MOVEMENT

Dr. Steinmetz

OUTLINE

- The Control of Movement: Muscles!
- Motor Reflexes
- Brain Mechanisms of Movement
- Mirror Neurons
- Disorders of Movement
  - Parkinson’s Disease
  - Huntington’s Disease
**Types of Movement**

- Simple reflexes
- Posture and postural changes
- Locomotion
- Sensory orientation
- Fixed action patterns
- Complex learned behaviors

**Level of Motor Control in the CNS**

Diagram showing the flow from somatosensory cortex (feedback from muscles and tendons) through secondary motor cortex (planning and sequencing information), basal ganglia (integrates movement), brainstem, cranial nerves, spinal cord (spinal nerves), cerebellum (coordinates skilled action), posterior parietal cortex (visual, auditory, and somatosensory information), to primary motor cortex (controls voluntary movements), and finally to movement.
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MUSCLE TYPES

3 different types of muscles:

1. Smooth muscle - controls internal organs
2. Cardiac muscle - specialized for heart
3. Skeletal muscle - controls movement of the body in the environment
THE MECHANICS OF MOVEMENT

- Extension
- Flexion
- Antagonistic Muscles
- Coordinated sequences of both

(a)

(b)

NEUROMUSCULAR JUNCTION
**NEUROMUSCULAR JUNCTION**

- Motor neurons release **acetylcholine (ACh)** as their neurotransmitter.
- Muscle fibers **always contract when ACh is present**, they relax when ACh is not present.

![Neuromuscular Junction Diagram](http://www.youtube.com/watch?v=zOocsLrm7_A&feature=fvwrel)

**PRODUCTION OF MUSCLE POTENTIALS**

- Muscles = thousands of individual fibers that are
  - divided into **sarcomere** segments
- Thin filament = **actin** & Thick filament = **myosin**

![Muscle Production Diagram](http://www.youtube.com/watch?v=zOocsLrm7_A&feature=fvwrel)
**Production of Muscle Potentials**

- ACh receptors open Na\(^+\) channels producing intracellular depolarization of muscle fiber.
- Voltage-gated Ca\(^{2+}\) channels in sarcoplasmic reticulum (SR) open flooding fiber with intracellular calcium.

**Muscle Contraction Video**

http://www.youtube.com/watch?v=ZscXOvDgCmQ&NR=1
MORE MUSCLE CONTRACTION VIDEOS

- http://www.youtube.com/watch?v=gJ309LfHQ3M
- http://www.youtube.com/watch?v=0kFmbrRJq4w&NR=1

ADAPTATION OF MUSCLES

- Fast-twitch muscles - fast but fatigue rapidly
- Slow-twitch muscles - slow but slow to fatigue
- Distribution of muscle type influences function
What kind of muscles would jaguars and cheetahs have?
What kind of animals would have the opposite?
Where in your body would you be more likely to have fast vs. slow twitch?

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MONOSYNAPTIC REFLEXES

Requires only one synapse between sensory and motor neurons

Patellar Tendon (knee jerk) Reflex

POLYSYNAPTIC REFLEXES

Requires more than one synapse

Reciprocal Inhibition Reflex
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THE MAIN PLAYERS.....

- Cerebral Cortex
- Cerebellum
- Basal Ganglia
CEREBRAL CORTEX

- Primary motor cortex
- Prefrontal cortex
- Posterior parietal cortex
- Supplementary motor area (SMA)
- Pre-motor cortex

BRAIN CONTROL OF MOVEMENT

- Primary motor cortex
  - Control of voluntary movements
  - Axons connect to the brainstem and the spinal cord
  - Function is dependent upon information from other brain areas
BRAIN CONTROL OF MOVEMENT
WHY DOES HOMUNCULUS LOOK THIS WAY?

BRAIN MECHANISMS OF MOVEMENT

- **Prefrontal cortex:**
  - Responds to lights, noises and other sensory signals that lead to movement.
  - **Calculates** predictable outcomes of actions and **plans** movement according to those outcomes.
Brain Mechanisms of Movement

- **Posterior parietal cortex:**
  - Respond to visual or somatosensory stimuli, current or future movements.
  - Damage to this area causes difficulty coordinating visual stimuli with movement.

- **Premotor cortex:**
  - Preparation for movement
  - Receives information about a target in space.
  - Integrates information about position and posture of the body and organizes the direction of the movement in space.
  - **Supplementary (secondary) motor cortex:** Plan & organize a rapid sequence of movements.
SEARCH FOR “FREE WILL”

- Where is “decision” to act produced?
- fMRI studies suggest supplementary motor area

BASAL GANGLIA

- Caudate nucleus
- Putamen
- Globus pallidus
- Integrates voluntary movement & control of posture
CEREBELLUM
- Essential for coordinated/timed movements
- Integrates sensory & basal ganglia information
- Damage results in jerky, erratic and uncoordinated movements: can’t dribble ball; must pause + plan

VOLUNTARY MOVEMENT CIRCUITS

1 Decision to make a movement originates in prefrontal cortex and parietal lobe.

2 Movement is planned in SMA and PMA, incorporating input from the thalamus and basal ganglia.

3 Primary motor cortex sends signals via lateral pathway.

4 Lateral pathway carries signals to spinal motor neurons, which initiate muscle contractions.
NEUROLOGICAL ASSESSMENT:

- What might be damaged and why?
- Symptoms:
  - Patient 1 cannot reach out and grasp something
  - Patient 2 showers with his clothes on
  - Patient 3 exhibits involuntary movements

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MIRROR NEURONS

- Active during preparation for movement
- Watching someone else move
- Empathy?
- http://www.youtube.com/watch?v=Sv1qUj3MuEc
- http://www.pbs.org/wgbh/nova/body/mirror-neurons.html
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DISORDERS OF MOVEMENT
**PARKINSON’S DISEASE**

- Involves muscle rigidity, resting tremor, slow movements
  - Parkinson’s results from damage to dopamine neurons within the nigrostriatal bundle (projects to caudate and putamen)
**PARKINSON’S DISEASE**

- **Causes?**
  - Some forms inherited
  - Toxin induced?
    - Drug MPTP destroys substantia nigra like PD
    - Damage occurs when MAO converts MPTP to MPP+ which is extremely toxic
    - If give MAO inhibitors, can prevent further damage to brain

**TREATMENTS FOR PARKINSON’S DISEASE**

- L-Dopa crosses BBB – works, but causes problems over time
- Transplants of dopamine-secreting neurons (fetal substantia nigra cells or cells from the adrenal)
- Stereotaxic lesions of the globus pallidus (internal division) alleviates some symptoms of Parkinson’s disease
- Deep brain stimulation
Deep Brain Stimulation

http://www.youtube.com/watch?v=EMnfROo7k9A

Parkinson’s Disease Therapies

- Deep brain stimulation
  - http://www.youtube.com/watch?v=EMnfROo7k9A
  - http://www.youtube.com/watch?v=xejclvwbwsk
**HUNTINGTON’S DISEASE (CHOREA)**

- Hereditary disorder caused by a dominant gene on chromosome 4: Woody Guthrie; Arlo Guthrie?
- Involves uncontrollable, jerky movements of the limbs, head and face
  - Twitches, tremors and writhing

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**HUNTINGTON’S DISEASE**

- Caused by degeneration of the caudate nucleus and putamen
- Cell loss involves inhibitory GABA-secreting axons that innervate the external division of the globus pallidus
- Lack of inhibition causes enhancement of dopaminergic systems
- L-Dopa increases Huntington’s
HUNTINGSTON’S DISEASE

http://www.youtube.com/watch?v=65xf1olEpQM