

ME 498 / ME 599

# Biological Frameworks for Engineers

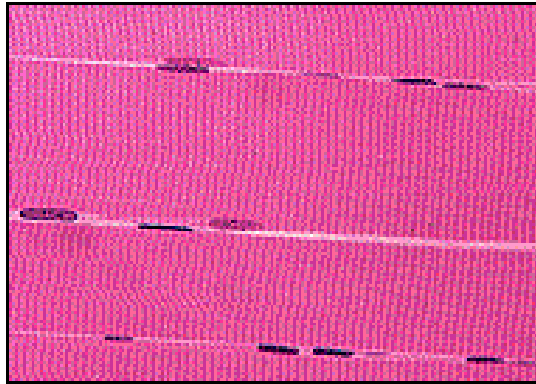
# Class Organization

- HW6 assigned. Due Mon.
- Lab 3 – Muscle Lab
  - MEB 127

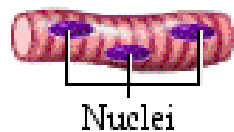
ME 498 / ME 599

# Muscle Cells to Tissues

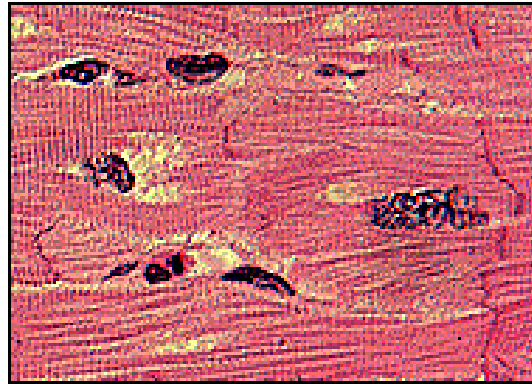
# Muscle Overview



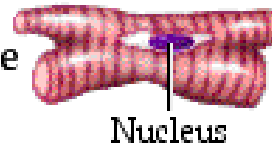
Skeletal Muscle  
300 x



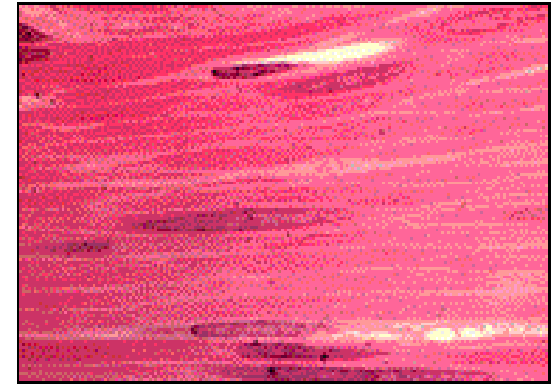
- Elongated cell
- Multiple peripheral nuclei
- Visible striations
- Voluntary



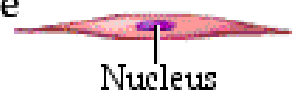
Cardiac Muscle  
400 x



- Branching cell
- Single central nucleus
- Visible striations
- Involuntary

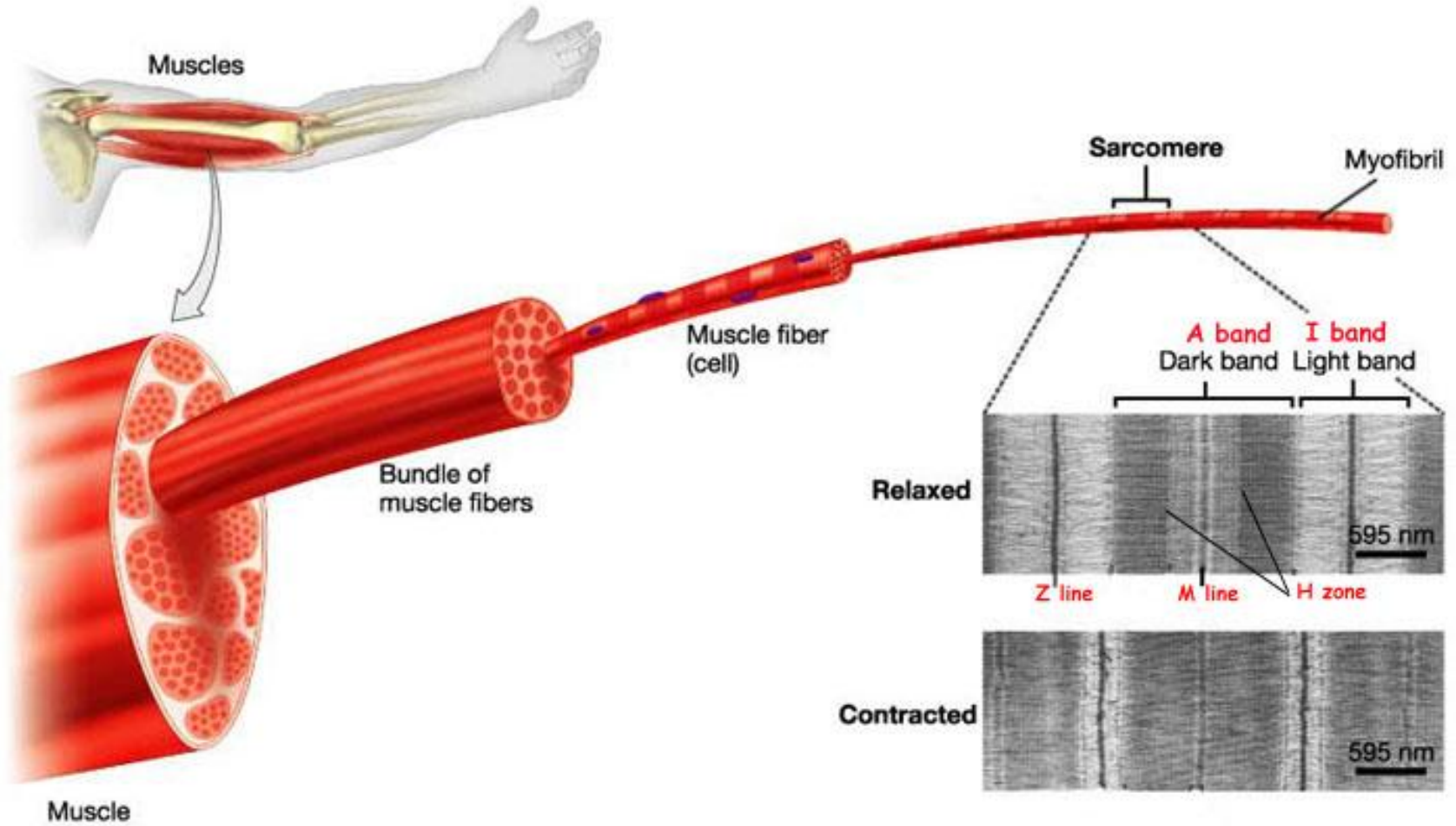


Smooth Muscle  
1200 x

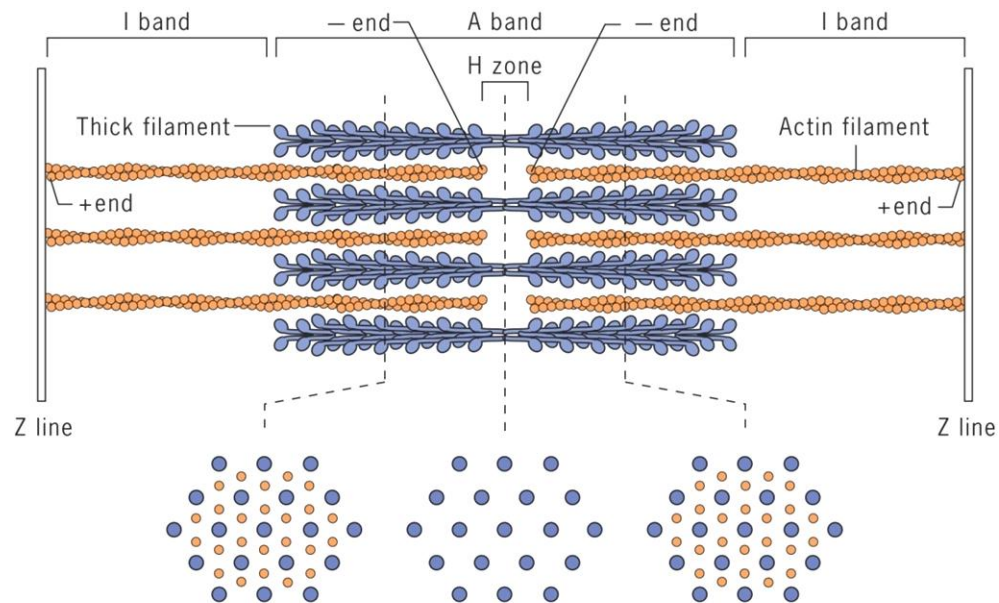
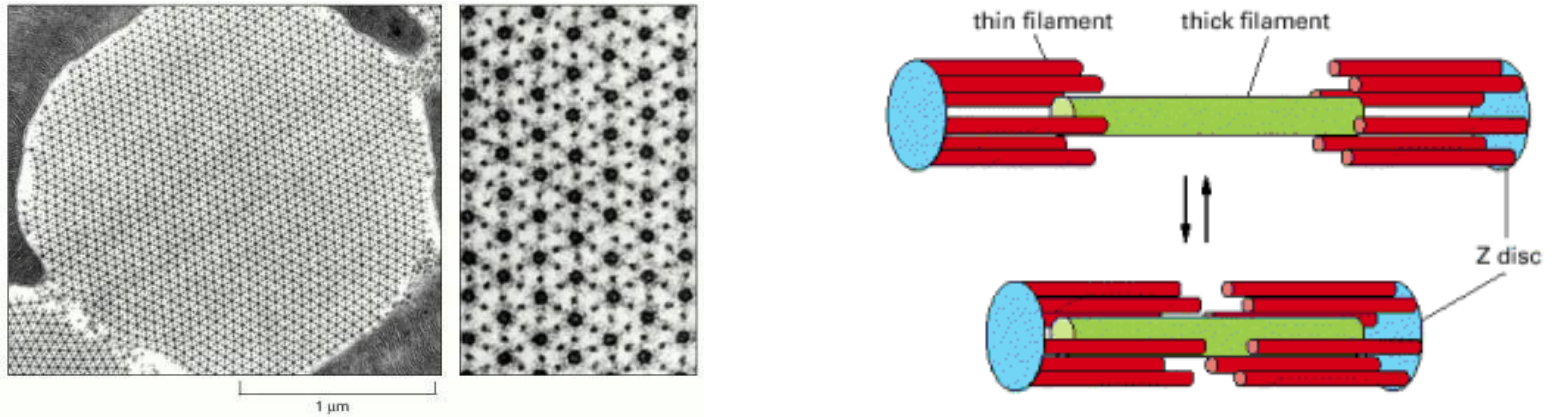


- Spindle-shaped cell
- Single central nucleus
- Lack visible striations
- Involuntary

# Structure of Muscle



# Cross-Section

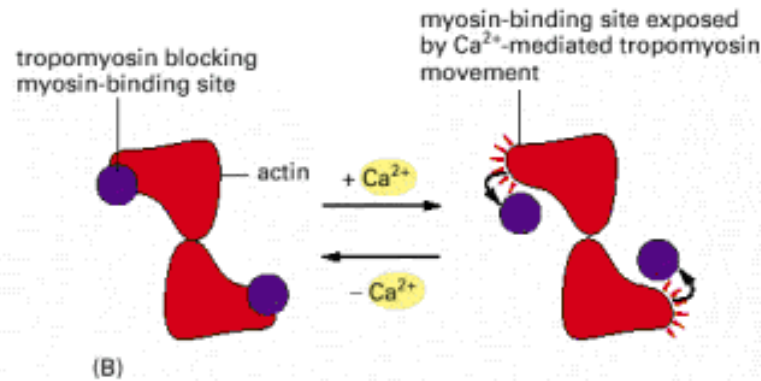
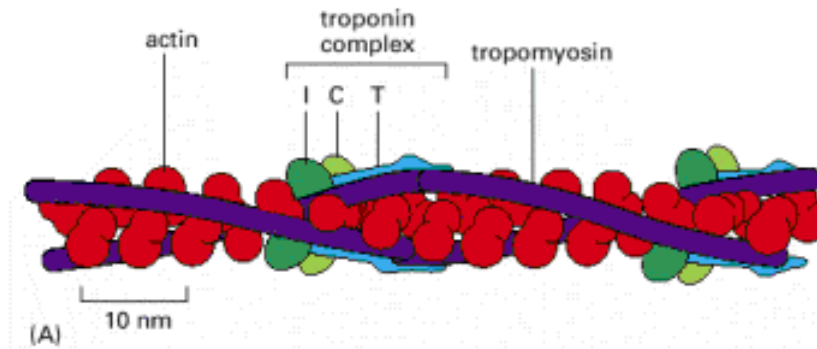


(a)

# Contractile Participants

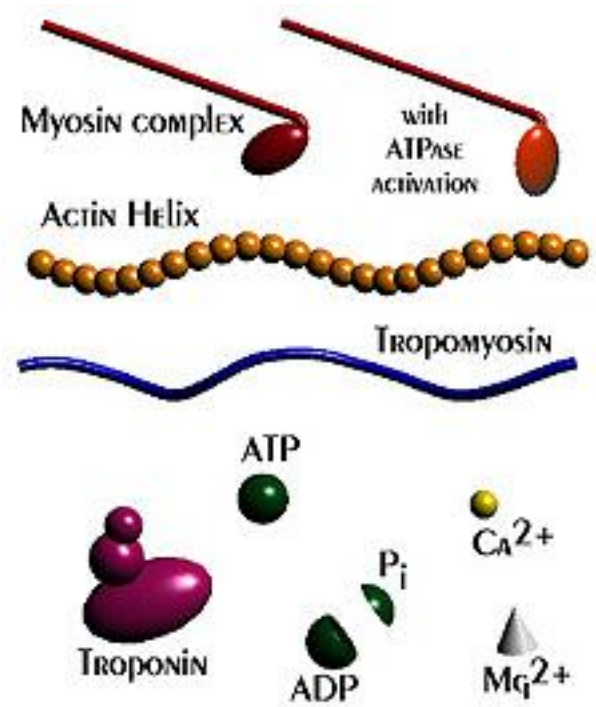
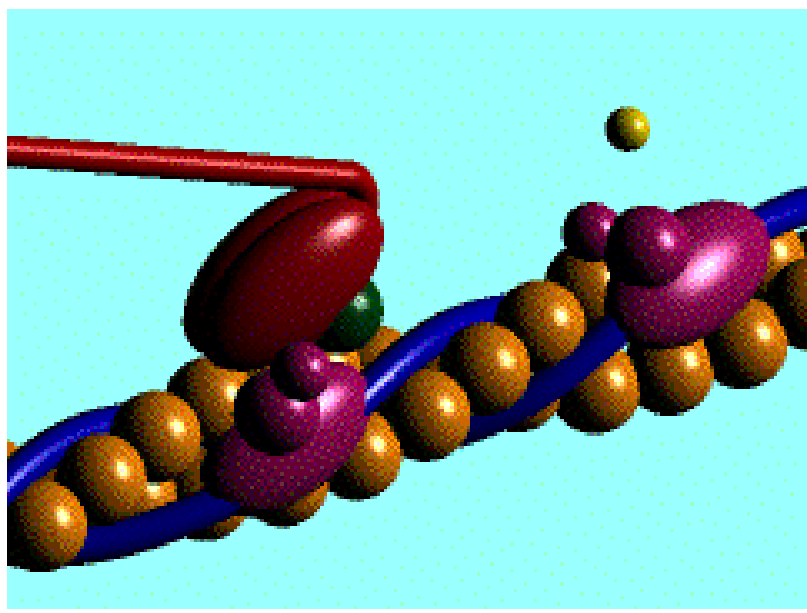


# Tropomyosin & Troponin



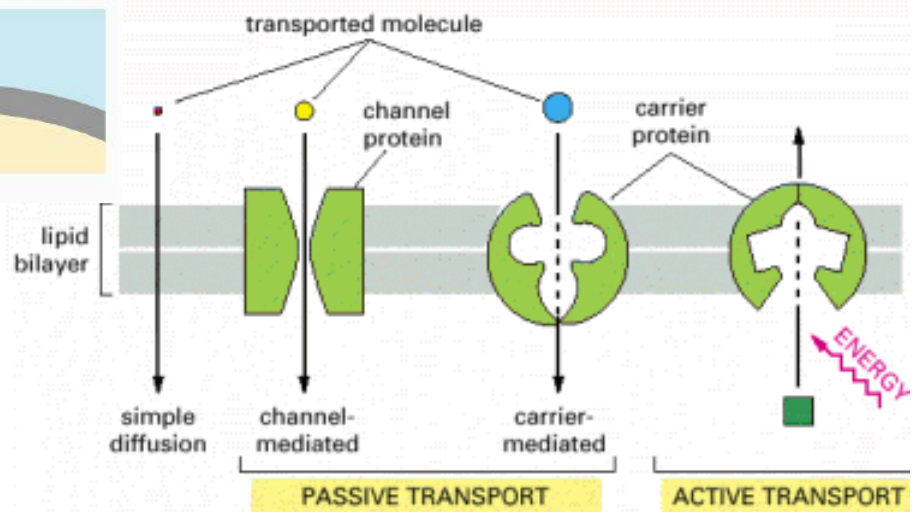
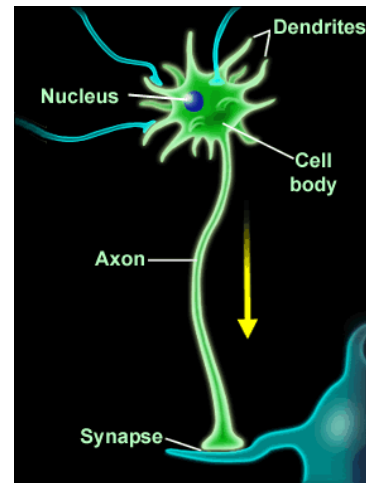
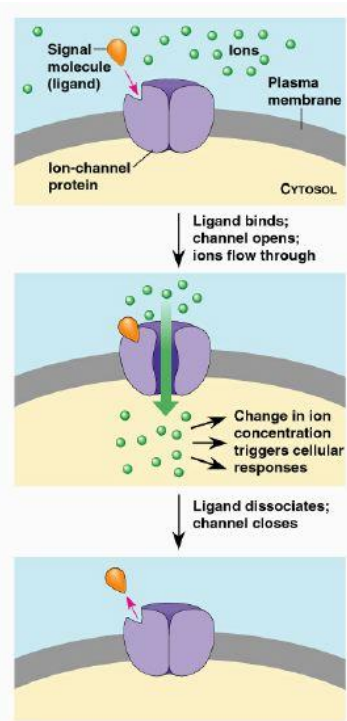
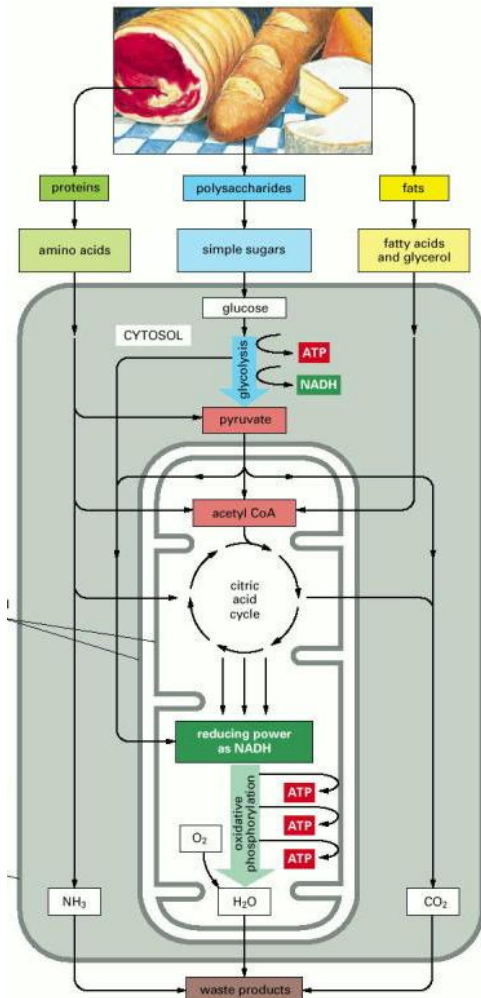


# Actomyosin Contraction

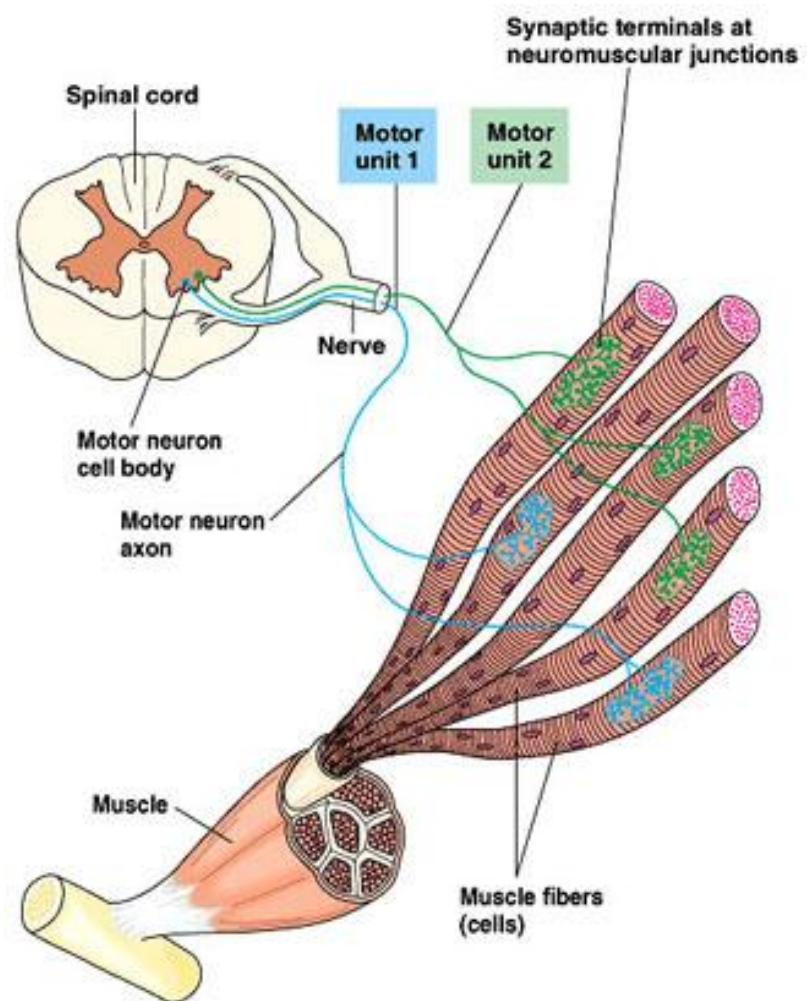


Courtesy of San Diego State University

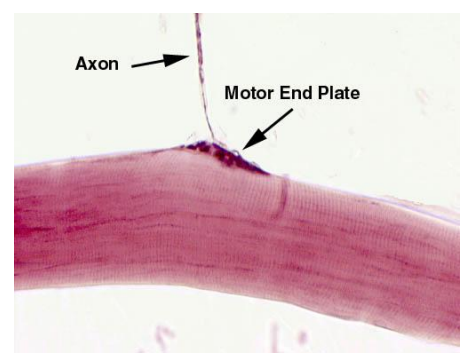
# Supporters



# Motor Units



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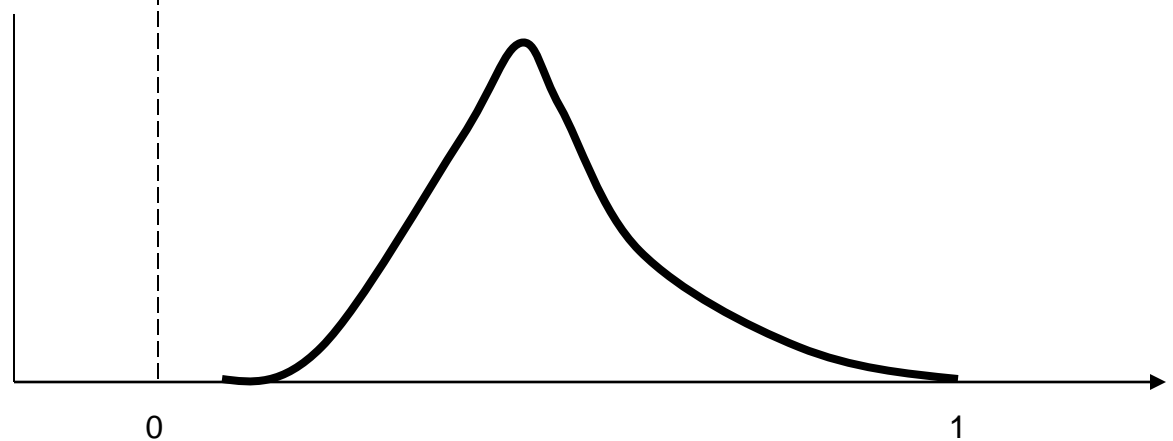


# Twitch

Membrane Potential



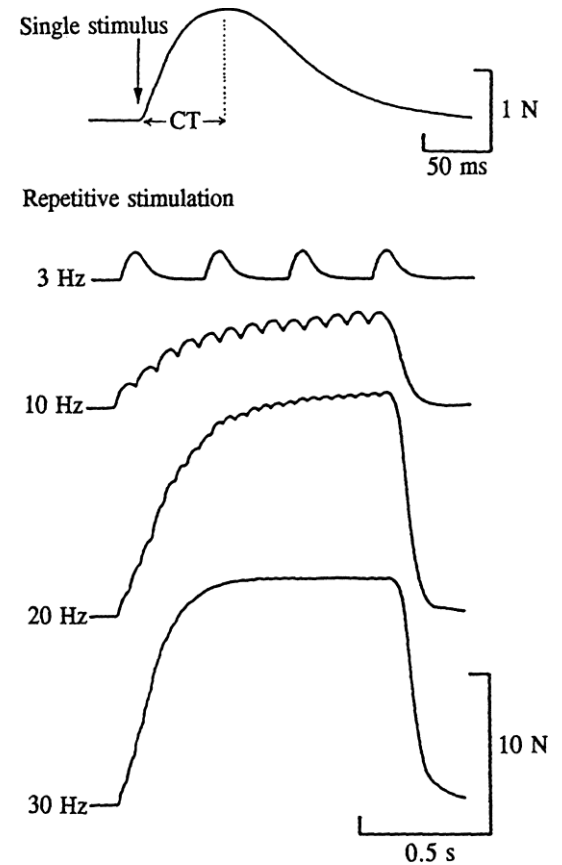
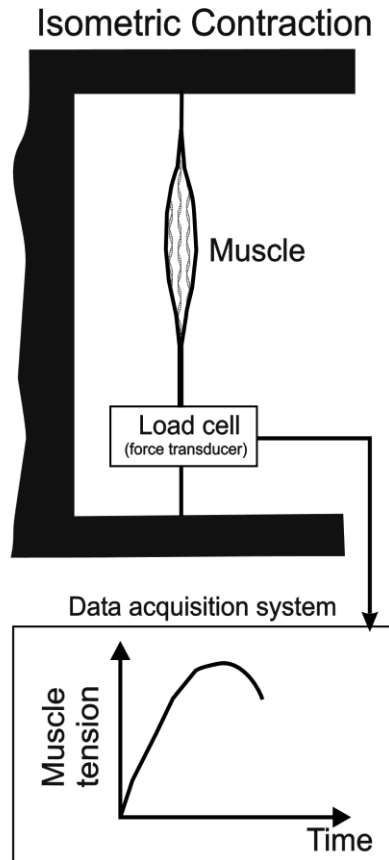
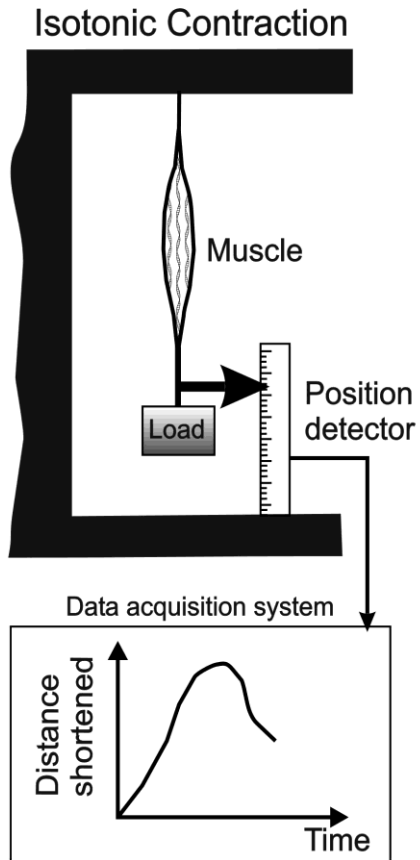
Muscle Force



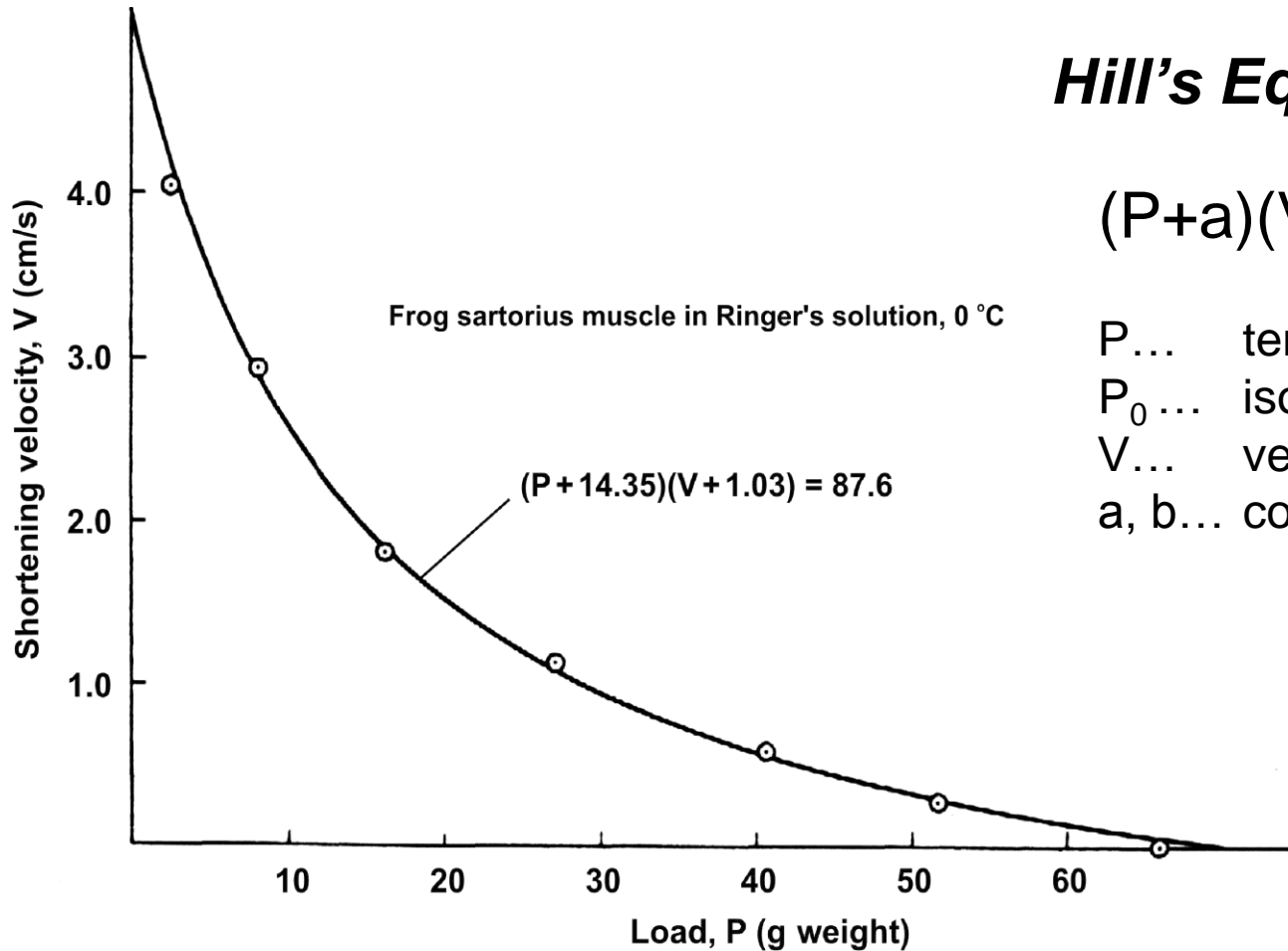
Latency Period  
15 ms

Time (s)

# Ex Vivo Frog Muscle



# Force vs. Velocity



**Hill's Eqn:**

$$(P+a)(V+b) = (P_0+a)b$$

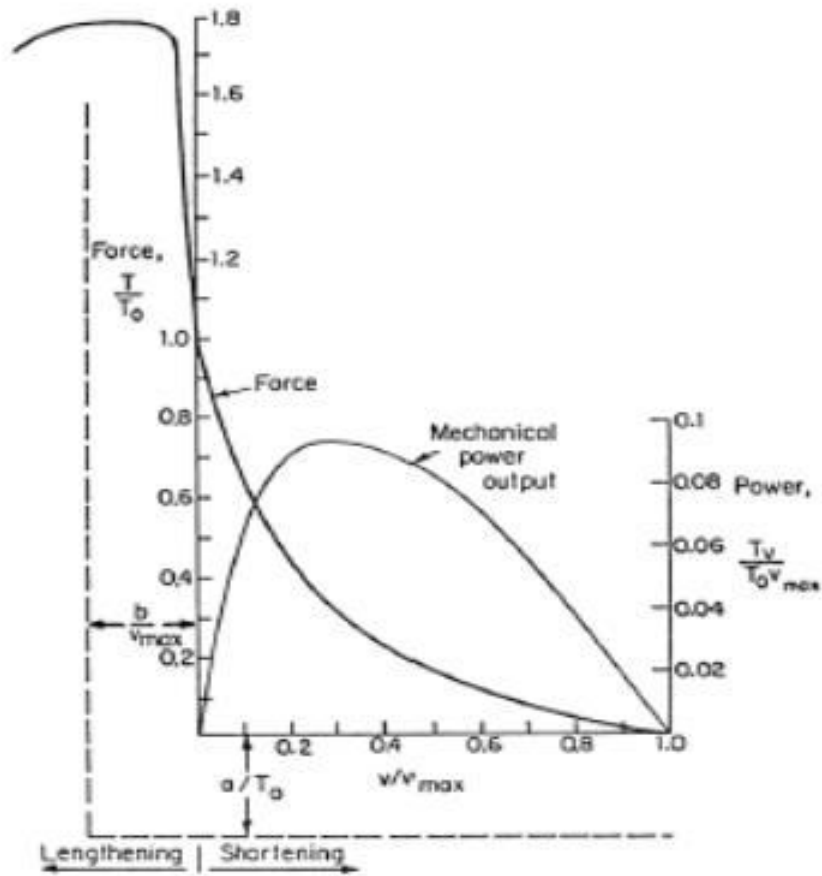
P... tension

$P_0$ ... isometric tension

V... velocity

a, b... constants

# Force vs. Velocity



**Hill's Eqn:**

$$(T+a)(v+b) = (T_0+a)b$$

T... tension

$T_0$ ... isometric tension

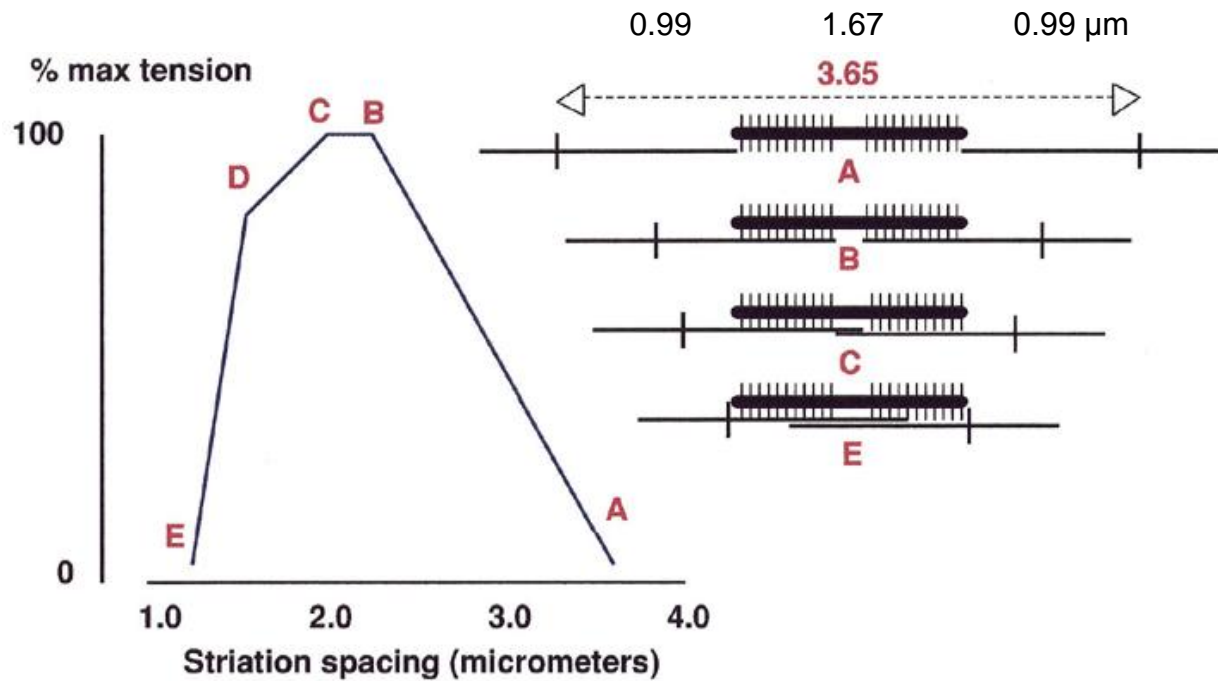
v... velocity

$v_{max}$ ... velocity against no load

$$v_{max} = b \cdot T_0 / a$$

$$Power = T \cdot v$$

# Force vs. Length - Micro

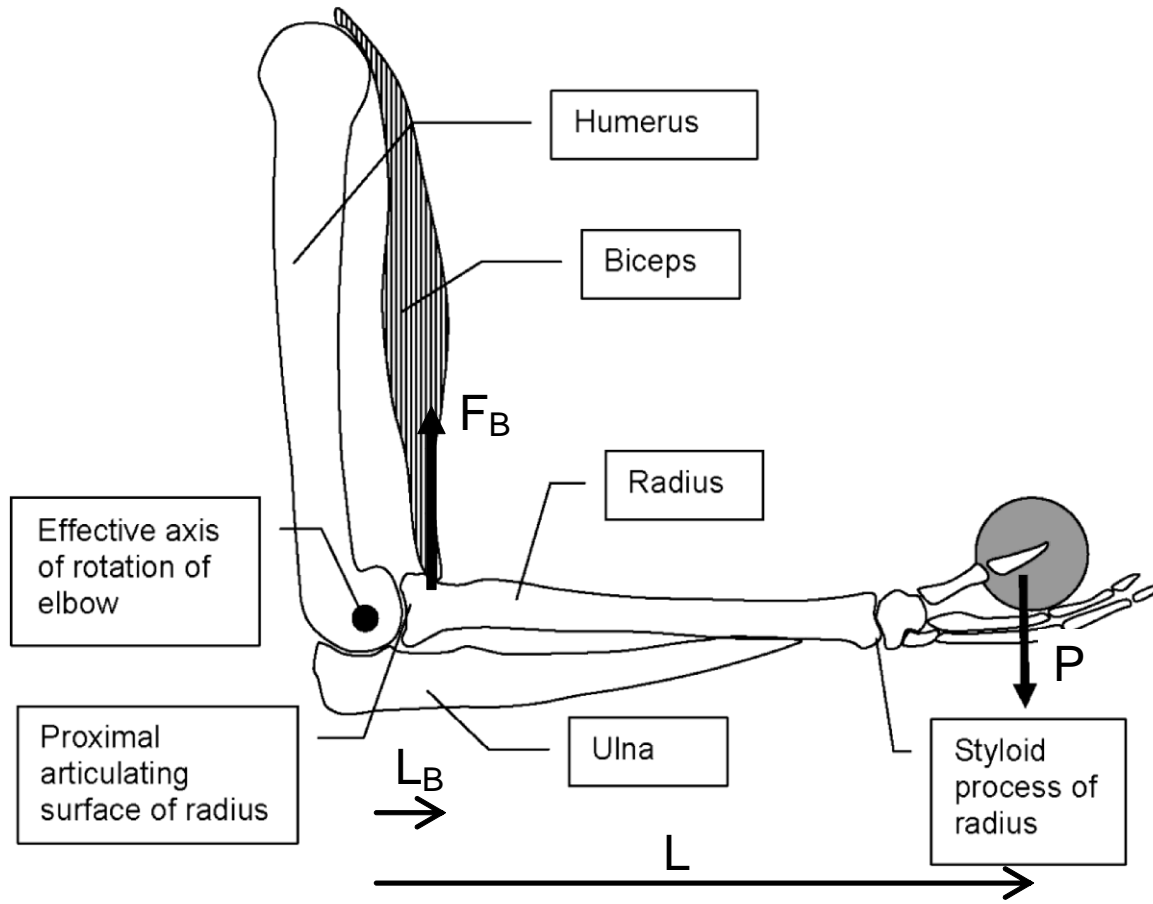




# Muscle Lab



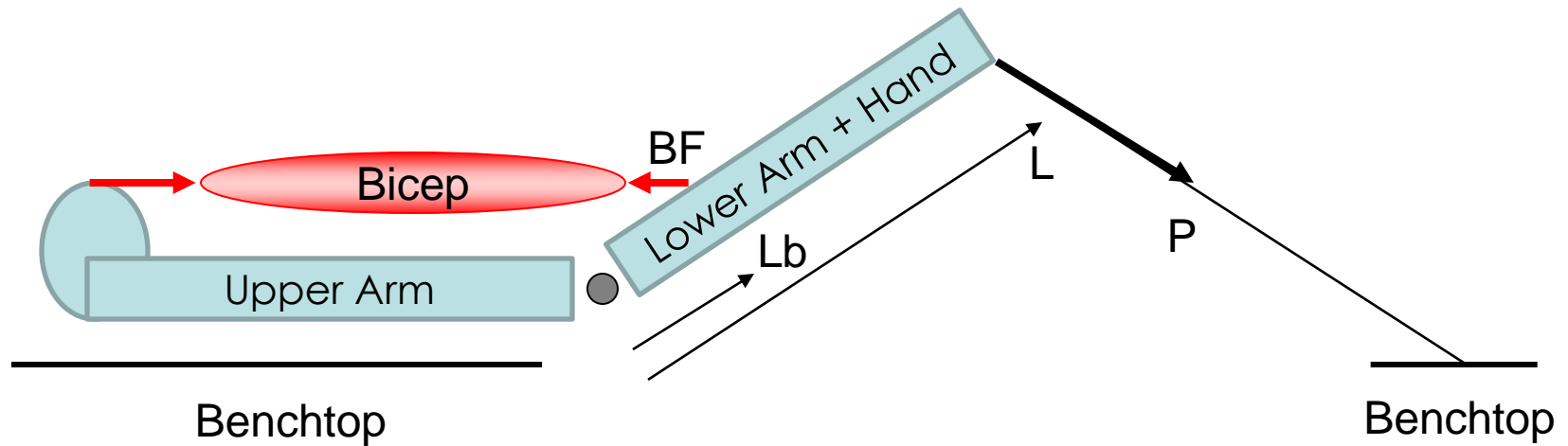
# Bicep Brachii



# Free Body Diagram

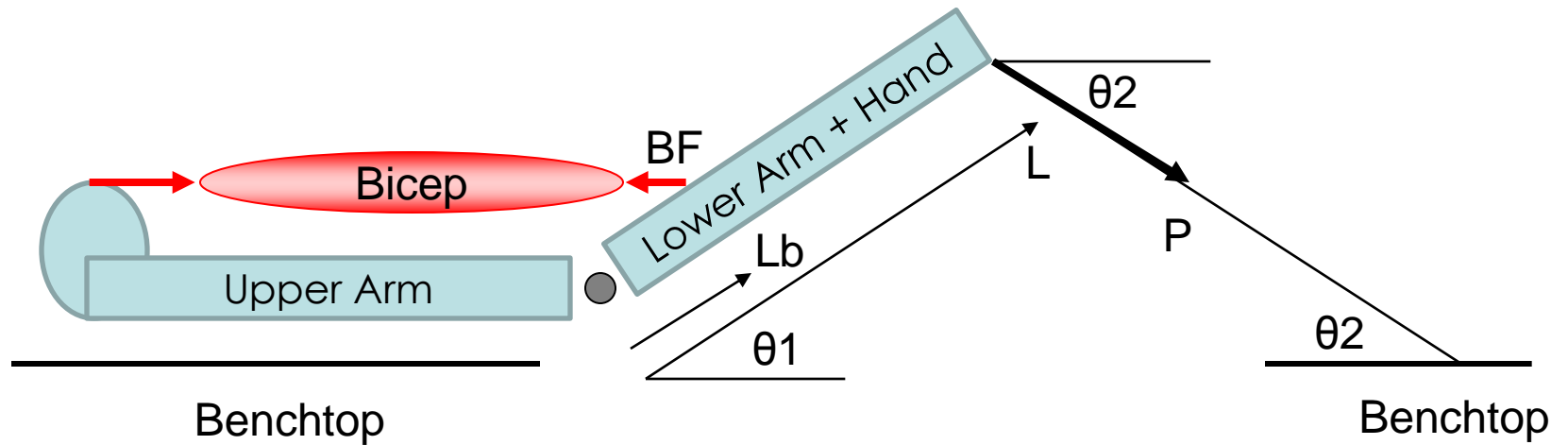
$$M = (P \otimes L) + (BF \otimes Lb)$$

$\otimes$  = cross product



# Free Body Diagram

$$P * L * \sin(\theta_1 + \theta_2) = BF * L_b * \sin(\pi - \theta_1)$$



Questions?