ELEC ENG 3BB3:

Cellular Bioelectricity

Notes for Lecture 29

Thursday, March 27, 2014

Recruitment:

In myelinated nerve, the fiber diameter d can have a strong effect on the threshold current I_{th}.

The diameter has a direct effect through the axoplasmic resistance per unit length r_i.

An indirect effect of the diameter results from the fact that the internodal segment length (i.e., the distance between nodes of Ranvier) is proportional to the fiber diameter.

Recruitment (cont.):

I_{th} versus fiber diameter and electrode-fiber distance.

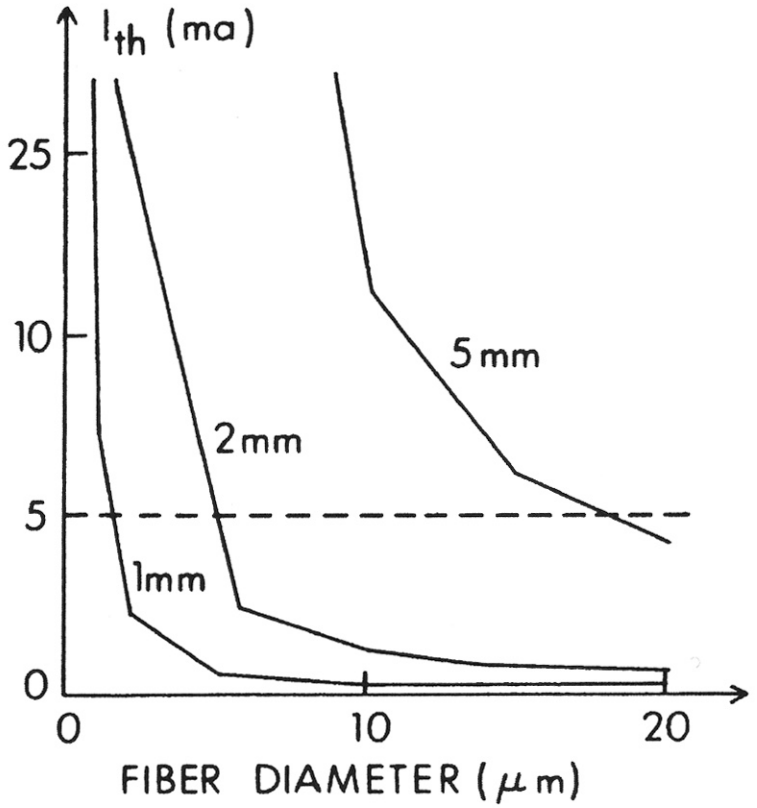

Figure 12.11. Effect of increasing separation between electrode and axon on stimulus threshold to fiber diameter relationship. The stimulus pulse width is fixed at 100 μs. Calculated by Mortimer [1] from the model by McNeal [10]. (From J. T. Mortimer, Motor prostheses, in *Handbook of Physiology*, Sec. I: *The Nervous System*, Vol. II, *Motor Control*, Part I, American Physiological Society, Bethesda, Maryland, 1981, pp. 155–187.)

Recruitment (cont.):

I_{th} versus fiber diameter and pulse duration.

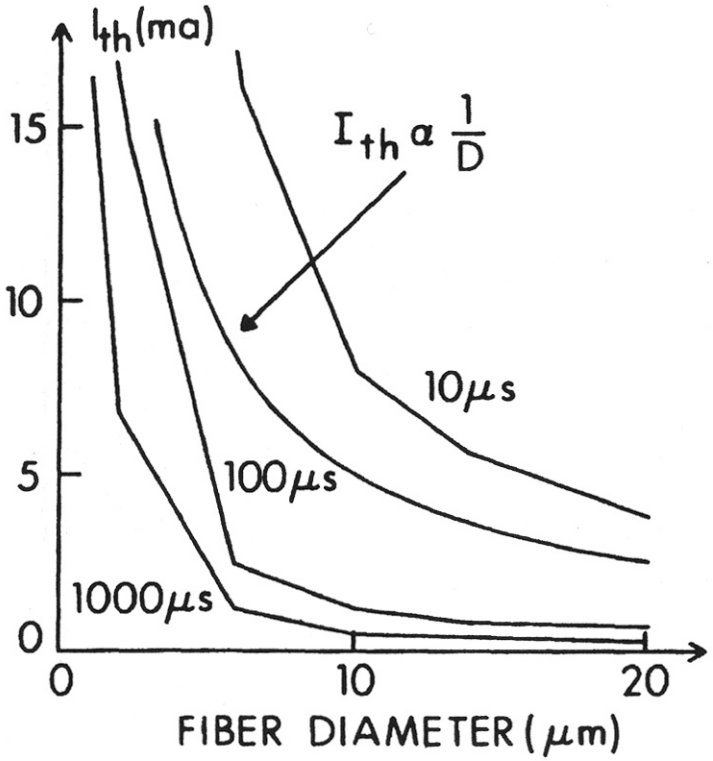

Figure 12.12. Stimulus threshold as a function of nerve diameter for several values of stimulus pulse width. Stimulus–fiber distance is 2 mm. Calculated by Mortimer [1] using the model of McNeal [10]. (J. T. Mortimer, Motor prostheses, in *Handbook of Physiology*, Sec. I: *The Nervous System*, Vol. II, *Motor Control*, Part I, American Physiological Society, Bethesda, Maryland, 1981, pp. 155–187.)

Recruitment (cont.):

I_{th} versus pulse duration for nerve and muscle.

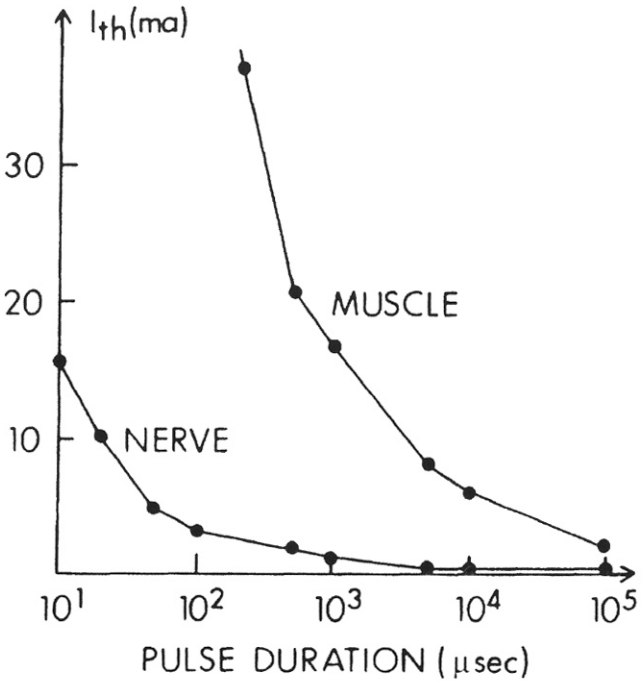

Figure 12.13. Strength–duration relationship for nerve excitation (indirect muscle excitation) and direct muscle excitation. During these experiments, evoked muscle response was held constant at small fraction of total possible muscle force. The stimulus was delivered through an intramuscular electrode before and after administration of curare. (Data are representative of those collected from laboratory experiments and are, in principle, identical to the type of curves classically presented for innervated and denervated muscle.) (From J. T. Mortimer, Motor prostheses, in *Handbook of Physiology*, Sec. I: *The Nervous System*, Vol. II, *Motor Control*, Part I, American Physiological Society, Bethesda, Maryland, 1981, pp. 155–187.)

Recruitment (cont.):

Considering the results of the simulations and experimental data shown in the previous three slides, large diameter fibers tend to be *recruited* before small diameter fibers.

However, under physiological conditions for *motor units*, small diameter fibers innervating slow oxidative (SO) muscle fibers tend to be recruited *before* larger diameter fibers innervating fast glycolytic (FG) muscle fibers.

Thus, the natural order of recruitment is reversed in FES.

Recruitment (cont.):

One approach to combat this recruitment-order problem is to utilize two electrodes.

The *first* electrode supplies a *large depolarizing current* that excites fibers with a large range of diameters.

The *second* electrode supplies a *small hyperpolarizing current* that *prevents action potential propagation* on the *large diameter fibers* excited by the first electrode.

The hyperpolarizing pulse must be designed with a ramp that prevents anode-break excitation.