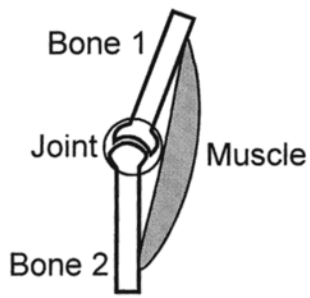
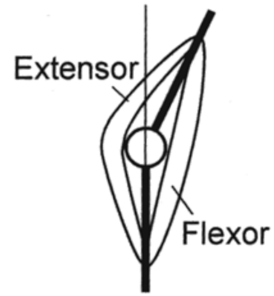
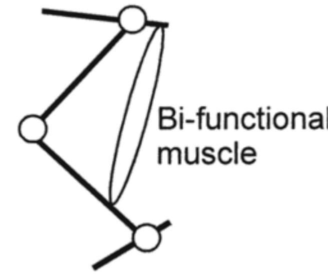
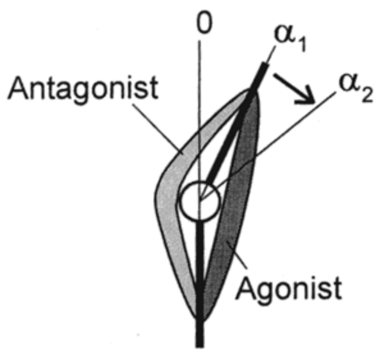
MOTOR UNITS

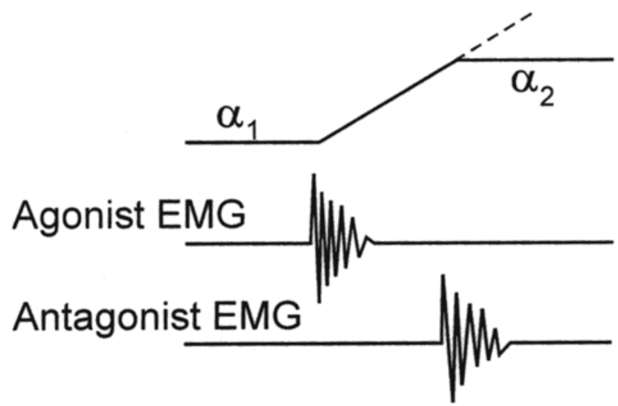
Muscles and joints



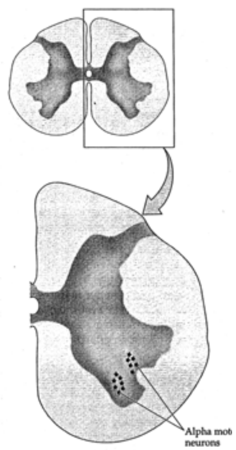


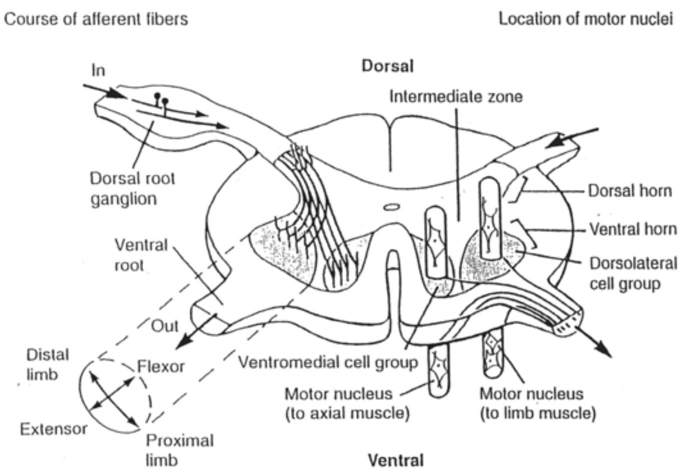


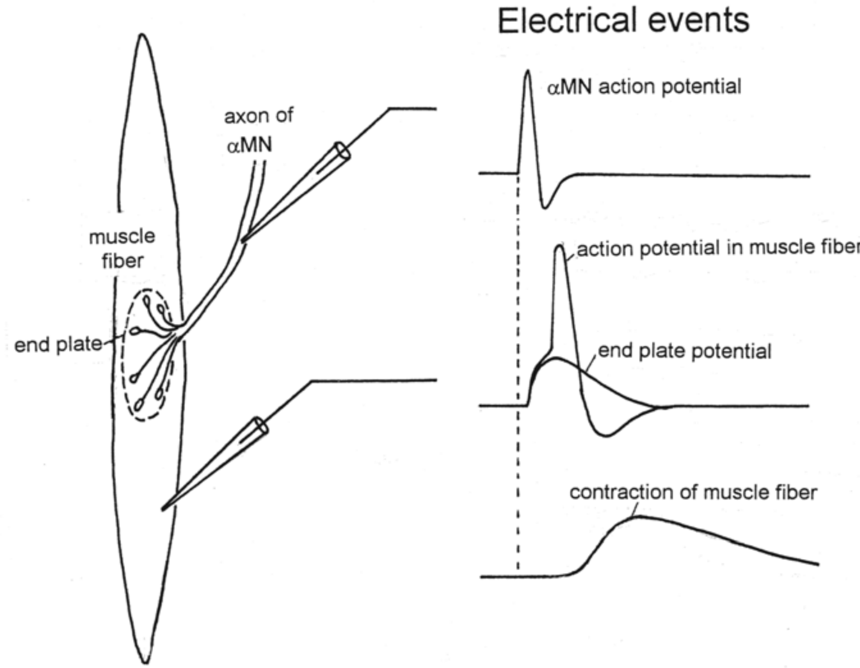




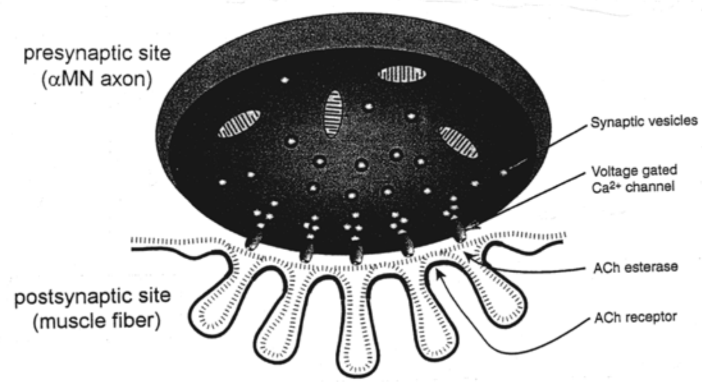
Sequence of electrical and chemical events leads to muscle contraction





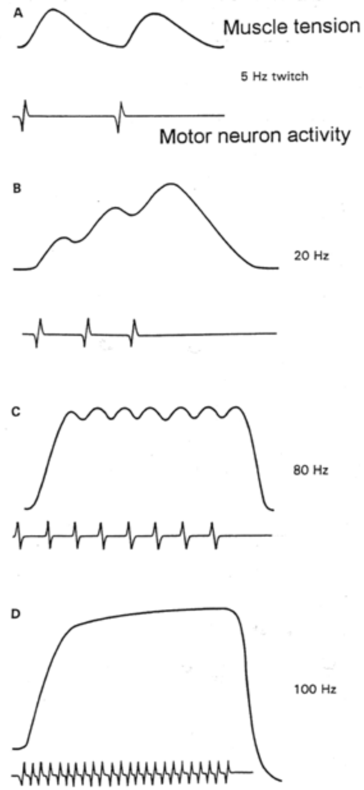


Neuromuscular junction

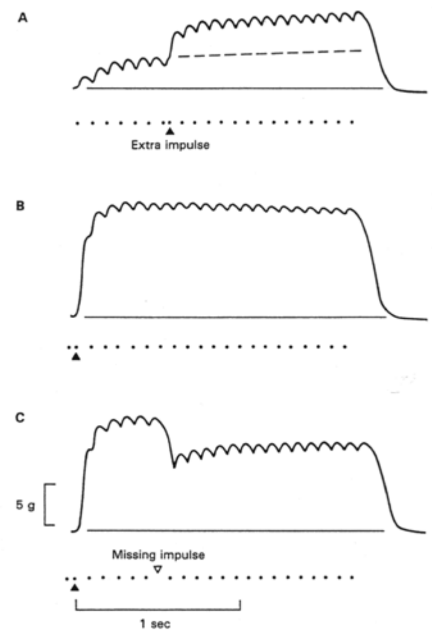


Muscles contract slowly and the force generated by a train of impulses summates

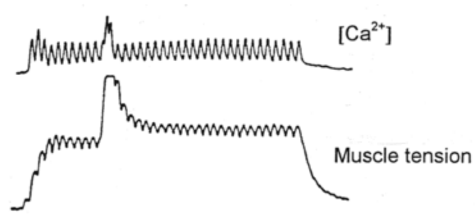
Active tension varies with the rate of stimulation



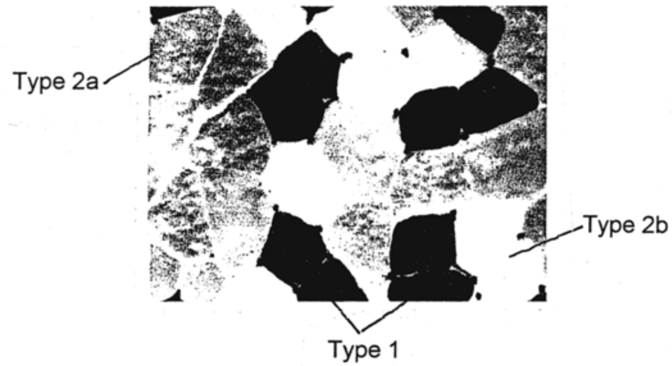
Active tension depends upon the pattern of stimulation



Sharp rise in tension evoked by extra spike correlates with sudden increase in Ca^{2+} concentration in the muscle fiber



Three basic types of mammalian skeletal muscle fibers



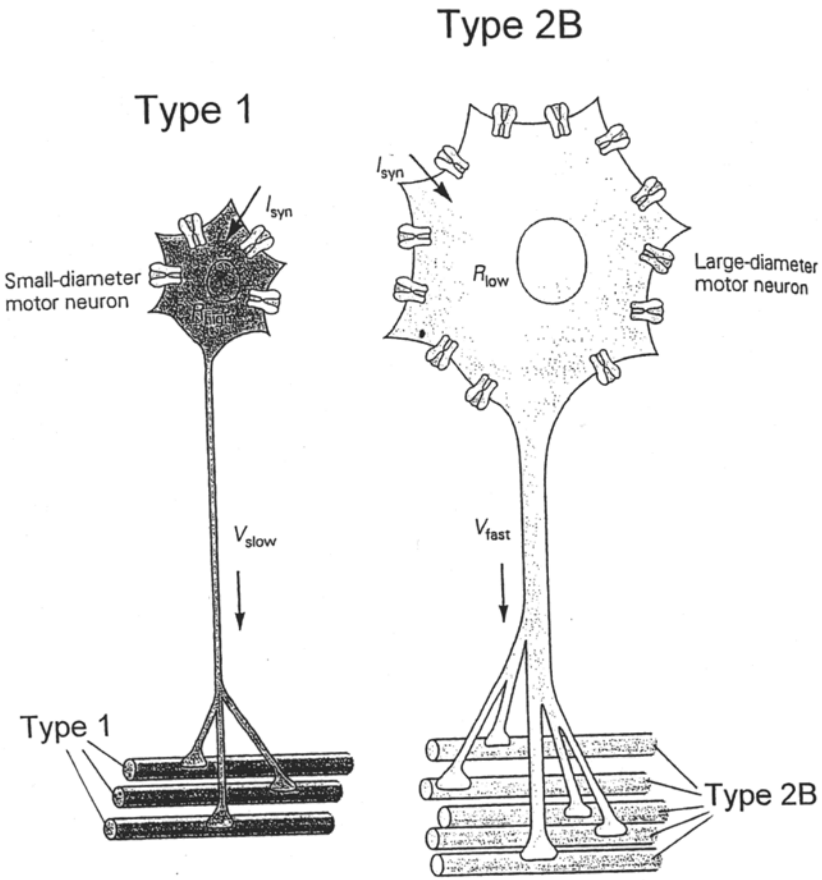
Type 1, or red, fibers are specialized for slow, sustained, aerobic exercise

Type 2, or white, fibers are specialized for rapid contractions

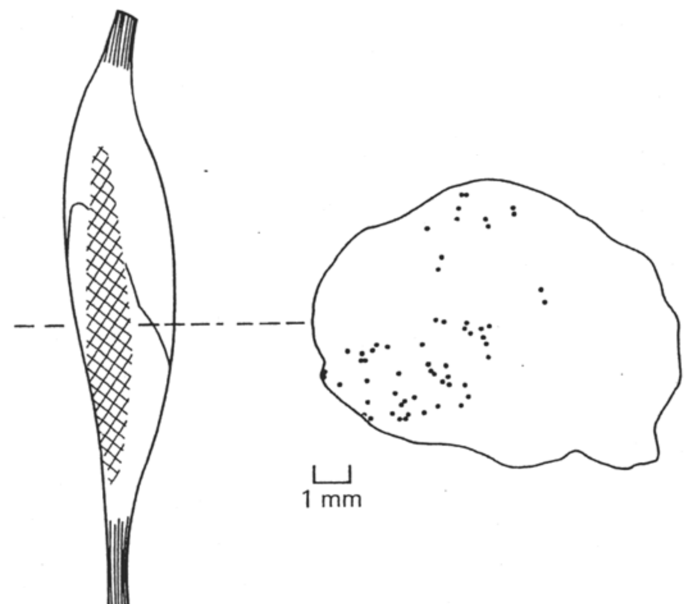
Type 2a
capable of rapid contractions that can be sustained for a relatively long time without fatigue

Type 2b
capable of rapid contractions, duration of which is limited by fatigue

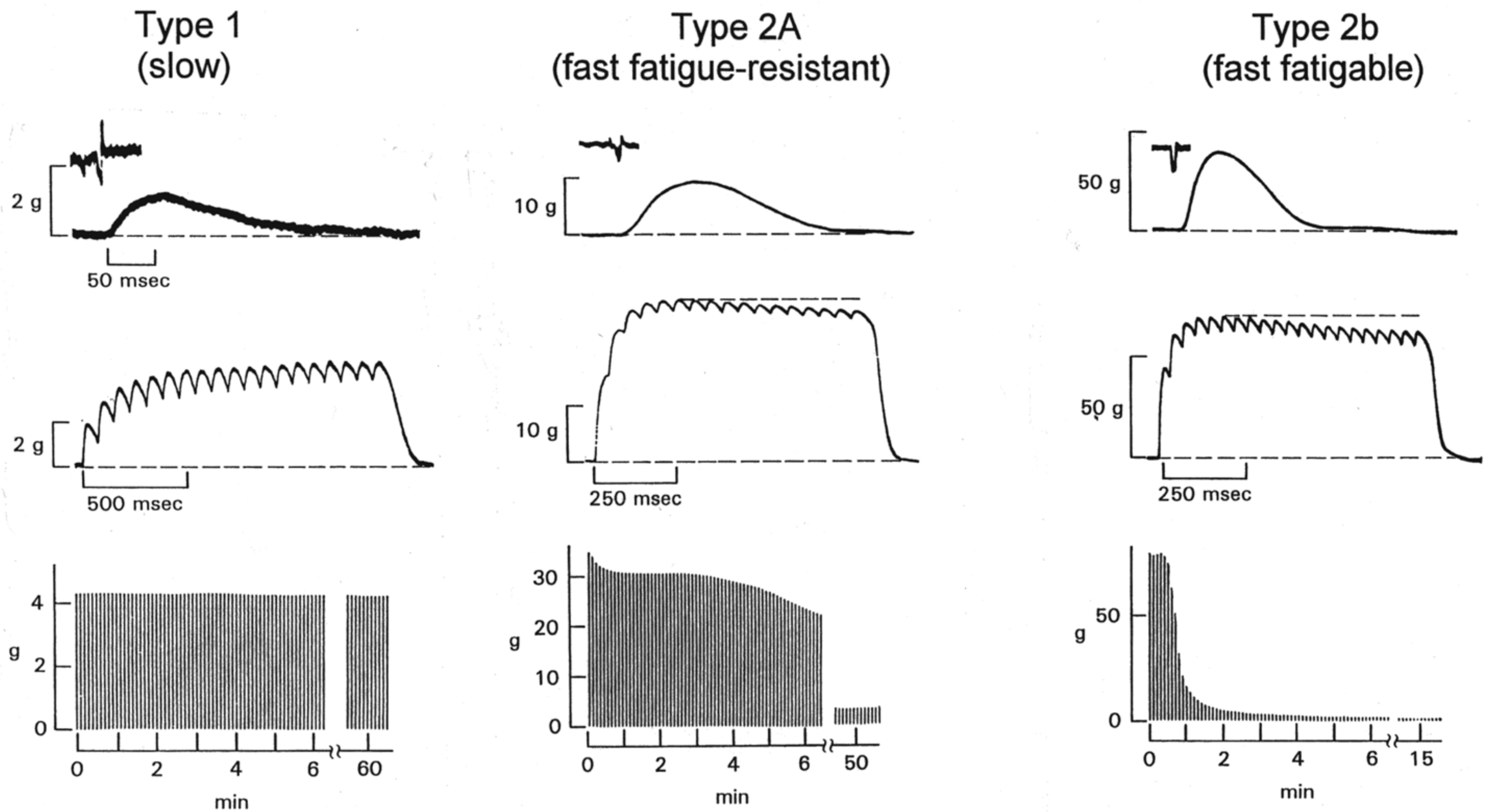
A single motor neuron and the muscle fibers it innervates constitute a motor unit



The location of individual muscle fibers making up the motor unit in soleus muscle

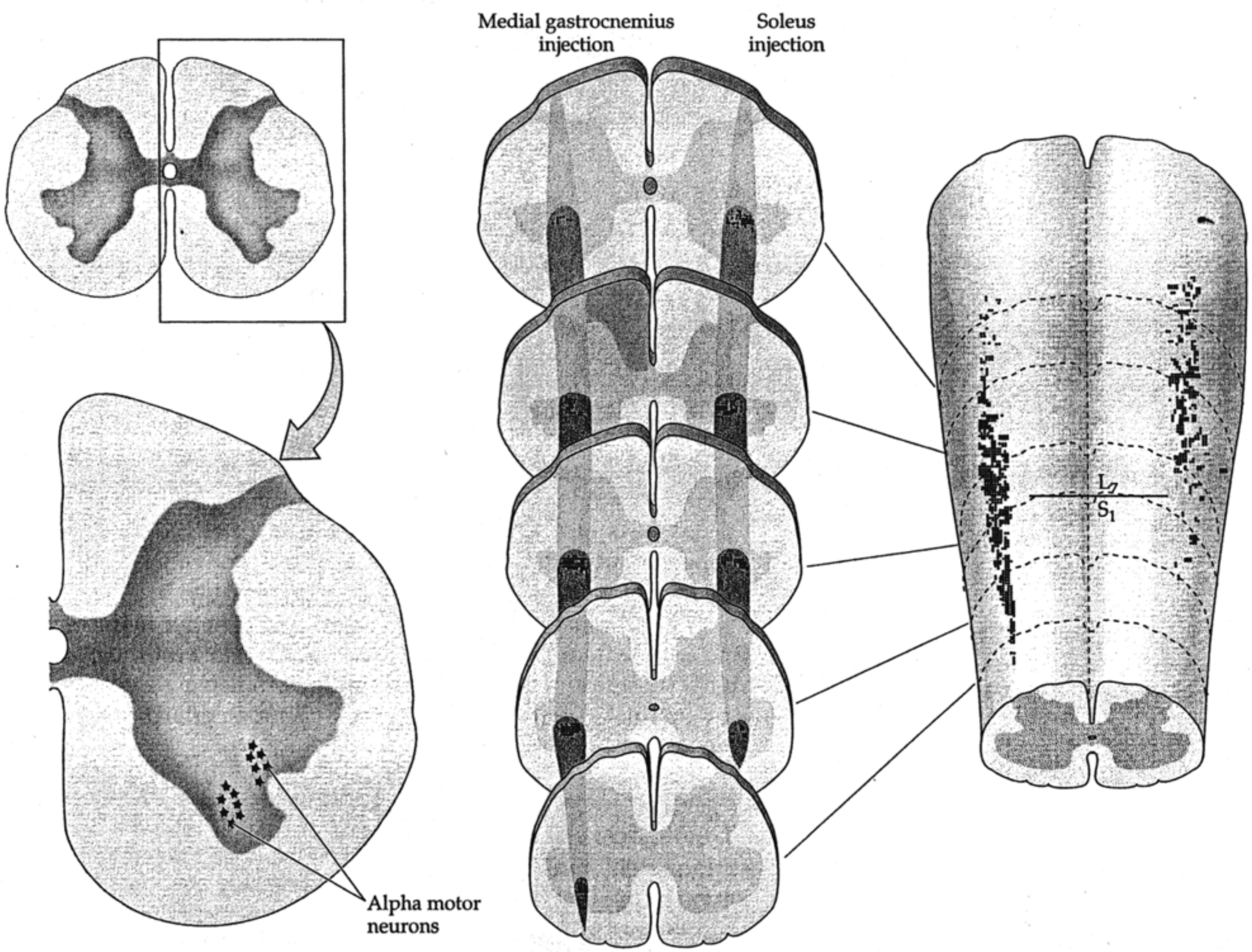


Three types of motor units

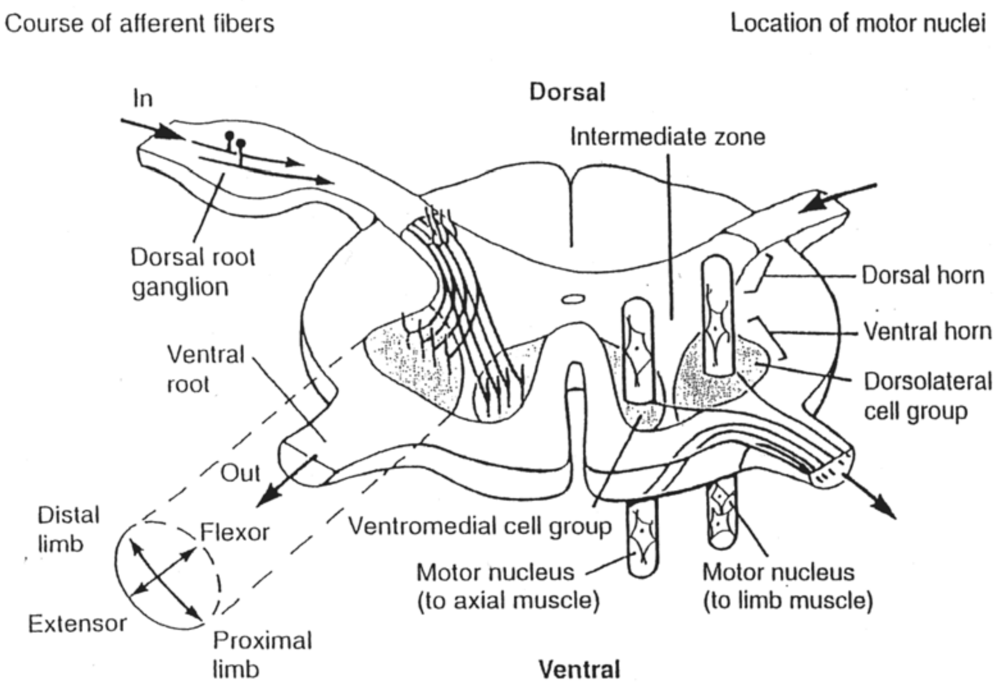


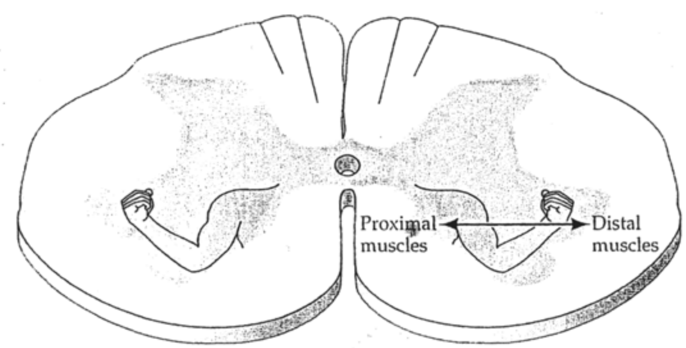
A muscle is innervated by a pool of motor neurons

Organization of *m. gastrocnemius* and *m. soleus* motor neuron pools



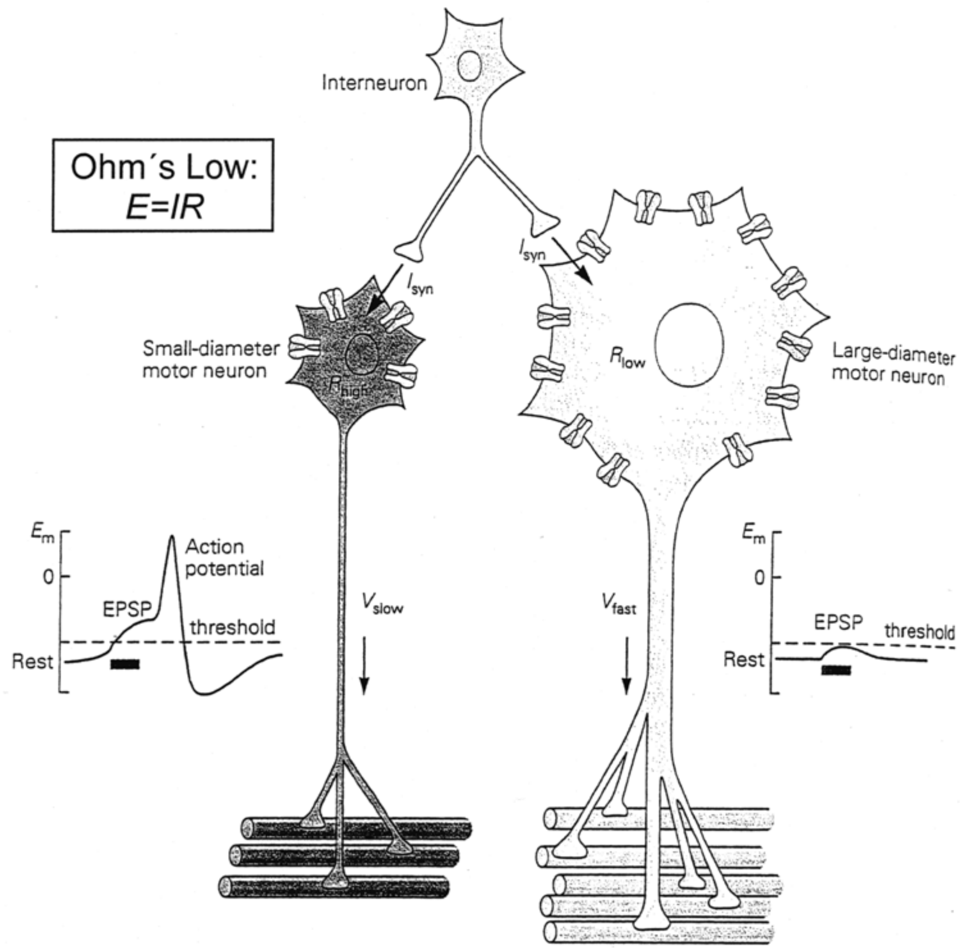
The motor nuclei of the spinal cord are grouped functionally in distinct medial and lateral positions





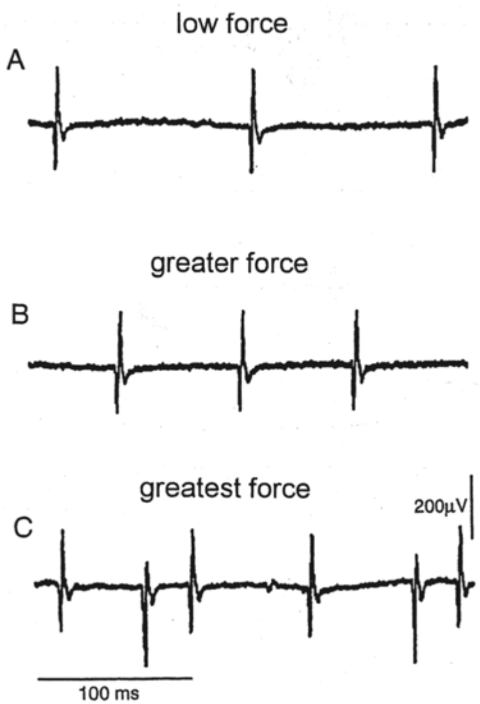
Size principle

Motor units are recruited in fixed order

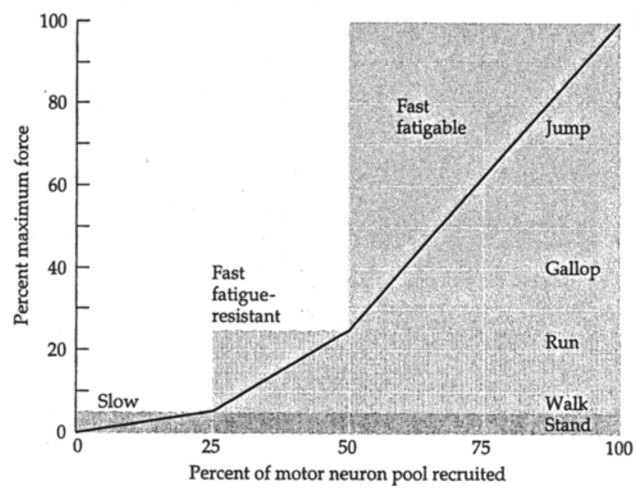


The nervous system grades the force of muscle contraction by increasing of firing rate of motor units and by recruitment of new motor units

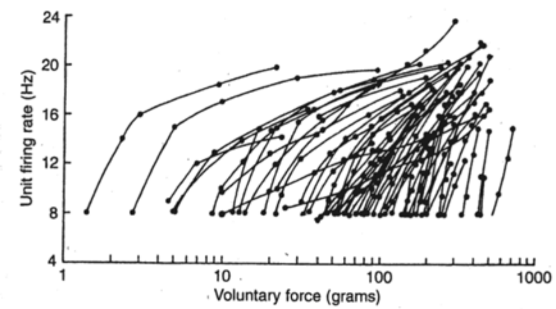
Activity of motor units during voluntary contractions of a fingers extensor muscle



Motor units are recruited in a fixed order from weakest to strongest

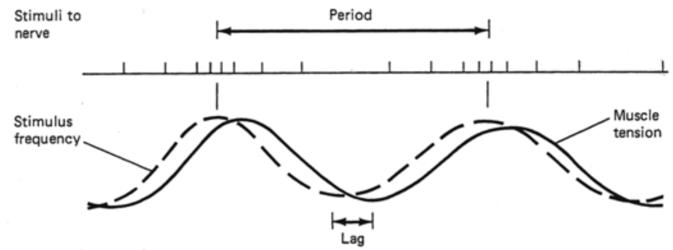


Increases in firing rate of motor units produce increasing force output

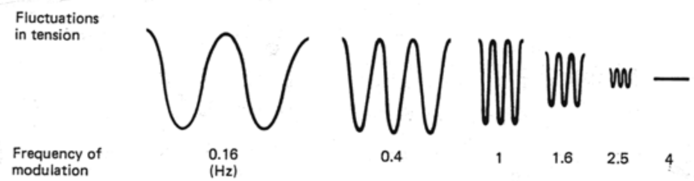


Skeletal muscles are low-pass filters of neural input

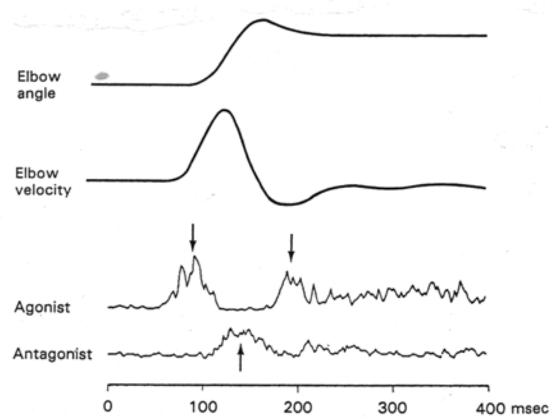
The oscillation in the muscle tension lags behind the changes in stimulus frequency



Changes in frequency of the sinusoidal stimulation cause changes in the frequency and amplitude of muscle tension



Rapid voluntary limb movements are associated with a triphasic pattern of muscle contraction.



Conclusions

1. Locomotion is an active propulsive movement of the animal in space. Movements of locomotor organs (limbs, wings, etc.) are cyclic. In terrestrial animals, each cycle of the limb movement consists of the stance and swing phases.

2. The basic locomotor pattern of each limb can be generated without sensory feedback from the limb, by a spinal network termed the central pattern generator, CPG. It provides the basic features of the movement – the rhythm, the duration of the stance and swing phases, and the level of muscle activity. In intact animals, however, afferent influences from the moving limb can be strongly modify this centrally generated pattern thus adapting it to the environmental conditions. Coordination of movements of the limbs is achieved due to interactions of individual CPGs.

3. Activation of spinal locomotor CPGs is produced by a population of reticulospinal neurons. They can be activated via two inputs – from the mesencephalic locomotor region (MLR) and from the subthalamic locomotor region (SLR). MLR receives input from the basal ganglia – substantia nigra, ventral pallidum. Via the MLR, these structures may initiate and terminate locomotion.

4. During locomotion, the cerebellum receives information about intended locomotor movements (from CPGs) and about ongoing locomotor movements (sensory information from limbs). It processes this information and through the descending pathways of the brainstem optimizes the locomotor pattern.

5. The motor cortex does not play any significant role in the control of steady locomotion in a regular environment. Its role becomes decisive, however, when visually induced modifications of the locomotor pattern are necessary.