MECHANICS OF SKELETAL MUSCLE CONTRACTION

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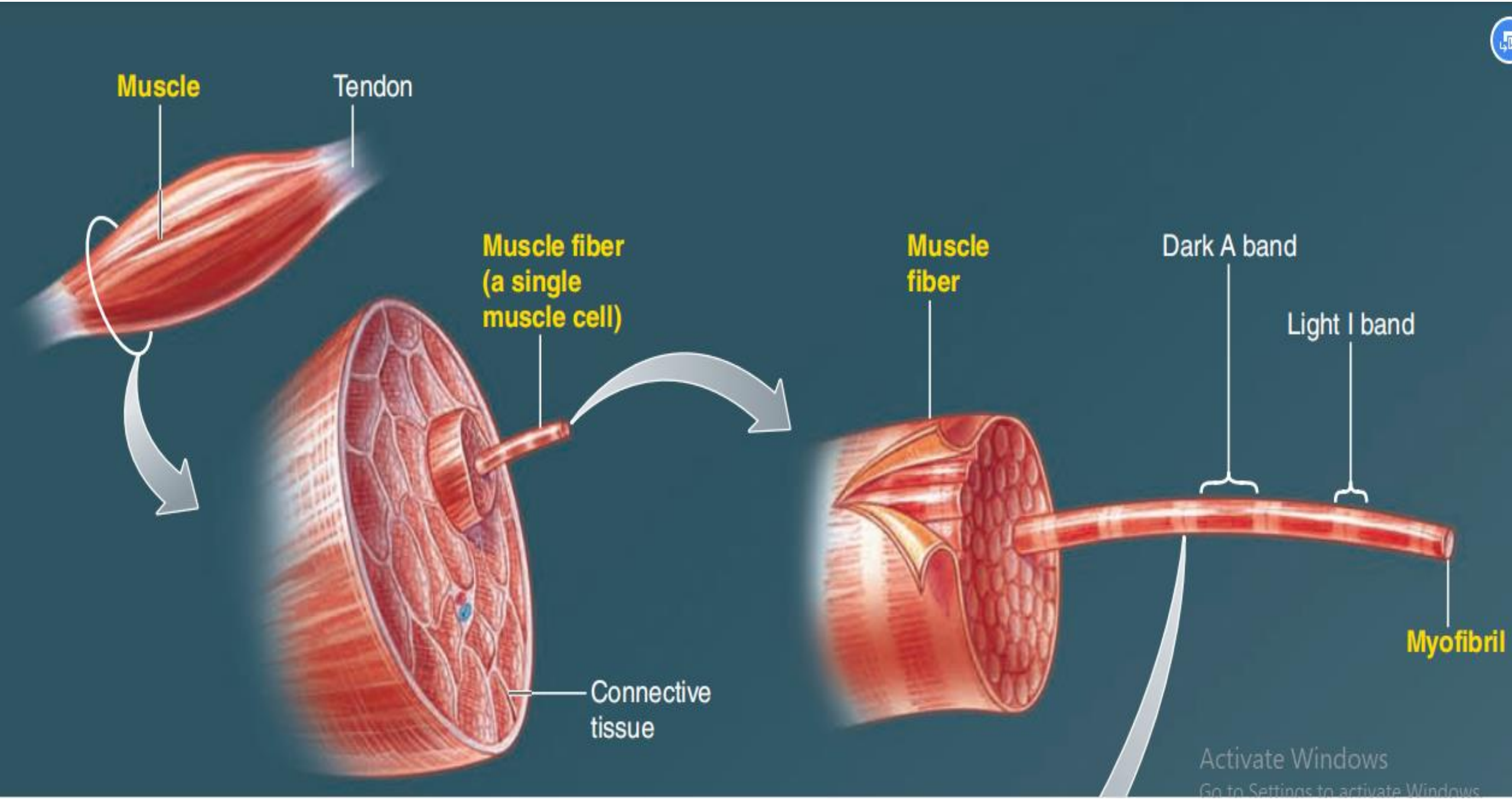
Contents

Introduction

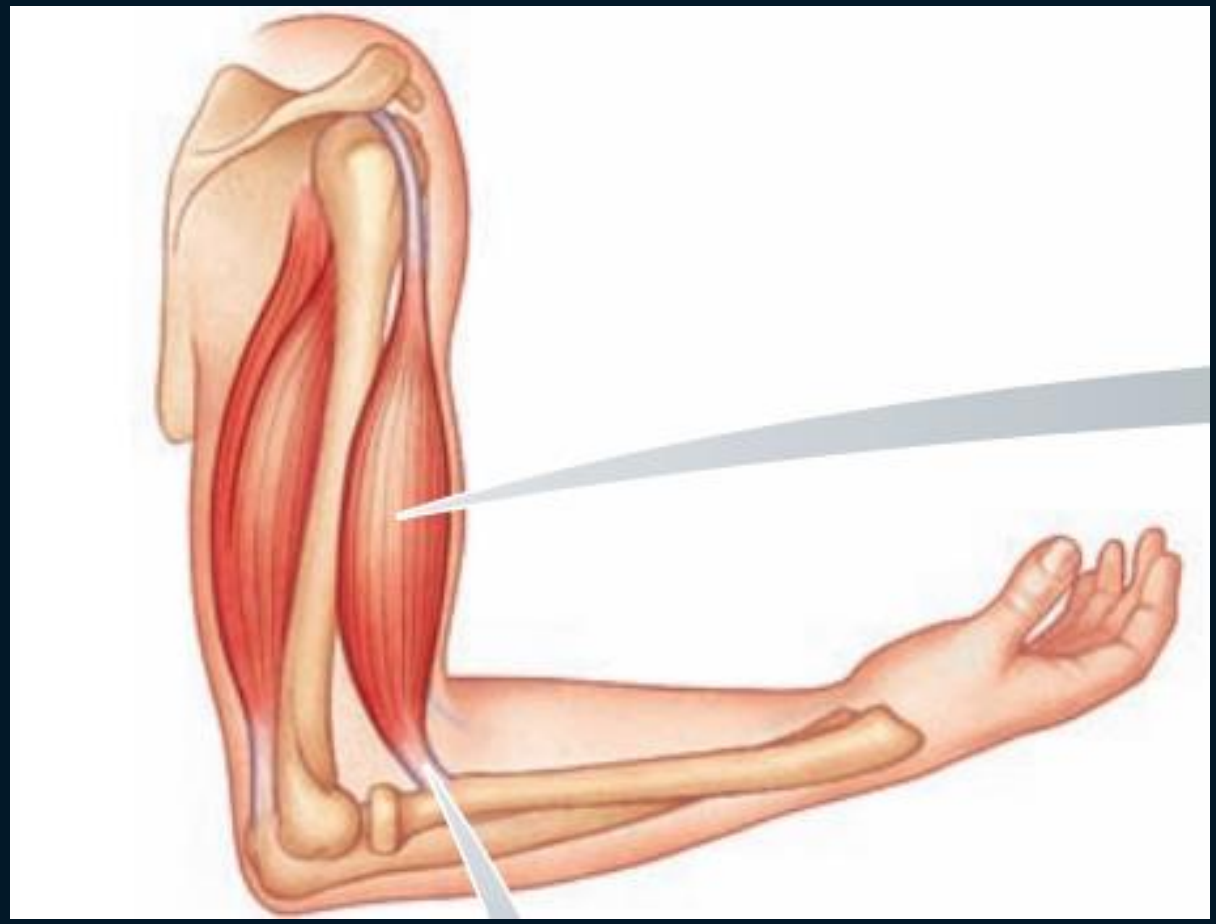
Introduction

- **Whole muscles** are groups of muscle fibers bundled together and attached to bones.
- 600 skeletal muscles in the body range in size.
- Each muscle is **sheathed by connective tissue** that penetrates from the surface into the muscle to envelop each individual fiber and divide the muscle into bundles.



Introduction

- The connective tissue extends beyond the ends of the muscle to form **tough, collagenous tendons** that attach the muscle to bones.



Introduction

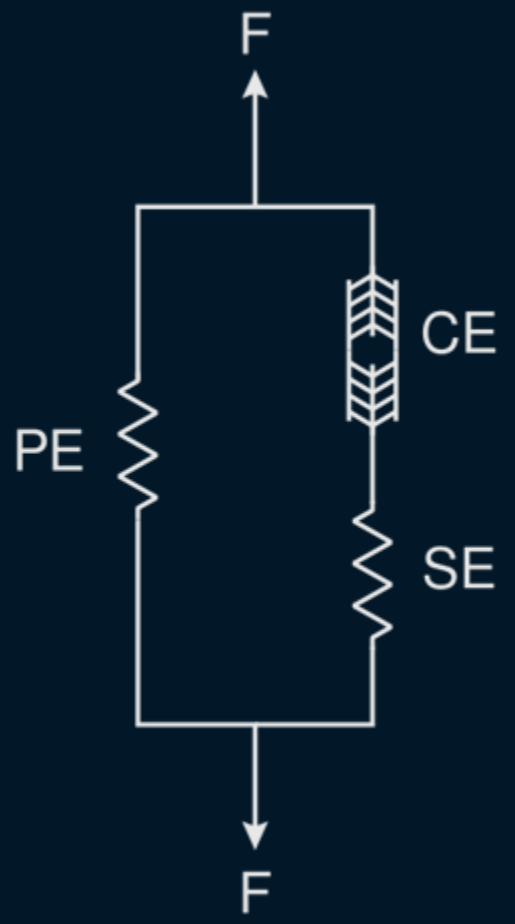
- **Tension** is produced **internally within the sarcomeres** (considered the **contractile component** of the muscle).

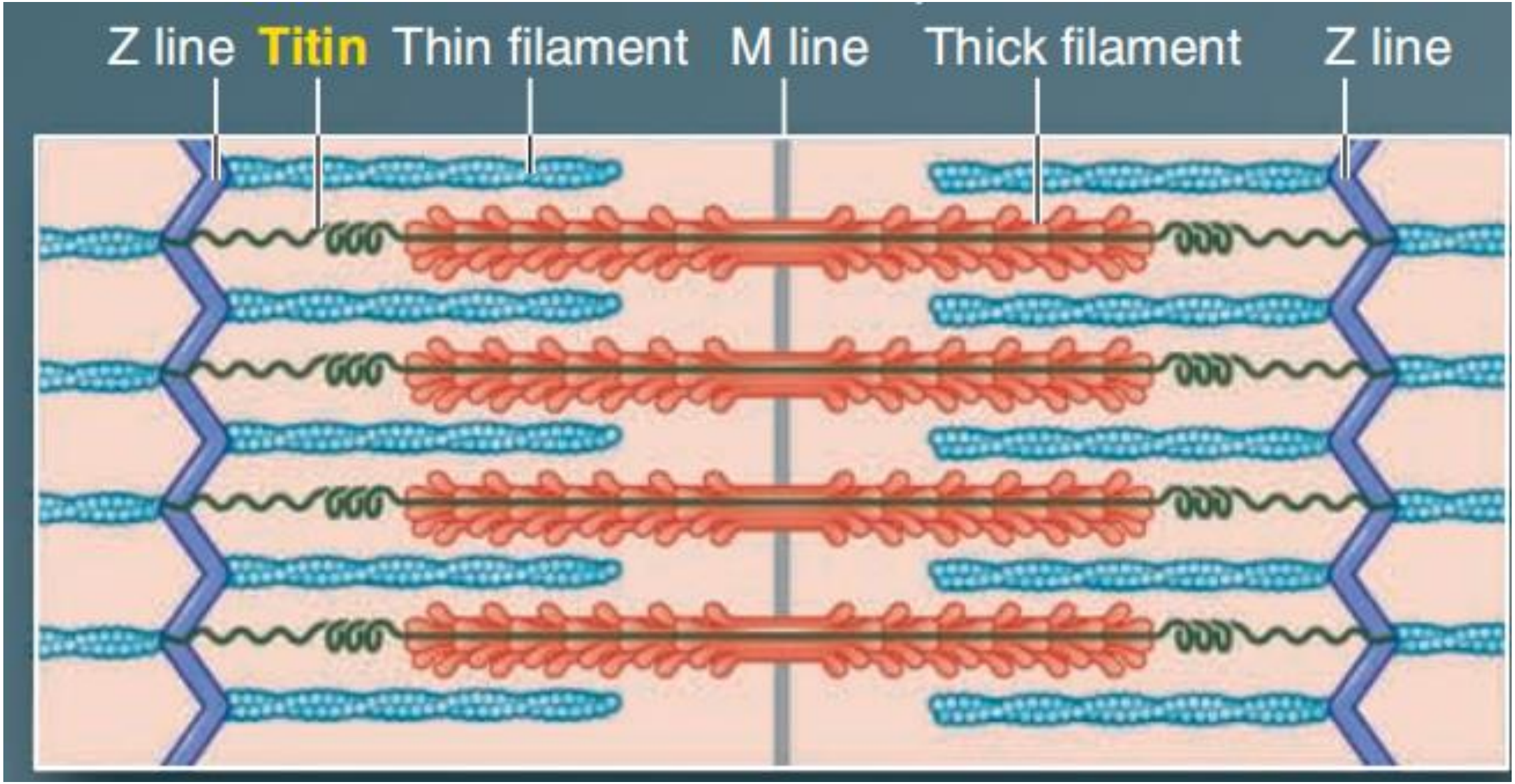
- The tension generated by these contractile elements **must be transmitted to the bone via a tendon** before the bone can be moved.

Introduction

- Two types of noncontractile components:

1. Parallel-elastic component
2. Series-elastic component

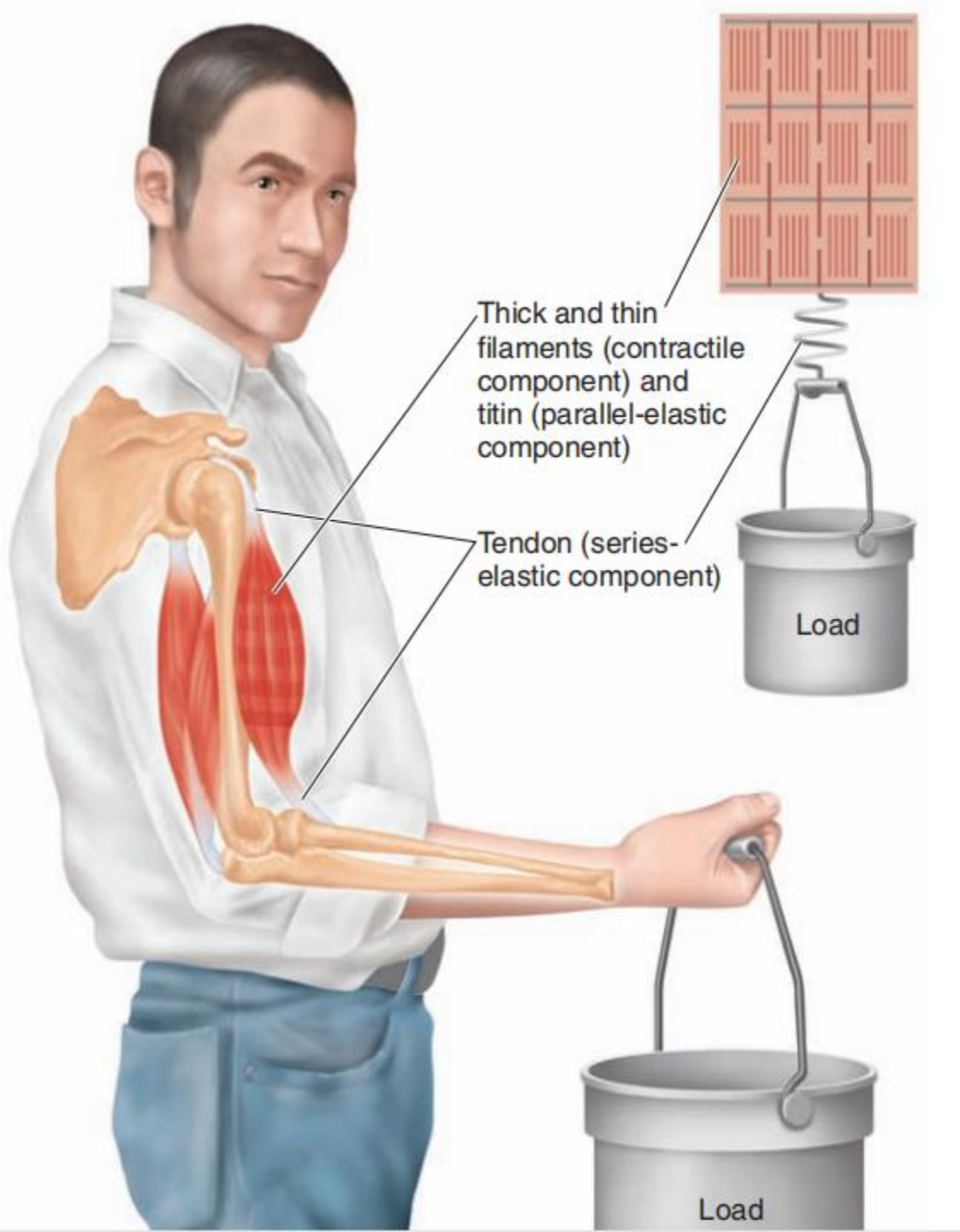



Z line
Titin
Thin filament
M line
Thick filament
Z line

Introduction

- The series-elastic component behaves like a stiff spring placed between the contractile elements and the bone that is to be moved against an external load, or opposing force.

- Muscle tension is transmitted to the bone by this tightening of the series-elastic component.



Types of contraction

Types of contraction

- There are two types of skeletal muscle contraction:

1. Isometric contraction.
2. Isotonic contraction.

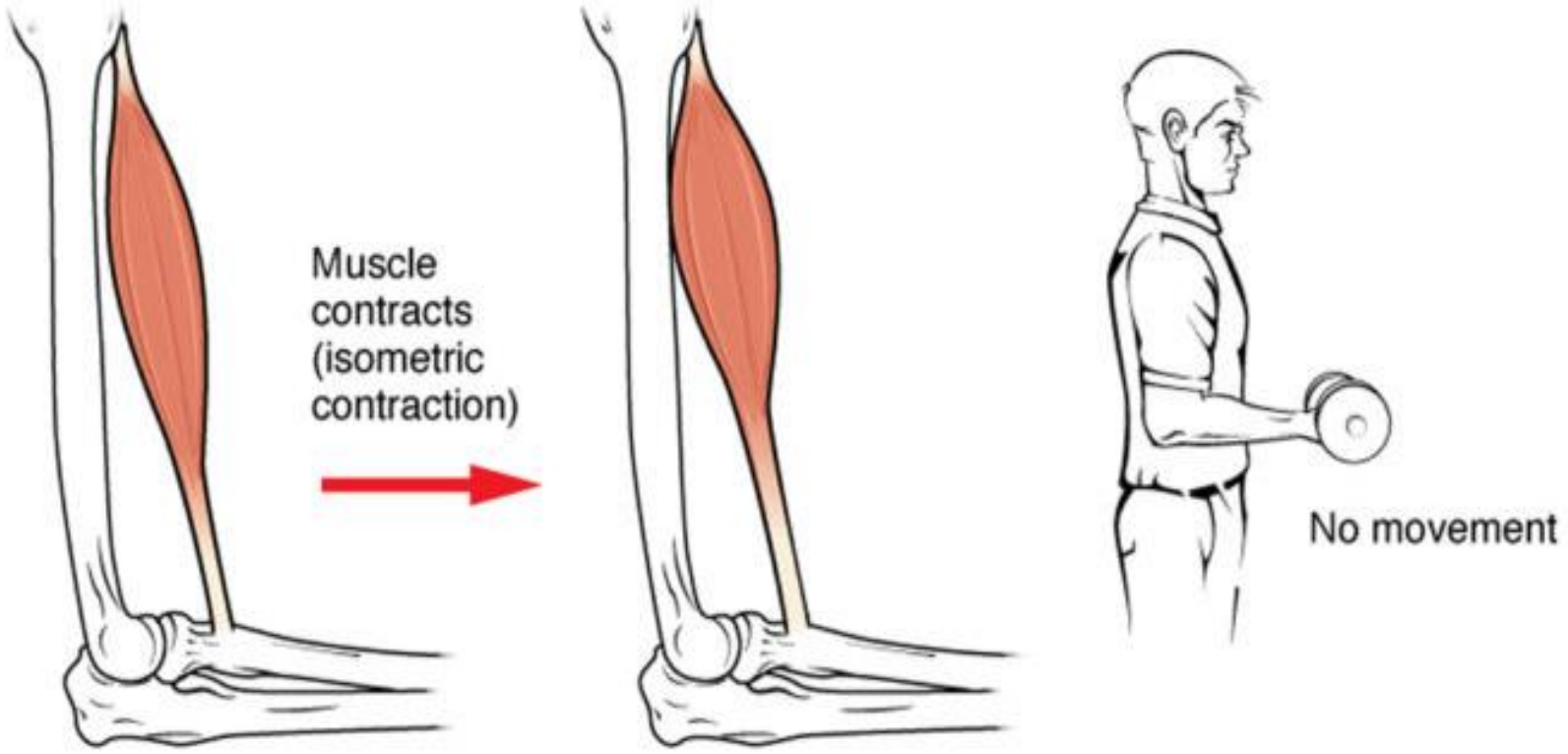
- Normal muscle activity is a combination of isometric and isotonic contractions.

1- ISOMETRIC CONTRACTION

- Involves the development of tension without any change in length (constant length).
- The muscle contracts without shortening but the tension is much increased.

- Mechanism: When the sarcomeres shorten, they pull on the elastic elements, stretching them; however, because the external load is too heavy or fixed, the overall muscle length stays constant while internal tension increases.

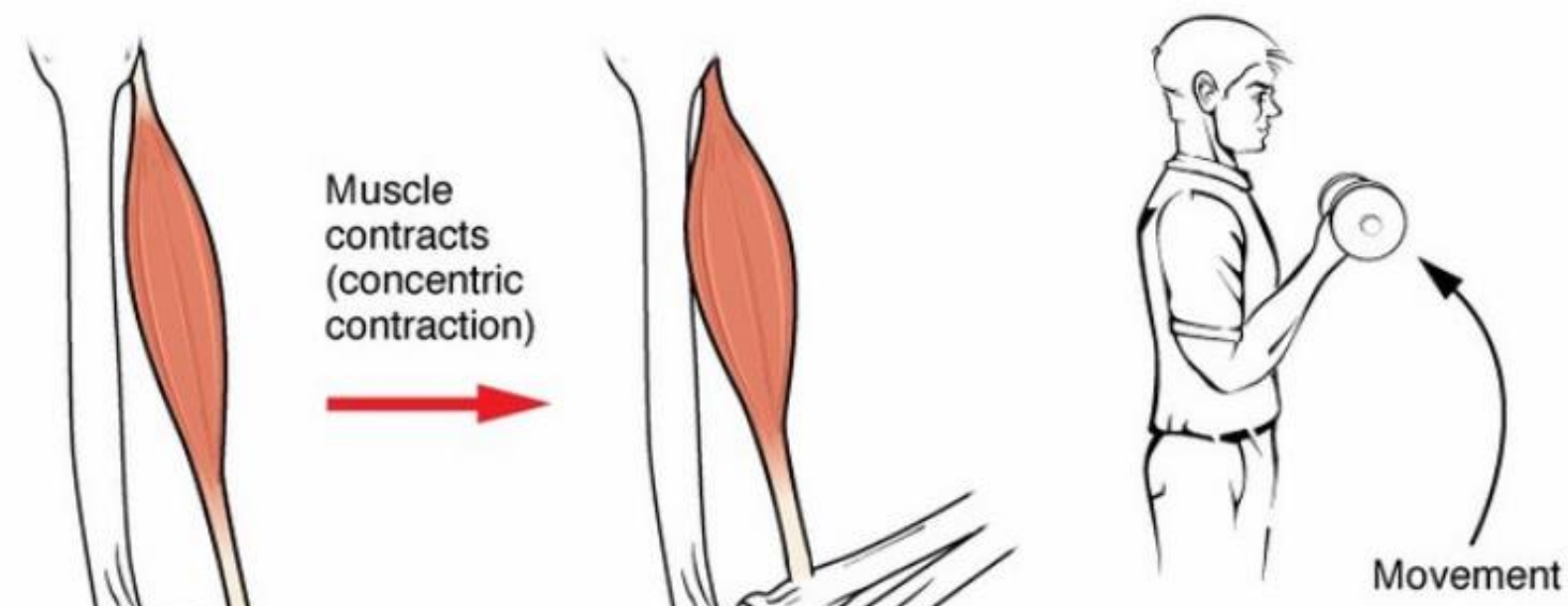
1- ISOMETRIC CONTRACTION



2- ISOTONIC CONTRACTION

- Involves the change in length without any change in tension (constant tension).
- The muscle shortens and carries a weight (i.e. mechanical work is done) without change in tension.

2- ISOTONIC CONTRACTION



	Isotonic Contraction	Isometric Contraction
Length of muscle	Decreases (muscle shortens)	Constant length
Tension	Constant	Greatly increased
Work	External work is performed	No external work is done
Mechanical efficiency	20–25% (rest of energy released as heat)	Zero (energy is consumed but no work produced)
Example	Carrying a weight against gravity	Carrying a weight that is too heavy to lift

Load–Velocity Relationship

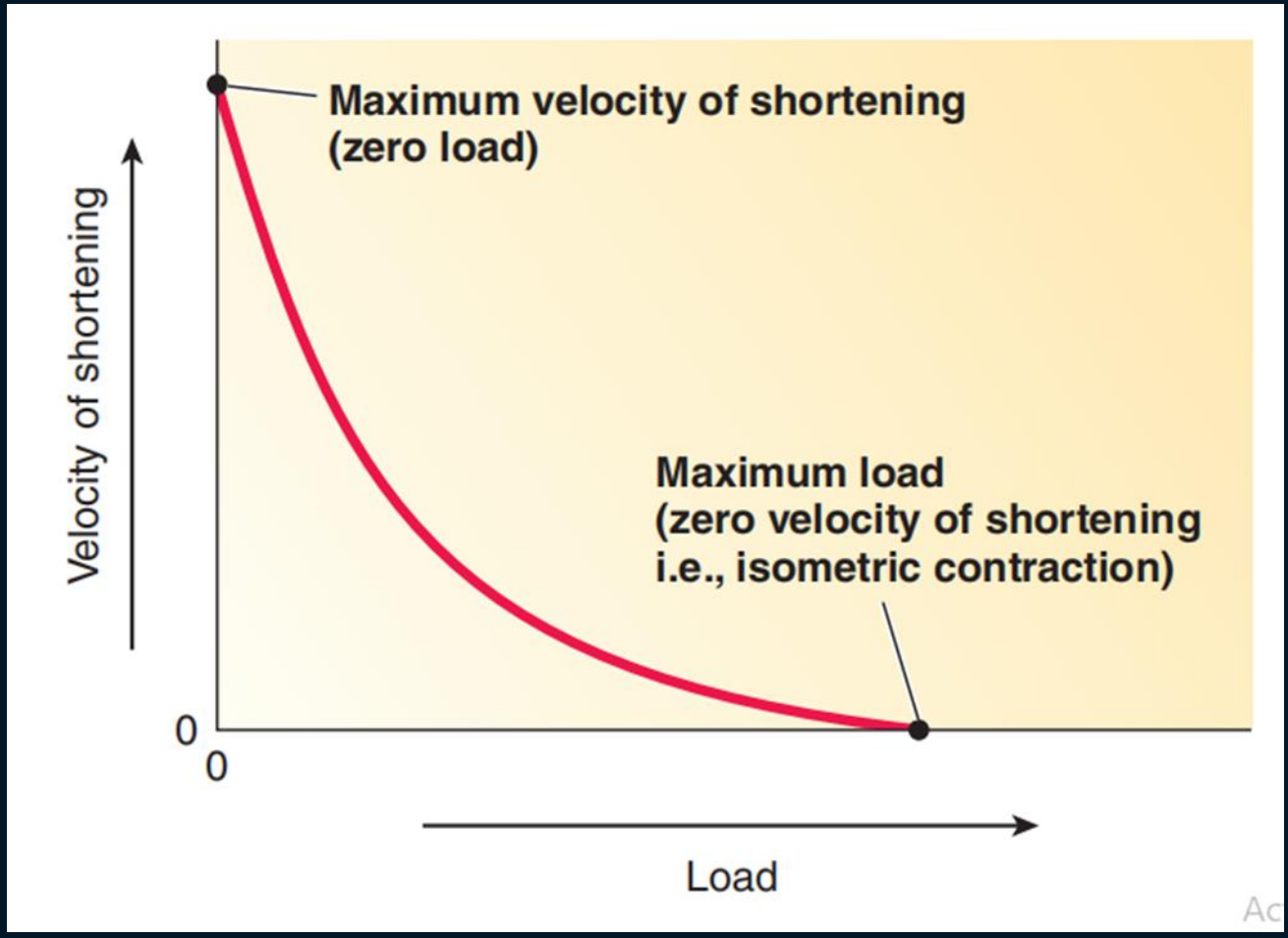
Load–Velocity Relationship

- The load is also an important determinant of the velocity with which a muscle changes length.

- The greater the load, the lower the velocity at which a single muscle fiber shortens.

Load–Velocity Relation

- The speed of shortening is :
- maximal when there is no external load,
- progressively decreases with an increasing load,
- and falls to zero (no shortening—isometric contraction) when the load cannot be overcome by maximal tension.



Types of Skeletal Muscle Fibers

Types of Skeletal Muscle Fibers

- There are three major types of muscle fibers:

- 1. Slow-oxidative (type I) fibers
- 2. Fast-oxidative (type IIa) fibers
- 3. Fast-glycolytic (type IIx) fibers

Characteristic	Slow-Oxidative (Type I) Fiber	Fast-Oxidative (Type IIa) Fiber	Fast-Glycolytic (Type IIx) Fiber
Myosin–ATPase activity	Low	High	High
Speed of contraction	Slow	Fast	Fast
Resistance to fatigue	High	Intermediate	Low
Oxidative phosphorylation capacity	High	High	Low
Enzymes for anaerobic glycolysis	Low	Intermediate	High
Mitochondria	Many	Many	Few
Capillaries	Many	Many	Few
Myoglobin content	High	High	Low
Color of fiber	Red	Red	White
Glycogen content	Low	Intermediate	High

Thank you