Chapter 16:
Lower Motor Neuron Circuits
Upper motor neurons: CNS (premotor & primary motor cortex)

Lower motor neurons: Motor neurons from the spinal cord
Wilder Penfield

WWW I

1934 he founded and became the first Director of McGill University's world-famous Montreal Neurological Institute and the associated Montreal Neurological Hospital

Published 1951 the homunculus
Spinal cord cross section
Motor unit

- Alpha motor neuron and muscle Types
  - Slow, fast fatigable, fast fatigue-resistant
  - Muscle fiber types match
<table>
<thead>
<tr>
<th>Property</th>
<th>Slow oxidative (type I)</th>
<th>Fast oxidative (type IIa)</th>
<th>Fast glycolytic (type IIb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber diameter</td>
<td>↓</td>
<td></td>
<td>↑</td>
</tr>
<tr>
<td>Force per cross-sectional area</td>
<td>↓</td>
<td>↔</td>
<td>↑</td>
</tr>
<tr>
<td>Rate of contraction ((V_{\text{max}}))</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Myosin ATPase activity</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Resistance to fatigue</td>
<td>↑</td>
<td>↔</td>
<td>↓</td>
</tr>
<tr>
<td>Number of mitochondria</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Capacity for oxidative phosphorylation</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Enzymes for anaerobic glycolysis</td>
<td>↓</td>
<td>↔</td>
<td>↑</td>
</tr>
</tbody>
</table>

Source: Adapted from Sherwood, 2001. Key = ↓ Low ↔ Intermediate ↑ High
Single muscle twitches (5 Hz)

Temporal summation (20 Hz)

Unfused tetanus (80 Hz)

Fused tetanus (100 Hz)
Muscle responses: force and electrical events (think comparative: vertebrate vs. invertebrate)
LIST OF DIFFERENCES
Vert

- Ach ⊕
- Belly ⊕
- Ap

Invert

⊕ ⊕ Θ

- glutamate ⊕ EPSP
- GABA ⊕ IPSP
- multi-terminal
- poly neuronal.
- Graded.
- pre synaptic

Inhibition
The electrical activity and control
Crayfish Tail
Muscle receptor organ

m.r.c.  Same Exp.
MUSCLE ACTIVELY CONTRACTED

(1) Muscle spindles

- Muscle contracted
- Stimulate α motor neuron
- Stimulate spindle afferent
- Record

- Shorten
- Muscle length

(2) Golgi tendon organs

- Muscle contracted
- Stimulate α motor neuron
- Stimulate Golgi tendon organ afferent

- Shorten
- Muscle length
Within the spinal cord circuits: (mammal)
(C) Extensors

Flexors

Stance Swing

Level of transection of spinal cord
LEECH

(a) Segmental ganglion of Hirudo

- Anterior
- Peripheral nerve trunks
- Neuronal somata
- Interganglionic connectives

- Soma
- Axons to body wall
- Axons to connectives

Scale: 200 μm, 100 μm
Diseases of motor unit:

Amyotrophic lateral sclerosis (ALS) (Lou Gehrig's disease) a form of motor neurone disease caused by the degeneration of upper and lower neurons, located in the ventral horn of the spinal cord and the cortical neurons that provide their efferent input.

Peripheral nerve damage (peripheral neuropathy)

Mononeuropathy-Mononeuropathy and radiculopathy is most often due to trauma of some type.

Radiculopathy-Radiculopathy indicates damage to nerve root(s), and typically occurs as a component of several spinal diseases.

Polyneuropathy-Polyneuropathy is a common condition. It is not always easy to determine its cause. In this condition the longest peripheral nerve fibers are usually first. Peripheral neuropathy can affect either the axon, or myelin sheaths (demyelinating), or both.

Mononeuritis Multiplex "Mononeuritis multiplex" is a relatively rare presentation of certain disorders that damage nerves primarily by interfering with blood flow to nerves or plexi or by an autoimmune process damaging either the myelin or axon.
End-plate (neuromuscular junction)
Acetylcholine is the neurotransmitter at this synapse that couples motor nerve activity with response in the muscles. Botulinum toxin or a block of nicotinic ACh receptor (such as curare).

Myasthenia gravis.
Myasthenia gravis is the most common disorder affecting neuromuscular transmission. This condition is autoimmune, with antibodies directed against nicotinic acetylcholine receptors of the neuromuscular junction. It is not extremely common (about 1:10,000) and incidence is highest in young adult women. * thymic tumors.

Myasthenic syndrome. There is another interesting and uncommon disorder of neuromuscular transmission -- the myasthenic syndrome or Lambert Eaton Syndrome (LEMS).

Muscle Disease (myopathy)
There are many things that can go wrong in muscles
Chapter 17: Upper motor neurons
Upper motor neurons in cerebral cortex -> Upper motor neurons in brainstem -> Anterior-medial white matter of spinal cord -> Lower motor neurons in medial ventral horn -> Axial and proximal limb muscles (posture and balance)

Midline

Lower motor neurons in medial ventral horn -> Axial and proximal limb muscles (posture and balance)

Lower motor neurons in lateral ventral horn -> Distal limb muscles (skilled movements)
Decorticate

Decorticate posturing is also called **decorticate response, decorticate rigidity, flexor posturing**, or, colloquially, **mummy baby**

Decorticate posturing indicates that there may be damage to areas including the cerebral hemispheres, the internal capsule, and the thalamus. It may also indicate damage to the midbrain.

Decorticate posturing, with elbows, wrists and fingers flexed, and legs extended and rotated inward
Decerebrate

Decerebrate posturing is also called **decerebrate response**, **decerebrate rigidity**, or **extensor posturing**. It describes the involuntary extension of the upper extremities in response to external stimuli.

Decerebrate rigidity or abnormal extensor posturing.
Chapter 19: Modulation of Movement
Critical Period

- Central circuits are well defined after a critical period, which is due to the sensory input early in the life.

- The central circuits are altered by hormones and neuromodulators throughout development.
Comparative

*Drosophila*
• Sensory input early in developmental stages.
• The central circuits are altered by hormones and neuromodulators.
• **Challenge in the field is:** Integration of sensory input that controls the muscular movement in a coordinated fashion.
Neuromodulators

• Recovery of locomotion by using selective agonists and antagonists of neurotransmitters involved in sensory-CNS-motor circuits.

(Chau et al., 2002)
contd...

• Rapid changes in the neural circuit activity can be induced by neuromodulators.
  Eg: aggressive behavior of *Drosophila*

  (Baier et al., 2002)

• 3 common neuromodulators:
  - Serotonin
  - Octopamine
  - Dopamine
• In *Drosophila*
• 5-HT modulate the heart rate and voltage dependent potassium channels.
• DA is known to alter the sexual behavior in adult flies.
• OA is expressed in stress conditions.
Preliminary Studies
Intracellular Recording in m6

Stimulate Posterior 2 roots
The effects of octopamine on a semi-intact larva