatomy of muscle fibers



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Agonist/antagonist muscle pairs



http://2.bp.blogspot.com/-TpOC4my_NBc/T0j-MhEv29I/AAAAAAAFA88/dYLv7QzFwmg/s1600/Hamstring-Quad4.jpg

Meat preference?



Muscle fiber types

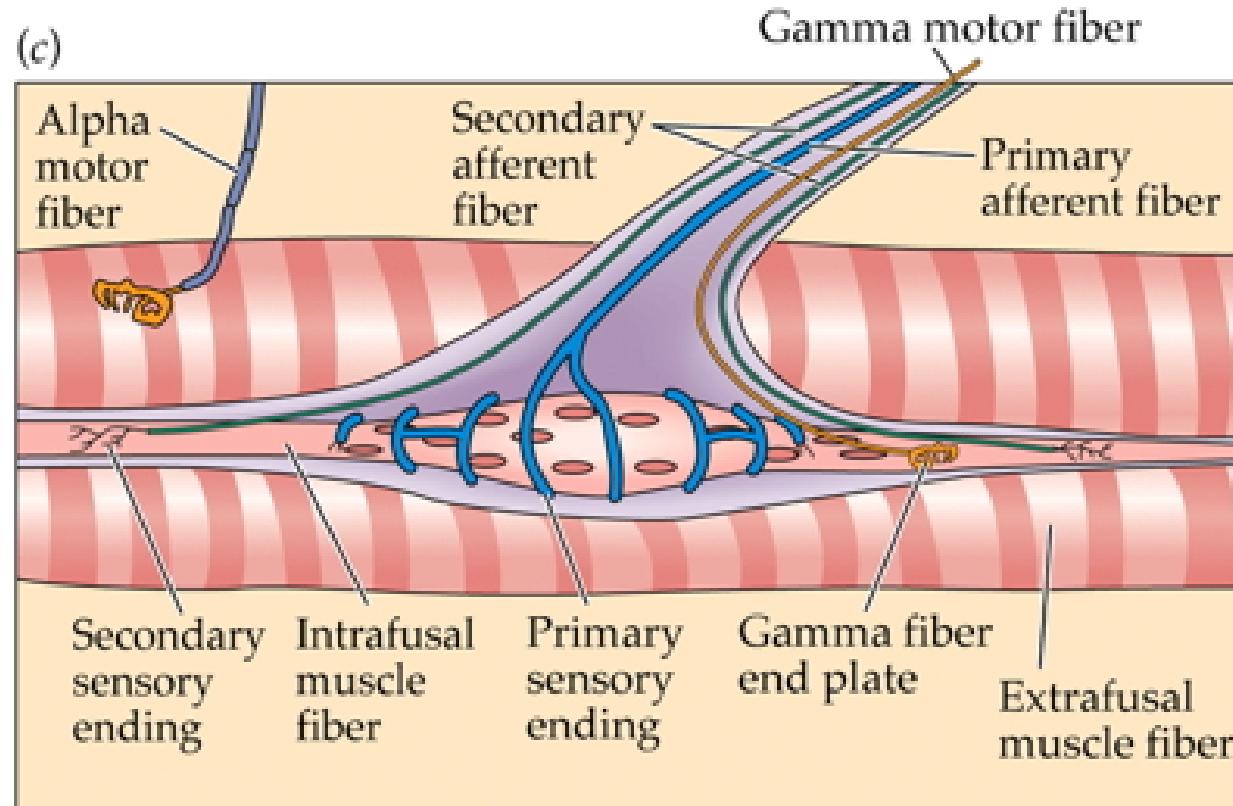
- Fast twitch/fatiguing
 - Type II
 - White meat
- Slow twitch/fatiguing
 - Type I
 - Red meat

Muscles are sensory organs, too!



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Two muscle fiber types



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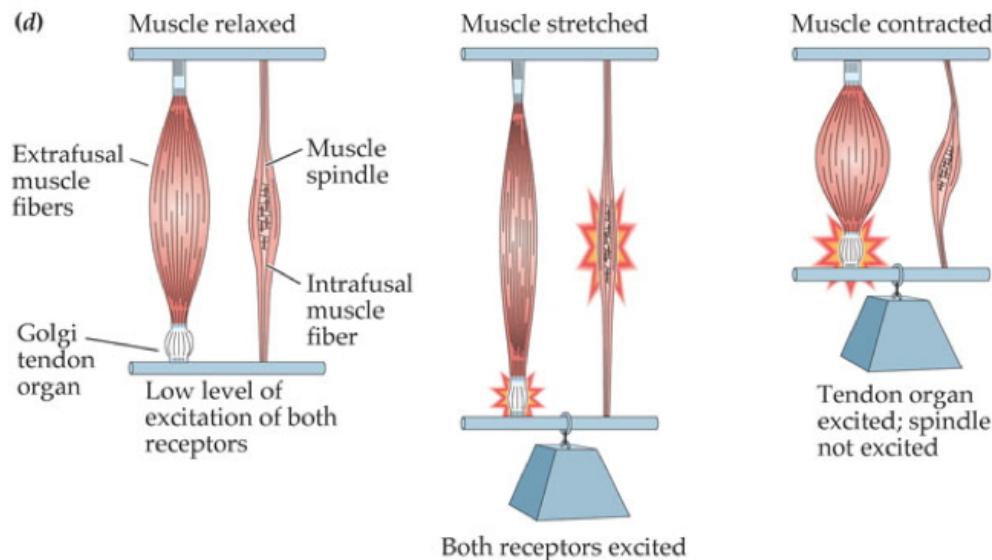
Two muscle fiber types

- **Intrafusal** fibers
 - Sense length/tension
 - Contain muscle spindles linked to Ia afferents
 - innervated by gamma (γ) motor neurons
- **Extrafusal** fibers
 - Generate force
 - innervated by alpha (α) motor neurons

Monosynaptic stretch (myotatic) reflex

- Muscle stretched (length increases)
- Muscle spindle in intrafusal fiber activates
- Ia afferent sends signal to spinal cord
 - Activates alpha (α) motor neuron
- Muscle contracts, shortens length

Monosynaptic stretch (myotatic) reflex



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- Gamma (γ) motor neuron fires to take up intrafusal fiber slack

A Record-Setting Ascent of El Capitan

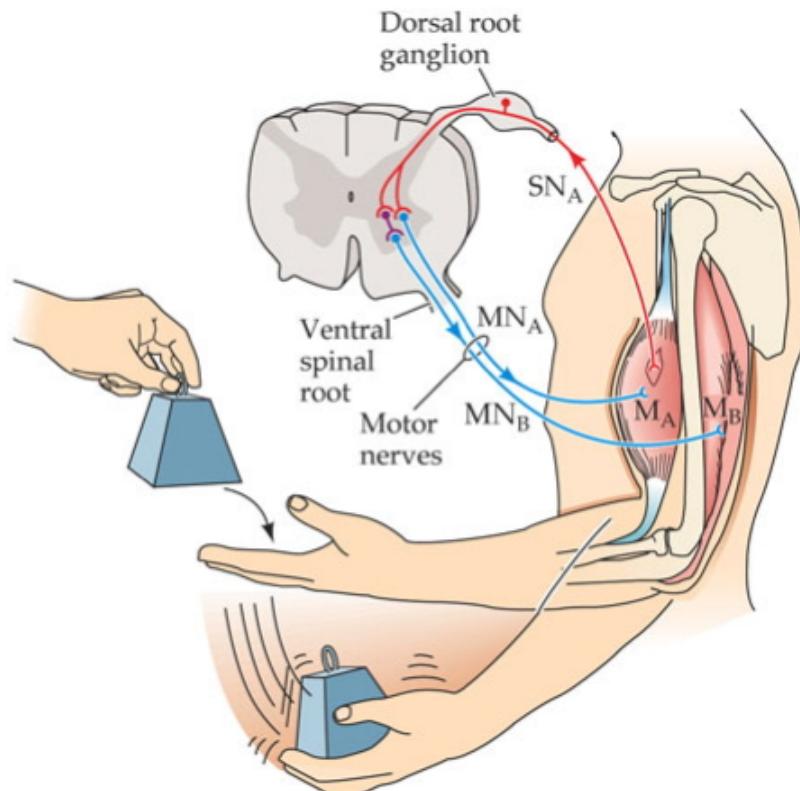
Emily Harrington is the first woman to free-climb the Golden Gate route up El Capitan, a 3,000-foot-high monolith in Yosemite National Park, in under 24 hours.



Emily Harrington, 34, climbing El Capitan in Yosemite National Park last Wednesday.
Jon Glassberg/Louder Than 11

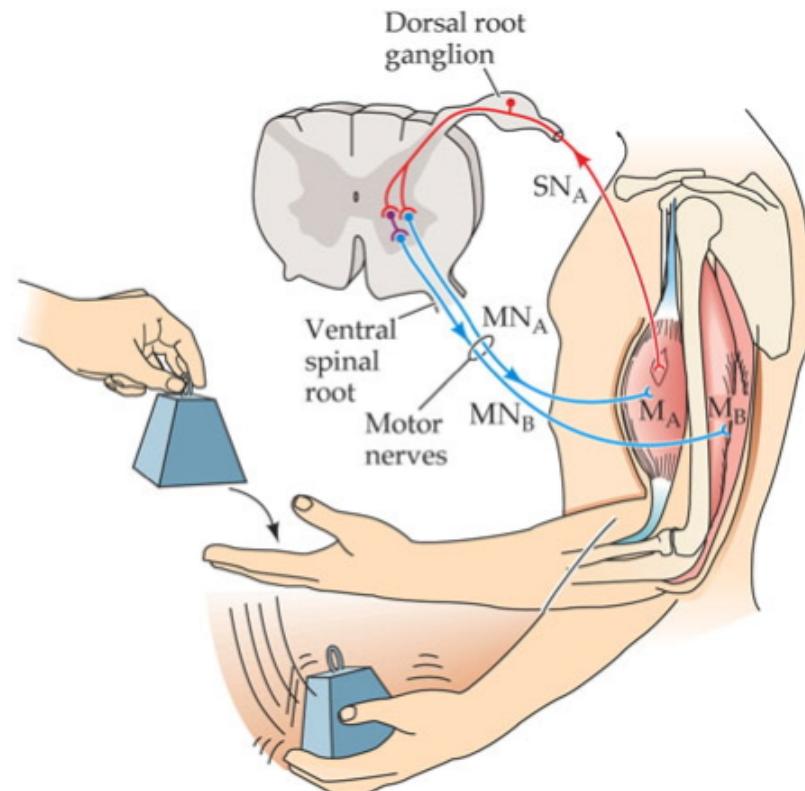
<https://www.nytimes.com/2020/11/09/sports/emily-harrington-free-climb-yosemite.html>

Monosynaptic stretch (myotatic) reflex



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Why doesn't antagonist muscle respond?



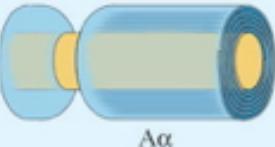
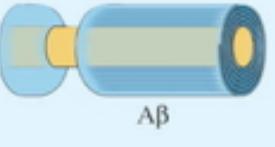
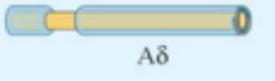
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Why doesn't antagonist muscle respond?

- Polysynaptic inhibition of antagonist muscle
- Prevents/dampens tremor

Brain gets fast(est) sensory info from spindles

TABLE 8.2 *Fibers That Link Receptors to the CNS*

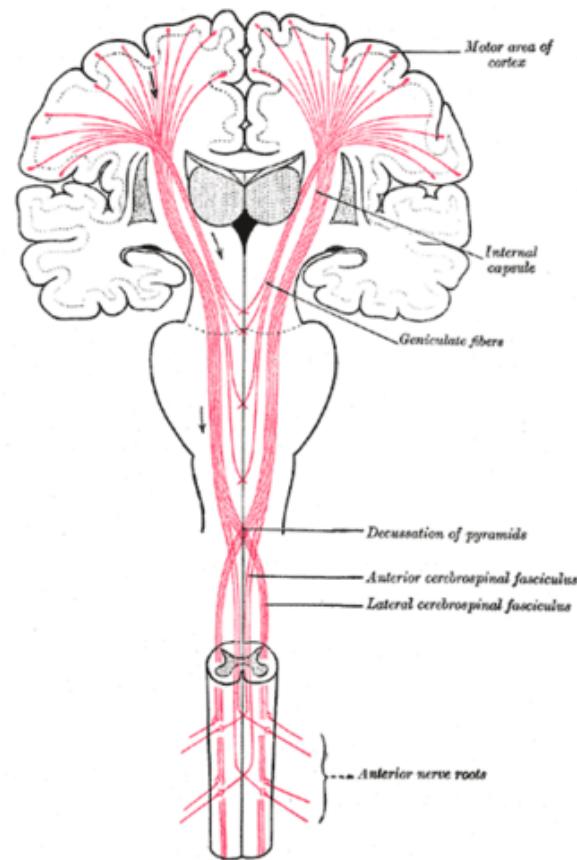
Sensory function(s)	Receptor type(s)	Axon type	Diameter (μm)	Conduction speed (m/s)
Proprioception (see Chapter 11)	Muscle spindle	 A α	13–20	80–120
Touch (see Figures 8.12 and 8.13)	Pacinian corpuscle, Ruffini's ending, Merkel's disc, Meissner's corpuscle	 A β	6–12	35–75
Pain, temperature	Free nerve endings; VR1	 A δ	1–5	5–30
Temperature, pain, itch	Free nerve endings; VR1, CMR1	 C	0.02–1.5	0.5–2

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How the brain controls the muscles

- Pyramidal system
 - Pyramidal cells (from Cerebral Cortex Layer 5) in primary motor cortex (M1)
 - Corticobulbar (cortex -> brainstem) tract
 - Corticospinal (cortex -> spinal cord) tract
- Crossover (decussate) in medulla
 - L side of brain innervates R side of body

Corticospinal tract

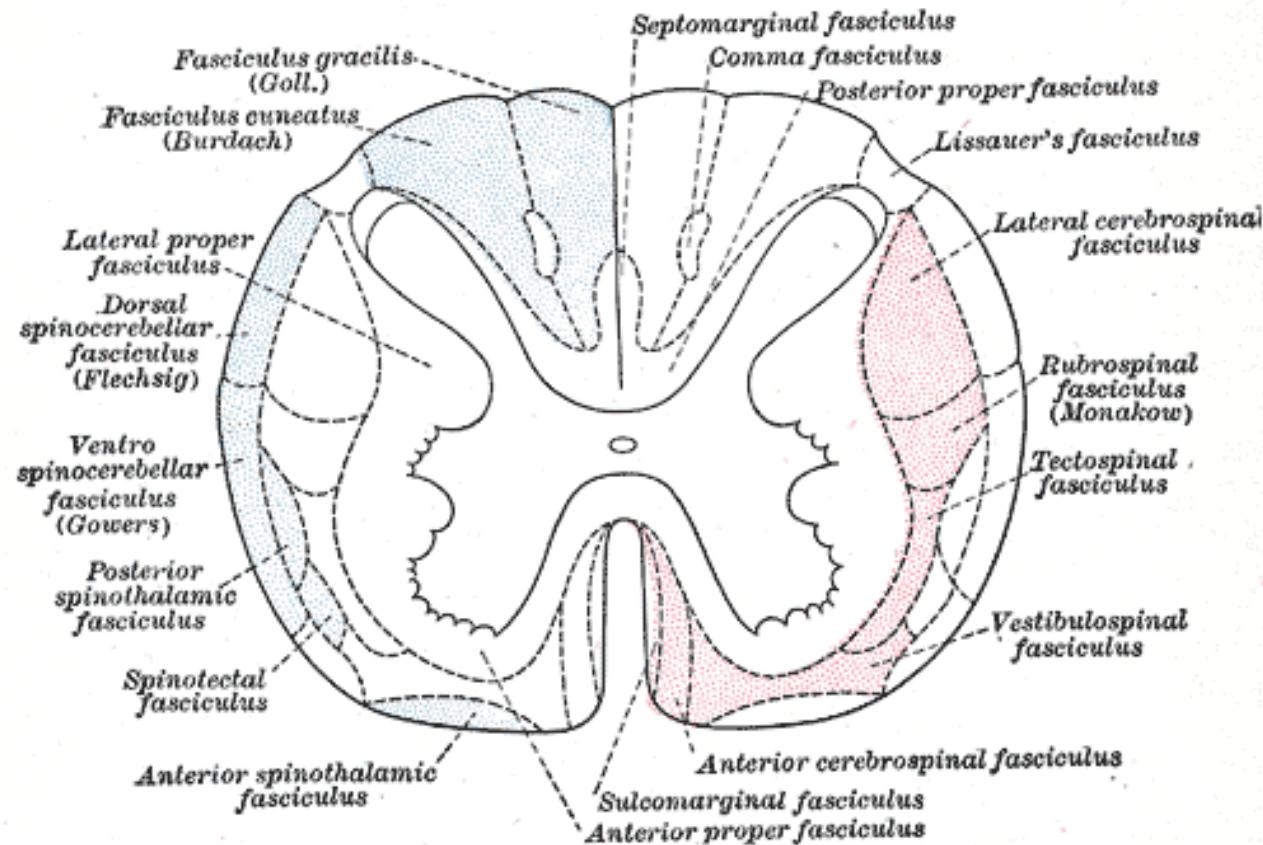


<https://commons.wikimedia.org/wiki/File:Gray764.png#/media/File:Gray764.png>

How the brain controls the muscles

- Extrapyramidal system
 - Tectospinal tract
 - Vestibulospinal tract
 - Reticulospinal tract
- Involuntary movements
 - Posture, balance, arousal

Extrapyramidal system



<https://upload.wikimedia.org/wikipedia/commons/b/be/Gray672.png>

This figure shows that the descending motor pathways in red on the right have their own spatial organization depending on where they originate in the brain.

Disorders

- Parkinson's
- Huntington's

The Faces of Parkinson's



Parkinson's

- Slow, absent movement, resting tremor
- Cognitive deficits, depression
- DA Neurons in substantia nigra degenerate
- Treatments
 - DA agonists
 - DA agonists linked to impulse control disorders in ~1/7 patients ([Ramirez-Zamora, Gee, Boyd, & Biller, 2016](#))
 - Levodopa (L-Dopa), DA precursor

Huntington's



<http://cp91279.biography.com/1000509261001/100050926-guthrie-centennial-1.jpg>

Huntington's

- Formerly Huntington's Chorea
 - “Chorea” from Greek for “dance”
 - “Dance-like” pattern of involuntary movements
- Cognitive decline
- Genetic + environmental influences
- Disturbance in striatum
- No effective treatment

Huntington's



Final thoughts

- Control of movement determined by multiple sources
- Cerebral cortex + basal ganglia + cerebellum + spinal circuits

Next time...

- Vision
- Review for Exam 3

References

Ramirez-Zamora, A., Gee, L., Boyd, J., & Biller, J. (2016). Treatment of impulse control disorders in Parkinson's disease: Practical considerations and future directions. *Expert Review of Neurotherapeutics*, 16(4), 389–399. <https://doi.org/10.1586/14737175.2016.1158103>