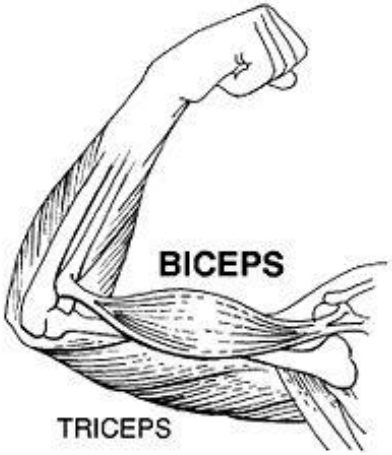
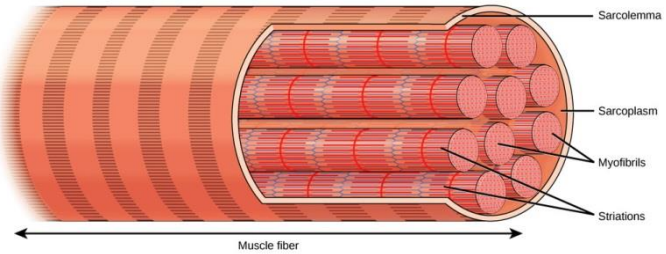
BE172 Week 2: Skeletal Muscle Length-Tension Relation

Muscles in Biomechanics:

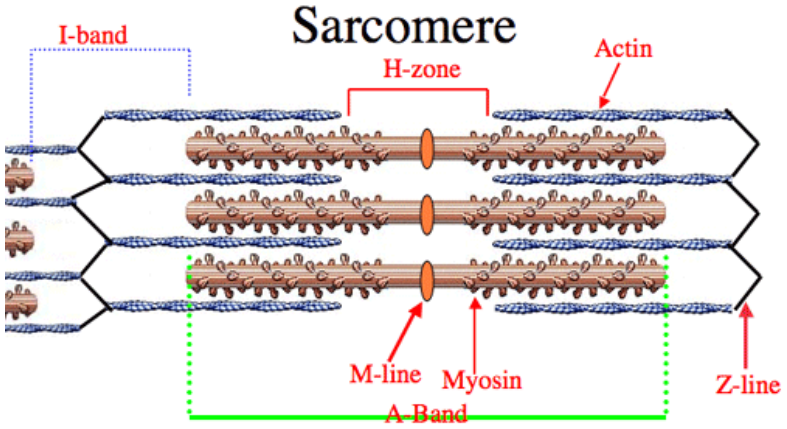
Tissue level:
Rigid and Deformable bodies





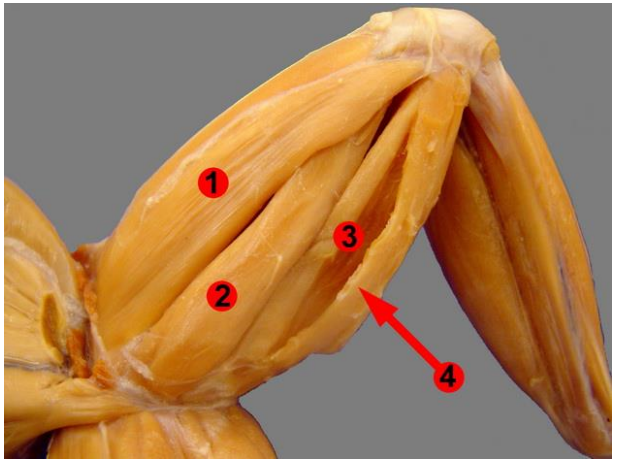
Cell level:
Myocyte structure and function

Protein level:
Force generation at the sarcomere



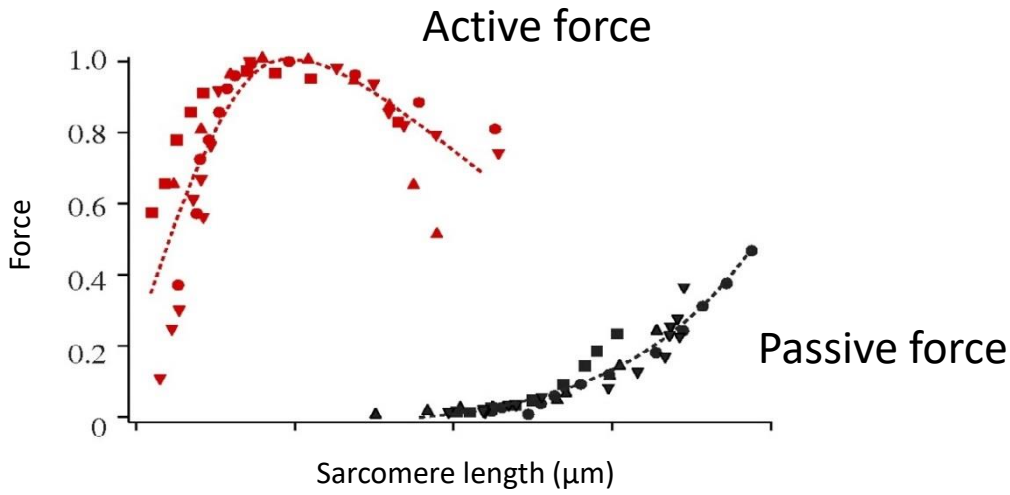
Experimental System for BE172:
Isolated Frog Semitendinosis Muscle

- 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

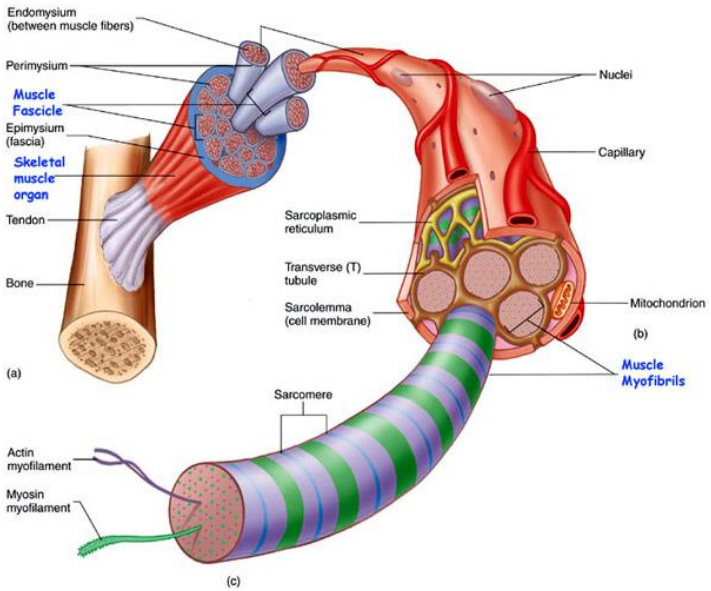


Goal of Lab: measure force-length relations in isolated skeletal muscle

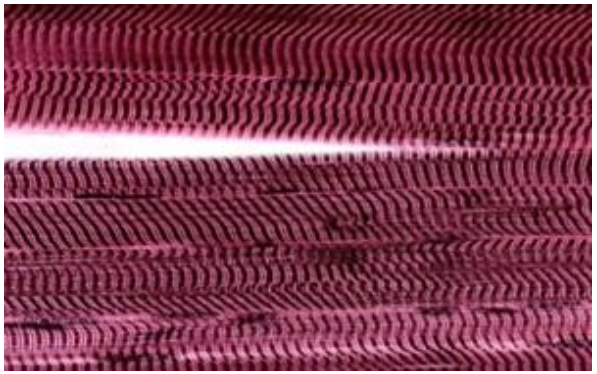
- Isolate muscle from frogs….keep muscle alive!
- Set up and calibrate force measuring system
- Control muscle passive length
- Apply electrical stimulation to find total active force being generated
- Present results in terms of sarcomere length changes



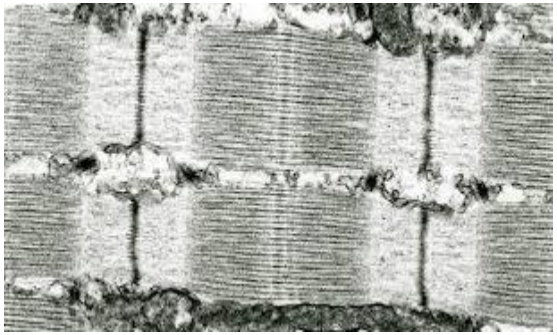
How do muscles generate force: the sarcomere as a molecular motor

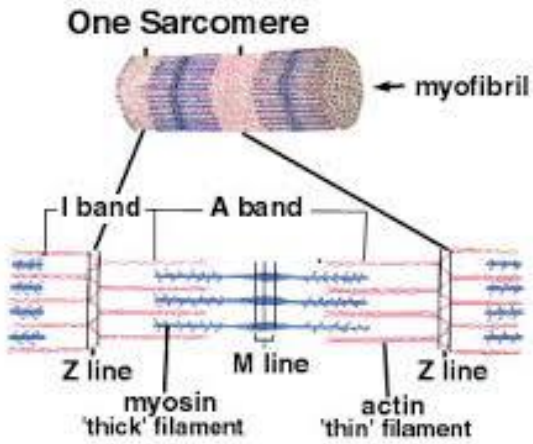


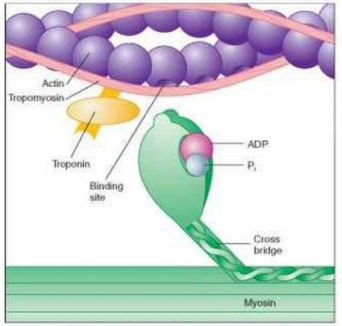
Lower magnification "striations"

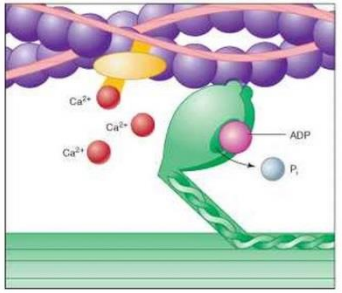


High magnification
electron microscopy

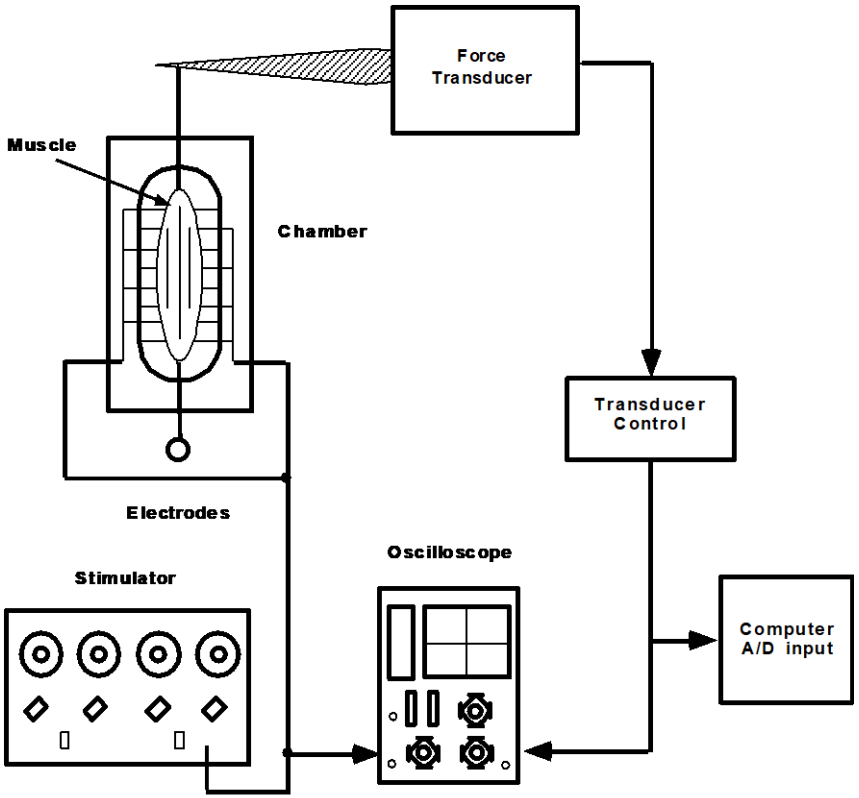




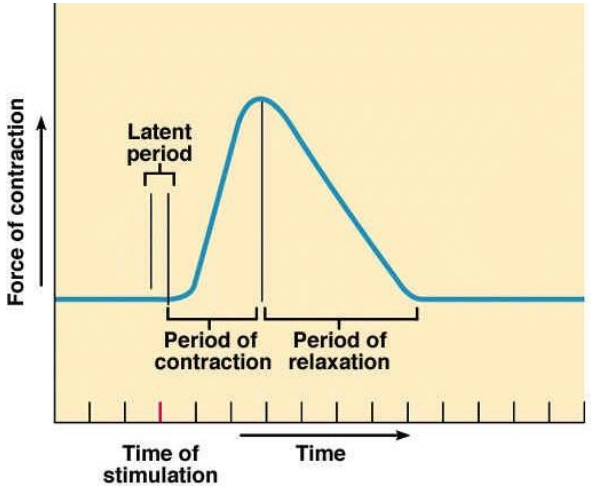




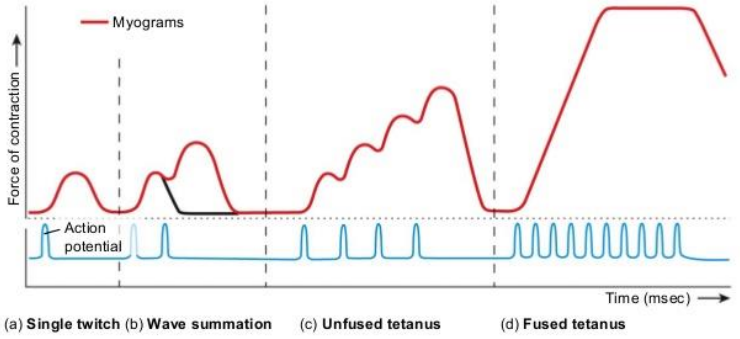
Experimental Setup and Measurement



Muscle twitch

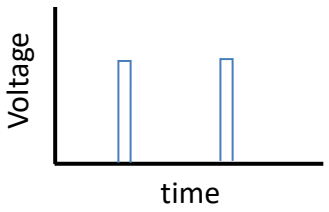


Twitch summations: tetanus

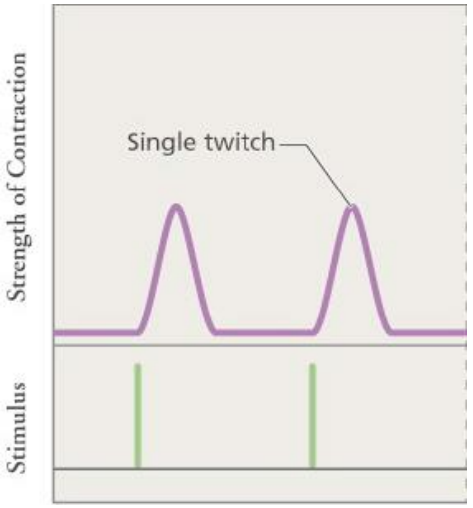


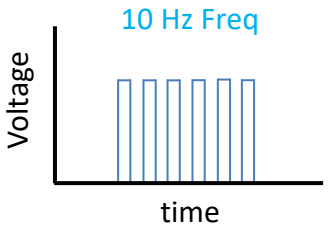
Recording a tetanic force: increase stimulation rate

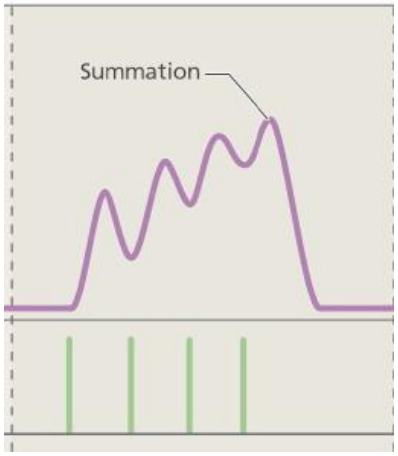
Electrical stimulation

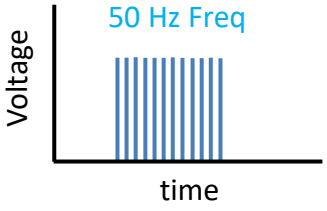


single twitches
(20-50 ms duration)
5-10g force

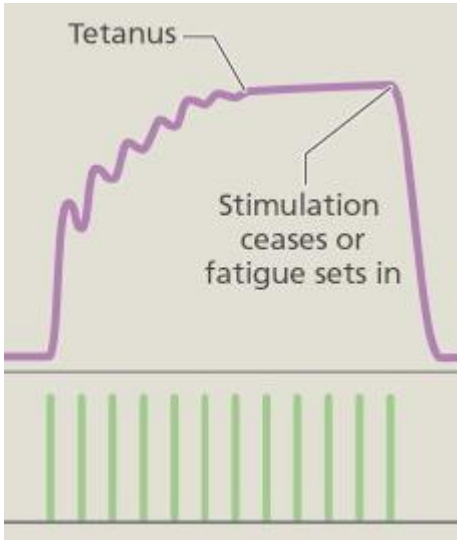








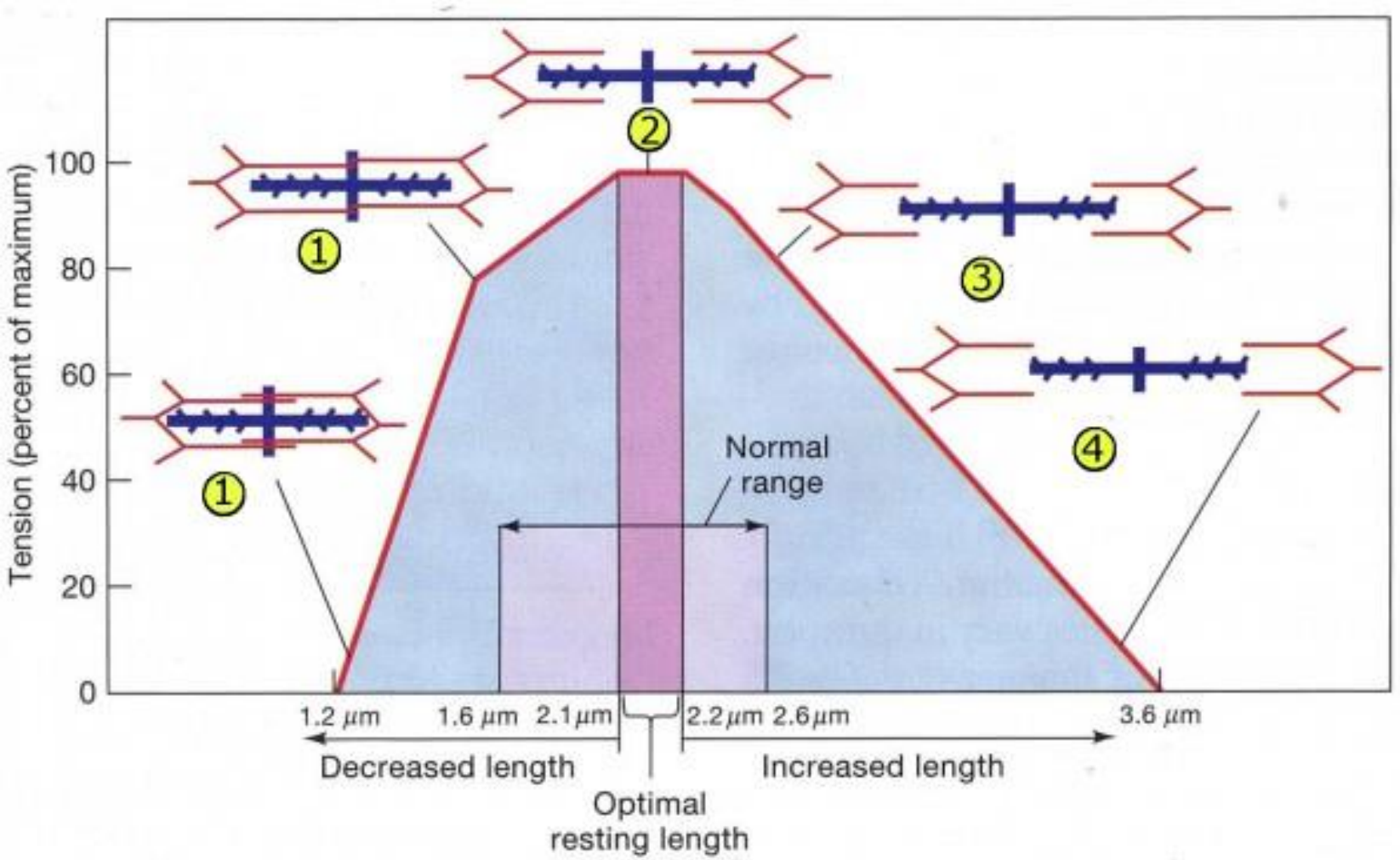
Tetanic contraction
(~ 1 sec)
20-40 g force



Total force

Passive force zero

Skeletal Muscle Active (Developed) Force vs. Sarcomere length



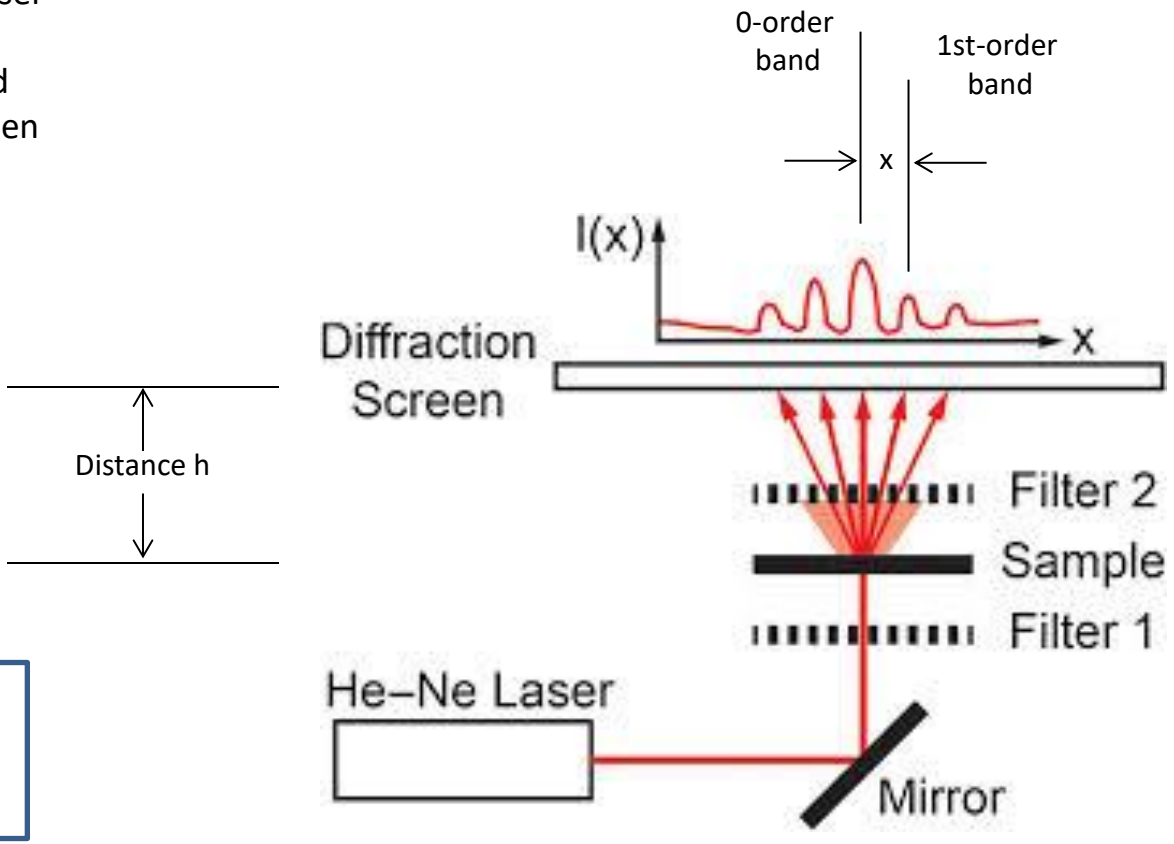
Estimate sarcomere length: laser diffraction

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

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

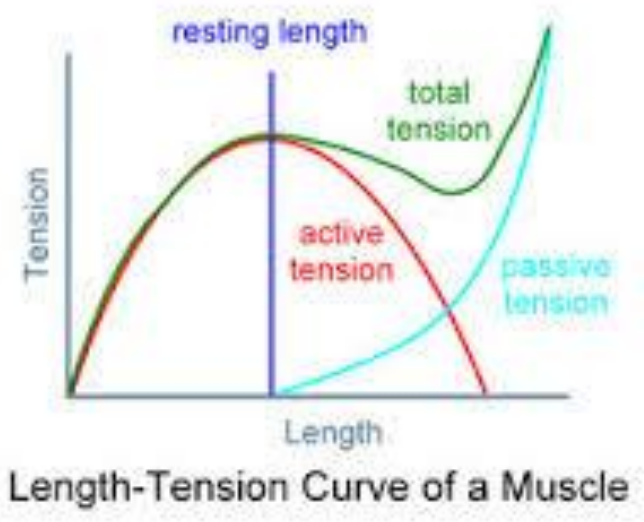
n = order of band above 0-order
λ = wavelength of laser He-Ne laser
d = grid spacing of sample
x = band spacing to n-order band
h = distance from sample to screen

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

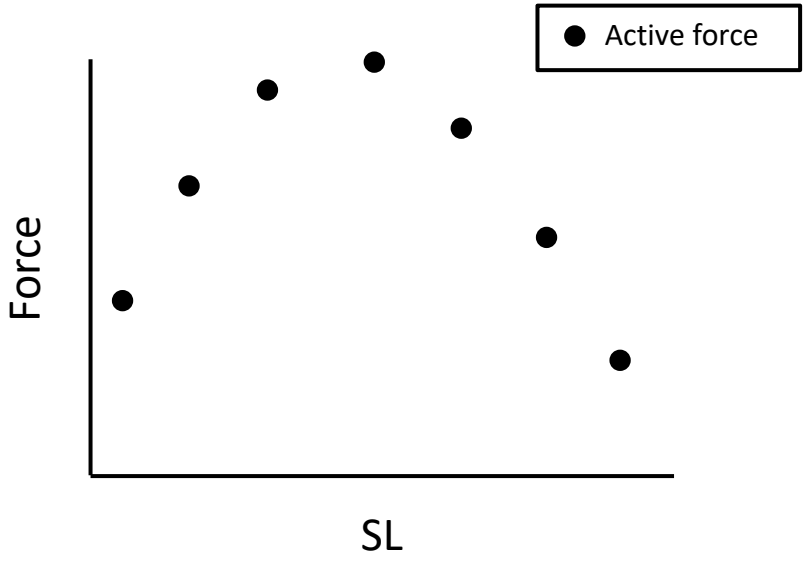


Remember to measure muscle length also!

Active, Passive and Total Tension



Length-Tension Curve of a Muscle



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

- 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