PSYCH 260

Action

Rick Gilmore

2021-11-11 08:00:11

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

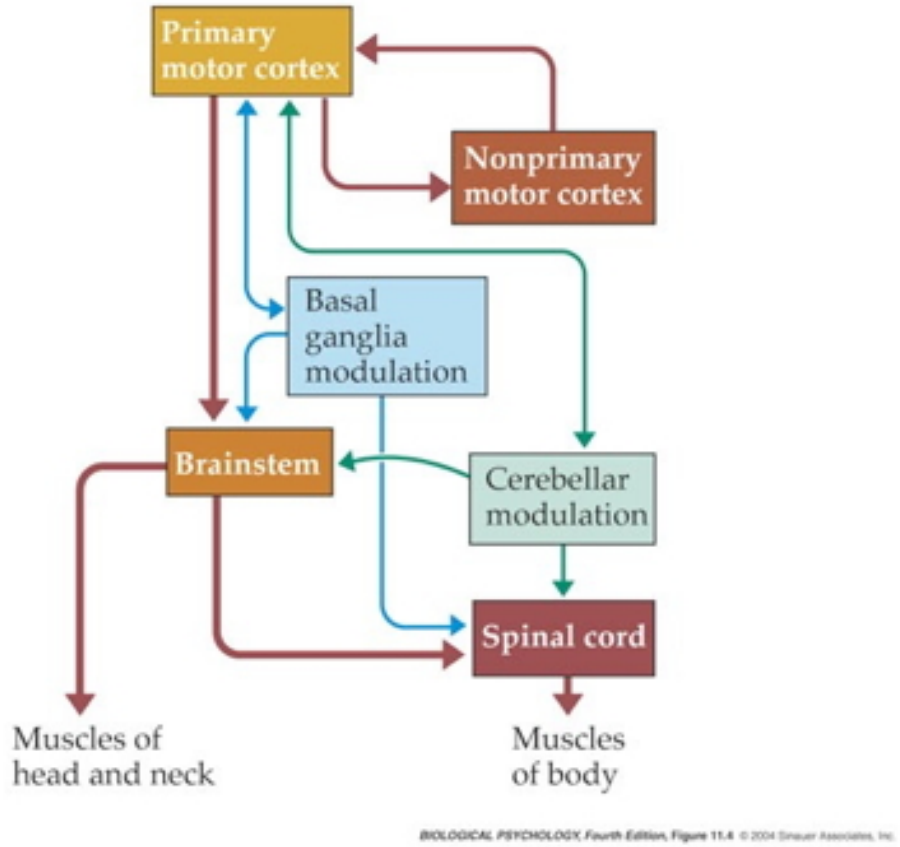
Remember

- 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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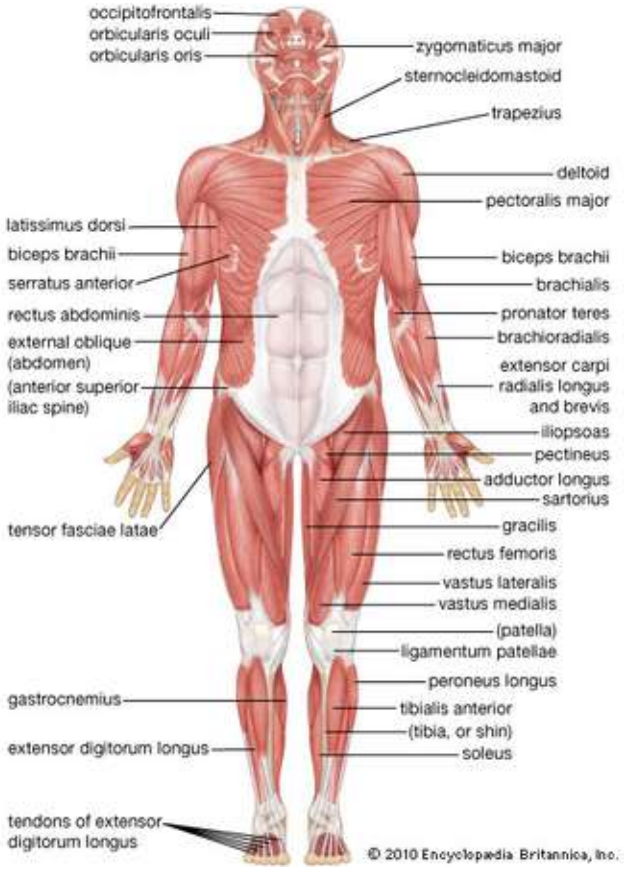
Key “nodes” in network

- 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



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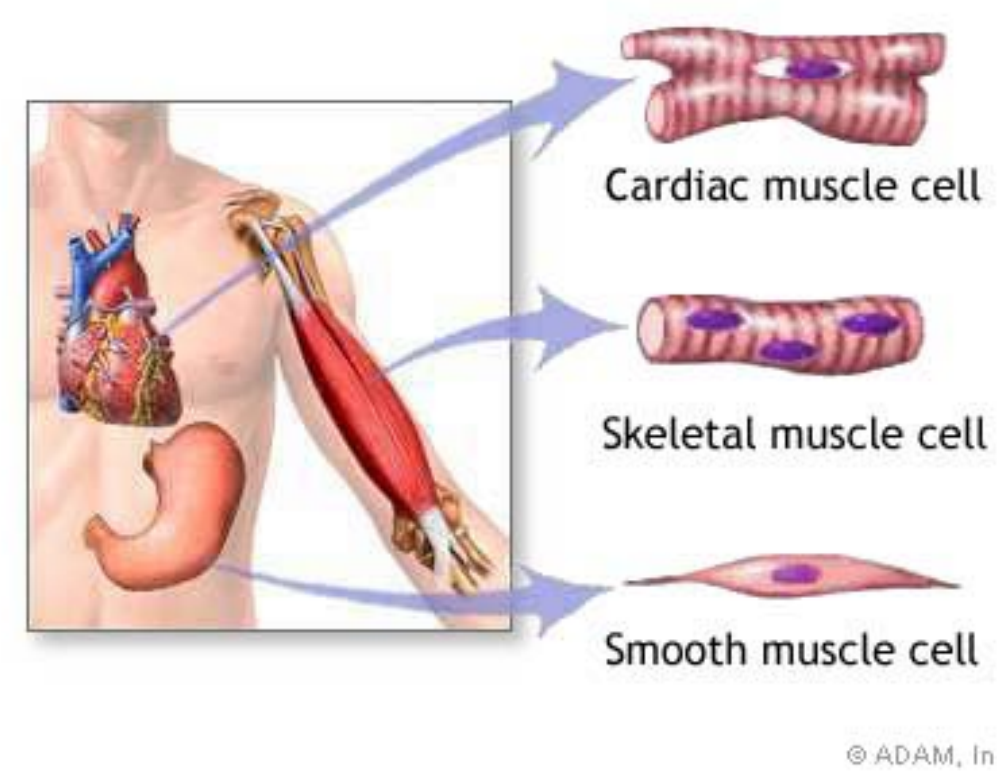
Muscle types

- 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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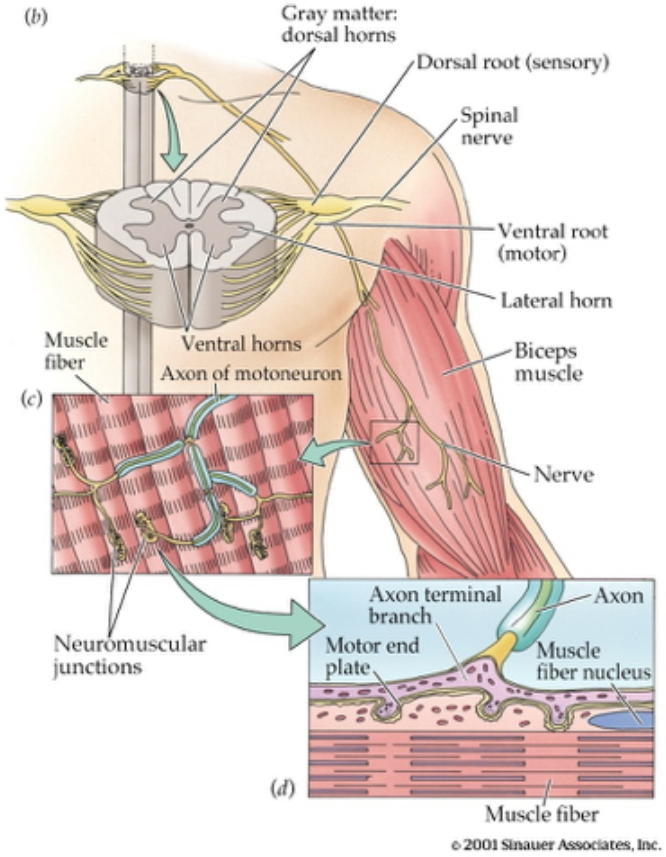
How skeletal muscles contract

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

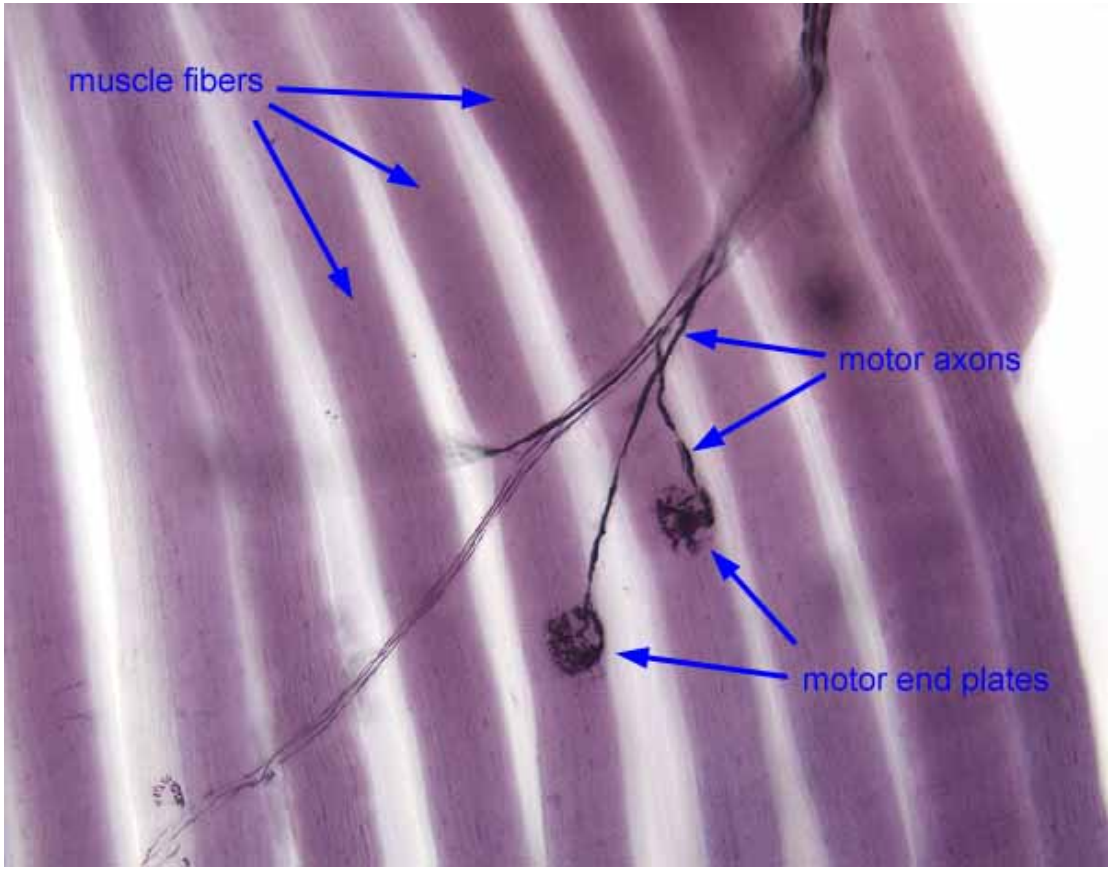
From spinal cord to muscle



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

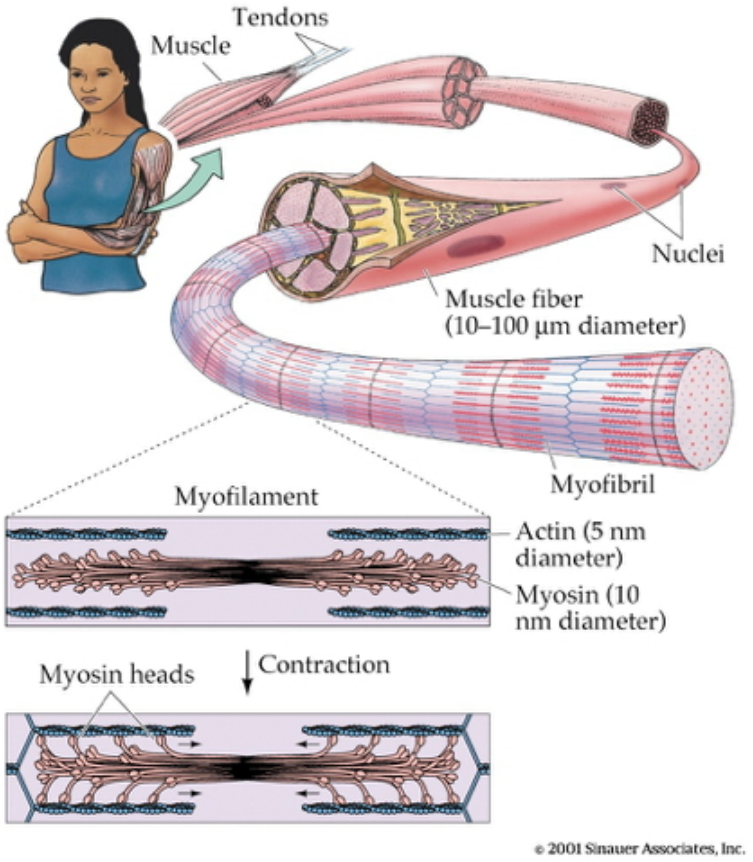


Anatomy of motor endplate

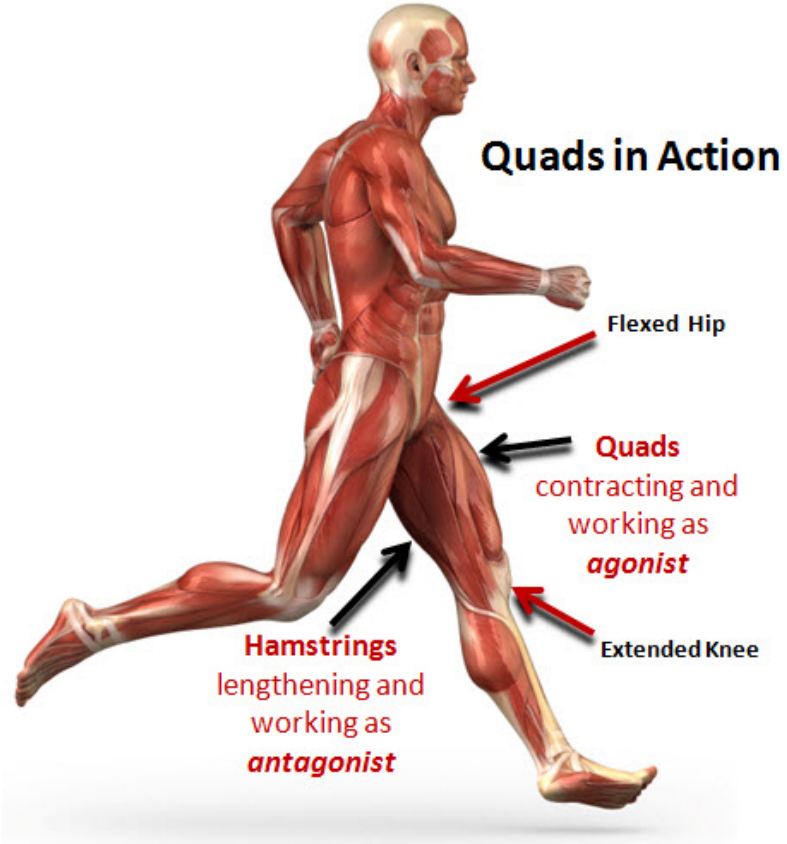
How skeletal muscles contract

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

Anatomy of muscle fibers



Agonist/antagonist muscle pairs



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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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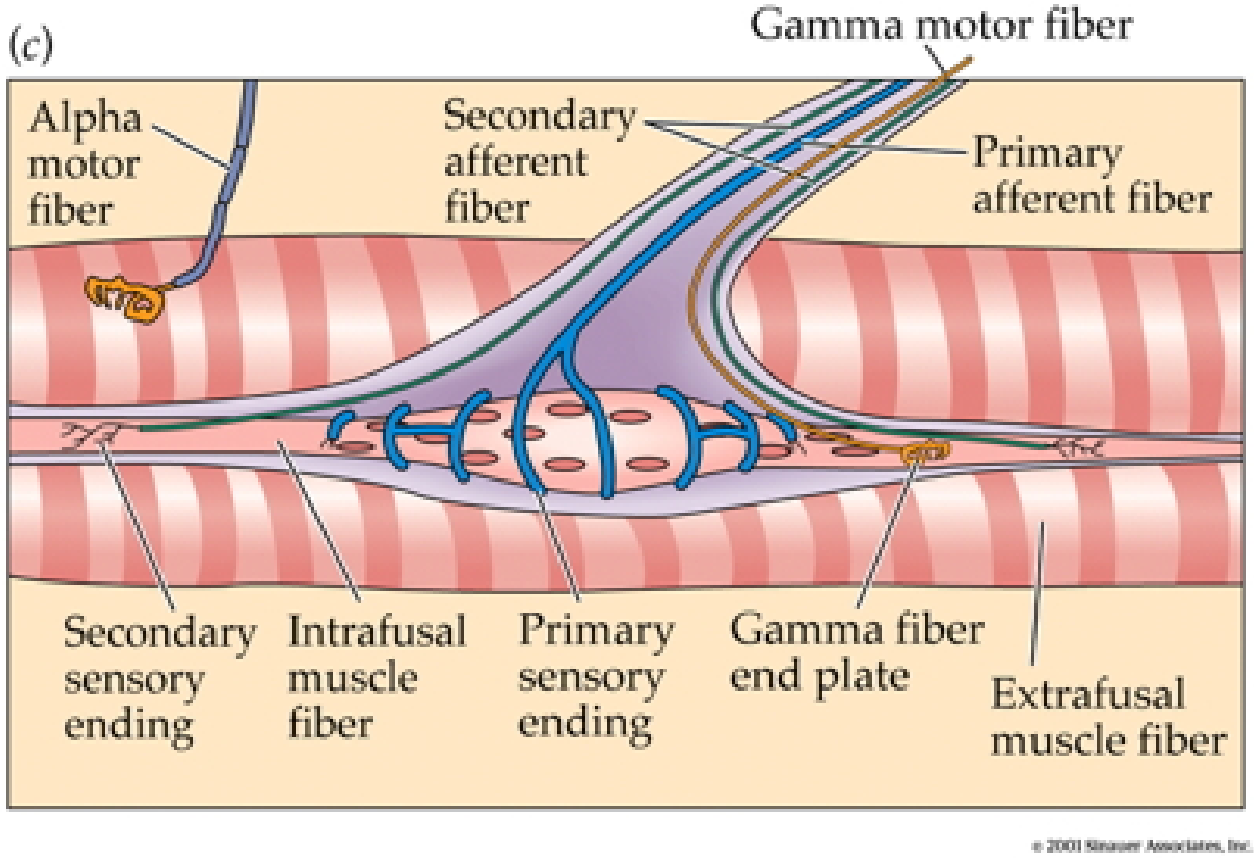
Two muscle fiber types



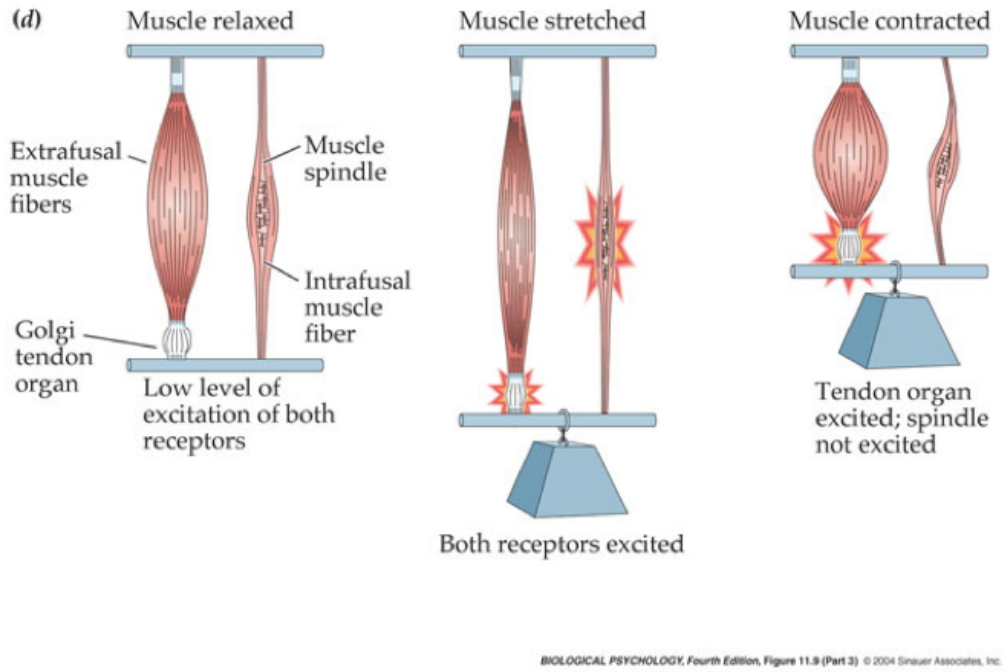
Two muscle fiber types

- **Intrafusal** fibers
  - Sense length/tension
  - Contain muscle spindles linked to Ia afferents
  - ennervated by gamma (γ) motor neurons
- **Extrafusal** fibers
  - Generate force
  - ennervated 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 stetch (myotatic) reflex



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

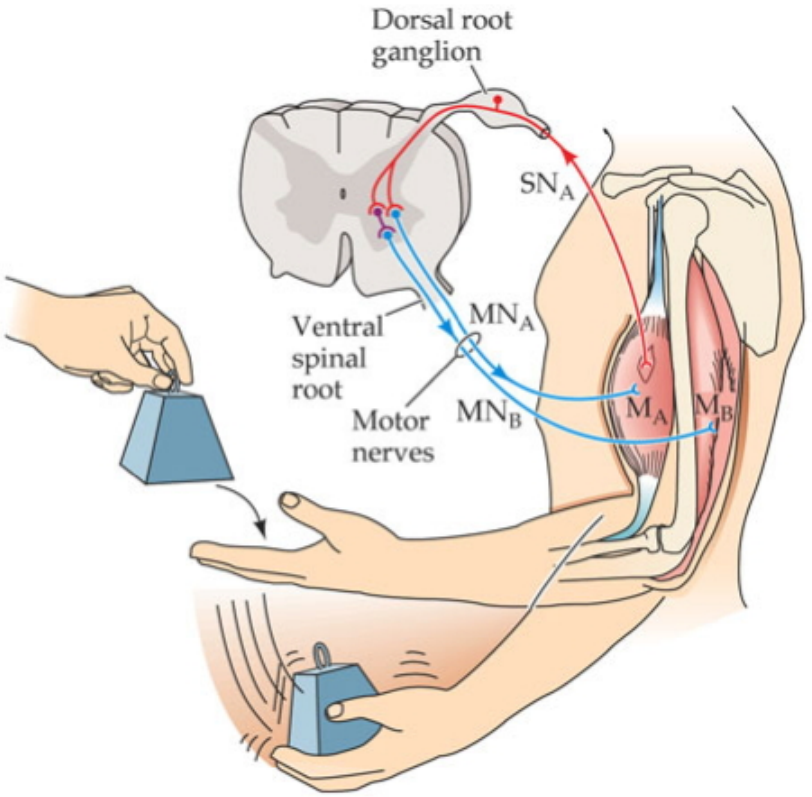
A Record-Setting Ascent of El Capitan

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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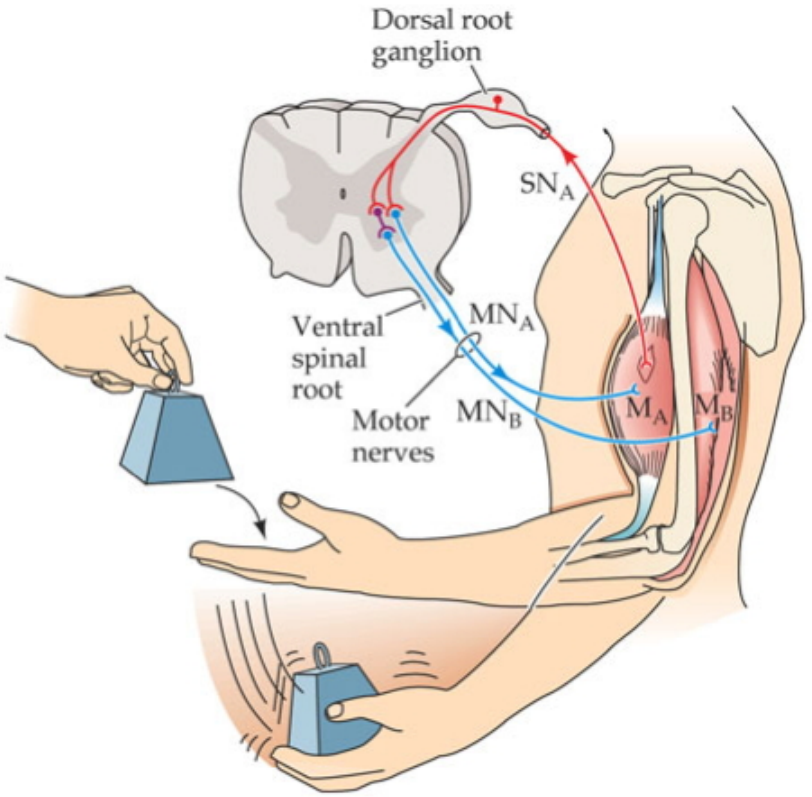
Why doesn't antagonist muscle respond?



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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	 Aα	13–20	80–120
Touch (see Figures 8.12 and 8.13)	Pacinian corpuscle, Ruffini's ending, Merkel's disc, Meissner's corpuscle	 Aβ	6–12	35–75
Pain, temperature	Free nerve endings; VRL1	 Aδ	1–5	5–30
Temperature, pain, itch	Free nerve endings; VR1, CMR1	C	0.02–1.5	0.5–2

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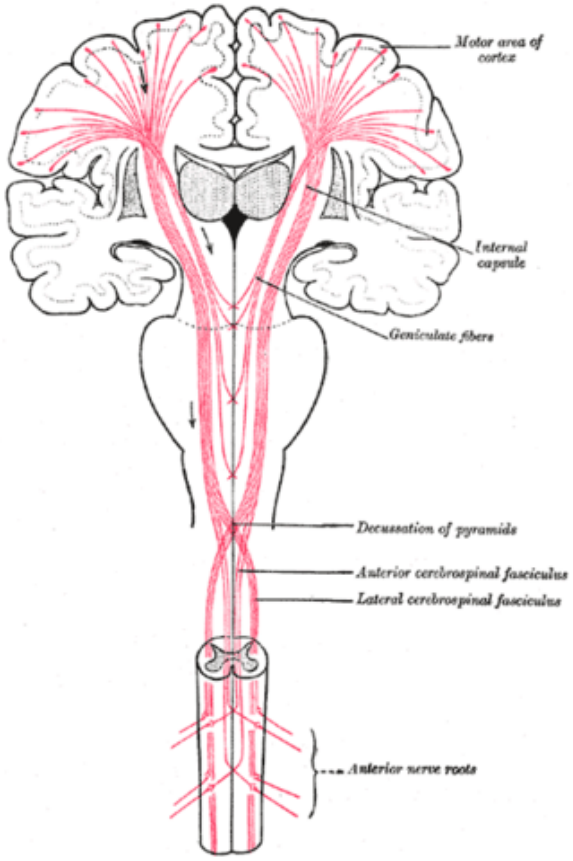
How the brain controls the muscles

- 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 ennervates R side of body

Corticospinal tract



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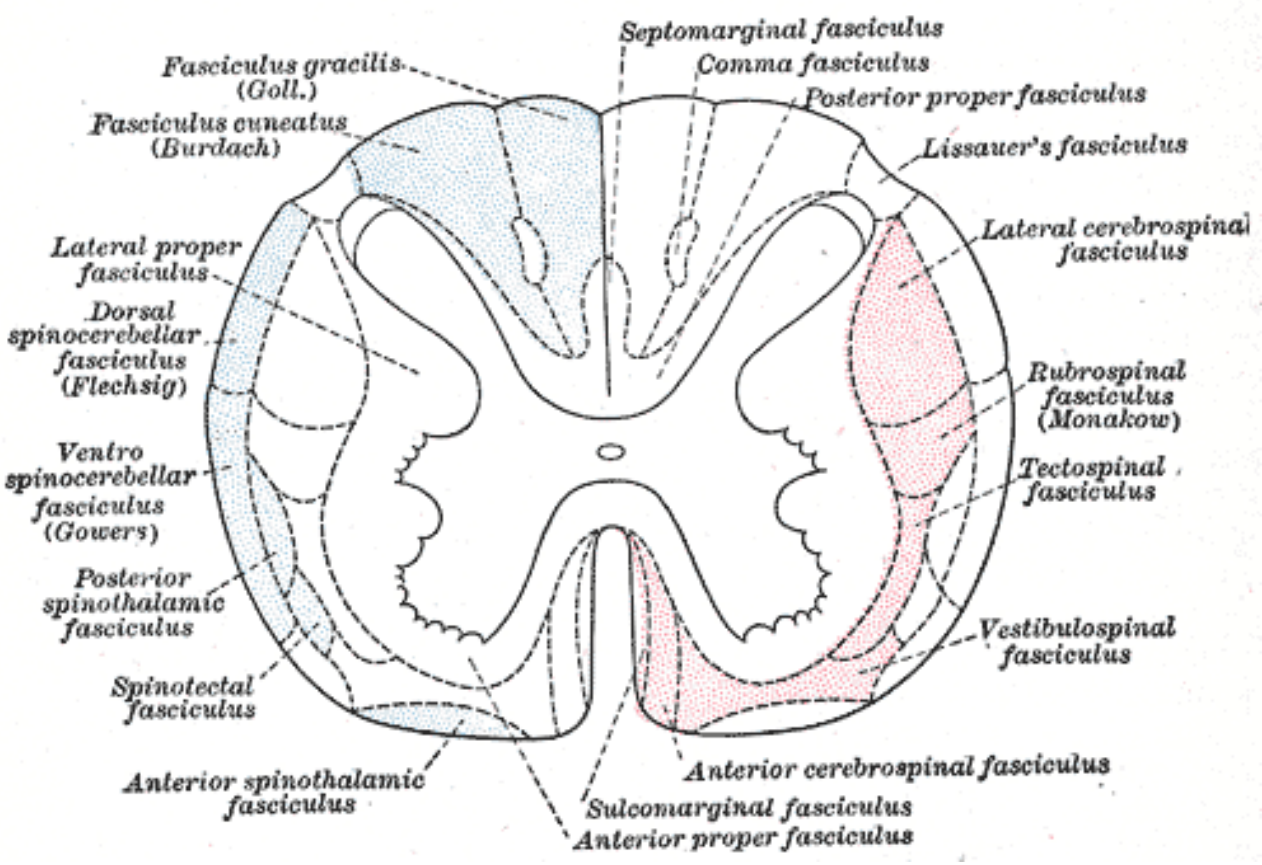
How the brain controls the muscles

- 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

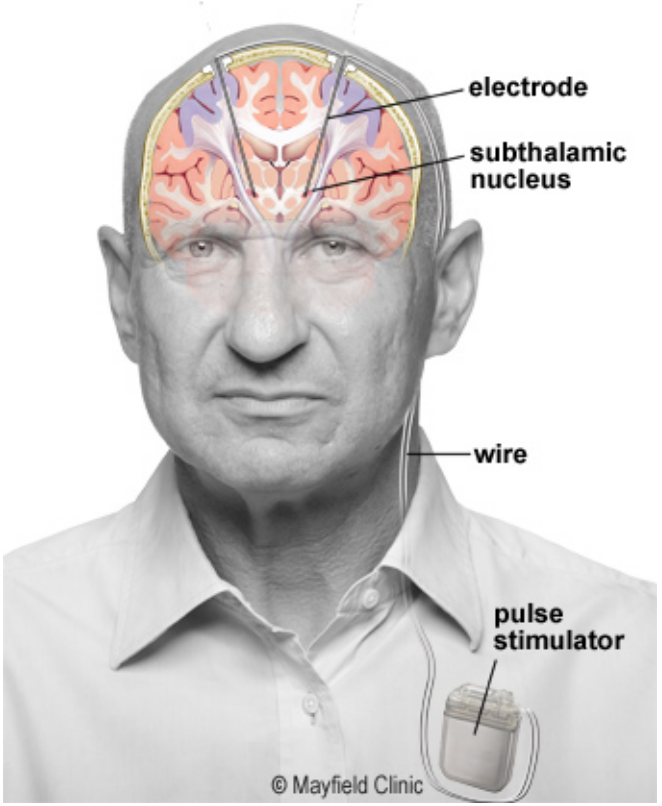
The Faces of Parkinson's

Parkinson's

- Symptoms
  - Slow, absent movement, resting tremor
  - Cognitive deficits, depression
- Biological correlates
  - DA neurons in substantia nigra degenerate
  - Autoimmune disorder? (Garretti, Agalliu, Lindestam Arlehamn, Sette, & Sulzer, 2019)

Parkinson's

- 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
  - Deep brain stimulation



https://mayfieldclinic.com/pe-dbs.htm

Huntington's

http://cp91279.biography.com/1000509261001/1000509261001_guthrie-centennial-1.jpg

Huntington's

- Formerly Huntington's Chorea
  - "Chorea" from Greek for "dance"
  - "Dance-like" pattern of involuntary movements
  - Cognitive decline

Huntington’s

Huntington's

- Genetic + environmental influences
  - Gene fragment (CAG) duplication
  - High levels of *huntingtin* protein accumulate in basal ganglia
  - People with familial risk may want to consider genetic testing
- No effective treatment
  - Promising gene therapy trial halted this spring (Kwon, 2021)

Final thoughts

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

Next time…

- Vision
- Review for Exam 3

References

Garretti, F., Agalliu, D., Lindestam Arlehamn, C. S., Sette, A., & Sulzer, D. (2019). Autoimmunity in parkinson's disease: The role of α-Synuclein-Specific T cells. *Frontiers in Immunology*, *10*, 303. https://doi.org/10.3389/fimmu.2019.00303

Kwon, D. (2021). Failure of genetic therapies for huntington's devastates community. *Nature*, *593*(7858), 180. https://doi.org/10.1038/d41586-021-01177-7

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