



Mechanics of Skeletal Muscle Contraction

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LEARNING OBJECTIVES

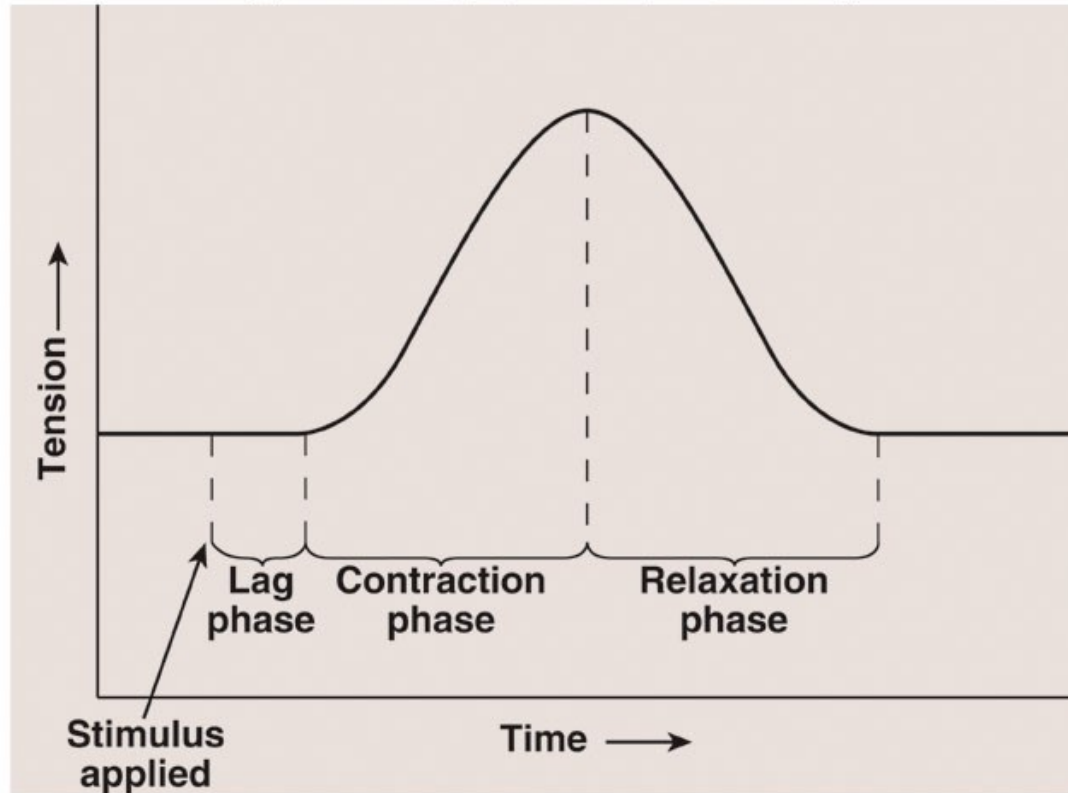
At the end of the session, the students should be able to:

- Describe Summation and its various types.
- Discuss the Staircase effect
- Discuss the muscle tone and its importance.
- Explain the remodeling of muscle to match function.



Muscle Twitch

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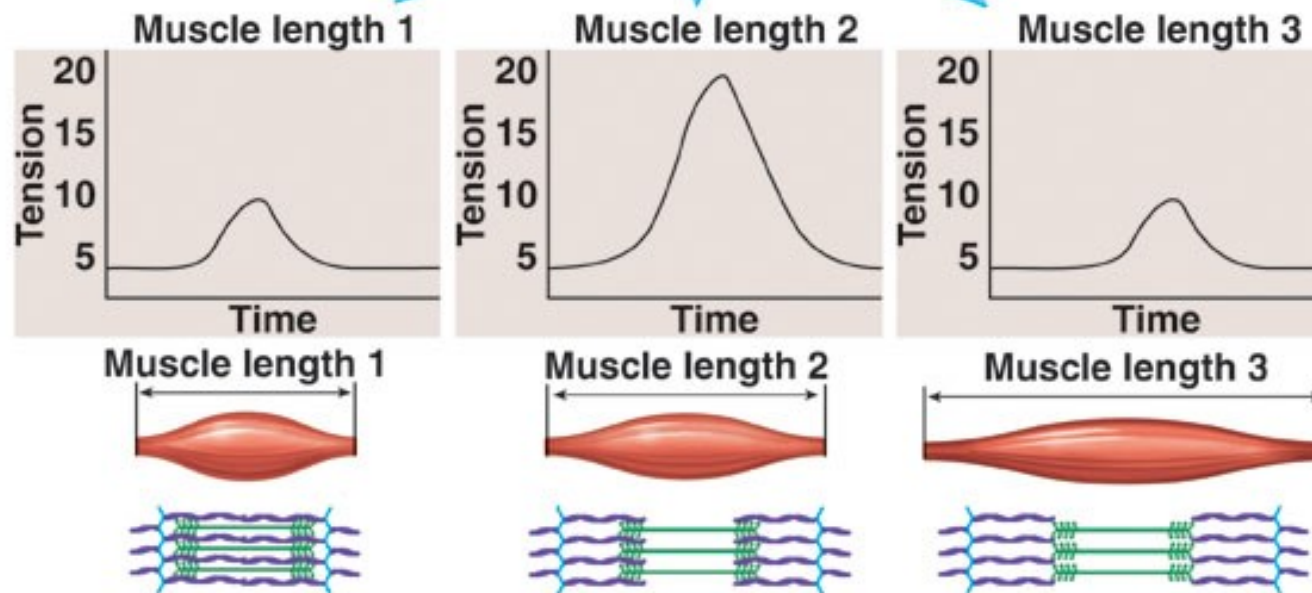
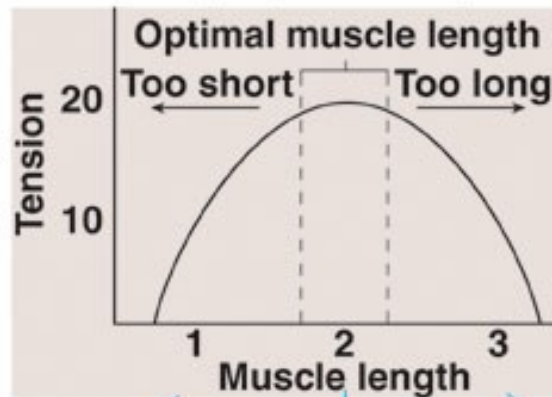


- Muscle contraction in response to a stimulus that causes action potential in one or more muscle fibers
- Phases
 - Lag or latent
 - Contraction
 - Relaxation



Muscle Length and Tension

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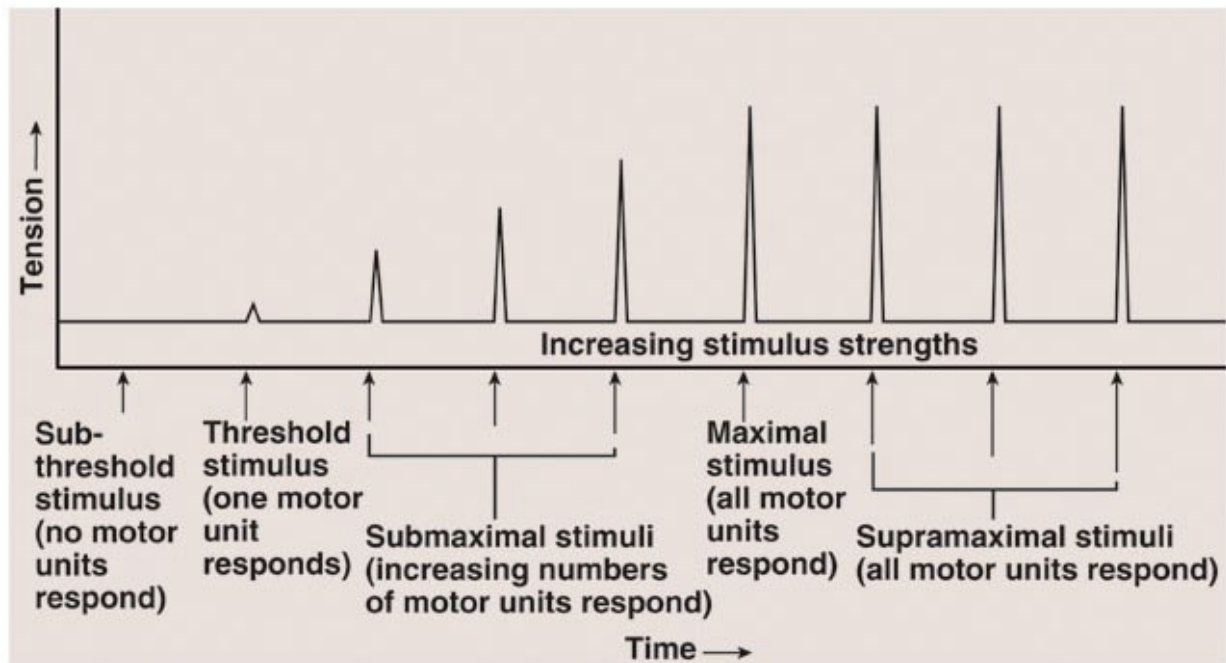


Summation

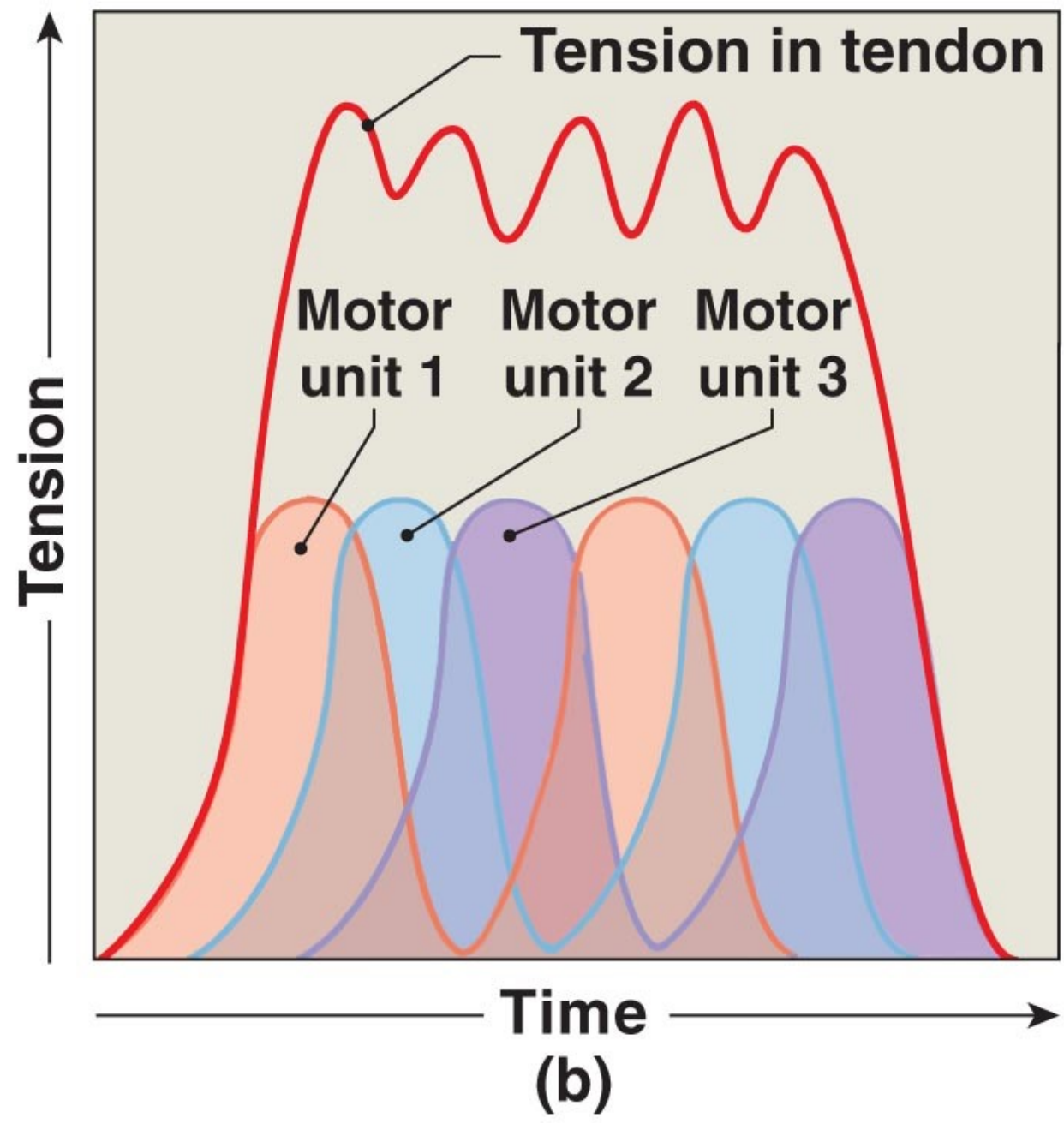


Multiple Motor Unit Summation

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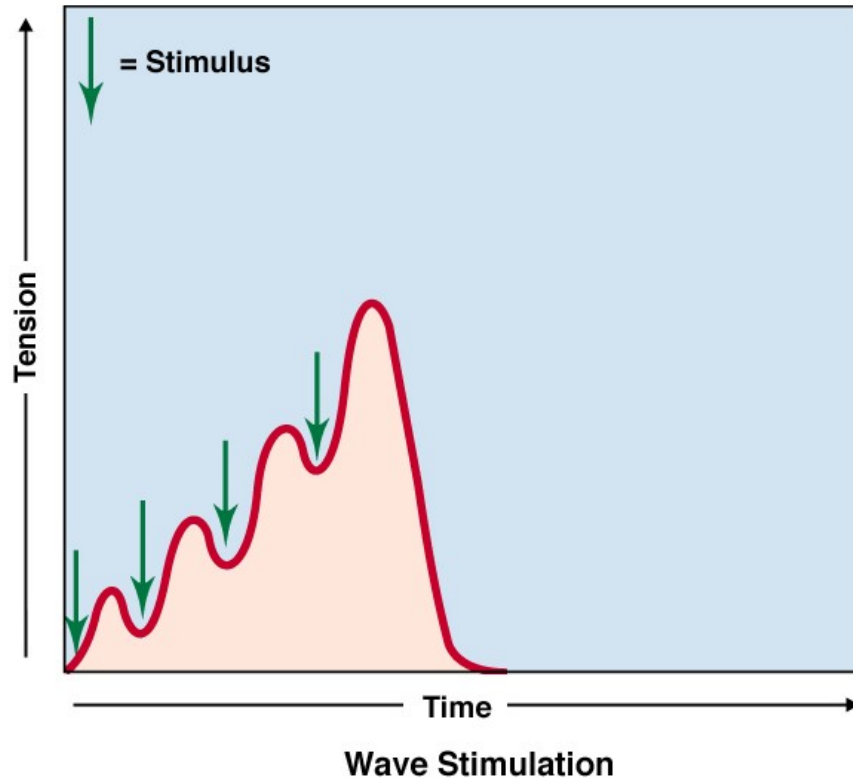


Multiple Fiber Summation





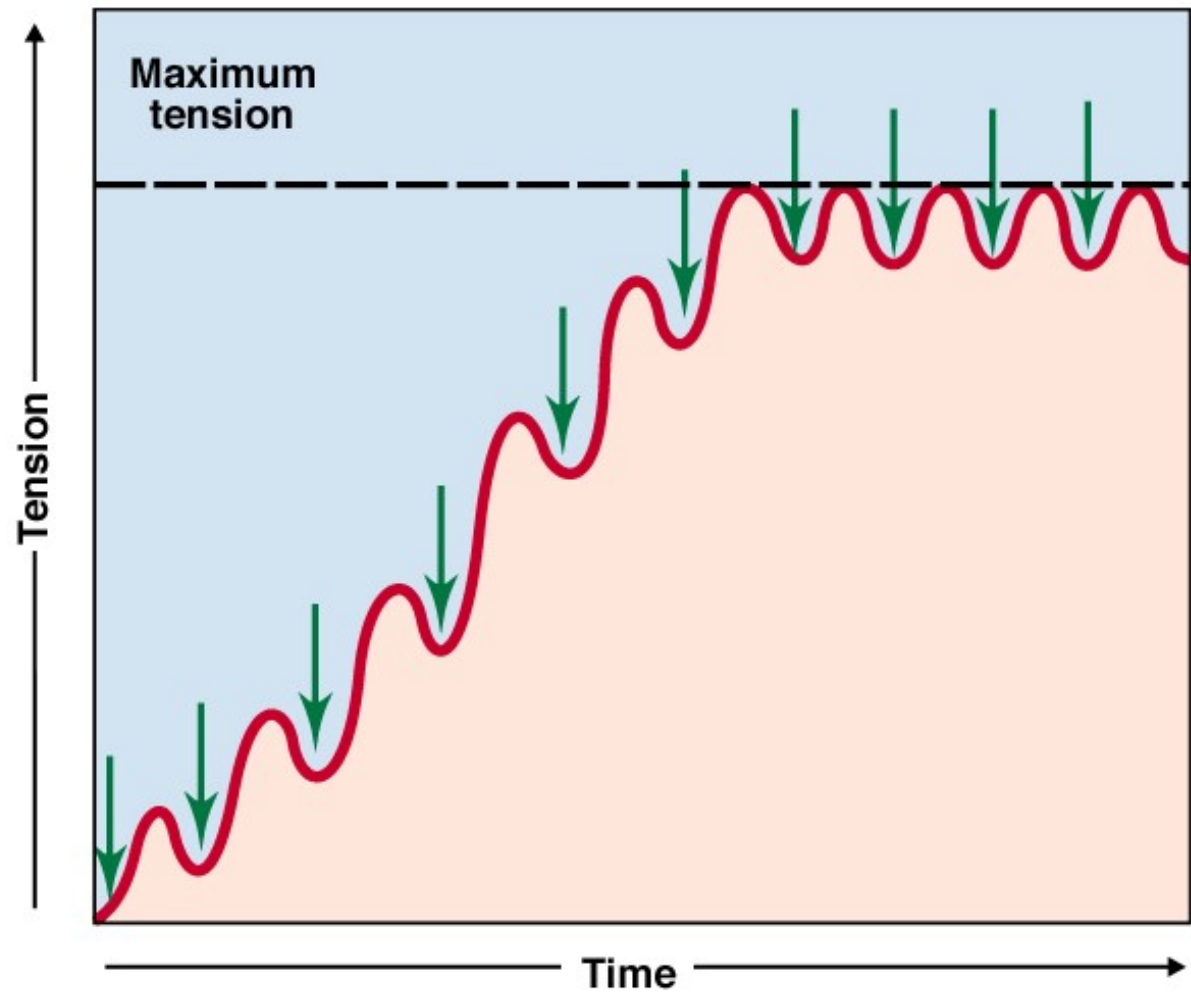
Multiple-Wave Summation or Frequency Summation



- As frequency of action potentials increase, frequency of contraction increases
- Action potentials come close enough together so that the muscle does not have time to completely relax between contractions.



Incomplete tetanization





INCOMPLETE TETANIZATION

- Stimulation of muscle fiber by increasing frequency, that every next stimulus acts during the preceding one i.e. relaxation period
- Every contraction starts before the end of previous one
- Partial relaxation between the subsequent contractions
- Calcium ions increase the strength of contraction



Complete tetanization

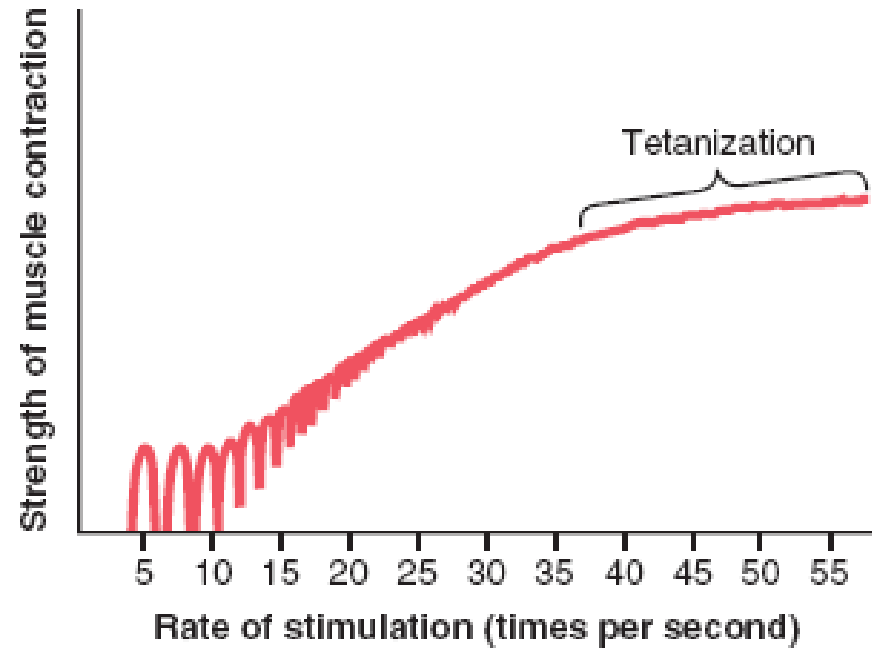
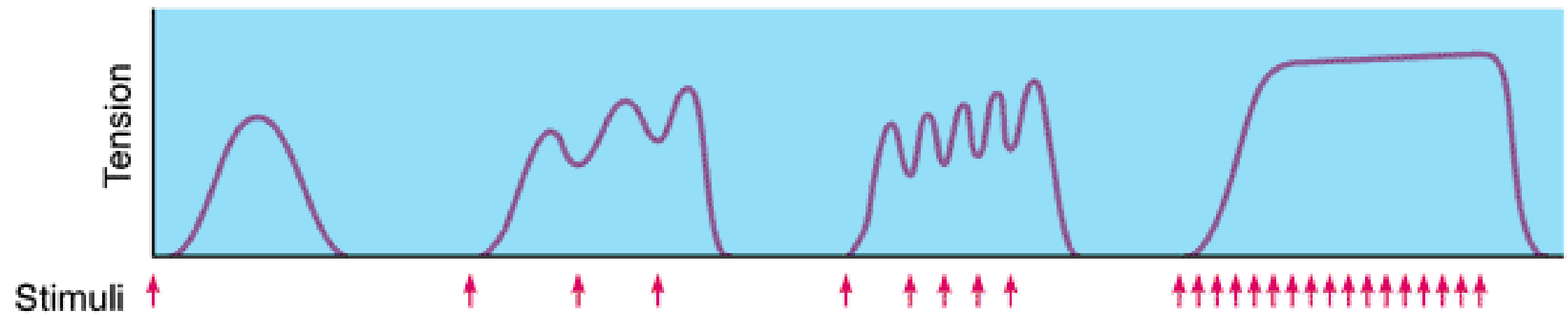


Figure 6-15. Frequency summation and tetanization.



Tetanization



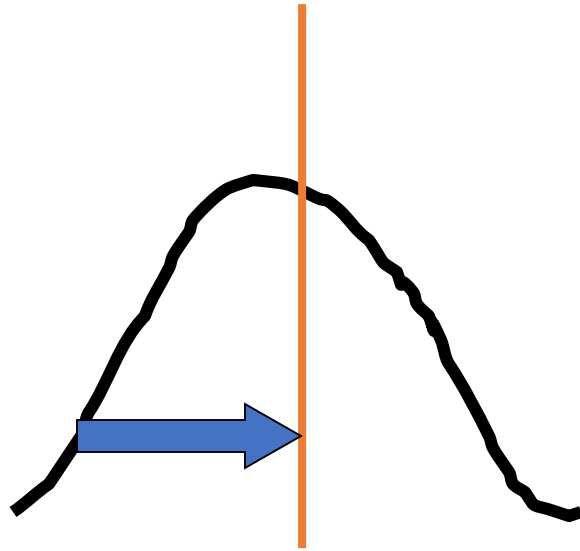


COMPLETE TETANIZATION

- Stimulation of muscle fiber by increasing frequency, that every next stimulus acts during the preceding one i.e. contraction period
- Every contraction merges with the previous one
- No relaxation between the contractions
- Smooth sustained contraction
- Early fatigue



Refractory Periods

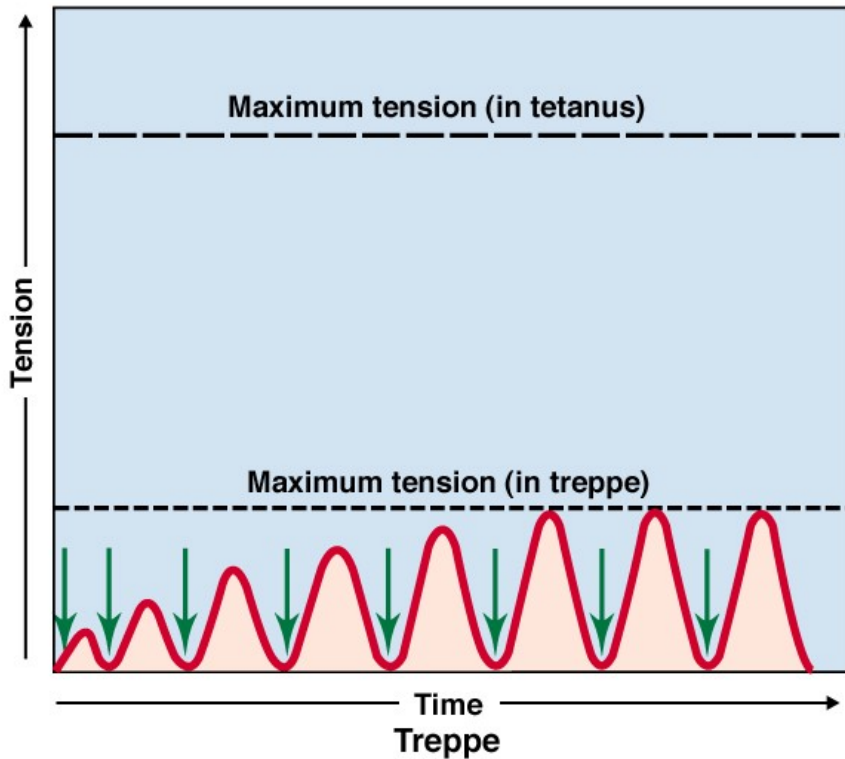


Skeletal Muscle

Brief period of time in which muscle cells will not respond to a stimulus



Treppe or Staircase effect



- Graded response
- Occurs in muscle rested for prolonged period
- Each subsequent contraction is stronger than previous until all equal after few stimuli



Muscle Remodelling

- Atrophy
- Hypertrophy
- Hyperplasia
- Adjustment of Muscle length





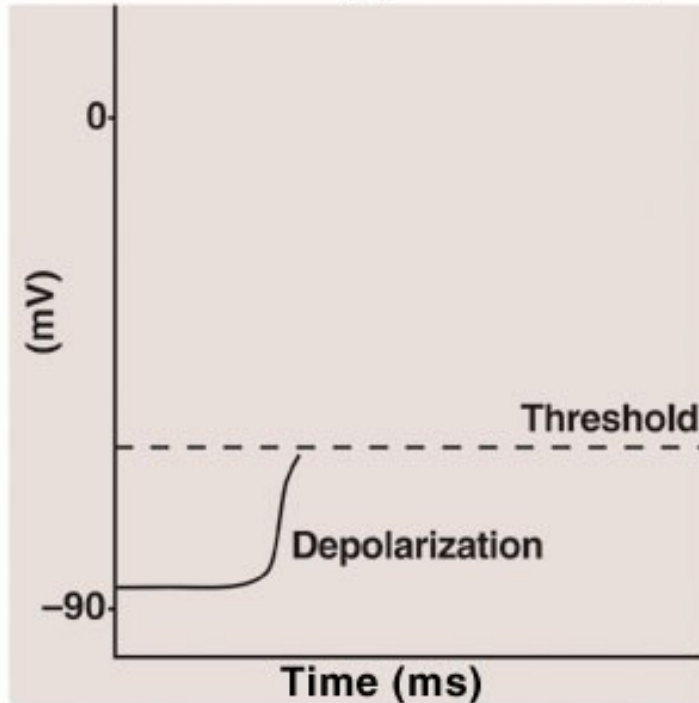
Summary of Mechanics

- 1 Muscles pull. The sarcomere shorten to around 30%
- 2 Muscle force can be graded by recruitment of motor units
- 3 Small motor units are activated first: the size principle
- 4 Muscle force can be increased by repetitive stimulation
- 5 Muscle velocity is inversely related to muscle force
- 6 Muscles fatigue: they drop force on continued use
- 7 Muscle are in certain amount of tautness even at rest
- 8 Muscle remodels to match the functions

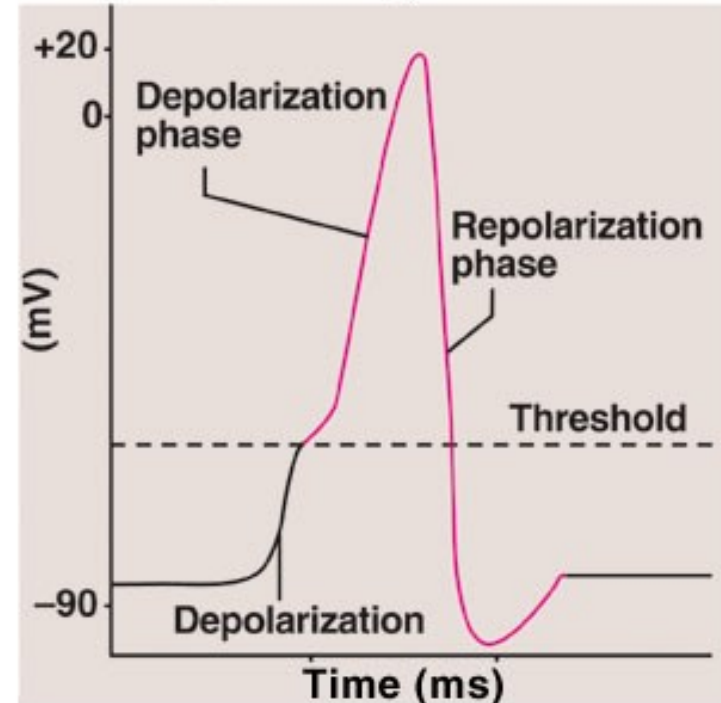


Skeletal Muscle Action Potential

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- (a) Depolarization is a change of the charge difference across the plasma membrane, making the charge inside of the cell less negative and the outside of the plasma membrane less positive.



- (b) During the depolarization phase the membrane potential changes from approximately -85 mV to approximately $+20$ mV. During the repolarization phase of the resting membrane potential, the inside of the plasma membrane changes in charge from approximately $+20$ mV to -85 mV. This is the repolarization phase of the action potential.



Questions?