511-2018-10-19-action-II

Rick Gilmore

2018-10-19 10:53:44

Prelude

https://www.youtube.com/embed/L0CVoFsUhC4

Prelude

https://www.youtube.com/embed/XaI5IRuS2aE

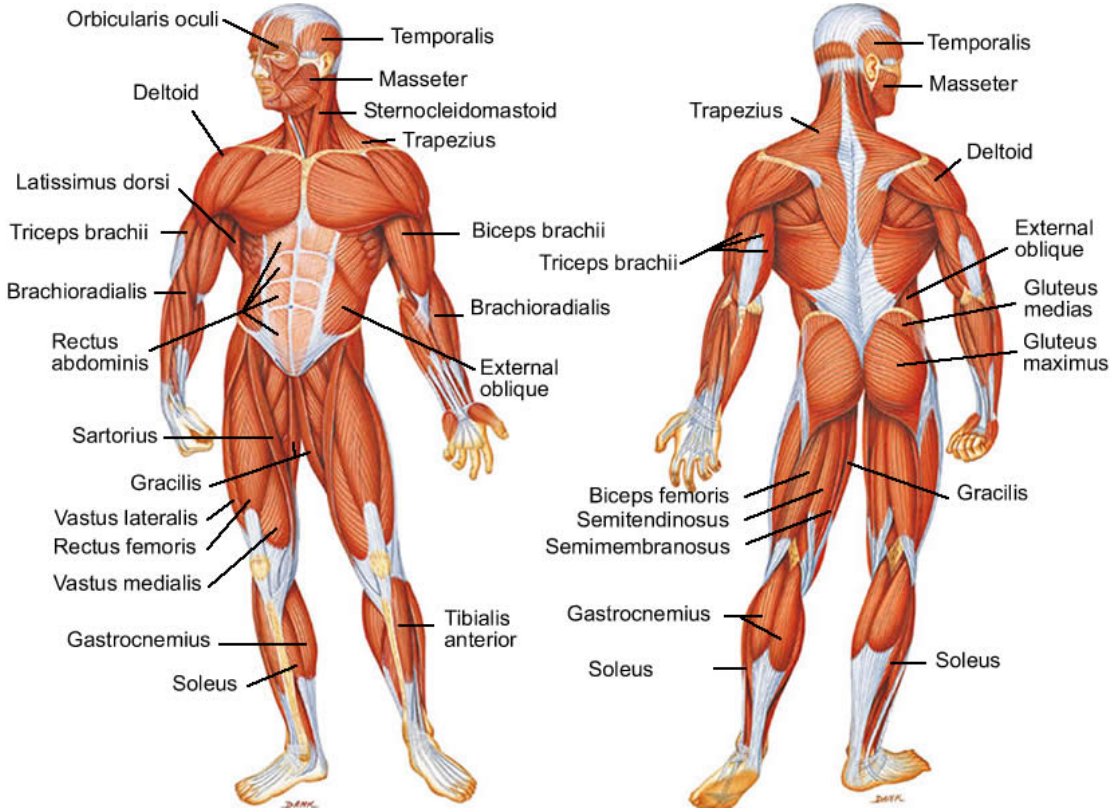
Today's Topics

- The neuroscience of action
- Quiz 2 now available; due next Friday

Muscle classes

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

Muscles

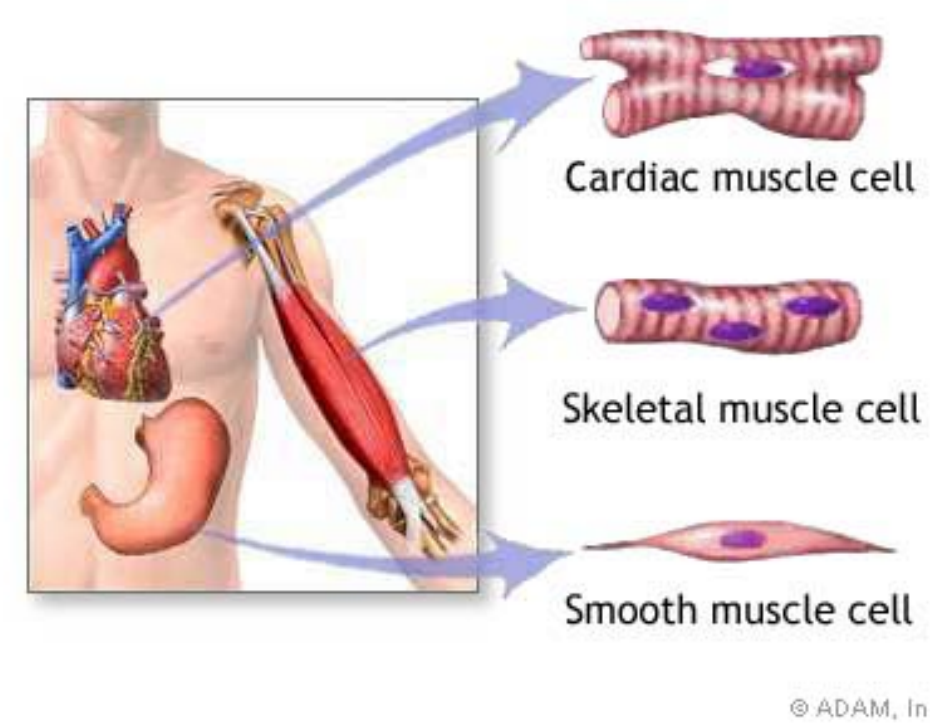


http://mypages.valdosta.edu/dodrobin/2651/Muscles/Muscles.jpg

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

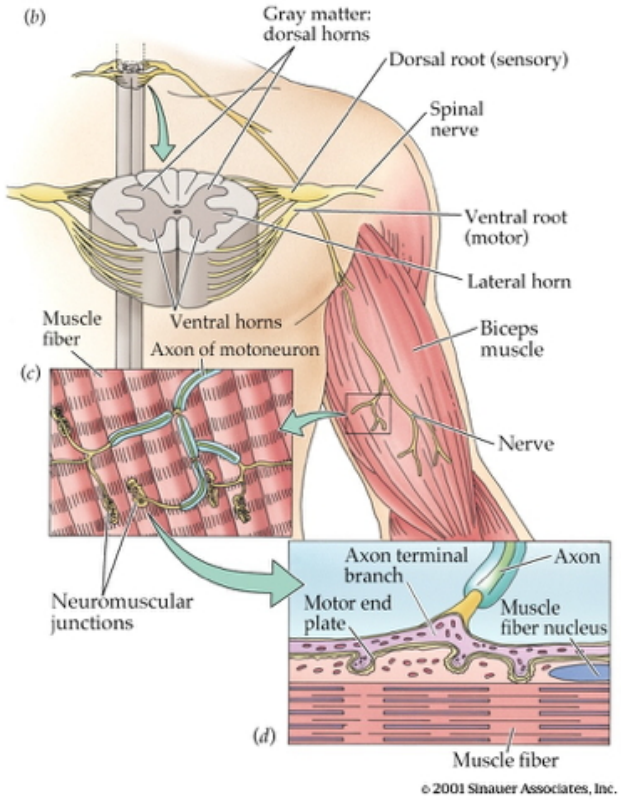


http://graphics8.nytimes.com/images/2007/08/01/health/adam/19917.jpg

How skeletal muscles contract

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

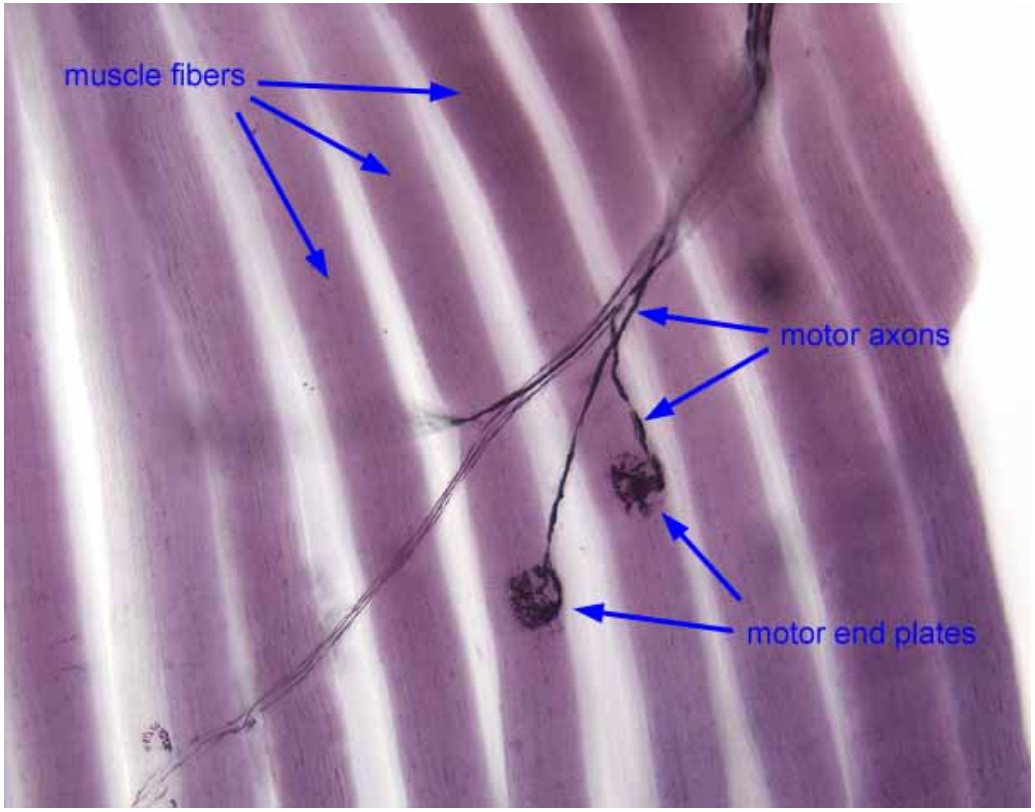
From spinal cord to muscle



How skeletal muscles contract

- Motor endplate
  - Nicotinic ACh receptor
- Excitatory endplate potential
  - Muscle fibers depolarize
  - Depolarization spreads along fibers like an action potential
  - Sarcomeres are segments of fibers
  - Intramuscular stores release Ca++

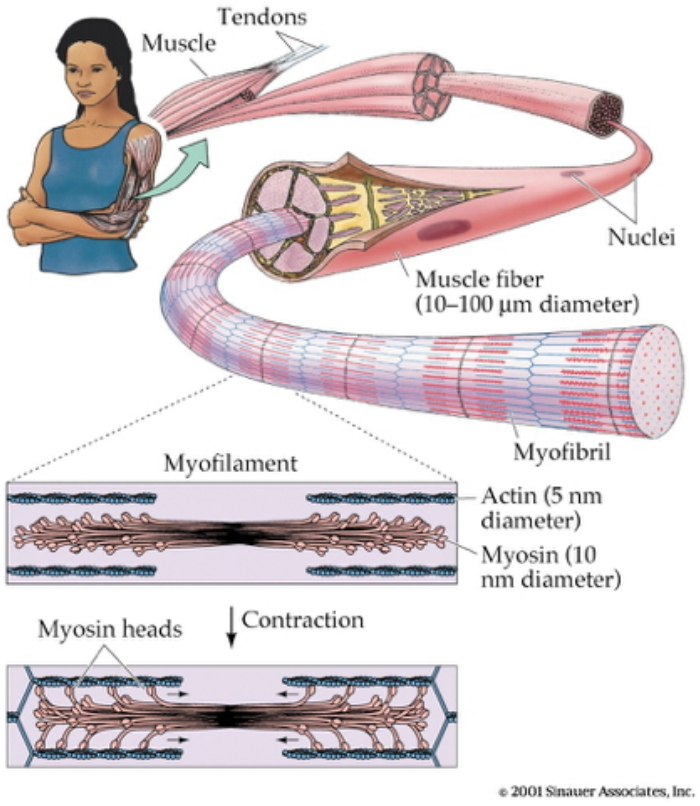
Motor endplate



How skeletal muscles contract

- Myofibrils (w/in sarcomere)
  - Actin & mysosin proteins
  - “Molecular gears”
- Bind, move, unbind in presence of Ca++, ATP

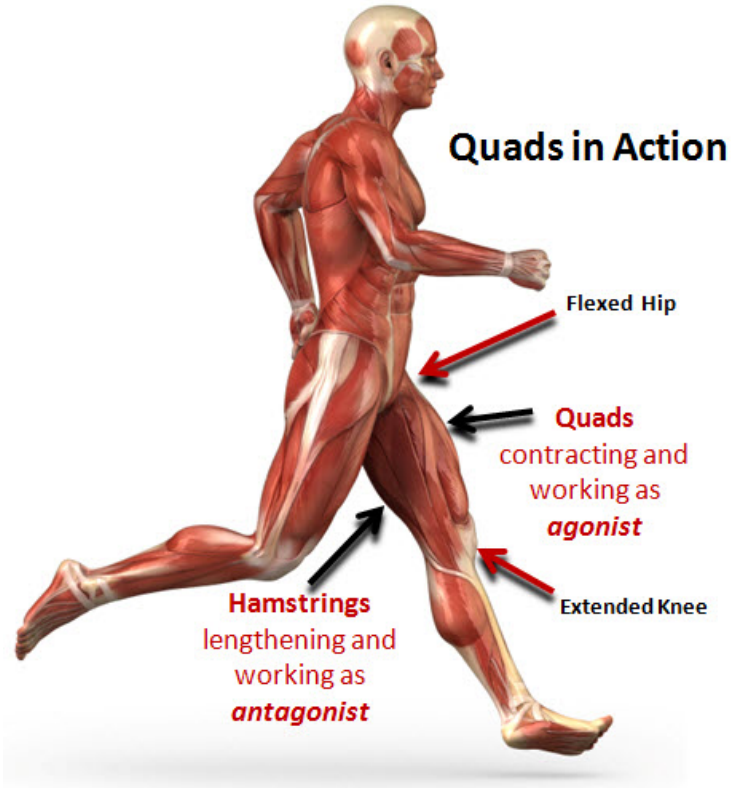
Anatomy of muscle fibers



Anatomy of motor endplate

Muscle contraction

Agonist/antagonist muscle pairs



http://2.bp.blogspot.com/-TpOC4my_NBc/T0J-MhEv29I/AAAAAAAAF88/dYLv7QzFwmg/s1600/Hamstring-Quad4.jpg

Meat preference?

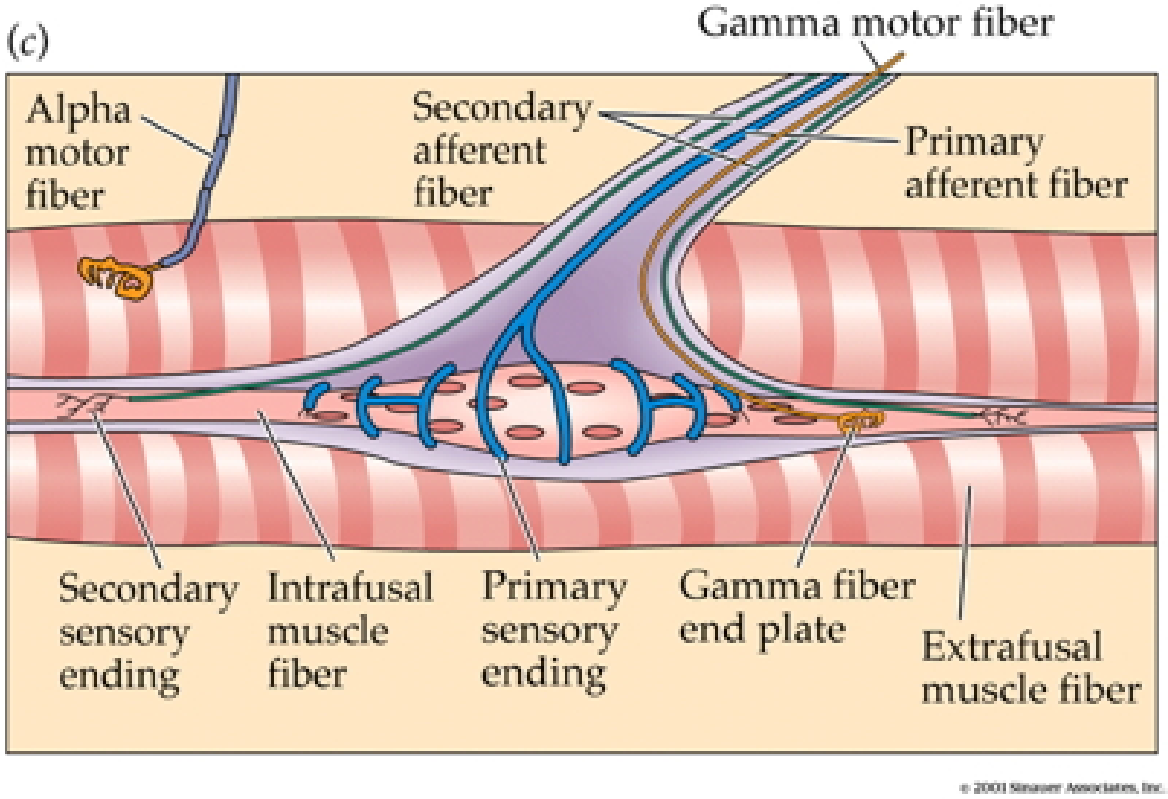
Muscle fiber types

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

Muscles are sensory organs, too!

© Can Stock Photo

Two muscle fiber types



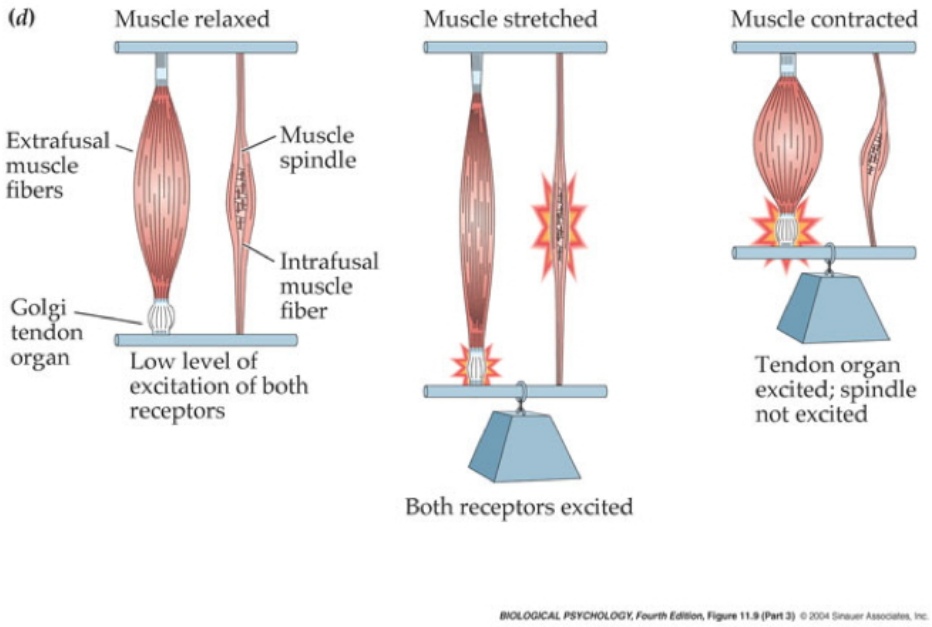
Two muscle fiber types

- *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

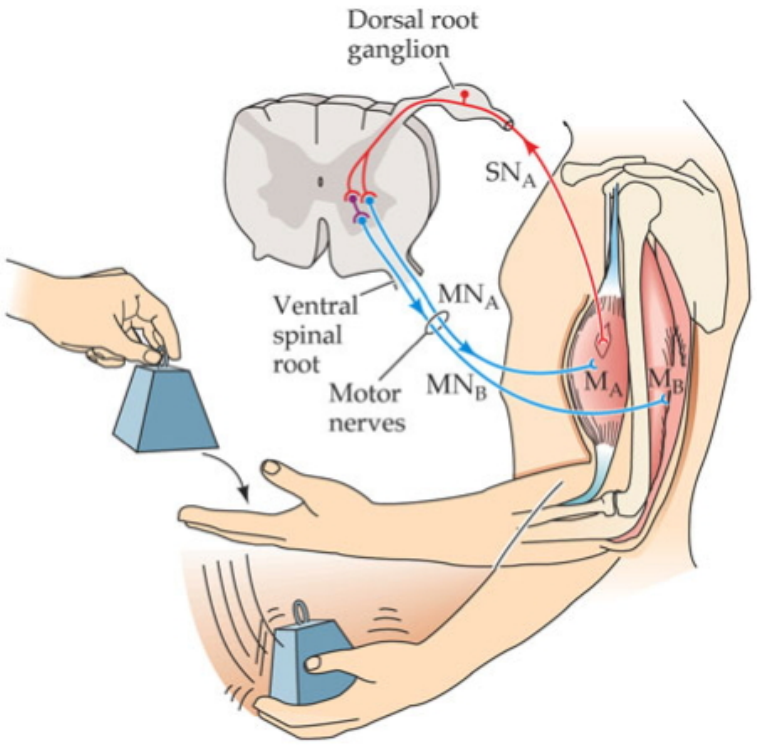
Monosynaptic stetch (myotatic) reflex



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

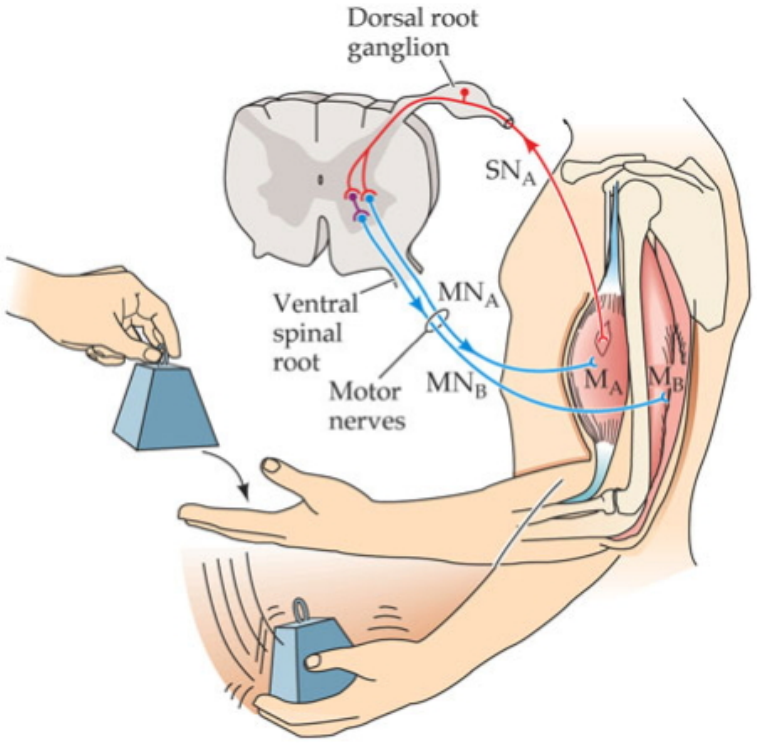

How to
Belay
Rope to Climber
Guide Hand
Rope Threaded
Through
Belay Device
Brake Hand

Monosynaptic stretch (myotatic) reflex



BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 11.10 (Part 1) © 2004 Sinauer Associates, Inc.

Why doesn't antagonist muscle respond?



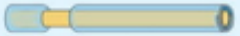
BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 11.10 (Part 1) © 2004 Sinauer Associates, Inc.

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*

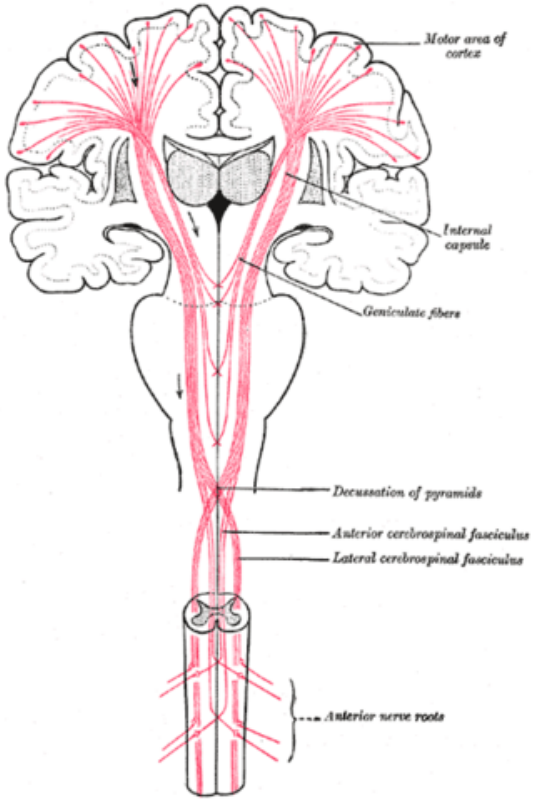
Sensory function(s)	Receptor type(s)	Axon type	Diameter (μm)	Conduction speed (m/s)
Proprioception (see Chapter 11)	Muscle spindle	 Aα	13–20	80–120
Touch (see Figures 8.12 and 8.13)	Pacinian corpuscle, Ruffini's ending, Merkel's disc, Meissner's corpuscle	 Aβ	6–12	35–75
Pain, temperature	Free nerve endings; VRL1	 Aδ	1–5	5–30
Temperature, pain, itch	Free nerve endings; VR1, CMR1	C	0.02–1.5	0.5–2

BIOLOGICAL PSYCHOLOGY, Fourth Edition, Table 8.2 © Sinauer Associates, Inc.

How the brain controls the muscles

- Pyramidal tracts
  - Pyramidal cells (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



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

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

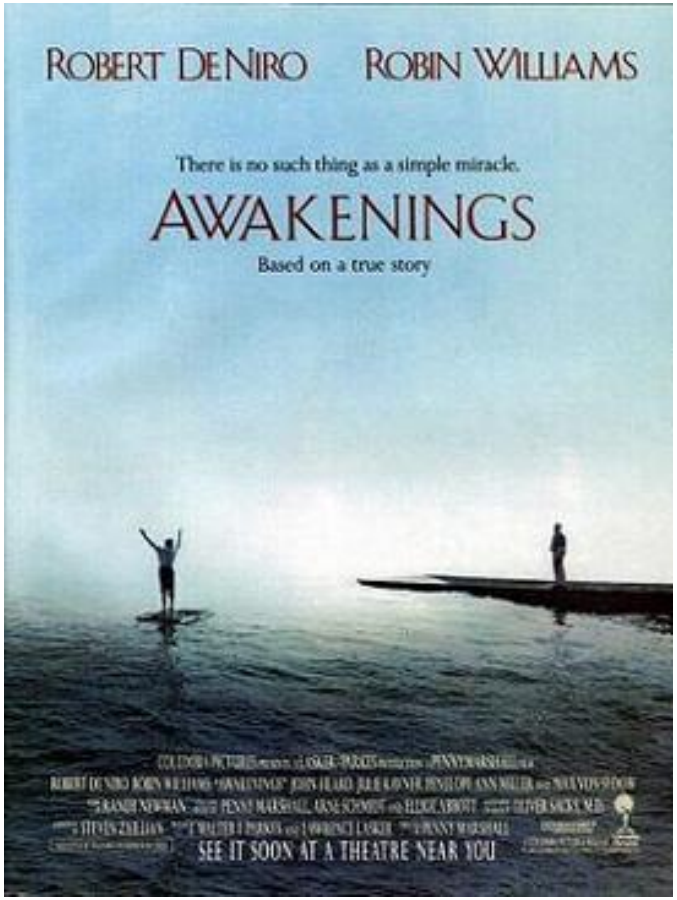
- Parkinson's
- Huntington's

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

Awakenings


ROBERT DE NIRO
ROBIN WILLIAMS
There is no such thing as a simple miracle.
AWAKENINGS
Based on a true story
SEE IT SOON AT A THEATRE NEAR YOU

Huntington's

http://cp91279.biography.com/1000509261001/1000509261001_17338247guthrie-centennial-1.jpg

Huntington's

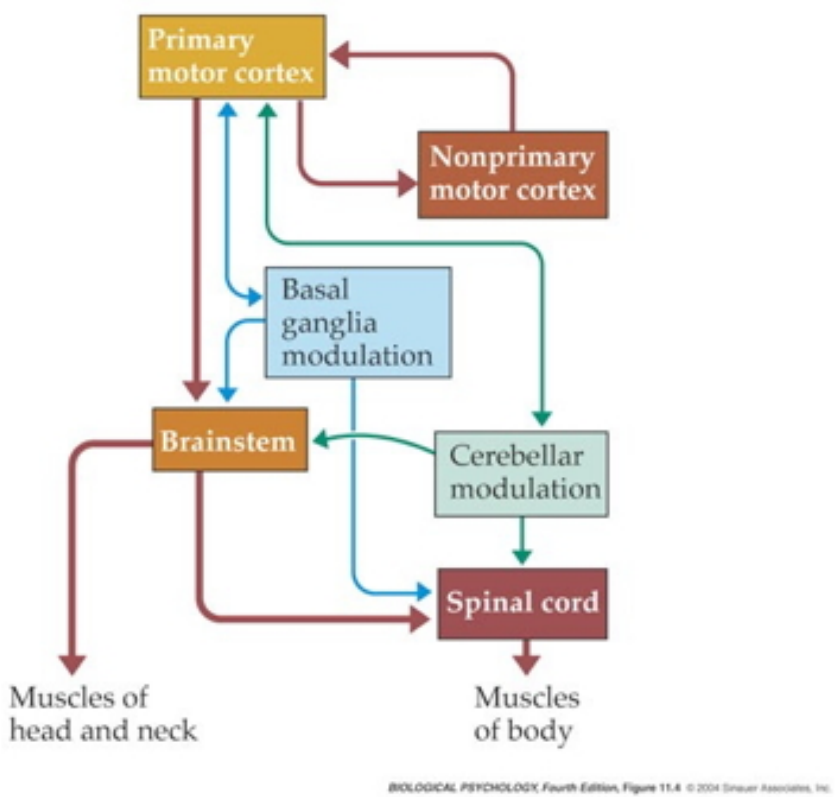
- Formerly Huntington’s Chorea
  - "Chorea" from Greek for "dance"
  - “Dance-like” pattern of involuntary movements
- Cognitive decline
- Genetic + environmental influences
- Disturbance in striatum
- No effective treatment

Huntington's

Remember

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

Multiple, parallel controllers



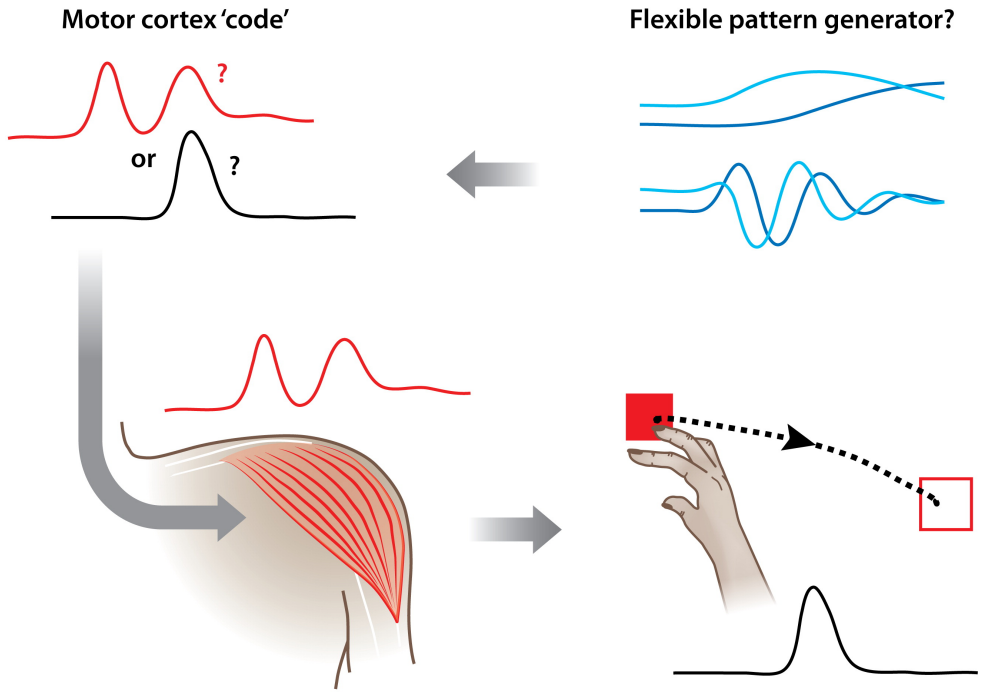
Cerebellum as predictor of future sensory states? (Ito, 2008)

http://venturebeat.com/wp-content/uploads/2009/10/star-trek-holodeck.jpg

The Real Reason for Brains

What does motor cortex activity encode?

Muscle activity? Limb velocity? Or…?



Shenoy KV, et al. 2013.
Annu. Rev. Neurosci. 36:337–59

Shenoy et al., 2013

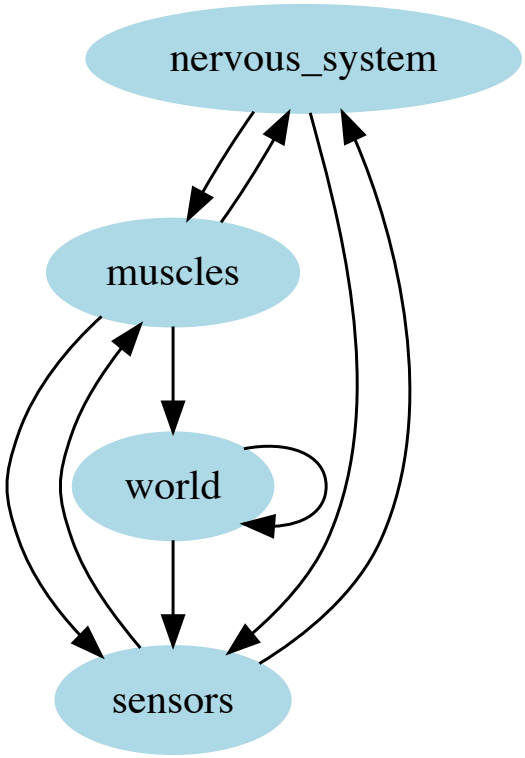
Cortical Control of Arm Movements: A Dynamical Systems Perspective

Annual Review of Neuroscience

Vol. 36:337-359 (Volume publication date July 2013)
First published online as a Review in Advance on May 29, 2013
https://doi.org/10.1146/annurev-neuro-062111-150509

Dynamic systems perspective

- Dynamics of
  - World events, $\dot{W}$
  - Extero- and interoceptive sensory systems, $\dot{S}$
  - Nervous system states, $\dot{N}$
  - Muscle states, $\dot{M}$
  - Body states, $\dot{B}$
  - Effects of muscles on world, $\dot{W} = f(\dot{M})$


nervous_system
muscles
world
sensors

Next time…

- Language

References

Ito, M. (2008). Control of mental activities by internal models in the cerebellum. *Nat. Rev. Neurosci.*, *9*(4), 304–313. https://doi.org/10.1038/nrn2332

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 Rev. Neurother.*, *16*(4), 389–399. https://doi.org/10.1586/14737175.2016.1158103