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Terminology

Dr Zubia Shah

Learning Objectives

Describe a Motor unit.

Explain Summation.

Discuss Tetanization.

Describe the Staircase Effect.

Describe the Muscle fatigue.

Compare and contrast Agonists and Antagonists.

Describe coactivation of Agonist and Antagonists.

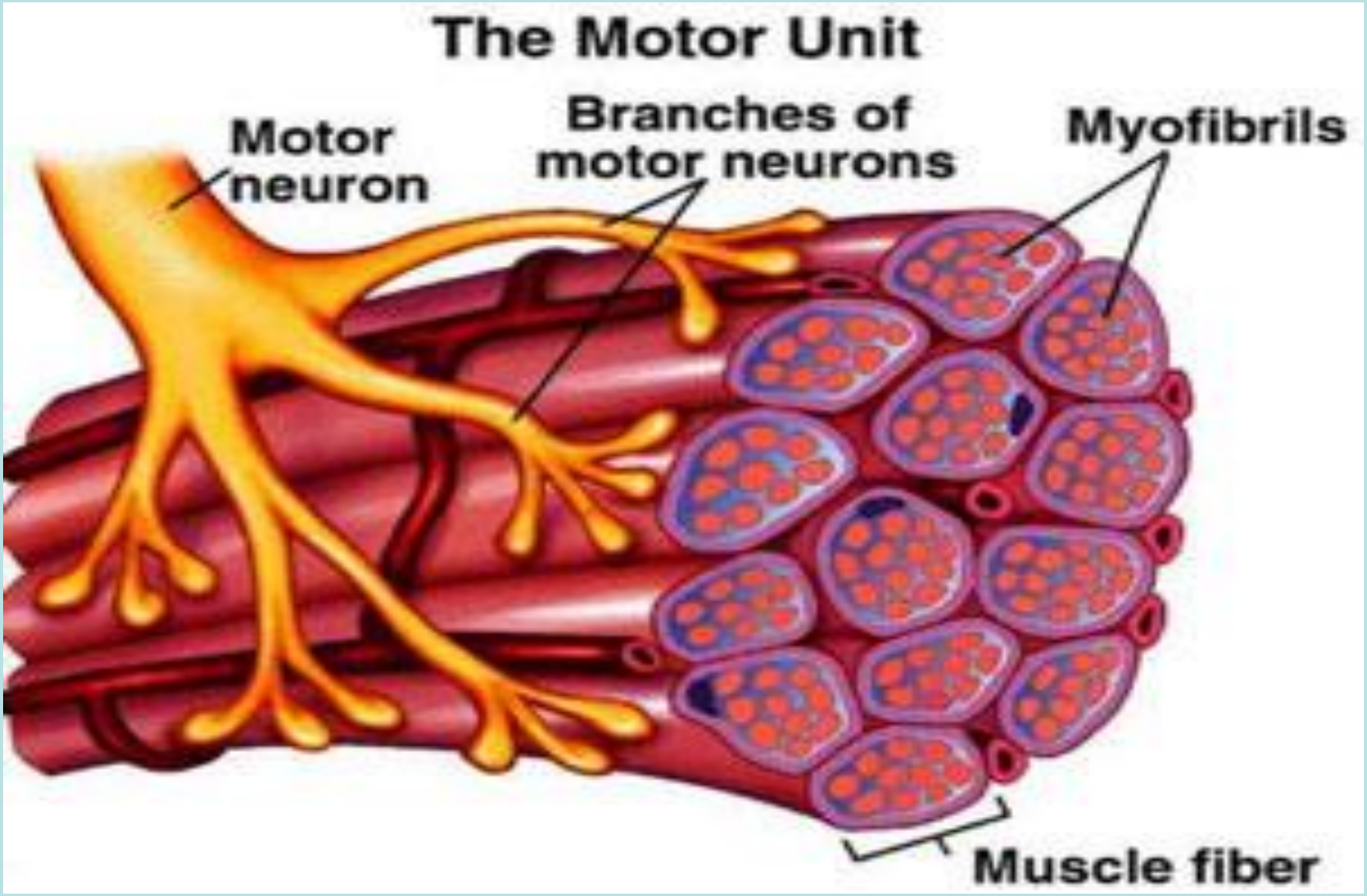
Motor units

- **A motor unit** is a single motor neuron and all muscle fibers it innervates
- Motor units are the physiological functional unit in muscle
- All cells in motor unit contract synchronously

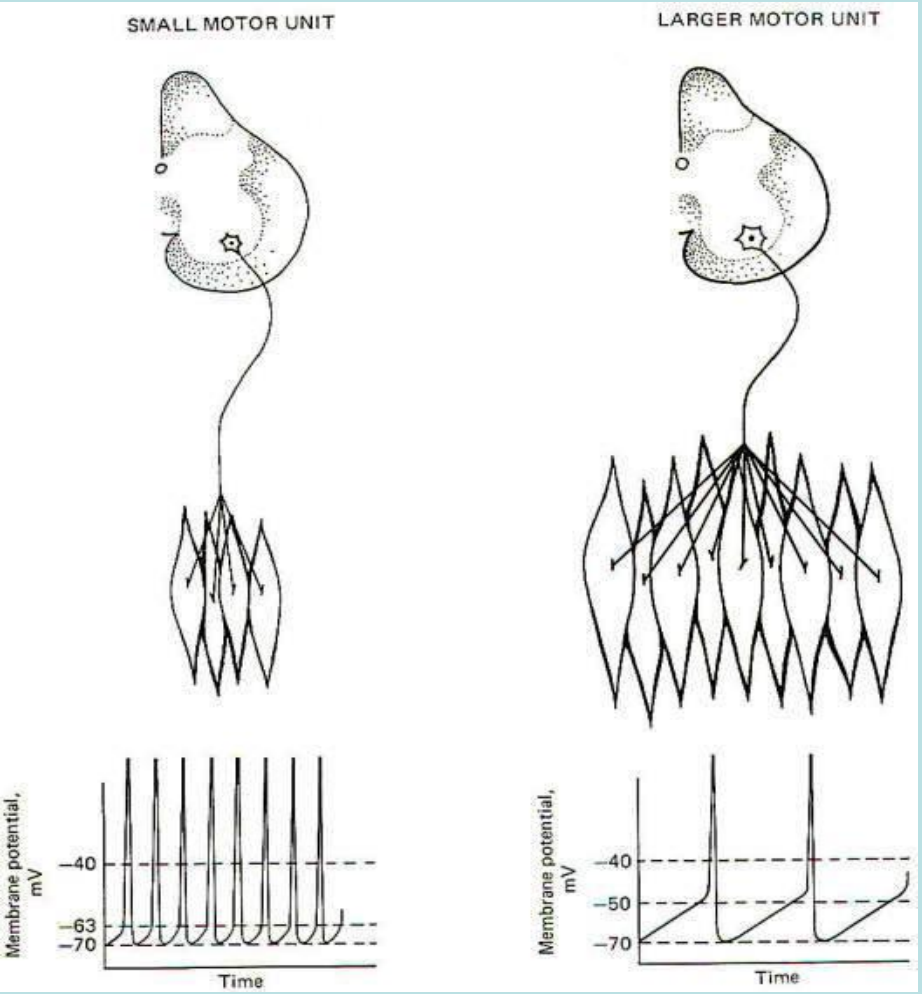
Motor unit…

- **Motor neuron pool** include motor neurons that innervate fibers within the same muscle

- **Size principle** states that recruitment of more motor units, more tension or strength is generated

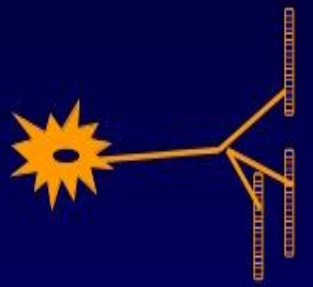

The Motor Unit
Motor neuron
Branches of motor neurons
Myofibrils
Muscle fiber

Motor Unit Innervation Ratio

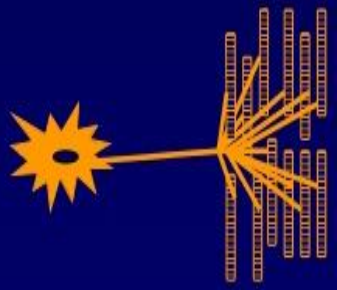


motor unit

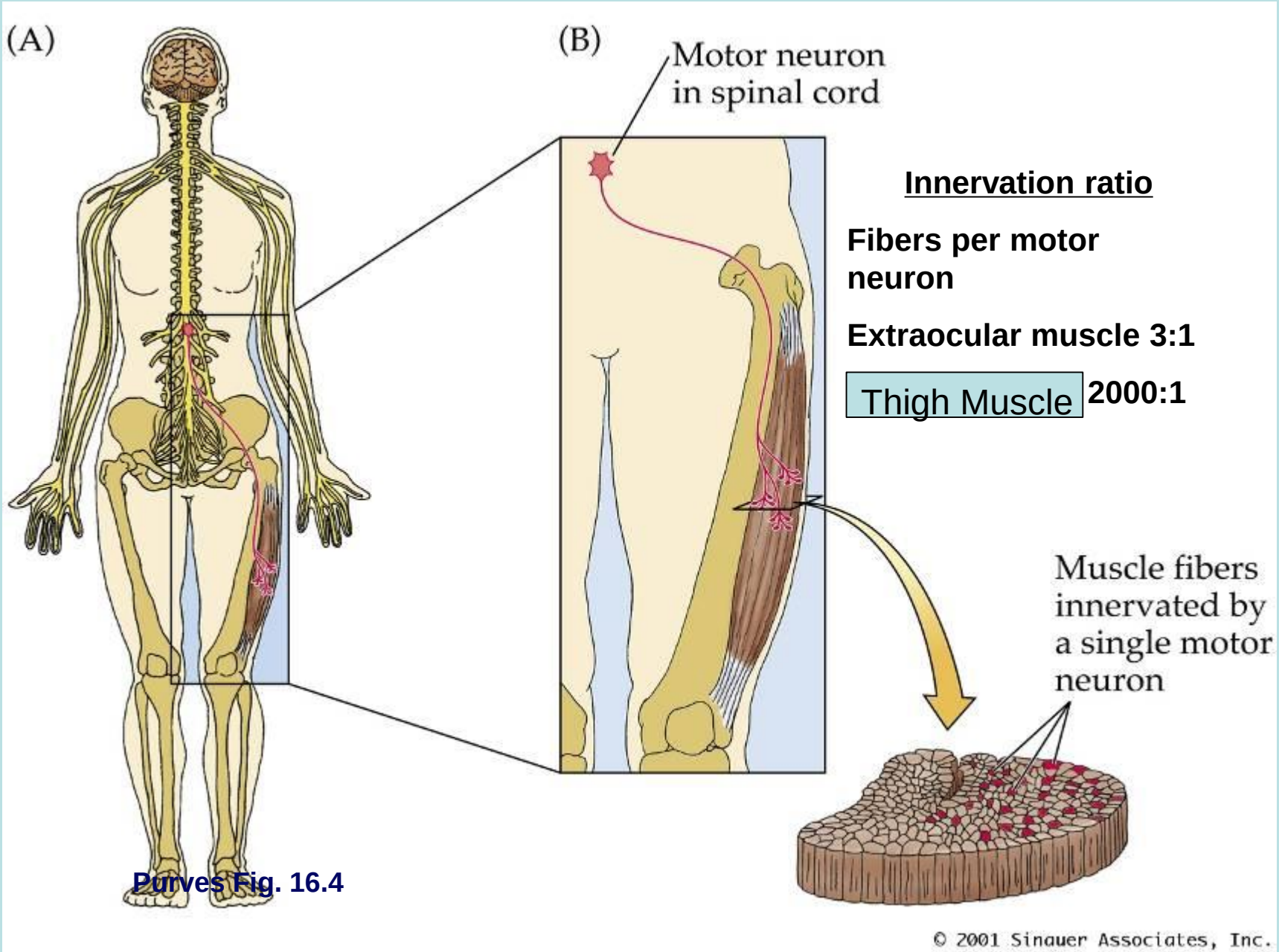
- Innervation ratio
  - motor neuron:number of muscle fibres
- in eye muscles
  - 1:23 offers a fine degree of control



- in calf muscles
  - 1:1000 more strength



Motor units and innervation ratio



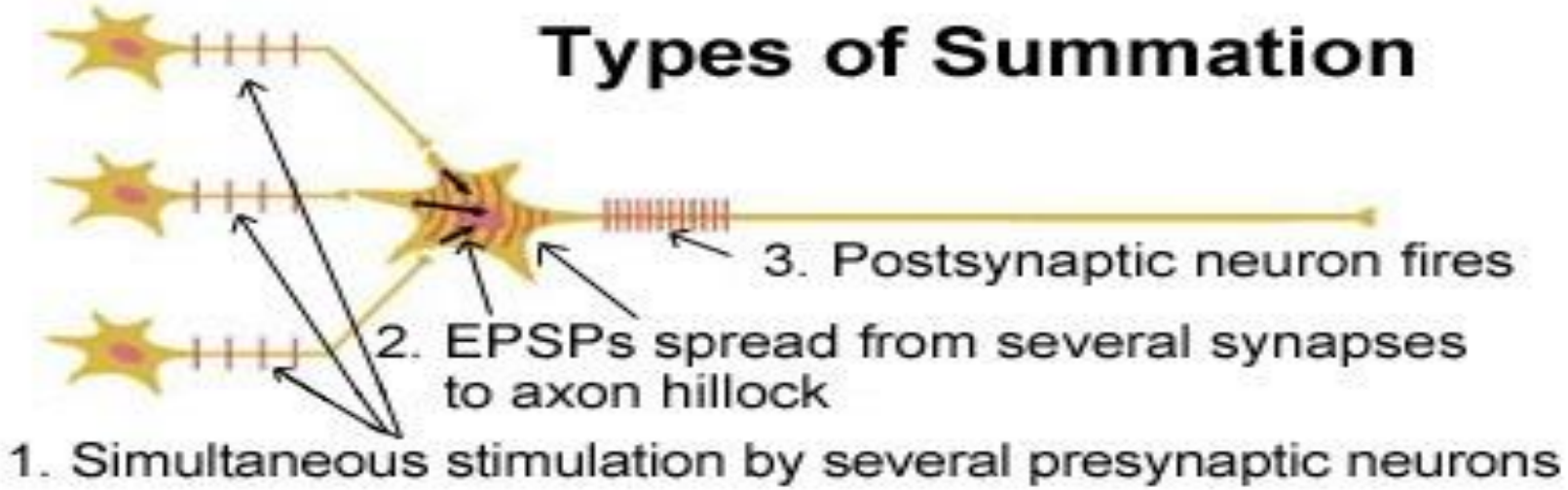
Summation

Summation

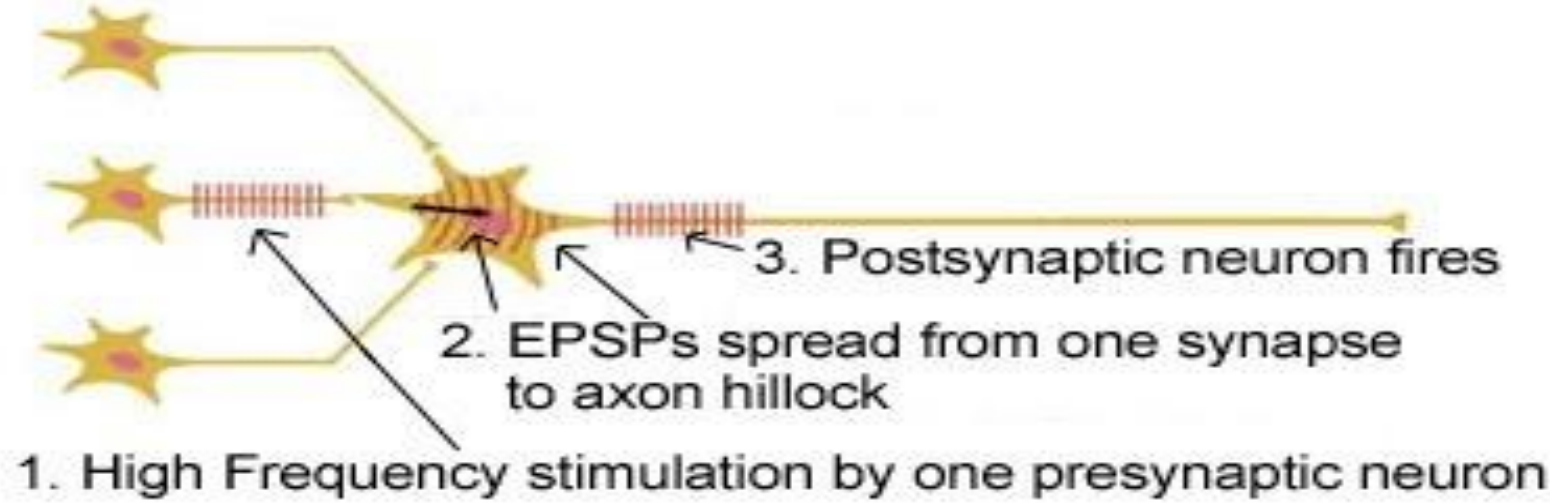
- Means adding together of individual twitch contractions to increase intensity of muscle contraction

- **multiple fiber summation** → ↑ no of motor Units contracting simultaneously
- **Frequency summation** → ↑ frequency of contraction

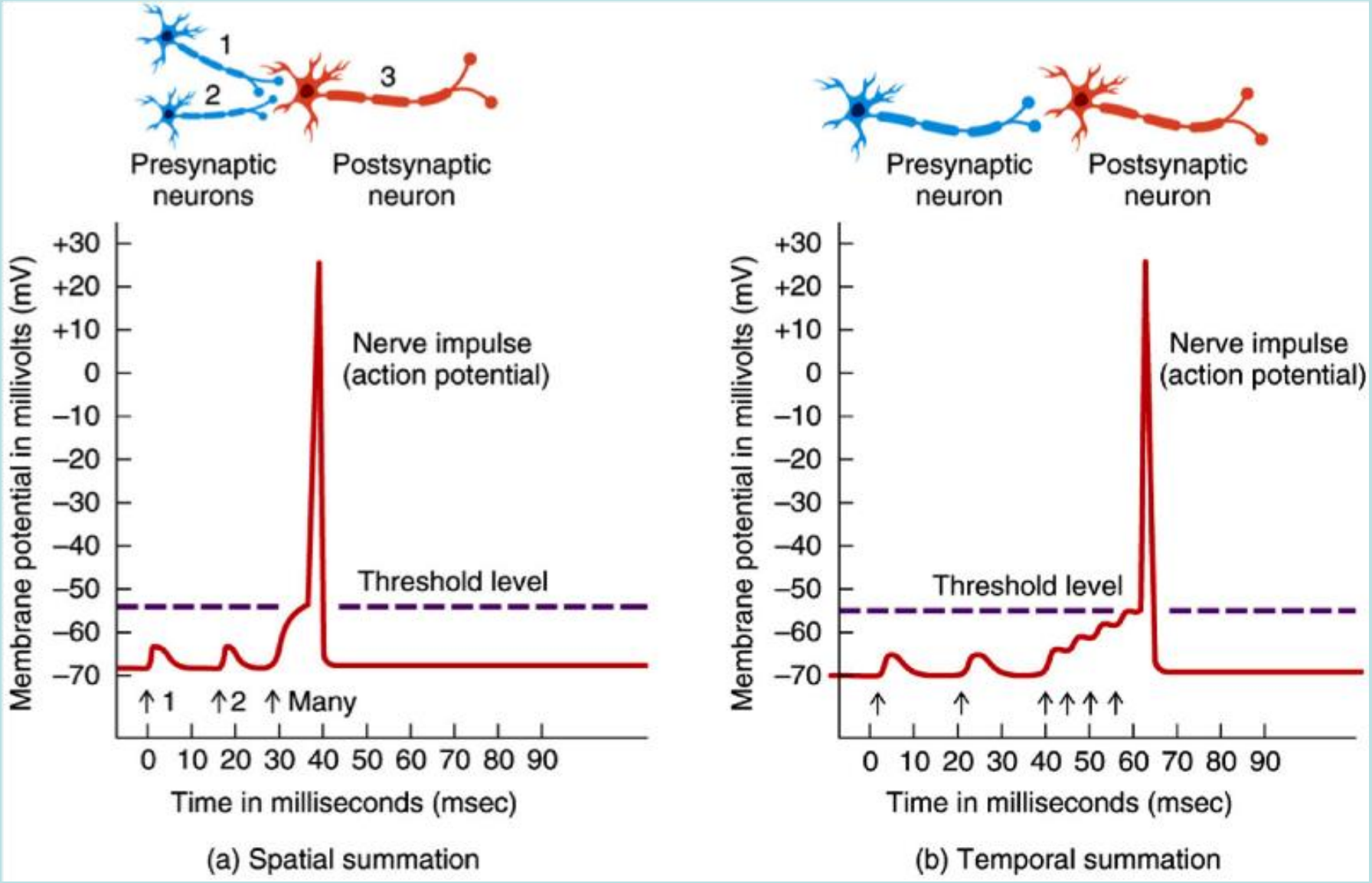
Types of Summation



Spatial summation



Temporal summation


1
2
3
Presynaptic neurons
Postsynaptic neuron
Membrane potential in millivolts (mV)
+30
+20
+10
0
−10
−20
−30
−40
−50
−60
−70
Nerve impulse (action potential)
Threshold level
↑1
↑2
↑ Many
0 10 20 30 40 50 60 70 80 90
Time in milliseconds (msec)
(a) Spatial summation
Presynaptic neuron
Postsynaptic neuron
Membrane potential in millivolts (mV)
Nerve impulse (action potential)
Threshold level
0 10 20 30 40 50 60 70 80 90
Time in milliseconds (msec)
(b) Temporal summation

Treppe Effect

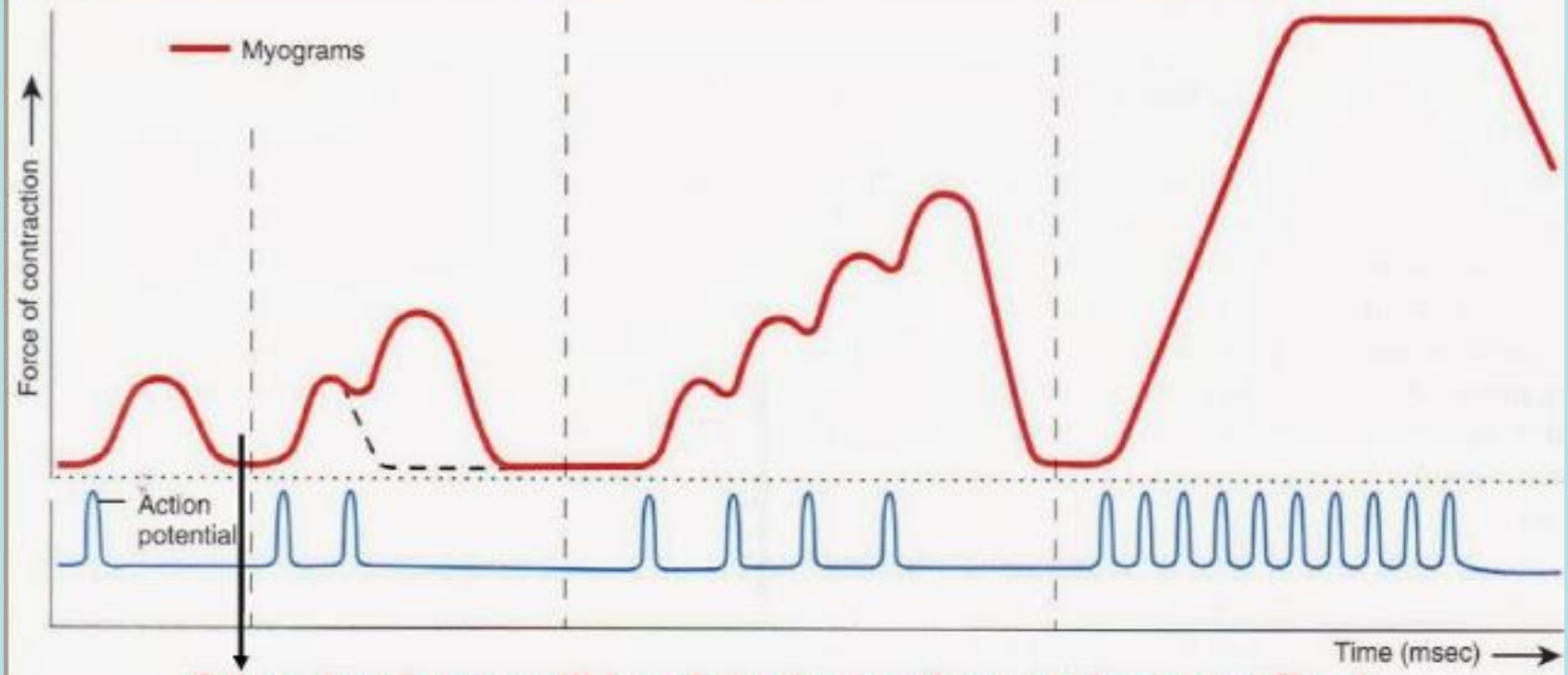
Treppe Effect

- series of increasingly vigorous contractions resulting when a corresponding series of identical stimuli is applied to a **Rested muscle**

- Exact Mechanism is not known but is believed to be because of calcium ions released with each contraction

    - also called **Staircase Effect** or staircase phenomenon (Warm Up)

Frequency summation



Stimulus here will lead to 'treppe' or staircase effect (individual twitch contractions but every subsequent contraction will have higher amplitude)

Treppe: The Staircase Effect

- Staircase – increased contraction in response to multiple stimuli of the same strength
- Contractions increase because:
  - There is increasing availability of Ca^{2+} in the sarcoplasm
  - Muscle enzyme systems become more efficient because heat is increased as muscle contracts

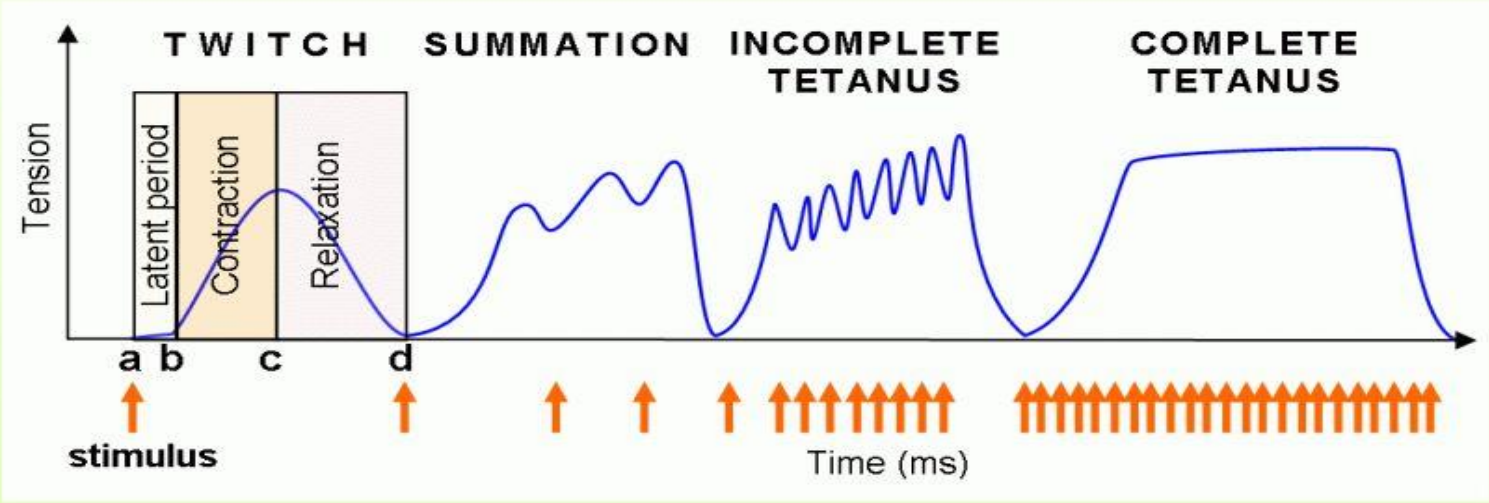
PLAY *InterActive Physiology*®: Muscular System: Contraction of Whole Muscle

Tetanization

Physiological Tetanus

a state of **sustained muscular contraction** without periods of relaxation caused by repetitive stimulation of the motor nerve trunk at frequencies so high that individual muscle twitches are fused and cannot be distinguished from one another

Tetanization



Tetanization

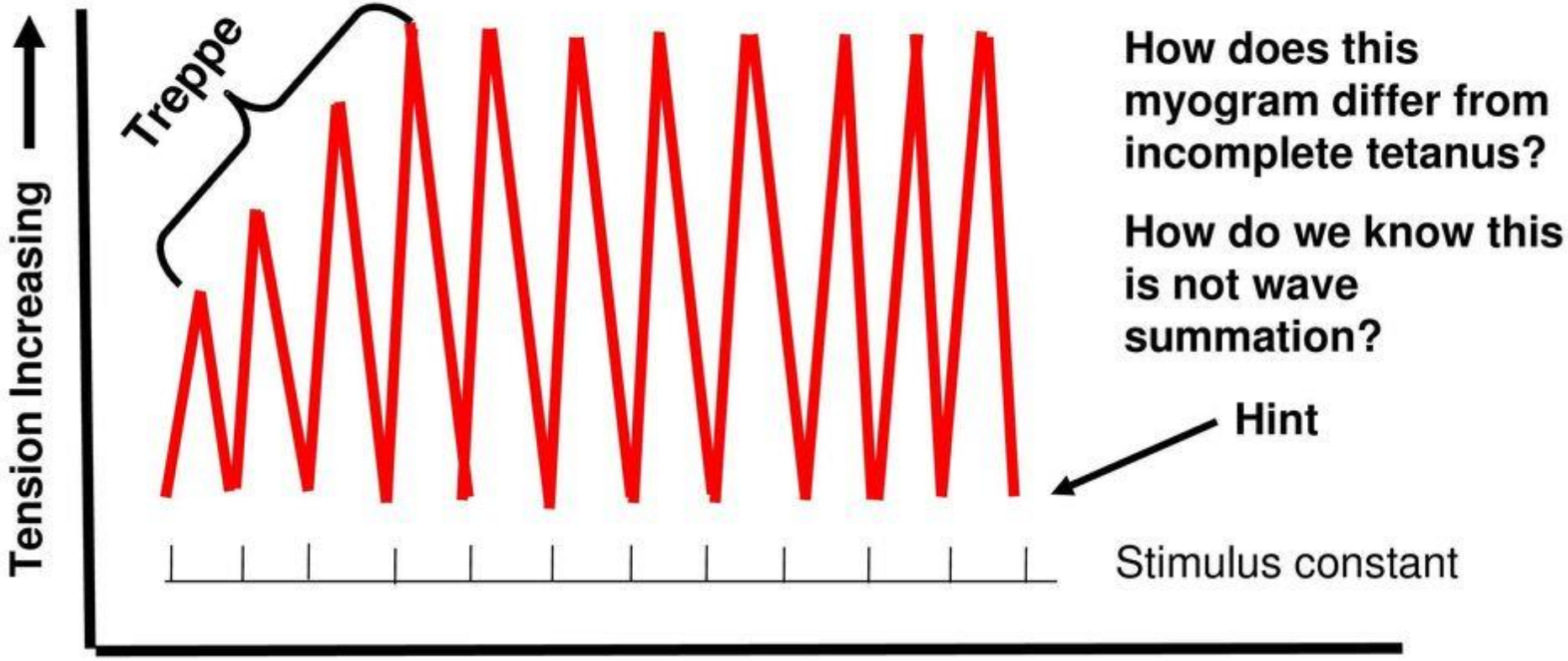
- prolonged contraction without relaxation and results from repeating stimulation before the muscle has a chance to relax at all

Treppe Effect

- addition of a second twitch/contraction resulting in greater tension
- and it results from stimulating the muscle before it has a chance to relax

Types of Skeletal Muscle (cont.)

- Treppe – increased strength of contraction as muscle "warms up" due to identical stimuli too far apart for wave summation to occur.
- It is also known as the 'staircase effect', as the muscle steps up its strength with each contraction.



Muscle Fatigue

Muscle Fatigue

- A decrease in muscle activity due to repeated stimuli

- After repeated muscle stimulation, there is no more any response from muscle

Causes of Muscle Fatigue

- Exhaustion of acetyl choline
- Accumulation of lactic acid
- Lack of nutrients mainly glycogen
- Lack of oxygen

Interruption of blood flow through a contracting muscle can lead to fatigue within 1-2 min

Agonist and Antagonist

Agonist versus Antagonists

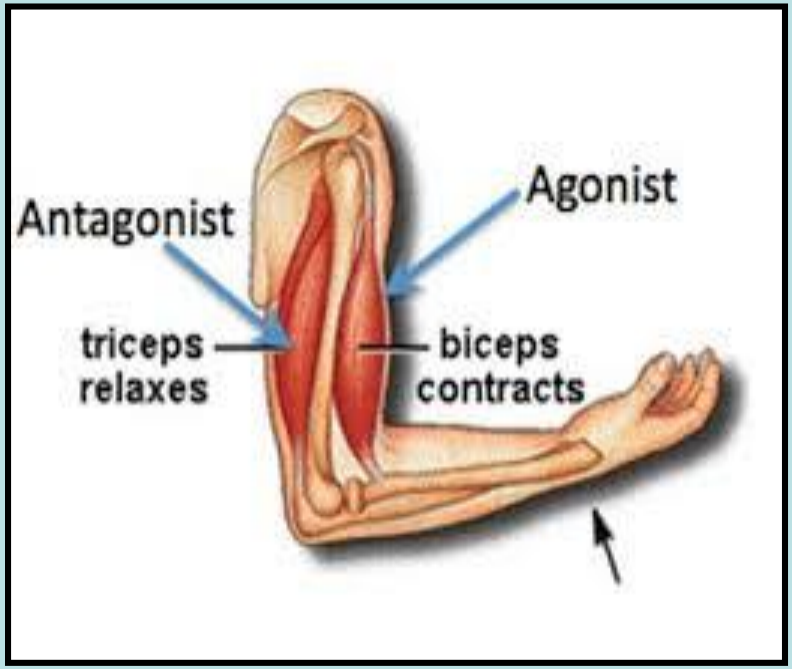
a **muscle** that contracts while another relaxes

when bending the elbow, the biceps are the **agonist**

a **muscle** that opposes the action of another

the biceps and triceps are antagonistic **muscles**

Agonist versus Antagonists



Muscle Coactivation

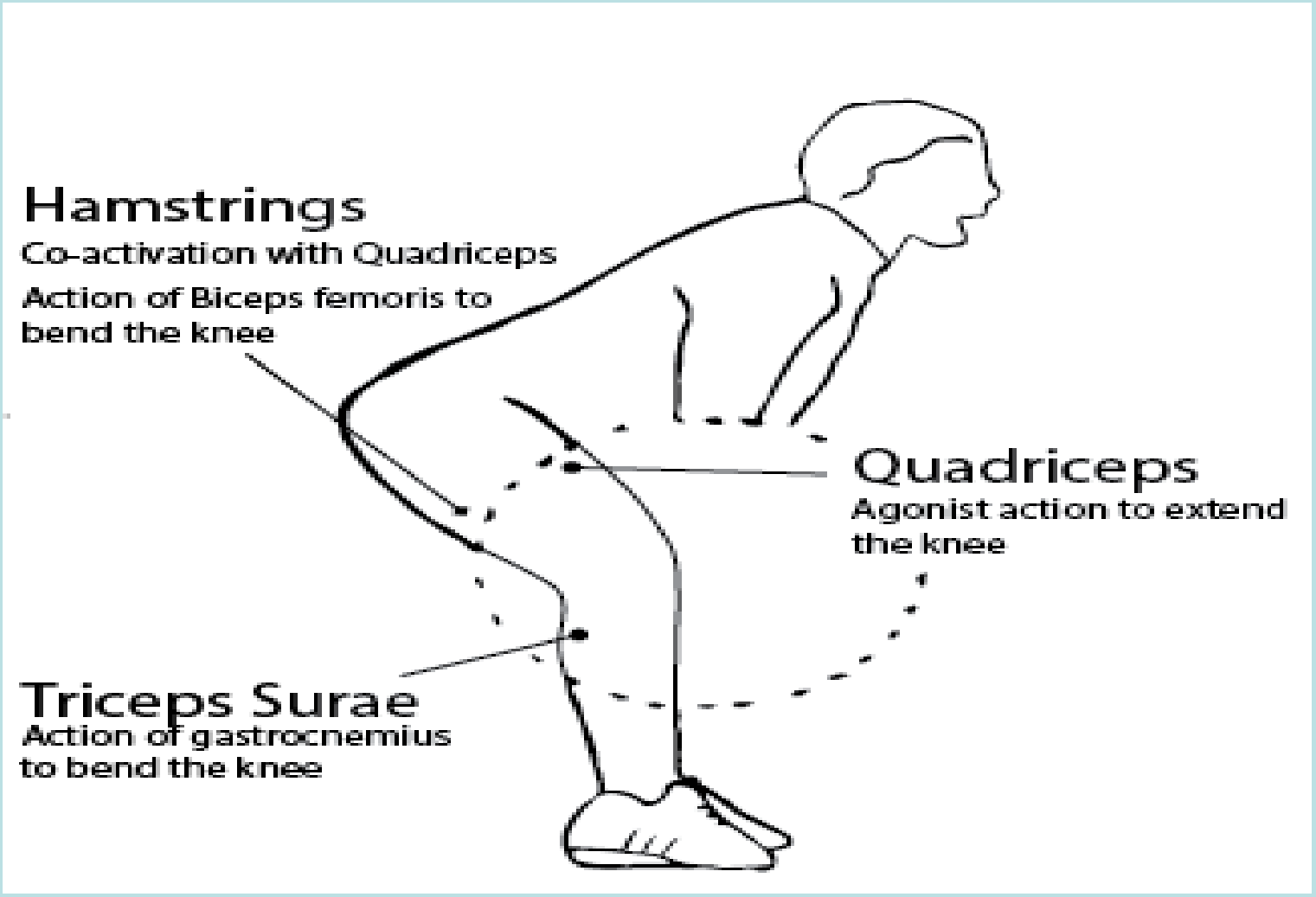
Muscle Coactivation

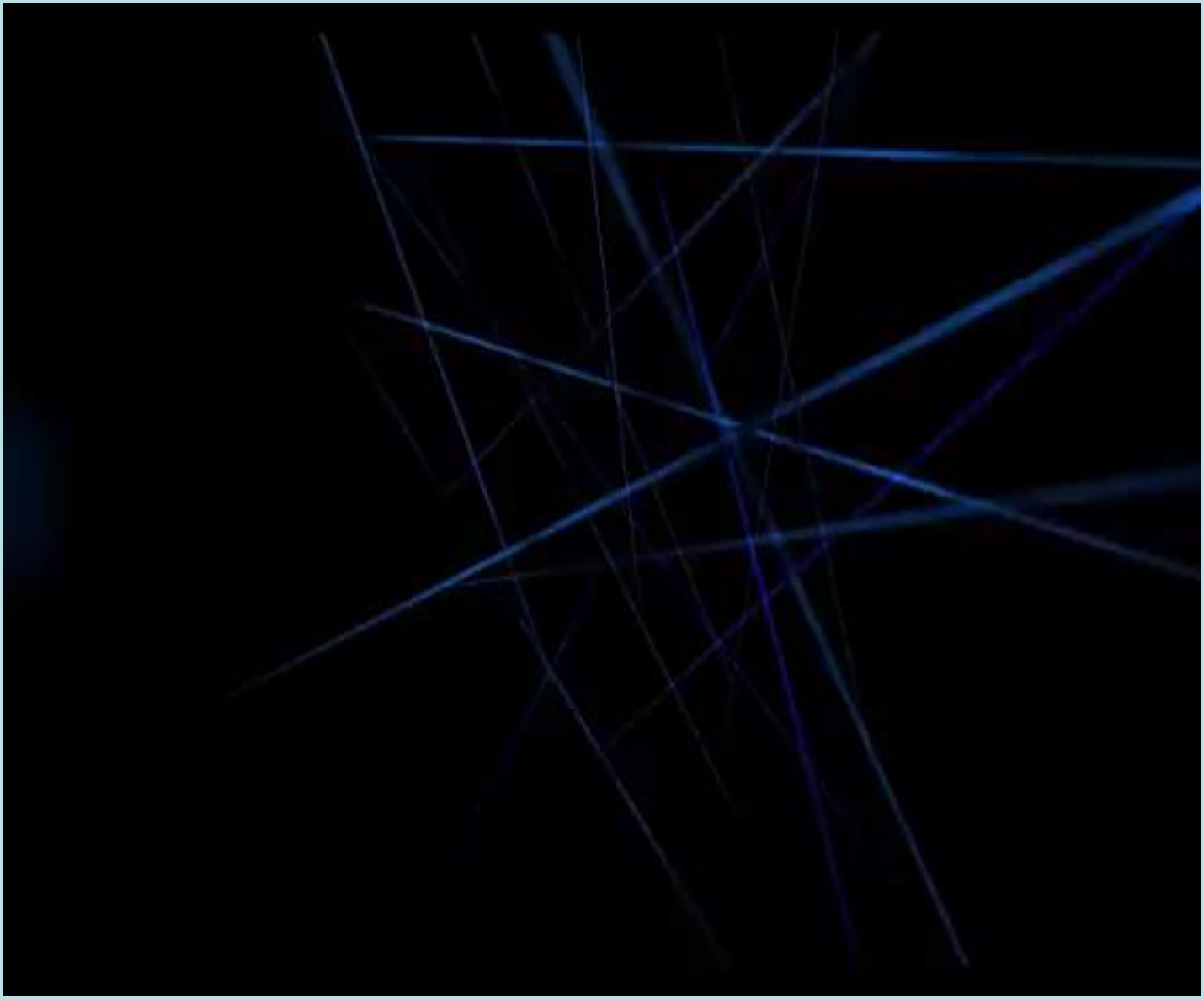
- when **Agonist** and **Antagonist** muscles surrounding a joint **contract simultaneously** to provide joint stability

- the bicep and triceps coactivate

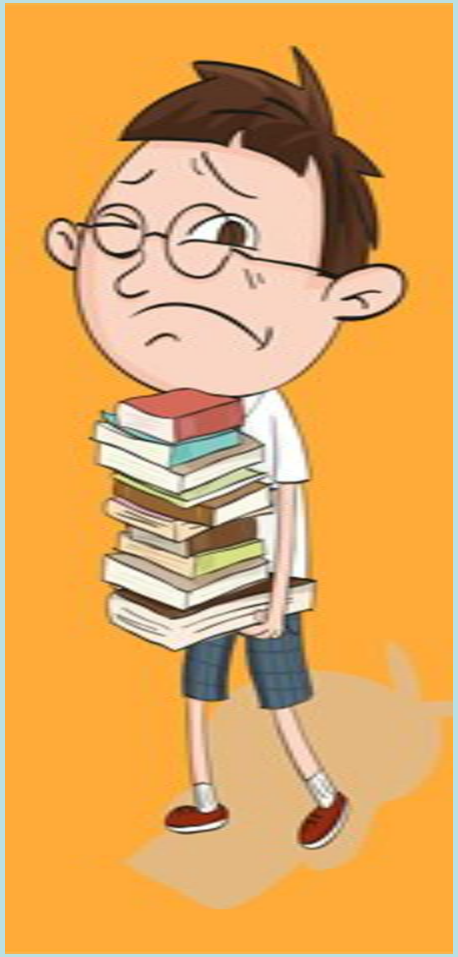
- The elbow joint becomes more stable and stiffer

Muscle Coactivation





References



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Any Questions ?
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Thank you