Muscles in Biomechanics:

- **Tissue level:**
  Rigid and Deformable bodies

- **Cell level:**
  Myocyte structure and function

- **Protein level:**
  Force generation at the sarcomere
Experimental System for BE172: Isolated Frog Semitendinosis Muscle

- Size: 1-2 cm in length, 1-2 mm diameter
- Classical preparation to study muscle mechanics
- Can generate 20-30 grams force with maximal electrical stimulation
- Well known that active and passive muscle forces are functions of muscle length
Goal of Lab: measure force-length relations in isolated skeletal muscle

- Isolate muscle from frogs...keep muscle alive!
- Set up and calibrate force measuring system
- Control muscle passive length
- Apply electrical stimulation to find total active force being generated
- Present results in terms of sarcomere length changes
How do muscles generate force: the sarcomere as a molecular motor

High magnification electron microscopy

Lower magnification “striations”
Experimental Setup and Measurement

Muscle twitch

Twitch summations: tetanus
Recording a tetanic force: increase stimulation rate

Electrical stimulation

- Single twitches (20-50 ms duration) 5-10g force
- Tetanic contraction (~1 sec) 20-40g force
Skeletal Muscle Active (Developed) Force vs. Sarcomere length
Estimate sarcomere length: laser diffraction

Measure sarcomere length at a given muscle length, assume linear relation

\[ n \lambda = d \sin(\tan^{-1}(x/h)) \]

- \( n \) = order of band above 0-order
- \( \lambda \) = wavelength of laser He-Ne laser
- \( d \) = grid spacing of sample
- \( x \) = band spacing to \( n \)-order band
- \( h \) = distance from sample to screen

\[ \tan^{-1}(x/h) = \text{angle of diffraction} \]

Remember to measure muscle length also!
Active, Passive and Total Tension

- Need to wait 2 minutes between tetanic contractions, need a timer!
- Only stimulate muscle as long as needed, don’t use up all of the ATP early!
- Remember to acquire passive forces as you change muscle length
- Have TA initial raw data; turn in pre-lab before you leave

Number of points to define a curve:
(6-8 points)