

Muscle Tissue

TOPIC 9



Functions of Muscular Tissue

Produces movement for the body

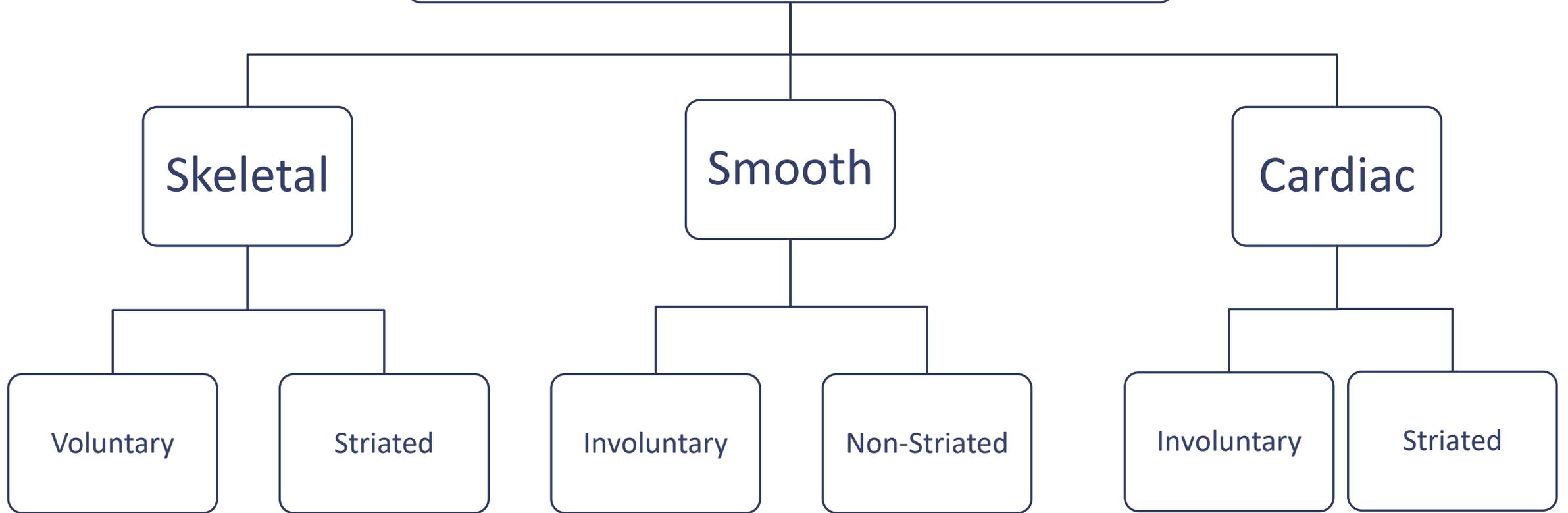
Stabilizing body positions

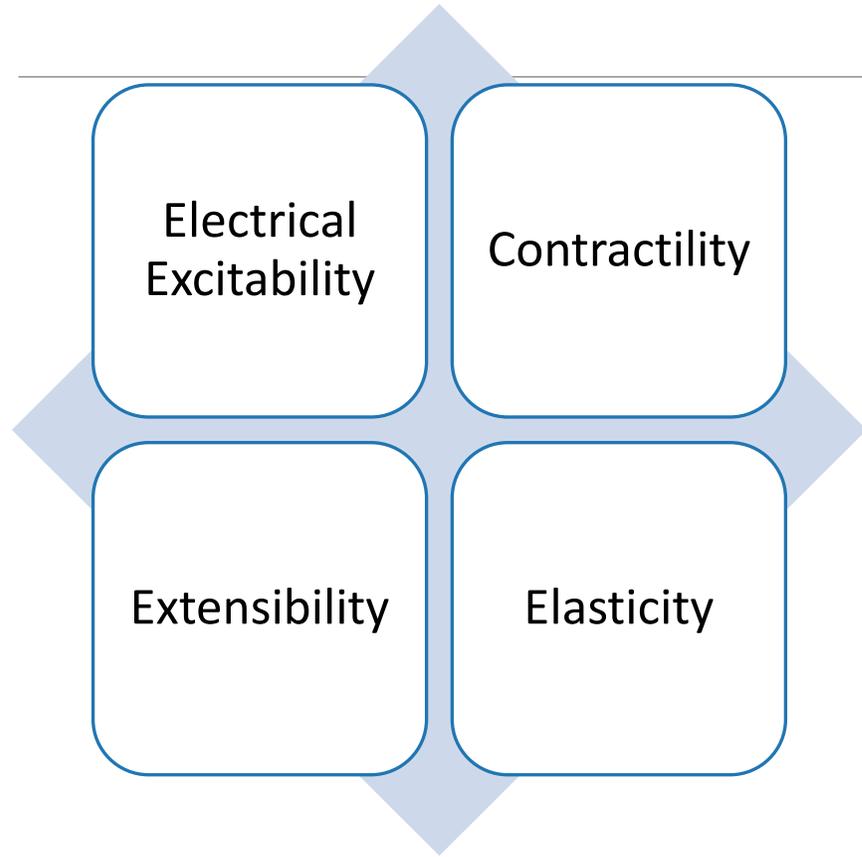
Heat production

Respiration

Moves substances through the body

Types of Muscle Tissue





Special Properties of Muscular Tissue

Muscle Tissue Terminology

Epimysium

Perimysium

Endomysium

Fascia

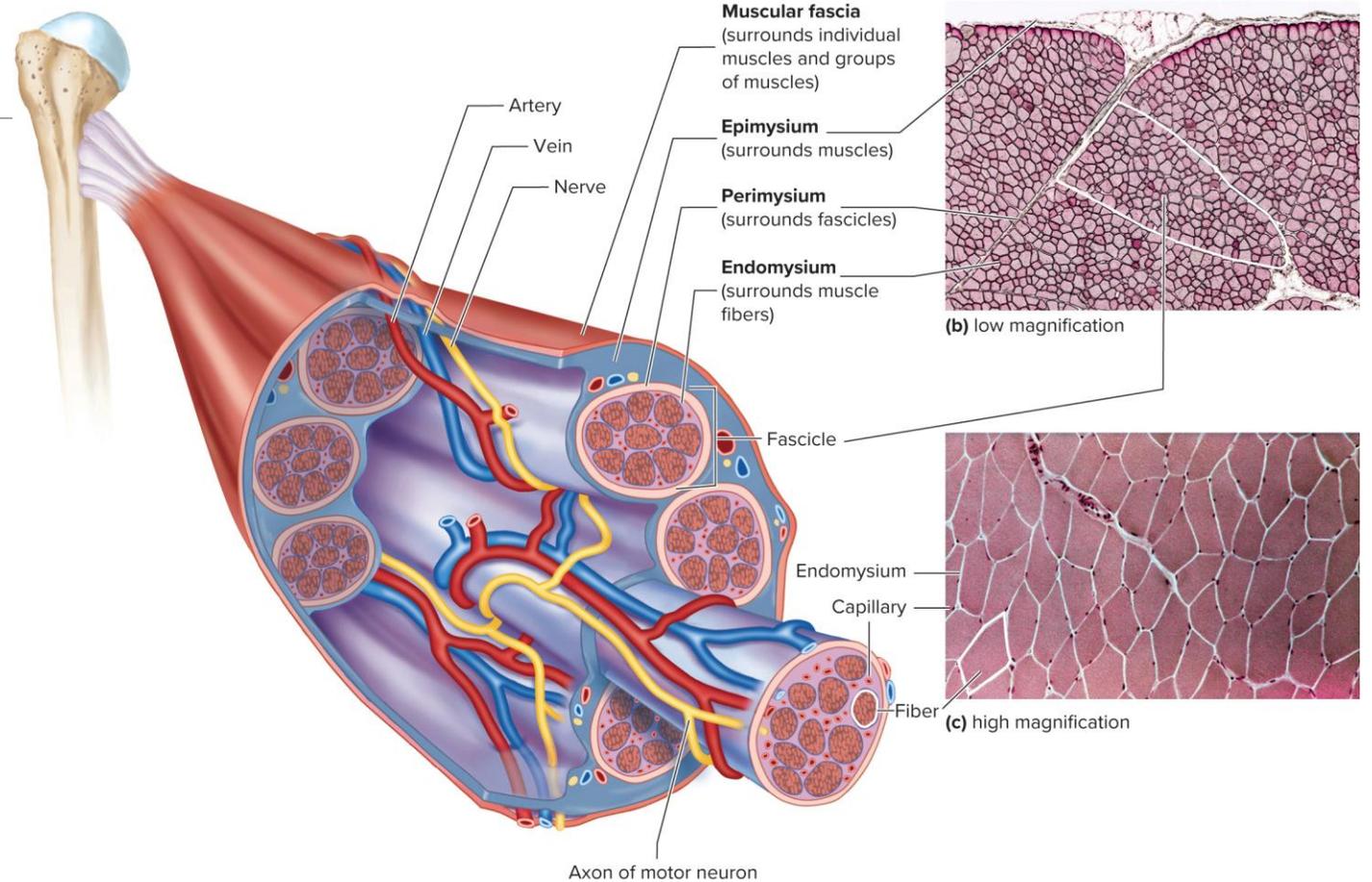
Tendons

Epimysium

Outer layer

Encircles the entire muscle

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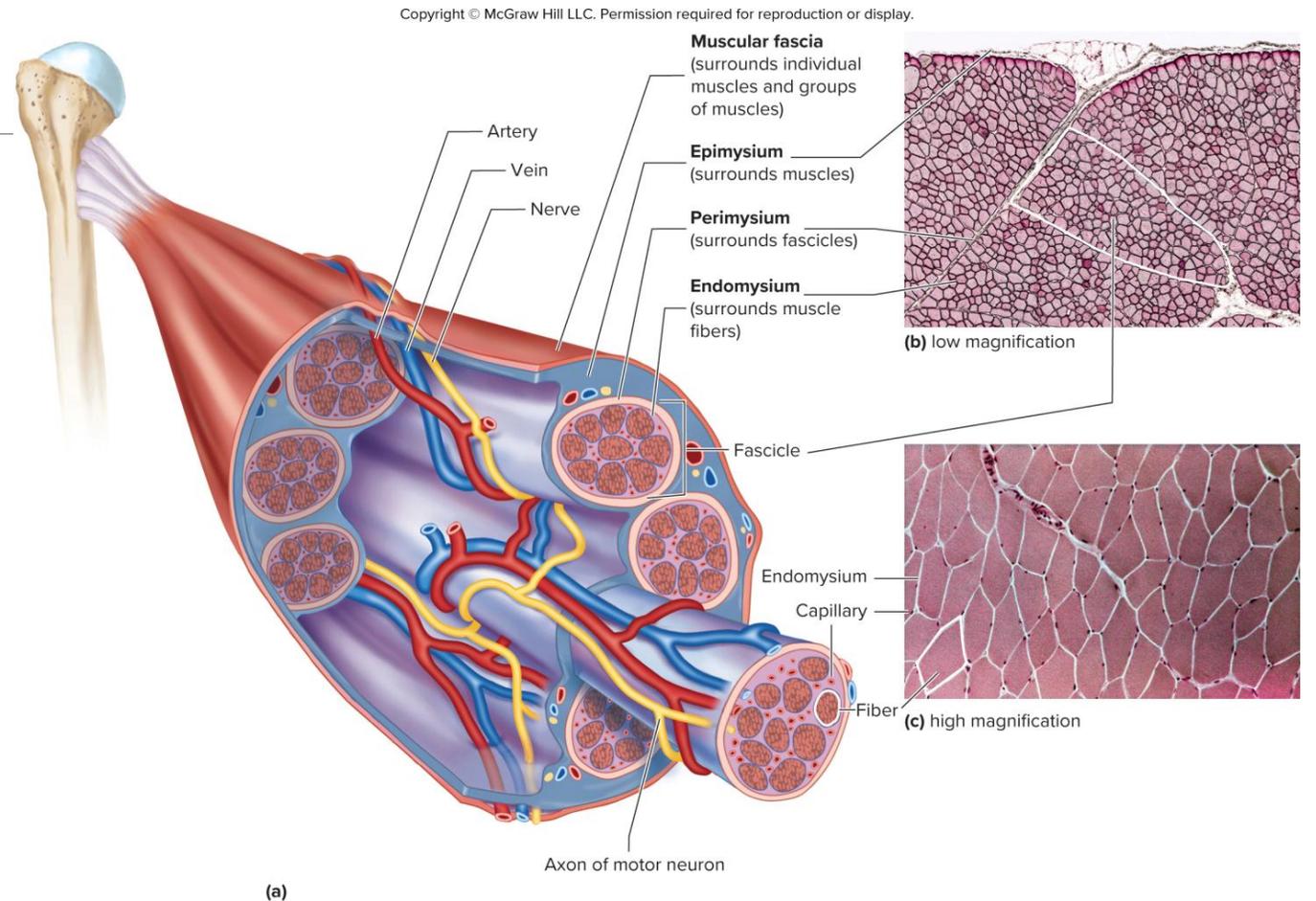
(a)

(b) Alvin Telsler/Science Source; (c) Biophoto Associates/Science Source

Perimysium

Surrounds groups of 10 to 100 muscle fibers

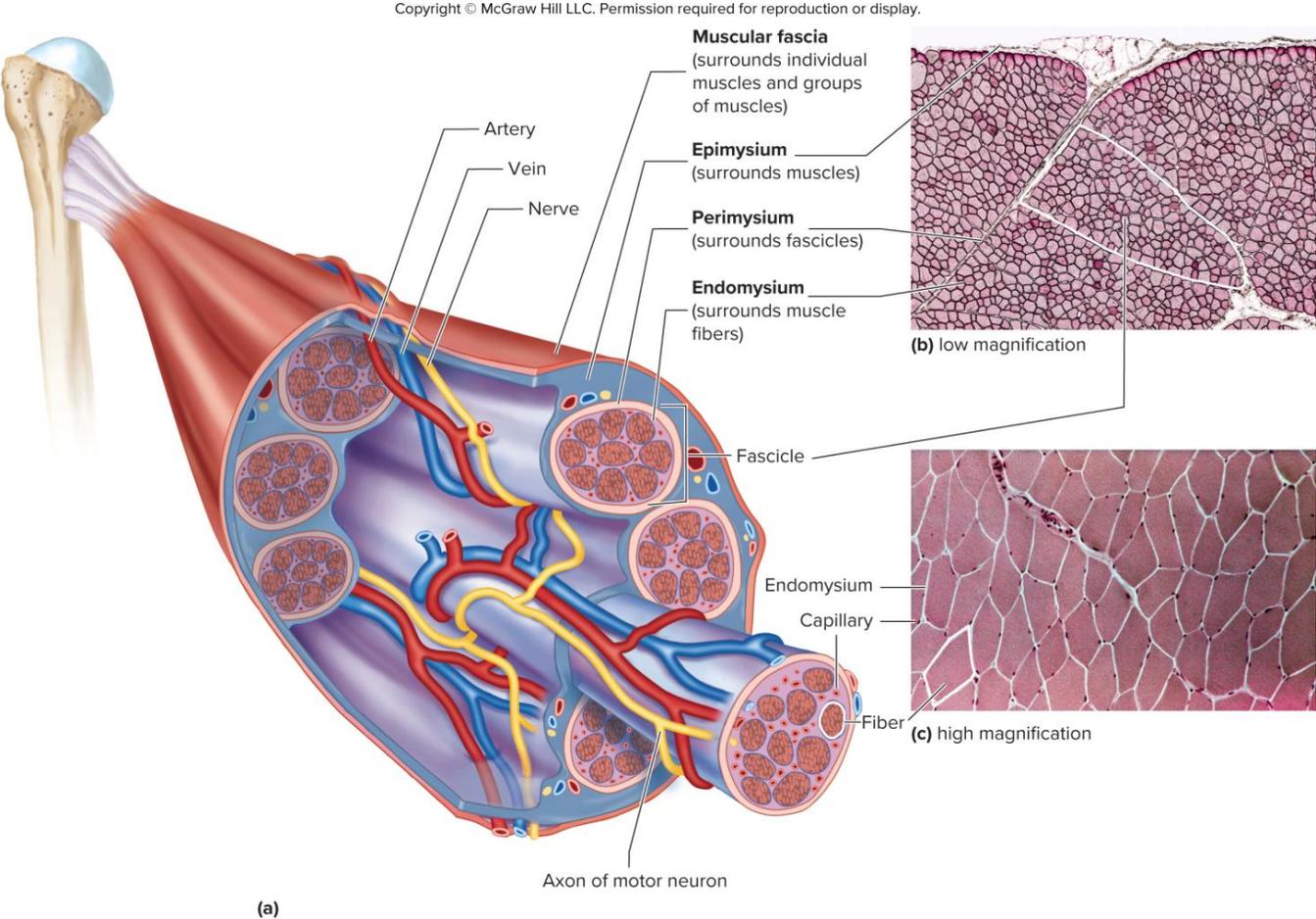
Creates *muscle fascicles*



(b) Alvin Telser/Science Source; (c) Biophoto Associates/Science Source

Endomysium

Separates each individual muscle fiber inside the fascicles



(b) Alvin Telsler/Science Source; (c) Biophoto Associates/Science Source

Fascia

Layer of connective tissue that lines the body walls and limbs, to support and surround muscle groups

Holds muscles with similar functions together

Tendons

How muscles attach to bones

Continuous with epimysium, perimysium and endomysium

Attaches to periosteum of bone

Muscle Fiber Components

Sarcolemma

T Tubules

Sarcoplasm

Sarcoplasmic Reticulum

Myofibrils

Filaments

Sarcomere

Components

Sarcolemma

- Plasma membrane of muscle fiber

T Tubules

- Tunnels leading into the muscle fiber from sarcoplasm

Sarcoplasm

- Cytoplasm of muscle fiber

Components

Sarcoplasmic Reticulum

- Fluid filled sacs that surround myofibrils
- Contain Ca^{++} needed for muscle contractions

Myofibrils

- Contractile unit of skeletal muscle
- Bundles of protein filaments

Components

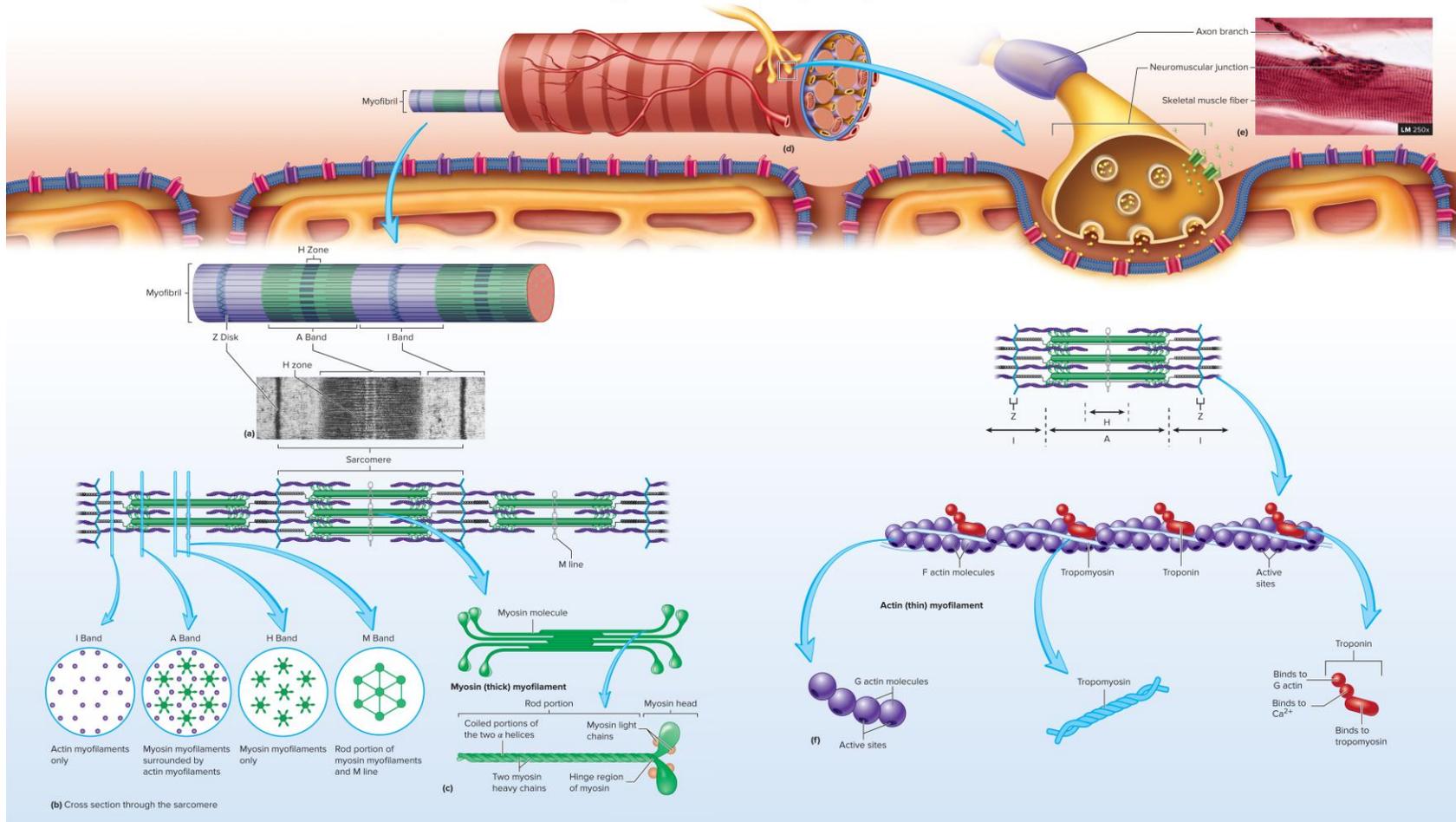
Filaments

- Small protein structures inside myofibrils
- **Actin** = *thin filaments*
- **Myosin** = *thick filaments*

Sarcomere

- Functional unit of skeletal muscles

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(b) Cross section through the sarcomere

(c)

(f)

(e)

(d)

(a)

Components of the sarcomere

Z Disc

- Separates sarcomeres

A Band

- Thick Filaments (Myosin) completely and some of the Thin Filaments (Actin)

I Band

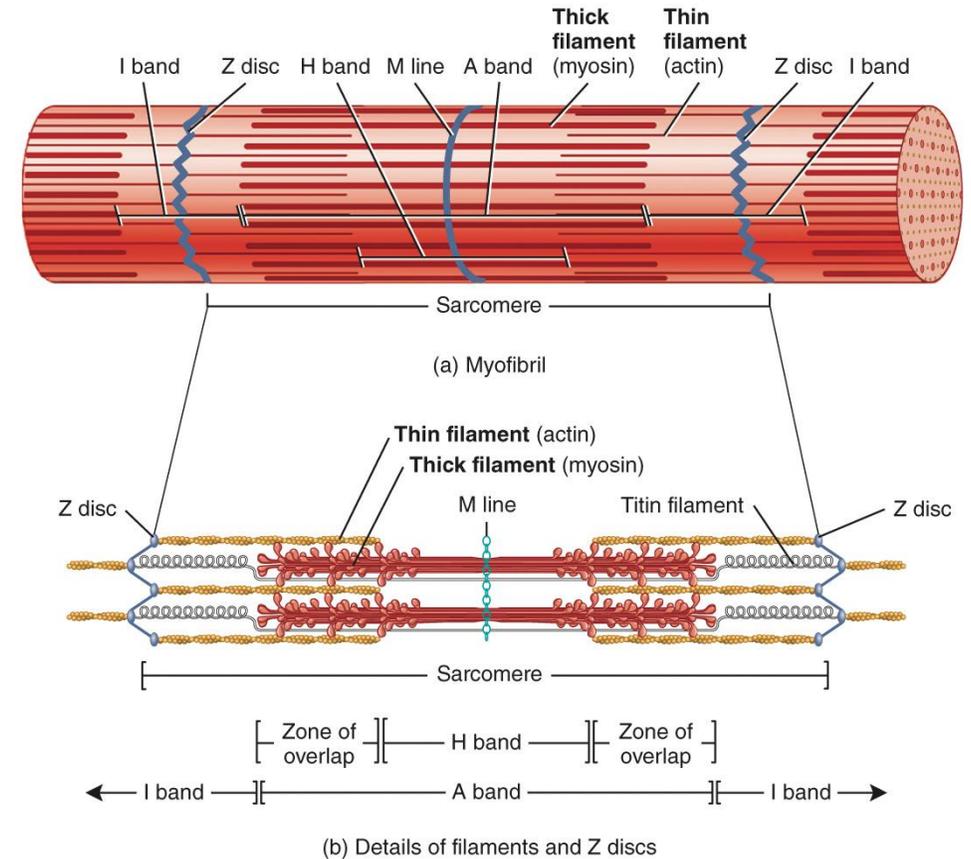
- Thin Filaments only

H Band

- Thick Filaments only

M Line

- Middle of sarcomere



Muscle Proteins

Contractile Proteins

- *Actin and Myosin*
- Generate contraction

Regulatory Proteins

- *Tropomyosin and Troponin*
- Switch contraction on and off

Structural Proteins

- Keeps things aligned properly

Neuromuscular Junction

In order for muscles to be able to contract they must be stimulated by a motor (somatic) nerve

Every muscle fiber has one

4 Steps of the Neuromuscular Junction

1.) Release of Acetylcholine (ACh)

- Stimulation of the nerve causes an electrical signal to go to the nerve ending
- Vesicles in the nerve ending contain ACh, which gets released

2.) Activation of ACh Receptors

- ACh starts to fill the space between the nerve ending and the receptors on the muscle fiber
- ACh binds to receptor sites on the muscle membrane (known as the motor end plate)
- The binding causes ion channels to open (Na⁺)

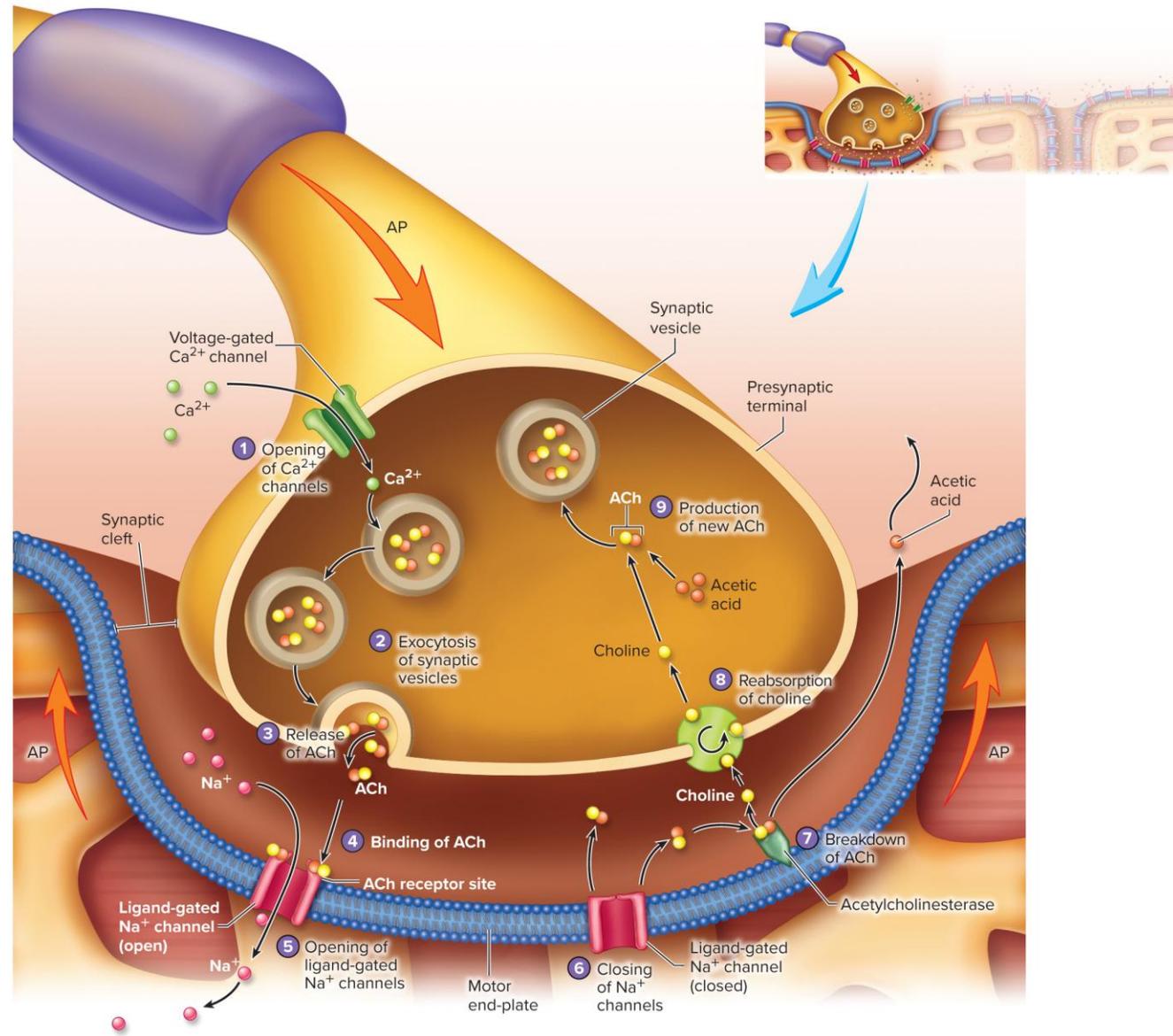
4 Steps of the Neuromuscular Junction

3.) **Action Potential is produced**

- The influx of Na^+ into the muscle fiber triggers an action potential to start
- The electrical signal moves along the sarcolemma to the T tubules, which leads to the sarcoplasmic reticulum releasing Ca^{++}

4.) **Termination of ACh activity**

- Acetylcholinesterase (AChE) breaks down ACh, so receptors are inactivated

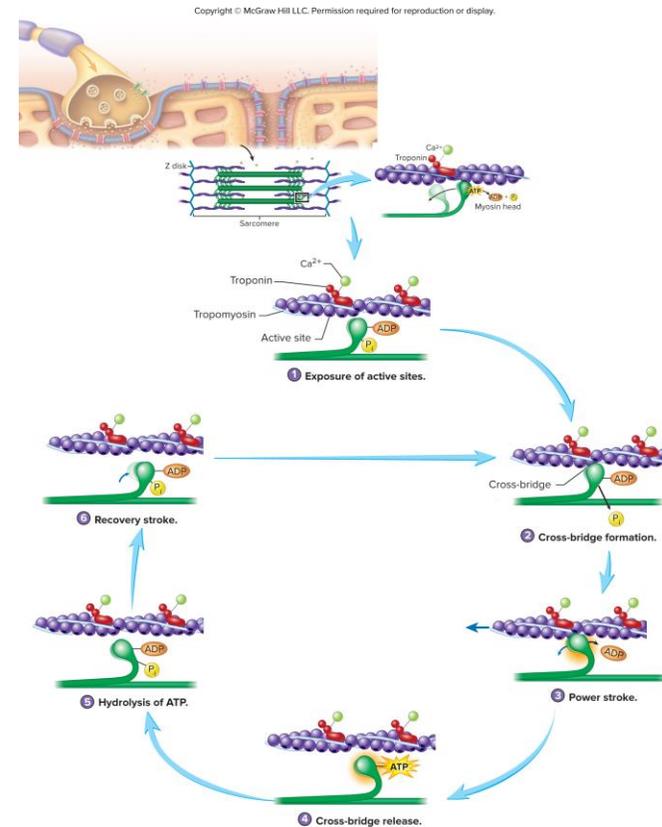


Contraction and Relaxation of Muscle Fibers

Sliding Filament Mechanism

Myosin head has two binding sites:

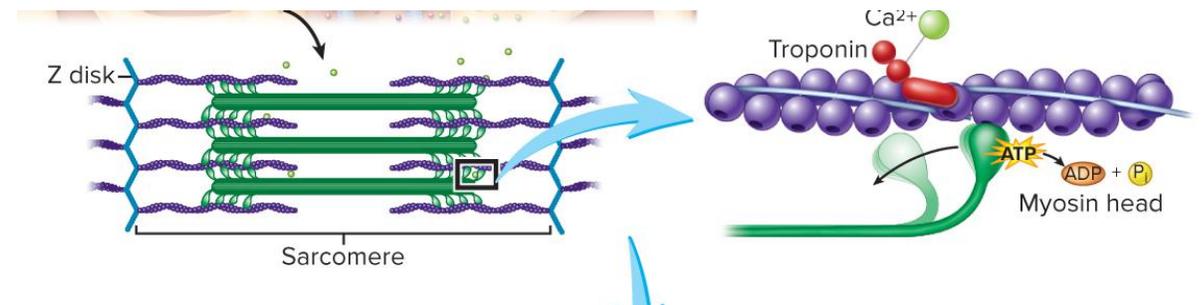
- ATP-binding site that will hydrolyze ATP into ADP
- The energy from this process is stored in the myosin head to use later
- Binding site for actin filaments and pull them toward the midline



Sliding Filament Mechanism

4 Step Process

- 1) ATP Hydrolysis positions myosin head in “cocked” position
- 2) Ca^{++} binds with troponin which then removes tropomyosin away from actin → myosin now binds with actin
- 3) Power Stroke - ATP provides this energy
- 4) Actin detaches from myosin, and tropomyosin reattaches



Muscle Metabolism



Three Ways to Make ATP

Creatine Phosphate

Glycolysis/Krebs Cycle

Electron Transport Chain

Creatine Phosphate

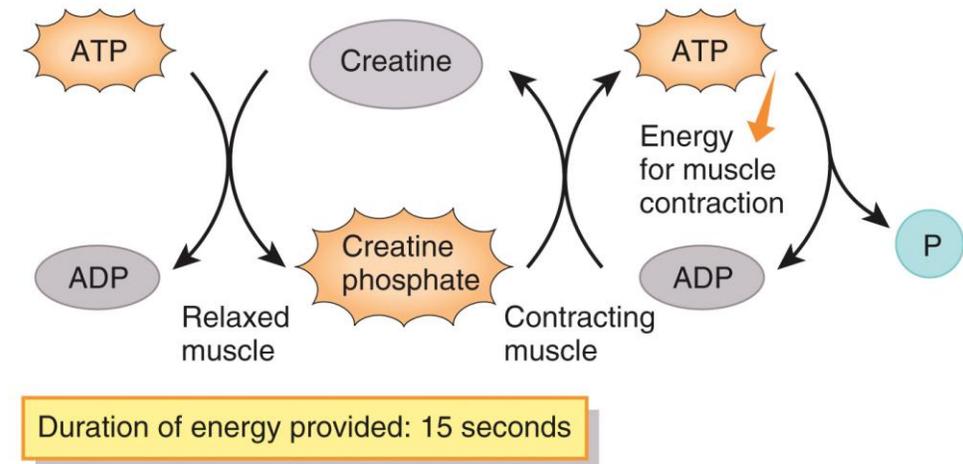
Muscle fibers are constantly producing ATP even when its not needed

Excess ATP transfers its high energy phosphate groups to creatine (amino acid)

When needed the phosphate can get transferred back to ADP

- This happens extremely quickly so this is always the first source of energy used for muscle contraction

Creatine Supplements → some people believe this can help with explosive movements



(a) ATP from creatine phosphate

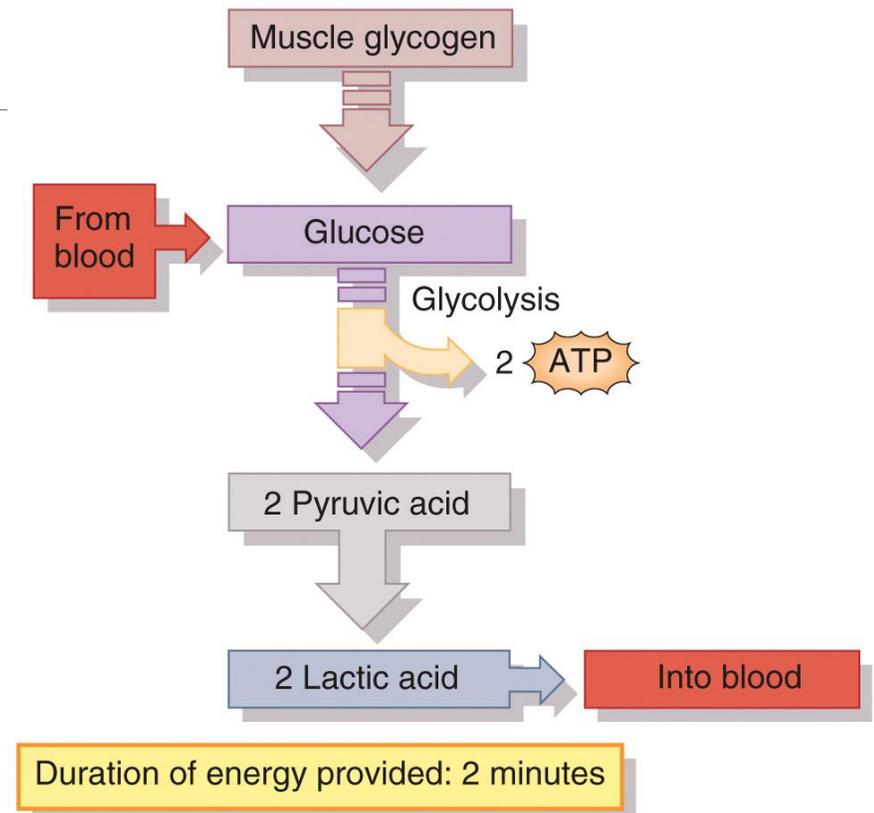
Glycolysis and Krebs Cycle (both are anerobic)

Glucose is catabolized to generate ATP

Occurs in the cytosol of the cell and does not require O₂

Glucose is broken down into 2 pyruvic acid molecules & also produces 2 ATP molecules

- If O₂ is present, pyruvic acid enters aerobic respiration
- If O₂ is not present, pyruvic acid converts to lactic acid



(b) ATP from anaerobic glycolysis

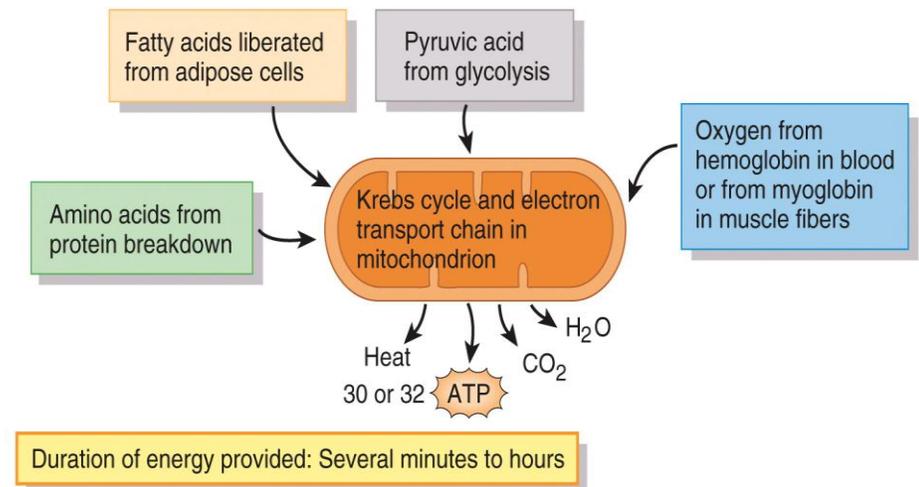
Electron Transport Chain (aerobic)

Occurs in the mitochondria of the cell

Series of oxygen-requiring reactions that produce ATP

Slower process, but yields the most ATP (30-32 per glucose)

This is used for endurance activities



(c) ATP from aerobic respiration

Muscle Contractions

Terms for Contractile Activity

Twitch Contractions

- Brief contraction of all muscle fibers of a motor unit by a single stimulus
- Not very useful for accomplishing things

Tetanus

- Sustained muscle contraction
- No time for relaxation
- Plays a role with posture

Muscle Tone

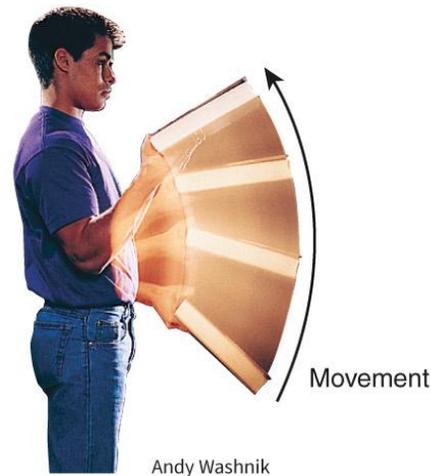
- Normal state of partial muscle contraction

Types of muscle contractions

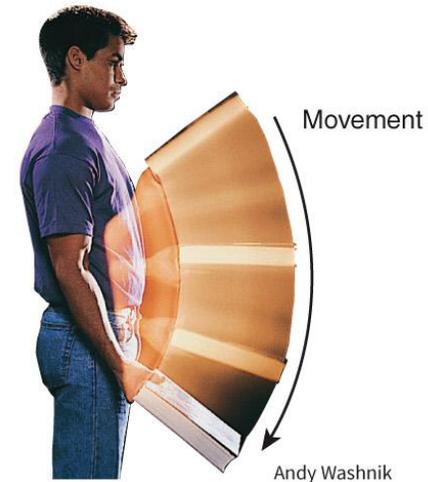
Isotonic (equal tension)

- *Concentric* – muscle shortens while contracting
- *Eccentric* – muscle lengthens while contracting

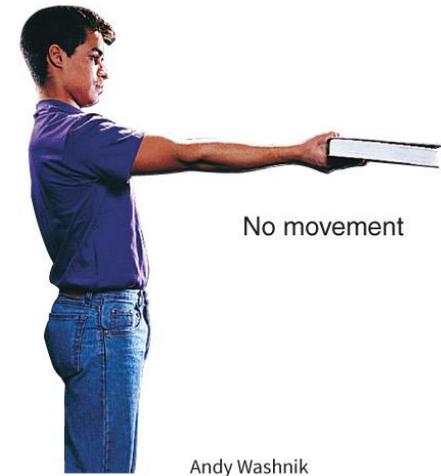
Isometric (equal length)



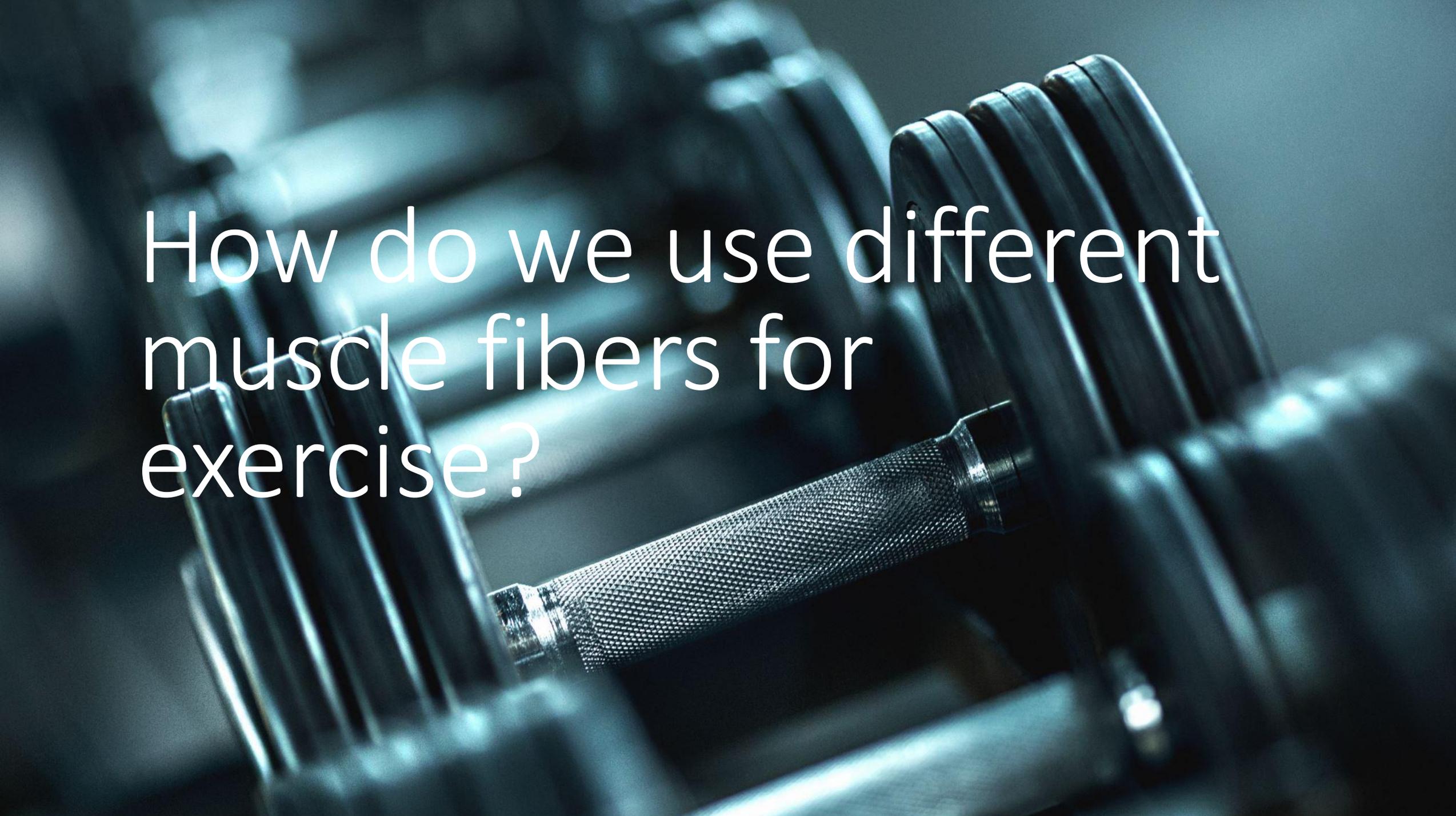
(a) Concentric contraction while picking up a book



(b) Eccentric contraction while lowering a book



(c) Isometric contraction while holding a book steady



How do we use different muscle fibers for exercise?

Types of Skeletal Muscle Fibers

Slow Oxidative

Slow twitch
Resistant to fatigue

Fast Oxidative-Glycolytic

Faster than slow oxidative
Mild resistance to fatigue

Examples:
walking & sprinting

Fast Glycolytic

Strong, quick contractions
Very little endurance

Example:
Weight lifting

Homeostatic Imbalances

Overuse and Underuse

Hypertrophy → increase in size

- Result of overuse or overworking muscles
- This is useful for all muscles in the body except the heart

Atrophy → muscle getting smaller or “wasting away”

- Result of not being used
- Someone in a cast or bedridden

Myasthenia Gravis

Autoimmune Disease

There is damage to the NMJ at the receptor sites of the muscles

Muscle contraction is impaired → person experiences extreme weakness and fatigue

This can effect skeletal muscles and muscle of respiration (in rare cases)

Muscular Dystrophy

Term for a group of inherited muscle destroying diseases

Progressive degeneration of skeletal muscle fibers

Most common → Duchenne Muscular Dystrophy

- Due to a mutated gene on X chromosome (mostly boys)

Typically becomes apparent by 2-5 years old – difficulty running and jumping

By 12, most are unable to walk

By 20, usually effects respiratory and cardiac muscle leading to death